Scilab Textbook Companion for Power Electronics Devices,circuits And Application by Muhammad. H. Rashid[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 2

Power Diodes and Switched RLC Circuits

Scilab code Exa 2.1 Finding the Saturation Current

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 2.1
//Finding the Saturation Current

clc;
clear;
VD=1.2;                          //Forward Voltage drop
    of Diode in Volts.
ID=300;                          //Forward Current in
    Amps.
n=2;                             //Emprical Constant or
    Ideality factor.
VT=25.7;                         //Thermal Voltage
    constant in mV.
```

```
Is=ID/(exp(VD/(n*VT*10^-3))-1);//Calcualating Is.
printf("The reverse saturation Current Is is %0.5e A
    ",Is);
```

Scilab code Exa 2.2 Finding the Reverse Recovery Current

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 2.2
//Finding the reverse recovery Current

clc;
clear;
trr=3;                  //Reverse recovery time of the
    diode in micro second.
di_by_dt=30;            //The rate of fall of diode
    current in A/micro second.
QRR=(0.5*di_by_dt*10^6*((trr*10^-6)^2))*10^6;
    //Calculating Storage charge QRR;
IRR=sqrt(2*QRR*10^-6*di_by_dt*10^6);          //
    Calculating reverse recovery current IRR.
printf("\n\tThe storage charge QRR is %i C",QRR);
printf("\n\tThe Peak Reverse current IRR is %iA",IRR
    );
```

Scilab code Exa 2.3 Finding the Voltage Sharing Resistors

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H. Rashid
```

```
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example 2.3
//Finding the voltage-Sharing resistors

clc;
clear;
Is1=30;Is2=35;            //Reverse leakage Current of two diodes in milli ampere.
R=100;R1=100;             //Resistance of two diodes in Ohm.
VD=5;                     //Dc Reverse Voltage in KV.
VD1=VD/2;VD2=VD/2;        //Volage acrssos the diode in volts.
Vd1=((VD*10^3)/2)+(((R*10^3)/2)*((Is2*10^-3)-(Is1*10^-3)));    //Calculating the voltage across the doiode.
Vd2=(VD*10^3)-Vd1;
r2=(VD2*R1)/(VD1-(R1*((Is2-Is1)*10^-3)));
printf("\n\t(a) The Voltage across diode D1, VD1 is %iV",Vd1);
printf("\n\t    The Voltage across diode D2, VD2 is %iV",Vd2);
printf("\n\t(b) The Voltage Sharing Resistance R2 is %iKilo Ohm",r2);
```

Scilab code Exa 2.4 Finding the peak Current and energy loss in an RC Circuit

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.
```

```

//Example 2.4
//Finding the peak Current and energy loss in an RC Circuit.

clc;
clear;
Vc0=220;                   //Intial voltage of the capacitor in Volts.
R=44;                      //Resistance in Ohm.
C=0.1;                     //Capacitance in Micro Farad
Ip=Vc0/R;                  //Calculating the peak diode current.
W=0.5*C*10^-6*Vc0^2;       //Calculating the energy dissipated.
printf("\n\t(a) The Peak diode current Ip is %iA",Ip);
printf("\n\t(b) The Energy dissipated W is %0.2fmJ",W*10^3);
t=2;                        //Time in Micro second;
Vc=Vc0*exp(-t/(R*C));       //Calculating the value of capacitor voltage.
printf("\n\t(c) The Capcitor Voltage at t=2 s  is %0.2fV",Vc);
```

Scilab code Exa 2.5 Finding the Steady State Current and the energy Stored in an I

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 2.5
//Finding the Steady-State Current and the energy
```

```
Stored in an Inductor

clc;
clear;
Vs=220;                    //Voltage across the diode in volts.
R=4;                       //Resistance in Ohms.
L=5;                       //Inductance in milli Henry.
Ip=Vs/R;                   //Calculating the peak diode current.
printf("\n\t(a). The steady state peak diode current Ip is %iA",Ip);
W=0.5*L*10^-3*Ip^2;        //Calculating the energy stored in inductor.
printf("\n\t(b). The energy stored in the Inductor L, W is %0.3fmJ",W);
di_by_dt=Vs/(L);            //Calculating the intial di/dt.
printf("\n\t(c). The intial change in current di/dt is %iA/ms",di_by_dt);
t=1;                       //time in milli second.
i=(Vs/R)*(1-exp(-t*R/L));
printf("\n\t(d). The inductor current at t=1ms is %0.3fA",i);
```

Scilab code Exa 2.6 `Finding the voltage and Current in an LC Circuit`

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 2.6
```

```
//Finding the voltage and Current in an LC Circuit

clc;
clear
Vo=220;          //Intial voltage of capacitor in
   Volts.
C=20;            //Capacitance in micre farad.
L=80;            //Inductance in micro Henry.
printf("\n\tThe circuit is shown in the Figure 2.19a
   ");
wo=10^6*sqrt(C*L);
Ip=Vo*sqrt(C/L);
t1=%pi*sqrt(L*C);
Vct=-Vo*cos(%pi);
printf("\n\t(a). The peak current Ip is %iA",Ip);
printf("\n\t(b). The conduction time t1 is %0.2f  s"
   ,t1);
printf("\n\t(c). The capcitor voltage at time t1 Vc(
   t1) is %iV",Vct);
```

Scilab code Exa 2.7 Finding the Current in an RLC Circuit

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 2.7
//Finding the Current in an RLC Circuit.

clc;
clear;
```

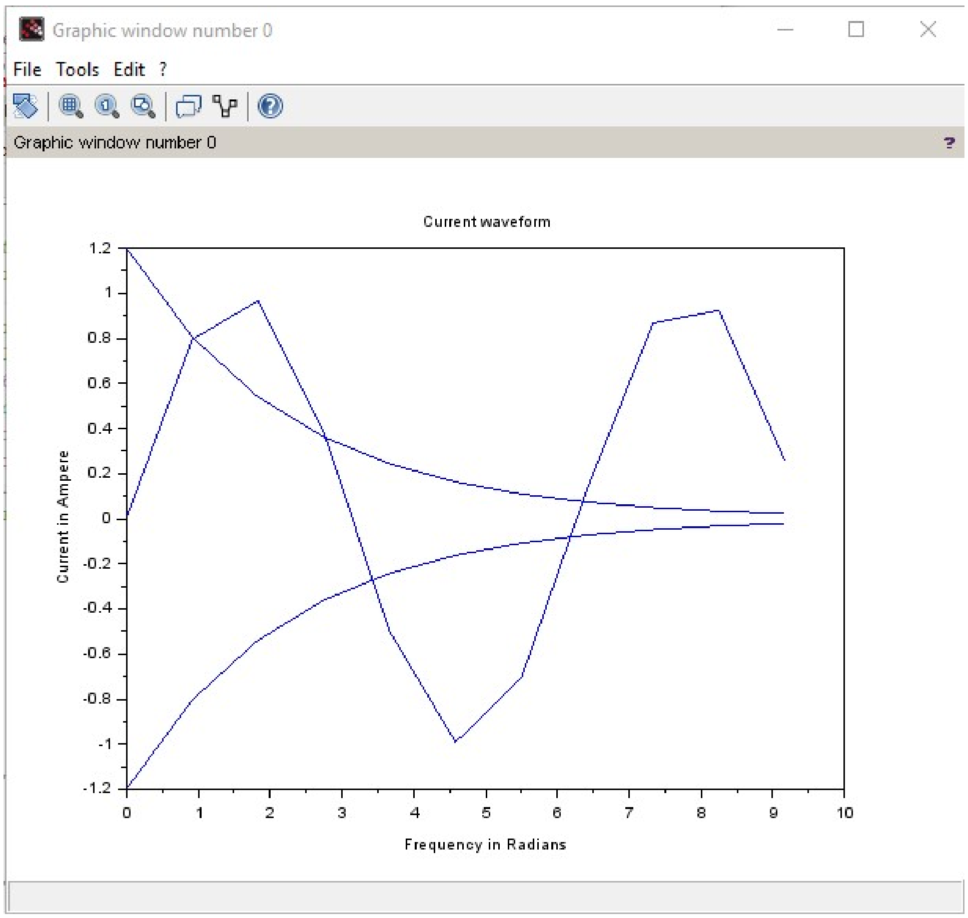

Figure 2.1: Finding the Current in an RLC Circuit

```
Vs=220;          //Source Voltage in Volts.
L=2;             //Inductance in milli Henry.
C=0.05;          //Capacitance in micro Farad.
R=160;           //Resistance in Ohm.
alp=(R*10^3)/(2*L);      //Calculation of the damping factor alp.
wo=1/(sqrt((L*10^-3)*(C*10^-6)));      //Calculation of resonant frequency.
wr=sqrt(wo^2-alp^2);    //Calculation of ringing frequncy.
t1=%pi/wr;                       //Calculating the conduction time of diode.
printf("\n\tThe damping ratio alp is %irad/s",alp);
printf("\n\tThe resonant frequency wo is %0.0frad/s",wo);
printf("\n\tThe ringing frequncy wr is %0.0frad/s",wr);
printf("\n\t(b).The Conduction time of diode when t=0, t1 is %0.2f  s",t1*10^6);
printf("\n\t(c).The current waveform is shown in figure.");
//Ploting the current waveform in the figure 2.21.
t=[0:0.00001:0.0001];
//Calculating the values in the graph with respect to time.
wrt=wr*t;
g1=1.2*exp(-alp*t);
g=-1.2*exp(-alp*t);
g2=sin(wr*t);
clf;
plot(wrt,g1);
plot(wrt,g);
xlabel("Frequency in Radians");
ylabel("Current in Ampere");
title("Current waveform");
plot(wrt,g2);
xlabel("Frequency in Radians");
ylabel("Current in Ampere");
```

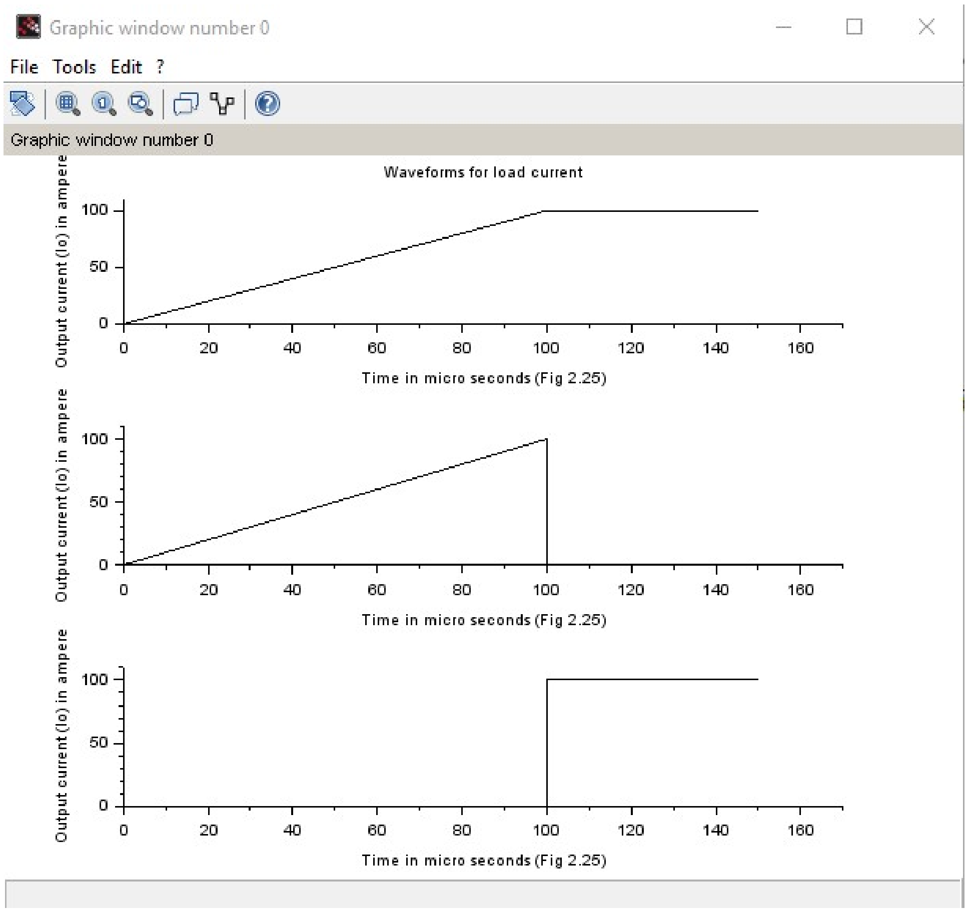

Figure 2.2: Finding the Stored energy in an Inductor with a Freewheeling Diode

```
title("Current waveform");
//The plot given in the textbook have some error.
//Some answers may vareid due to round-off error.
```

Scilab code Exa 2.8 Finding the Stored energy in an Inductor with a Freewheeling D

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 2.8
//Finding the Stored energy in an Inductor with a
   Freewheeling Diode.

clc;
clear;
Vs=220;              //Source Voltage in Volts.
L=220;               //Load inductance in micro Henry
   .
t1=100               //Time in micro seconds.
Io=(Vs/L)*t1;        //Calculating the output current
   .
//Plotting the Current waveform in fingure 2.25(b)
t=[0 100 150];
I=[0 Io Io]
subplot(311);
plot2d(t,I,rect=[0,0,170,110]);
xlabel("Time in micro seconds (Fig 2.25)");
ylabel("Output current (Io) in ampere");
title("Waveforms for load current");
subplot(312)
t0=[0,100,100]'
I1=[0,Io,0];
plot2d(t0,I1,rect=[0,0,170,110]);
xlabel("Time in micro seconds (Fig 2.25)");
ylabel("Output current (Io) in ampere");
subplot(313);
t2=[0 100 100 150];
I2=[0 0 Io Io]
plot2d(t2,I2,rect=[0,0,170,110]);
xlabel("Time in micro seconds (Fig 2.25)");
ylabel("Output current (Io) in ampere");
```

```
E=0.5*L*10^-6*Io^2;    //Calculating energy stored in
    inductor.
printf("\n\t(a).The output current Io is %0.0fA",Io)
    ;
printf("\n\t    The graph is shown in the figure");
printf("\n\t(b).The energy stored in the inducutor
    Lo is %0.1fJ",E);
```

Scilab code Exa 2.9 Finding the recovery energy in an Inductor with a Feedback Dio

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2       ;OS : Windows.

//Example : 2.9
//Finding the recovery energy in an Inductor with a
    Feedback Diode

clc;
clear;
Lm=250;                 //Magnetizing inductance of
    transformer in micro Hery.
N1=10;N2=100;           //Primary and Secondry turns of
    the transformer.
Vs=220;                 //Source voltage in volts.
t1=50                   //Time for which switch S1 is
    close in micro seconds.
a=N2/N1;                //Calculating the turns ratio.
VD=Vs*(1+a);            //Calculating reverse voltage
    of the diode.
Io=(Vs/Lm)*(t1);        //Calculating the peak value of
    the primary current.
Io1=Io/a;               //Calculating the peak value of
```

```
    the secondary current.
t2=(a*Lm*Io)/(Vs);    //Calculating the conduction
   time of the diode.
W=0.5*(Lm*10^-6)*(Io^2);       //Calculating the
   source energy.
printf("\n\tThe turns ratio a = %i",a);
printf("\n\t(a). The reverse voltage of the diode VD
     is %iV",VD);
printf("\n\t(b). The peak value of the primary
   current Io is %iA",Io);
printf("\n\t(c). The peak value of the secondary
   current Io1 is %0.1fA",Io1);
printf("\n\t(d). The conduction time ot the diode t2
     is %i s",t2);
printf("\n\t(e). The source energy, W is %0.3fJ",W);
```

Chapter 3

Diode Rectifiers

Scilab code Exa 3.3 Finding the performance parameters of a full Wave rectifier wi

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.3
//Finding the performance parameters of a full-Wave rectifier with an RL load.

clc;
clear;
L=6.5;                  //Inductance in milli Henry.
R=2.5;                  //Resistance in Ohm.
E=10;                   //The voltage of the battery in volts.
Vs=120;                 //Supply voltage in volts.
f=60;                   //Frequency in Hertz.
//Calculating Diode parameters.
IS=(2.2*E)-(15);BV=1800;
w=2*%pi*f;
```

```
Z=((R^2)+((w*(L*10^-3))^2))^0.5;
theta=atan((w*(L*10^-3))/(R));
printf("\n\ttheta = %0.2f degree",theta*180/%pi);
printf("\n\tw = %0.0frad/sec",w);
printf("\n\tZ = %0.1fOhm",Z);
//Calculating the load current.
a1=(R/(L*10^-3))*(%pi/(w));a5=(sqrt(2)*Vs)/(Z);
a2=1-(exp(-a1));a3=1+(exp(-a1));a4=a3/a2;
I0=(a5*sin(theta)*a4)-(E/R);
//Calculating the average diode current.
funcprot(0)
function a=f(wt)
    a=(a5*(sin(wt-theta)+((2/a2)*sin(theta)*(exp(-((R/(L*w*10^-3))*wt))))))-(E/R)
endfunction
a=0;b=%pi;
b1=intg(a,b,f);
ID_av=(1/(2*%pi))*b1;
//Calculating the rms diode current.
funcprot(0)
function b=f(wt)
    b=((a5*(sin(wt-theta)+((2/a2)*sin(theta)*(exp(-((R/(L*w*10^-3))*wt))))))-(E/R))^2
endfunction
c1=intg(a,b,f);
ID_rms=sqrt((1/(2*%pi))*c1);
I0_rms=sqrt(2)*ID_rms;                    //Calculating rms output voltage.
Pac=I0_rms^2*R;                           //Calculating ac load power.
PF=Pac/(Vs*I0_rms);                       //Calculating input power factor.
printf("\n\tThe steady state current at wt = 0,I0 is %0.1fA",I0);
printf("\n\tThe average diode current ID(avg) is %0.2fA",ID_av);
printf("\n\tThe rms diode current ID(rms) is %0.1fA",ID_rms);
```

```
printf("\n\tThe rms output power I0(rms) is %0.1fA",I0_rms);
printf("\n\tThe ac load power Pac is %0.2fKW",Pac*10^-3);
printf("\n\tThe input power factor is %0.2f(lagging)",PF);
```

Scilab code Exa 3.8 Finding the Performance Parameters of a Three Phase Bridge Rec

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.8
//Finding the Performance Parameters of a Three-Phase Bridge Rectifier with an RL Load.

clc;
clear;
L=1.5;                     //Inductance in milli Henry.
R=2.5;                     //Resistance in Ohm.
E=10;                      //Voltage of the battery in volts.
Vab=208;                   //Input voltage in volts.
f=60;                      //Supply frequency in Hz.
Vs=120;                    //Supply voltage in volts.
w=2*%pi*f;                 //Calculating frequency in rad/sec.
Z=sqrt(R^2+(w*L*10^-3)^2); //Calculating input impedence.
theta=atan((w*L*10^-3)/R);     //Calculating the
```

```
suply thetale.
//Calculating the steady state current.
a1=(sqrt(2)*Vab)/Z;a2=sin(((2*%pi)/3)-theta);a3=(R/(L*10^-3))*(%pi/(3*w));
a4=exp(-a3);a5=sin((%pi/3)-theta)*a4;a7=exp(-a3);a6=1-a7;
Io=(a1*((a2-a5)/a6))-(E/R);
//Calculating the average diode current.
funcprot(0)
function a=f(wt)
    a=(a1*((sin(wt-theta))+(((a2-sin((%pi/3)-theta))/a6)*exp((R/(L*10^-3))*((%pi/(3*w))-(wt/w))))))-(E/R)
endfunction
a=%pi/3;b=(2*%pi)/3;
b1=intg(a,b,f);
ID_av=(2/(2*%pi))*b1;
//Calculating rms diode current.
funcprot(0)
function b=f(wt)
    b=((a1*((sin(wt-theta))+(((a2-sin((%pi/3)-theta))/a6)*exp((R/(L*10^-3))*((%pi/(3*w))-(wt/w))))))-(E/R))^2
endfunction
c1=intg(a,b,f);
ID_rms=sqrt((2/(2*%pi))*c1);
Io_rms=sqrt(3)*ID_rms;                    //Calculating output rms current.
Pac=Io_rms^2*R;                           //Calculating ac load power.
PF=Pac/(3*sqrt(2)*Vs*ID_rms);             //Calculating the power factor.
printf("\n\tThe steady state load current Io is %0.2fA",Io);
printf("\n\tThe average diode current ID(av) is %0.1fA",ID_av);
printf("\n\tThe rms diode current ID(rms) is %0.2fA",ID_rms);
```

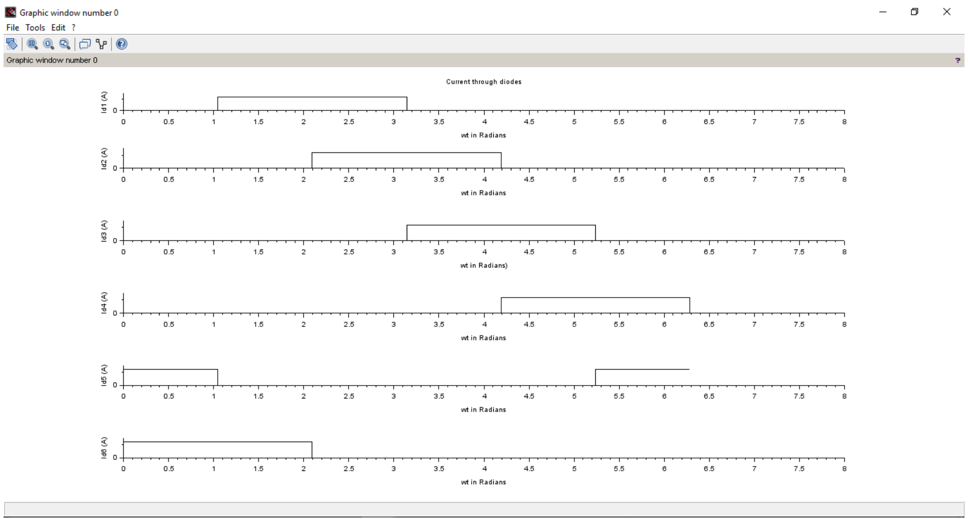

Figure 3.1: Finding the Diode Ratings from the Diode Currents

```
printf("\n\tThe output rms current Io(rms) is %0.1fA
    ",Io_rms);
printf("\n\tThe ac load power Pac is %0.1fKW",Pac
    *10^-3);
printf("\n\tThe power factor PF is %0.2f(lagging)",
    PF);
//Some answers are varied due to round-off error.
```

Scilab code Exa 3.9 `Finding the Diode Ratings from the Diode Currents`

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2        ;OS : Windows.

//Example : 3.9
```

```
//Finding the Diode Ratings from the Diode Currents.

clc;
clear;
Idc=60;                          //Average load current in ampere.
V=120;                           //Supply voltage in volts.
f=60;                            //Supply frequency in Hz.
Id=Idc/3;                        //Calculating average diode current.
Ir=Idc/sqrt(3);                  //Calculating rms diode current.
PIV=sqrt(3)*sqrt(2)*V;           //Calculating peak inverse voltage.
printf("\n\tThe average diode current Id is %0.0fA",Id);
printf("\n\tThe rms diodoe current Ir is %0.2fA",Ir);
printf("\n\tThe peak inverse voltage PIV is %0.0fV",PIV);
//Ploting the graph of the current through the diode
a=[0,Idc,Idc,0];
b1=[%pi/3,%pi/3,%pi,%pi];
b2=[2*%pi/3,2*%pi/3,4*%pi/3,4*%pi/3];
b3=[%pi,%pi,5*%pi/3,5*%pi/3];
b4=[4*%pi/3,4*%pi/3,2*%pi,2*%pi];
a1=[0,Idc,Idc,0,0,Idc,Idc]
b5=[0,0,%pi/3,%pi/3,5*%pi/3,5*%pi/3,2*%pi];
b6=[0,0,2*%pi/3,2*%pi/3];
subplot(511)
plot2d(b1,a,rect=[0,0,8,75]);
xlabel("wt in Radians");
title("Current through diodes");
ylabel("Id1 (A)");
subplot(612)
plot2d(b2,a,rect=[0,0,8,75]);
```

```
xlabel("wt in Radians");
ylabel("Id2 (A)");
subplot(613)
plot2d(b3,a,rect=[0,0,8,75]);
xlabel("wt in Radians)");
ylabel("Id3 (A)");
subplot(614)
plot2d(b4,a,rect=[0,0,8,75]);
xlabel("wt in Radians");
ylabel("Id4 (A)");
subplot(615)
plot2d(b5,a1,rect=[0,0,8,75]);
xlabel("wt in Radians");
ylabel("Id5 (A)");
subplot(616)
plot2d(b6,a,rect=[0,0,8,75]);
xlabel("wt in Radians");
ylabel("Id6 (A)");
```

Scilab code Exa 3.10 Finding the Diode Average and rms Currents from the Waveforms

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.10
//Finding the Diode Average and rms Currents from
    the Waveforms.

clc;
clear;
```

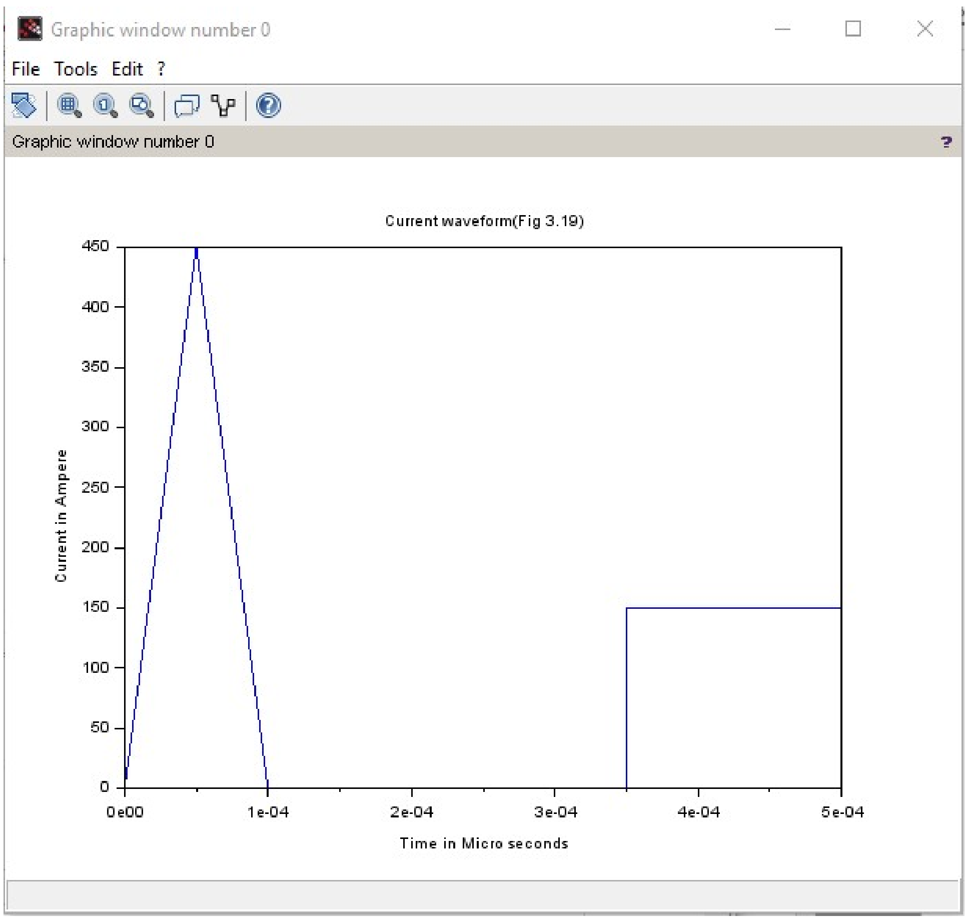

Figure 3.2: Finding the Diode Average and rms Currents from the Waveforms

```
t1=100;                    //Time in micro seconds.
t2=350;                    //Time in micro seconds.
t3=500;                    //Time in micro seconds.
f=250;                     //Resonant frequency in Hz.
fs=5;                      //Resonant frequency in KHz.
Im=450;                    //Magnetizing current in ampere.
Ia=150;                   //Average current in ampere.
ID_rms=sqrt(((Im^2*f*t1*10^-6)/2)+(Ia^2*f*(t3-t2)*10^-6));//Calculating rms diode current.
ID_av=((Im*f)/(%pi*fs*10^3))+(Ia*f*(t3-t2)*10^-6);   //Calculating average diode current.
printf("\n\t(a).The rms value of diode current ID(rms) is %0.2fA",ID_rms);
printf("\n\t(b).The average diode current ID(av) is %0.2fA",ID_av);
//Ploting the Current waveform in Fig 3.19.
ws=2*%pi*fs*10^3;
t11=[0:((t1*10^-6)/2):(t1*10^-6)];
I11=Im*sin(ws*t11);
t22=[0 (t2*10^-6) (t2*10^-6) (t3*10^-6) (t3*10^-6)]
I22=[0 0 Ia Ia 0]
plot(t11,I11);
plot(t22,I22);
title("Current waveform(Fig 3.19)");
xlabel("Time in Micro seconds");
ylabel("Current in Ampere");
```

Scilab code Exa 3.11 Finding the Load Inductance to Limit the Amount of Ripple Cur

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
```

```
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.11
//Finding the Load Inductance to Limit the Amount of
    Ripple Current.

clc;
clear;
Vs=120;                         //Supply voltage in
   volts.
f=60;                           //Supply frequency in
   Hz.
R=500;                          //Resistace in Ohm.
RF=0.05;                        //Ripple factor.
L=sqrt((0.4714^2/RF^2)-1)*(R/(2*2*%pi*f));//
   Calculating the value of inductance.
printf("\n\tThe value of inductance required to
   limit the rms ripple current Iac to less than 5
   Percent of Idc, L is %0.2fH",L);
```

Scilab code Exa 3.12 Finding the Filter Capacitance to Limit the Amount of Output

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.12
//Finding the Filter Capacitance to Limit the Amount
    of Output Ripple Voltage.

clc;
```

```
clear;
Vs=120;                          //Supply voltage in volts.
f=60;                            //Frequency in Hz.
R=500;                           //Resistance in Ohm.
RF=0.05;                         //Ripple factor.
Ce=(1/(4*f*R))*(1+(1/RF));  //Calculating the value of capacitance.
Vo_av=(sqrt(2)*Vs/2)*(2-(1/(R*2*f*Ce)));//Calculating the average output voltage
printf("\n\t(a).The value of filter capacitane Ce is %0.0f F",Ce*10^6);
printf("\n\t(b).The average output voltage Vo(av) is %0.2fV",Vo_av);
//Book answer is wrong.
```

Scilab code Exa 3.13 Finding the Values of an LC Output Filter to Limit the Amount

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.13
//Finding the Values of an LC Output Filter to Limit the Amount of Output Ripple Voltage.

clc;
clear;
R=40;                       //Resistance in Ohm.
L=10;                       //Inductance in milli Henry.
f=60;                       //Frequency in Hz.
w=2*%pi*f;                  //Frequency in rad/sec.
```

```
RF=10;                        //Ripple factor of output voltage in percentage.
Ce=RF/(2*w*sqrt(R^2+(2*w*L*10^-3)^2));//Calculating value of filter capacitance.
Le=(4.714+1)/((2*w)^2*Ce);               //Calculating value of filter inductance.
printf("\n\t(a).The value of filter capacitance Ce is %0.0f  F",Ce*10^6);
printf("\n\t    The value of filter capacitance Le is %0.2fmH",Le*10^3);
//Some answers may be changed due to roundoff-error.
```

Scilab code Exa 3.14 Finding the Values of an LC Input Filter to Limit the Amount

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.14
//Finding the Values of an LC Input Filter to Limit the Amount of Input Ripple Current.

clc;
clear;
f=60;                          //Supply frequency in Hz.
w=2*%pi*f;                     //Calculating frequency in rad/sec.
Ci=1000;                       //Asummed value of capacitance in micro farad.
Li=(99/((100*w^2)-(3*(3*w)^2)))/(Ci*10^-6);//Calculating the value of capacitance by asumming the value of capacitance.
printf("\n\tThe value of Inductance at capacitance (
```

```
    Ci=1000 F ), Li is %0.3fmH",Li*10^3);
//Answer is change due to round off error.
```

Scilab code Exa 3.15 Finding the Critical Value of Inductor for Continuous Load Cu

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.15
//Finding the Critical Value of Inductor for Continuous Load Current.

clc;
clear;
Vs=120;                          //Supply voltage in volts.
f=60;                            //Frequency in Hz.
Vdc=100;                         //Dc output voltage in volts.
Idc=10;                          //Dc output current in amoere.
k=0.2575;                        //Average current ratio.
Le=6.5;                          //Filter inductance in milli Henry.
Idc1=15;                         //Dc output current in ampere.
kr=0.324;                        //RMS currnt ratio.
w=2*%pi*f;                       //Calculating frequency in rad/sec.
Vm=sqrt(2)*Vs;                   //Calculating phase voltage.
```

```
//When Vdc=100V and Idc=10A.
x=Vdc/Vm;                          //Calculating voltage ratio.
alp=asind(x);                         //Calculating the firing angle.
Ipk=Idc/k;                         //Calculating peak current.
Lcr=Vm/(w*Ipk);                    //Calculating critical value of inductance.
Irms=kr*Ipk;                       //Calculating rms current.
//When Le=6.5mH and Idc=15A.
Idc1=15;                            //Average output current in ampere.
Ipk1=Vm/(w*Le*10^-3);               //Calculating peak current.
k1=(Idc1/Ipk1)*100;                 //Calculating current ratio.
x12=60;x13=65;                      //The voltage ratio from table 3.6.
k12=23.95;k13=15.27;                //Currnt ratio from table 3.6.
x1=60+((x13-x12)*(k1-k12))/(k13-k12);//Calculating Voltage ratio.
Vdc1=x1*10^-2*Vm;                         //Calculating dc output voltage.
alp12=36.87;alp13=40.54;                  //Firing angle from table 3.6.
alp1=alp12+(((alp13-alp12)*(k1-k12))/(k13-k12));//Calculating the firing angle.
bet12=216.87;bet13=220.54;                           //Calculating firing angle.
bet=bet12+(((bet13-bet12)*(k1-k12))/(k13-k12));//Calculating firing angle.
kr12=31.05;kr13=26.58;                              //Calculating rms current ratio in table 3.6.
kr1=kr12+(((kr13-kr12)*(k1-k12))/(k13-k12));//Calculating rms current ratio.
```

```
Irms1=kr1/100*Ipk1;                          //Calculating rms current.
printf("\n\t(a).When Vdc=100V and Idc=10A");
printf("\n\t    The voltage ratio x is %0.4f",x);
printf("\n\t    The firing angle alp is %0.2f degree",alp);
printf("\n\t    The peak current Ipk is %0.2fA",Ipk);
printf("\n\t    The critical value of inductance Lcr is %0.2fmH",Lcr*10^3)
printf("\n\t    The rms current Irms is %0.2fA",Irms);
printf("\n\t(b).When Le=6.5mH and Idc=15A");
printf("\n\t    The peak current Ipk is %0.2fA",Ipk1);
printf("\n\t    The current ratio k is %0.2fpercent",k1);
printf("\n\t    The volatage ratio x is %0.2fpercent",x1);
printf("\n\t    The dc voltage Vdc is %0.2fV",Vdc1);
printf("\n\t    The firing angle alp is %0.2f degree",alp1);
printf("\n\t    The firing angle bet is %0.2f degree",bet);
printf("\n\t    The rms current ratio kr is %0.2fpercent",kr1);
printf("\n\t    The rms output current Irms is %0.2fA",Irms1);
//Some answers are changed due to round-off error.
//Some answers given in the textbook are wrong
```

Scilab code Exa 3.16 Finding the Effect of Line Inductance on the Output Voltage o

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
```

```
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.16
//Finding the Effect of Line Inductance on the Output Voltage of a Rectifier.

clc;
clear;
V=208;                              //Supply voltage in volts.
f=60;                               //Suppky frequency in Hz.
Idc=60;                             //Average load current in ampere.
Lc=0.5;                             //Inductance per phase in milli Henry.
Vs=V/sqrt(3);                       //Caculating voltage per phase.
Vm=sqrt(2)*Vs                       //Calculating phase voltage.
Vdc=1.654*Vm;                       //Calculating average output voltage.
Vx=6*Idc*Lc*10^-3*f;                //Calculating the reduction of output voltage.
Vo=Vdc-Vx;                          //Calculating effectinve output voltage.
printf("\n\tThe average output voltage Vdc is %0.2fV",Vdc);
printf("\n\tThe rduction in output voltage Vx is %0.1fV",Vx);
printf("\n\tThe effective output voltage Vo is %0.2fV",Vo);
//Some answers are changed due to round-off error.
```

Scilab code Exa 3.17 Finding the Effect of Diode Recovery Time on the Output Volta

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 3.17
//Finding the Effect of Diode Recovery Time on the Output Voltage of a Rectifier

clc;
clear;
trr=50;                        //Reverse recovery time in micro seconds.
Vs=120;                        //Supply voltage in volts.
fs1=2;                         //Supply frequency in kHz.
fs2=60;                        //Supply frequency in Hz.
Vm=sqrt(2)*Vs;                 //Calculating the phase voltage.
Vdc=0.6336*Vm;                 //Calculating average output voltage.
//When fs=2000Hz,
Vrr1=(Vm/%pi)*(1-cos(2*%pi*fs1*10^3*trr*10^-6));//Calculating the reduction of average output voltage.
//When fs=60Hz,
Vrr2=(Vm/%pi)*(1-cos(2*%pi*fs2*trr*10^-6));//Calculating the reduction of average output voltage.
```

```
printf("\n\t(a).When fs=2000Hz");
printf("\n\t    The reduction of average output voltage is %0.1fV or %0.2f percent of Vdc",Vrr1,Vrr1/Vdc*100);
printf("\n\t(b).When fs=60Hz");
printf("\n\t    The reduction of average output voltage is %0.1eV or %0.2e percent of Vdc",Vrr2,Vrr2/Vdc*100);
//Some answers are changed due to round-off error.
```

Chapter 4

Power Transistors

Scilab code Exa 4.1 Finding the Saturation Parameters of a BJT

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 4.1
//Finding the Saturation Parameters of a BJT.

clc;
clear;
Rc=11;                            //Load resistance in Ohm.
Vcc=200;                          //Supply voltage in Volts.
VB=10;                            //Input Voltage to the base in Volts.
Vce_sat=1;                        //Collector emitter Voltage in Volts.
Vbe_sat=1.5;                      //Base emitter Voltage in Volts.
```

```
ODF=5;                          //Over drive factor.
bet_min=8;bet_max=40;               //Maximum and minimum current gain.
Ics=(Vcc-Vce_sat)/(Rc);         //Calculating the collector current.
Ibs=Ics/bet_min;                  //Calculating the base current.
Ib=ODF*Ibs;                     //Calculating the base current with ODF.
Rb=(VB-Vbe_sat)/(Ib);           //Calculating the base Resistance.
bet_forced=Ics/Ib;                //Calculating the Forced current gain.
PT=(Vbe_sat*Ib)+(Vce_sat*Ics);          //calculating the total power loss.
printf("\n\tThe Collector current Ics is %0.1fA",Ics);
printf("\n\tThe Base current Ibs is %0.4fA",Ibs);
printf("\n\tThe base current for an ODF of 5, Ib is %0.4fA",Ib);
printf("\n\t(a).The value of base resistance Rb is %0.4f Ohm",Rb);
printf("\n\t(b).The forced current gain beta_forced is %0.1f",bet_forced);
printf("\n\t(c).The total power loss Pt is %0.2fW",PT);
//Answers in the book are varied due to ruounoff error.
```

Scilab code Exa 4.2 Finding the Switching Loss of a Transistor

```
//Power Electronics Devices, Circuits, and Applications.By M.H. Rashid
```

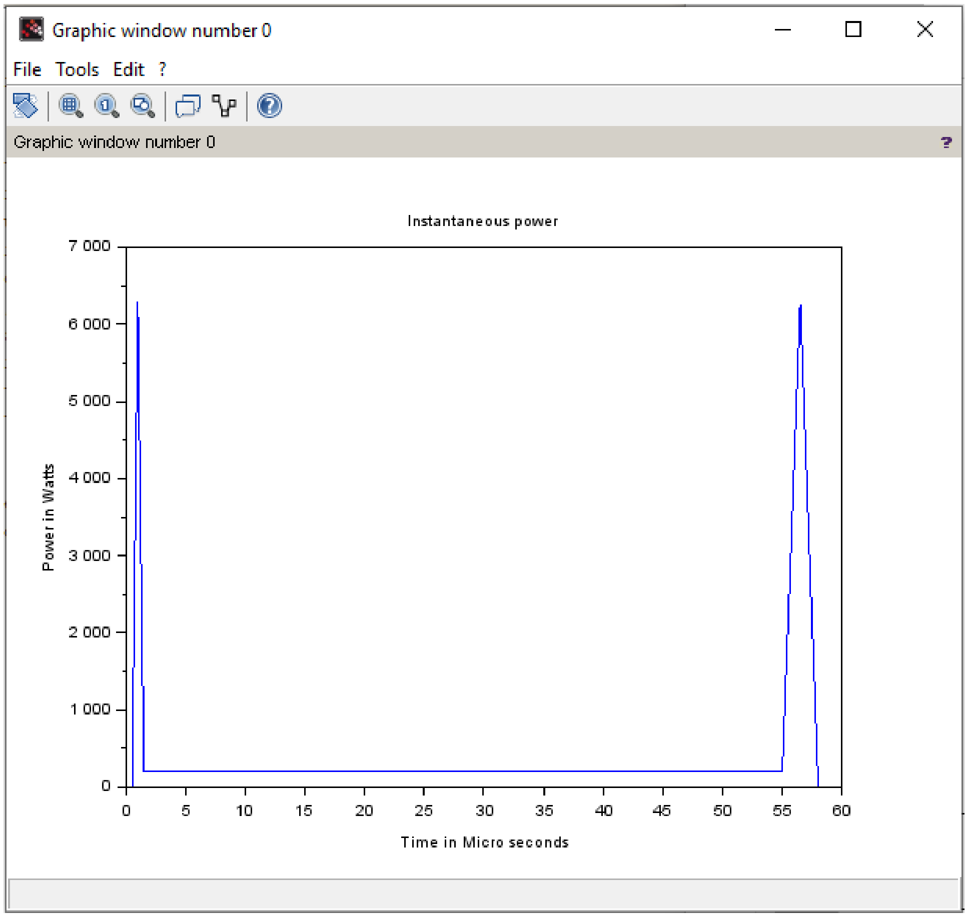

Figure 4.1: Finding the Switching Loss of a Transistor

```
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 4.2
//Finding the Switching Loss of a Transistor.

clc;
clear;
Vcc=250;                    //Collector voltage in Volts.
Vbe_sat=3;                  //Base emitter Voltage in volts.
Ib=8;                       //Base Current in Ampheres.
Vce_sat=2;                  //Collector emitter voltage in volts.
Ics=100;                    //Collector current in volts.
td=0.5;                    //Delay time of transistor in micro seconds.
tr=1;                      //Rise time of transistor in micro seconds.
ts=5;                      //Stoping time of transistor in micro seconds.
tf=3;                     //Fall time of transistor in micro seconds.
fs=10;                    //Frequency in KHZ.
k=0.5;                     //Duty cycle.
Iceo=3;                   //Collector to emitter leakage current in mill Amps.
T=1/fs;                    //Calculating the total time.
tn=(50)-td-tr;            //Calculating the turn on time.
to=(50)-ts-tf;           //Calculating the turn off time.
Pct=Iceo*10^-3*Vcc;       //Calculating the power
```

```
    due to collector current during delay time.
Pd=Iceo*10^-3*Vcc*td*10^-6*fs*10^3;//Calculaing the average power loss during delay time.
tm=(tr*Vcc)/(2*(Vcc-Vce_sat));     //Calculating the maximum time.
Pp=(Vcc^2*Ics)/(4*(Vcc-Vce_sat));  //Calculating the peak power.
Pr=fs*10^3*Ics*tr*10^-6*((Vcc/2)+((Vce_sat-Vcc)/3)); //Caculating power loss during rise time
Pon=Pd+Pr;                         //Calculating the total power loss during turn on time.
Pn=Vce_sat*Ics*tn*10^-6*fs*10^3;   //Calculating the power loss during the conduction time.
Ps=Vce_sat*Ics*ts*10^-6*fs*10^3;   //Calculating the power loss during the storage time.
Pm=(Vcc*Ics)/4;                    //Calculating the peak power.
Pf=(Vcc*Ics*tf*10^-6*fs*10^3)/(6);//Calculating the power loss during peak time.
Poff=Ps+Pf;                        //Calculating the power loss during turn off.
Po=Iceo*10^-3*Vcc*to*10^-6*fs*10^3;//Calculating the power loss due to collector current during turn off.
Pt=Pon+Pn+Poff+Po;                 //Calculating the total power loss due to collector current.
printf("\n(a). During delay time,:");
printf("\n\tThe instantaneous power due to the collector current Pc(t) is %0.2fW",Pct);
printf("\n\tThe average power loss during the delay time Pd is %0.2fmW",Pd*10^3);
printf("\n\tThe maximum time tm is %0.3f s",tm);
printf("\n\tThe power during rise time Pr is %0.2fW",Pr);
printf("\n\tThe peak power loss during rise time Pp is %iW",Pp);
printf("\n\tThe total power loss during turn on Pon is %0.2fW",Pon);
```

```
printf("\n(b). During the conduction period,");
printf("\n\tThe power loss during conduction time, Pn is %iW",Pn);
printf("\n(c). During the storage period,");
printf("\n\tThe power loss during storage period Ps is %iW",Ps);
printf("\n\tThe maximum power durring fall time Pm is %iW",Pm);
printf("\n\tThe power loss during the peak time Pf is %iW",Pf);
printf("\n\tThe power loss during turn off time Poff is %iW",Poff);
printf("\n(d).During off period,");
printf("\n\tThe power loss due to collector current during turn off Po is %0.3fW",Po);
printf("\n(e).The total power loss in the transistor due to collector current is Pt is %0.2fW",Pt);
//Ploting graph using above values.
clf;
t=[0.5 1 1.5 50 55 56.5 58 60];
p=[0.75 6300 200 200 200 6250 0.75 0.75];
plot(t,p);
xlabel("Time in Micro seconds");
ylabel("Power in Watts");
title("Instantaneous power");
printf("\n(f).The plot of the instantaneous power is shown in graph");
```

Scilab code Exa 4.3 Finding the Base Drive Loss of a Transistor

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2        ;OS : Windows.
```

```
//Example : 4.3
//Finding the Base Drive Loss of a Transistor.

clc;
clear;
Vcc=250;                    //Collector voltage in
    Volts.
Vbe_sat=3;                  //Base emitter Voltage
    in volts.
Ib=8;                       //Base Current in
    Ampheres.
Vce_sat=2;                  //Collector emitter
    voltage in volts.
Ics=100;                    //Collector current in
    volts.
td=0.5;                    //Delay time of
    transistor in micro seconds.
tr=1;                      //Rise time of transistor
     in micro seconds.
ts=5;                      //Stoping time of
    transistor in micro seconds.
tf=3;                     //Fall time of transistor
    in micro seconds.
fs=10;                    //Frequency in KHZ.
k=0.5;                     //Duty cycle.
Iceo=3;                   //Collector to emitter
    leakage current in mill Amps.
ton=td+tr;                //Calculating the turn on
    time.
toff=ts+tf;              //Calculating the turn off
    time.
T=1/fs;                    //Calculating the total
    time.
tn=(50)-td-tr;            //Calculating the turn on
    time.
Pbt=Vbe_sat*Ib;            //Calculating the power
    due to base current.
```

```
Pb=Pbt*(ton+tn+ts+tf)*10^-6*fs*10^3;//Calculating the average power loss.
printf("\n\tThe instantaneous power due to the base current Pb(t) is %iW",Pbt);
printf("\n\tThe average power loss Pb is %0.2fW",Pb);
```

Scilab code Exa 4.4 Finding the Case Temperature of a Transistor

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 4.4
//Finding the Case Temperature of a Transistor.

clc;
clear;
Tj=150;                     //Maximum temperature of transistor in C .
Ta=25;                      //The ambient temperature of transistor in C .
Rjc=0.4;Rcs=0.1;Rsa=0.5;    //The thermal impedences of transistor in C /W.
Pt=(Tj-Ta)/(Rjc+Rcs+Rsa);//Calculating the maximum power dissipated.
Tc=Tj-(Pt*Rjc);             //Calculating the case temperature.
printf("\n\t(a).The maximum power dissipated Pt is %iW",Pt);
printf("\n\t(b).The case temperature Tc is %i C",Tc);
```

Scilab code Exa 4.5 Finding the Snubber Values for Limiting voltage and current Va

```
//Power Electronics Devices, Circuits, and Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 4.5
//Finding the Snubber Values for Limiting dv/dt and di/dt Values of a BJT Switch.

clc;
clear;
fs=10;                              //Frequency in KHZ.
Vs=220;                             //Dc voltage of the chopper in volts.
I_L=100;                             //Load current in Amps.
Vce_sat=0;                          //Collector to emitter voltage in volts.
td=0;                               //Turn on delay time in micro seconds.
tr=3;                               //Turn on rise time in micro seconds.
tf=1.2;                             //Fall time in micro seconds.
Ls=(Vs*tr)/(I_L);                    //Calculating the inductance.
Cs=(I_L*tf)/(Vs);                    //Calculating the capacitance.
Rs=2*sqrt(Ls/Cs);                   //Calculating the resistance.
```

```
Rs1=1/(3*fs*10^3*Cs*10^-6);          //Calculating the resistance.
Rs2=Vs/(0.1*I_L);                     //Calculating the resistance.
Ps=0.5*Cs*10^-6*Vs^2*fs*10^3;//Calculating the power loss in diode.
printf("\n\t(a).Inductance of the switch Ls is %0.1f H",Ls);
printf("\n\t(b).Capacitance of the switch Cs is %0.2f F",Cs);
printf("\n\t(c).Resistance at critically damped conditions Rs is %0.2f ",Rs);
printf("\n\t(d).Resistance if the discharge time is limited to one third of switching period Rs is %0.1f ",Rs1);
printf("\n\t(e).Resistance if the peak current is limited to 10 percent of load current Rs is %i ",Rs2);
printf("\n\tThe power loss Ps is %0.1fW",Ps);
//Answer is changed due to round of error.
```

Scilab code Exa 4.6 Finding the Current Sharing by Two Parallel MOSFETs

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 4.6
//Finding the Current Sharing by Two Parallel MOSFETs.

clc;
clear;
```

```
It=20;                  //Total current through mosfet in amps.
Vds1=2.5;               //Drain to source voltage of mosfet 1 in volts.
Vds2=3;                 //Drain to source voltage of mosfet 2 in volts.
Rs11=0.3;Rs12=0.2       //Series resistance in Ohms.
Rs21=0.5                //Series resistance in ohms.
Id11=(Vds2-Vds1+(It*Rs12))/(Rs11+Rs12);//Calculating current through thyristor1.
Id12=It-Id11;                               //Calculating current through thyristor2.
delI1=((Id12-Id11)/It)*100                 //Calculating change in current.
Id21=(Vds2-Vds1+(It*Rs21))/(Rs21+Rs21);//Calculating current through thyristor1.
Id22=It-Id21                                //Calculating current through thyristor2.
delI2=((Id21-Id22)/It)*100                  //Calculating change in current.
printf("\n(a).Drain current of each thyristor when Rs1=0.3 ,Rs2=0.2 is ,");
printf("\n\tId1 = %iA\n\tId2 = %iA\n\t I = %i percent",Id11,Id12,delI1);
printf("\n(b).Drain current of each thyristor when Rs1=Rs2=0.5 is ,");
printf("\n\tId1 = %0.1fA\n\tId2 = %iA\n\t I = %i percent",Id21,Id22,delI2);
```

Scilab code Exa 4.7 Finding the Transistor Voltage and Current with Clamping

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
```

```
//Scilab Version : 6.0.2       ;OS : Windows.

//Example : 4.7
//Finding the Transistor Voltage and Current with Clamping

clc;
clear;
Vcc=100;                      //Collector voltage in Volts.
Rc=1.5;                       //Collector resistance in Ohms.
Vd1=2.1;Vd2=0.9;              //Voltage across swintches in Volts.
Vbe=0.7;                      //Base emitter voltage in volts.
Vb=15;                        //Base voltage in Volts.
Rb=2.5;                       //Base resistance in Ohms.
bet=13.6                        //Duty cydle.
I1=(Vb-Vd1-Vbe)/Rb;           //Calculating the current from the source.
Ic1=bet*I1;                     //Calculating the collector current.
Vce=Vbe+Vd1-Vd2;              //Calculating the collector emitter voltage.
I_L=(Vcc-Vce)/Rc;              //Calculating the load current.
Ic2=bet*((I1+I_L)/(bet+1))         //Calculating the collector current.
printf("\n\t(a).The current from the source I1 is %0.2fA",I1);
printf("\n\t    The collector current without clamping Ic is %0.3fA",Ic1);
printf("\n\t(b).The collector emitter clamping voltage Vbe is %0.1fV",Vce);
printf("\n\t(c).The current through the load I_L is %0.1fA",I_L);
```

```
printf("\n\t    The collector current with clamping
   Ic is %0.3fA",Ic2);
//Some answers may be changed due to round-off error
   .
```

Chapter 5

DC to DC Converters

Scilab code Exa 5.1 Finding the Performances of a Dc to Dc Converter

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 5.1
//Finding the Performances of a D c Dc  Converter.

clc;
clear;
R=10;                    //Load resistance in Ohms.
Vs=220;                  //Input voltage in Volts.
Vch=2;                   //Voltage drop across the
    chopper in Volts.
f=1;                     //Chopper frequency in KHZ.
k=0.5                    //Duty cycle.
Va=k*(Vs-Vch);           //Calculating the average
    output voltage.
Vo=sqrt(k)*(Vs-Vch);     //Calculting the rms output
    voltage.
```

```
Po=k*((Vs-Vch)^2/R);      //Calculating the ouput power of converter.
Pi=k*Vs*((Vs-Vch)/R);     //Calculating the input power to converter.
eff=(Po/Pi);              //Calculating the converter efficiency.
Ri=Vs/(Va/R);             //Calculating the input resistance.
RFo=sqrt(((1/k)-1));      //Calculating the ripple factor.
V1=(((Vs-Vch)*2)/%pi)/sqrt(2);//Calculating the rms voltage.
printf("\n\t(a). The average output voltage Va is %iV",Va);
printf("\n\t(b). The rms output voltage Vo is %0.2fV",Vo);
printf("\n\t(c). The output power Po is %0.1fW",Po);
printf("\n\t     The input power Pi is %iW",Pi);
printf("\n\t     The converter efficiency is %0.2f percent",eff*100);
printf("\n\t(d). The input resistance Ri is %0.2f ",Ri);
printf("\n\t(e). The ripple factor RFo is %i percent",RFo*100);
printf("\n\t(f). The root mean square value V1 is %0.2fV",V1);
```

Scilab code Exa 5.2 Finding the Currents of a Dc Converter with an RL Load

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2       ;OS : Windows.

```

```
//Example : 5.2
//Finding the Currents of a Dc Converter with an RL Load.

clc;
clear;
Vs=220;                     //Supply voltage in volts.
R=5;                        //Resistance in Ohms.
L=7.5;                      //Inductance in milli Henry.
f=1;                        //Frequency in KHZ.
k=0.5;                      //Duty cycle.
E=0;                        //Battery voltage in volts.
T=1/(f*10^3);
//Calculating the constat value of the equation I1 and I2 from Eq(5.23 and 5.24)
x1=exp(-((k*T*R)/(L*10^-3)));x2=((Vs-E)/R)*(1-(exp(-((k*T*R)/(L*10^-3)))));
y1=exp(-(((1-k)*T*R)/(L*10^-3)));y2=0;
A=[-x1 1;1 -y1];B=[x2;y2];
I=inv(A)*B;                 //Calculating the value of current.
I1=I(1,1);                  //minimum load current.
I2=I(2,1);                  //The peak load current.
del_I=I2-I1;                   //Calculating the peak to peak ripple current.
del_Imax1=(Vs/R)*(tanh(R/(4*f*10^3*L*10^-3)));//Calculating the maximum peak to peak ripple current.
del_Imax2=(Vs)/(4*f*10^3*L*10^-3);
Ia=(I2+I1)/2;               //Calculating the average load current.
Io=sqrt(((I1)^2)+(((I2-I1)^2)/3)+(I1*(I2-I1)));//Calculating the rms value of load current
Is=k*Ia;                                          //Calculating the average source current.
Ri=Vs/Is;                                         //Calculating the efective input resistance.
Ir=sqrt(k)*Io                                     //
```

```
Calculating the rms value of coverter current.
z=52.5;
L1=(T*R)/z;                                     //Calculating the value of inductance.
printf("\n\t(a).The minimum instantaneous load current I1 is %0.2fA",I1);
printf("\n\t(b).The peak instantaneous load current I2 is %0.2fA",I2);
printf("\n\t(c).The maximum peak to peak ripple current del_I is %0.2fA",del_I);
printf("\n\t    From Eq. (5.29), del_Imax is %0.2fA",del_Imax1);
printf("\n\t    From Eq. (5.30), the approximate value of del_Imax is %0.2fA",del_Imax2);
printf("\n\t(d).The average load current Ia is %0.0fA",Ia);
printf("\n\t(e).The rms value of load current Io is %0.1fA",Io);
printf("\n\t(f).The average source current Is is %0.0fA",Is);
printf("\n\t    The effective input resistance Ri is %i Ohm",Ri);
printf("\n\t(g).The rms value of converter current Ir is %0.2fA",Ir);
printf("\n\t(h).The critical value of load inductance for continuous load current L is %0.3fmH",L1*10^3);
```

Scilab code Exa 5.3 Finding the Load Inductance to Limit the Load Ripple Current

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.
```

```
//Example : 5.3
//Finding the Load Inductance to Limit the Load Ripple Current.

clc;
clear;
R=0.25;                              //Load resistance in Ohms.
Vs=550;                             //Input voltage in Volts.
E=0;                                //Battery voltage in Volts.
Ia=200;                             //Average load current in Amps.
f=250;                              //Chopping frequency in HZ.
T=1/f;
del_i=Ia*0.1;
//Differentiating del_i with respect to k and equate it to zero to obtain the value of k.
k=0.5;                              //Duty cycle.
L=(Vs*(1-k)*k*T)/del_i;             //Calculating the value of inductance.
printf("\n\tThe required value of inductance L is %0.1fmH",L*10^3);;
```

Scilab code Exa 5.4 Finding the Currents of a Step up Dc Converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

```

```
//Example : 5.4
//Finding the Currents of a Step−up Dc Converter.

clc;
clear;
Vs=10;                  //Input voltage in Volts.
f=1;                    //Frequency in KHZ.
R=5;                    //Resistance in Ohm.
L=6.5;                  //Inductance in milli Henry.
E=0;                    //Battery voltage in Volts.
k=0.5;                  //Duty cycle.
T=1/(f*10^3);
z=(T*R)/(L*10^-3);
I1=(((Vs*k*z)/R)*((exp((-1+k)*z))/(1-(exp((-1+k)*z)))))+((Vs-E)/R);//Calcualting the current I1.
I2=(((Vs*k*z)/R)*((1)/(1-(exp((-1+k)*z)))))+((Vs-E)/R);             //Calculating the current I2.
del_I=I2-I1;                                                         //Calculating the change in current.
printf("\n\tThe current I1 is %0.2fA",I1);
printf("\n\tThe current I2 is %0.2fA",I2);
printf("\n\tThe change in current del_I is %0.2fA",del_I);
```

Scilab code Exa 5.5 Finding the Values of LC Filter for the Buck Regulator

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 5.5
//Finding the Values of LC Filter for the Buck
```

```
Regulator.

clc;
clear;
Vs=12;                  //Input voltage in Volts.
Va=5;                   //Average output voltage in Volts.
R=500;                  //Resistance in Ohm.
Vc=20;                  //Peak to peak ripple output voltage in milli volts.
f=25;                   //Frequency in kHz.
del_I=0.8;              //Peak to peak ripple current of inductor in Amps.
k=(Va/Vs);              //Calculating the duty cycle.
L=(Va*(Vs-Va))/(del_I*f*10^3*Vs);//Calculating the filter inductance.
C=del_I/(8*Vc*10^-3*f*10^3);     //Calculating the filter capacitance.
Lc=((1-k)*R)/(2*f*10^3);      //Calculating the critical value of inductance.
Cc=(1-k)/(16*L*10^-6*(f*10^3)^2);//Calculating the critical value of capacitance.
printf("\n\t(a).The Duty Cycle k is %0.2f percent",k*100);
printf("\n\t(b).The filter inductance L is %0.2fmicroH",L*10^6);
printf("\n\t(c).The filter capacitance C is %imicroF",C*10^6);
printf("\n\t(d).The critical value of inductance Lc is %0.2fmH",Lc*10^3);
printf("\n\t    The critical value of capacitance Cc is %0.1fmicroF",Cc);
```

Scilab code Exa 5.6 `Finding the Currents and Voltage in the Boost Regulator`

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 5.6
//Finding the Currents and Voltage in the Boost Regulator.

clc;
clear;
Vs=5;                          //Input voltage in Volts.
Va=15;                         //Average output voltage in Volts.
Ia=0.5;                        //Average output current in Amps.
f=25;                          //Frequency in KHZ.
L=150;                         //Inductance in micro Henry.
C=220;                         //Capacitance in micro Farad.
k=1-(Vs/Va);                   //Calculating the duty cycle.
del_I=(Vs*(Va-Vs))/(f*10^3*L*10^-6*Va);//Calculating the ripple current of inductor.
Is=Ia/(1-k);                             //Calculating the input current.
I2=Is+(del_I/2);                            //calculating the peak inductor current.
del_Vc=(Ia*k)/(f*10^3*C*10^-6);          //Calculating the ripple voltage of capacitor
R=Va/Ia;                                 //Calculating the input resistance.
Lc=((1-k)*k*R)/(2*f*10^3);               //Calculating the critical value of inductor.
Cc=k/(2*f*10^3*R);                       //Calculating the critical value of capacitor
```

```
printf("\n\t(a).The Duty Cycle K is %0.2f percent",k*100);
printf("\n\t(b).The ripple current of inductor del_I is %0.2fA",del_I);
printf("\n\t(c).The peak current of inductor I2 is %0.3fA",I2);
printf("\n\t(d).The ripple voltage of filter capacitor del_Vc is %0.2fmV",del_Vc*10^3);
printf("\n\t(e).The critical value of inductor Lc is %i microH",Lc*10^6);
printf("\n\t    The critical value of capacitor Cc is %0.2f microF",Cc*10^6);
```

Scilab code Exa 5.7 Finding the Currents and Voltage in the Buck Boost Regulator

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 5.7
//Finding the Currents and Voltage in the Buck Boost Regulator.

clc;
clear;
Vs=12;                          //Input voltage in Volts.
k=0.25;                         //Duty cycle.
f=25;                           //Frequency in KHZ.
L=150;                          //Inductance in micro Henry.
C=220;                          //Capacitance in micro Farad.
```

```
Ia=1.25;                         //Average load current in Amps.
Va=(-Vs*k)/(1-k);                //Calculating the average output voltage.
del_Vc=(Ia*k)/(f*10^3*C*10^-6);  //Calculating the peak output ripple voltage.
del_I=(Vs*k)/(25*10^3*L*10^-6);  //Calculating the peak ripple current of inductor.
Is=(Ia*k)/(1-k);                 //Calculating the average output current.
Ip=(Is/k)+(del_I/2);             //Calculating the peak current of transistor.
R=-Va/Ia;                        //Calculating the resistance.
Lc=((1-k)*R)/(2*f*10^3);         //Calculating the critical value of inductance.
Cc=(k)/(2*f*10^3*R);             //Calculating the critical value of capacitance.
printf("\n\t(a).The average output voltage Va is %iV",Va);
printf("\n\t(b).The peak to peak output ripple voltage del_Vc is %0.1fmV",del_Vc*10^3);
printf("\n\t(c).The peak to peak ripple current of inductor del_I is %0.1fA",del_I);
printf("\n\t(d).The input current Is is %0.4fA",Is);
printf("\n\t    The peak current of transistor Ip is %0.3fA",Ip);
printf("\n\t(e).The Resistance R is %0.1f Ohm",R);
printf("\n\t    The critical value of inductance Lc is %i microH",Lc*10^6);//Book answer is wrong.
printf("\n\t    The critical value of capacitance Cc is %0.2f microF",Cc*10^6);
```

Scilab code Exa 5.8 Finding the Current and Voltages in Chuk Regulator

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 5.8
//Finding the Currents and Voltages in the C k Regulator.

clc;
clear;
Vs=12;                    //Input Voltage in Volts.
k=0.25;                   //Duty cycle.
f=25;                     //Frequency in KHZ.
L2=150;                   //The filter inductance in micro Henry.
C2=220;                   //The filter capacitance in micro Farad.
C1=200;                   //The energy transfer capacitance in micro Farad.
L1=180;                   //The energy transfer inductance in micro Henry.
Ia=1.25;                  //Average load current in amps.
Va=(-k*Vs)/(1-k);         //Calculating the average load voltage.
Is=(k*Ia)/(1-k);          //Calculating the input current.
del_I1=(Vs*k)/(f*10^3*L1*10^-6);     //Calculating the peak to peak ripple current of inductor L1
del_Vc1=(Is*(1-k))/(f*10^3*C1*10^-6);//Calculating the peak to peak ripple current of capacitor C1.
del_I2=(k*Vs)/(f*10^3*L2*10^-6);     //Calculating the peak to peak ripple current of inductor L2.
del_Vc2=del_I2/(8*f*10^3*C2*10^-6);    //Calculating the peak to peak ripple current of capacitor C2.
IL2=Ia;                             //Average output
```

```
value of current in inductor L2
Ip=(Is)+(del_I1/2)+(del_I2/2)+IL2;      //Calculating the peak current of transistor
printf("\n\t(a).The average output voltage Va is %iV",Va);
printf("\n\t(b).The input current Is is %0.2fA",Is);
printf("\n\t(c).The peak to peak ripple current of inductor L1, del_I1 is %0.2fA",del_I1);
printf("\n\t(d).The peak to peak ripple voltage of capacitor C1, del_Vc1 is %0.0fmV",del_Vc1*10^3);
printf("\n\t(e).The peak to peak ripple current of inductor L2, del_I2 is %0.1fA",del_I2);
printf("\n\t(f).The peak to peak ripple voltage of capacitor  C2, del_Vc2 is %0.2fmV",del_Vc2*10^3);
printf("\n\t(g).The peak current of transistor Ip is %0.3fA",Ip);
```

Scilab code Exa 5.9 Finding the Harmonic Input Current of a Dc Converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 5.9
//Finding the Harmonic Input Current of a Dc Converter.

clc;
clear;
Ia=100;                    //Average load current in Volts.
Le=0.3;                    //Inductance in milli Henry.
```

```
Ce=4500;                    //Capacitance in micro Farad.
f=350;                      //Frequency in Hertz.
k=0.5;                      //Duty cycle.
fo=1/(2*%pi*sqrt(Ce*10^-6*10^-3*Le));//Calculating the intial frequceny.
I1h=(Ia/%pi)*(sqrt(1-cos(2*%pi*k)));//Calculating the rms value of current.
I1s=(1/(1+(f/fo)^2))*I1h;           //Calculating the conveter generated harmonic current.
printf("\n\tThe rms value of current I1h is %0.2fA",I1h);
printf("\n\tThe fundamental component of converter-generated harmonic current in the supply I1s is %0.2fA",I1s);
```

Scilab code Exa 5.10 Finding the parameters of buck converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 5.10
//Finding the parameters of buck converter

clc;
clear;
Vs=110;                            //Input voltage in volts.
Va=60;                             //Average load voltage in volts.
Ia=20;                             //Average load current in amperes.
```

```
f=20;                              //Frequency in KHZ.
Vl=0.025;                          //Peak to peak ripple for load volatage.
Il=0.05;                           //Peak to peak ripple for load current.
ILc=0.1;                           //Peak to peak ripple for filter Lc current.
del_Vc=Vl*Va;                      //Calculating the change in capacitor voltage.
R=Va/Ia;                           //Calculating the load resistance.
k=Va/Vs;                           //Calculating the duty cycle.
Is=k*Ia;                           //Calculating the source current.
del_IL=Il*Ia;                      //Calculating the change in inductor current.
del_I=ILc*Ia;                      //Calculating the change in load current.
Le=(Va*(Vs-Va))/(del_I*f*10^3*Vs); //Calculating the value of inductance Le.
Ce=(del_I)/(del_Vc*8*f*10^3);      //Calculating the value of capacitance Ce.
L=(k*del_Vc)/(del_IL*f*10^3);      //Calculating the approximate value icductance of circuit
printf("\n\t(a).The value of inductance Le is %0.2f microH",Le*10^6);
printf("\n\t    The vlaue of capacitance Ce is %0.2f microF",Ce*10^6);
printf("\n\t    The approximate value of inductance of the circuit L is %0.2f microH",L*10^6);
```

Chapter 6

DC AC Converters

Scilab code Exa 6.1 Finding the Parameters of the Single Phase Half Bridge Inverte

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 6.1
//Finding the Parameters of the Single-Phase Half-
    Bridge Inverter.

clc;
clear;
Vs=48;                        //Dc input voltage in
    volts.
R=2.4;                        //Resistance in Ohm.
k=0.5;                        //Duty cycle.
Vo1=0.45*Vs;                  //Calculating the rms
    output voltage.
Vo=Vs/2;                      //Calculatint the output
    voltage.
Po=Vo^2/R;                    //Calculating the output
```

```
power.
Ip=Vo/R;                        //Calculaitng the peak transistor current.
Iq=k*Ip;                        //Calculatingthe average current of each transistor.
Vbr=2*Vo;                       //Calcuating the peak reverse blocking voltage.
Is=Po/Vs;                       //Calculating the average supply current.
Vh=0.2176*Vs        ;           //Calculating the rms harmonic voltage.
THD=Vh/Vo1;                     //Calculating the total harmonic distrotion.
Von=0.024*Vs;                   //Calculating the instantaneous output voltage.
DF=Von/Vo1;                     //Calculating the distrotion factor.
LOH=Vo1/3;Vo3=LOH;              //Calculating the lowest order harmonic.
HF3=Vo3/Vo1;                    //Calculating the harmonic factor.
DF3=(Vo3/3^2)/Vo1;              //Calculating the distrotion factor.
printf("\n\t(a).The rms output voltage Vo1 is %0.1fV",Vo1);
printf("\n\t(b).The output voltage Vo is %iV",Vo);
printf("\n\t    The output power Po is %iW",Po);
printf("\n\t(c).The peak transistor current Ip is %iA",Ip);
printf("\n\t    The average current of each transistor Iq is %iA",Iq);
printf("\n\t(d).The peak reverse blocking voltage Vbr is %iV",Vbr);
printf("\n\t(e).The average supply current Is is %iA",Is);
printf("\n\t(f).The rms harmonic voltage Vh is %0.4fV",Vh);
printf("\n\t    The total harmonic distrotion factor
```

```
THD is %0.2f percent",THD*100);
printf("\n\t(g).The instantaneous output voltage Von is %0.2fV",Von);
printf("\n\t    The distrotion factor DF is %0.2f percent",DF*100);
printf("\n\t(h).The least order harmonic LOH is %0.2f ",LOH);
printf("\n\t    The harmonic facrot HF3 is %0.2f percent",HF3*100);
printf("\n\t    The distrotion factor DF3 is %0.2f percent",DF3*100);
//Answers varies due to round off error.
```

Scilab code Exa 6.2 Finding the Parameters of the Single Phase Full Bridge Inverte

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 6.2
//Finding the Parameters of the Single-Phase Full-Bridge Inverter.

clc;
clear;
Vs=48;                    //Dc input voltage in volts.
R=2.4;                    //Resistance in Ohm.
k=0.5;                    //Duty cycle.
V1=0.90*Vs;               //Calculating the rms output voltage.
Po=Vs^2/R;                //Calculating the output power.
```

```
Ip=Vs/R;                   //Calculaitng the peak transistor current.
Iq=k*Ip;                   //Calculatingthe average current of each transistor.
Vbr=Vs;                    //The peak reverse blocking voltage is equal to Vs.
Is=Po/Vs;                  //Calculating the average supply current.
Vh=0.4359*Vs;              //Calculating the rms harmonic voltage.
THD=Vh/V1;                 //Calculating the total harmonic distrotion.
DF=(0.048*Vs)/V1;          //Calculating the distrotion factor.
LOH=V1/3;Vo3=LOH;          //Calculating the lowest order harmonic.
HF3=Vo3/V1;                //Calculating the harmonic factor.
DF3=(Vo3/3^2)/V1;          //Calculating the distrotion factor.
printf("\n\t(a).The rms output voltage V1 is %0.1fV",V1);
printf("\n\t(b).The output power Po is %iW",Po);
printf("\n\t(c).The peak transistor current Ip is %iA",Ip);
printf("\n\t    The average current of each transistor Iq is %iA",Iq);
printf("\n\t(d).The peak reverse blocking voltage Vbr is %iV",Vbr);
printf("\n\t(e).The average supply current Is is %iA",Is);
printf("\n\t(f).The rms harmonic voltage Vh is %0.4fV",Vh);
printf("\n\t    The total harmonic distrotion factor THD is %0.2f percent",THD*100);
printf("\n\t(g).The distrotion factor DF is %0.2f percent",DF*100);
printf("\n\t(h).The least order harmonic LOH is %0.2
```

```
f ",LOH);
printf("\n\t    The harmonic facrot HF3 is %0.2f percent",HF3*100);
printf("\n\t    The distrotion factor DF3 is %0.3f percent",DF3*100);
```

Scilab code Exa 6.5 Finding the Allowable Limit of the Dc Input Source

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 6.5
//Finding the Allowable Limit of the Dc Input Source.

clc;
clear;
Vs=220;                  //Input voltage in volts.
del_a=30;                //Width of each pulse in degree.
p=5;                     //Number of pulses per half cycle.
Vo=Vs*sqrt(p*(del_a/180));//Calculating the rms voltage of the load.
Vs1=Vs*(110/100);
del_b=((Vo/Vs1)^2)*(180/p);//Calculating the pulse width if supply voltage increased by 10 percentage.
del_c=35;                     //Width of each pulse in degree.
Vs2=Vo/sqrt(p*(del_c/180));//Calculating the supply voltage if the pulse width is 35 degrees
```

```
printf("\n\t(a).The rms voltage of the load Vo is %0
    .1fV",Vo);
printf("\n\t(b).The pulse width to maintain the same
     load power if supply is increased by 10percent
    del_ is %0.2f degree",del_b);
printf("\n\t(c).The dc supply voltage to maintain
    pulse width at 35 degree, Vs is %0.2fV",Vs2);
//Answers are changed due to round-off error.
```

Scilab code Exa 6.6 Finding the Number of Notches and Their Angles

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 6.3
//Finding the Number of Notches and Their Angles.

clc;
clear;
function [fval,jac] = g(X)
    b1=X(1);
    b2=X(2);
    b3=X(3);
    b4=X(4);
    fval(1,1)=1-(2*cosd(5*b1))+(2*cosd(5*b2))-(2*
       cosd(5*b3))+(2*cosd(5*b4));
    fval(2,1)=1-(2*cosd(7*b1))+(2*cosd(7*b2))-(2*
       cosd(7*b3))+(2*cosd(7*b4));
    fval(3,1)=1-(2*cosd(11*b1))+(2*cosd(11*b2))-(2*
       cosd(11*b3))+(2*cosd(11*b4));
    fval(4,1)=1-(2*cosd(13*b1))+(2*cosd(13*b2))-(2*
       cosd(13*b3))+(2*cosd(13*b4));
```

```
    jac = [2*5*-(sind(5*b1)), 2*5*-(sind(5*b2)),2*5*-(sind(5*b3)), 2*5*-(sind(5*b4));
    2*7*-(sind(7*b1)), 2*7*-(sind(7*b2)), 2*7*-(sind(7*b3)), 2*7*-(sind(7*b4));
    2*11*-(sind(11*b1)), 2*11*-(sind(11*b2)), 2*11*-(sind(11*b3)), 2*11*-(sind(11*b4));
    2*13*-(sind(13*b1)), 2*13*-(sind(13*b2)), 2*13*-(sind(13*b3)), 2*13*-(sind(13*b4))];
endfunction
X0 = [10; 16; 30; 32];
maxIter = 100;
tot = 0.9;
X = X0;
Xold = X0;
for i = 1:maxIter
    [f,j] = g(X);
    X =X- inv(j)*f;
    a = abs(X-Xold);
    Xold =X;
    if (a<tot)
        break;
    end
end
printf("\n\tThe angles of the nothches are,")
printf("\n\t 1 = %0.2f ",X(1,1));
printf("\n\t 2 = %0.2f ",X(2,1));
printf("\n\t 3 = %0.2f ",X(3,1));
printf("\n\t 4 = %0.2f ",X(4,1));
//Answers are changed due to round off error.
```

Chapter 7

Resonant Pulse Inverters

Scilab code Exa 7.1 Analysis of the Basic Resonant Inverter

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 7.1
//Analysis of the Basic Resonant Inverter.

clc;
clear;
L=50;                              //Inductance in
    micro Henry.
C=6;                               //Capacitance in
    micro Farad.
R=2;                               //Resistance in ohm.
Vs=220;                            //Input voltage in
    volts.
fo=7;                              //Frequency in KHZ.
```

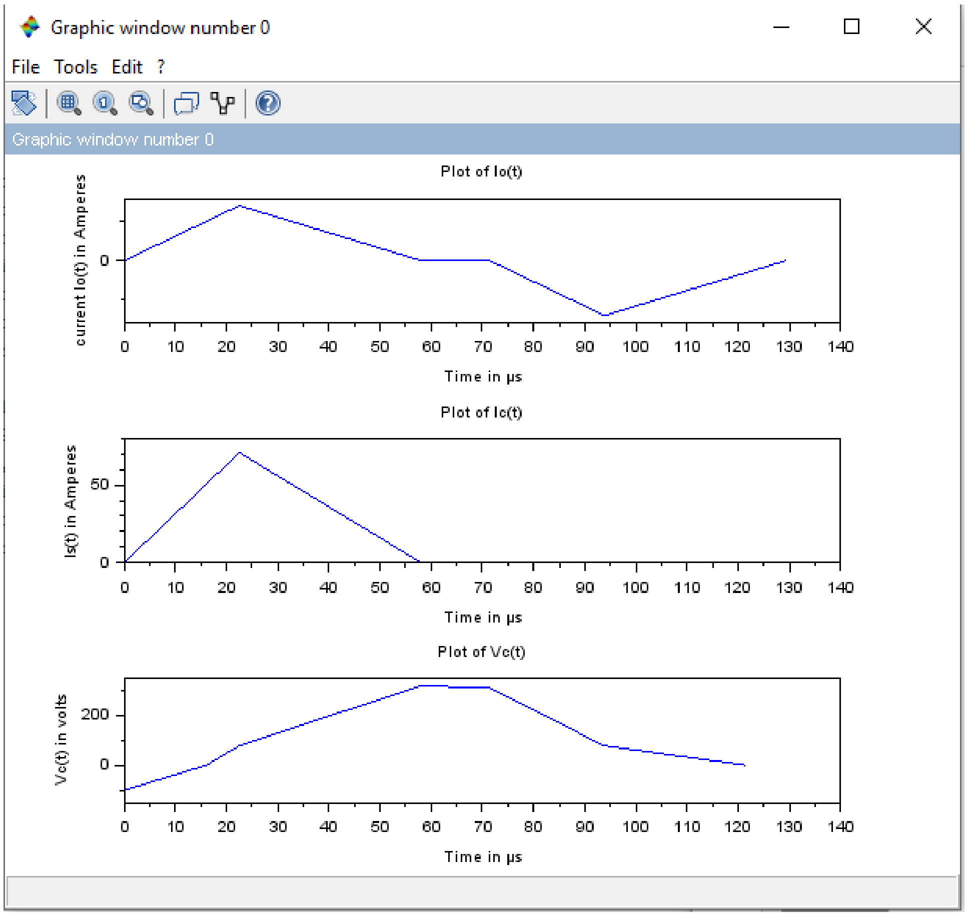

Figure 7.1: Analysis of the Basic Resonant Inverter

```
toff=10;                          //Turn of time of tansistors in micro seconds.
wo=2*%pi*fo*10^3;
wr=sqrt((1/(L*C*10^-12))-((R^2)/(4*(L^2)*10^-12)));  //Calculating the resonant frequency in radians per second.
fr=wr/(2*%pi);                                 //Calculating the resonant frequcncy in HZ.
Tr=1/fr;                                       //Calculating the time per cycle.
alp=R/(2*L*10^-6);
toff1=(%pi/wo)-(%pi/wr);                      //Calculating the circuit turn off time.
fmax=(1/(2*((toff*10^-6)+(%pi/wr)))); //Calculating the maximum frequency.
Vc=Vs/((exp((alp*%pi)/wr))-1);         //Calculating the capacitor voltage.
Vc1=Vs+Vc;                             //Calculating the maximum capacitor voltage.
Vpp=Vc+Vc1;                           //Calculating peak to peak capactor voltage.
tm=(1/wr)*(atan(wr/alp));             //Calculating the time at peak load current.
Ip=((Vc1)*(exp(-(alp*tm)))*(sin(wr*tm)))/(wr*L*10^-6);//Calculating the peak load current.
//Ploting the graph for I(t), Vc(t), Is(t).
to=[0 22.47 58 71.4 93.87 129.4];       //Time in micro seconds
Io1=[0 70.82 0 0 -70.82 0];             //Output current in amphere
t1=[0 22.47 58 71.4 93.87 129.4];      //Time in micro seconds.
Is=[0 70.82 0 0 0 0];                  //Supply current in amperes.
t2=[0 16 22.47 58 71.4 93.87 121.6];        //Time in micro seconds.
Vc11=[-100.4 0 78.36 320.4 310.2 78.36 0];//Capacitor voltage in volts.
```

```
subplot(311);
plot(to,Io1)                                  //Plot of
   Io(t).
xlabel("Time in  micros");
ylabel("current Io(t) in Amperes");
title("Plot of Io(t)");
subplot(312);
plot(t1,Is);                                  //Plot of Is(t
   ).
xlabel("Time in  micros");
ylabel("Is(t) in Amperes");
title("Plot of Ic(t)");
subplot(313);
plot(t2,Vc11);                                //Plot of Vc(t
   );
xlabel("Time in  micros");
ylabel("Vc(t) in volts");
title("Plot of Vc(t)");
//Calculating the rms load current.
function Io2=f(t);
    Io2=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*t))*(sin
       (wr*t)))^2;
endfunction
x=intg(0,Tr/2,f);
Io=sqrt(2*fo*10^3*x);
Po=Io^2*R;                              //Calculating the
   output power.
Is=Po/Vs                                //Calculating the
   average supply current.
//Calculating the average transistor current.
funcprot(0);
function Ia=f(t);
    Ia=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*t))*(sin(
       wr*t)));
endfunction
y=intg(0,Tr/2,f);
IA=fo*10^3*y;
Ipk=Ip;                                 //The peak
```

```
transistor current.
IR=Io/sqrt(2);                    //Calculating rms transistor current.
printf("\n\two=%irad/s\n\twr=%irad/s\n\tfr=%0.1fHz\n\tTr=%0.0f micros\n\talp=%i",wo,wr,fr,Tr*10^6,alp);
printf("\n\t(a).The circuit turn off time toff is %0.2f micro sec",toff1*10^6);
printf("\n\t(b).The maximum possible frequency fmax is %0.0fHz",fmax);
printf("\n\t(c).The capacitor voltage Vc is %0.1fV",Vc);
printf("\n\t    The maximum capacitor voltage Vc1 is %0.1fV",Vc1);
printf("\n\t    The peak to peak capacitor voltage Vpp is %0.1fV",Vpp);
printf("\n\t(d).The maximum time tm is %0.2f micro sec",tm*10^6);
printf("\n\t    The peak load current Ip is %0.2fA",Ip);
printf("\n\t(e).The sketeches for i(t), Vc(t) and is(t) are shown in graph");
printf("\n\t(f).The rms value of load current Io is %0.1fA",Io);
printf("\n\t(g).The output power Po is %0.0fW",Po);
printf("\n\t(h).The average supply current Is is %0.2fA",Is);
printf("\n\t(i).The average transistor current IA is %0.2fA",IA);
printf("\n\t    The peak transistor current Ipk is %0.2fA",Ipk);
printf("\n\t    The rms transistor current IR is %0.2fA",IR);
```

Scilab code Exa 7.2 Analysis of the Half Bridge Resonant Inverter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 7.2
//Analysis of the Half-Bridge Resonant Inverter.

clc;
clear;
Vs=220;                             //Supply voltage in volts.
fo=7                                //Ouput frequency in KHZ.
C=3;                                //Capacitance in micro farad.
L=50;                               //Inductance in micro Henry.
R=2;                                //Resistance in Ohm.
Ce=2*C;                             //Calculating the effective resistance.
wr=sqrt((1/(2*L*10^-6*C*10^-6))-((R^2)/(4*L^2*10^-12)));
alp=R/(2*L*10^-6);
fr=wr/(2*%pi);                          //Calculating the resonant frequcncy in HZ.
Tr=1/fr;                                //Calculating time per cycle.
Vc=Vs/((exp((alp*%pi)/wr))-1);          //Calculating the capacitor voltage.
Vc1=Vs+Vc;                             //Calculating the maximum capacitor voltage.
tm=(1/wr)*(atan(wr/alp));             //Calculating the time at peak load current
Ip=((Vc1)*(exp(-(alp*tm)))*(sin(wr*tm)))/(wr*L*10^-6);//Calculating the peak load current.
```

```
//Calculating the rms load current.
function Io1=f(t);
    Io1=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*t)))*(sin(wr*t)))^2;
endfunction
x=intg(0,Tr/2,f);
Io=sqrt(2*fo*10^3*x);
Ips=Ip/2;                          //Calculating the peak supply current.
funcprot(0);
function Ia=f(t);
    Ia=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*t)))*(sin(wr*t)));
endfunction
y=intg(0,Tr/2,f);
IA=fo*10^3*y;
Ipk=Ip;                            //The peak transistor current.
IR=Io/sqrt(2);                     //Calculating rms transistor current.
printf("\n\twr=%irad/sec\n\talp=%i\n\tfr=%0.1frad\n\tTr=%0.0f micro sec",wr,alp,fr,Tr*10^6);
printf("\n\t(a).The effective capacitance Ce is %i micro Farad",Ce);
printf("\n\t    The maximum time tm is %0.2f micro sec",tm*10^6);
printf("\n\t    The peak load current Ip is %0.2fA",Ip);
printf("\n\t    The capacitor voltage Vc is %0.1fV",Vc);
printf("\n\t    The maximum capacitor voltage Vc1 is %0.1fV",Vc1);
printf("\n\t    The rms value of load current Io is %0.1fA",Io);
printf("\n\t    Thr Peak supply current Ips is %0.2fA",Ips)
printf("\n\t(b).The average transistor current IA is %0.2fA",IA);
```

```
printf("\n\t(c).The rms transistor current IR is %0
    .2fA",IR);
```

Scilab code Exa 7.3 Finding the Currents and Voltages of a Simple Resonant Inverte

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 7.3
//Finding the Currents and Voltages of a Simple
    Resonant Inverter.

clc;
clear;
Vs=220;                              //Supply voltage
     in volts.
C=2;                                 //Capacitance in
     micro farad.
L=20;                                //Inductance in
    micro henry.
tsw=12;                              //Switching time
     in micro seconds.
fo=20;                               //Output
    frequency in KHZ.
wr=1/(sqrt(L*C*10^-12));            //Calculating
    Resonant frequency in rad per second
fr=wr/(2*%pi);                      //Calculating
    Resonant frequncy in Hz.
Tr=1/fr;                            //Calculating
    time per cycle.
t1=Tr/2;                            //Calculating
    time per half cycle.
```

```
Vc1=2*Vs;                          //Calculating maximum capacitance voltage.
Vc=0;                              //Intial capacitance voltage.
Ip=Vs*sqrt(C/L);                   //Calculating peak supply current.
IA=(Ip*fo*10^3)/(%pi*fr);          //Calculating avergae device current.
IR=Ip*(sqrt((fo*10^3*t1)/2));      //Calculating rms device current.
Vpp=Vc1-Vc                         //Calculating peak to peak capacitor voltage.
fmax=1/(2*tsw*10^-6);              //Calculating maximum frequency.
Is=0;                              //Average supply current.
printf("\n\twr=%0.0frad/sec\n\tfr=%0.0fHz\n\tTr=%0.2f  s\n\tt1=%0.2f  s",wr,fr,Tr*10^6,t1*10^6);
printf("\n\tThe maximum capcitor current Vc1 is %0.0fV",Vc1);
printf("\n\tThe intial capacitor current Vc is %i",Vc);
printf("\n\t(a).The peak supply current Ip is %0.2fA",Ip);
printf("\n\t(b).The average device current IA is %0.1fA",IA);
printf("\n\t(c).The rms device current IR is %0.2fA",IR);
printf("\n\t(d).The peak to peak capacitor voleatge Vpp is %0.0fV",Vpp);
printf("\n\t(e).The maximum output frequency fmax is %0.2fKHz",fmax*10^-3);
printf("\n\t(f).Because there is no power loss in the circuit average supply cuurent Is is %i",Is);
```

Scilab code Exa 7.4 Analysis of the Half Bridge Resonant Inverter with Bidirection

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 7.4
//Analysis of the Half-Bridge Resonant Inverter with Bidirectional Switches.

clc;
clear;
fo=3.5;                      //Frequency in KHz.
C=3;                         //Capacitance in micro farad.
L=50;                        //Inductance in micro henry.
R=2;                         //Resistance in Ohm.
Vs=220;                      //Supply voltage in volts.
Ce=2*C;                      //Calculating the effective capacitance.
wr=sqrt((1/(2*L*10^-6*C*10^-6))-((R^2)/(4*L^2*10^-12)));//Calculating resonant frequency in rad per second from the Eq 7.21.
fr=wr/(2*%pi);               //Calculating resonant frquency in Hz.
Tr=1/fr;                     //Calculating time per cycle.
t1=Tr/2;                     //Calculating time per half cyle.
To=1/(fo*10^3);             //Calculating time per output cycle.
alp=R/(2*L*10^-6);
td=To-Tr;                   //Calculating turn off period of load current.
```

```
Vc=Vs/((exp((alp*%pi)/wr))-1); //Calculating the
    capacitor voltage from Eq 7.14.
Vc1=Vs+Vc;                      //Calculating the
    maximum capacitor voltage from Eq 7.16.
tm=(1/wr)*(atan(wr/alp));       //Calculating the time
     at peak load current from the Eq 7.7
Ip=((Vc1)*(exp(-(alp*tm)))*(sin(wr*tm)))/(wr*L
    *10^-6);//Calculating the peak load current from
    eauation of io(t), where t=tm.
//Calculating average device current.
function Ia=f(t);
    Ia=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*t)))*(sin(
        wr*t)));
endfunction
y=intg(0,t1,f);
IA=fo*10^3*y;
//Calculating the rms device current.
funcprot(0);
function Ir=f(t);
    Ir=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*t)))*(sin(
        wr*t)))^2;
endfunction
x=intg(0,Tr/2,f);
IR=sqrt(fo*10^3*x);
Io=2*IR;                                  //Calculating
    rms load current.
Po=Io^2*2                                 //Calculating
    the output power.
Is=Po/Vs;                                 //Calculating
    the average supply current.
printf("\n\twr=%0.0frad/sec\n\tfr=%0.1fHz\n\tTr=%0.0
    f micro secs\n\tt1=%0.0f micro sec\n\tTo=%0.2f
    micro sec",wr,fr,Tr*10^6,t1*10^6,To*10^6);
printf("\n\tThe turn off period of load current td
    is %0.2f micro sec",td*10^6);
printf("\n\tThe intial capacitor current Vc is %0.1
    fV",Vc);
printf("\n\tThe maximum capacitor current Vc1 is %0
```

```
.1fV",Vc1);
printf("\n\t(a).The time at which peak load occurs tm is %0.2f micro sec",tm*10^6);
printf("\n\t     The peak load current Ip is %0.2fA",Ip);
printf("\n\t(b).The average device current IA is %0.2fA",IA);
printf("\n\t(c).The rms device current IR is %0.2fA",IR);
printf("\n\t(d).The rms load curret Io is %0.1fA",Io);
printf("\n\t(e).The output power Po is %0.0fW",Po);
printf("\n\t     The average supply current Is is %0.2fA",Is);
```

Scilab code Exa 7.5 Analysis of the Full Bridge Resonant Inverter with Bidirection

```
//Power Electronics Devices, Circuits, and Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 7.5
//Analysis of the Full-Bridge Resonant Inverter with Bidirectional Switches.

clc;
clear;
fo=3.5;                             //Frequency in KHz.
C=6;                                //Capacitance in micro farad.
L=50;                               //Inductance in micro henry.
R=2;                                //Resistance i  Ohm.
```

```
Vs=220;                          //Supply voltage in
    volts.
wr=sqrt((1/(L*C*10^-12))-((R^2)/(4*(L^2)*10^-12)));
    //Calculating the resonant frequency in radians
    per second from the Eq 7.21.
fr=wr/(2*%pi);                   //Calculating resonant
    frquency in Hz.
Tr=1/fr;
t1=Tr/2;
To=1/(fo*10^3);
td=To-Tr;                        //Calculating turn off
    period of load current.
alp=R/(2*L*10^-6);
z=(alp*%pi)/wr
Vc=Vs*(((exp((alp*%pi)/wr))+1)/((exp((alp*%pi)/wr))
    -1));//Calculating the capacitor voltage from the
     Eq 7.14.
tm=(1/wr)*(atan(wr/alp));                              //
    Calculating the time at peak load current from
    the Eq 7.7
Ip=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*tm)))*(sin(wr*
    tm)));//Calculating the peak load current from Eq
     7.28.
//Calculating average device current.
function Ia=f(t);
    Ia=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*t)))*(sin(
        wr*t)));
endfunction
y=intg(0,t1,f);
IA=fo*10^3*y;
//Calculating the rms device current.
funcprot(0);
function Ir=f(t);
    Ir=(((Vs+Vc)/(wr*L*10^-6))*(exp(-(alp*t)))*(sin(
        wr*t)))^2;
endfunction
x=intg(0,Tr/2,f);
IR=sqrt(fo*10^3*x);
```

```
Io=2*IR;                                    //Calculating rms load current.
Po=Io^2*2                                   //Calculating the output power.
Is=Po/Vs;                                   //Calculating the average supply current.
printf("\n\twr=%0.0frad/sec\n\tfr=%0.1fHz\n\tTr=%0.0f micro sec\n\tt1=%0.0f micro sec\n\tTo=%0.2f micro sec",wr,fr,Tr*10^6,t1*10^6,To*10^6);
printf("\n\tThe turn off period of load current td is %0.2f micro sec",td*10^6);
printf("\n\tThe intial capacitor current Vc is %0.1fV",Vc);
printf("\n\t(a).The time at which peak load occurs tm is %0.2f micro sec",tm*10^6);
printf("\n\t    The peak load current Ip is %0.2fA",Ip);
printf("\n\t(b).The average device current IA is %0.2fA",IA);
printf("\n\t(c).The rms device current IR is %0.1fA",IR);
printf("\n\t(d).The rms load curret Io is %0.1fA",Io);
printf("\n\t(e).The output power Po is %0.0fW",Po);
printf("\n\t    The average supply current Is is %0.2fA",Is);
```

Scilab code Exa 7.6 Finding the Values of L and C for a Series Loaded Resonant Inv

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

```

```
//Example : 7.6
//Finding the Values of L and C for a Series-Loaded Resonant Inverter to Yield Specific Output Power.

clc;
clear;
PL=1;                          //Load power in killo watts.
R=10;                          //Load resistance in Ohm.
fo=20;                         //Resonant frequency in KHz.
P1=250;                        //Power in watts.
u=0.8;
//Calculating the supply voltage.
Vp1=round(sqrt(PL*10^3*2*R));
Vs=floor((Vp1*%pi)/4);
Qs=sqrt((((PL*10^3)/P1)-1)/(((u)-(1/u))^2));//Calculating the quality factor.
L=(Qs*R)/(2*%pi*fo*10^3);                    //Calculating the inductance.
C=((1/(fo*10^3*2*%pi))^2)*(1/L);       //Calculating the capacitance.
printf("\n\t(a).The input supply current Vs is %iV",Vs);
printf("\n\t(b).The Quality factor if the power is to be reduced to 250w, Qs is %0.2f",Qs);
printf("\n\t(c).The inductor L is %0.1f H",L*10^6);
printf("\n\t(d).The capacitor C is %0.4f F",C*10^6);
```

Scilab code Exa 7.7 Finding the Values of L and C for a Parallel Loaded Resonant I

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
```

```
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2        ;OS : Windows.

//Example : 7.7
//Finding the Values of L and C for a Parallel-Loaded Resonant Inverter to Yield Specific Output Power

clc;
clear;
PL=1;                           //Load power in killo watts.
R=10;                           //Load resistance in Ohm.
fo=20;                          //Resonant frequency in KHz.
Vp=330;                         //Peak load voltage in volts.
//Calculating the supply voltage.
Vp1=round(sqrt(PL*10^3*2*R));
Vs=floor((Vp1*%pi)/4);
Vi_pk=(4*Vs)/%pi;               //Calculating the peak input voltage.
Q=Vp/Vi_pk;                     //Calculating the quality factor.
//Calculating the value of frequency ratio from Eq 7.36.
x=poly(0,"u");
u1=((1-x^2)^2)+(x/Q)^2-4;
u2=roots(u1);
u=u2(2,1);
L=R/(2*%pi*20*10^3*Q);                   //Calculating the Inductance.
C=((1/(fo*10^3*2*%pi))^2)*(1/L);         //Calculating the capacitance.
printf("\n\t(a).The dc supply voltage Vs is %iV",Vs);
```

```
printf("\n\t    .The peak input voltage Vi(pk) is %0.2fV",Vi_pk);
printf("\n\t(b).The quality factor Q is %0.3f",Q);
printf("\n\t    The frequency ratio u is %0.3f",u);
printf("\n\t(c).The inductance L is %0.2f H",L*10^6);
printf("\n\t(d).The capacitance C is %0.3f F",C*10^6);
```

Scilab code Exa 7.8 Finding the Values of L and C for a Parallel Resonant Inverter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 7.8
//Finding the Values of L and C for a Parallel Resonant Inverter to Yield Specific Output Power.

clc;
clear;
PL=1;                              //Load power in Killo watt.
Vp=170;                            //Peak load voltage in  volts
R=10;                              //Resistance in Ohm.
fo=20;                             //Resonant frequency in KHz.
u=1.25;                            //Frequency ratio
Is=sqrt((PL*10^3*2*%pi^2)/(4^2*R)); //Calculating the supply current.
Qp=sqrt((4-1)/(u-(1/u))^2);        //Calculating the quality factor.
```

```
C=Qp/(2*%pi*fo*10^3*R);              //Calculating
    the value of capacitance.
L=((1/(fo*10^3*2*%pi))^2)*(1/C);     //Calculating
    the inductance.
printf("\n\t(a).The dc supply current Is is %0.1fA",
    Is);
printf("\n\t(b).The Quality factor if the power is
    to be reduced to 250w, Qp is %0.2f",Qp);
printf("\n\t(c).The capacitance C is %0.2f F",C
    *10^6);
printf("\n\t(d).The Inductance L is %0.2f H",L
    *10^6);
```

Scilab code Exa 7.9 Finding the Optimum Values of C and L for a Class E Inverter

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 7.9
//Finding the Optimum Values of C  s  and  L s  for
     a Class E Inverter.

clc;
clear;
Vs=12;                       //Supply voltage in
    volts.
R=10;                        //Resistance in Ohm.
fs=25;                       //Switching frequency in
     KHz.
Q=7;                         //Quality factor.
a1=0.4001;a2=2.165;a3=0.3533;//Constant values
    calculated from mode 3 operation of the circuit
```

```
   in Fig 7.20;
ws=2*%pi*fs*10^3;              //Calculating the
   switching frequency in rad/sec.
Le=(a1*R)/ws;              //Calculating the effective
   inductance.
Ce=a2/(R*ws);              //Calculating the effective
    capacitance.
L=(Q*R)/(ws);                  //Calculating the
   Inductace.
C=1/(((ws*L)-(a3*R))*ws);//Calculating the value of
   capacitance.
del=(R/2)*(sqrt(C/L));          //Calculating the
   damping factor.
fo=1/(2*%pi*sqrt(L*C));       //Calculating the
   resonant frequency.
printf("\n\t(a).The effective inductance Le is %0.2f
    micro Henry",Le*10^6);
printf("\n\t    The effective capacitance Ce is %0.2
   f micro Farad",Ce*10^6);
printf("\n\t    The  inductance L is %0.2f micro
   Henry",L*10^6);
printf("\n\t    The effective capacitance C is %0.4f
    micro Farad",C*10^6);
printf("\n\t    The damping factor del is %0.4f",del
   );
printf("\n\t    The resonant frequency fo is %0.2
   fkHz",fo*10^-3);
```

Scilab code Exa 7.10 Finding the Values of L and C for a Class E Rectifier

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.
```

```
//Example : 7.10
//Finding the Values of L s and C s for a Class E Rectifier.

clc;
clear;
PL=400;                         //Load power in milli watts.
Vo=4;                           //Load voltage in volts.
Vm=10;                          //Peak supply voltage in volts.
f=250;                          //Supply frequency in KHz.
del_Vo=40;                        //Peak to peak ripple output voltage in milli volts.
C=10;                           //Chosed suitable value of capacitance nano farad.
L=(1/(2*%pi*f*10^3))^2/(C*10^-9);          //Calculating the inductance from the equation of resonant frequency fo.
R=Vo^2/(PL*10^-3);                         //Calculating the Resistance from the equation of load power PL.
Io=Vo/R;                                   //Calculating the output current.
Cf=(Io*10^3)/(2*f*10^3*del_Vo*10^-3);        //Calculating the capacitance.
Im=Vm/R;                                   //Calculating the peak supply current.
IL_rms=sqrt(((Io*10^3)^2)+(f^2/2));        //Calculating the rms inductor current.
IL_dc=Io                                   //The Inductor current.
IC_rms=f/sqrt(2);                          //Calculating the rms capacitor current.
IC_dc=0;                                   //The
```

```
capacitor current.
printf("\n\t(a).The suitable value of capacitance
    choosen is %inF",C);
printf("\n\t    The inductance L is %0.1f micro
    Henry",L*10^6);
printf("\n\t    The resistance R is %0.0f Ohm",R);
printf("\n\t    The output current Io is %0.0fmA",Io
    *10^3);
printf("\n\t    The capacitance Cf is %0.0f micro
    Farad",Cf*10^3);
printf("\n\t(b).The peak supply current Im is %0.0
    fmA",Im*10^3);
printf("\n\t    The rms inductor current IL(rms) is
    %0.1fmA",IL_rms);
printf("\n\t    The indctance current IL(dc) is %0.0
    fmA",IL_dc*10^3);
printf("\n\t    The rms capacitor current IC(rms) is
     %0.2fmA",IC_rms);
printf("\n\t    The capacitor current IC(dc) is %i",
    IC_dc);
```

Scilab code Exa 7.11 Finding the Values of L and C for a Zero Current Switching In

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 7.11
//Finding the Values of L and C for a Zero-Current-
    Switching Inverter.

clc;
clear;
```

```
PL=400;                         //Load power in milli watts.
Vo=4;                           //Load voltage in volts.
Vs=12;                          //Supply voltage in volts.
fmax=50;                        //Maximum frequency in KHz.
x=1.5;
T=1/(fmax*10^3);
Io=(PL*10^-3)/Vo;                    //Calculating output current.
C=T/(((%pi*Vs)/(x*Io))+(2*Vs/Io));//Calculating the value of capacitance.
L=(Vs/(x*Io))^2*C;                  //Calculating the value of inductance.
printf("\n\tThe output current Io is %0.0fmA",Io*10^3);
printf("\n\tThe Capacitance C is %0.4f F",C*10^6);
printf("\n\tThe inductance L is %0.2f H",L*10^6);
```

Chapter 9

Thyristors

Scilab code Exa 9.1 `Finding the Critical Value of deviation in voltage for a Thyri`

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 9.1
//Finding the Critical Value of dv/dt for a Thyristor.

clc;
clear;
Cj2=20;                               //Capacitance of thyristor J2 in pico farad.
Ij2=16;                               //Charging current of thyristor in milli Ampere.
dv=(Ij2*10^-3)/(Cj2*10^-12);          //Calculating the change in voltage.
printf("\n\tThe critical value of dv/dt is %0.0fV/s ",dv*10^-6);
```

Scilab code Exa 9.2 Finding the Average On State Current of a Thyristor

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 9.2
//Finding the Average On-State Current of a Thyristor.

clc;
clear;
fs=50;                              //Supply frequency in Hz.
Itm=1000;                           //Thyristor current in Ampere.
t1=5;                               //Ontime of thyristor in micro seconds.
T=1/fs;                             //Calculating the time per cycle.
//Calculating the average on state current from figure 9.28
It=((0.5*(t1*10^-6)*(Itm*10^-3))+((T-(2*(t1*10^-6)))*Itm)+(Itm*(t1*10^-6)*0.5))/T;
printf("The average on state current It is %0.1fA",It);
//Answer is Changed due to round-off error.
```

Scilab code Exa 9.3 Finding the Voltage Sharing of Series Connected Thyristors

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 9.3
//Finding the Voltage Sharing of Series-Connected Thyristors.

clc;
clear;
Vs=15;                              //Supply voltage in kilo volts.
del_Id=10;                              //Maximum leakage current in milli Ampere.
del_Q=150;                              ///Recovery charge difference in micro coloumb.
R=56;                               //Resistance in killo Ohm.
C1=0.5;                             //Capacitance in micro Farad.
ns=10;                              //No of thyristors in the string.
Vds_max=((Vs*10^3)+((ns-1)*R*10^3*del_Id*10^-3))/ns;//Calculating the maximum steady state voltage sharing.
DRF=1-((Vs*10^3)/(ns*Vds_max));                     //Calculating steady state derating factor.
Vdt_max=((Vs*10^3)+(((ns-1)*del_Q*10^-6)/(C1*10^-6)))/ns;//Calculating maximum transient voltage sharing.
DRF1=1-((Vs*10^3)/(ns*Vdt_max));
                        //Calculating transient derating factor
printf("\n\t(a).The maximum steady state voltage sharing Vde(max) is %0.0fV",Vds_max);
printf("\n\t(b).The steady state derating factor is
```

```
   DRF is %0.2fpercent",DRF*100);
printf("\n\t(c).The maximum transient voltage
   sharing Vdt(max) is %0.0fV",Vdt_max);
printf("\n\t(d).The transient derating factor is DRF
   is %0.2fpercent",DRF1*100);
```

Scilab code Exa 9.4 Finding the Values of the Snubber Circuit for a Thyristor Circ

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 9.4
//Finding the Values of the Snubber Circuit for a
   Thyristor Circuit.

clc;
clear;
Vs=200;                          //Input voltage in
   volts.
R=5;                             //Load Resistance in
   Ohm.
fs=2;                            //Supply frequency in
   kHz.
dv=100;                          //Change in voltage in
   V/ s .
Itd=100;                         //Discharge current in
   Ampere.
Rs=Vs/Itd;                       //Calculating the
   snubber resistance.
Cs=(0.632*R*Vs)/((dv*10^6)*(R+Rs)^2);//Calculating
   the snubber capacitance.
Ps=0.5*Cs*Vs^2*fs*10^3;                //Calculating
```

```
the snubber loss.
Psr=Ps;                                   //Calculating power rating of snuber resistnace.
printf("\n\t(a).The snubber resistance Rs is %0.0f  ",Rs);
printf("\n\t    The snubber capacitance Cs is %0.3f F",Cs*10^6);
printf("\n\t(b).The snubber loss Ps is %0.1fW",Ps);
printf("\n\t(c).The power rating of snubber resistor is %0.1fW",Psr);
```

Scilab code Exa 9.5 `Finding the Circuit Values of a UJT Triggering Circuit`

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 9.5
//Finding the Circuit Values of a UJT Triggering Circuit.

clc;
clear;
Vs=30;                               //Suply voltage in volts.
eff=0.51;                            //Efficiency of the circuit.
Vv=3.5;                              //Volatage in volts.
Iv=10;                               //Current in milli Ampere.
Ip=10;                               //Peak inpiut current Ip in Ampere.
```

```
Io=10;                                  //Output current in Ampere.
f=60;                                   //Oscillation frequency in Hz.
tg=50;                                  //Width of the triggering pulse in micro seconds.
Vd=0.5;
C=0.5;                                  //Asumed value of capacitance in micro farad.
T=1/f;                                  //Calculating the time per cycle.
Vp=eff*Vs+Vd;                           //Calculating the peak voltage.
R1=(Vs-Vp)/(Ip*10^-6);R2=(Vs-Vv)/(Iv*10^-3);//Calculating the limiting value of resistance.
R=T/((C*10^-6)*log(1/(1-eff)));         //Calculating the value of resistance.
Vb1=Vp;                                 //Calculating the peak gate voltage.
RB1=tg/C;                               //Calculating the Resistance of gate 1.
RB2=10^4/(eff*Vs);                      //Calculating the resistance of gate 2.
printf("\n\tThe value of peak resistance vp is %0.1fV",Vp);
printf("\n\tThe limiting vlaue of R are %0.2fMega Ohm > R > %0.2fKilo Ohm",R1*10^-6,R2*10^-3);
printf("\n\tThe value of Resistance R is %0.1fKilo Ohm",R*10^-3);
printf("\n\tThe peak gate voltage VB1 is %0.1fV",Vb1);
printf("\n\tThe resistance of gate1 RB1 is %0.0f Ohm",RB1);
printf("\n\tThe resistance of gate2 RB2 is %0.0f Ohm",RB2);
```

Scilab code Exa 9.6 Finding the Circuit Values of a Programmable UJT Triggering Ci

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2        ;OS : Windows.

//Example : 9.6
//Finding the Circuit Values of a Programmable UJT Triggering Circuit.

clc;
clear;
Vs=30;                              //Supply voltage in volts.
Ig=1;                               //Gate current in milli Ampere.
f=60;                               //Oscillation frequency in Hz.
tg=50;                              //Pulse width in micro second.
Vrk=10;                             //Peak triggering voltage in volts.
T=1/f;                              //Calculating the width of a cycle.
C=0.5;                              //Assumed value of capacitance in micro farad.
Rk=tg/C;                            //Calculating the triggering resistance.
Vp=Vrk;                             //Calculating the peak voltage.
eff=Vp/Vs;                            //Calculating the efficiency.
```

```
R=T/((C*10^-6)*log(1/(1-eff)));    //Calculating the
    value of resistance.
Rg=(1-(1/3))*(Vs/(Ig*10^-3));    //Calculating the
    gate resistance.
R1=(Rg/eff);                       //Calculating the
    value of resistance R1.
R2=Rg/(1-eff);                     //Calculating the
    value of resistance R2.
printf("\n\tThe value of triggering resistance Rk is
     %0.0f Ohm",Rk);
printf("\n\tThe value of peak voltage Vp is %iV",Vp)
    ;
printf("\n\tThe efficiency eff is %0.2f",eff);
printf("\n\tThe value of Reistance R is %0.3f kilo
    Ohm",R*10^-3);
printf("\n\tThe value of gate resistance Rg is %0.0f
     Kilo Ohm",Rg*10^-3);
printf("\n\tThe value of resistance R1 is %0.0f kilo
     Ohm",R1*10^-3);
printf("\n\tThe value of resistance R2 is %0.0f Kilo
     Ohm",R2*10^-3);
```

Chapter 10

Controlled Rectifiers

Scilab code Exa 10.2 Finding the Current Ratings of Single Phase Full Converter wi

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 10.2
//Finding the Current Ratings of Single-Phase Full
   Converter with an RL load.

clc;
clear;
L=6.5;                          //Load inductance
   in milli Henry.
R=0.5;                          //Load resistance
   in Ohm.
E=10;                           //Voltage of
   battery in volts.
Vs=120;                         //Supply voltage
   in volts.
f=60;                           //Frequency in Hz.
```

```
alp=60;                                  //Firing angle in degree.
w=2*%pi*f;                               //Calculating frequency in rad/sec.
theta=atan((w*L*10^-3)/R);                //Calculating the load angle.
Z=sqrt(R^2+(w*L*10^-3)^2);               //Calculating load impedence.
alp1=alp*%pi/180;                        //Converting the firing angle into radians
ILo=((sqrt(2)*Vs/Z)*((-(sin(alp1-theta))-(sin(alp1-theta)*(exp(-((R/(L*10^-3))*(%pi/w))))))/(1-(exp(-((R/(L*10^-3))*(%pi/w))))))-(E/R);//Calculating the steady state load current.
//Calculating the equation of average thyristor current from Eq 10.8.
funcprot(0)
function a=f(wt)
     a=((sqrt(2)*Vs/Z)*sin(wt-theta))-(E/R)+(((ILo)+(E/R)-((sqrt(2)*Vs/Z)*(sin(alp1-theta))))*exp((R/(L*10^-3))*((alp1/w)-(wt/w))))
endfunction
a=alp1;b=%pi+alp1;                           //Limits of integeration of eq 10.8 for calculating tyristor current.
IA=(1/(2*%pi))*(intg(a,b,f));             //Calculating the thyristor current by integrating eq 10.8
//Calculating the eqation of rms thyristor current from Eq 10.8.
funcprot(0)
function b=f(wt)
     b=(((sqrt(2)*Vs/Z)*sin(wt-theta))-(E/R)+(((ILo)+(E/R)-((sqrt(2)*Vs/Z)*(sin(alp1-theta))))*exp((R/(L*10^-3))*((alp1/w)-(wt/w)))))^2
endfunction
IR=sqrt((1/(2*%pi))*(intg(a,b,f)));    //Calculating the thyristor rms current.
Irms=sqrt(2)*IR;                           //Calculating
```

```
rms output current.
Idc=2*IA;                                //Calculating average dc output current.
//Calculating critical value of delay angle from Eq 10.10.
alp_c=theta-asin(((1-(exp(-(%pi/tan(theta)))))/(1+(exp(-(%pi/tan(theta))))))*(((E/(sqrt(2)*Vs))/cos(theta))));
printf("\n\t(a).The steady state load curret ILo is %0.2fA",ILo);
printf("\n\t(b).The average thyristor current IA is %0.2fA",IA);
printf("\n\t(c).The rms thyristor current IR is %0.2fA",IR);
printf("\n\t(d).The rms output current Irms is %0.1fA",Irms);
printf("\n\t(e).The average output current Idc is %0.1fA",Idc);
printf("\n\t    Tht critical delay angle alp_c is %0.2f degree",alp_c*180/%pi);
//Some answers are changed due to roundoff error.
```

Scilab code Exa 10.3 Finding the Peak Currents of a Single Phase Dual Converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 10.3
//Finding the Peak Currents of a Single-Phase Dual Converter.

clc;
```

```
clear;
Vs=120;                              //Supply voltage in volts.
f=60;                                //Supply frequency in Hz.
R=10;                                //Resistance in Ohm.
Lr=40;                               //Circulating inductance in milli Henry.
alp1=60;alp2=120;                    //Delay angles in degree.
w=2*%pi*f;                           //Calculating frequency in rad/sec.
Vm=sqrt(2)*Vs;                       //Calculating the converter voltage.
Ir_max=((2*Vm)/(w*Lr*10^-3))*(1-cosd(alp1));//Calculating the peak circulating current.
Ip=Vm/(R);                                   //Calculating the peak load current.
Ip1=Ip+Ir_max;                               //Calculating the peak current of converter 1.
printf("\n\tThe peak circulating current Ir(max) is %0.2fA",Ir_max);
printf("\n\tThe peak load current Ip is %0.2fA",Ip);
printf("\n\tThe peak current of converter1 is %0.2fA",Ip1);
```

Scilab code Exa 10.4 Finding the Performances of a Three Phase Full Wave Converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 10.3
```

```
//Finding the Performances of a Three-Phase Full-Wave Converter.

clc;
clear;
V=208;                      //Three phase Supply voltage in volts.
f=60;                       //Supply frequency in Hz.
R=10;                       //Load resistance in Ohm.
Vs=V/sqrt(3);               //Calculating the single phase supply voltage.
Vm=sqrt(2)*Vs;              //Calculating the converter voltage.
Vn=50;                      //Average output voltage to be improved in percentage.
Vdm=(3*sqrt(3)*Vm)/%pi;     //Calculating the maximum output voltage.
Vdc=(Vn/100)*Vdm;           //Calculating the average output voltage.
alp=acosd(Vdc/Vdm);           //Calculating the delay angle.
Idc=Vdc/R;                 //Calculating the average output current.
Vrms=(sqrt(3)*Vm)*(sqrt(0.5+(((3*sqrt(3))/(4*%pi))*(cosd(2*alp)))));//Calculating rms voltage
Irms=Vrms/R;                //Calculating rms current.
IA=Idc/3;                   //Calculating average thyristor current.
IR=Irms*(sqrt(2/6));        //Calcultaing rms current of thyristor.
eff=(Vdc*Idc)/(Vrms*Irms);    //Calculating rectification efficiency.
Is=Irms*(sqrt(4/6));        //Calculating the rms line current.
VI=3*Vs*round(Is);          //calculating the input
```

```
VAR rating.
TUF=(Vdc*Idc)/VI;            //Calculating transformer utilization factor.
Po=Irms^2*R;                 //Calculating the output power.
PF=Po/VI;                    //Calculating the power factor.
printf("\n\tThe single phase supply voltage Vs is %0.1fV",Vs);
printf("\n\tThe converter voltage Vm is %0.2fV",Vm);
printf("\n\tThe maximum output voltage Vdm is %0.1fV",Vdm);
printf("\n\tThe average output voltage Vdc is %0.2fV",Vdc);
printf("\n\t(a).The delay angle alp is %0.0f degree",alp);
printf("\n\t(b).The average output current Idc is %0.2fA",Idc);
printf("\n\t    The rms output voltage Vrms is %0.2fV",Vrms);
printf("\n\t    The rms output current Irms is %0.2fA",Irms);
printf("\n\t(c).The average current of a thyristor IA is %0.2fA",IA);
printf("\n\t    The rms current of thyristor IR is %0.1fA",IR);
printf("\n\t(d).The rectification efficiency eff is %0.1fpercent",eff*100);
printf("\n\t(e).The rms input line current Is is %0.0fA",Is);
printf("\n\t    The input VAR rating VI is %0.1fVA",VI);
printf("\n\t    The transformer utilization factor TUF is %0.3f",TUF);
printf("\n\t(f).The output power Po is %0.1fW",Po);
printf("\n\t    The power factor PF is %0.3f(lagging)",PF);
//Answers may vary due to round-off error.
```

Scilab code Exa 10.6 Finding the Current Ratings of Three Phase Full Converter wit

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 10.6
//Finding the Current Ratings of Three−Phase Full−
   Converter with an RL Load.

clc;
clear;
L=1.5;                            //Load inductance in
   milli Henry.
R=2.5;                            //Load resistance in
   Ohm.
E=10;                             //Battery voltage in
   Volts.
Vab=208;                          //Line to line input
   voltage.
f=60;                             //Supply frequency in
    Hz.
alp=%pi/3;                          //Delay angle in
   radians.
w=2*%pi*f;                        //Calculating the
   resonant frequency.
Z=sqrt(R^2+(w*L*10^-3)^2);        //Calculating the
   load impedence.
theta=atan((w*L*10^-3)/R);           //Calculating the
   load angle.
//Calculating the steady state load current from the
    Eq.10.21.
```

```
IL1=(((sqrt(2)*Vab)/Z)*(((sin(((2*%pi)/3)+alp-theta))-((sin((%pi/3)+alp-theta))*(exp(-((R/(L*10^-3))*(%pi/(3*w)))))))/(1-(exp(-((R/(L*10^-3))*(%pi/(3*w))))))))-(E/R);
//Calculating the equation of average thyristor current from Eq.10.20
funcprot(0)
function a=f(wt)
    a=(((sqrt(2)*Vab)/Z)*sin(wt-theta))-(E/R)+((((IL1)+(E/R)-(((sqrt(2)*Vab)/Z)*(sin((%pi/3)+alp-theta))))*(exp((R/(L*10^-3))*((((%pi/3)+alp)/w)-(wt/w)))))
endfunction
a=(%pi/3)+alp;b=((2*%pi)/3)+alp;//Limits for integrating average thyristor current
IA=(1/(%pi))*(intg(a,b,f));      //Calculating average tyristor current
//Calculating the equation of  rms thyristor current from the Eq 10.20.
funcprot(0)
function b=f(wt)
    b=((((sqrt(2)*Vab)/Z)*sin(wt-theta))-(E/R)+((((IL1)+(E/R)-(((sqrt(2)*Vab)/Z)*(sin((%pi/3)+alp-theta))))*(exp((R/(L*10^-3))*((((%pi/3)+alp)/w)-(wt/w))))))^2
endfunction
IR=sqrt((1/%pi)*(intg(a,b,f)));    //Calculating rms thyristor current.
Irms=sqrt(3)*IR;                   //Calculating rms output current.
Idc=3*IA;                          //Calculating average output current.
printf("\n\t(a).The steady state load current IL1 is %0.2fA",IL1);
printf("\n\t(b).The average thyristor current IA is %0.1fA",IA);
printf("\n\t(c).The rms thyristor current IR is %0.2fA",IR);
```

```
printf("\n\t(d).The rms output current Irms is %0.2fA",Irms);
printf("\n\t(e).The average output current Idc is %0.2fA",Idc);
//Some answers are varied due to round--off error.
```

Scilab code Exa 10.8 Finding the Thyristor Ratings of a Three Phase Full Converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 10.8
//Finding the Thyristor Ratings of a Three-Phase Full Converter.

clc;
clear;
V=230;                          //Three phase input voltage in volts.
f=60;                           //Supply frequency in Hz.
Ia=150;                         //Average load current in ampere.
alp=%pi/3;                        //Delay angle in radians.
Vs=V/sqrt(3);                   //Calculating the single phase voltage.
Vm=sqrt(2)*Vs;                  //Calculating phase voltage.
Vdc=3*(sqrt(3)/%pi)*Vm*cos(alp);//Calculating average output voltage.
Pdc=Vdc*Ia;                       //Calculating output
```

```
power.
IA=Ia/3;                            //Calculating average current through thyristor.
IR=Ia*sqrt(2/6);                    //Calculating rms thyristor current.
IPT=Ia;                             //Calculating peak current through thyristor.
PIV=sqrt(3)*Vm;                     //Calculating peak inverse voltage.
printf("\n\tThe single phase voltge Vm is %0.2fV",Vm);
printf("\n\tThe average output voltage Vdc is %0.1fV",Vdc);
printf("\n\tThe output power Pdc is %0.0fW",Pdc);
printf("\n\tThe average current through thyristor IA is %0.0fA",IA);
printf("\n\tThe rms current through a thyristor IR is %0.1fA",IR);
printf("\n\tThe peak inverse voltage PIV is %0.2fV",PIV);
//Answers may vary due to round-off error.
```

Scilab code Exa 10.10 Finding the Overlap Angle for a Three Phase Full Converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 10.10
//Finding the Overlap Angle for a Three-Phase Full Converter.

clc;
```

```
clear;
Vs=230;                          //Supply voltage in volts.
fs=60;                            //Frequency in Hz.
Idc=150;                         //Average load current in ampere.
Lc=0.1;                          //Commutatting inductance in milli henry.
alp0=10;                           //Overlap angle in degree.
alp1=30;                           //Overlap angle in degree.
alp2=60;                           //Overlap angle in degre.
Vm=sqrt(2)*Vs/sqrt(3);          //Calculating phase voltage.
Vdm=(3*sqrt(3)*Vm)/%pi;         //Calculating diode voltage.
//Calculating the overlap angles.
mu0=(acosd(cosd(alp0)-((6*fs*Idc*Lc*10^-3)/Vdm)))-alp0;
mu1=(acosd(cosd(alp1)-((6*fs*Idc*Lc*10^-3)/Vdm)))-alp1;
mu2=(acosd(cosd(alp2)-((6*fs*Idc*Lc*10^-3)/Vdm)))-alp2;
printf("\n\t    The overlap angles are")
printf("\n\t(a).For alp = %0.0f  , mu = %0.2f degree",alp0,mu0);
printf("\n\t(b).For alp = %0.0f  , mu = %0.2f degree",alp1,mu1);
printf("\n\t(c).For alp = %0.0f  , mu = %0.2f degree",alp2,mu2);
//Some answers are changed due to round-off error.
```

Scilab code Exa 10.11 Finding the Minimum Value of Gate Pulse Width for a Single P

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 10.11
//Finding the Minimum Value of Gate Pulse Width for a Single-Phase Full Converter.

clc;
clear;
IH=0.5;                          //Holding current of thyristor in ampere.
td=1.5;                          //Delay time in micro seconds.
Vs=120;                          //Supply voltage in volts.
f=60;                            //Frequency in Hz.
L=10;                            //Inductance in milli Henry.
R=10;                            //Resistance in Ohm.
alp=30;                            //Delay angle in degree.
Vm=sqrt(2)*Vs;                   //Calculating the phase voltage.
V1=Vm*sin(%pi/6);                //Calculating the voltage at delay angle alp.
di=V1/(L*10^-3);                 //Calculating the rate of rise of anode voltage at alp.
t1=IH/(di*10^-6);               //Calculating the time required for anode current to rise to holding curret.
tG=t1+td;                       //Calculating the minimum width of the gate pulse.
printf("\n\tThe voltage at wt=alp=30  , V1 is %0.2fV",V1);
printf("\n\tThe rate of rise of di/dt at instant of
```

```
triggering is %0.0fA/s",di);
printf("\n\tThe time required for anode current to
    rise to holding current t1 is %0.2f micro seconds
    ",t1);
printf("\n\tThe minimum width of the gate pulse is
    %0.2f micro seconds",tG);
```

Chapter 11

AC Voltage Controllers

Scilab code Exa 11.1 `Finding the Performance Parameters of a Single Phase Full Wav`

```
//Power Electronics Devices, Circuits, and Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 11.1
//inding the Performance Parameters of a Single-Phase Full-Wave Controller

clc;
clear;
R=10;                         //Resistance in Ohm.
Vs=120;                       //Supply volatage in volts.
f=60;                         //Frequency in Hz.
alp=%pi/2;                         //Delay angle in degree.
Vm=sqrt(2)*Vs;                //Calculating the converter voltage.
Vo=Vs/sqrt(2);                //Calculating rms value
```

```
of output voltage.
Io=Vo/R;                        //Calculating rms value of load current.
Po=Io^2*R;                      //Calculating load power.
VA=Vs*Io;                       //Calculating the VA rating.
PF=Po/VA;                       //Calculating the power factor.
IA=(sqrt(2)*Vs*(cos(alp)+1))/(2*%pi*R);//Calculating average thyristor current.
IR=(Vs/(sqrt(2)*R))*(sqrt((1/%pi)*(%pi-alp+(sin(2*alp)/2))));//Calculating rms value of thrysitor current.
printf("\n\t(a).The rms output voltage Vo is %0.2fV",Vo);
printf("\n\t(b).The rms value of load current Io is %0.3fA",Io);
printf("\n\t    The load power Po is %0.2fW",Po);
printf("\n\t    The input rating VA is %0.1fW",VA);
printf("\n\t    The input power factor is %0.3f(lagging)",PF);
printf("\n\t(c).The average  thyristor current IA is %0.1fA",IA);
printf("\n\t(d).The rms value of thyristor current IR is %iA",IR);
////Answers may vary due to round-off error.
```

Scilab code Exa 11.2 Finding the Performance Parameters of a Single Phase Full Wav

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.
```

```

//Example : 11.2
//Finding the Performance Parameters of a Single-Phase Full-Wave Controller with an RL Load.

clc;
clear;
Vs=120;                     //Input rms voltage in volts.
L=6.5;                      //Load inductance in milli Henry.
R=2.5;                      //Load inductance in Ohm.
alp=(90*%pi)/180;            //Delay angle in degree.
f=60;
w=2*%pi*f;                  //Calculating the resonant frequency.
ang=atan((w*L*10^-3)/R);   //Calculating load angle.
Z=sqrt(R^2+(w*L*10^-3)^2);//Calculating load impedence.
//Calculating the values of Eq 11.11 to find the excitation angle.
function a=f(bet)
    a=((sin(alp-ang))*(exp(((R/(L*10^-3))*(alp-bet))/w)))-sin(bet-ang)
endfunction
bet0=3                      //Intial condition for solving Eq 11.8 to find excitation angle
bet=fsolve(bet0,f);         //Solving the Eq 11.9 to find the excitation angle.
del=bet-alp;                //Calculating the conduction angle.
Vo=Vs*sqrt((1/%pi)*((del)+(sin(2*alp)/2)-(sin(2*bet)/2)));//Calculating output voltage.(Book answer is wrong).
//Calculating the Equation to find rms thyristor current from the Eq 11.11.
funcprot(0)
function a=f(wt)
```

```
    a=(sin(wt-ang)-(sin(alp-ang)*exp((R/(L*10^-3))*((alp/w)-(wt/w)))))^2
endfunction
a=alp;b=bet;    //Values of limits to integrate the Eq 1111 to find rms thyristor current.
IR=sqrt((1/%pi)*(intg(a,b,f)))*(Vs/Z);//Integrating the Eq 11.11 to find the rms thyristorcurrent.
Io=sqrt(2)*IR;                  //Calculating thyrister output curretnt.
//Calculating the  Equation average thyristor current from Eq 11.12.
funcprot(0)
function b=f(wt)
    b=(sin(wt-ang)-(sin(alp-ang)*exp((R/(L*10^-3))*((alp/w)-(wt/w)))))
endfunction
IA=((sqrt(2)*Vs)/(2*%pi*Z))*(intg(a,b,f));//Integrating the Eq 11.12 to find the average thyristor current.
Po=Io^2*R;                      //Calculating the output power.
VA=Vs*Io;                       //Calculting the input VA rating.
PF=Po/VA;                       //Calculating the power factor.
printf("\n\t(a).The excitatation angle bet is %0.1f degree",bet*180/%pi);
printf("\n\t    The conduction angle del is %0.1f degree",del*180/%pi);
printf("\n\t(b).The rms output voltage Vo is %0.2fV",Vo);
printf("\n\t(c).The rms thyristor current IR is %0.2fA",IR);
printf("\n\t(d).The output current Io is %0.1fA",Io);
printf("\n\t(e).The average thyristor current IA is %0.2fA",IA);
printf("\n\t(f).The output power Po is %0.1fW",Po);
```

```
printf("\n\t     The input VA rating is %0.0fW",VA);
printf("\n\t     The power factor PF is %0.3f(lagging)",PF);
//Some answers are changed due to round off error.
```

Scilab code Exa 11.3 Finding the Performance Parameters of a Three Phase Full Wave

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 11.3
//Finding the Performance Parameters of a Three-Phase Full-Wave Controller.

clc;
clear;
R=10;                                   //Load resistance in Ohm.
VL=208;                                 //Line to line input voltage in volts.
f=60;                                   //Frequency in Hz.
alp=%pi/3;                                //Delay angle in radians.
Vs=VL/sqrt(3);                          //Calculating th phase voltage.
Vo=sqrt(6)*Vs*(sqrt((1/%pi)*((%pi/6)-(alp/4)+(sin(2*alp)/8))));//Calculating the rms output voltage from the Eq 11.19.
Ia=Vo/R;                                                      //Calculating rms load current.
Po=3*Ia^2*R;                                                  //Calculating output power.
```

```
VA=3*Vs*Ia;                                   //Calculating the input VA rating.
PF=Po/VA;                                     //Calculating the power factor.
printf("\n\t(a).The rms phase output voltage Vo is %0.2fV",Vo);
printf("\n\t(b).The rms phase load current Ia is %0.2fA",Ia);
printf("\n\t    The output power Po is %0.2fW",Po);
printf("\n\t    The input Volt ampere rating VA is %0.1fVA",VA);
printf("\n\t    The power factor PF is %0.2f(lagging)",PF);
//Answers are changed due to round off error.
```

Scilab code Exa 11.4 Finding the Performance Parameters of a Three Phase Delta Con

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 11.4
//Finding the Performance Parameters of a Three-Phase Delta-Connected Controller.

clc;
clear;
R=10;                              //Resistance in Ohm.
Vs=208;                            //Supply voltage in volts.
f=60;                              //Frequency in Hz.
```

```
alp=2*%pi/3;                                //Delay angle in radians.
Im=sqrt(2)*Vs/R;                            //Calculating peak value of phase current.
Vo=Vs*sqrt((1/%pi)*(%pi-alp+(sin(2*alp)/2)));//Calculating output voltage from Eq 11.22.
Iab=9.2;Ia=13.01;                           //Fundamental component of current.
Po=3*Iab^2*R;                               //Calculating output power.
VA=3*Vs*Iab;                                //Calculating the VA rating.
PF=Po/VA;                                   //Calculating the power factor.
IR=Iab/sqrt(2);                             //Calculating the thyristor current.
printf("\n\t(a).The output volatage Vo is %0.0fV",Vo);
printf("\n\t(c).The output power Po is %0.0fW",Po);
printf("\n\t    The VA rating is %0.0f",VA);
printf("\n\t    The power factor PF is %0.3f(lagging)",PF);
printf("\n\t(e).The thyristor current IR is %0.1fA",IR);
//Some answers are varied due to round-off error.
```

Scilab code Exa 11.5 Finding the Performance Parameters of a Single Phase Connecti

```
//Power Electronics Devices, Circuits, and Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 11.5
```

```
//Finding the Performance Parameters of a Single-Phase Connection Changer.

clc;
clear;
V=240;                          //Primary rms voltage in volts.
f=60;                           //Primary frequency in Hz.
V1=120;V2=120;                  //The secondary voltages in volts.
R=10;                           //Resistance in Ohm.
V0=180;                         //RMS load voltage in volts.
s=98;                           //Delay angle in degree.
//Calculating the equation for delay angle alp from the reference Eq 11.30.
function a=f(b)
    a=(sqrt(((V1^2/%pi)*(b-((sin(2*b))/2)))+((((V1+V2)^2/%pi)*(%pi-b+((sin(2*b))/2))))))-V0
endfunction
alpha=fsolve(0.1,f)         //Solving the Eq 11.30 to find the value of alpha.
IR1=((V1+V2)/(sqrt(2)*R))*sqrt((1/%pi)*(%pi-alpha+(sin(2*alpha)/2)));//Calculating the rms current of thyristors T1 and T2.
IR3=(V1/(sqrt(2)*R))*sqrt((1/%pi)*(alpha-(sin(2*alpha)/2)));     // Calculating the rms current of thyristor T3 and T4.
I2=sqrt(2)*IR1;                  //Calculating the rms current of secondary winding.
I1=sqrt((sqrt(2)*IR1)^2+(sqrt(2)*IR3)^2);//Calculating the total rms current.
VA=(V1*I1)+(V2*I2);                          //Calculating the VA rating.
Po=V0^2/R;                                   //Calculating the output power.
```

```
PF=Po/VA;                              //Calculating the power factor.
printf("\n\t(a).The delay angle alp is %0.0f degree",alpha*180/%pi);
printf("\n\t(b).The rms current of thyristor T1 and T2 IR1 is %0.1fA",IR1);
printf("\n\t    The rms current of thyristor T3 and T4 IR3 is %0.1fA",IR3);
printf("\n\t(c).The rms current of secondary winding I2 is %0.1fA",I2);
printf("\n\t    The total rms current I1 is %0.2fA",I1);
printf("\n\t    The VA rating of primary and secondary VA is %0.1f",VA);//Book answer is wrong.
printf("\n\t    The output power Po is %0.0fW",Po);
printf("\n\t    The power factor PF is %0.4f(lagging)",PF);//Book answer is wrong.
//Some answers are changed due to round off error.
```

Scilab code Exa 11.6 Finding the Performance Parameters of a Single Phase Cyclocon

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 11.6
//Finding the Performance Parameters of a Single-Phase Cycloconverter.

clc;
clear;
Vs=120;                        //Supply voltage in
```

```
volts.
fs=60;                              //Frequency in Hz.
R=5;                                //Load resistance in Ohm.
L=40;                               //Load inductance in milli Henry.
fo=20;                              //Frequency of the output voltage.
alp=(2*%pi)/3;                       //Delay angle in radians.
wo=2*%pi*fo;                        //Calculating frequency in rad/sec.
XL=wo*L*10^-3;                      //Calculating the reactance.
Vo=Vs*sqrt((1/%pi)*(%pi-alp+(sin(2*alp)/2)));//Calculating rms output voltage.
Z=sqrt(R^2+(wo*L*10^-3)^2);                  //Calculating input impedence.
theta=atan((wo*L*10^-3)/R);                  //Calculating power angle.
Io=Vo/Z;                                     //Calculating output current.
Ip=Io/sqrt(2);                               //Calculating rms current of each convrter.
IR=Ip/sqrt(2);                               //Calculating rms current of each thyristor.
Is=Io;                                       //Calcuating rms input current.
VA=Vs*Is;                                    //Calculating VA rating of converter.
Po=Vo*Io*cos(theta);                              //Calculating output power.
PF=Po/(Vs*Is);                               //Calculating power factor.
printf("\n\t(a).The rms output voltage Vo is %0.0fV",Vo);
printf("\n\t(b).The input impedence Z is %0.2 f  ",Z);
```

```
printf("\n\t    The angle ang is %0.1f  ",theta*180/%pi);
printf("\n\t    The load current Io is %0.2fA",Io);
printf("\n\t    The rms current through each converter Up is %0.2fA",Ip);
printf("\n\t    The rms current through each thyristor IN IR is %0.2fA",IR);
printf("\n\t(c).The rms input current Is is %0.2fA",Is);
printf("\n\t    The VA rating is %0.1fVA",VA);
printf("\n\t    The output power Po is %0.2fW",Po);
printf("\n\t    The power factor PF is %0.3f(lagging)",PF);
//Some answers may change due to round-off error.
```

Scilab code Exa 11.7 Finding the Performance Parameters of a Single Phase Cyclocon

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 11.7
//Finding the Performance Parameters of a Single-Phase Cycloconverter with a Cosine Reference Signal.

clc;
clear;
Vs=120;                              //Supply voltage in volts.
fs=60;                               //Supply frequency in Hz.
fo=20;                               //Frequency in Hz.
```

```
R=5;                              //Resistance in Ohm.
L=40;                             //Inductance in milli Henry.
alp=(2*%pi)/3;                    //Delay angle in radians.
wo=2*%pi*fo;                      //Calculating frequency in rad/sec.
XL=wo*L*10^-3;                    //Calculating the reactance.
Vo=((2*Vs)/%pi);                  //Calculating output voltage.
Z=sqrt(R^2+(wo*L*10^-3)^2);       //Calculating input impedence.
theta=atan((wo*L*10^-3)/R);       //Calculating power angle.
Io=Vo/Z;                          //Calculating output current.
Ip=Io/sqrt(2);                    //Calculating rms current of each convrter.
IR=Ip/sqrt(2);                    //Calculating rms current of each thyristor.
Is=Io;                            //Calcuating rms input current.
VA=Vs*Is;                         //Calculating VA rating of converter.
Po=Vo*Io*cos(theta);              //Calculating output power.
PF=Po/(Vs*Is);                    //Calculating power factor.
printf("\n\t(a).The rms output voltage Vo is %0.2fV",Vo);
printf("\n\t(b).The input impedence Z is %0.2f Ohm",Z);
printf("\n\t    The angle ang is %0.1f degree",theta*180/%pi);
printf("\n\t    The load current Io is %0.2fA",Io);
printf("\n\t    The rms current through each converter Up is %0.2fA",Ip);
```

```
printf("\n\t    The rms current through each
   thyristor IN IR is %0.2fA",IR);
printf("\n\t(c).The rms input current Is is %0.2fA",
   Is);
printf("\n\t    The VA rating is %0.1fVA",VA);
printf("\n\t    The output power Po is %0.2fW",Po);
printf("\n\t    The power factor PF is %0.3f(lagging
   )",PF);
//Some Answers may vary due to round-off error.
```

Scilab code Exa 11.8 Finding the Device Ratings of the Single Phase Full Wave Cont

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 11.8
//Finding the Device Ratings of the Single-Phase
   Full-Wave Controller.

clc;
clear;
Vs=230;                        //Supply voltage in
   volts.
f=60;                          //Supply frequency in
   Hz.
Po=10;                         //Output power in killo
    watts.
Vm=sqrt(2)*Vs;                 //Calculating phase
   voltage.
Vo=Vs;                         //Calculating the
   output voltage.
R=Vo^2/(Po*10^3);              //Calculating load
```

```
    resistance.
Iom=Vo/R;                          //Calculating maximum rms value of load current.
Irm=Iom/sqrt(2);                   //Calculating maximum rms value of thyristor current.
Iam=(sqrt(2)*Vo)/(%pi*R);          //Calculating maximum average current of thyristor.
Ip=Vm/R;                           //Calculating peak thristor current.
Vp=Vm;                             //Calculating peak thyristor voltage.
printf("\n\t    The Resistnace R is %0.2 f  ",R)
printf("\n\t(a).The maximum value of rms load current Iom is %0.2fA",Iom);
printf("\n\t    The maximum value of rms thyristor current Irm is %0.2fA",Irm);
printf("\n\t(b).The maximum average current of thyristor Iam is %0.2fA",Iam);
printf("\n\t(c).The peak thyristor current Ip is %0.1fA",Ip);
printf("\n\t(d).The peak thyristor voltage Vp is %0.1fV",Vm);
```

Chapter 12

Flexible AC Transmission Systems

Scilab code Exa 12.1 Finding the Inductive Reactance and the Delay Angle of TCR

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 12.1
//Finding the Inductive Reactance and the Delay Angle of TCR.

clc;
clear;
V=220;                      //Supply voltage in volts.
f1=60;                       //Frequency in Hz.
Pp=56;                      //Power in kilo Wats.
IL_max=100;                 //Maximum load current in ampere.
w=2*%pi*f1;                  //Calpculating frequency in rad/sec.
```

```
k=0.6;X=1.2;
del=2*asind((X*Pp*10^3)/(2*V^2));//Calpculating phase angle.
I=((4*V)/X)*sind(del/4);          //Calpculating linear current.
Qp=((4*V^2)/X)*(1-cosd(del/2));   //Calpculating reactive power of shunt compensator.
IQ=Qp/V;                         //Calpculating current through TCR.
XL=V/(IL_max);                   //Calpculating the inductance.
IL=k*IL_max;                     //Calpcualpating the 60% of load current.
//Calpculating delay angle
function a=f(alp)
    a=(V/XL)*(1-((2/%pi)*alp)-((1/%pi)*sin(2*alp)))-IL
endfunction
a0=18
alp=fsolve(a0,f);
printf("\n\t(a).The phase angle del is %0.2f degree",del);
printf("\n\t(b).The linear current I is %0.1fA",I);
printf("\n\t(c).The reactive power of shunt compensator Qp is %0.1fA",Qp);
printf("\n\t(d).The current through TCR IQ is %0.3fA",IQ);
printf("\n\t(e).The inductance reactance XL is %0.1f Ohm",XL);
printf("\n\t(f).The delay angle alp is %0.2f ",alp*180/%pi)
```

Scilab code Exa 12.2 Finding the Series Compensating Reactance and the Delay Angle

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 12.2
//Finding the Series Compensating Reactance and the Delay Angle of TCSC

clc;
clear;
V=220;                      //Supply voltage in volts.
f=60;                       //Frequency in Hz.
X=12;                       //Reactance in Ohm
Pp=56;                      //Power in Killo watt.
del=80;                       //Delay angle in degree.
C=20;                       //Capacitance in micro farad.
L=0.4;                     //Inductance in milli Henry.
w=2*%pi*f;                 //Calculating frequency in rad per second.
Xc=-1/(w*C*10^-6);         //Calculating capacitive reactance.
XL=w*L*10^-3;              //Calculating incductive reactance.
r=1-(((V^2)/(X*Pp*10^3))*sind(del));//Calculating degree of compensarion from Eq 12.25.
X_comp=r*X;                 //Calculating compensating capacitance reactance.
I=((2*V)/((1-r)*X))*(sind(del/2));        //Calculating line current from Eq 12.24.
Qc=((2*V^2)/X)*(r/(1-r)^2)*(1-cos(del));//Calculating reactive power from Eq 12.26.
//Calculating the eqution to find delay angle from Eq 12.27b.
function a=f(alp)
    a=((Xc*(XL*((%pi)/(%pi-(2*alp)-sin(2*alp)))))/((
```

```
    XL*((%pi)/(%pi-(2*alp)-sin(2*alp))))-Xc))+50
endfunction
alp=fsolve(1.5,f)//Solving the Eq 12.27b to find the
    delay angle alpha.
printf("\n\tw=%irad/sec\n\tXc=%0.2f Ohm\n\tXL=%0.3f
    Ohm",w,Xc,XL);
printf("\n\t(a).The degree of compensation r is %0.3
    f",r);
printf("\n\t(b).The compensating capacitive
    reactance Xcomp is %0.1f Ohm",X_comp);
printf("\n\t(c).The line current I is %0.2fA",I);
printf("\n\t(d).The reactive power Qc is %0.3e",Qc);
printf("\n\t(e).The delay angle alp is %0.2f degree"
    ,alp*180/%pi);
//Some anwers are changed due to round off error.
```

Chapter 13

Power Supplies

Scilab code Exa 13.1 Finding the Performance Parameters of a Flyback Converter

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 13.1
//Finding the Performance Parameters of a Flyback
   Converter.

clc;
clear;
Vo=24;                              //Output voltage in
   volts.
R=0.8;                              //Resistance in Ohm.
k=50;                               //Duty cycle ratio in
   percentage.
f=1;                                //Switching frequency
   in KHz.
Vt=1.2;                             //On state voltage
   drop of transistor in Volts.
```

```
Vd=0.7;                          //On state voltage drop of diode in Volts.
a=0.25;                          //Turns ratio of the transformer.
Io=Vo/R;                         //Calculating output current.
Po=Vo*Io;                        //Calculating the output power.
V2=Vo+Vd;                        //Calculating the secondary voltage.
V1=V2/a;                         //Calculating the primary voltage.
Vs=V1+Vt;                        //Calculating the input voltage.
Is=((Vd*Io)+Po)/(Vs-Vt);         //Calculating the input current.
Pi=Vs*Is;                        //Calculating the input power.
eff=Po/Pi;                         //Calculating the efficiency.
IA=Is;                           //Calculating the average transistor current.
Ip=(2*IA)/(k/100);               //Calculating the peak transistor current.
IR=(sqrt((k/100)/3))*Ip;         //Calculating the rms transistor current.
Voc=Vs+(V2/a);                   //Calculating open circuit transistor voltage.
Lp=(Vs*(k/100))/(f*10^3*Ip);     //Calculating the primary magnetizing inductance.
printf("\n\t(a).The output current Io is %0.0fA",Io);
printf("\n\t    The output power Po is %0.0fW",Po);
printf("\n\t    The secondry voltage V2 is %0.1fV",V2);
printf("\n\t    The primary voltage V1 is %0.1fV",V1);
printf("\n\t    The input voltage Vs is %0.0fV",Vs);
```

```
printf("\n\t    The average input current Is is %0.1fA",Is);
printf("\n\t(b).The input power Pi is %0.0fW",Pi);
printf("\n\t    The efficiency eff is %0.1fPercent",eff*100);
printf("\n\t(c).The average transistor current IA is %0.1fA",IA);
printf("\n\t(d).The peak transistor current Ip is %0.0fA",Ip);
printf("\n\t(e).The rms transistor current IR is %0.2fA",IR);
printf("\n\t(f).The open circuit transistor current Voc is %0.1fV",Voc);
printf("\n\t(g).The primary magnetizing inductance Lp is %0.2fmH",Lp*10^3);
```

Scilab code Exa 13.2 Finding the Performance Parameters of a Forward Converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 13.2
//Finding the Performance Parameters of a Forward Converter.

clc;
clear;
Vo=24;                              //Output voltage in volts.
R=0.8;                              //Resistance in Ohm.
Vt=1.2;                             //On state voltage
```

```
drop of transistor in volts.
Vd=0.7;                              //On state voltage drop of diode in volts.
k=0.4;                               //Duty cycle.
f=1;                                 //Switching frequency in KHz.
Vs=12;                               //Supply voltage in volts.
a=0.25;                              //Turns ratio of the transformer.
Ip1=4;                                //Percentage of ripple current to be maintained of its average value.
Ip2=3;                                //Ripple current of output voltage in percentage.
Io=Vo/R;                             //Calculating output current.
Po=Vo*Io;                            //Calculating the output power.
V2=Vo+Vd;                            //Calculating the secondary voltage.
V1=Vs-Vt;                            //Calculating the primary voltage.
a1=V2/V1;                            //Calculating the turns ratio.
Is=((Vd*Io)+Po)/(Vs-(Vt*k)-(Vd*(1-k)));//Calculating the supply current.
Pi=Vs*Is;                                  //Calculating the input power.
eff=Po/Pi;                                   //Calculating the efficiency.
IA=k*Is;                                   //Calculating the average transistor current.
Ip=Is;                                     //Calculating the peak transistor current.
del_Ip=0.05*Is;                              //Calculating change in peak transistor current.
IR=sqrt(k)*((Ip^2)+(del_Ip/3)+(del_Ip*Ip))^0.5;//
```

```
Calculating rms transistor current.
Voc=Vs+(V2/a1);                                    //Calculating open circuit transistor voltage.
del_IL1=(Ip1/100)*Io;                              //Calculating change in inductor current.
del_Vo=(Ip2/100)*Vo;                               //Calculating change in output voltage.
L1=(del_Vo*k)/(f*10^3*del_IL1);                    //Calculating the value of inductance.
Lp=((Vs-Vt)*k)/((f*10^3)*(del_Ip-(a1*del_IL1)));//Calculating value of peak inductance.
printf("\n\t(a).The output current Io is %0.0fA",Io);
printf("\n\t    The output power Po is %0.0fW",Po);
printf("\n\t    The secondry voltage V2 is %0.1fV",V2);
printf("\n\t    The primary voltage V1 is %0.1fV",V1);
printf("\n\t    The turns ratio a is %0.3f",a1);
printf("\n\t    The average input current Is is %0.2fA",Is);
printf("\n\t(b).The input power Pi is %0.0fW",Pi);
printf("\n\t    The efficiency eff is %0.1fPercent",eff*100);
printf("\n\t(c).The average transistor current IA is %0.1fA",IA);
printf("\n\t(d).The change in peak transistor current del_Ip is %0.3fA",del_Ip);
printf("\n\t(e).The rms transistor current IR is %0.1fA",IR);//Book answer is wrong.
printf("\n\t(f).The open circuit transistor voltage Voc is %0.1fV",Voc);
printf("\n\t(g).The change in inductor current del_IL1 is %0.2fV",del_IL1);
printf("\n\t    The change in output voltage del_Vo is %0.2fV",del_Vo);
printf("\n\t    The inductance L1 is %0.2fmH",L1*10^3);
```

```
printf("\n\t(h).The value of peak inductance Lp is %0.2fmH",Lp*10^3);
//Some answers may change due to round-off error.
```

Scilab code Exa 13.3 Finding the Performance Parameters of a Push Pull Converter

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 13.3
//Finding the Performance Parameters of a Push Pull Converter.

clc;
clear;
Vo=24;                              //Output voltage in volts.
R=0.8;                              //Resistance in Ohm.
Vt=1.2;                             //On state voltage drop of transistor in volts.
Vd=0.7;                             //On state voltage drop of diode in volts.
a=0.25;                             //Turns ratio of the transformer.
k=0.5;                              //Duty cycle.
Io=Vo/R;                            //Calculating the output current.
Po=Vo*Io;                           //Calculating the output power.
V2=Vo+Vd;                           //Calculating the secondary voltage.
```

```
V1=V2/a;                          //Calculating the primary voltage.
Vs=V1+Vt;                         //Calculating the supply voltage.
Is=((Vd*Io)+(Po))/(Vs-Vt);        //Calculating the supply current.
Pi=Vs*Is;                         //Calculating the input power.
eff=Po/Pi;                          //Calculating the efficiency.
IA=Is/2;                          //Calculating the average transistor current.
Ip=Is;                            //Calculating the peak transistor current.
IR=sqrt(k)*Ip;                    //Calculating the rms transistor current.
Voc=2*Vs;                        //Calculating open circuit transistor voltage.
printf("\n\t(a).The output current Io is %0.0fA",Io);
printf("\n\t    The output power Po is %0.0fW",Po);
printf("\n\t    The secondry voltage V2 is %0.1fV",V2);
printf("\n\t    The primary voltage V1 is %0.1fV",V1);
printf("\n\t    The input voltage Vs is %0.0fV",Vs);
printf("\n\t    The average input current Is is %0.1fV",Is);
printf("\n\t(b).The input power Pi is %0.0fW",Pi);
printf("\n\t    The efficiency eff is %0.1fPercent",eff*100);
printf("\n\t(c).The average transistor current IA is %0.2fA",IA);
printf("\n\t(d).The peak transistor current Ip is %0.1fA",Ip);
printf("\n\t(e).The rms transistor current IR is %0.2fA",IR);
printf("\n\t(f).The open circuit transistor current
```

```
Voc is %0.0fV",Voc);
```

Scilab code Exa 13.4 Finding the Performance Parameters of a Half Bridge Resonant

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 13.4
//Finding the Performance Parameters of a Half-
   Bridge Resonant Inverter.

clc;
clear;
Vo=24;                              //Output voltage in
    volts.
RL=0.8;                             //Load resistance
   in Ohm.
C=1;                                //Capacitance in
   micro Farad.
L=20;                               //Inductance in
   micro Henry.
R=0;                                //Resistance in ohm
   .
Vs=100;                             //Supply voltage in
    volts.
a=0.25;                             //Turns ratio of
   transformer.
Ce=2*C;                             //Calculating
   effective capacitance.
wr=1/sqrt(Ce*10^-6*L*10^-6);        //Calculating
   resonant frequency in rad/sec.
fr=wr/(2*%pi);                      //Calculating
```

```
resonant frequecny in Hz.
Io=Vo/RL;                          //Calculating output current.
Po=Vo*Io;                          //Calculating output power.
V2=(%pi*Vo)/(2*sqrt(2));           //Calculating secondary voltage.
Is=Po/Vs;                          //Calculating supply current.
IA=Is;                             //Calculating average transistor current.
Ip=IA*%pi;                         //Calculating peak transistor current.
IR=Ip/2;                           //Calculating rms transistor current.
Voc=Vs;                            //Calculating open circuit trasistor voltage.
printf("\n\twr=%0.1frad/sec\n\tfr=%0.1fHz",wr,fr);
printf("\n\t(a).The output current Io is %0.0fA",Io);
printf("\n\t    The output power Po is %0.0fW",Po);
printf("\n\t    The secondary rms voltage V2 is %0.2fV",V2);
printf("\n\t    The average input current Is is %0.1fA",Is);
printf("\n\t(b).The average transistor current IA is %0.1fA",IA);
printf("\n\t(c).The peak transistor current Ip is %0.2fA",Ip);
printf("\n\t(d).The rms transistor current IR is %0.2fA",IR);
printf("\n\t(e).The open circuit transistor voltage Voc is %0.0fV",Voc);
```

Scilab code Exa 13.5 Finding the Performance Parameters of an AC Power Supply with

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 13.5
//Finding the Performance Parameters of an AC Power Supply with a PWM Control.

clc;
clear;
R=2.5;                          //Resistance in Ohm.
Vs=100;                         //Supply voltage in volts.
f=20;                           //Input frequency in KHz.
a=0.5;                          //Turns ratio of the transformer;
del=18;                           //Width of each pulse in degree.
p=4;                            //Number of pulses per half cycle.
V1=Vs;                          //Calculating rms primary voltage.
V2=a*V1;                        //Calculating rms secondary voltage.
Vo=V2;                          //Calculating the output power.
VL=Vo*(sqrt((p*del)/180));        //Calculating the load voltage.
IL=VL/R;                        //Calculating the load current.
printf("\n\tThe rms primary voltage V1 is %0.0fV",V1);
printf("\n\tThe rms secondary voltage V2 is %0.0fV",V2);
printf("\n\tThe output voltage Vo is %0.0fV",Vo);
```

```
printf("\n\tThe rms load voltage VL is %0.1fV",VL);
printf("\n\tThe rms load current IL is %0.2fA",IL);
```

Scilab code Exa 13.6 Design of a Transformer

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 13.6
//Design of a Transformer.

clc;
clear;
f=60;                          //Supply frequency in Hz.
V1=120;                        //Transformer primary voltage in volts.
Vo=40;                         //Output voltage in Volts.
Io=6.5;                        //Output current in Ampere.
eff=0.95;                        //Transformer efficiency.
Ku=0.4;                        //Window factor.
Kt=4.44;                       //Sapce factor for square wave.
Po=Vo*Io;                      //Calculating output power.
Pt=(1+(1/eff))*Po;               //Calculating transformer appearent power..
kj=366;x=-0.14;               //Magnetic core costants for E-laminated core.
Bm=1.4;                       //Peak flux density.
Ap=((Pt*10^4)/(Kt*f*Bm*Ku*kj))^(1/(1+x));//
```

```
Calculating area product.
Wt=3.901;                               //Core weight choosed based on Ap.
Ac=24.4;                                //Core area in cm^2.
Iml=27.7;                               //Mean length of a turn in cm.
Np=(V1*10^4)/(Kt*f*Bm*Ac);              //Calculating primary number of turns.
Ns=(Np*Vo)/(V1);                       //Calculating secondary number of turns.
J=kj*(Ap^x);
I1=(Pt-Po)/V1;                         //Calculating primary current.
Awp=I1/J;                             //Calculating Primary bare wire cross sectional area.
den_p=131.8;                              //Primary current density in micro ohm per cm.
Rp=Iml*Np*den_p*10^-6;                   //Calculating primary winding resistance.
Pp=I1^2*Rp;                           //Calculating primary copper loss.
Aws=Io/J;                             //Calculating secondary bare wire cross sectional area.
den_s=41.37;                            //Secondary current density in micro ohm per cm
Rs=Iml*Ns*den_s*10^-6;                  //Calculating secondary winding resistance.
Ps=Io^2*Rs;                          //Calculating secondary copper loss.
Pfe=(0.557*10^-3)*(f^1.68)*(Bm*1.86);    //Calculating transformer core loss.
eff=Po/(Po+Pp+Ps+Pfe);                 //Calculating transformer efficiency.
printf("\n\tThe output power Po is %0.0fW",Po);
printf("\n\tThe transformer apparent power Pt is %0.1fW",Pt);
printf("\n\tFrom table 13.1, for E-laminated core,
```

```
Magnetic core constants are");
printf("\n\tKj=%0.0f\n\tx=%0.2f\n\tBm=%0.1f",kj,x,Bm);
printf("\n\tThe area product Ap is %0.1fcm^4",Ap);
printf("\n\tChoose E-core type ");
printf("\n\tThe core weight Wt is %0.3fkg",Wt);
printf("\n\tThe core area Ac is %0.1fcm^2",Ac);
printf("\n\tThe mean core length Iml is %0.1fcm",Iml);
printf("\n\tThe primary number of turns Np is %0.0f",Np);
printf("\n\tThe secondary number of turns Ns is %0.0f",Ns);
printf("\n\tThe primary current I1 is %0.2fA",I1);
printf("\n\tThe primary bare wire cross sectional area Awp is %0.3fcm^2",Awp);
printf("\n\tThe primary winding resistance Rp is %0.2f Ohm",Rp);
printf("\n\tThe primary copper loss Pp is %0.1fW",Pp);
printf("\n\tThe secondary bare wire cross sectional area Aws is %0.3fcm^2",Aws);
printf("\n\tThe secondary resistance Rs is %0.2f Ohm",Rs);
printf("\n\tThe secondary copper loss Ps is %0.1fW",Ps);
printf("\n\tThe transformer copper loss Pfe is %0.2fW",Pfe);//Book answer is wrong
printf("\n\tThe transformer effeciency eff is %0.0fpercent",eff*100);//Book answer is wrong
```

Scilab code Exa 13.7 Designing a Dc Inductor

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
```

```
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 13.7
//Designing a Dc Inductor.

clc;
clear;
L=450;                      //Inductance in micro henry.
IL=7.2;                     //Inductor current in ampere.
del_I=1;                        //Ripple inductor current in ampere.
Ku=0.4;                     //Window factor.
Im=IL+del_I;                    //Calculating peak inductor current.
Wt=(L*10^-6*Im^2)/2;        //Calculating inductor energy.
Kj=403;x=-0.12;Bm=0.3;      //Maagnetic constant for power core.
Ap=((2*Wt*10^4)/(Bm*Ku*Kj))^(1/(1+x));//Calculating area product.
Wi=1.131;                   //Core weight in kg.
Ac=1.32;                    //Core area in cm^2.
lc=11.62;                   //magnetic path length in cm.
lmt=6.66;                   //Mean length of a turn in cm.
J=Kj*Ap^x;
ur=(Bm*lc*10^5)/(4*%pi*(Ap/Ac)*J*Ku); //Calculating the relative permiability.
Lc=86;                      //Core inductance in milli Henry.
Nc=1000;                    //Number of turns of the coil.
N=Nc*sqrt((L*10^-6)/(Lc*10^-3));      //Calculating
```

```
the no of turns.
Aw=Im/J;                                    //Calculating bare-wire cross sectional area.
den=82.8;                                    //Current density in micro ohm per cm.
R=lmt*N*den*10^-6;                           //Calculating the windiding resistance.
Pcu=IL^2*R;                                  //Calculating copper loss.
lg=(((4*%pi*10^-7*Ac*N^2)/(L*10^-6))-(lc/ur))*10^-2;    //Calculating the air gap length.
printf("\n\tThe peak inductor current Im is %0.1fA",Im);
printf("\n\tThe inductor energy Wt is %0.0fmJ",Wt*10^3);
printf("\n\tFrom the table 13.1, for power core the magnetic constants are,");
printf("\n\tKj=%0.0f\n\tx=%0.2f\n\tBm=%0.1f",Kj,x,Bm);
printf("\n\tThe Area product Ap is %0.2fcm^4",Ap);
printf("\n\tThe core weight Wt is %0.3fkg",Wi);
printf("\n\tThe core area Ac is %0.2fcm^2",Ac);
printf("\n\tThe magnetic path length lc is %0.2fcm",lc);
printf("\n\tThe mean length of a turn lmt is %0.2fcm",lmt);
printf("\n\tThe relative permitivity ur is %0.1f",ur);
printf("\n\tTht material with ur>36.3 is MPP-330T, which gives");
printf("\n\tLc=%0.0fmH\n\tNc=%0.0fturns",Lc,Nc);
printf("\n\tThe number required turns N is %0.0f",N);
printf("\n\tThe bare wire cross sectional area Aw is %0.3fcm^2",Aw);
printf("\n\tThe winding resistance R is %0.2f Ohm",R);
printf("\n\tThe copper loss Pcu is %0.1fW",Pcu);
```

```
printf("\n\tThe air gap length lg is %0.2fcm",lg);
```

Chapter 14

Dc Drives

Scilab code Exa 14.1 Finding the Voltage and Current of a Seperately Excited Motor

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.1
//Finding the Voltage and Current of a Seperately
   Excited Motor.

clc;
clear;
P=15;                     //Rated Capacity of the
   motor in hp.
N=2000;                   //Rated Speed of motor in
   rpm.
TL=45;                    //Load torgue in Nm.
N1=1200;                  //Running speed of motor.
Rf=147;                   //Field resistance in Ohm.
Ra=0.25;                  //Armature Resistance in
   Ohm.
```

```
Kv=0.7032;                    //Voltage constant of the motor in V/Arad/sec.
Vf=220;                       //Field voltage in volts.
w=(N1*%pi)/(30);              //Calculating the resonant frequency.
If=Vf/Rf;                     //Calculating field current.
Ia=TL/(Kv*If);                //Calculating armature current.
Eg=Kv*w*If;                   //Calculating the back emf.
Va=(Ra*Ia)+Eg;                //Calculating the armature voltage.
Irated=(P*746)/Vf;            //Calculating the rated armature current of motor.
printf("\n\tThe resonant frequency w is %0.2frad/sec",w);
printf("\n\tThe field current If is %0.3fA",If);
printf("\n\t(a).The armature current Ia is %0.2fA",Ia);
printf("\n\tThe back emf Eg is %0.2fV",Eg);
printf("\n\t(b).The armature voltage Va is %0.2fV",Va);
printf("\n\t(c).The rated armature current of  motor Irated is %0.2fA",Irated);
//Answers are changed due to round off error.
```

Scilab code Exa 14.2 Determining the Effects of Gear Ratio on the Effective Motor

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.2
```

```
//Determining the Effects of Gear Ratio on the Effective Motor Torque and Inertia

clc;
clear;
B1=0.025;                     //Load side friction coefficient in Nm/rad/sec.
w1=210;                       //Motor Resonant frequency in rad/sec.
Bm=0.045;                     //Motor side friction coefficient in kg-m^2.
Jm=0.32;                      //Motor side inertia in kg-m^2.
J1=0.25;                      //Load side inertia in kg-m^2.
T2=20;                        //Load torque
w2=21;                        //Load resonant frequency in rad/sec.
GR=w1/w2;                     //Calculating gear ratio.
T1=T2/GR^2;                   //Calculating effective motor torque.
J=Jm+(J1/GR^2);               //Calculating effective inertia.
B=Bm+(B1/GR^2);               //Calculating effective friction coefficient.
printf("\n\t(a).The gear ratio GR is %0.0f",GR);
printf("\n\t(b).The effective motor torque T1 is %0.1fNm",T1);
printf("\n\t(c).The effective inertia J is %0.3fKg-m^2",J);
printf("\n\t(d).The effective friction coefficient B is %0.3fNm/rad/sec",B);
```

Scilab code Exa 14.3 Finding the Performance Parameters of a Single Phase Semiconv

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.3
//Finding the Performance Parameters of a Single-Phase Semiconverter Drive

clc;
clear;
Vs=208;                        //Supply voltage in volts.
f=60;                          //Frequency in Hz.
Ra=0.25;                       //Armature resistance in Ohm.
Rf=147;                        //Field resistance in Ohm.
Kv=0.7032;                     //Motor voltage constant V/Arad/sec.
TL=45;                         //Load torque in Nm.
N=1000;                        //Motor speed in rpm.
Vm=sqrt(2)*Vs;                 //Calculating Phase voltage.
Td=TL;                         //Calculating developed torque.
w=(N*%pi)/30;                  //Calculating resonant frequency.
Vf=(2*Vm)/%pi;                 //Calculating field voltage.
If=Vf/Rf;                      //Calculating field current.
Ia=Td/(Kv*If);                 //Calculating armature current.
Eg=Kv*w*If;                    //Calculating back
```

```
emf.
Va=Eg+(Ia*Ra);                    //Calculating armature voltage.
alpha_a=acosd(((Va*%pi)/Vm)-1);        //Calculating the delay angle.
Po=Va*Ia;                         //Calculating output power.
Isa=Ia*sqrt((180-alpha_a)/180);        //Calculatung the rms input current.
VI=Vs*Isa;                        //Calculating the input VA rating.
PF=Po/VI;                         //Calculating the power factor.
printf("\n\t(a).The field voltage Vf is %0.2fV",Vf);
printf("\n\t    The field current If is %0.3fA",If);
printf("\n\t(b).The armature current Ia is %0.2fA",Ia);
printf("\n\t    The back emf Eg is %0.2fV",Eg);
printf("\n\t    The delay angle alpha_a is %0.1f  ",alpha_a);
printf("\n\t(c).The output power Po is %0.1fW",Po);
printf("\n\t    The rms input current Isa is %0.2fA",Isa);
printf("\n\t    The input volt-ampere rating VI is %0.1fA",VI);
printf("\n\t    The power factor PF is %0.3f(lagging)",PF);
//Some answers are varied due to round-off error.
```

Scilab code Exa 14.4 Finding the Performance Parameters of a Single Phase Full Con

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
```

```
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.4
//Finding the Performance Parameters of a Single-Phase Full-Converter Drive.

clc;
clear;
Vs=440;                       //Supply voltage in volts.
f=60;                         //Frequency in Hz.
Ra=0.25;                      //Armature Resistance in Ohnm.
Rf=175;                       //Field resistance in Ohm.
Kv=1.4;                       //Motor voltage constant in V/Arad/s.
Ia=45;                        //Armature current in ampere.
alpha_a=60;                        //Delay angle in degree.
Vm=sqrt(2)*Vs;                //Calculating phase voltage.
Vf=(2*Vm)/%pi;                //Calculating feild voltage.
If=Vf/Rf;                     //Calculating field current.
Td=Kv*If*Ia;                  //Calculating the developed torque.
Va=((2*Vm)/%pi)*cosd(alpha_a);    //Calculating armature voltage.
Eg=Va-(Ia*Ra);                //Calculating back emf.
w=Eg/(Kv*If);                 //Calculating the speed.
Pt=(Va*Ia)+(Vf*If);           //Calculating the input power.
Isa=Ia;                       //Calculating rms value of armature current.
Isf=If;                       //Calculating rms value
```

```
of field current.
Is=sqrt(Isa^2+Isf^2);        //Calculating the supply current.
VI=Vs*Is;                    //Calculating VI rating.
PF=Pt/VI;                    //Calculating power factor.
printf("\n\t(a).The field voltage Vf is %0.2fV",Vf);
printf("\n\t    The field current If is %0.2fA",If);
printf("\n\t    The developed torque Td is %0.1fNm",Td);
printf("\n\t    The armature voltage Va is %0.2fV",Va);
printf("\n\t    The back emf Eg is %0.2fV",Eg);
printf("\n\t(b).The speed w is %0.2frad/sec",w);
printf("\n\t(c).The total input power Pt is %0.1fW",Pt);
printf("\n\t    The rms value of armature current Isa is %0.2fA",Isa);
printf("\n\t    The rms value of field current Isf is %0.2fA",Isf);
printf("\n\t    The effective rms supply current Is is %0.2fA",Is);
printf("\n\t    The Volt ampere rating VI is %0.1fVA",VI);
printf("\n\t    The power factor PF is %0.3f(lagging)",PF);
//Some answers are changed due to round off error.
```

Scilab code Exa 14.5 Finding the Delay Angle and Feedback Power in Regenerative Br

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.
```

```
//Example : 14.5
//Finding the Delay Angle and Feedback Power in Regenerative Braking.

clc;
clear;
Vs=440;                              //Supply voltage in volts.
Eg=-186.82;                          //From part (a) of Example 14.4, the back emf at the time of polarity reversal is Back in Volts.
Ia=45;                               //Armature current in ampere.
Ra=0.25;                             //Armature resistance in Ohm.
Vm=sqrt(2)*Vs;                       //Calculating phase voltage.
Va=Eg+(Ia*Ra);                       //Calculating the armature voltage.
alpha_a=acosd((Va*%pi)/(2*Vm));           //Calculating the delay angle.
Pa=Va*Ia;                            //Calculating the armature power.
printf("\n\t(a).The armature voltage Va is %0.2fV",Va);
printf("\n\t    The delay angle alpa is %0.2f  ",alpha_a);
printf("\n\t(b).The power fed back to supply Pa is %0.1fW",Pa);
//Polarity of Pa given in the textbook is wrong.
```

Scilab code Exa 14.6 Finding the Performance Parameters of a Three Phase Full Conv

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.6
//Finding the Performance Parameters of a Three-Phase Full-Converter Drive.

clc;
clear;
P=20;                         //Rated Capacity of the motor in hp.
V=300;                        //Rated voltage in volts.
N=1800;                       //Rated speed of the motor.
VL=208;                       //Load voltage in volts.
f=60;                         //Frequency in Hz.
Ra=0.25;                      //Armature resistance in Ohm.
Rf=245;                       //Field resistance in Ohm.
Kv=1.2;                       //Motor voltage constant V/Arad/sec.
w=(N*%pi)/30;                 //Calculating the spped in rad/sec.
Vp=VL/sqrt(3);                //Calculating the phase voltage.
Vm=sqrt(2)*Vp;                //Calculating converter voltage.
Irated=(P*746)/V;             //Calculating rated armature current.
Vf=(3*sqrt(3)*Vm)/%pi;        //Calculating field voltage.
If=Vf/Rf;                     //Calculating field
```

```
current.
Ia=Irated;                        //Calculating armature current.
Eg=Kv*If*w;                       //Calculating back emf.
Va=Eg+(Ia*Ra);                    //Calculating armature voltage.
alpa=acosd((Va*%pi)/(3*sqrt(3)*Vm));//Calculating delay angle.
Ia1=0.1*Ia;                             //Calculating 10% of aramature current.
Ego=Va-(Ra*Ia1);                        //Calculating the back emf at no load.
wo=Ego/(Kv*If);                         //Calculating the no load speed.
N1=wo*(30/%pi);                         //Calculating no load speed in rpm.
reg=(N1-N)/N;                           //Calculating the speed regulation.
printf("\n\tThe phase voltage Vp is %0.0fV",Vp);
printf("\n\tThe rated current Irated is %0.2fA",Irated);
printf("\n\tThe field voltage Vf is %0.1fV",Vf);
printf("\n\tThe field current If is %0.3fA",If);
printf("\n\t(a).The armature current Ia is %0.2fA",Ia);
printf("\n\t    The back emf Eg is %0.1fV",Eg);
printf("\n\t    The armatue voltage Va is %0.2fV",Va);
printf("\n\t    The delay angle alpa is %0.2f  ",alpa);
printf("\n\t(b).When Ia=10percent of 49.73 Ia is %0.3fA",Ia1);
printf("\n\t    The back emf at no load Ego is %0.2fV",Ego);
printf("\n\t    The no load speed wo is %0.2frad/sec",wo);
printf("\n\t(c).The speed regulation is %0.1fpercent",reg*100);
```

```
//Some answers are changed due to round off error.
```

Scilab code Exa 14.7 Finding the Performance of a Three Phase Full Converter Drive

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 14.7
//Finding the Performance of a Three-Phase Full-Converter Drive with Field Control.

clc;
clear;
P=20;                        //Rated Capacity of the motor in hp.
V=300;                       //Rated voltage in volts.
N=900;                       //Rated speed of the motor.
VL=208;                      //Load voltage in volts.
f=60;                        //Frequency in Hz.
Ra=0.25;                     //Armature resistance in Ohm.
Rf=145;                      //Field resistance in Ohm.
Kv=1.2;                      //Motor voltage constant V/Arad/s.
Td=116;                      //Developed torque in Nm.
Vp=VL/sqrt(3);               //Calculating phase voltage.
```

```
Vm=sqrt(2)*Vp;                    //Calculating converter
     voltage.
w=(N*%pi)/30;                     //Calculating the spped
     in rad/sec.
Vf=(3*sqrt(3)*Vm)/%pi;            //Calculating field
    voltage.
If=Vf/Rf;                         //Calculating field
    current.
Ia=Td/(Kv*If);                    //Calculating armature
    current.
Eg=Kv*If*w;                       //Calculating back emf.
Va=Eg+(Ia*Ra);                    //Calculating armature
    volatge.
alpa=acosd((Va*%pi)/(3*sqrt(3)*Vm));//Calculating
    delay angle.
//When alpa=0;
Va1=(3*sqrt(3)*Vm)/%pi;               //Calculating
    armature current.
Eg1=Va1-(Ia*Ra);                      //Calculating back
     emf.
w1=Eg1/(Kv*If);                       //Calculating the
    spped in rad/sec.
//When speed N=1800 rpm;
N2=1800;                              //Speed in rpm.
w2=(N2*%pi)/30;                       //Calculating the
    speed in rad/sec.
If2=Eg1/(Kv*w2);                      //Calculating
    field current.
Vf2=If2*Rf;                           //Calculating
    field voltage.
alpf2=acosd((Vf2*%pi)/(3*sqrt(3)*Vm));//Calculating
    the delay angle.
printf("\n\tVp=%0.0fV\n\tVm=%0.1fV",Vp,Vm);
printf("\n\t(a).The field voltage Vf is %0.1fV",Vf);
printf("\n\t    The field current If is %0.3fA",If);
printf("\n\t    The armature current Ia is %0.1fA",
    Ia);
printf("\n\t    The back emf Eg is %0.2fV",Eg);
```

```
printf("\n\t    The armature voltage Va is %0.2fv",Va);
printf("\n\t    The delay angle alpa is %0.2f  ",alpa);
printf("\n\t(b).When alpa=0;");
printf("\n\t    The armature voltage Va is %0.1fV",Va1);
printf("\n\t    The back emf Eg is %0.2fV",Eg1);
printf("\n\t    The speed in rad/sec w is %0.2frad/sec",w1);
printf("\n\t(c).When speed is N=1800rpm;");
printf("\n\t    The field current If is %0.3fA",If2);
printf("\n\t    The field voltage Vf is %0.2fV",Vf2);
printf("\n\t    The delay angle alpf is %0.2f  ",alpf2);
//Some answers may be change due to round off error.
```

Scilab code Exa 14.8 Finding the Performance Parameters of a Dc dc Converter Drive

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 14.8
//Finding the Performance Parameters of a  Dc dc Converter Drive.

clc;
clear
Vs=600;                              //Dc supply voltage in volts.
```

```
Ra=0.05;                                    //Armature resistance in Ohm.
Kv=1.527;                                   //Back emf constant of motor in V/A rad/s.
Ia=250;                                     //Average armature current in ampere.
If=2.5;                                     //Field current in ampere.
k=0.6;                                      //Duty cycle.
Rm=Ra;                                      //Calculating totlal circuit resistance.
Pt=k*Vs*Ia;                                 //Calculating total power.
Req=Vs/(Ia*k);                              //Calculating equivalent resistance.
Va=k*Vs;                                    //Calculating armature volatage.
Eg=Va-(Rm*Ia);                              //Calculating back emf.
w=Eg/(Kv*If);                               //Calculating speed in rad/sec.
N=(w*30)/%pi;                               //Calculating speed in rpm.
Td=Kv*Ia*If;                                //Calculating the developed torque.
printf("\n\t(a).The total power Pf is %0.0fkW",Pt*10^-3);
printf("\n\t(b).The equivalent reisitance Req is %0.0f  ",Req);
printf("\n\t(c).The armature volatge Va is %0.0fV",Va);
printf("\n\t    The back emf Eg is %0.1fV",Eg);
printf("\n\t    The motor speed in rad/sed w is %0.2frad/sec",w);
printf("\n\t    The motor speed in rpm N is %0.1frpm",N);
printf("\n\t(d).The developed torque Td is %0.2fN-m",Td);
```

Scilab code Exa 14.9 Finding the Performance of a Dc dc Converter Fed Drive in Reg

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.9
//Finding the Performance of a D c dc Converter-Fed Drive in Regenerative Braking.

clc;
clear;
Vs=600;                              //Dc supply voltage in volts.
Ra=0.02;                             //Armature resistance in Ohm.
Kv=15.27;                            //Back emf constant of motor in mV/A rad/s.
Ia=250;                              //Average armature current in ampere.
Rf=0.03;                             //Field resistance in Ohm.
k=0.6;                               //Duty cycle.
Rm=Ra+Rf;                            //Calculating total circuit resistance.
Vch=(1-k)*Vs;                        //Calculating the voltage across dc-dc converter from Eq 14.37.
Pg=Ia*Vs*(1-k);                      //Calculating the power regenerated to dc supply from Eq 14.38.
Req=((Vs/Ia)*(1-k))+(Rm);            //Calculating the equivalent resistance from Eq 14.40.
wmin=Rm/(Kv*10^-3); Nmin=(wmin*30)/%pi   //
```

```
Calculating minimum braking speed form Eq 14.42.
wmax=(Vs/(Kv*10^-3*Ia))+(Rm/(Kv*10^-3));Nmax=(wmax*30)/%pi//Calculating maximum braking speed from Eq 14.43.
Eg=Vch+(Rm*Ia);                              //Calculating back emf from Eq 14.39.
w=Eg/(Kv*10^-3*Ia);N=(w*30)/%pi;             //Calculating speed of the motor.
printf("\n\tThe series resistance Rm is %0.2f ",Rm);
printf("\n\t(a).The voltage across dc-dc converter Vch is %0.0fV",Vch);
printf("\n\t(b).The power regenerated to dc supply Pg is %0.0fKW",Pg*10^-3);
printf("\n\t(c).The equivalent resistance Req is %0.2f ",Req);
printf("\n\t(d).The minimum permissible braking speed wmin is %0.3frad/sec = %0.2frpm",wmin,Nmin);
printf("\n\t    The maximim permissible braking speed wmax is %0.3frad/sec = %0.2frpm",wmax,Nmax);
printf("\n\t(f).The back emf Eg is %0.1fV",Eg);
printf("\n\t    The speed of the motor w is %0.2frad/sec = %0.1frpm",w,N);
//Some answers are varied due to round-off error.
```

Scilab code Exa 14.10 Finding the Performance of a Dc dc Converter Fed Drive in Rh

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

```

```
//Example : 14.10
//Finding the Performance of a D c dc Converter-Fed Drive in Rheostatic Braking.

clc;
clear;
Ra=0.05;                              //Armature resistance in Ohm.
Rb=5;                                 //Braking rsistance in Ohm.
Kv=1.527;                             //Back emf constant in V/A rad/sec.
Ia=150;                               //Armature current in ampere.
If=1.5;                               //Fiield current in ampere.
k=0.4;                                //Duty cycle.
Rm=Ra;                                //Calculating total circuit resistance.
Vch=Rb*Ia*(1-k);                      //Calculating voltage across dc-dc converter.
Pb=Ia^2*Rb*(1-k);                     //Calculating the pwer dessipated in braking resistor.
Req=(Rb*(1-k))+Ra;                    //Calculating equivalent resistance.
Eg=Vch+(Ra*Ia);                       //Calculating back emf.
w=Eg/(Kv*If);N=(w*30)/%pi;            //Calculating the brking speed.
Vp=Ia*Rb;                             //Calculating peak converter voltage.
printf("\n\t(a).The average voltage across dc-dc converter Vch is %0.0fV",Vch);
printf("\n\t(b).The power dessipated in braking resistor Pb is %0.1fKW",Pb*10^-3);
printf("\n\t(c).The equivalent resistance Req is %0.2f  ",Req);
printf("\n\t(d).The back emf Eg is %0.1fV",Eg);
```

```
printf("\n\t    The braking speed w is %0.2frad/sec = %0.1frpm",w,N);
printf("\n\t(e).The peak dc-dc converter voltage Vp is %0.0fV",Vp);
```

Scilab code Exa 14.11 Finding the Peak Load Current Ripple of Two Multiphase Dc dc

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.11
//Finding the Peak Load Current Ripple of Two Multiphase D c dc Converters.

clc;
clear;
Vs=220;                          //Supply voltage in volts.
Rm=4;                            //Total armature resistance in Ohm.
Lm=15;                           //Total armature circuit inductance in milli henry.
f=350;                           //Frequency of each converter in Hz.
fe=2*f;                          //Calculating chopper frequency.
u=2;                             //Number of dc-dc converters.
x=4*u*f*Lm*10^-3;                //Checking the conditon if 4ufLm>>Rm.
delI_max=Vs/x;                   //Calculating the peak to peak ripple current from Eq 14.49.
```

```
printf("\n\tThe effective chopping frequency fe is %0.0fHz",fe);
printf("\n\tBecause 4ufLm = %0.0f>>R;",x);
printf("\n\tThe maximum peak to peak load ripple current delImax is %0.2fA",delI_max);
```

Scilab code Exa 14.12 Finding the Line Harmonic Current of Two Multiphase Dc dc Co

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.12
//Finding the Line Harmonic Current of Two Multiphase Dc dc Converters with an Input Filter

clc;
clear;
Ia=100;                          //Armature current in ampere.
Le=0.3;                          //Inductance in milli Henry.
Ce=4500;                          //Capcitance in micro farad.
f=350;                           //Frequency in Hz.
u=2;                             //Number of converters.
fo=1/(2*%pi*sqrt(Le*10^-3*Ce*10^-6));//Calculating the intial frequency.
fe=2*f;                                //Calculating the efective converter frequency.
k=0.5;                              //Calculating the
```

```
voltage constant.
I1h=(Ia/%pi)*(sqrt(1-cos(2*%pi*k)));//Calculating fundamental component of current.
I1s=I1h/(1+(2*(f/fo))^2);             //Calculating the fundamental component of harmonic current.
printf("\n\tThe intial frequency fo is %0.2fHz",fo);
printf("\n\tThe effective converter frequency fe is %0.0f",fe);
printf("\n\tThe fundamental component of dc−dc converter current I1h is %0.2fA",I1h);
printf("\n\tThe fundamental component of dc−dc converter generated harmonic current I1s is %0.2fA",I1s);
```

Scilab code Exa 14.13 Finding the Speed and Torque Response of a Converter Fed Dri

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.13
//Finding the Speed and Torque Response of a Converter−Fed Drive.

clc;
clear;
P=50;                            //Rated capacity of the motor in KW.
V=240;                           //Rated voltage of the motor  in volts.
N=1700;                          //Rated speed of the motor in rpm.
If=1.4;                          //Field current in
```

```
ampere.
Kv=0.91;                        //Back emf constant in V/A rad/sec.
Rm=0.1;                         //Armature resistance in Ohm.
B=0.3;                          //Viscous friction constant in N-m/rad/sec.
K1=95;                          //The amplification of the speed sensor in mV/rad/sec.
K2=100;                         //The gain of the power controller.
w_rated=(N*%pi)/30;             //Calculating the rated speed in rad/sec.
TL=(P*10^3)/w_rated;            //Calculating the rated torque.
Va=(w_rated*((Rm*B)+(Kv*If)^2))/(Kv*If);//Calculating the armature voltage.
Vb=K1*w_rated*10^-3;                    //Calculating the feedback voltage.
Vr=(Va+(Vb*K2))/K2;                     //Calculating the reference voltage.
//When del_TL=TL;
del_w=-(Rm*TL)/((Rm*B)+(Kv*If)^2+(K1*10^-3*K2*Kv*If));//Calculating the change in speed.
w=w_rated+del_w;No=(w*30)/%pi
                              //Calculating speed at rated torque
//When del_TL=1.1TL;
del_TL=1.1*TL;
                                        //Calcualting the change in torque.
del_w1=-(Rm*del_TL)/((Rm*B)+(Kv*If)^2+(K1*10^-3*K2*Kv*If));//Calculating the change in speed.
w1=w_rated+del_w1;N1=(w1*30)/%pi
                             //Calculating the speed.
//When del_Vr=-0.1Vr;
del_Vr=-0.1*Vr;
                                        //
```

```
Calculating change in reference voltage.
del_w2=(K2*Kv*If*del_Vr)/((Rm*B)+(Kv*If)^2+(K1*10^-3*K2*Kv*If));//Calculating the change in speed.
w2=w_rated+del_w2;N2=(w2*30)/%pi                                    //Calculating the speed.
w3=w_rated+del_w1+del_w2;N3=(w3*30)/%pi;                          //Calculating motor speed using superposition.
//When del_Vr=2.31V;
del_Vr3=2.31;                                                                    //Change in reference voltage.
del_w3=(K2*Kv*If*del_Vr3)/((Rm*B)+(Kv*If)^2);N3=(del_w3*30)/%pi;//Calculating change in speed.
del_w4=-(Rm*TL)/((Rm*B)+(Kv*If)^2);                       //Calculating no load speed.
w4=w_rated+del_w4;N4=(w4*30)/%pi;                         //Calculating the full load speed.
reg=(N3-N4)/N4;                                                                    //Calculating the speed regulation.
reg1=(N3-No)/No;                                                                   //Calculating speed regulation.
printf("\n\tThe rated speed W_rated is %0.2frad/sec",w_rated);
printf("\n\t(a).The rated torque TL is %0.2fN-m",TL);
printf("\n\t(b).At rated speed armature voltage Va is %0.2fV",Va);
printf("\n\t    The feedback voltage Vb is %0.2fV",Vb);
printf("\n\t    The reference voltage Vr is %0.3fV",Vr);
printf("\n\t(c).If the referenc voltage is unchanged,");
printf("\n\t    The change in speed del_w is %0.2
```

```
f rad/s",del_w);
printf("\n\t    The speed at rated torque w is %0.2f rad/sec = %0.2f rpm",w,No);
printf("\n\t(d).If the torque is incersed by 10 percent,");
printf("\n\t    The change in load torque del_TL is %0.2f N-m",del_TL);
printf("\n\t    The change in speed del_w is %0.3f rad/s",del_w1);
printf("\n\t    The motor speed w is %0.3f rad/s = %0.1f rpm",w1,N1);
printf("\n\t(e).If the reference voltage is decresed by 10 percent,");
printf("\n\t    The change in refrence voltage del_Vr is %0.2f V",del_Vr);
printf("\n\t    The change in speed del_w is %0.1f rad/sec",del_w2);
printf("\n\t    The speed of the motor w is %0.2f rad/s = %0.1f rpm",w2,N2);
printf("\n\t(f).If the torque is incresed and referce voltage is decreased by 10 percent respecively,");
printf("\n\t    The motor speed can be obtained by superpostion as w is %0.0f rad/s =%0.1f rpm",w3,N3);
printf("\n\t(g).If refrence voltage del_Vr is %0.2f V,",del_Vr3);
printf("\n\t    The no load  speed del_w is %0.2f rad/s = %0.0f rpm",del_w3,N3);
printf("\n\t    The chnge in speed at full load torque del_w is %0.2f rad/s",del_w4);
printf("\n\t    The full load speed w is %0.2f rad/s = %0.1f rpm",w4,N4);
printf("\n\t    The speed regulation with open loop control is %0.2f percent",reg*100);
printf("\n\t(h).The speed regulation with closed loop control is %0.2f percent",reg1*100);
```

Scilab code Exa 14.14 Determining the Optimized Gains and Time Constants of the Cu

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 14.14
//Determining the Optimized Gains and Time Constants
     of the Current and Speed Loop Controllers.

clc;
clear;
Vdc=220;                            //Rated voltage of
    in volts.
Idc=6.4;                            //Rated current of
    motor in ampere.
N=1570;                             //Rated speed of
    motor in rpm.
Rm=6.5;                             //Resistance in Ohm.
J=0.06;                             //Iertia of the
    motor in Kg-m^2.
Lm=67;                              //Inductance in
    milli Henry.
B=0.087;                            //Viscous friction
    constant in N-m/rad/s.
Kb=1.24;                            //Back emf constant
    in V/rad/s.
VL=220;                             //Supply voltage in
    volts.
fs=60;                              //Supply frequency
    in Hz.
Vcm=10;                             //Maximum control
```

```
input voltage in volts.
Vs=VL/sqrt(3);                       //Calculating the phase voltage.
Kr=(2.339*Vs)/Vcm;                   //Calculating gain of the converter.
Kw=0.074;                            //Gain constant.
tau_w=0.002;                          //Time constant.
Ia_max=20;                           //Maximum permisable motor current in ampere.
Vdc_max=Kr*Vcm;                      //Calculating maximum dc voltage.
Vc=(Vdc*Vcm)/Vdc_max;                //Calculating converter control voltage.
tau_r=1/(12*fs);                        //Calculating the time constant.
Hc=Vc/Ia_max;                        //Calculating current feedback gain.
Km=B/(Kb^2+(Rm*B));                  //Calculating gain constant of motor.
//Calculating the time constants of motor.
r=poly(0,"r");
a=r^2+((Rm/(Lm*10^-3))+(B/J))*r+((((Rm*B)+Kb^2)/(J*Lm*10^-3)));
a1=roots(a);
r1=a1(2,1);r2=a1(1,1);
tau_1=-1/r1;tau_2=-1/r2;
tau_m=J/B;
tau_c=tau_2;                                 //Calculating time constant of current controller.
Kc=(tau_1*tau_c)/(2*tau_r*Km*Kr*Hc*tau_m);    //Calculating gain constant of current controller.
K1=(Km*Kc*Kr*Hc*tau_m)/tau_c;            //Calculating the gain constant.
Ki=(1/Hc)*(K1/(1+K1));               //Calculating gain constant of current loop.
tau_3=tau_1+tau_r;                             //Calculating time constant.
tau_i=tau_3/(1+K1);                         //Calculating
```

```
time constant of current loop.
tau_e=tau_i+tau_w;                          //Calculating the time constant.
Kw=(Ki*Kb*Kw)/(B*tau_m);                    //Calculating gain constant.
Ks=1/(2*Kw*tau_e);                          //Calculating the gian constant of speed controller.
tau_s=4*tau_e;                              //Calculating the time constant of speed controller.
printf("\n\t(a).The phase voltage Vs is %0.2fV",Vs);
printf("\n\t    The maximum dc voltage Vdc(max) is %0.2fV",Vdc_max);
printf("\n\t    The converter control voltage Vc is %0.2fV",Vc);
printf("\n\t    The gain of the converter Kr is %0.2fV",Kr);
printf("\n\t    The time constant of the converter tau_r is %0.2fms",tau_r*10^3);
printf("\n\t(b).The current feedback gain Hc is %0.2fV/A",Hc);
printf("\n\t(c).The motor gain Km is %0.2f",Km);
printf("\n\t    r1 = %0.2f\n\t    r2 = %0.2f",r1,r2);
printf("\n\t    The time constant of motor are;");
printf("\n\t    t1=%0.2fs\n\t    tau_2=%0.1fs\n\t    tau_m=%0.2fs",tau_1,tau_2,tau_m);
printf("\n\t(d).The time constant of the current controller tau_c is %0.2fs",tau_c);
printf("\n\t    The gain of the current controller Kc is %0.2f",Kc);
printf("\n\t(e).The gain constnt of simplified current loop are,");
printf("\n\t    K1=%0.2f\n\t    Ki=%0.2f",K1,Ki);
printf("\n\t    The time constant of simplified current loop are,");
printf("\n\t    tau_3=%0.2fs\n\t    tau_i=%0.2fms",tau_3,tau_i*10^3);
printf("\n\t(f).The gain constant of current
```

```
    controller are,");
printf("\n\t    Kw=%0.2f\n\t    Ks=%0.2f",Kw,Ks);
printf("\n\t    The time constant of speed
    controller are,");
printf("\n\t    tau_e=%0.2fms\n\t    tau_s=%0.2fms",
    tau_e*10^3,tau_s*10^3);
//Some answers may change due to round-off error.
```

Chapter 15

Ac Drives

Scilab code Exa 15.1 `Finding the Performance Parameters of a Three Phase Induction`

```
//Power Electronics Devices, Circuits, and Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.1
//Finding the Performance Parameters of a Three-Phase Induction Motor.

clc;
clear;
VL=460;                                 //Rated voltage of the motor.
f=60;                                   //Frequency in Hz.
Rs=0.42;                                //Supply Resistance in Ohm.
Rr_dash=0.23;                               //Reistnace of motor in Ohm.
Xr_dash=0.82;                               //Reactance in Ohm.
```

```
Xm=22;                          //Reactance of motor in Ohm.
P_noload=60;                    //No load loss in Watts.
N=1750;                         //Rotor speed in rpm.
Vs=VL/sqrt(3);                  //Calculating the phase voltage.
w=2*%pi*f;                      //Calculating the frequency in rad/sec.
wm=(N*%pi)/30;                  //Calculating the speed in rad/sec.
ws=(2*w)/4;                     //Calculating synchronous speed.
s=(ws-wm)/ws;                   //Calculating the slip.
Zi=((-Xm*(Xr_dash+Xr_dash))+(%i*Xm*(Rs+(Rr_dash/s))))/(Rs+(Rr_dash/s)+(%i*(Xm+Xr_dash+Xr_dash)));//Calculating the input impedence.
[a1 a2]=polar(Zi);a21=a2*180/%pi;//Converting complex to polar form.
Ii=Vs/Zi;                       //Calculating input current.
[b1 b2]=polar(Ii);b21=b2*180/%pi;//Converting complex to polar form.
PFm=cos(b21);                   //Calculating power factor.
Pt=3*Vs*(b1)*0.858;                 //Calculating total power.
PFs=PFm;                        //Calculating power factor of input supply.
Ir1=Vs/sqrt((Rs+(Rr_dash/s))^2+(Xr_dash+Xr_dash)^2);//Calculating rms root current.
Pg=(3*Ir1^2*Rr_dash)/s;                             //Calculating the gap power.
Pru=3*Ir1^2*Rr_dash;                            //Calculating rotor copper loss.
Psu=3*Ir1^2*Rs;                             //
```

```
Calculating stator copper loss.
Td=Pg/ws;                                    //Calculating developed torque.
Po=Pg-Pru-P_noload;                          //Calculating output power.
eff=(Pt-Po)/Po;                              //Calculating the effeciency.
Irs=Vs/((Rs+Rr_dash)^2+(Xr_dash+Xr_dash)^2)^0.5;     //Calculating starting current.
Ts=(3*Rr_dash*Irs^2)/ws;                     //Calculating starting torque.
sm=Rr_dash/((Rs)^2+(Xr_dash+Xr_dash)^2)^0.5;   //Calculating slip for maximum torque.
Tmm=(3*Vs^2)/(2*ws*(Rs+(sqrt(Rs^2+(Xr_dash+Xr_dash)^2))));//Calculating maximum torque developed.
Tmr=-(3*Vs^2)/(2*ws*(-Rs+(sqrt(Rs^2+(Xr_dash+Xr_dash)^2))));//Calculating maximum regenerative torque.
sm1=Rr_dash/(Xr_dash+Xr_dash);   //Calculating slip for maximum torque by negleting supply resistance Rs.
Tmm1=(3*Vs^2)/(2*ws*(sqrt((Xr_dash+Xr_dash)^2)));//Calculating maximum torque developed.
Tmr1=Tmm1;                                   //Calculating regenerative motor torque.
printf("\n\tThe phase voltage Vs is %0.2fV",Vs);
printf("\n\tFrequency in rad/sec w is %0.0frad/s",w);
printf("\n\tThe motor speed in rad/sec is %0.2frad/s",wm);
printf("\n\t(a).The synchronous speed ws is %0.1frad/s.",ws);
printf("\n\t(b).The slip s is %0.3f",s);
printf("\n\t(c).The input impedence Zi is %0.3f %0.2f ",a1,a21);
printf("\n\t    The input current Ii is %0.2f %0.2f A",b1,b21);
printf("\n\t(d).The power factor of the motor PFm is
```

```
    %0.2f(lagging)",(PFm));
printf("\n\t     The total power Pt is %0.0fW",Pt);
printf("\n\t(e).The power factor of the input supply
    Pfs is %0.3f(lagging)",PFs);
printf("\n\t     The rms rotor current Ir1 is %0.1fA"
    ,Ir1);
printf("\n\t     The gap power Pg is %0.0fW",Pg);
printf("\n\t(g).The rotor copper loss Pru is %0.1fW"
    ,Pru);
printf("\n\t(h).The sator copper loss Psu is %0.0fW"
    ,Psu);
printf("\n\t(i).The developed torque Td is %0.1fN-m"
    ,Td);
printf("\n\t(j).The output power Po is %0.0fW",Po);
printf("\n\t     The effeciency eff is %0.2fpercent",
    eff*100);
printf("\n\t(k).The starting rms rotor current Irs
    is %0.1fA",Irs);
printf("\n\t     The starting torque Ts is %0.1fN-m",
    Ts);
printf("\n\t(l).The slip for maximum torque sm is %0
    .4f",sm);
printf("\n\t(m).The maximum developed torque Tmm is
    %0.2fN-m",Tmm);
printf("\n\t(n).The maximum regenerative torque Tmr
    is %0.2fN-m",Tmr);
printf("\n\t(o).If the suply resistance Rs is
    negleted;");
printf("\n\t     The slip of maximum torque sm is %0
    .4f",sm1);
printf("\n\t     The maximum torque developed Tmm = -
    Tmr is %0.1fN-m",Tmm1);
//Answers are changed due to round off error.
```

Scilab code Exa 15.2 Finding the Performance Parameters of a Three Phase Induction

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.2
//Finding the Performance Parameters of a Three-
   Phase Induction Motor with Stator Voltage Control
   .

clc;
clear;
VL=460;                        //Rated voltage of the
   motot in volts.
f=60;                          //Frequency in Hz.
Rs=1.01;                       //Supply resistance in
   Ohm.
Xs=1.3;                        //Supply reactance in
   ohm.
Rr_dash=0.69;                       //Rotor resistance
    in Ohm.
Xr_dash=1.94;                      //Rotor reactace in
    Ohm.
Xm=43.5;                       //Motor reactance in
   Ohm.
TL=41;                         //Load torque at rated
   speed in N-m.
Nm=1740;                       //Rated speed of the
   motor in rpm.
N=1550;                        //Motor running speed
   in rpm.
Vs=VL/sqrt(3);                 //Calculating phase
   voltage.
w=2*%pi*60;                    //Calculating
   frequecncy in rad/s.
ws=w*2/4;                      //Calculating speed in
   rad/sec.
```

```
wm=Nm*%pi/30;                    //Calculating rated motor speed in rad/sec.
Km=TL/wm^2                       //Calculating motor constant.
wm1=N*%pi/30;                    //Calculating running speed of motor in rad/s.
s=(ws-wm1)/ws;                   //Calculating the slip.
TL1=Km*wm1^2;                    //Calculating the load torque.
Ir_dash=sqrt((s*TL1*wm1)/(3*Rr_dash*(1-s)));//Calculating the rotor current.
Va=Ir_dash*sqrt((Rs+(Rr_dash/s))^2+(Xs+Xr_dash)^2);//Calculating stator supply voltage.
Zi=((-Xm*(Xs+Xr_dash))+(%i*Xm*(Rs+(Rr_dash/s))))/(Rs+(Rr_dash/s)+(%i*(Xm+Xs+Xr_dash)))
[a1 a2]=polar(Zi);a21=a2*180/%pi;//Converting complex to polar form.
Ii=Va/Zi;                            //Calculating input current.
[b1 b2]=polar(Ii);b21=b2*180/%pi;//Converting complex to polar form.
PFm=cosd(abs(b21));                          //Calculating power factor.
Pi=3*Va*PFm*b1;                          //Calculating total power.
sa1=1/3;
Ir_dash_max=ws*sqrt((4*Km*ws)/(81*Rr_dash));    //Cakulating maximum rotor current.
wa=(2/3)*ws;                                 //Calculating speed at maximum current.
Ta=9*Ir_dash_max^2*(Rr_dash/ws);                        //Calculating torque at maximum current.
printf("\n\t(a).The load torque TL is %0.1fN-m",TL1);
printf("\n\t(b).The no load loss Ir is %0.2fA",Ir_dash);
printf("\n\t(c).The stator supply voltage Va is %0.2fV",Va);
```

```
printf("\n\t(d).The motor input impedence Zi is %0.2f %0 .2 f ",a1,a21);
printf("\n\t    The motor input current Ii is %0.0f %0 .2 f ",b1,b21);
printf("\n\t(e).The motor power factor PFm is %0.3f(lagging)",PFm);
printf("\n\t    The total input power Pi is %0.3fW",Pi);
printf("\n\t(f).The slip at which rotor current is maximum sa is %0.3f",sa1);
printf("\n\t(g).The maximum rotor current Iri(max) is %0.1fA",Ir_dash_max);
printf("\n\t(h).The speed at the maximum current wa is %0.2frad/sec",wa);
printf("\n\t(i).The torque at maximum current Ta is %0.2fN-m",Ta);
//Some answers may change due to round-off error.
```

Scilab code Exa 15.3 Finding the Performance Parameters of a Three Phase Induction

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 15.3
//Finding the Performance Parameters of a Three-Phase Induction Motor with Rotor Voltage Control.

clc;
clear;
V=460;                          //Three phase supply voltage in volts.
f=60;                           //Frequency in Hz.
```

```
p=6;                                    //Number of poles of the motor.
Rs=0.041;                               //Stator resistance in Ohm.
Rr_dash=0.044;                              //Rotor resistance in Ohm.
Xs=0.29;                                //Stator reactance in Ohm.
Xr_dash=0.044;                              //Rotor reactance in Ohm.
Xm=6.1;                                 //Motor resitance in Ohm.
nm=0.9;                                 //Ratio of stator to rotor windidng.
T=750;                                  //Load torque in N-m.
N=1175;                                 //Rated Motor speed in rpm.
N1=1050;                                //Maximum running speed of motor in rpm.
Nm=800;                                 //Minimum speed of motor in rpm.
Vs=V/sqrt(3);                           //Calculating phase voltage.
w=2*%pi*f;                              //Calculating frequency in rad/sec.
ws=2*w/p;                               //Calculating the frequency per cycle.
wm=Nm*%pi/30;                           //Calculating mimimum motor speed in rad/s.
//At speed N=800 rpm.
TL=T*(Nm/N)^2;                          //Calculating load torque at mimimum speed.
Id=(TL*ws)/(2.3394*Vs*nm);              //Calculating the inductor current.
R=(1-(wm/ws))*((2.3394*Vs*nm)/(Id));//Calculating the resistance at minimum speed.
//At speed N=1050 rpm.
```

```
TL1=T*(N1/N)^2;                    //Calculating the load torque.
Id1=(TL1*ws)/(2.3394*Vs*nm);       //Calculating the inductor current.
wm1=N1*%pi/30;                     //Calculating the running speed in rad/sec.
k=1-((1-(wm1/ws))*((2.3394*Vs*nm)/(Id1*R)));//Calculating the duty cycle.
s=(ws-wm1)/ws;                                  //Calculating the slip.
Vd=2.3394*s*Vs*nm;                             //Calculating the inductor voltage.
P1=Vd*Id1;                                      //Calculating the power loss.
Po=TL1*wm1;                                    //Calculating the ouptut power.
Ir1=sqrt(2/3)*Id1*nm;                          //Calculating the rms stator current.
Psu=3*Rs*Ir1^2;                                //Calculating stator copper loss.
Pru=3*Rr_dash*Ir1^2;                                   //Calculating rotor copper loss.
Pi=Po+P1+Pru+Psu;                              //Calculating input power.
eff=Po/Pi;                                     //Calculating the effeciency.
Ir1_dash=0.7797*Id1*nm;                                //Calculating fundamental component of rotor current.
Im=Vs/Xm;                                      //Calculating magnetizing current.
Ii1=sqrt(Ir1_dash^2+Im^2);                             //Calculating fundamental component of input current.
theta_m=-atand(Im/Ir1_dash);
                          //Calculating power factor angle.
PF=cos((theta_m));                                //
```

```
Calculating the power factor.
printf("\n\t    At N=800 rpm");
printf("\n\t(a).The load torque at 800 rpm TL is %0.2fN-m",TL);
printf("\n\t    The inductor current Id is %0.2fA",Id);
printf("\n\t    The resitance at minimum speed R is %0.4f  ",R);
printf("\n\t    At N=1050 rpm");
printf("\n\t(b).The load torque TL is %0.2fN-m",TL1);
printf("\n\t    The inductor current Id is %0.1fA",Id1);
printf("\n\t(c).The duty cycle k is %0.3f",k);
printf("\n\t(d).The slip s is %0.3f",s);
printf("\n\t    The inductor voltage Vd is %0.1fV",Vd);
printf("\n\t(e).The power loss P1 is %0.0fW",P1);
printf("\n\t    The output power Po is %0.0fW",Po);
printf("\n\t    The rms rotor current of stator Ir1 is %0.1fA",Ir1);
printf("\n\t    The rotor copper loss Pru is %0.0fW",Pru);
printf("\n\t    The sator copper loss Psu is %0.0fW",Psu);
printf("\n\t    The input power Pi is %0.0fW",Pi);
printf("\n\t    The effeciency is %0.0fpercentage",eff*100);
printf("\n\t(f).The fundamental component of rotor current reffered to stator Ir1_dash is %0.2fA",Ir1_dash);
printf("\n\t    The magnetizing current Im is %0.2fA",Im);
printf("\n\t    The fundamental component of the input current Ii1 is %0.0fA",Ii1);
printf("\n\t    The PF angle ang_m is %0.2f degree",theta_m);
printf("\n\t    The power factor PF is %0.3f(lagging
```

```
)",PF);
//Some answers are changed due to round off error.
```

Scilab code Exa 15.4 Finding the Performance Parameters of a Static Kramer Drive

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.4
//Finding the Performance Parameters of a Static
   Kramer Drive.

clc;
clear;
nc=0.40;                              //Turns ratio of
   converter voltage.
TL=750;                               //Load torque in N
   -m.
N=1175;                               //Rated Speed in
   rpm.
N1=1050;                              //Running speed of
    motor in rpm.
V=460;                               //Three phase
   supply voltage in volts.
f=60;                                //Frequency in Hz.
Rs=0.041;                            //Stator resistance
    in Ohm.
Rr_dash=0.044;                           //Rotor
   resistance in Ohm.
Xs=0.29;                             //Stator reactance
   in Ohm.
Xr_dash=0.044;                           //Rotor
```

```
reactance in Ohm.
Xm=6.1;                          //Motor resitance in Ohm.
nm=0.9;                          //Ratio of stator to rotor winididng.
p=6;                             //Number of poles of the motor.
Vs=V/sqrt(3);                    //Calculating phase voltage.
w=2*%pi*f;                       //Calculating frequency in rad/sec.
ws=2*w/p;                        //Calculating the frequency per cycle.
wm=N1*%pi/30;                    //Calculating mimimum motor speed in rad/s.
s=(ws-wm)/ws;                    //Calculating the slip.
//At speed N=1050rpm;
TL1=TL*(N1/N)^2;                 //Calculating the load torque.
Id1=(TL1*ws)/(2.3394*Vs*nm);     //Calculating the inductor current.
Vd1=2.3394*s*Vs*nm;              //Calculating inductor voltage.
alp=acosd(((wm/ws)-1)*(nm/nc));    //Calculating the delay angle.
P1=Vd1*Id1;                      //Calculating the power feedback.
Po=TL1*wm;                       //Calculating the output power.
Ir_dash=sqrt(2/3)*Id1*nm;            //Calculating the rms rotor current refferd to stator.
Pru=3*Rr_dash*Ir_dash^2;                 //Calculating rotor copper loss.
Psu=3*Rs*Ir_dash^2;                  //Calcuulating stator copper loss.
Pi=Po+Pru+Psu;                   //Calculating input power.
```

```
eff=Po/Pi;                              //Calculating the efficiency.
Ir_dash1=0.7798*Id1*nm;                     //Calculating fundamental component on rotor current due to stator current.
Im=Vs/Xm;                               //Calculating magnetizing current.
Ii1=sqrt(Ir_dash1^2+Im^2);                  //Calculating fundamental component of input current.
ang_m=-atand(Im/Ir_dash1);                        //Calculating power factor angle.
a1=Ii1*cos(ang_m);a2=Ii1*sin(ang_m);//Converting to polar form.
Ii2=sqrt(2/3)*Id1*nc;                 //Calculating the rms current feedback to supply.
b1=Ii2*cos(-alp);b2=Ii2*sin(-alp);disp(complex(b1,b2))
Ii=complex(a1,a2)+complex(b1,b2);disp((Ii))
                           //Calculating effective input current.
[c1,c2]=polar(Ii);c21=c2*180/%pi; //Converting to polar form.
PF=cos(c21);                             //Calculating power factor.
printf("\n\tThe slip s is %0.3f",s);
printf("\n\tThe load torque TL is %0.2fN-m",TL1);
printf("\n\t(a).The inductor current Id is %0.1fA",Id1);
printf("\n\t(b).The inductor voltage Vd is %0.1fV",Vd1);
printf("\n\t(c).The delay angle alp is %0.1f  ",alp);
printf("\n\t(d).The power feedback P1 is %0.0fW",P1);
printf("\n\t    The output power Po is %0.0fW",Po);
printf("\n\t    The rotor current referred to stator Ir_dash is %0.1fA",Ir_dash);
printf("\n\t    The rotor copper loss Pru is %0.0fW"
```

```
,Pru);
printf("\n\t     The stator copper loss Psu is %0.0fW
   ",Psu);
printf("\n\t     The total power Pi is %0.0fW",Pi);
printf("\n\t     The efficiency is %0.0fpercentage",
   eff*100);
printf("\n\t(e).The rotor current reffered to stator
    Ir_dash1 is %0.2fA",Ir_dash1);
printf("\n\t     The magnetizing current Im is %0.2fA
   ",Im);
printf("\n\t     The fundamental component of input
   current Ii1 is %0.2 f %0 .2 f  ",Ii1,ang_m);
printf("\n\t     The rms current feedback to supply
   Ii2 is %0.2 f %0 .2 f  ",Ii2,-alp);
printf("\n\t     The effective current of the drive
   Ii is %0.2 f %0 .2 f  ",Ii,c21);
printf("\n\t     The input power power factor PF is
   %0.3f(lagging)",PF);
//Some answers may be changed due to round-off error
   .
```

Scilab code Exa 15.5 Finding the Performance Parameters of a Three Phase Induction

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.5
//Finding the Performance Parameters of a Three-
   Phase Induction Motor with Frequency Control.

clc;
clear;
```

```
Po=11.2;                              //Rated capacity of the motor in kilo watts.
N=1750;                               //Rated speed of the motor in rpm.
V=460;                                //Rated voltage of the motor in volts.
f=60;                                 //Rated frequency in Hz.
p=4;                                  //Number of poles of motor.
Rr_dash=0.38;                            //Rotor resistance in Ohm
Xs=1.14;                              //Stator reactance in Ohm.
Xr_dash=1.71;                            //Rotor reactance in Ohm.
Xm=33.2;                              //Magnetizing reactance in Ohm.
Tm=35;                                //Breakdown torque in N-m.
Vs=V/sqrt(3);                         //Calculating the suply voltage.
wb=2*%pi*f;                           //Calculating frequency in rad/sec.
Tmb=(Po*10^3)/(N*%pi/30);             //Calculating rated motor torque in N-m.
bet=sqrt(Tmb/Tm);                       //Calculating the frequency.
ws=bet*wb;                              //Calculating frequency in rad/sec.
w=4*ws/2;                             //Calculating the supply frequency.
sm=(Rr_dash/bet)/(Xs+Xr_dash);                  //Calculating slip for maximum torque.
wm=ws*(1-sm);                         //Calculating running speed of motor.
printf("\n\t(a).The frequency constant bet is %0.3f",bet);
```

```
printf("\n\t    The frequency ws is %0.2frad/s",ws);
printf("\n\t    The supply freqency w is %0.0frad/sec = %0.2fHz",w,w/(2*%pi));
printf("\n\t(b).The slip for maximum torque sm is %0.3f",sm);
printf("\n\t    The motor speed wm is %0.2frad/s",wm);
//Some answers may be changed due to round-off error.
```

Scilab code Exa 15.6 Finding the Performance Parameters of a Three Phase Induction

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.6
//Finding the Performance Parameters of a Three-Phase Induction Motor with Voltage and Frequency Control.

clc;
clear;
Po=11.2;                          //Rated capacity of the motor in kilo watts.
N=1750;                           //Rated speed of the motor in rpm.
V=460;                            //Rated voltage of the motor in volts.
f1=60;                            //Rated frequency in Hz.
f2=30;                            //Frequency in rad/sec.
```

```
Rs=0.66;                              //Stator resistance in Ohm.
p=4;                                  //Number of poles of motor.
Rr_dash=0.38;                             //Rotor resistance in Ohm
Xs=1.14;                              //Stator reactance in Ohm.
Xr_dash=1.71;                             //Rotor reactance in Ohm.
Xm=33.2;                              //Magnetizing reactance in Ohm.
Vs=V/sqrt(3);                         //Calculating the suply voltage.
w=2*%pi*f1;                            //Calculating frequency in rad/sec.
wb=2*w/p;                             //Calculating the synchronous speed.
//At frequency f=60Hz;
d=Vs/wb;                              //Calculating voltage to frequency ratio.
Va=d*wb;                              //Calculating motor running voltage.
sm=Rr_dash/sqrt(Rs^2+(Xs+Xr_dash)^2);       //Calculting slip of the motor.
wm=wb*(1-sm);                         //Calculating the motor speed.
Tm=(3*Vs^2)/(2*wb*(Rs+sqrt(Rs^2+(Xs+Xr_dash)^2)));//Calculating the maximum torque.
//At frequency f=30Hz;
ws1=2*2*%pi*30/p;                           //Calculating frequency in rad/sec.
bet=f2/f1;                                    //Calculating the frequency ratio.
Va1=d*ws1                                   //Clculating motor voltage.
sm1=Rr_dash/sqrt(Rs^2+(bet^2*(Xs+Xr_dash)^2));    //Calculting slip of the motor.
```

```
wm1=ws1*(1-sm1);                                    //Calculating the spees
Tm1=(3*Va1^2)/(2*ws1*(Rs+sqrt(Rs^2+(bet^2*(Xs+Xr_dash)^2))));//Calculating the maximum torque.
//At frequency f=60Hz;
sm2=Rr_dash/(Xs+Xr_dash);                              //Calculating the slip.
wm2=wb*(1-sm2);                                        //Calculating motor speed.
Tm2=((3*Va^2)/(2*wb*(Xs+Xr_dash)));                    //Calculating maximum torque.
//At frequency f=30Hz;
sm3=(Rr_dash/bet)/(Xs+Xr_dash);    //Calculating the slip.
wm3=ws1*(1-sm3);    //Calculating the speed.
Tm3=((3*Va^2)/(2*wb*(Xs+Xr_dash)));    //Calculating maximum torque.
printf("\n\t(a).At frequency f=%iHz",f1);
printf("\n\t    The frequency ws is %0.1frad/sec",wb);
printf("\n\t    The voltage Va is %0.2fV",Va);
printf("\n\t    The slip sm is %0.4f",sm);
printf("\n\t    The speed wm is %0.2frad/sec",wm);
printf("\n\t    The maximum torque Tm is %0.2fN-m",Tm);
printf("\n\t    At frequency f=%iHz",f2);
printf("\n\t    The frequency ws is %0.2frad/sec",ws1);
printf("\n\t    The voltage Va is %0.2fV",Va1);
printf("\n\t    The slip sm is %0.4f",sm1);
printf("\n\t    The speed wm is %0.2frad/sec",wm1);
printf("\n\t    The maximum torque Tm is %0.2fN-m",Tm1);
printf("\n\t(b).At frequency f=%iHz",f1);
printf("\n\t    The frequency ws is %0.1frad/sec",wb
```

```
);
printf("\n\t    The voltage Va is %0.2fV",Va);
printf("\n\t    The slip sm is %0.4f",sm2);
printf("\n\t    The speed wm is %0.2frad/sec",wm2);
printf("\n\t    The maximum torque Tm is %0.2fN-m",Tm2);
printf("\n\t    At frequency f=%iHz",f2);
printf("\n\t    The frequency ws is %0.1frad/sec",ws1);
printf("\n\t    The voltage Va is %0.2fV",Va1);
printf("\n\t    The slip sm is %0.4f",sm3);
printf("\n\t    The speed wm is %0.2frad/sec",wm3);
printf("\n\t    The maximum torque Tm is %0.2fN-m",Tm3);
//Some answers may be changed due to round-off error.
```

Scilab code Exa 15.7 Finding the Performance Parameters of a Three Phase Induction

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.7
//Finding the Performance Parameters of a Three-Phase Induction Motor with Current Control.

clc;
clear;
Po=11.2;                               //Rated capacity of the motor in kilo watts.
N=1750;                                //Rated speed of the motor in rpm.
```

```
V=460;                              //Rated voltage of the motor in volts.
f1=60;                              //Rated frequency in Hz.
f2=40;                              //Supply frequency in Hz.
Rs=0.66;                            //Stator resistance in Ohm.
p=4;                                //Number of poles of motor.
Rr_dash=0.38;                           //Rotor resistance in Ohm
Xs=1.14;                            //Stator reactance in Ohm.
Xr_dash=1.71;                           //Rotor reactance in Ohm.
Xm=33.2;                            //Magnetizing reactance in Ohm.
Ii=20;                              //Input current to the inverter.
Td=55;                              //Developed torque in N-m.
Va_rated=460/sqrt(3);               //Calculating the rated phase voltage.
w=2*%pi*f2;                         //Calculating supply frequency in rad/sec.
ws=2*w/p;                           //Calculating frequency.
Xs1=Xs*(f2/f1);Xr=Xr_dash*(f2/f1);    //Calculating the reactance.
Xm1=Xm*(f2/f1);                     //Calculating magnetizing reactance.
sm=Rr_dash/sqrt(Rs^2+(Xm1+Xr+Xs1)^2);//Calculting slip of the motor.
Tm=((3*Xm1^2)/(2*ws*(Xm1+Xr)))*Ii^2;//Calculating maximum torque.
//Calculating the slip.
R=poly(0,"Rr");
```

```
RR=R^2-83.74*R+578.04;                    //Equation obtained by solving the Eq 15.92.
Rr=roots(RR);a1=Rr(1,1);a2=Rr(2,1);
s1=Rr_dash/a1;s2=Rr_dash/a2;         //Calculating the approximate values of slip.
wm=ws*(1-s2);                             //Calculating the speed.
Ri=(Xm1^2*(Rs+(Rr_dash/s2)))/((Rs+(Rr_dash/s2))^2+(Xm1+Xs1+Xr)^2);//Calculating the input resistance.
Xi=(Xm1*((Rs+(Rr_dash/s2))^2+((Xs1+Xr)*(Xm1+Xs1+Xr))))/((Rs+(Rr_dash/s2))^2+(Xm1+Xs1+Xr)^2);//Calculating the input reactance.
theta_m=atan(Xi/Ri);                          //Calculating the angle.
Zi=sqrt(Ri^2+Xi^2);                       //Calculating the input impedence.
Va=Zi*Ii;                                 //Calcuating the input voltage.
PFm=cos(theta_m);                             //Calculating the power factor.
printf("\n\t(a).The maximum slip sm is %0.4f",sm);
printf("\n\t    The maximum torque Tm is %0.2fN-m",Tm);
printf("\n\t(b).The slip s is %00.5f or %0.4f",s1,s2);
printf("\n\t    The slected value of slip s is %0.4f",s2);
printf("\n\t(c).The speed wm is %0.2frad/sec",wm);
printf("\n\t(d).The input resistance Ri is %0.2f Ohm",Ri);
printf("\n\t    The input reactance Xi is %0.2f Ohm",Xi);
printf("\n\t    The angle theta_m is %0.1f  ",theta_m*180/%pi);
printf("\n\t    The input impedence Zi is %0.2f Ohm",Zi);
printf("\n\t    The input voltage Va is %0.1fV",Va);
```

```
printf("\n\t(e).The power factor PFm is %0.3f(lagging)",PFm)
//Some answers are changed due to round off error.
```

Scilab code Exa 15.8 Finding the Relationship between the Dc Link Voltage and the

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.8
//Finding the Relationship between the Dc−Link Voltage and the Stator Frequency.

clc;
clear;
HP=6;                           //Capacity of the motor in hp.
VL=220;                         //Rated voltage of motor in volts.
f=60;                           //supply frequency in Hz.
PF=0.86;                        //Power factor.
eff_i=0.84;                        //Input effeciency.
Rs=0.28;                        //Stator resistance in Ohm.
Rr=0.17;                        //Rotor resistance in Ohm.
Xm=24.3;                        //Magnetizing reactance in Ohm.
Xs=0.56;                        //Stator reactance in Ohm.
Xr=0.83;                        //Rotor reactance in Ohm
```

```
.
w=2*%pi*f;                        //Calculating frequency in rad/sec.
Po=HP*746;                        //Calculating capacity of motor in watts
Vph=VL/sqrt(3);                   //Calculating the phase voltage.
wd=(Rr*w)/(Xs+Xr);                //Calculating the slip speed.
Is=Po/(3*Vph*PF*eff_i);           //Calculating the stator current.
Vo=Is*Rs;                         //Calculating output voltage.
Kvf=(Vph-Vo)/f;                   //Calculating volt-frequency constant.
Vdc=(Vo+(Kvf*f))/0.45;            //Calculating the dc voltage.
printf("\n\t(a).The slip speed wd is %0.3frad/sec",wd);
printf("\n\t(b).The stator phase current Is is %0.3fA",Is);
printf("\n\t    The stator output voltage Vo is %0.3fV",Vo);
printf("\n\t(c).The volt-frequency constant Kvf is %0.3fV/Hz",Kvf);
printf("\n\t(d).The dc voltage Vdc is %0.2fV",Vdc);
//Some answers are changed due to roundoff error.
```

Scilab code Exa 15.9 Finding the Dimension Factors of the Control Variables

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.
```

```

//Example : 15.9
//Finding the Dimension Factors of the Control Variables.

clc;
clear;
HP=6;                          //Capacity of the motor in hp.
N=1760;                        //Motor speed in rpm.
Vcm=10;                        //Commutator voltage in volts.
VL=220;                        //Rated voltage of motor in volts.
f=60;                          //supply frequency in Hz.
PF=0.86;                       //Power factor.
eff_i=0.84;                       //Input effeciency.
Rs=0.28;                       //Stator resistance in Ohm.
Rr=0.17;                       //Rotor resistance in Ohm.
p=4;                           //Number of poles of motor.
w=2*%pi*f;                     //Calculating frequency in rad/sec.
wm=2*%pi*N/60;                 //Calculating speed in rad/sec.
wr=(p/2)*wm;                   //Calculating the rotor speed.
//The values of Kvf, Po, Vph, Vo, wr are taken from Example 15.8 as mentioned in the textbook.
wr_max=wr;                     //Calculating the maximum rotor speed.
Po=HP*746;                     //Calculating capacity of motor in watts.
Vph=VL/sqrt(3);                //Calculating the phase voltage.
```

```
Is=Po/(3*Vph*PF*eff_i);          //Calculating the stator current.
Vo=Is*Rs;                        //Calculating output voltage.
Kvf=(Vph-Vo)/f;                  //Calculating volt-frequency constant.
k_star=Vcm/wr_max;               //Calculating the propotionality constant.
Ktg=(p/2)*k_star;                //Calculating torque constant.
Kf=1/(2*%pi*k_star);             //Calculating frequency constant.
ws1=w/(2*%pi*Kf*k_star);
Vr=2.22*(Vo+(Kvf*Kf*k_star*(ws1)));//Calculating the rotor voltage.
printf("\n\t    The speed of the motor wm is %0.2f rad/sec",wm);
printf("\n\t    The maximum rotor speed wr_max is %0.3f rad/sec",wr_max);
printf("\n\t    The rotor speed wr is %0.3f rad/sec",wr);
printf("\n\t(a).The voltagege-frequency ratio Kvf is %0.3f V/Hz",Kvf);
printf("\n\t    The propotionality constant K* is %0.3f V/rad/s",k_star);
printf("\n\t    The torque constant Ktg is %0.3f V/rad/s",Ktg);
printf("\n\t    The frequency constant Kf is %0.0f Hz/rad/s",Kf);
printf("\n\t(b).The rectifier output voltage Vr is %0.3f V",Vr);
//Some answers given in the book is wrong.
```

Scilab code Exa 15.10 Finding the Rotor Flux Linkages

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Verpsion : 6.0.2     ;OS : Windows.

//Example : 15.10
//Finding the Rotor Flux Linkages.

clc;
clear;
HP=6;                              //Rated capacity of the motor in Hp.
f=60;                              //Frequency in Hz.
p=4;                               //Number of poles of the motor.
VL=220;                            //Rated voltage of the motor in volts.
Rs=0.28;                           //Stator repsistance in Ohm.
Rr=0.17;                           //Rotor repsistannce in Ohm.
Lm=61;                             //Magnetzing inductance in milli Henry.
Lr=56;                             //Rotor inductance in milli Henry.
Ls=53;                             //Stator inductance in milli Henry.
J=0.01667;                         //Work done by the motor in Kg-m^2.
N=1800;                            //Rated spedd of the motor in rpm.
Po=745.7*HP;                       //Calculating capacity of motor in watts.
w=2*%pi*f;                         //Calculating frequency in rad/sec.
wm=(2*%pi*N)/60;                   //Calculating motor speed in rad/sec.
```

```
wr=(p/2)*wm;                        //Calculating the
   rotor speed.
wc_max=wr;                          //Calculating maximum
   rotor speed.
Vqs=(sqrt(2)*VL)/sqrt(3)            //Calculating the
   stator voltage
Vds=0;ws1=0;                        //Calculating the
   stator voltage.
//Calculating the stator curret;
B=[Rs w*Ls*10^-3 0 w*Lm*10^-3;
-w*Ls*10^-3 Rs -w*Lm*10^-3 0;
0 ws1*Lm*10^-3 Rr ws1*Lr*10^-3;
-ws1*Lm*10^-3 0 -ws1*Lr*10^-3 Rr];
X=[Vqs; Vds; 0; 0;];
A=inv(B)*X;
iqs=A(1,1);ids=A(2,1);iqr=A(3,1);idr=A(4,1);
//Calculating the stator flux linkages;
psi_qs=(Ls*10^-3*iqs)+(Lm*10^-3*iqr);
psi_ds=(Ls*10^-3*ids)+(Lm*10^-3*idr);
psi_s=sqrt(psi_qs^2+psi_ds^2);
//Calculating the rotor flux linkages;
psi_Qr=(Lr*10^-3*iqr)+(Lm*10^-3*iqs);//Answer given
   in the book is wrong.
psi_dr=(Lr*10^-3*idr)+(Lm*10^-3*ids);
psi_r=sqrt(psi_Qr^2+psi_dr^2);
//Calculating the magnetizing flux linkages;
psi_mq=(Lm*10^-3)*(iqs+iqr);
psi_md=(Lm*10^-3)*(ids+idr);
psi_m=sqrt(psi_mq^2+psi_md^2);
If=sqrt(ids^2+iqs^2);                //Calculating flux
   producing stator current.
Td=(3*p/4)*((psi_ds*iqs)-(psi_ds*ids));//Calculating
    the developed torque.
Td1=(3*p/4)*(((Lm*10^-3)^2*ids*iqs)/(Lr*10^-3));//
   Calculating developed torque.
Te=Po/wm;                                            //
   Calculating the torque for output power.
Ke=(3*p/4)*(Lm/Lr);                                 //
```

```
Calculating torque constant.
Ir=Te/(Ke*psi_r);                                    //Calculating rotor current.
Is=sqrt(If^2+Ir^2);                                  //Calculating stator current.
theta_T=atand(Is/If);                                //Calculating the torque angle.
ws1=(Rr/(Lr*10^-3))*(Is/If);                         //Calculating the slip speed.
Ks1=(Lm*10^-3*Rr)/(psi_r*Lr*10^-3);                  //Calculating slip gain.
printf("\n\t(a).Ths stator currents are");
printf("\n\t    iqs = %0.3fA\n\t    ids = %0.3fA\n\t    iqr = %i\n\t    idr = %i",iqs,ids,iqr,idr);
printf("\n\t    The stator flux linkages are");
printf("\n\t    psi_qs = %0.3fmWb-turn\n\t    psi_ds = %0.3fWb-turn\n\t    psi_s = %0.3fWb-turn",psi_qs*10^3,psi_ds,psi_s);
printf("\n\t    The rotor flux linkages are");
printf("\n\t    psi_qr = %0.3fmWb-turn\n\t    psi_dr = %0.3fWb-turn\n\t    psi_r = %0.3fWb-turn",psi_Qr*10^3,psi_dr,psi_r);
printf("\n\t    The magnetizing flux linkages are");
printf("\n\t    psi_mq = %0.3fmWb-turn\n\t    psi_md = %0.3fWb-turn\n\t    psi_m = %0.3fWb-turn",psi_mq*10^3,psi_md,psi_m);
printf("\n\t(b).The flux producing stator current If is %0.3fA",If);
printf("\n\t    From Eq(15.132) gives developed torque Td is 0");
printf("\n\t    From Eq(15.149) the value of developed torque Td is %0.3fN-m",Td1);
printf("\n\t(c).The torque needed to produce output power Po, Te is %0.3fN-m",Te);
printf("\n\t    The torque constant Ke is %0.3f",Ke);
printf("\n\t    The rotor current Ir is %0.3fA",Ir);
printf("\n\t    The stator current Is is %0.2fA",Is)
```

```
;
printf("\n\t     The torque angle theta_T is %0.2f  ",theta_T);
printf("\n\t(d).The slip speed wsl is %0.2frad/sec",ws1);
printf("\n\t     The slip gaing Ks1 is %0.3f",Ks1);
//Some answers may change due to round-off error.
```

Scilab code Exa 15.11 Finding the Performance Parameters of a Cylindrical Rotor Sy

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 15.11
//Finding the Performance Parameters of a Cylindrical Rotor Synchronous Motor.

clc;
clear;
VL=460;                    //Rated voltage in volts.
f=60;                      //Frequency in Hz.
p=6;                       //Number of poles of the motor.
Xs=2.5;                    //Stator reactance in Ohm.
TL=398;                    //Load torque in N-m.
N=1200;                    //Rated speed of motor in rpm.
PF=1;                      //Power factor.
Nm=720;                    //Running speed of the motor.
fi=36;                     //Inverter frequency in
```

```
Hz.
Vs=VL/sqrt(3);              //Calculating the phase voltage.
w=2*%pi*f;                  //Calculating frequency in rad/sec.
wm=2*w/p;                   //Calculating speed in rad/sec.
d=Vs/wm;                    //Calculating voltage-frequency constant.
TL1=TL*(Nm/N)^2;            //Calculating load torque at 720 rpm.
ws=Nm*(%pi/30);             //Calculating speed in rad/sec.
Po=TL1*ws;                  //Calculating the output power.
Va=d*ws;                    //Calculating input voltage.
Ia=Po/(3*Va*PF);            //Calculating input current.
Vf=Va-((Ia*(1+0*%i))*(Xs*%i));     //Calculating excitation voltage.
[a1,a2]=polar(Vf);a21=a2*180/%pi;//Converting into rectangular form.
del=a21;                            //Calculating torque angle.
Tp=(3*Vf*a1)/(Xs*ws);              //Calculating pull out torque.
printf("\n\tThe load torque TL is %0.2fN-m",TL1);
printf("\n\tThe output power Po is %0.0fW",Po);
printf("\n\t(a).The input voltage Va is %0.2fV",Va);
printf("\n\t(b).The input current Ia is %0.1fA",Ia);
printf("\n\t(c).The excitation voltage Vf is %0.2f %0.2f ",a1,a21);
printf("\n\t(d).The torque angle del is %0.2f ",del);
printf("\n\t(e).The pull out torqe Tp is %0.2fN-m",Tp);
```

Scilab code Exa 15.12 Finding the Performance Parameters of a Reluctance Motor

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.12
//Finding the Performance Parameters of a Reluctance Motor.

clc;
clear;
VL=230;                               //Rated voltage of the motor.
f=60;                                 //Frequency in Hz.
p=4;                                  //Number of poles of the motor.
Xd=22.5;                              //Motor reactance in Ohm.
Xq=3.5;                               //Motor reactance in Ohm.
TL=12.5;                              //Load torque in N-m.
Va=VL/sqrt(3);                        //Calculating rated phase voltage.Since Va=Va_rated=Vb
w=2*%pi*f;                            //Calculating frequency in rad/sec.
ws=2*w/p;                             //Calculating motor speed.Since ws=wm.
del=asind((TL*2*ws*Xd*Xq)/(3*Va^2*(Xd-Xq)))/2;//Calculating the torque angle.
Po=TL*ws;                                      //
```

```
Calculating output power.
a=Po/(3*Va);
theta_m=atand((Va-((3.5*a)/tand(del)))/(3.5*a));  //
   Calculating the load angle.
Ia=Po/(3*Va*cosd(theta_m));                      //
   Calculating the load current.
PF=cosd(theta_m);                                //
   Calculating the power factor.
printf("\n\t(a).The torque angle del is %0.2f  ",del
   );
printf("\n\t(b).The output power Po is %0.0fW",Po);
printf("\n\t    The load angle theta_m is %0.1f  ",
   theta_m);
printf("\n\t    The load current Ia is %0.1fA",Ia);
printf("\n\t(c).The power factor PF is %0.3f",PF);
```

Scilab code Exa 15.13 Finding the Speed Control Parameters of a PMSM Drive System

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2     ;OS : Windows.

//Example : 15.13
//Finding the Speed Control Parameters of a PMSM
   Drive System.

clc;
clear;
VL=220;                   //Rated voltage in volts.
f=60;                     //Frequency in Hz.
p=6;                      //Number of poles of the
   motor.
Rs=1.2;                   //Stator resistance in
```

```
Ohm.
Ld=5;                    //Inductance in milli Henry.
Lq=8.4;                  //Inductance in milli Henry.
psi_r=0.14;                 //Rotor flux linkage in Wb-turns.
BT=0.01;                 //Torque in N.mn/rad/s.
J=0.006;                 //Work done by the motor in kg-m^2.
fc=2.5;                  //Converter frequency in kHz.
Vcm=10;                  //Commutator voltage in volts.
Hw=0.05;                 //Feedback of speed controller in V/A.
Hc=0.8;                  //Feebback of current controller in V/A.
Vdc=200;                 //Dc output voltage in volts.
Vph=VL/sqrt(3);          //Calculating the phase voltage.
Kin=0.65*Vdc/Vcm;        //Calculating inverter gain.
Tin=1/(2*fc*10^3);      //Calculating time constant.
s=poly(0,"s");
Gr_s=Kin/(1+s*Tin);      //Calculating inverter transfer function.
Ka=1/Rs;                 //Calculating motor electrincal gain.
Ta=Lq*10^-3/Rs;          //Calculating motor time constant.
Ga_s=Ka/(1+s*Ta);        //Calculating the motor transfer function.
KT=(3/2)*(p/2)^2*psi_r;     //Calculating torque constant of induced emf.
Km=1/BT;                 //Calculating mechanical
```

```
   gain.
Tm=J/BT;                         //Calculating mechanical
   time constant.
Kb=KT*Km*psi_r;                     //Calculating emf
   feedback constant.
Gb_s=Kb/(1+s*Tm);                //Calculating emf
   feedback transfer function.
Gm_s=(KT*Km)/(1+s*Tm);           //Calculating motor
   mechanical transfer function.
//Calculating electrical time constants.
a=Tm*(Ta+Tin);
b=Tm+(Ka*Kin*Tm*Hc);
c=Ka*Kb;
T=a*s^2-b*s+c;T11=roots(T)
T1=1/T11(1,1);T2=1/T11(2,1);
Tt=T1;                           //Calculating current-
   loop time constant.
Ki=(Tm*Kin)/(T2*Kb);             //Calculating current-
   loop gain.
Gts_s=Ki/(1+s*Tt);               //Calculating crrent-loop
    transfer function.
Kg=(Ki*Km*KT*Hw)/Tm;             //Calculating speed
   controller constant.
Tw=0.002;                        //The time constant in
   sec.
Twi=Tw+Tt;                       //Calculating time
   constant.
Ts=6*Twi;                        //Calculating time
   constant.
Ks=4/(9*Kg*Twi);                 //Calculating gain
   constant,
Gs_s=(Ks/Ts)*((1+Ts*s)/s);       //Calculating speed-loop
   transfer function.
Gw_s=Hw/(1+s*Tw);                //Calculating speed-loop
   transfer function.
printf("\nInverter gain Ktm is %0.0fV/V",Kin);
printf("\nTime  constant Tin is %0.1fms",Tin*10^3);
disp(Gr_s,"The inverter transfer function Gr(s) is "
```

```
);
printf("\nMotor electricl gain Ka is %0.4fs",Ka);
printf("\nMotor time constant Ta is %0.3fs",Ta);
disp(Ga_s,"The motor transfer function Ga(s) is");
printf("\nTorque constant of induced emf loop is %0.2fN.m/A",KT);
printf("\nMechanical gain Km is %0.0frad/s/N.m",Km);
printf("\nMechanical time constant Tm is %0.1fs",Tm);
printf("\nEmf feedback constant Kb is %0.2f",Kb);
disp(Gb_s,"The emf feedback transfer function Gb(s) is ");
disp(Gm_s,"The motor mechanical transfer function Gm(s) is");
disp(T,"Electrical time constant of motor can be solved from roots of following equation");
printf("The elctrical time constants are \nT1 = %0.4fms\nT2 = %0.4fms",T1*10^3,T2*10^3);
printf("\nThe current-loop time constant Tt is %0.4fms",Tt*10^3);
printf("\nThe curret-loop gain Ki is %0.5f",Ki);
disp(Gts_s,"The current-loop transfer functio Gts(s) is ");
printf("\nThe speed controller constant Kg is %0.5f",Kg);
printf("\nThe time constant Twi is %0.4fms",Twi*10^3);
printf("\nThe time constant Ts is %0.2fms",Ts*10^3);
printf("\nThe gain constant Ks is %0.4f",Ks);
disp(Gs_s,"The speed loop transfer function Gs(s) is ");
disp(Gw_s,"The speed loop transfer function Gw(s) is ");
//Some answers may change due to round-off error.
```

Scilab code Exa 15.14 Finding the Developed Power by the Linear Inductor Motor

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 15.14
//Finding the Developed Power by the Linear Inductor Motor.

clc;
clear;
Lamda=0.5;                    //Pole pitch of motor in metre.
f=60;                         //Supply frequency in Hz.
v=210;                        //Speed of primary side in Km/h.
Fa=120;                       //Thrust developed in motor in kN.
vm=v*10^3/3600;               //Calculating motor speed.
Pd=Fa*10^3*vm;                //Calculating the developed power.
vs=2*Lamda*f;                 //Calculating the synchronous speed.
s=(vs-vm)/vm;                 //Calculating the slip in speed.
Pcu=Fa*10^3*s*vs;             //Calculating the copper loss.
printf("\n\t(a).The motor speed vm is %0.3fm/s",vm);
printf("\n\t(b).The developed power Pd is %0.0fMW",Pd*10^-6);
printf("\n\t(c).The synchronous speed vs is %0.0fm/s",vs);
printf("\n\t(d).The slip s is %0.3f",s);
```

```
printf("\n\tThe copper loss Pcu is %0.0fkW",Pcu
    *10^-3);
//Some answers are changed due to roundoff error.
```

Chapter 16

Introduction to Renewable Energy

Scilab code Exa 16.1 Determining the Power Density and the Solar Efficiency

```
//Power Electronics Devices, Circuits, and
   Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.1
//Determining the Power Density and the Solar
   Efficiency.

clc;
clear;
theta=35;                          //Zenith angle in
   degree.
alp_dt=75;                        //Transmitance of
   all gases in percentage.
bet_wa=5;                         //Water vapour
   absorbtion in percentage.
alp_p=85;                         //Transmittance of
```

```
aerosols in percentage.
sigma=3.5;                              //Standard deviation of solar distribution function.
t=2;                                    //Time in hours.
rho_o=1353;                             //The extraterrestrial power density in W/m^2.
rho_ir=rho_o*cosd(theta)*((alp_dt/100)-(bet_wa/100))*(alp_p/100);//Calculating solar power density.
eta_s=cosd(theta)*((alp_dt/100)-(bet_wa/100))*(alp_p/100);//Calculating solar efficiency.
rho_max=rho_o*cos(0)*((alp_dt/100)-(bet_wa/100))*(alp_p/100);//Calculating maximum power density.
rho=rho_max*(exp((-t)/(2*sigma^2)));        //Calculating power density at t=2pm.//Book answer is wrong.
printf("\n\t(a).The solar power density rho_ir is %0.2fW/m^2",rho_ir);
printf("\n\t    The solar efficiency eta_s is %0.2fpercentage",eta_s*100);
printf("\n\t(b).The maximum power density rho_max is %0.2fW/m^2",rho_max);
printf("\n\t    The power density at t=2pm, rho is %0.2fW/m^2",rho);//Book answer is wrong.
//Some answers may change due to round-off error.
```

Scilab code Exa 16.2 Determining the Output Voltage and Power of a PV Cell

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.2
//Determining the Output Voltage and Power of a PV
```

```
Cell.

clc;
clear;
Tem=30;                          //Temperature of the PV cell in degree Celsius.
Is=10;                           //Revese saturation current in nano Ampere.
Ic=1.2;                          //Solar current in ampere.
k=273;                           //Absolute temperature constant in kelvin
T=1.38*10^-23;                   //Boltzman's constant in Joule per kelvin.
q=1.602*10^-19;                   //Charge of a electron in Columb.
iL=0.6;                          //Load current in ampere.
VT=(T*(k+Tem))/(q);              //Calculating the thermal voltage, Fro Eq 2.2.
Vd=VT*log(((Ic-iL)/(Is*10^-9))+1);    //Calculating PV voltage.
//Calculating the load voltage.
function a=f(Vmp)
    a=((1+(Vmp/VT))*exp(Vmp/VT))-(1+(Ic/(Is*10^-9)))
endfunction
Vmp0=0.4
Vmp=fsolve(Vmp0,f);
Imp=Ic-((Is*10^-9)*(exp(Vmp/VT)-1));//Calculating load current.//(Book answer are wrong)
Pmax=Vmp*Imp;                    //Calculating maximum power.
RL=Vmp/Imp;                      //Calculating load resistance.
printf("\n\tThe thermal voltage VT is is %0.0fmV",VT*10^3);
printf("\n\t(a).The PV voltage Vd is %0.3fV",Vd);
printf("\n\t(b).The voltage Vmp is %0.3fV",Vmp);
printf("\n\t    The load current Imp is %0.3fA",Imp)
```

```
;
printf("\n\t    The maximum output power Pmax is %0.3fW",Pmax);
printf("\n\t    The load resitance RL is %0.3fOhm",RL);
//Book answers are wronng.
//Some answers are changed due to round-off error.
```

Scilab code Exa 16.3 Determining the Effects of Practical Model Parameters on Outp

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.3
//Determining the Effects of Practical Model Parameters on Output Voltage and the Output Power of PV Cells.

clc;
clear;
Tem=30;                          //Temperature of the PV cell in degree Celsius.
Is=10;                          //Revese saturation current in nano Ampere.
Ic=1.2;                         //Solar current in ampere.
iL=0.6;                         //Load current in ampere.
Rs=20;                          //Seies resistance in milli Ohm.
Rp=2;                           //Parallel resistance in Kilo Ohm.
k=273;                          //Absolute temperature
```

```
    constant in kelvin
T=1.38*10^-23;              //Boltzman's constant in
    Joule per kelvin.
q=1.602*10^-19;              //Charge of a electron
    in Columb.
VT=(T*(k+Tem))/(q);         //Calculating the thermal
     voltage, Fro Eq 2.2.
//Calculating the diode voltage.
function a=f(vd)
    a=iL-Ic+(Is*10^-9*(exp(vd/VT)-1))+(vd/(Rp*10^3))
endfunction
vd0=0.4
Vd=fsolve(vd0,f);
VL=Vd-(Rs*10^-3)*(Ic-(Is*10^-9*(exp(Vd/VT)-1))-(Vd/(
    Rp*10^3)));//Calculating the load voltage.
PL=VL*iL;                   //Calculating output load
     power.
printf("\n\tThe Thermal voltage VT is %0.0fmV",VT
    *10^3);
printf("\n\t(a).The voltage Vd is %0.3fV",Vd);
printf("\n\t    The load voltage VL is %0.3fA",VL);
printf("\n\t    The output power PL is %0.3fW",PL);
//Some answers are changed due to round-off error.
```

Scilab code Exa 16.4 Determining the Voltage Current and Power at the MPPT Point

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.4
//Determining the Voltage, Current, and Power at the
    MPPT Point.
```

```
clc;
clear;
//Ip Vs Vp characteristic of  a Pv cell can be described by below  two segments.
Vp1=poly(0,"Vp");Vp2=poly(0,"Vp");
Ip1=-0.01*Vp1+1;Ip2=-3.5*Vp2+2.8
//Constnts obtained from the given equation
C1=1;C2=2.8;
m1=-0.1;m2=-3.5;
Vp=(C2-C1)/(m1-m2);           //Calculating the voltage Vp.
Ip=(-0.1*Vp)+1;               //Calculating the current Ip.
Po=Vp*Ip;                     //Calculating output power.
printf("\n\tThe voltage Vp is %0.3fV",Vp);
printf("\n\tThe current Ip is %0.3fA",Ip);
printf("\n\tThe output power Po is %0.3fV",Po);
```

Scilab code Exa 16.5 Determining the Power Density and the Available Power of a Wi

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.5
//Determining the Power Density and the Available Power of a Wind Farm.

clc;
clear;
T=30;                   //Air temperature in degree.
```

```
h=320;                    //Elevation of wind farm in metre.
r=12;                     //Length of the blade in metre.
d=24;                     //Sweep diameter of the turbine in meter.
v=10;                     //Speed of the wind in m/sec.
g=9.8;                    //Gravity cinstant in m/s^2.
k=273;                        //Absolute temperature constant in kelvin;
Kg=29.3;                   //Specific gas constant for air.
Pat=353;                  //Standard atmosperic perseure in sea level in bar.
density=(Pat/(T+k))*(exp(-h/(Kg*(T+k))));//Calculating air density of wind from Eq 16.42.
rho=0.5*density*10^3;                              //Calculating wind density frp,m Eq 16.37.
As=%pi*r^2;                                 //Calculating swep area pf blade from Eq 16.8.
P_wind=As*rho;                                //Calculating the wind power from Eq 16.37.
printf("\n\t(a).The air density of the wind  is %0.3fkg/m^3",density);
printf("\n\t(b).The wind density p is %0.2fW/m^3",rho);
printf("\n\t(c).The sweep area of the blade As is %0.3fm^2",As);
printf("\n\t    The wind power Pwind is %0.1fkw",P_wind*10^-3);
```

Scilab code Exa 16.6 Determining the Speed and the Turbine Speed and the Gear Rati

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
```

```
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.6
//Determining the Speed and the Turbine Speed and the Gear Ratio.

clc;
clear;
Ng=870;                          //Generated speed in rpm.
va=6;                            //Wind speed in m/sec.
TSR=8;                           //Speed ratio of the turbine.
d=12;                            //Sweep diameter of turbine in meter.
r=d/2;                           //Calculating the radius of the blade.
v_tip=TSR*va;                    //Calculating the tip speed.
Nt=(v_tip/(2*%pi*r))*60;         //Calculating lower speed of the gear.
GRt=Ng/Nt;                       //Calculating the gear ratio
printf("\n\t(a).The tip speed Vtip is %0.0fm/s",v_tip);
printf("\n\t    The low speed of the gear Nt is %0.2frpm",Nt);
printf("\n\t(b).The gear ratio GRt is %0.2f",GRt);
```

Scilab code Exa 16.7 Determining the Potential Energy in the Tidal Wave

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
```

```
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.7
//Determining the Potential Energy in the Tidal Wave
    .

clc;
clear;
R=1;                            //Radius of base of the
    lagoon in km.
H_high=25;                      //The maximum height of
    tide in metre.
H_low=15;                       //The lowest height of
    tide in metre.
g=9.807;                        //Gravitational constant
    in m/s^2.
Cp=0.35;                        //Power coefficient of
    the blade.
eff_t=0.9;                        //Efficiency of the
    turbine.
eff_g=0.95;                       //Efficiency of the
    generator.
rho=1000;                        //Density of sea water
    in kg//m^3.
del_H=(H_high-H_low)/2;          //Difference in height
     of the water.
vol=0.5*%pi*(R*10^3)^2*del_H; //Calculating the
    total volume of water.
PE=vol*g*rho*del_H;                //Calculating the
    potential energy.
Eout=PE*Cp*eff_t*eff_g;            //
    Calculatingelectrical energy of tidal system.
printf("\n\t(a).The change in height of water del_H
    is %0.0fm",del_H);
printf("\n\t    The total volume of water vol is %0
    .3em^2",vol);
```

```
printf("\n\t     The potential energy is %0.3eJ",PE);
printf("\n\t     The electrical energy of the tidal system Eout is %0.3eJ",Eout);
```

Scilab code Exa 16.8 Determining the Electrical Energy of a Small Hydroelectric an

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.8
//Determining the Electrical Energy of a Small Hydroelectric and the Water Velocity.

clc;
clear;
f=100;                  //Rate of passage of water through penstock in kg/s.
h=5;                    //Height of the reservoir.
eff_p=0.95;                //Efficiency of penstock.
Cp=0.47;                //The power coefficient.
eff_t=0.85;                //Efficiency of turbine.
eff_g=0.9;                 //Efficiency of generator.
c=0.15;                 //Cost of energy in dollar per Kwh.
t=30;                   //Time of operation of generator in days.
g=9.807;                //Gravity constant.
Eg=f*g*h*t*24*Cp*eff_p*eff_t*eff_g;//Calculating the energy generater per month.
Inc=Eg*c*10^-3;            //Calculating the aount of energy cost.
m=f;                       //Calculating the mass of
```

```
water for a flow of 1sec.
PEp_in=m*g*h;                    //Calculating the potential energy of penstock.
KEp_out=eff_p*PEp_in;            //Calculating the kinetic energy of penstock.
v=sqrt((2*KEp_out)/m)
printf("\n\t(a).The energy generated per month Eg is %0.3eJ",Eg);
printf("\n\t    The amount of cost is %0.3fdollars",Inc);
printf("\n\t(b).The input potential enegy of penstock KEp-in is %0.3fKg",PEp_in*10^-3);
printf("\n\t    The kinetic energy of the penstock iKEp-out is %0.3fKJ",KEp_out*10^-3);
printf("\n\t    The speed of the water v is %0.3fm/s",v);
```

Scilab code Exa 16.9 Determining the Output Voltage of a PAFC

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.9
//Determining the Output Voltage of a PAFC.

clc;
clear;
q=1.602*10^-19;             //Charge of one electon.
NA=0.6002*10^24;            //Avagadro's number.
GH=237.13*10^3;             //Gibbs free energy constant.
Nm=100;                     //Number of moles of
```

```
hydrogen.
qe=NA*q;                    //Calculating the amount of charge in mol of electron
Ne=2*NA;                    //Calculating no fo electronics for 1 mol of H2.
qm=Ne*q;                    //Calculating total charge of ekectron in 1mol of H2.
Vc=GH/qm;                   //Calculating output voltage of a single FC.
Vo=Nm*Vc;                   //Calculating the total output voltage.
printf("\n\tThe amount of charge in mol of electrons qe is %0.3eC",qe);
printf("\n\tThe number of electronics for 1 mol of H2 Ne is %0.1e",Ne);
printf("\n\tThe total charge of electrons in 1 mol of H2 qm is %0.3eC",qm);
printf("\n\tThe output voltage of a single FC, Vc is %0.3fV",Vc);
printf("\n\tThe output voltage Vo is %0.1fV",Vo);
```

Scilab code Exa 16.10 Determining the Maximum Power of a Fuel Cell

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 16.10
//Determining the Maximum Power of a Fuel Cell.

clc;
clear;
//Calculating the current.
```

```
function a=f(t)
    a=0.75-(0.125*tan(t-1.2))-(0.125*t*(1/(cos(t
       -1.2))^2))
endfunction
t0=2;
Imp=fsolve(t0,f);
Vmp=0.75-(0.125*tan(Imp-1.2));//Calculating the
   voltage
Pmax=Vmp*Imp;                  //Calculating maximum
    power.
printf("\n\tThe current of the cell Imp is %0.2fA",
   Imp);
printf("\n\tThe voltage of the cell Vmp is %0.4fV",
   Vmp);
printf("\n\tThe maximum power of the cell Pmax is %0
   .3fW",Pmax);
```

Chapter 17

Protections of Devices and Circuits

Scilab code Exa 17.1 Plot the Instantaneous Junction Temperature

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 17.1
//Plot the Instantaneous Junction Temperature

clc;
clear
P1=800;                      //Power in wats.
P3=1200;                     //Power in watts.
P5=600;                      //Power in watts.
t=1;                         //Time in milli seconds.
Z_td=0.035;                 //Temperature rise in
```

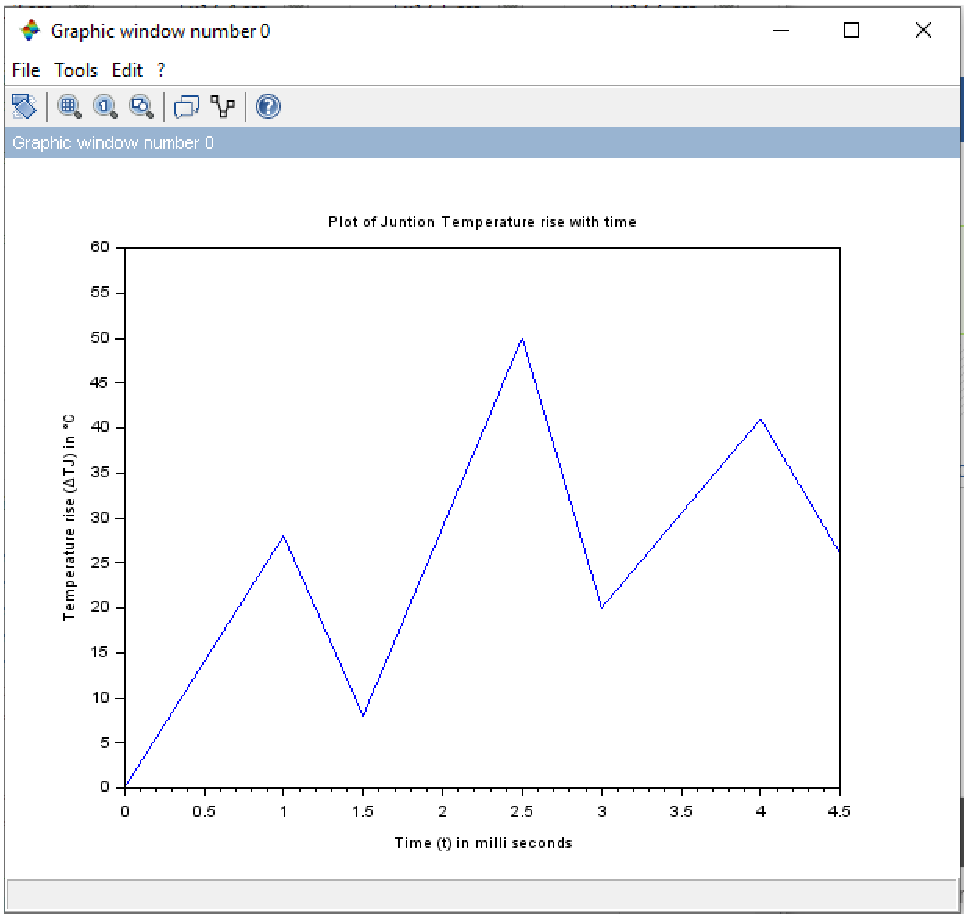

Figure 17.1: Plot the Instantaneous Junction Temperature

```
degree celsius per watts.
Z_te=0.025;                    //Temperature rise in degree celsius per watts.
//Calculating the junction temperature rise.
del_TJ_t1=Z_td*P1;
del_TJ_t2=del_TJ_t1-(Z_te*P1);
del_TJ_t3=del_TJ_t2+(Z_td*P3);
del_TJ_t4=del_TJ_t3-(Z_te*P3);
del_TJ_t5=del_TJ_t4+(Z_td*P5);
del_TJ_t6=del_TJ_t5-(Z_te*P5);
printf("\nThe junction temperature rise are;");
printf("\n\tdel_TJ(t=1ms) = %0.0f  C",del_TJ_t1);
printf("\n\tdel_TJ(t=1.5ms) = %0.0f  C",del_TJ_t2);
printf("\n\tdel_TJ(t=2.5ms) = %0.0f  C",del_TJ_t3);
printf("\n\tdel_TJ(t=3ms) = %0.0f  C",del_TJ_t4);
printf("\n\tdel_TJ(t=4ms) = %0.0f  C",del_TJ_t5);
printf("\n\tdel_TJ(t=4.5ma) = %0.0f  C",del_TJ_t6);
//Ploting the values of junction temperature rise.
t1=[0 1 1.5 2.5 3 4 4.5];                              //Time in ms
del_TJ=[0 del_TJ_t1 del_TJ_t2 del_TJ_t3 del_TJ_t4 del_TJ_t5 del_TJ_t6];//Junction temperature rise in  C
subplot(1,1,1);
plot(t1,del_TJ);
xlabel("Time (t) in milli seconds");
ylabel("Temperature rise (del_TJ) in degree Celcius");
title("Plot of Juntion Temperature rise with time");
```

Scilab code Exa 17.2 Calculating the Parameters of the Thermal Equivalent Circuit

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
```

```
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 17.2
//Calculating the Parameters of the Thermal Equivalent Circuit.

clc;
clear;
d_foil=0.3;                          //Tickness of the foil in mm.
Rth_kk=25;                           //Thermal resistance of the heat sink in K/W.
msk=2;                               //Mass of heat sink in gram.
Ask=1;                               //Surface are of TO-220 package in cm^2;
Acu=10;                              //Surface area of device chip in mm^2.
mcu=1;                               //Amount of copper around  pyramind stunp in g
dcu=0.8;                             //Thickness of copper in mm.
csk=0.95;                            //Specific heat of aluminium material in J/gK.
Cth_kk=csk*msk;                      //Calculating capacitance of heat sink.
Lamda_th_foil=1.1;                           //Area constant of alminium in W/mk.
Lamda_th=390;                                //Area constant of copper in W/mk.
Rth_foil=(d_foil*10^-3)/(Lamda_th_foil*Ask*10^-4);  //Calculating thermal resistance of foil.
Ccu=0.39;                            //Capcitance constant of copper in J/gk.
Cth7=Ccu*mcu;                        //Calculating thermal capacitance of chip.
Rth7=(dcu*10^-3)/(Lamda_th*Acu*10^-6);             //
```

```
Calculating thermal capacitance of chip.
printf("\n\tThe thermal capacitance of the heat sink Cth_kk is %0.1fg",Cth_kk);
printf("\n\tThe thermal resistance of the foil Rth_foil is %0.1fK/W",Rth_foil);
printf("\n\tThe thermal capacitance of the chip Cth7 is %0.2fJ/K",Cth7);
printf("\n\tThe thermal resistance of the chip is %0.3fK/W",Rth7);
```

Scilab code Exa 17.3 `Finding the Values of the Snubber Circuit`

```
//Power Electronics Devices, Circuits, and Applications.By M.H. Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 17.3
//Finding the Values of the Snubber Circuit.

clc;
clear;
IR=20;                      //Recovery current of the diode in ampere.
L=50;                       //Inductance in micro henry.
Vs=220;                     //Input voltage in colts.
Vp=1.5*Vs;                  //Calculating peak transient voltage.
d0=0.75;                    //Optimum current factor from fig(17.9).
del_o=0.4;                     //Optimum damping factor from fig(17.9).
C=(L)*(IR/(d0*Vs))^2;       //Calculating snubber
```

```
    capacitance.
R=2*del_o*sqrt(L/C);          //Calculating snubber
    resistance.
wo=10^6/sqrt(L*C);          //Calculating resonant
    frequncy.
dv=0.88*Vs*wo;              //Calculating the change
    in voltage.
v_t0=R*IR;                  //Calculating intial
    reverse voltage.
printf("\n\t(a).The optimum current factor do is %0
    .2f",d0);
printf("\n\t(b).The optimum damping factor del_o is
    %0.1f",del_o);
printf("\n\t(c).The snubber capacitance C is %0.3
    f F",C);
printf("\n\t(d).The snubber resistance R is %0.1 f
    ",R);
printf("\n\t(e).The resonant frequency wo is %irad/s
    ",wo);
printf("\n\t    The change in voltage dv/dt is %0.1
    fV/ s ",dv*10^-6);
printf("\n\t(f).The intial reverse voltage v(t=0) is
     %0.0fV",v_t0);
```

Scilab code Exa 17.4 Finding the Peak Value the change in current and voltage Valu

```
//Power Electronics Devices, Circuits, and
    Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2       ;OS : Windows.

//Example : 17.4
//Finding the Peak Value, the di/dt, and the dv/dt
    Values of the Snubber Circuit.
```

```

clc;
clear;
C=0.75;                          //Capcitance in micro farad.
R=6.6;                           //Resistance in Ohm.
Vs=220;                          //Supply voltage in volts.
L=50;                            //Inductance in micro henry.
alp=R/(2*L*10^-6);                 //Calculating damping constant from Eq 17.13.
wo=10^6/sqrt(L*C);                   //Calculating undamped natural frequency from Eq 17.14.
del=(R/2)*sqrt(C/L);               //Calculating damping ratio from Eq 17.15.
w=wo*sqrt(1-del^2);                 //Calculating underdamped natural frequency from Eq 17.16.
t1=(%pi-(atan(((2*del)*(sqrt(1-del^2)))/(1-(2*del^2)))))/w;//Calculating the intial time from Eq 17.33.
Vp=Vs*(1+exp(-alp*t1));            //Calculating peak voltage from Eq 17.32.
dv_by_dt=Vs*(R/L);                       //Calculating the intial change in voltage from Eq 17.28.
tm=(atan((w*(w^2-(3*alp^2)))/(alp*((3*w^2)-alp^2))))/w;//Calculating the maximum circuit time from Eq 17.34.
dv_by_dt_max=Vs*sqrt(w^2+(alp^2))*(exp(-alp*tm));//Calculating maximum change in voltage from Eq 17.35.
printf("\n\t(a).The damping constant alp is %0.0f",alp);
printf("\n\t    The undamped natural frequency wo is %0.0frad/s",wo);
printf("\n\t    The damping ratio del is %0.3f",del);
printf("\n\t    The underdamped natural frequency w
```

```
is %0.0frad/s",w);//Answer of underdamped natural frequency is wrong.
printf("\n\t     The initial time t1 is %0.2f  s",t1*10^6);
printf("\n\t     The peak voltage Vp is %0.1fV",Vp);
printf("\n\t(b).The initial change in voltage dv/dt is %0.0fV/ s ",dv_by_dt);
printf("\n\t(c).The maximum time tm is %0.2f  s",tm*10^6);
printf("\n\t     The maximum dv/dt is %0.1fV/ s ",dv_by_dt_max*10^-6);
//Some answers are changed due to round-off error.
```

Scilab code Exa 17.5 Finding the Performance Parameters of Switching Transients

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 17.5
//Finding the Performance Parameters of Switching Transients.

clc;
clear;
Vs=120;                      //Secondary voltage in volts.
Lm=2;                        //Secondary magnetizing inductance in milli Henry.
f=60;                        //Frequency in Hz.
theta=180;                   //Supply Angle at which primary is disconnected in degree.
Vp=300;                      //Maximum transient
```

```
voltage.
Vm=sqrt(2)*Vs;                    //Calculating phase voltage.
w=2*%pi*f;                        //Calculating frequency in rad/sec.
Vc=Vm*sin(%pi);                   //Calculating the capacitor voltage.
Io=(Vm/(w*Lm*10^-3))*cosd(%pi);        //Calculating the magetizing currnet.
C=Io*(Vm/(Vp^2*w));               //Calculating the required capacitance.
printf("\n\t(a).The capacitor voltage Vc is %0.1fV",Vc);
printf("\n\t(b).The magnetizing current Io is %0.0fA",Io);
printf("\n\t(c).The required capacitance C is %0.1f F",C*10^6);
//Answeres are changed due to round off error.
```

Scilab code Exa 17.6 `Selecting a Fast Acting Fuse for Protecting a Thyristor`

```
//Power Electronics Devices, Circuits, and Applications.By M.H.Rashid
//Publisher : Pearson Education.
//Edition : Fourth.
//Scilab Version : 6.0.2      ;OS : Windows.

//Example : 17.6
//Selecting a Fast-Acting Fuse for Protecting a Thyristor.

clc;
clear;
Vs=240;                       //Input voltage in volts.
f=60;                         //Frequency in Hz.
```

```
Ia=400;                      //Average thyristor current in ampere.
IT_av=540;                   //Rated average current of thyristor in ampere.
IT_rms=850;                  //Rated rms current of thyristor in ampere.
P=300;                       //Power rating of thyristor at kA^2s.
t=8.33;                      //Operating tine of thyristor in milli second.
it=4650;                     //R
Itsm=10;                     //
I=540;                       //Current rating of fuse in ampere.
Imax=8500;                   //Maximum fuse current in ampere.
Pt=280;                      //Power rating of fuse in KA^2.
tc=8;                        //Total clearing time in milli second.
L=0.07;                      //Inductance in milli Henry.
Isc=Vs/(2*%pi*f*L*10^-3);//Calculating the short circuit current.
printf("\n\tThe short circuit current Isc is %0.0fA",Isc);
//Some answeres are changed due to round off error.
```