Scilab Textbook Companion for Introduction to Electric Drives by V. Singhal[1]

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Book Description

Title: Introduction to Electric Drives

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Thyristors Principles and Characteristics

Scilab code Exa 1.1 Anode Current

```
//Example 1_1
clc;
clear;close;

//Given data
alfa1=0.35;
alfa2=0.4;
IG=40*10^-3;//A

//Solution :
IA=alfa2*IG/(1-(alfa1+alfa2));//A
disp(IA,"Anode current in A : ");
```

Scilab code Exa 1.2 Equivalent capacitance

```
//Example 1_2
```

```
clc;
clear;close;

//Given data
dv_dt=190;//V/ s
IC=8*10^-3;//A

//Solution :
C=IC/(dv_dt/10^-6);//F
disp(C,"Capacitance of depletion layer in F : ");
```

Scilab code Exa 1.3 Find various voltages

```
//Example 1_3
clc;
clear;close;

//Given data
RG=2000;//ohm
VCC=20;//V
VT=0.75;//V
Vthy=0.7;//V(Voltage across thyristor)
R=200;//ohm
IT=7*10^-3;//A
Ih=5*10^-3;//A


//Solution :
//part (a)
Vo=VCC;//V////thyristor not conducting
disp(Vo,"(a) When thyristor is in off state, Output voltage in V")
//part (b)
Vs=VT+IT*RG;//V
disp(Vs,"(b) Voltage necessary to turn on the
```

```
thyristor in V")
//part (c)
VR1=Ih*R;//V
disp("(c) Current through thyristor should be less than holding current. Voltage should be reduced to less than "+string(VR1)+" V")
//part (d)
VR2=VR1+Vthy;//V
disp("(d) VCC should be reduced to less than "+string(VR2)+" V")
```

Scilab code Exa 1.4 Find VG IG and RG

```
//Example 1_4
clc;
clear;close;

//Given data
IG=poly(0,'IG');//A
VG=1+9*IG;//V
Vgate=25;//V
t=%pi;//radian(duration)
Pavg=0.6;//W

//Solution :
Ploss=Pavg*2*%pi/t;//W
//Ploss=VG*IG
X=VG*IG-Ploss;
IG=roots(X);//A
IG=IG(2);//A(taking +ve value only)
VG=1+9*IG;//V
//Vgate=RG*IG+VG
RG=(Vgate-VG)/IG;//ohm
disp(VG,"VG in V");
disp(IG,"IG in A");
```

```
disp(RG,"RG in ohm");
```

Scilab code Exa 1.5 Minimum width of gate pulse

```
//Example 1_5
clc;
clear;close;

//Given data
Vdc=100;//V
L=10;//H
i=80*10^-3;//A

//Solution :
t=i*L/Vdc;//s
disp("Width of pulse should be more than "+string(t
    *1000)+" milli-seconds.");
```

Scilab code Exa 1.6 Minimum width of gate pulse

```
//Example 1_6
clc;
clear;close;

//Given data
Vdc=100;//V
R=10;//ohm
L=5;//H
i=50*10^-3;//A

//Solution :
//i=Vdc/R*(1-exp(-R*t/L))
t=-log(1-i/Vdc*R)/R*L;//s
```

```
disp("Minimum width of gate pulse is "+string(t*1000)+" milli-seconds.");
```

Scilab code Exa 1.7 Maximum value of R

```
//Example 1_7
clc;
clear;close;

//Given data
i_latch=40*10^-3;//A
t=40*10^-6;//s
Vdc=90;//V
R=25;//ohm
L=0.5;//H

//Solution :
i=Vdc/R*(1-exp(-R*t/L));//A
disp("Current in the circuit is "+string(i)+" A, it is less than latchig current, the thyristor will not turn on.");
R=Vdc/(i_latch-i);//ohm
disp("Maximum value of R is "+string(R)+" ohm.");
```

Scilab code Exa 1.8 Maximum value of R

```
//Example 1_8
clc;
clear;close;

//Given data
i_h=50*10^-3;//A
t=50*10^-6;//s
```

```
Vdc=100; //V
R=20; //ohm
L=0.5; //H

//Solution :
i=Vdc/R*(1-exp(-R*t/L)); //A
//i<i_h ;;; so thyristor will return to off state
iR=i_h-i; //A//current through R
R=Vdc/iR; //ohm
disp("Maximum value of R is "+string(R)+" ohm.");
```

Scilab code Exa 1.9 Find Triggering angle

```
//Example 1_9
clc;
clear;close;

//Given data:
V=240; //Volt
f=50; //Hz
R=5; //ohm
L=0.05; //H
theta=atand(2*%pi*f*L/R); //degree
Vm=V*sqrt(2); //Volt
//sind(fi-theta)=0;//for no current transient
fi=theta+asind(0); //degree
disp(fi,"For no current transient, triggering angle
    in degree");
//sind(fi-theta)=1;//for worst current transient
fi=theta+asind(1); //degree
disp(fi,"For worst current transient, triggering
    angle in degree");
```

Scilab code Exa 1.12 RMS current and form factor

```
//Example 1_12
clc;
clear;close;

//Given data:
I=120;//A
Gamma=180;//degree
RMS_current=I*sqrt(Gamma/360);//A
AVG_current=I*(Gamma/360);//A
FormFactor=RMS_current/AVG_current;//no unit
disp(RMS_current,"rms current (in A) : ");
disp(FormFactor,"Form Factor : ");
```

Scilab code Exa 1.13 Power supplied

```
//Example 1_13
clc;
clear;close;

//Given data:
V=130;//V
R=100;//ohm
theta1=60;//degree
theta2=45;//degree
v=sqrt(2)*V;//
Irms=sqrt(1/2/%pi*integrate('(3.25*sin(omega_t))^2',
    'omega_t',theta1*%pi/180,%pi));//A
P=Irms^2*R;//W
disp(P,"(a) Power supplied to load (in W) : ");
Irms=sqrt(1/2/%pi*integrate('(3.25*sin(omega_t))^2',
    'omega_t',theta2*%pi/180,%pi));//A
P=Irms^2*R;//W
disp(P,"(a) Power supplied to load (in W) : ");
```

Scilab code Exa 1.14 Average power loss

```
//Example 1_14
clc;
clear;close;

//Given data:
Iavg=200;//A
period1=2*%pi;
period2=%pi;
Vth1=1.8;//V
I1=200;//A
Vth2=1.9;//V
I2=400;//A
//part (a)
Ploss1=I1*Vth1*period1/2/%pi;//W
disp(Ploss1,"(a) Average power loss (in W) : ");
Ploss2=I2*Vth2*period2/2/%pi;//W
disp(Ploss2,"(b) Average power loss (in W) : ");
```

Scilab code Exa 1.15 Average on state current

```
//Example 1_15
clc;
clear;close;

//Given data:
Irms=40;//A
f=50;//Hz
period1=170;//degree
period2=100;//degree
```

```
period3=40;//degree
//part (a)
alfa1=%pi-period1*%pi/180;//degree
Irms_by_Im=sqrt(1/2/%pi*((%pi-alfa1)/2+sin(2*alfa1)
   /4));
Im=Irms/Irms_by_Im;//A
Iav1=Im/2/%pi*(1+cos(alfa1));//A
disp(Iav1,"(a) Average current (in A) : ");
//part (b)
alfa2=%pi-period2*%pi/180;//degree
Irms_by_Im=sqrt(1/2/%pi*((%pi-alfa2)/2+sin(2*alfa2)
   /4));
Im=Irms/Irms_by_Im;//A
Iav2=Im/2/%pi*(1+cos(alfa2));//A
disp(Iav2,"(b) Average current (in A) : ");
//part (c)
alfa3=%pi-period3*%pi/180;//radian
Irms_by_Im=sqrt(1/2/%pi*((%pi-alfa3)/2+sin(2*alfa3)
   /4));
Im=Irms/Irms_by_Im;//A
Iav3=Im/2/%pi*(1+cos(alfa3));//A
disp(Iav3,"(c) Average current (in A) : ");
```

Scilab code Exa 1.16 Mean power dissipation

```
//Example 1_16
clc;
clear;close;

//Given data:
//VT=0.9+0.02*IT;//V
//part (a)
IT=20;//A
VT=0.9+0.02*IT;//V
Pdiss=VT*IT;//W
```

```
disp(Pdiss,"(a) Mean power dissipation (in W) : ");
//part (b)
IT_mean=20;//A
IT_peak=20*%pi;//A
Pdiss=1/2/%pi*integrate('(0.9+0.02*IT_peak*sin(theta
    ))*(IT_peak*sin(theta))','theta',0,%pi);//W
disp(Pdiss,"(b) Mean power dissipation (in W) : ");
//part (c)
IT=20;//A//for half cycle
VT=0.9+0.02*IT;//V
Pdiss=VT*IT/2;//W
disp(Pdiss,"(c) Power dissipation occur only during
    half cycle. Mean power dissipation (W)");
//part (d)
IT=20;//A//for half cycle
VT=0.9+0.02*IT;//V
Pdiss=VT*IT/3;//W
disp(Pdiss,"(d) Power dissipation occur only during
    1/3rd period in a cycle. Mean power dissipation (
   W)");
```

Scilab code Exa 1.17 Current rating and I2t rating

```
//Example 1_17
clc;
clear;close;

//Given data
Isub=2000;//A
f=50;//Hz
t=10*10^-3;//s
T=2*t;//s//duration of half cycle
I=sqrt(Isub^2*t/T);//A
I2t=I^2*t;//A^2 seconds
disp(I2t,"I^2*t rating in A^2-seconds");
```

Scilab code Exa 1.18 Series resistance and average gate power loss

```
//Example 1_18
clc;
clear;close;

//Given data
Vgate=12;//V
t=60*10^-6;//s
cycle=0.3;
P_peak=6;//W
//part (a)
//P_peak=Vg*Ig leads to 9*Ig^2+Ig-P_peak=0
X=[9 1 -6];//polynomial
Ig=roots(X);//A
Ig=Ig(2);//A(taking +ve value)
Vg=1+9*Ig
Rg=(Vgate-Vg)/Ig;//ohm
disp(Rg,"Series resistance Rg in ohm");
PavgLoss=P_peak*cycle;//W
disp(PavgLoss,"Average power loss in W ");
```

Scilab code Exa 1.19 Source Resistance Trigger Current and voltage

```
//Example 1_19
clc;
clear;close;

//Given data
Vs=12;//V
P=0.3;//W
```

```
Rs=100;//ohm//as slope is −100V/A
//Vs=Vg+Ig*Rg leads to Rs*Ig^2−Vs*Ig+P=0
X=[Rs -Vs P];//polynomial
Ig=roots(X);//A
Ig=Ig(2);//A(taking one value)
disp(Rs,"Source resistance, Rs in ohm ");
disp(Ig*1000,"Trigger current in mA ");
Vg=P/Ig;//V
disp(Vg,"Voltage Vg in V ");
```

Scilab code Exa 1.20 Find Rs R1 and R2

```
//Example 1_20
clc;
clear;close;

//Given data
V=800;//V
I=110;//A
Es=12;//V
Im=250;//mA
Ish=600;//mA
VG=2.4;//V
IG=50;//mA
IGm=100;//mA
VGm=3;//V
Rs=Es/(Ish*10^-3);//ohm
disp(Rs,"Value of Rs in ohm ");
R1=Es/(Im*10^-3)-Rs;//ohm(Assumed R2 is not
    connected)
//Rs_plus_R1>=Es/(IGm*10^−3);//ohm
Rs_plus_R1=Es/(IGm*10^-3);//ohm
R1_Lower=Rs_plus_R1-Rs;//ohm
//Rs_plus_R1<=(Es−VG)/(IGm*10^−3);//ohm
Rs_plus_R1=(Es-VG)/(IG*10^-3);//ohm
```

```
R1_Upper=Rs_plus_R1-Rs;//ohm
disp("R1 must be more than "+string(R1_Lower)+" ohm
    and less than "+string(R1_Upper)+" ohm.")
disp("Let R1 is 125 ohm.");
R1=125;//ohm
//R2*Es/(R1+R2+Rs)<=VGm
R2=(VGm*R1+VGm*Rs)/(Es-VGm);//ohm
disp("R2<="+string(R2)+" ohm ")
disp("Let R2 is 48 ohm.");
```

Scilab code Exa 1.21 Finf thermal resistance

```
//Example 1_21
clc;
clear;close;

//Given data:
l=0.2;//m
w=0.01;//m
d=0.01;//m
P=3;//W
Tc=220;//W/m/degreeC
T1=30;//degreeC
theta=l/Tc/w/d;//degreeC/W
T2=P*theta+T1;//degreeC
disp(T2,"Temperature of the surface in degree C ");
```

Scilab code Exa 1.22 Find maximum losses

```
//Example 1_22
clc;
clear;close;

```

```
//Given data:
l=2/1000;//m
A=12/10000;//m^2
T21=4;//degreeC(T2-T1)
Tc=220;//W/m/degreeC
theta=l/Tc/A;//degreeC/W
Losses=T21/theta;//W
disp(Losses,"Maximum losses in W");
```

Scilab code Exa 1.23 Thermal resistance of heat sink

```
//Example 1_23
clc;
clear;close;

//Given data:
P=30;//W
T1=125;//degreeC
T2=50;//degreeC
theta=1;//degree C/W
theta_mica=0.3;//degree C/W
Rth_total=(T1-T2)/P;//degree C/W
Rth_heat_sink=Rth_total-theta-theta_mica;//degree C/W
disp(Rth_heat_sink,"Thermal resistance of heat sink in degree C/W");
```

Scilab code Exa 1.24 Find Junction temperature

```
//Example 1_25
clc;
clear;close;

```

```
//Given data:
T1=120;//degreeC(Junction Temperature)
T2=35;//degreeC(Ambient Temperature)
P=40;//W
theta_dash=0.8;//degree C/W(junction to heat sink)
theta=(T1-T2)/P;//degree C/W
disp(theta-theta_dash,"Resistance of heat sink in
    degree C/W");
```

Scilab code Exa 1.25 Maximum thermal resiatance

```
//Example 1_25
clc;
clear;close;

//Given data:
T1=120;//degreeC(Junction Temperature)
T2=35;//degreeC(Ambient Temperature)
P=40;//W
theta_dash=0.8;//degree C/W(junction to heat sink)
theta=(T1-T2)/P;//degree C/W
disp(theta-theta_dash,"Resistance of heat sink in
    degree C/W");
```

Scilab code Exa 1.26 Average power loss and increase in rating

```
//Example 1_26
clc;
clear;close;

//Given data:
Tj=125;//degreeC
Ts=80;//degreeC
```

```
theta_jc=0.7;//degree C/W
theta_cs=0.4;//degree C/W
//part (a)
Pav1=(Tj-Ts)/(theta_jc+theta_cs);//W
disp(Pav1,"(a) Average power loss in W")
//part (b)
Ts=50;//degreeC
Pav2=(Tj-Ts)/(theta_jc+theta_cs);//W
disp(Pav2,"(b) Permisible average power loss in W")
rating_increase=(sqrt(Pav2)-sqrt(Pav1))/sqrt(Pav1)*100;//%
disp(rating_increase,"Percentage increase in rating")
```

Scilab code Exa 1.27 Minimum and maximum firing angle

```
//Example 1_27
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
vc=25;//V
C=0.6*10^-6;//F
R=2000:20000;//ohm
Xc=1/(2*%pi*f*C);//ohm
//When R=2000 ohm
Z=min(R)-%i*Xc;//ohm
I=Vs/Z;//A
Vc=-%i*I*Xc;//V
//vc=sqrt(2)*abs(Vc)*sind(omega_t+atand(imag(Vc),real(Vc)))
omega_t=asind(vc/sqrt(2)/abs(Vc))-atand(imag(Vc),real(Vc));//degree
```

```
alfa1=omega_t;//degree

//When R=20000 ohm
Z=max(R)-%i*Xc;//ohm
I=Vs/Z;//A
Vc=-%i*I*Xc;//V
//vc=sqrt(2)*abs(Vc)*sind(omega_t+atand(imag(Vc),
    real(Vc)))
omega_t=asind(vc/sqrt(2)/abs(Vc))-atand(imag(Vc),
    real(Vc));//degree
alfa2=omega_t;//degree
disp(alfa1,"Minimum firing angle in degree")
disp(alfa2,"Maximum firing angle in degree")
```

Scilab code Exa 1.28 Design a UJTcircuit

```
//Example 1_28
clc;
clear;close;

//Given data:
V=32;//V
Eta=0.63;
Ip=10*10^-6;//A
Vv=3.5;//V
Iv=10*10^-3;//A
Vf=0.5;//V
f=50;//Hz
tau=50*10^-3;//s
T=1/f//s
Vp=Eta*V+Vf;//V
C=0.4*10^-6;//F//assumed
disp(C*10^6,"Suitable value of C in micro F ")
//V-Ip*R>Vp
R_upper=(V-Vp)/Ip;//ohm
```

```
//V-Iv*R<Vv
R_lower=(V-Vv)/Iv;//ohm
disp("Value of R should be lie between "+string(
    R_lower)+" ohm to "+string(R_upper)+" ohm")
R=T/C/log(1/(1-Eta));//ohm
disp(R,"Suitale value of R in ohm ");
R4=tau/C;//ohm
disp(R4,"Suitale value of R4 in ohm ");
R3=10^4/Eta/V;//ohm
disp(R3,"Suitale value of R3 in ohm ");
//Answer for R4 is wrong in the book
```

Scilab code Exa 1.29 Various component of circuit

```
//Example 1_29
clc;
clear;close;

//Given data:
f=2*1000;//Hz
Vdc=10;//V
Eta=0.6;
Ip=5*10^-3;//A
Vf=0.5;//V//assumed
Vp=Eta*Vdc+Vf;//V
//Vdc-Ip*R>Vp
R_upper=(Vdc-Vp)/Ip;//ohm
disp("Value of R should be less than "+string(
    R_upper)+" ohm")
C=0.5*10^-6;//F//assumed
disp(C*10^6,"Let value of C in micro F ")
T=1/f//s
R=T/C/log(1/(1-Eta));//ohm
disp("For C=0.5 micro F, calculated value of R "+
    string(R)+" ohm. But it is not suitable");
```

```
C=1*10^-6;//F//assumed
disp(C*10^6,"Let value of C in micro F ")
R=T/C/log(1/(1-Eta));//ohm
disp("For C=1 micro F, calculated value of R "+
   string(R)+" ohm. It is suitable");
```

Scilab code Exa 1.30 Range of firing angle

```
//Example 1_30
clc;
clear;close;

//Given data:
Vs=230;//V
R=1000:22000;//ohm
Vg=2;//V
C=0.47*10^-6;//F
f=50;//Hz
Xc=1/(2*%pi*f*C);//ohm
//When R=1000 ohm
theta=atand(min(R)/Xc);//degree
Z=min(R)-%i*Xc;//ohm
I=Vs/Z;//A
Vc=-%i*I*Xc;//V
//vc=sqrt(2)*abs(Vc)*sind(omega_t+atand(imag(Vc),
   real(Vc)))
omega_t=asind(Vg/sqrt(2)/abs(Vc))-atand(imag(Vc),
   real(Vc));//degree
alfa1=omega_t;//degree
//When R=22000 ohm
Z=max(R)-%i*Xc;//ohm
I=Vs/Z;//A
Vc=-%i*I*Xc;//V
//vc=sqrt(2)*abs(Vc)*sind(omega_t+atand(imag(Vc),
   real(Vc)))
```

```
omega_t=asind(Vg/sqrt(2)/abs(Vc))-atand(imag(Vc),real(Vc));//degree
alfa2=omega_t;//degree
disp(alfa1,"Minimum firing angle in degree")
disp(alfa2,"Maximum firing angle in degree")
```

Scilab code Exa 1.31 Time of conduction

```
//Example 1_31
clc;
clear;close;

//Given data:
R=0.8;//ohm
L=10*10^-6;//H
C=50*10^-6;//F
//R<sqrt(4*L/C)
Rupper=sqrt(4*L/C);//ohm
disp("Maximum value of R should be "+string(Rupper)+" ohm")
disp("Given value of R is "+string(R)+" ohm. The circuit is underdamped.")
t0=%pi/sqrt(1/L/C-R^2/4/L^2);//s
disp(t0,"Time of conduction of thyristor in seconds")
```

Scilab code Exa 1.32 Find value of L and C

```
//Example 1_32
clc;
clear;close;

//Given data:
```

```
V=90; //V
Iload=8; //A
t_off=40*10^-6; //s
//Ipeak=2*Iload;//assumed
//V*sqrt(C/L)=2*Iload
C_by_L=(2*Iload/V)^2;
//t_off=%pi/2*sqrt(L*C)
L_into_C=(t_off/%pi*2)^2;
C=sqrt(L_into_C*C_by_L); //F
L=L_into_C/C; //H
disp(L,"Value of L(H)");
disp(C,"Value of C(F)");
```

Scilab code Exa 1.33 Find value of C

```
//Example 1_33
clc;
clear;close;

//Given data:
RL=10; //ohm
V=100; //V
t_off=50*10^-6; //s
C=t_off/RL/log(2); //F
disp(C,"Value of C(F)");
```

Scilab code Exa 1.34 Find value of L and C

```
//Example 1_34
clc;
clear;close;

//Given data:
```

```
IL=40;//A
VC=100;//V
t_off=60*10^-6;//s
C=t_off*IL/VC;//F
disp(C,"Value of C(F)");
//L>VC^2*C/IL
L_lower=VC^2*C/IL^2;//H
Ip=VC*sqrt(C/L_lower);//A
disp("Value of L should be greater than "+string(
    L_lower)+" H. For this value of L, Peak capacitor
     current is "+string(Ip)+" A. But it should be
    less than maximum load current.")
//Let Ip=34.6 A
Ip=34.6;//A
L=C/(Ip/VC)^2;//H
disp(L,"Value of L(H)");
```

Scilab code Exa 1.35 Current rating of thyristor

```
//Example 1_35
clc;
clear;close;

//Given data:
Vdc=100;//V
L=0.1*10^-3;//H
C=10*10^-6;//F
Vc=100;//V
t_off_thyristor=25*10^-6;//s
IL=10;//A
t_off=Vc*C/IL;//s
disp("T_off is "+string(t_off)+" seconds. It is
    greater than thristor turn off time, so it is
    sufficient for communication.")
Ip=Vdc*sqrt(C/L);//A
```

```
disp(Ip,"Current rating(A)");
```

Scilab code Exa 1.36 Find value of R and C

```
//Example 1_36
clc;
clear;close;

//Given data:
dv_by_dt=25/10^-6;//V/s
L=0.2*10^-3;//H
Vrms=230;//V
damping=0.65;//damping factor
Vm=sqrt(2)*Vrms;//V
C=1/(2*L)*[0.564*Vm/dv_by_dt]^2;//F
R=2*damping*sqrt(L/C);//ohm
disp(C,"Value of C(F)");
disp(R,"Value of R(ohm)");
```

Scilab code Exa 1.37 Value of R and C Power loss and rating

```
//Example 1_37
clc;
clear;close;

//Given data:
V=300;//V
RL=10;//ohm
L=0;//H
Ith=100;//A
f=2000;//Hz
dv_by_dt=100*10^6;//V/s
//dv/dt=(vth(tau)-vth(0))/tau
```

```
//dv/dt=RL*(1-0.368)*V/(R+RL)/((R+RL)*C)
R=V/Ith;//ohm
C=RL*(1-0.368)*V/(R+RL)/(R+RL)/dv_by_dt
disp(R,"Value of R(ohm)");
disp(C,"Value of C(F)");
Ploss=1/2*C*V^2*f;//W
disp(Ploss,"Power loss in snubber circuit(W)")
disp("Power rating of resitance is "+string(Ploss)+"
    W as all energy will be disspated in the
    resistance.")
```

Scilab code Exa 1.38 Value of dvbydt and dibydt

```
//Example 1_38
clc;
clear;close;

//Given data:
R=4;//ohm
L=6*10^-6;//H
C=6*10^-6;//F
V=300;//V
di_by_dt_max=V/L;//A/s
Isc=V/R;//A
dvc_by_dt=R*di_by_dt_max+Isc/C;//V/s
disp(di_by_dt_max,"Maximum permissible value of di/
    dt(A/s)");
disp(dvc_by_dt,"Maximum permissible value of dv/dt(V
    /s)");
```

Scilab code Exa 1.39 Design a snubber circuit

```
//Example 1_39
```

```
clc;
clear;close;

//Given data:
RL=8;//ohm
V=230;//V
Ip=100;//A
SF=2;//safety factor
di_by_dt_max=40/10^-6/2;//A/s
dv_by_dt_max=150/10^-6/2;//V/s

 L=sqrt(2)*V/di_by_dt_max;//H
disp(L,"Value of L(H)");
R=L/(sqrt(2)*V)*dv_by_dt_max;//ohm
disp(R,"Value of R(ohm)");
IL_peak=(sqrt(2)*V)/RL;//A
Ic_peak=(sqrt(2)*V)/R;//A
Itotal=IL_peak+Ic_peak;//A
disp(Itotal,"Total current through capacitor for these values(A)");
disp("Itotal>Ip, therefore value of R should be increased.");
Ic_max=Ip-IL_peak;//A
R=(sqrt(2)*V)/Ic_max;//ohm
R=ceil(R);//ohm
disp(R,"New Value of R(ohm)");
damping=0.65;
C=4*damping^2*L/R^2;//F
disp(C*10^6,"Value of C(micro F)");
disp(L*10^6,"Value of L(micro H)");
//Ic_switching=C*dv/dt
dv_by_dt=sqrt(2)*V/(R+RL)/C;//V/s
disp("Value of dv/dt is "+string(dv_by_dt)+" V/s. It is within the limit for the calculated value of R, L & C. Design is safe.")
```

Scilab code Exa 1.40 Fault clearing time

```
//Example 1_40
clc;
clear;close;

//Given data:
V=230;//V
R1=2;//ohm
R2=5;//ohm
R3=1;//ohm
R4=6;//ohm
R5=5;//ohm
Isqr_t=30;//A^2-s
R=R1+R2*R3/(R2+R3);//ohm(X grounded)
Ifault=sqrt(2)*V/R;//A
tc=Isqr_t/Ifault^2;//s
disp(tc,"Fault clearing time in seconds");
```

Chapter 2

Phase Controlled Rectifiers

Scilab code Exa 2.1 Average Load and rms load voltage and current

```
//Example 2_1
clc;
clear;close;

//Given data:
Vin=400;//V
alfa=30;//degree
R=50;//ohm

//Solution :
Vdc=Vin/%pi/2*(1+cosd(alfa));//V
disp(Vdc,"Average load voltage(V) : ");
I=Vdc/R;//A
disp(I,"Average load current(A) : ");
Vrms=Vin*sqrt((180-alfa)/4/180+sind(2*alfa)/8/%pi);
    //V
disp(Vrms,"rms load voltage(V) : ");
Irms=Vrms/R;//A
disp(Irms,"rms load current(A) : ");
```

Scilab code Exa 2.2 Find average curren

```
//Example 2_2
clc;
clear;close;

//Given data:
Vo=50;//V
R=10;//ohm
//Vin=100*sin(omega*t);//V
Vm=100;//V

//Solution :
omega_t=asin(Vo/Vm);//radian
Iavg=1/2/%pi*integrate('(Vm*sin(omega_t)-Vo)/R','
    omega_t',omega_t,omega_t+2*%pi/3);//A
disp(Iavg,"Average current in the circuit(A) : ");
```

Scilab code Exa 2.3 Find average current

```
//Example 2_3
clc;
clear;close;

//Given data:
Eb=55.5;//V
R=10;//ohm
//Vin=110*sin(omega*t);//V
Vm=110*sqrt(2);//V

//Solution :
omega_t=asind(Eb/Vm);//degree
```

```
Iavg=1/2/180*integrate('(Vm*sind(omega_t)-Eb)/R','
    omega_t',omega_t,180-omega_t);//A
disp(Iavg,"Average current in the circuit(A) : ");
```

Scilab code Exa 2.4 Vdc Idc Vrms Irms

```
//Example 2_4
clc;
clear;close;

//Given data:
Vs=230;//V
R=15;//ohm
alfa=%pi/2;//radian

//Solution :
Vm=sqrt(2)*Vs;//V
Vdc=Vm/2/%pi*(1+cos(alfa));//V
disp(Vdc,"Vdc(V) : ");
Idc=Vdc/R;//A
disp(Idc,"Idc(A) : ");
Vrms=Vm*sqrt((%pi-alfa)/4/%pi+sin(%pi)/8/%pi);//V
disp(Vrms,"Vrms(V) : ");
Irms=Vrms/R;//A
disp(Irms,"Irms(A) : ");
Pdc=Vdc*Idc;//W
disp(Pdc,"Pdc(W) : ");
Pac=Vrms*Irms;//W
disp(Pac,"Pac(W) : ");
R_eff=Pdc/Pac;//rectification efficiency
disp(R_eff,"Rectification efficiency(unitless) : ");
Kf=Vrms/Vdc;//Form factor
disp(Kf,"Form factor(unitless) : ");
Kr=sqrt(Kf^2-1);//Ripple factor
disp(Kr,"Ripple factor(unitless) : ");
```

```
VA_rating=Vs*Irms;//VA
disp(VA_rating,"VoltAmpere rating(VA) : ");
TUF=Pdc/VA_rating;//Transformer utilization factor
disp(TUF,"Transformer utilization factor(unitless) : ");
PIV=Vm;//V
disp(PIV,"Peak Inverse Voltage across thyristor(V) : ");
//Ans in the book is wrong for some part.
```

Scilab code Exa 2.5 Vdc Vrms Irms

```
//Example 2_5
clc;
clear;close;

//Given data:
Vo=150;//V
R=30;//ohm
alfa=45;//degree

//Solution :
Vdc=sqrt(2)*Vo/%pi*(1+cosd(alfa));//V
disp(Vdc,"Average dc Voltage(V) : ");
Iavg=Vdc/R;//A
disp(Iavg,"Average load current(A) : ");
Vrms=sqrt(2)*Vo*sqrt((180-alfa)/2/180+sind(90)/4/%pi);//V
disp(Vrms,"rms load Voltage(V) : ");
Irms=Vrms/R;//A
disp(Irms,"rms load current(A) : ");
```

Scilab code Exa 2.6 Turn ratio VA rating PIV

```
//Example 2_6
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
Vdc=100;//V
Ip=15;//A
alfa=30;//degree

//Solution :
Vm=Vdc*%pi/(2*cosd(alfa))+1.7;//V
Vrms_2nd=Vm/sqrt(2);//V
TurnRatio=Vs/Vrms_2nd;
disp(TurnRatio,"(a) Turn ratio of transformer");
Irms_2nd=sqrt(Ip^2/2);//A
Rating=2*Vrms_2nd*Irms_2nd;//VA
disp(Rating,"(b) Transformer rating in VA");
PIV=2*Vm;//V
disp(PIV,"(c) PIV in V");
disp(Irms_2nd,"(d) RMS value of thyristor current in
    A");
///Answer in the book is wrong for some part.
```

Scilab code Exa 2.7 Rated voltage of thyristor

```
//Example 2_7
clc;
clear;close;

//Given data:
P=10;//kW
Idc=50;//A
SF=2;//safety factor
```

```

//Solution :
Vdc=P*1000/Idc;//V
alfa=0;//degree
Vm=Vdc*%pi/(2*cosd(alfa))+1.7;//V
PIV=2*Vm;//V
Vthy=SF*PIV;//V
disp(Vthy,"(a) Voltage rating of thristor in V");
PIV=Vm;//V//for bridge rectifier
Vthy=SF*PIV;//V
disp(Vthy,"(b) Voltage rating of thristor in V");
///Answer in the book is wrong.
```

Scilab code Exa 2.8 Firing angle and power factor

```
//Example 2_8
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
Io=15;//A
R=0.5;//ohm
L=0.3;//H
E1=100;//V
E2=-100;//V

//Solution :
///part (a)
Vm=sqrt(2)*Vs;//V
//2*Vm/%pi*cosd(alfa)=E1+Io*R
alfa1=acosd((E1+Io*R)/(2*Vm/%pi));//degree
disp(alfa1,"(a) Firing angle in degree");
///part (b)
```

```
alfa2=acosd((E2+Io*R)/(2*Vm/%pi));//degree
disp(alfa2,"(b) Firing angle in degree");
disp("Part(c)");
//Pin=Vs*Io*cosd(theta)
Pout=E1*Io+Io^2*R;//W
//Pin=Pout
cos_theta=(Pout/Vs/Io);//laging
disp(cos_theta,"When E=100, input power factor(lagging)");
Pout=-E2*Io-Io^2*R;//W
//Pin=Pout
cos_theta=(Pout/Vs/Io);//laging
disp(cos_theta,"When E=-100, input power factor(lagging)");
```

Scilab code Exa 2.9 Average load current

```
//Example 2_9
clc;
clear;close;

//Given data:
V=230;//V
f=50;//Hz
R=5;//ohm
L=8*10^-3;//H
E=50;//V
alfa=40;//degree

//Solution :
//Vdc=2*sqrt(2)*V*cosd(alfa)/%pi=E+Io*R
Io=(2*sqrt(2)*V*cosd(alfa)/%pi-E)/R;//A
disp(Io,"Average value of load current in A");
```

Scilab code Exa 2.10 Average load current

```
//Example 2_10
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
Vdc=100;//V
Ip=15;//A
alfa=30;//degree

//Solution :
//Vdc=2*Vm*cosd(alfa)/%pi-2*1.7//(Full converter bridge)
Vm=(Vdc+2*1.7)/2/cosd(alfa)*%pi;//V
Vrms=Vm/sqrt(2);//V
TurnRatio=Vs/Vrms;
disp(TurnRatio,"(a) Turn ratio of transformer");
Irms=sqrt(Ip^2/2);//A
Rating=Vrms*Ip;//VA
disp(Rating,"(b) Transformer rating in VA");
PIV=Vm;//V
disp(PIV,"(c) PIV in V");
disp(Irms,"(d) RMS value of thyristor current in A");
```

Scilab code Exa 2.11 Vrms Vdc Form factor

```
//Example 2_11
clc;
```

```
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
alfa=90;//degree

//Solution :
Vm=Vs*sqrt(2);//V
Vdc=Vm/%pi*(1+cosd(alfa))//V
disp(Vdc,"Vdc in V");
Vrms=Vm/sqrt(2)*sqrt(1/%pi*[%pi-%pi/2+sin(%pi)/2]);//V
disp(Vrms,"Vrms in V");
FormFactor=Vrms/Vdc;
disp(FormFactor,"Form factor");
```

Scilab code Exa 2.12 Vrms Vdc form factor power factor

```
//Example 2_12
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
alfa=90;//degree

//Solution :
Vm=Vs*sqrt(2);//V
Vdc=Vm/%pi*(1+cosd(alfa))//V
disp(Vdc,"Vdc in V");
Vrms=Vm/sqrt(2)*sqrt(1/%pi*[%pi-%pi/2+sin(%pi)/2]);//V
disp(Vrms,"Vrms in V");
```

```
Is_by_I=sqrt(1-%pi/2/%pi);
Is1_by_I=2*sqrt(2)/%pi*cos(%pi/4);
HF=sqrt((Is_by_I/Is1_by_I)^2-1);//unitless
disp(HF,"Harmonic factor");
theta1=-alfa/2*%pi/180;//radian
DF=cos(theta1);//unitless
disp(DF,"Displacement factor");
PF=(Is1_by_I/Is_by_I)*DF;//lagging
disp(PF,"Power factor(lagging)");
```

Scilab code Exa 2.13 Vrms Vdc form factor power factor

```
//Example 2_13
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
alfa=%pi/3;//radian

//Solution :
Vm=Vs*sqrt(2);//V
Vdc=2*Vm/%pi*cos(alfa)//V
disp(Vdc,"Vdc in V");
Vrms=Vs;//V
disp(Vrms,"Vrms in V");
Is_by_I=sqrt(1-%pi/2/%pi);
Is1_by_I=2*sqrt(2)/%pi*cos(%pi/4);
HF=sqrt((Is_by_I/Is1_by_I)^2-1);//unitless
disp(HF,"Harmonic factor");
fi1=-alfa;//radian
DF=cos(fi1);//unitless
disp(DF,"Displacement factor");
PF=(Is1_by_I/Is_by_I)*DF;//lagging
```

```
disp(PF,"Power factor(lagging)");
```

Scilab code Exa 2.14 Find output volage and current

```
//Example 2_14
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
alfa=30*%pi/180;//radian
I=4;//A

//Solution :
disp("part (a)");
Vm=Vs*sqrt(2);//V
Vdc=2*Vm/%pi*cos(alfa)//V
RL=Vdc/I;//ohm
IL=I*2*sqrt(2)/%pi;//A
Pin_active=Vs*IL*cos(alfa);//W
Pin_reactive=Vs*IL*sin(alfa);//vars
Pin_appearent=Vs*IL;//VA
disp(Vdc,"dc output voltage(V)");
disp(Pin_active,"Active power input(W)");
disp(Pin_reactive,"Reactive power input(vars)");
disp(Pin_appearent,"Appearent power input(VA)");
disp("part (b)");
Vdc=Vm/%pi*(1+cos(alfa))//V
IL=Vdc/RL;//A
I_fund=2*sqrt(2)/%pi*IL*cos(alfa/2);//A
Pin_active=Vs*I_fund*cos(alfa/2);//W
Pin_reactive=Vs*I_fund*sin(alfa/2);//vars
Pin_appearent=Vs*I_fund;//VA
disp(Vdc,"dc output voltage(V)");
```

```
disp(Pin_active,"Active power input(W)");
disp(Pin_reactive,"Reactive power input(vars)");
disp(Pin_appearent,"Appearent power input(VA)");
disp("part (c)");
Vdc=Vs/sqrt(2)/%pi*(1+cos(alfa))//V
Idc=Vdc/RL;//A
disp(Vdc,"dc output voltage(V)");
disp(Idc,"dc output current(A)");
```

Scilab code Exa 2.15 Voltage current and various factors

```
//Example 2_15
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
alfa=30;//degree
IL=10;//A

//Solution :
Vm=Vs*sqrt(2);//V
Vdc=2*Vm/%pi*cosd(alfa)//V
disp(Vdc,"(a) dc output voltage(V)");
Irms=IL;//A
disp(Irms,"(b) Irms in A");
Is1=2*sqrt(2)/%pi*IL;//A
disp(Is1,"(c) Fundamental component of input current in A");
DF=cosd(-alfa);//unitless
disp(DF,"(d) Displacement fator");
pf_in=Is1/IL*DF;//lagging
disp(pf_in,"(e) Input power fator(lagging)");
HF=sqrt((IL/Is1)^2-1);//unitless
```

```
disp(HF,"(f) Harmonic factor");
Vrms=Vs;//V
FF=Vrms/Vdc;//form fator
RF=sqrt(FF^2-1);//ripple fator
disp(RF,"(g) Ripple factor");
```

Scilab code Exa 2.16 Voltage current power factor and power disipated

```
//Example 2_16
clc;
clear;close;

//Given data:
Vs=240;//V
f=50;//Hz
alfa=60;//degree
RL=10;//ohm

//Solution :
Vm=Vs*sqrt(2);//V
Vdc=Vm/%pi*(1+cosd(alfa))//V
disp(Vdc,"(a) average load voltage(V)");
I=Vdc/RL;//A
Is=I*sqrt(1-alfa/180);//A
Irms=Is;//A
disp(Irms,"(b) rms input current(A)");
Is1=2*sqrt(2)/%pi*I*cosd(alfa/2);//A
fi1=-alfa/2;//degree
DF=cosd(fi1);//unitless
pf_in=Is1/Is*DF;//lagging
disp(pf_in,"(c) Input power fator(lagging)");
Pavg=I^2*RL;//W
disp(Pavg,"(d) Average power dissipated(W)");
```

Scilab code Exa 2.17 Firing angle Power and variation in firing angle

```
//Example 2_17
clc;
clear;close;

//Given data:
IL=200;//A
VL=400;//V
Vdc=360;//V
variation=10;//%

//Solution :
Vm=VL*sqrt(2)/sqrt(3);//V
//Vdc=3*sqrt(3)/%pi*Vm*cosd(alfa)//V
alfa=acosd(Vdc/(3*sqrt(3)/%pi*Vm))//degree
disp(alfa,"Firing angle in degree");
S=sqrt(3)*VL*IL;//VA
disp(S,"Apparent power(VA)");
P=S*cosd(alfa);//W
disp(P,"Active power(W)");
Q=sqrt(S^2-P^2);//vars
disp(Q,"Rective power(vars)");
Vac1=(1+variation/100)*VL;//V
alfa1=acosd(Vdc/(3*Vac1*sqrt(2)/%pi));//degree
Vac2=(1-variation/100)*VL;//V
alfa2=acosd(Vdc/(3*Vac2*sqrt(2)/%pi));//degree
disp(alfa1,"When variation is +10%, firing angle(
    degree)");
disp(alfa2,"When variation is -10%, firing angle(
    degree)");
//Answer in the book is wrong for some part.
```

Scilab code Exa 2.18 Pdc Current and PIV

```
//Example 2_18
clc;
clear;close;

//Given data:
Vs=400;//V
f=50;//Hz
Idc=150;//A
alfa=60;//degree

//Solution :
Vm=Vs*sqrt(2)/sqrt(3);//V
Vdc=3*sqrt(3)/%pi*Vm*cosd(alfa)//V
Pdc=Vdc*Idc;//W
disp(Pdc,"Output power, Pdc(W)");
Iavg=Idc/3;//A
disp(Iavg,"Average thyristor current(A)");
Irms=Idc/sqrt(3);//A
disp(Irms,"RMS value of thyristor current(A)");
Ipeak=Idc;//A
disp(Ipeak,"Peak current through thyristor(A)");
PIV=sqrt(2)*Vs;//V
disp(PIV,"Peak inverse voltage(V)");
//Answer of first part in the book is wrong.
```

Scilab code Exa 2.19 Firing angle Power and current

```
//Example 2_19
clc;
clear;close;
```

```

//Given data:
V=415;//V
Vdc=460;//V
I=200;//A
f=50;//Hz

//Solution :
Vm=V*sqrt(2)/sqrt(3);//V
alfa=acosd(Vdc/(3*sqrt(3)/%pi*Vm));//degree
disp(alfa,"Converter firing angle(degree)");
Pdc=Vdc*I;//W
disp(Pdc/1000,"dc power(kW)");
IL=I*sqrt(120/180);//A
disp(IL,"AC line current(A)");
Ipeak=I;//A
Irms=Ipeak*sqrt(120/360);//A
disp(Irms,"RMS value of thyristor current(A)");
Iavg=Ipeak/3;//A
disp(Iavg,"Average thyristor current(A)");
```

Scilab code Exa 2.20 Firing angle and power factor

```
//Example 2_20
clc;
clear;close;

//Given data:
Vs=230;//V
f=50;//Hz
emf=200;//V
Rint=0.5;//ohm
I=20;//A

//Solution :
```

```
Vm=Vs*sqrt(2)/sqrt(3);//V
Vdc=emf+Rint*I;//V
alfa=acosd(Vdc/(3*sqrt(3)/%pi*Vm));//degree
disp(alfa,"Firing angle(degree)");
Pout=emf*I+I^2*Rint;//W
Is=sqrt(I^2*120/180);//A
cos_theta=Pout/(sqrt(3)*Vs*Is);//power factor
disp(cos_theta,"Input power factor(lagging)");
```

Scilab code Exa 2.21 Firing angle current and power factor

```
//Example 2_21
clc;
clear;close;

//Given data:
Vs=400;//V
R=10;//ohm
f=50;//Hz

//Solution :
Vm=Vs*sqrt(2)/sqrt(3);//V
Vdc_max=3*sqrt(3)*Vm/2/%pi*(1+cosd(0));//V
//Vdc should be Vdc_max/2
Vdc=Vdc_max*50/100;//V
alfa=acosd(1-Vdc/(3*sqrt(3)*Vm/2/%pi));//degree
disp(alfa,"Firing angle(degree)");
Idc=Vdc/R;//A
disp(Idc,"Average output current(A)");
Vrms=sqrt(3)*Vm*sqrt(3/4/%pi*(%pi-%pi/2+sin(%pi)/2));//V
Irms=Vrms/R;//A
disp(Vrms,"RMS output voltage(V)");
disp(Irms,"RMS output current(A)");
Iavg_thy=Idc/3;//A
```

```
disp(Iavg_thy,"Average thyristor current(A)");
Irms_thy=Irms/sqrt(3);//A
disp(Irms_thy,"RMS thyristor current(A)");
Eff=Vdc*Idc/(Vrms*Irms)*100;//%
disp(Eff,"Rectification Efficiency(%)");
Iline_rms=Irms*sqrt(120/180);//A
VA_in=3*Vs*Iline_rms/sqrt(3);//VA
TUF=Vdc*Idc/VA_in;
disp(TUF,"Transformer utilisation factor");
Pin_active=Irms^2*R;//W
pf_in=Pin_active/VA_in;//lagging
disp(pf_in,"Input power factor(lagging)");
//Answer in the book is wrong for some part.
```

Scilab code Exa 2.22 Firing angle current and power factor

```
//Example 2_22
clc;
clear;close;

//Given data:
Vs=400;//V
R=10;//ohm
f=50;//Hz

//Solution :
Vm=Vs*sqrt(2)/sqrt(3);//V
alfa=60;//degree(For 50% output voltage)
Vdc=3*sqrt(3)*Vm/%pi*cosd(alfa);//V
alfa=acosd(Vdc/3/sqrt(3)/Vm*%pi);//V
disp(alfa,"Firing angle in degree");
Idc=Vdc/R;//A
disp(Idc,"Average output current(A)");
Vrms=sqrt(3)*Vm*sqrt(0.5+3*sqrt(3)/4/%pi*cosd(2*alfa
    ));//V
```

```
Irms=Vrms/R;//A
disp(Vrms,"RMS output voltage(V)");
disp(Irms,"RMS output current(A)");
Iavg_thy=Idc/3;//A
disp(Iavg_thy,"Average thyristor current(A)");
Irms_thy=Irms/sqrt(3);//A
disp(Irms_thy,"RMS thyristor current(A)");
Eff=Vdc*Idc/(Vrms*Irms)*100;//%
disp(Eff,"Rectification Efficiency(%)");
Iline_rms=Irms*sqrt(120/180);//A
VA_in=3*Vs*Iline_rms/sqrt(3);//VA
TUF=Vdc*Idc/VA_in;
disp(TUF,"Transformer utilisation factor");
Pin_active=Irms^2*R;//W
pf_in=Pin_active/VA_in;//lagging
disp(pf_in,"Input power factor(lagging)");
//Answer in the book is wrong for some part.
```

Scilab code Exa 2.25 Firing angle of converter

```
//Example 2_25
clc;
clear;close;

//Given data:
Vs=400;//V
f=50;//Hz
Eb=300;//V

//Solution :
Vdc=Eb;//V
Vm=Vs*sqrt(2);//V
//Vdc=3*sqrt(3)/2/%pi*Vm*cosd(alfa);//V
alfa=acosd(Vdc/(3*sqrt(3)/2/%pi*Vm));//degree
disp(alfa,"Firing angle(degree)");
```

Chapter 3

Inverters

Scilab code Exa 3.1 Maximum output frequency

```
//Example 3_1
clc;
clear;close;

//Given data:
R=80;//ohm
L=8;///mH
C=1.2;// micro F

//Solution :
if R^2<4*(L*10^-3)/(C*10^-6) then
    disp("As R^2<4*L/C, Circuit will work as a
        series inverter.");
else
    disp("As R^2>4*L/C, Circuit will not work as a
        series inverter.");
end
omega_m=sqrt(1/(L*10^-3*C*10^-6)-R^2/4/(L*10^-3)^2);
    //rad/s
fm=omega_m/2/%pi;//Hz
disp(fm,"Maximum frequency in Hz : ");
```

Scilab code Exa 3.2 Frequency of output

```
//Example 3_2
clc;
clear;close;

//Given data:
R=80;//ohm
L=8;///mH
C=1.2;// micro F
Toff=14;//micro sec

//Solution :
omega_m=sqrt(1/(L*10^-3*C*10^-6)-R^2/4/(L*10^-3)^2);
    //rad/s
fm=omega_m/2/%pi;//Hz
T=1/fm;//sec
f=1/(T+2*Toff*10^-6);//Hz
disp(f,"Frequency of output in Hz : ");
```

Scilab code Exa 3.3 Voltage power and current

```
//Example 3_3
clc;
clear;close;

//Given data:
RL=3;//in ohm
V=30;//in V

//Solution :
```

```
Vpeak=2*V/%pi;//V
Vrms=Vpeak/sqrt(2);//V
disp(Vrms,"(a) RMS value of output voltage(V) : ");
//VL=sqrt(2/T*integrate('(V/2)^2','t',0,T/2));//V
VL=V/2;//V
Pout=VL^2/RL;//W
disp(Pout,"(b) Output power(W) : ");
Ipeak=VL/RL;//A
disp(Ipeak,"(c) Peak current in thyristor(A) : ");
Iavg=Ipeak*50/100;//A
disp(Iavg,"(d) Average current of each thyristor(A)
    : ");
Vprb=2*VL;//V
disp(Vprb,"(e) Peak reverse braking voltage(V) : ");
```

Scilab code Exa 3.4 Voltage power and current

```
//Example 3_4
clc;
clear;close;

//Given data:
RL=3;//in ohm
V=30;//in V

//Solution :
Vpeak=4*V/%pi;//V
Vrms=Vpeak/sqrt(2);//V
disp(Vrms,"(a) RMS value of output voltage in volt :
    ");
//VL=sqrt(2/T*integrate('V^2','t',0,T/2));//V
VL=V;//V
Pout=VL^2/RL;//W
disp(Pout,"(b) Output power(W) : ");
Ipeak=VL/RL;//A
```

```
disp(Ipeak,"(c) Peak current in thyristor(A) : ");
Iavg=Ipeak*50/100;//A
disp(Iavg,"(d) Average current of each thyristor(A)
    : ");
Vprb=VL;//V
disp(Vprb,"(e) Peak reverse braking voltage(V) : ");
```

Scilab code Exa 3.5 Current Distortion and power

```
//Example 3_5
clc;
clear;close;

//Given data:
V=200;//V
R=10;//in ohm
L=20;//mH
C=100;//pF
f=50;//Hz

//Solution :
Z1=R+%i*(2*%pi*f*L*10^-3-1/(2*%pi*f*C*10^-6));//ohm
Z3=R+%i*(3*2*%pi*f*L*10^-3-1/(3*2*%pi*f*C*10^-6));//
    ohm
Z5=R+%i*(5*2*%pi*f*L*10^-3-1/(5*2*%pi*f*C*10^-6));//
    ohm
Z7=R+%i*(7*2*%pi*f*L*10^-3-1/(7*2*%pi*f*C*10^-6));//
    ohm
Z9=R+%i*(9*2*%pi*f*L*10^-3-1/(9*2*%pi*f*C*10^-6));//
    ohm
I=4*V/%pi/abs(Z1);//A
Irms=I/sqrt(2);//A
disp(Irms,"RMS load current(A)");
Ip=sqrt((4*V/%pi/abs(Z1))^2+(4*V/3/%pi/abs(Z3))
    ^2+(4*V/5/%pi/abs(Z5))^2+(4*V/7/%pi/abs(Z7))
```

```
    ^2+(4*V/9/%pi/abs(Z9))^2);//A
disp(Ip,"Peak value of load current(A)");
Ih=sqrt(Ip^2-I^2)/sqrt(2);//A
disp(Ih,"RMS harmonic current(A)");
hd=sqrt(Ip^2-I^2)/I;//harmonic distortion
disp(hd*100,"Harmonic distortion(%)");
Irms_load=Ip/sqrt(2);//A
Pout=Irms_load^2*R;//W
disp(Pout,"Total output power(W)");
Pout_com=Irms^2*R;//W(fundamental component)
disp(Pout_com,"Fundamental component of power(W)");
Iavg_in=Pout/V;//A
disp(Iavg_in,"Average input current(A)");
Ip_thy=Ip;//A
disp(Ip_thy,"Peak thyristor current(A)");
```

Scilab code Exa 3.6 Find value of C

```
//Example 3_6
clc;
clear;close;

//Given data:
R=2;//in ohm
XL=10;//ohm
f=4;//kHz
Toff=12;//micro sec

//Solution :
Toff_time=Toff*1.5;//micro sec
theta=2*%pi*f*10^3*Toff_time*10^-6;//radians
Xc=tan(theta)*R+XL;//ohm
C=1/(2*%pi*f*1000*Xc);//F
disp(C,"Value of Capacitance in F : ");
```

Scilab code Exa 3.7 Current and power

```
//Example 3_7
clc;
clear;close;

//Given data:
V=400;//V
R=10;//in ohm/phase

//Solution :
Ipeak=V/2/R;//A
Irms=sqrt(Ipeak^2*2/3);//A
disp(Irms,"RMS load current in A : ");
Pout=Irms^2*R*3;//W
disp(Pout,"Power output(W) : ");
Iavg=Ipeak/3;//A
disp(Iavg,"Average thyristor current(A) : ");
Irms_thyristor=sqrt(Ipeak^2/3);//A
disp(Irms_thyristor,"RMS value of thyristor current(
    A) : ");
```

Scilab code Exa 3.8 Current and power

```
//Example 3_8
clc;
clear;close;

//Given data:
V=400;//V
R=10;//in ohm/phase

```

```
//Solution :
RL=R+R/2;//ohm
i1=V/RL;//A
i2=V/RL;//A
i3=V/RL;//A
Irms_load=sqrt(1/2/%pi*(integrate('i1^2','theta',0,2*%pi/3)+integrate('(i1/2)^2','theta',2*%pi/3,2*%pi)));//A
disp(Irms_load,"RMS load current in A : ");
Pout=Irms_load^2*R*3;//W
disp(Pout,"Power output(W): ");
Ipeak=i1;//A
Iavg=1/2/%pi*[Ipeak*%pi/3+Ipeak/2*2*%pi/3];//A
disp(Iavg,"Average thyristor current(A) : ");
Irms_thyristor=sqrt(1/2/%pi*[Ipeak^2*%pi/3+(Ipeak/2)^2*2*%pi/3]);//A
disp(Irms_thyristor,"RMS value of thyristor current(A) : ");
```

Chapter 4

Choppers

Scilab code Exa 4.1 Period of conduction and blocking

```
//Example 4_1
clc;
clear;close;

//Given data:
V=230;//V
Vav=150;//V
f=1*1000;//Hz

//Solution :
T=1/f;//s
Ton=Vav*T/V;//s
Toff=T-Ton;//s
disp(Toff,Ton,"Periods of conduction & blocking(
    seconds)");
```

Scilab code Exa 4.2 Periods of conduction and blocking

```
//Example 4_2
clc;
clear;close;

//Given data:
Ra=0.06;//ohm
Rf=0.03;//ohm
Iav=15;//A
f=500;//Hz
Eb=100;//V
V=200;//V

//Solution :
Vav=Iav*(Ra+Rf)+Eb;//V
T=1/f;//s
Ton=Vav*T/V;//s
Toff=T-Ton;//s
disp(Toff,Ton,"Periods of conduction & blocking(
    seconds)");
```

Scilab code Exa 4.3 Find duty cycle

```
//Example 4_3
clc;
clear;close;

//Given data:
N=800;//rpm
I=20;//A
Ra=0.5;//ohm
Vs=240;//V
Ndash=600;//rpm

//Solution :
Eb_800=Vs-I*Ra;//V
```

```
Eb_600=Eb_800*Ndash/N;//V
Vav=I*Ra+Eb_600;//V
alfa=Vav/Vs;//duty cycle
disp(alfa,"(a) Duty cycle");
//Torque reduced to half will reduce I to half
I=I/2;//A
Vav=I*Ra+Eb_600;//V
alfa=Vav/Vs;//duty cycle
disp(alfa,"(b) Duty cycle");
```

Scilab code Exa 4.4 Voltage Efficiency and resistance

```
//Example 4_4
clc;
clear;close;

//Given data:
V=200;//V
RL=8;//ohm
Vthy=2;//V
f=800;//Hz
alfa=0.4;//duty cycle

//Solution :
Vav=alfa*(V-Vthy);//V
disp(Vav,"(a) Average output voltage(V)");
VL=sqrt(alfa)*(V-Vthy);//V
disp(VL,"(b) RMS output voltage(V)");
Pout=VL^2/RL;//W
Pin=alfa*V*(V-Vthy)/RL;//W
Eff=Pout/Pin*100;//%
disp(Eff,"(c) Chopper efficiency(%)");
Rin=RL/alfa;//ohm
disp(Rin,"(d) Input resistance(ohm)");
V1=(V-Vthy)*sqrt(2)/%pi;//V
```

```
disp(V1,"(e) RMS value of fundamental component(V)")
  ;
```

Scilab code Exa 4.5 Chopping frequency

```
//Example 4_5
clc;
clear;close;

//Given data:
V=400;//V
R=0;//ohm
L=0.05;//H
alfa=0.25;//duty cycle
delta_i=10;//A

//Solution :
Vav=alfa*V;//V
delta_T=L*delta_i/(V-Vav);//s
Ton=delta_T;///s
T=Ton/alfa;//s
f=1/T;//pulses/s
disp(f,"Chopping frequency(pulses/s)");
```

Scilab code Exa 4.6 Find the current

```
//Example 4_6
clc;
clear;close;

//Given data:
R=4;//ohm
L=6/1000;//H
```

```
V=200; //V
alfa=0.5; //duty cycle
f=1000; //Hz

//Solution :
T=1/f; //s
E=0; //V
Imax=V/R*[(1-exp(-alfa*T*R/L))/(1-exp(-T*R/L))]-E/R; //A
Imin=V/R*[(exp(alfa*T*R/L)-1)/(exp(T*R/L)-1)]-E/R; //A
disp(Imax,"Maximum current(A)");
disp(Imin,"Minimum current(A)");
Iavg=(Imax+Imin)/2; //A
disp(Iavg,"Average load current(A)");
IL=sqrt(1/alfa/T*integrate('(Imin+(Imax-Imin)*t/alfa/T)^2','t',0,alfa*T)); //A
disp(IL,"RMS load current(A)");
Iavg_in=alfa*Iavg; //A
disp(Iavg_in,"Average input current(A)");
Irms_in=sqrt(1/T*integrate('(Imin+(Imax-Imin)*t/alfa/T)^2','t',0,alfa*T)); //A
disp(Irms_in,"RMS input current(A)");
```

Scilab code Exa 4.7 Find load inductance

```
//Example 4_7
clc;
clear;close;

//Given data:
V=300; //V
R=4; //ohm
f=250; //Hz
ripple=20; //%
```

```
Iavg=30;//A

//Solution :
T=1/f;//s
E=0;//V
Imax_sub_Imin=ripple/100*Iavg;//A
L=V/Imax_sub_Imin/R/f;//H
disp(L,"Load Inductance(H)");
```

Scilab code Exa 4.8 Find the current

```
//Example 4_8
clc;
clear;close;

//Given data:
Ra=0.5;//ohm
L=16/1000;//H
V=200;//V
E=100;//V
Imin=10;//A
t_off=2/1000;//s

//Solution :
i=(V-E)/Ra*[1-exp(-Ra*t_off/L)]+Imin*exp(-Ra*t_off/L
    );//A
disp(i,"Current at instant of turn off(A)");
t=5/1000;//s
i_dash=i*exp(-Ra*t/L);//A
disp(i_dash,"Current 5 ms after turn off(A)");
//Answer is wrong in the book.
```

Scilab code Exa 4.9 Speed of motor

```
//Example 4_9
clc;
clear;close;

//Given data:
V=220;//V
N_NoLoad=1000;//rpm
alfa=0.6;//duty cycle
I=20;//A
Ra=1;//ohm

//Solution :
Eb1=V;//V////at no load
Vin=alfa*V;//V
Eb2=Vin-I*Ra;//V
N=N_NoLoad*Eb2/Eb1;//rpm
disp(N,"Speed of the motor(rpm)");
```

Scilab code Exa 4.10 Average load voltage

```
//Example 4_10
clc;
clear;close;

//Given data:
V=230;//V
Ton=25/1000;//s
Toff=10/1000;//s

//Solution :
Vavg=V*Ton/(Ton+Toff);//V
disp(Vavg,"Average load voltage(V)");
```

Scilab code Exa 4.11 Find curent and voltage

```
//Example 4_11
clc;
clear;close;

//Given data:
V=100;//V
R=0.5;//ohm
L=1/1000;//H
Ton=1/1000;//s
T=3/1000;//s

//Solution :
Toff=T-Ton;//s
alfa=Ton/T;//duty cycle
E=0;//V
Imax=V/R*[(1-exp(-alfa*T*R/L))/(1-exp(-T*R/L))]-E/R;//A
Imin=V/R*[(exp(alfa*T*R/L)-1)/(exp(T*R/L)-1)]-E/R;//A
disp(Imax,"Maximum current(A)");
disp(Imin,"Minimum current(A)");
Iavg=(Imax+Imin)/2;//A
disp(Iavg,"Average load current(A)");
Vavg=alfa*V;//V
disp(Vavg,"Average load voltage(V)");
```

Scilab code Exa 4.12 Output current and voltage

```
//Example 4_12
clc;
clear;close;

//Given data:
```

```
V=100;//V
E=12;//V
L=0.8/1000;//H
R=0.2;//ohm
T=2.4/1000;//s
Ton=1/1000;//s

//Solution :
alfa=Ton/T;//duty cycle
Imax=V/R*[(1-exp(-alfa*T*R/L))/(1-exp(-T*R/L))];//A
Imin=V/R*[(exp(alfa*T*R/L)-1)/(exp(T*R/L)-1)];//A
disp(Imax,"Maximum current(A)");
disp(Imin,"Minimum current(A)");
Vavg=alfa*V;//V
disp(Vavg,"Average load voltage(V)");
```

Scilab code Exa 4.13 Find series inductance

```
//Example 4_13
clc;
clear;close;

//Given data:
V=500;//V
I=10;//A
f=400;//Hz

//Solution :
alfa=0.5;//for maximum swing
//I=V/(4*f*L);//A
L=V/(4*f*I);//H
disp(L,"Series inductance(H)");
```

Scilab code Exa 4.14 Motor speed and current swing

```
////Example 4_14
clc;
clear;close;

//Given data:
V=800;//V
P=300;//HP
Eff=0.9;//Efficiency
R=0.1;//ohm
L=100/1000;//H
alfa=0.2;//duty cycle
N=900;//rpm
f=400;//Hz

//Solution :
Pout=P*735.5/1000;//kW
Pin=Pout/Eff;//kW
I=Pin*1000/V;//A
E=V-I*R;//V(at rated voltage)
Edash=V*alfa-I*R;//V(at 0.2 duty cycle)
Ndash=N*Edash/E;//rpm
disp(Ndash,"Motor speed(rpm)");
T=1/f;//s
d_ia=(V-alfa*V)/L*alfa*T;//A
disp(d_ia,"Current swing(A)");
```

Scilab code Exa 4.17 Find the current

```
////Example 4_17
clc;
clear;close;

//Given data:
```

```
V=200; //V
R=2; //ohm
L=10/1000; //H
E=20; //V
T=1000/10^6; //s
Ton=300/10^6; //s

//Solution :
f=1/T; //Hz
alfa_min=1/(R*T/L)*log(1+E/V*(exp(R*T/L)-1)); //duty cycle
alfa=Ton/T; //duty cycle
disp(alfa_min,"Minimum value required of alfa");
disp(alfa,"Actual value of alfa");
disp("Load current is continuous as alfa_actual>alfa_min")
Imax=V/R*[(1-exp(-alfa*T*R/L))/(1-exp(-T*R/L))]-E/R; //A
Imin=V/R*[(exp(alfa*T*R/L)-1)/(exp(T*R/L)-1)]-E/R; //A
disp(Imax,"Maximum current(A)");
disp(Imin,"Minimum current(A)");
Iavg=(alfa*V-E)/R; //A
disp(Iavg,"Average load current(A)");
Iavg_in=alfa*(V-E)/R-L/R/T*(Imax-Imin); //A
disp(Iavg_in,"Average input current(A)");
```

Scilab code Exa 4.18 RMS value of load current

```
////Example 4_18
clc;
clear;close;

//Given data:
V=200; //V
```

```
T=1000/10^6;//s
Ton=300/10^6;//s
R=4;//ohm
L=10/1000;//H

//Solution :
f=1/T;//Hz
Vrms1=sqrt((200/%pi*sin(2*%pi*0.3))^2+(200/%pi*((1-cos(2*%pi*0.3))))^2)/sqrt(2);//V
Vrms2=sqrt((200/2/%pi*sin(2*%pi*2*0.3))^2+(200/2/%pi*((1-cos(2*%pi*2*0.3))))^2)/sqrt(2);//V
Vrms3=sqrt((200/3/%pi*sin(2*%pi*3*0.3))^2+(200/3/%pi*((1-cos(2*%pi*3*0.3))))^2)/sqrt(2);//V
Z1=R+%i*(2*%pi*f*L);//ohm
I1=Vrms1/abs(Z1);//A
disp(I1,"RMS value of 1st harmonic of load current(A)");
Z2=R+%i*(2*2*%pi*f*L);//ohm
I2=Vrms2/abs(Z2);//A
disp(I2,"RMS value of 2nd harmonic of load current(A)");
Z3=R+%i*(3*2*%pi*f*L);//ohm
I3=Vrms3/abs(Z3);//A
disp(I3,"RMS value of 3rd harmonic of load current(A)");
Iavg=V/R*Ton/T;//A
Irms=sqrt(Iavg^2+I1^2+I2^2+I3^2);//A
disp(Irms,"RMS value of load current(A)");
```

Scilab code Exa 4.19 Period of conduction

```
//Example 4_19
clc;
clear;close;

```

```
//Given data:
V=200;//V
Vav=250;//V
Toff=0.6*10^-3;//s

//Solution :
T=Vav/V*Toff;//s
Ton=T-Toff;//s
disp(Ton,"Period of conduction(seconds)");
```

Scilab code Exa 4.20 Period of conduction

```
//Example 4_20
clc;
clear;close;

//Given data:
V=150;//V
Vav=250;//V
Toff=1*10^-3;//s

//Solution :
T=Vav/V*Toff;//s
Ton=T-Toff;//s
disp(Ton,"Period of conduction(seconds)");
```

Chapter 6

Control of DC drives

Scilab code Exa 6.1 Proper size of motor

```
//Example 6_1
clc;
clear;close;

//Given data:
hp=[50 100 150 120 0];//hp
t=[20 20 10 20 15];//seconds

//Solution :
hp_rms_t=0;//initializing
for i=1:5
    hp_rms_t=hp_rms_t+(hp(i)^2*t(i));//hp
end
hp_rms=sqrt(hp_rms_t/sum(t));//hp
disp(hp_rms,"Required hp(rms)");
disp("Motor size should be 100 hp");
```

Scilab code Exa 6.2 Thermal time constant and temperature rise

```
//Example 6_2
clc;
clear;close;

//Given data:
P=30;//kW
theta1=30;//degree C
t1=40;//minutes
theta2=45;//degree C
t2=80;//minutes
t2=2*t1;//minutes
Loss_fl=2;//kW
Loss_Cu=2.5;//kW

//Solution :
//theta1=theta_f*(1-exp(-t1/T));
//let exp(-t1/T)=a
a=poly(0,'a');
polynomial=(1-a^2)*(theta1/theta2)-1+a;
a=roots(polynomial)
a=a(2);
T=-t1/log(a);//s
disp(T,"Thermal time constant(minutes)");
theta_f=theta1/(1-exp(-t1/T));
disp(theta_f,"Final temperature rise(degree C)");
alfa=Loss_fl/Loss_Cu;
t=20;//minutes
rating=P*sqrt((1+alfa)/(1-exp(-t/T))-alfa);//kW
disp(rating,"20 minute rating of motor(kW)");
```

Scilab code Exa 6.3 Field current

```
//Example 6_3
clc;
clear;close;
```

```

//Given data:
V=230;//V
f=50;//Hz
alfa=0;//degree
Rf=200;//ohm
Ra=0.3;//ohm
T=50;//N-m
N=900;//rpm
Kv=0.8;//V/A-rad/s
Kt=0.8;//N-m/A^2

//Solution :
Vm=V*sqrt(2);//V
Vf=2*Vm/%pi;//V
If=Vf/Rf;//A
disp(If,"Field current(A)");
Ia=T/(Kt*If);//A
omega=(2*%pi/60)*N;//radian/s
Eb=Kv*omega*If;//V
Va=Eb+Ia*Ra;//V
alfa_a=acosd(Va/(Vm/%pi)-1);//degree
disp(alfa_a,"Firing angle of armture circuit(degree)");
Pout=Va*Ia;//W
I_in=sqrt(2/(2*%pi)*integrate('Ia^2','t',alfa_a*%pi/180,%pi));//A
VA_in=V*I_in;//VA
pf_in=Pout/VA_in;//lagging
disp(pf_in,"Input power factor(lagging)");
```