

Scilab Textbook Companion for
Power Electronics
by M. D. Singh and K. B. Khanchandani¹

Created by
Mohit Garg
B.Tech
Electronics Engineering
ABES Engineering College, Ghaziabad
College Teacher
None
Cross-Checked by
Spandana

July 31, 2019

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

Book Description

Title: Power Electronics

Author: M. D. Singh and K. B. Khanchandani

Publisher: Tata McGraw-Hill

Edition: 2

Year: 2006

ISBN: 978-0070583894

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	4
2 Thyristors Principles and Characteristics	5
3 Gate Triggering Circuits	16
4 Series and Parallel Operation of Thyristors	22
5 Power Semiconductor Devices	28
6 Phase Controlled Convertors	39
7 Dual Converters	82
8 Choppers	85
9 Inverters	117
10 Cycloconverters	152
11 A C Regulators	158
12 Resonant Convertors	168
13 Protection and Cooling of Power Switching Devices	180

14 Control of D C Drives	196
15 Control of A C Drives	213
16 Power Electronic Applications	218

List of Scilab Codes

Exa 2.1	Will the thyristor get fired	5
Exa 2.2	Obtain the minimum gating pulse	6
Exa 2.3	Compute average power loss	6
Exa 2.4	Find the value of series resistor and average power	7
Exa 2.5	Calculate the required gate resistance source	8
Exa 2.6	Calculate the mean power loss	9
Exa 2.7	Compute the peak inverse voltage	10
Exa 2.8	Calculate the resistance gate power dissipa- tion and maximum triggering frequency . .	11
Exa 2.9	Calculate the value of commutating capaci- tance	12
Exa 2.10	Compute the value of commutating capaci- tance and inductance	12
Exa 2.11	Calculate shortest fault clearance time . . .	14
Exa 2.12	Calculate one cycle surge current rating . .	14
Exa 3.1	Determine the trigger angle	16
Exa 3.2	Determine the value of Vee	17
Exa 3.3	Design UJT relaxation oscillator	17
Exa 3.5	Design free running UJT relaxation oscillator	19
Exa 4.1	Calculate the value of R and C	22
Exa 4.2	Calculate the series resistance	23
Exa 4.3	Calculate the number of thyristors and value of resistance and capacitance	23
Exa 4.4	Calculate the number of thyristors	25
Exa 4.5	Determine the current taken by each SCR and value of equal resistors	26

Exa 5.1	What will be the maximum and minimum firing angle	28
Exa 5.2	Compute the drain current and differences in current sharing	30
Exa 5.3	Determine series resistance and safe highest frequency	32
Exa 5.4	Determine the power dissipated by each MOS-FET	33
Exa 5.5	Calculate the rise time of driving waveform	34
Exa 5.6	Determine power loss	34
Exa 5.7	Calculate the total power loss	35
Exa 5.8	Determine avg load current and power losses	37
Exa 6.2	Determine the heater power	39
Exa 6.3	Determine various parameters	40
Exa 6.4	Determine average current power supplied and dissipated and power factor	41
Exa 6.5	Determine design details	42
Exa 6.6	Determine variuos parameters	45
Exa 6.7	Determine the firing angle	46
Exa 6.8	Determine firing angle output current and thyristor current	47
Exa 6.9	Find average output current and power delivered	49
Exa 6.10	Determine various parameters	50
Exa 6.11	Find displacement factor harmonic factor and input power factor	51
Exa 6.12	Determine average output voltage	52
Exa 6.13	Determine average load voltage current PIV and power dssipation	53
Exa 6.14	Calculate thyristor current ratings	54
Exa 6.15	Determine various parameters	55
Exa 6.17	Calculate firing angle and supply power factor	57
Exa 6.19	Find out SCR rating	59
Exa 6.20	Determine fundamental and various harmonics for various angle	60
Exa 6.21	Determine average voltage	62
Exa 6.22	Determine the minimum width of gate pulse	63
Exa 6.23	Plot average voltage and load voltage	64

Exa 6.24	Determine various parameters	65
Exa 6.25	Determine DPF DF HF and PF	67
Exa 6.26	Determine overlap angles	68
Exa 6.27	Find the mean voltage at the load	69
Exa 6.28	Compute source inductance load resistance and overlap angle	69
Exa 6.29	Compute the average load voltage	70
Exa 6.30	Compute the average generator voltage	71
Exa 6.32	Compute the firing angle and overlap angle	72
Exa 6.33	Design the 3 phase bridge convertor	73
Exa 6.34	Calculate delay angle power delivered and fun- damental reactive power	76
Exa 6.35	Calculate reduction in dc output voltage and overlap angle	77
Exa 6.36	Calculate various parameters	78
Exa 7.1	Compute the peak value of circulating current	82
Exa 7.2	Design dual convertor	83
Exa 8.1	Determine time ratio of the chopper	85
Exa 8.3	Determine average and rms output voltage chopper efficiency and effective input resis- tance	86
Exa 8.4	Calculate the required pulse width	87
Exa 8.5	Calculate the conduction and blocking period of the thyristor	87
Exa 8.6	Calculate limit of current pulsation chopping frequency duty cycle and output voltage	88
Exa 8.7	Compute following quantities	89
Exa 8.8	Calculate the mean values of load voltage and current	91
Exa 8.9	Find the chopping frequency	93
Exa 8.10	Find the on period average load current mag- nitude of ripple current and its rms value	94
Exa 8.11	Compute the current in the motor	96
Exa 8.12	Determine the ON time of the chopper	97
Exa 8.13	Determine average and rms output voltage and form and ripple factor	97

Exa 8.14	Determine duty cycle for motoring regenerating mode and to achieve regenerating mode and power returned	98
Exa 8.15	Determine duty cycle for motoring regenerating mode and to achieve regenerating mode power returned and switching frequency . . .	99
Exa 8.16	Determine duty cycle of chopper	101
Exa 8.17	Compute the value of commutating capacitor and inductor	102
Exa 8.18	Compute the value of commutating capacitor and inductor Maximum capacitor voltage and peak commutating current	103
Exa 8.19	Compute the value of commutating capacitance average output voltage circuit off time total commutation interval	104
Exa 8.20	Compute the value of commutating capacitance and transformer inductances	105
Exa 8.21	Compute the inductance steady state speed and current swing	106
Exa 8.22	Design the jones chopper	107
Exa 8.23	Find duty cycle filter inductance and filter capacitance	109
Exa 8.24	Determine maximum ON period of MOSFET Battery drain current and the value of choke required	110
Exa 8.25	Determine duty cycle ripple and peak current of inductor ripple voltage	111
Exa 8.26	Compute average output voltage peak to peak output ripple voltage peak to peak current of the inductor and peak current of the device	112
Exa 8.27	Determine range of duty cycle peak to peak choke ripple current and average supply current	113
Exa 8.28	Compute average output voltage average input current peak to peak current of the inductors peak to peak output ripple voltages and peak current of the device	115

Exa 9.1	Compute rms value of output voltage fundamental component of the output voltage waveform first five harmonics of the output voltage fundamental power consumed rms power consumed rms value by harmonic summation method	117
Exa 9.2	Compute fundamental output voltage first five harmonics of the output voltage rms value by direct integration and harmonic summation method output rms and fundamental power and transistor switch ratings	118
Exa 9.3	Determine rms load current at fundamental frequency rms value of load current power output and average supply current	120
Exa 9.4	Determine IGBT ratings THD DF and HF and DF of the lowest order harmonic	121
Exa 9.5	Determine transistor ratings THD DF and HF and DF of the lowest order harmonic	123
Exa 9.6	Determine carrier ratio and the number of pulses per cycle Fundamental output voltage DF and HF of the output voltage and the order of first five significant harmonics	124
Exa 9.7	Compute DC and switch voltage ratings	126
Exa 9.8	Compute Total rms output voltage fundamental output voltage DF and HF and gain of the inverter	127
Exa 9.9	What should be the amplitude of modulation index	128
Exa 9.10	Determine fundamental output voltage and first five dominant harmonics	128
Exa 9.12	Determine rms value of the output line and phase voltages rms value of the fundamental component of the line and phase voltage	129
Exa 9.14	Determine various parameters	130
Exa 9.17	Determine dc voltage rms line and phase voltages and Device voltage ratings	133
Exa 9.18	Design a series inverter circuit	134

Exa 9.19	Design a self commutated inverter circuit and compute output power	135
Exa 9.20	Design a parallel inverter	137
Exa 9.21	Calculate rms output voltage at fundamental frequency output power average and peak current and peak reverse blocking voltage	139
Exa 9.22	Calculate rms output voltage at fundamental frequency output power average and peak current and peak reverse blocking voltage	140
Exa 9.23	What value of C should the load have in order to obtain load commutation of SCR	141
Exa 9.24	Obtain the value of commutating components L and C	142
Exa 9.25	Obtain the value of commutating components and the value of resistance	143
Exa 9.26	Find the rms load current load power and thyristor ratings	144
Exa 9.27	Determine commutating capacitor load current $F_{critical}$ and $R_{critical}$	145
Exa 9.28	Design an OTT filter	147
Exa 9.29	Design a 400 Hz parallel inverter	148
Exa 10.1	Determine required supply voltage thyristor rating and power factor of the supply current	152
Exa 10.2	Estimate peak and rms value of load voltage	153
Exa 10.3	Determine the value of fundamental rms output voltage rms output current and output power	154
Exa 10.4	Determine the value of fundamental rms output voltage rms output current and output power	155
Exa 10.5	Determine the input current to the convertors	157
Exa 11.1	Determine various parameters	158
Exa 11.2	Determine rms value of output voltage input power factor and average input current	160
Exa 11.3	Determine various parameters	161
Exa 11.4	Plot a curve of load power against firing delay angle and determine required thyristor rating	162

Exa 11.5	Determine rms current of thyristor T1 and T2 rms current of Thyristor T3 and T4 and input power factor	164
Exa 11.6	Determine rms output phase voltage input power factor	165
Exa 11.7	Determine required ratings of triacs and thyristors	166
Exa 12.1	Determine circuit turn off time maximum possible output frequency capacitor voltage rms load current output power and average and rms SCR currents	168
Exa 12.2	Determine resonant frequency maximum operating frequency Peak thyristor current average thyristor current rms thyristor current rms load current and average supply current	170
Exa 12.3	Determine resonant frequency maximum operating frequency Peak thyristor current average thyristor current rms thyristor current rms load current and average supply current	171
Exa 12.4	Design E class resonant inverter	173
Exa 12.5	Determine values of resonant components Lr and Cr peak switching current peak voltage rating of the resonant capacitor	175
Exa 12.6	Determine values of resonant components Lr and Cr peak voltage rating of the resonant capacitor and charging and discharging period of capacitor	176
Exa 12.7	Design a ZVS three level PWM converter	177
Exa 13.1	Compute the values of di/dt inductor and the snubber circuit component Rs and Cs	180
Exa 13.2	Compute the required parameters snubber circuit	181
Exa 13.3	Design a snubber circuit	181
Exa 13.4	Compute initial capacitor voltage magnetizing current and capacitor value to limit the transient capacitor voltage	182
Exa 13.5	Determine the snubber component values for critical damping value of R and power loss	183

Exa 13.6	Design a suitable selenium voltage protection circuit and compute energy dissipated per plate	185
Exa 13.7	Design a suitable circuit	186
Exa 13.8	Calculate the peak value of the fault current	186
Exa 13.9	Compute the required fusing time	187
Exa 13.10	What is the minimum value of load inductance and what will be the new value of L	188
Exa 13.11	Compute the values of RF filter components	188
Exa 13.12	Determine the value of thermal resistance heat sink and temperature at base	189
Exa 13.13	Determine junction temperature	190
Exa 13.14	Determine total average power loss and percentage increase in device rating	191
Exa 13.15	Plot instantaneous junction temperature	191
Exa 13.16	Determine the heat sink required	193
Exa 13.17	Determine the thermal resistance of the heat sink	194
Exa 13.18	Determine the maximum power dissipation	195
Exa 14.1	Determine motor terminal voltage and the value of flux as a percentage of rated flux	196
Exa 14.2	Compute the speed at which motor can hold the load by regenerative braking	197
Exa 14.3	Compute the field current firing angle of the convertor and the input power factor	198
Exa 14.4	Determine motor torque speed of the motor supply power factor firing angle and power fed back to the supply	200
Exa 14.5	What should be firing angle different speeds and calculate the motor speed	201
Exa 14.6	Determine the motor speed	203
Exa 14.7	Determine the triggering angle of the convertor	204
Exa 14.8	Determine no load speeds firing angle supply power factor and the speed regulation	205
Exa 14.9	Determine motor torque motor current and supply power factor	206

Exa 14.10	Determine the firing angle of the armature convertor speed of the motor and firing angle of the field convertor	208
Exa 14.11	Determine the firing angle power factor active power and reactive power at rated speed and its 10 and their ratio	209
Exa 14.12	Determine the range of frequencies of the chopper	211
Exa 15.1	Determine the new value of torque developed by motor	213
Exa 15.2	Determine the angle of firing advance in different cases voltage ratio and power flow . .	214
Exa 15.3	Determine the input voltage armature current excitation voltage torque angle and pull out torque	216
Exa 16.1	Determine kVA rating of inverter Wattage of the rectifier and AH rating of battery	218
Exa 16.2	Select a suitable battery	219
Exa 16.3	Determine AH efficiency and WH efficiency	220
Exa 16.4	Determine dc supply voltage and charging current	221
Exa 16.5	Calculate back up time and charger peak output power	222
Exa 16.6	Determine maximum duty cycle and flyback convertor turns ratio	223
Exa 16.7	Determine average input power and current ratings of the transistor primary winding inductance and number of turns and ratings of the diode	224
Exa 16.8	Determine turn ratio of demagnetizing winding with primary winding switch voltage rating and dc supply current	226
Exa 16.9	Determine the value of coupling capacitor verify if the value is acceptable or not If not then determine the new value	227
Exa 16.10	Determine rms current and peak reverse voltage	229

Exa 16.11	Determine depth of heating and heat generated per unit surface area	229
Exa 16.12	Determine supply frequency	230
Exa 16.13	Determine voltage and current	231
Exa 16.14	Determine supply frequency	232
Exa 16.15	Calculate the value of load resistance commutating capacitor and resistance connected in series	232
Exa 16.16	What will be the firing angle and output power available	233

Chapter 2

Thyristors Principles and Characteristics

Scilab code Exa 2.1 Will the thyristor get fired

```
1 // chapter 2
2 // example 2.1
3 // fig. E2.1
4 // Will the thyristor get fired
5 // page-21-22
6 clear;
7 clc;
8 // given
9 I_L=50; // in mA (Latching current)
10 t=50; // in us (duration of firing pulse)
11 R=20; // in ohm (resistance of circuit)
12 L=0.5; // in H (Inductance of circuit)
13 V=100; // in V (Battery voltage)
14 // calculate
15 tou=L/R; // calculation of total time period
16 t=t*1E-6; // changing unit from us to sec
17 i=(V/R)*(1-exp(-t/tou)); // calculation of current
    at t=50 us
18 i=i*1E3; // changing unit from A to mA
```



```

19 printf("\nThe value of current is \t i(50 us) = %.2 f
      mA\n", i);
20 if i < I_L then
21     printf("\nSCR will not get fired");
22
23     else printf("\nSCR will get fired");
24 end

```

Scilab code Exa 2.2 Obtain the minimum gating pulse

```

1 // chapter 2
2 // example 2.2
3 // fig. E2.2
4 // Obtain the minimum gating pulse
5 // page-22
6 clear;
7 clc;
8 // given
9 i=4; // in mA (Latching current)
10 L=0.1; // in H (Inductance of circuit)
11 V=100; // in V (Battery voltage)
12 // calculate
13 i=i*1E-3; // changing unit from mA to A
14 // Since  $V=L*(di/dt)$ , therefore we get
15 t_min=(L/V)*i; // calculation of minimum gating
      pulse
16 t_min=t_min*1E6; // changing unit from sec to us
17 printf("\nThe minimum gating pulse is \t t_min=%.f
      us", t_min);

```

Scilab code Exa 2.3 Compute average power loss

```

1 // chapter 2

```

```

2 // example 2.3
3 // fig. E2.3
4 // Compute average power loss
5 // page-22-23
6 clear;
7 clc;
8 // given
9 Beta1=180, Beta2=360; // in degrees (conduction
    angles)
10 Iav=100; // in A (average current)
11 // calculate
12 // since Iav=Im*Beta/360, therefore
13 Im1=Iav*360/Beta1; // calculation of current during
    180 conduction
14 V_T1= 1.8; // in V (given corresponding to value of
    Im1)
15 Pavg1=V_T1*Im1*(Beta1/360); // calculation of
    average power loss during 180 conduction
16 printf("\n\nThe average power loss during %.f
    conduction is %.f W",Beta1,Pavg1);
17 Im2=Iav*360/Beta2; // calculation of current during
    360 conduction
18 V_T2= 1.5; // in V (given corresponding to value of
    Im2)
19 Pavg2=V_T2*Im2*(Beta2/360); // calculation of
    average power loss during 360 conduction
20 printf("\n\nThe average power loss during %.f
    conduction is %.f W",Beta2,Pavg2);

```

Scilab code Exa 2.4 Find the value of series resistor and average power

```

1 // chapter 2
2 // example 2.4
3 // Find the value of series resistor and average
    power

```

```

4 // page-31
5 clear;
6 clc;
7 // given
8 // Vg=1.5+8*Ig; // relation between Vg and Ig
9 Vgs=12; // in V
10 t=50; // in us
11 D=0.2; // duty cycle
12 P=5; // in W
13 // calculate
14 // since Vgs=Ig*Rg+Vg=Ig*Rg+1.5+8*Ig or
15 // Vgs=(Rg+8)*Ig+1.5, (i)
16 // since P=Vg*Ig and therefore
17 // P=(1.5+8*Ig)*Ig,
18 // P=1.5*Ig+8*Ig^2.
19 // This is quadratic equation and can be written as
20 // 8*Ig^2+1.5*Ig-P=0 solving it
21 Ig1=(-1.5+sqrt(1.5^2-(4*8*(-P))))/(2*8);
22 Ig2=(-1.5-sqrt(1.5^2-(4*8*(-P))))/(2*8);
23 if Ig1>0 then
24     Ig=Ig1
25 else
26     Ig=Ig2
27 end
28 Rg=((Vgs-1.5)/Ig)-8; // calculation of series
    resistance
29 Pavg=P*D; // calculation of average power
30 printf("\nThe series resistance is \t Rg=%.f ohm",Rg
    );
31 printf("\nThe average power is \t\t Pavg=%.f W",Pavg
    );

```

Scilab code Exa 2.5 Calculate the required gate resistance source

```
1 // chapter 2
```

```

2 // example 2.5
3 // Calculate the required gate resistance source
4 // page-31
5 clear;
6 clc;
7 // given
8 Pg=0.012; // in W (power) Pg=Vg*Ig
9 gradient=3E3; // gradient=Vg/Ig
10 Egs=10; // in V
11 // calculate
12 // Since gradient*Pg=Vg^2 therefore we get
13 Vg=sqrt(gradient*Pg); // calculation of gate voltage
14 Ig=Pg/Vg; // calculation of gate current
15 Rg=Vg/Ig; // calculation of gate resistance
16 Ig=Ig*1E3; // changing unit from A to mA
17 Rg=Rg*1E-3; // changing unit from ohm to kohm
18 printf("\nThe required gate voltage is \tVg=%f V\n"
        ,Vg);
19 printf("\nThe required gate current is \tIg=%f mA\n"
        ",Ig);
20 printf("\nThe required gate source resistance is \
        tRg=%f kohm\n",Rg);
21 // Note: the value of gate source resistance has
        not been calculated in the book.

```

Scilab code Exa 2.6 Calculate the mean power loss

```

1 // chapter 2
2 // example 2.6
3 // Fig. E2.6
4 // Calculate the mean power loss
5 // page-31-32
6 clear;
7 clc;
8 // given

```

```

 9 // V_T=1.0+(1.1*I/60) (from graph)
10 I_a=23; // in A (steady current)\
11 I_b=18; // in A (Half-sine wave)
12 I_c=39.6; // in A (level current for half cycle)
13 I_d=48.5; // in A (level current for one-third cycle
   )
14 // calculate
15 V_T_a=1.0+(1.1*I_a/60); // calculation of ON state
   voltage corresponding to I_a
16 P_a=V_T_a*I_a; // calculation of power loss
   corresponding to I_a
17 printf("\nThe Power loss is \t%.1f W\n",P_a);
18 I_m_b=I_b*%pi; // maximum value of sine wave current
19 P_b=(1/(2*%pi))*(integrate('(1+(1.1*I_m_b*sin(x)
   /60))*I_m_b*sin(x)', 'x',0,%pi)); // calculation
   of power loss corresponding to I_b
20 printf("\nThe Power loss is \t%.2f W\n",P_b);
21 V_T_c=1.0+(1.1*I_c/60); // calculation of ON state
   voltage corresponding to I_c
22 P_c=V_T_c*I_c/2; // calculation of power loss
   corresponding to I_c
23 printf("\nThe Power loss is \t%.1f W\n",P_c);
24 V_T_d=1.0+(1.1*I_d/60); // calculation of ON state
   voltage corresponding to I_d
25 P_d=V_T_d*I_d/3; // calculation of power loss
   corresponding to I_d
26 printf("\nThe Power loss is \t%.1f W\n",P_d);
27 // Note: the answer of part (b) varies slightly due
   to precise calculation and round off

```

Scilab code Exa 2.7 Compute the peak inverse voltage

```

1 // chapter 2
2 // example 2.7
3 // Compute the peak inverse voltage

```

```

4 // page-32
5 clear;
6 clc;
7 // given
8 Vin=415; // in V (input voltage)
9 Vf=2.1; // voltage safety factor
10 // calculate
11 PIV=sqrt(2)*Vin*Vf; // calculation of peak inverse
    voltage
12 printf("\nThe peak inverse voltage is \tPIV=%.2f V",
    PIV);

```

Scilab code Exa 2.8 Calculate the resistance gate power dissipation and maximum tr

```

1 // chapter 2
2 // example 2.8
3 // Fig. E2.8
4 // Calculate the resistance , gate power dissipation
    and maximum triggering frequency
5 // page-32-33
6 clear;
7 clc;
8 // given
9 Ig_min=500; // in mA (minimum gate current)
10 gradient=16; // in V/A
11 Egs=15; // in V (gate source voltage)
12 T_on=4; // in us (minimum turn on time)
13 Pg_av=0.3; // in W (average gate power dissipation)
14 // calculate
15 Ig_min=Ig_min*1E-3; // changing unit from mA to A
16 Vg=gradient*Ig_min; // calculation of gate voltage
17 Rs=(Egs-Vg)/Ig_min; // calculation of resistance
18 printf("\nThe resistance to be connected in series
    with SCR gate is \tRs= %.f ohm",Rs);
19 Pg=Vg*Ig_min; // calculation of power dissipation

```



```

1 // chapter 2
2 // example 2.10
3 // Fig. 2.19
4 // Compute the value of commutating capacitance and
   inductance
5 // page-54
6 clear;
7 clc;
8 // given
9 Edc=50; // in V (source voltage)
10 I_L=50; // in A (current)
11 t_off=30; // in us (turn-off time of SCR1)
12 f=500; // in Hz (chopping frequency)
13 neta1=10, neta2=100; // in % (load voltage variation
   )
14 // calculate
15 // Let us assume 50 % tolerance on turn-off time
16 t_off=t_off+(50*t_off/100); // calculation of turn-
   off time for reliable operation
17 printf("\n\nThe turn-off time for reliable operation
   is \tt_off= %.f us",t_off);
18 C=I_L*t_off/Edc; // calculation of commutating
   capacitance
19 printf("\n\nThe commutating capacitance is \t\t\tC=
   %.f uF",C);
20 V0_min=neta1*Edc/100; // calculation of minimum V0
21 T=1/f; // calculation of chopping time period
22 L1=((V0_min/Edc)^2)*(T^2)/(((%pi)^2)*C*1E-6);
23 L1=L1*1E6; // changing unit from H to uH
24 //L1=((V0_min/Edc)^2); // calculation of upper
   limit of commutating inductance
25 L2=C*(Edc/I_L)^2; // calculation of lower limit of
   commutating inductance
26 printf("\n\nThe commutating inductance lies in range
   \t %.f uH < L < %.f uH",L2,L1);

```

Scilab code Exa 2.11 Calculate shortest fault clearance time

```
1 // chapter 2
2 // example 2.11
3 // Fig. E2.11
4 // Calculate shortest fault clearance time
5 // page-54-55
6 clear;
7 clc;
8 // given
9 Vm=120; // in V (sinosoidal ac supply)
10 integration=15; // in a2.s (integral of square of
    current)
11 // calculate
12 t=integration/Vm2; // calculation of fault
    clearance time
13 t=t*1E3; // changing unit from s to ms
14 printf("\n\nThe fault clearance time is \t= %.2f ms"
    ,t);
```

Scilab code Exa 2.12 Calculate one cycle surge current rating

```
1 // chapter 2
2 // example 2.12
3 // Calculate one cycle surge current rating
4 // page-54-55
5 clear;
6 clc;
7 // given
8 I_sub=3000; // in A (half cycle surge current rating
    )
9 f=50; // in Hz (supply frequency)
```

```

10 T=100, t=50; // time ration for one and half cycle
    respectively
11 // calculate
12 //  $I^2 \cdot T = I_{\text{sub}}^2 \cdot t$ , therefore we get
13 I=sqrt(I_sub^2*(t/T)); // calculation of one cycle
    surge current rating
14 printf("\nThe one cycle surge current rating \tI= %
    .2f A",I);
15 rating=(I_sub/(5*sqrt(2)))^2*(1/(2*f)); //
    calculation of  $i^2 \cdot t$  rating
16 printf("\n\nThe  $i^2 \cdot t$  rating is \t %.f A^2.s",
    rating);
17 // Note: The answer in the book for  $i^2 \cdot t$  rating is
    wrong due to calculation mistake

```

Chapter 3

Gate Triggering Circuits

Scilab code Exa 3.1 Determine the trigger angle

```
1 // chapter 3
2 // example 3.1
3 // fig. E3.11
4 // Determine the trigger angle
5 // page-87
6 clear;
7 clc;
8 // given
9 Ig=0.1; // in mA (minimum gate current)
10 Vg=0.5; // in V (minimum gate voltage)
11 Emax=24; // in V (peak amplitude of input)
12 Rv=100; // in k-ohm
13 Rmin=10; // in k-ohm
14 Vd=0.7; // in V (threshold voltage for diode)
15 // calculate
16 e_s=Ig*(Rv+Rmin)+Vd+Vg; // Applying KVL in the loop
17 // since e_s=Emax* sin(alpha)
18 alpha=asind(e_s/Emax); // calculation of trigger
    angle
19 printf("The trigger angle is \t %.1f degree",alpha);
```

Scilab code Exa 3.2 Determine the value of V_{ee}

```
1 // chapter 3
2 // example 3.2
3 // Determine the value of  $V_{ee}$ 
4 // page-99
5 clear;
6 clc;
7 // given
8 Re=1; // in k-ohm
9 Iv=5; // in mA
10 Vv=2; // in V (voltage at valley point)
11 // calculate
12 Ie=Iv;
13 Ve=Vv;
14 Vee=Ie*Re+Ve; // calculation of  $V_{ee}$ 
15 printf("The required value to switch OFF UJT is \
    tVee=%f V",Vee);
```

Scilab code Exa 3.3 Design UJT relaxation oscillator

```
1 // chapter 3
2 // example 3.3
3 // Design UJT relaxation oscillator
4 // page-99-100
5 clear;
6 clc;
7 // given
8 neta=0.7; // (intrinsic stand-off ratio)
9 I_P=50; // in uA (peak point current)
10 Vv=2; // in V (valley point voltage)
11 I_V=6; // in mA (valley point current)
```

```

12 V_BB=20; // in V (maximum interbase voltage)
13 R_BB=7; // in k-ohm (interbase resistance)
14 I_E0=2; // in mA (emitter leakage current)
15 Vg_min=0.2 // in V (minimum gate voltage required to
    trigger SCR)
16 C=0.1; // in uF (assumption as done in the book)
17 // calculate
18 I_P=I_P*1E-6; // changing unit from uA to A
19 Rmax=V_BB*(1-neta)/I_P; // calculation of Rmax
20 I_V=I_V*1E-3; // changing unit from mA to A
21 Rmin=(V_BB-Vv)/I_V; // calculation of Rmin
22 R2=1E4/(neta*V_BB);
23 I_E0=I_E0*1E-3; // changing unit from mA to A
24 R1=Vg_min/I_E0;
25 C=C*1E-6; // changing unit from uF to F
26 Tmax=Rmax*C*log(1/(1-neta)); // calculation of
    maximum time period
27 Tmin=Rmin*C*log(1/(1-neta)); // calculation of
    minimum time period
28 fmin=1/Tmax; // calculation of minimum frequency
29 fmax=1/Tmin; // calculation of maximum frequency
30 Rmax=Rmax*1E-3; // changing unit from ohm to k-ohm
31 Rmin=Rmin*1E-3; // changing unit from ohm to k-ohm
32 Tmax=Tmax*1E3; // changing unit from s to ms
33 Tmin=Tmin*1E3; // changing unit from s to ms
34 fmax=fmax*1E-3; // changing unit from Hz to kHz
35 printf("\nThe maximum value of R is \t\t Rmax=%f k-
    ohm",Rmax);
36 printf("\nThe minimum value of R is \t\t Rmin=%f k-
    ohm",Rmin);
37 printf("\nThe value of R2 is \t\t\t R2=%f ohm",R2)
    ;
38 printf("\nThe value of R1 is \t\t\t R1=%f ohm",R1);
39 printf("\nThe maximum value of time period is \t
    Tmax=%f ms",Tmax);
40 printf("\nThe minimum value of time period is \t
    Tmin=%f ms",Tmin);
41 printf("\nThe minimum value of frequency is \t fmin=

```

```

    %.2f Hz",fmin);
42 printf("\nThe minimum value of frequency is \t fmax=
    %.2f kHz",fmax);
43 // Note : the answee of Tmax, fmin, fmax varies
    slightly due to exact calculation

```

Scilab code Exa 3.5 Design free running UJT relaxation oscillator

```

1 // chapter 3
2 // example 3.5
3 // Design free-running UJT relaxation oscillator
4 // page-105-106
5 clear;
6 clc;
7 // given
8 fmin=5; // in Hz (minimum frequency)
9 fmax=50; // in Hz (maximum frequency)
10 E_dc=12; // in V (DC supply)
11 I_P=80; // in mA (peak current)
12 T=8; // in us (trigger time)
13 V_drop=1; // in V (voltage drop across PUT)
14 Rs=39; // in ohm (Assumption as done in the book)
15 Ig=1; // in mA (assumption as done in the book)
16 // calculate
17 // since  $T=R_s*C$ 
18  $C=T/R_s$ ; // calculation of capacitance (in uF)
19 printf("\nThe value of capacitance is \t\t  $C=$ %.2f uF
    ",C);
20 I_P=I_P*1E-3; // changing unit from mA to A
21 V_P=(I_P*Rs)+V_drop; // calculation of peak point
    voltage
22 // since  $V_P=\eta*E_{dc}+V_D$ , neglecting  $V_D$ , we get
23  $\eta=V_P/E_{dc}$ ; // calculation of intrinsic stand-off
    ratio
24 Tmax=1/fmin; // calculation of maximum time period

```

```

25 Tmin=1/fmax; // calculation of maximum time period
26 C=C*1E-6; // changing unit from uF to F
27 Rmax=Tmax/(C*log(E_dc/(E_dc-V_P))); // calculation
    of maximum value of R
28 Rmin=Tmin/(C*log(E_dc/(E_dc-V_P))); // calculation
    of minimum value of R
29 I_V_max=E_dc/Rmin; // calculation of maximum anode
    current
30 I_V_min=E_dc/Rmax; // calculation of minimum anode
    current
31 // since  $I_g=2*neta*E_dc/R_g$  , therefore
32 Rg=2*neta*E_dc/Ig; // calculation of gate resistance
    in k-ohm
33 R1=Rg/neta; // calculation of R1 resistance
34 R2=Rg/(1-neta); // calculation of R1 resistance
35 Rmax=Rmax*1E-6; // changing unit from ohm to M-ohm
36 Rmin=Rmin*1E-6; // changing unit from ohm to M-ohm
37 I_V_max=I_V_max*1E6; // changing unit from A to uA
38 I_V_min=I_V_min*1E6; // changing unit from A to uA
39 printf("\nThe peak point voltage is \t\t V_P=%0.2f V"
    ,V_P);
40 printf("\nThe intrinsic stand-off ratio is \t neta=%0
    .2f" ,neta);
41 printf("\nThe maximum value of R is \t\t Rmax=%0.2f M
    -ohm" ,Rmax);
42 printf("\nThe minimum value of R is \t\t Rmin=%0.2f M
    -ohm" ,Rmin);
43 printf("\nThe maximum value of anode current is \t
    I_V_max=%0.2f uA" ,I_V_max);
44 printf("\nThe minimum value of anode current is \t
    I_V_min=%0.f uA" ,I_V_min);
45 printf("\nThe value of gate resistance is \t Rg=%0.2f
    k-ohm" ,Rg);
46 printf("\nThe value of R1 is \t\t\t R1=%0.f k-ohm" ,R1
    );
47 printf("\nThe value of R2 is \t\t\t Rg=%0.2f k-ohm" ,
    R2);
48 // Note : the answee of Rmax, I_V_max, Rg and R2

```

varies slightly due to exact calculation

Chapter 4

Series and Parallel Operation of Thyristors

Scilab code Exa 4.1 Calculate the value of R and C

```
1 // chapter 4
2 // example 4.1
3 // Calculate the value of R and C
4 // page-120-121
5 clear;
6 clc;
7 // given
8 n_s=18; // number of thyristors connected in series
9 E_D=500; // in V (maximum permissible blocking
    voltage)
10 E_s=7500; // in V (string voltage)
11 dI_b=1; // in mA (range of blocking current)
12 dQ=30; // in uC (maximum permissible difference
    between reverse recovery charge)
13 // calculate
14 R=(n_s*E_D-E_s)/((n_s-1)*dI_b); // calculation of R
    in k-ohm
15 C=(n_s-1)*dQ/(n_s*E_D-E_s); // calculation of C in
    uC
```

```

16 printf("\nThe value of R is \tR=%.2f k-ohm",R);
17 printf("\nThe value of C is \tC=%.2f uF",C);

```

Scilab code Exa 4.2 Calculate the series resistance

```

1 // chapter 4
2 // example 4.2
3 // Calculate the series resistance
4 // page-128-129
5 clear;
6 clc;
7 // given
8 I_T1=100; // in A (current of SCR 1)
9 I_T2=150; // in A (current of SCR 2)
10 V_T1=2.1; // in V (on-state voltage of SCR 1)
11 V_T2=1.75; // in V (on-state voltage of SCR 2)
12 // calculate
13 // since  $V_{T1}+I_{T1}*(R+R_{T1})=V_{T2}+I_{T2}*(R+R_{T2})$  and
    // assume  $R+R_{T1}=R_1$  (resistance to be connected in
    // series)
14 // therefore  $V_{T1}+I_{T1}*R_1=V_{T2}+I_{T2}*R_1$  or we get
15  $R_1=(V_{T1}-V_{T2})/(I_{T2}-I_{T1})$ ;
16 printf("The value of required series resistance is \
    \t R1=%.3f ohm",R1);

```

Scilab code Exa 4.3 Calculate the number of thyristors and value of resistance and

```

1 // chapter 4
2 // example 4.3
3 // Calculate the number of thyristors and value of
    // resistance and capacitance
4 // page-130-131
5 clear;

```

```

6  clc;
7  // given
8  Es=6; // in kV (string voltage)
9  Im=4; // in kA (string current)
10 E_D=1.2; // in kV (thyristor voltage)
11 I_T=1; // in kA (thyristor current)
12 neta=90; // in percentage (string efficiency)
13 I_B_max=15; // in mA (maximum blockin current)
14 dQ_max=25; // in uC (maximum permissible difference
    between reverse reovery charge)
15 // calculate
16 neta=netas/100; //changing efficiency from percentage
    to ratio
17 n_s_float=Es/(E_D*neta); // calculation of number of
    thyristos in series
18 n_s= int16(n_s_float)+1; // since n_s will be
    reduced by decimal value it containn if type
    conversion is done because the decimal part would
    be removed so we need to add 1 to it
19 n_p_float=Im/(I_T*neta); // calculation of number of
    thyristos in parallel
20 n_p= int16(n_p_float)+1; // since n_p will be
    reduced by decimal value it containn if type
    conversion is done because the decimal part would
    be removed so we need to add 1 to it
21 n_s=double(n_s); // converting again to double for
    various calculatios
22 n_p=double(n_p); // converting again to double for
    various calculatios
23 printf("\\n\\nThe number of thyristors in series is \\t
    n_s=%f",n_s);
24 printf("\\n\\nThe number of thyristors in parallel is
    n_p=%f",n_p);
25 E_D=(E_D*1E3); // changing unit from kV to V
26 Es=Es*1E3; // changing unit from kV to V
27 dI_b=(I_B_max); // (assumption as done in the book)
28 R=(n_s*E_D-Es)/((n_s-1)*dI_b); // calculation of
    resistance in k-ohm

```

```

29 C=(n_s-1)*dQ_max/(n_s*E_D-Es); // calculation of
    capacitance in uF
30 printf("\nThe value of resistance is \t\t R<=%f k-
    ohm",R);
31 printf("\nThe value of capacitance is \t\t C>=%f
    uF",C);

```

Scilab code Exa 4.4 Calculate the number of thyristors

```

1 // chapter 4
2 // example 4.4
3 // Calculate the number of thyristors
4 // page-132
5 clear;
6 clc;
7 // given
8 Es=7.5; // in kV (total applied voltage)
9 Im=1000; // in A (total forward current)
10 E_D=500; // in V (thyristor voltage)
11 I_T=75; // in A (thyristor current)
12 neta=14; // in percentage (derating factor)
13 // calculate
14 Es=Es*1E3; // changing unit from kV to V
15 neta=neta/100; //changing efficiency from percentage
    to ratio
16 // since neta=1-(Es/(n_s*E_D)) therefore
17 n_s_float=Es/(E_D*(1-neta)); // calculation of
    number of thyristos in series
18 n_s= int16(n_s_float)+1; // since n_s will be
    reduced by decimal value it contain if type
    conversion is done because the decimal part would
    be removed so we need to add 1 to it
19 // since neta=1-(Im/(n_s*I_T)) therefore
20 n_p_float=Im/(I_T*(1-neta)); // calculation of
    number of thyristos in parallel

```

```

21 n_p= int16(n_p_float)+1; // since n_p will be
    reduced by decimal value it contains if type
    conversion is done because the decimal part would
    be removed so we need to add 1 to it
22 printf("\nThe number of thyristors in series is \t
    n_s=%f",n_s);
23 printf("\nThe number of thyristors in parallel is
    n_p=%f",n_p);

```

Scilab code Exa 4.5 Determine the current taken by each SCR and value of equal res

```

1 // chapter 4
2 // example 4.5
3 // Determine the current taken by each SCR and value
    of equal resistors
4 // page-132
5 clear;
6 clc;
7 // given
8 // V1=0.9+2.4E-4*I_T1 (voltage characteristics of
    SCR 1)
9 // V2=1.0+2.3E-4*I_T2 (voltage characteristics of
    SCR 2)
10 I1=500, I2=1000, I3=1500, I4=2000; // in A (total
    current)
11 neta=10; // in percentage
12 // calculate
13 // since SCR are in parallel, therefore V1=V2 or
14 // 0.9+2.4E-4*I_T1=1.0+2.3E-4*I_T2. Simplifying this
    we get
15 // 2.4E-4*I_T1 - 2.3E-4*I_T2=0.1 (i)
16 // since I_T1+I_T2=I (ii)
17 // from (i) in (ii), we get
18 // 2.4E-4*I_T1 - 2.3E-4*(I-I_T1)=0.1 or
19 // 4.7E-4*I_T1=0.1+2.3E-4*I

```

```

20 // simplifying for I_T1, we get
21 // I_T1=(0.1+2.3E-4*I)/4.7E-4
22 for I=500:500:2000
23     I_T1=(0.1+2.3E-4*I)/4.7E-4;
24     I_T2=I-I_T1;
25     printf("\n\nFor I=%f A,\t I_T1=%f A \t and \t
           I_T2=%f A",I,I_T1,I_T2);
26 end
27 // For 10 % sharing I_T1=1100 A and I_T2=900 A ,
           therefore
28 I_T1=1100, I_T2=900; // in A
29 R=(0.1+2.3E-4*I-4.7E-4*I_T1)/(I_T1-I_T2);
30 printf("\n\nThe value of equal resistors is \t R=%f.3
           f m-ohm",R*1E3);

```

Chapter 5

Power Semiconductor Devices

Scilab code Exa 5.1 What will be the maximum and minimum firing angle

```
1 // chapter 5
2 // example 5.1
3 // Fig. 5.15
4 // What will be the maximum and minimum firing angle
5 // page-155
6 clear;
7 clc;
8 // given
9 Vc=40; // in V (breakdown voltage)
10 R1_min=1; R1_max=25; // in k-ohm
11 C=470; // in nF
12 Erms=240; // in V
13 f=50; // in Hz (AC supply frequency)
14 // calculate
15 C=C*1E-9; // changing unit from nF to F
16 R1_min=R1_min*1E3; // changing unit from k-ohm to
    ohm
17 R1_max=R1_max*1E3; // changing unit from k-ohm to
    ohm
18 Zc=1/(2*%pi*f*C); // impedance of capacitor
19 phi_min=90-atan(1/(2*%pi*f*R1_min*C)); //
```

```

    calculation of minimum phase angle
20 phi_max=90-atan(1/(2*pi*f*R1_max*C)); //
    calculation of minimum phase angle
21 Zd_min=sqrt(R1_min^2+Zc^2); // calculation of
    minimum impedance
22 Zd_max=sqrt(R1_max^2+Zc^2); // calculation of
    maximum impedance
23 Em=Erms*sqrt(2); // calculation of maximum value of
    voltage
24 Id_min=Em/Zd_max; //
25 Id_max=Em/Zd_min; // calculation of maximum
    impedance
26 Vc_min_peak=Id_min*Zc;
27 Vc_max_peak=Id_max*Zc;
28 // Now Vc=Vc_max_peak*sin(wt_min+phi_min) and Vc=
    Vc_min_peak*sin(wt_max+phi_max)
29
30 // evaluating both these, we get wt_min=asind(Vc/
    Vc_max_peak)+phi_min and wt_max=asind(Vc/
    Vc_min_peak)+phi_max
31
32 wt_min=asind(Vc/Vc_max_peak)+phi_min;
33 wt_max=asind(Vc/Vc_min_peak)+phi_max;
34 printf("\n\nThe value of impedance of capacitor is \t\
    t Zc=%.f ohm",Zc);
35 printf("\n\nThe value of minimum phase difference is
    \t %.1f degree",phi_min);
36 printf("\n\nThe value of maximum phase difference is \
    t %.2f degree",phi_max);
37 printf("\n\nThe value of minimum total impedance is
    \t Zd_min=%.f ohm",Zd_min);
38 printf("\n\nThe value of maximum total impedance is \t
    Zd_max=%.f ohm",Zd_max);
39 printf("\n\nThe value of minimum peak current is \t\
    t Id_min=%.3f A",Id_min);
40 printf("\n\nThe value of maximum peak current is \t\t
    Id_max=%.3f A",Id_max);
41 printf("\n\nThe value of minimum peak total voltage

```



```

    is \t Vc_min_peak=%0.2f V",Vc_min_peak);
42 printf("\n\nThe value of maximum peak total voltage is
    \t Vc_max_peak=%0.1f V",Vc_max_peak);
43 printf("\n\nThe value of minimum delay is \t\t\t =%
    .2f degree",wt_min);
44 printf("\n\nThe value of maximum delay is \t\t\t =%0.1f
    degree",wt_max);

```

Scilab code Exa 5.2 Compute the drain current and differences in current sharing

```

1 // chapter 5
2 // example 5.2
3 // Fig. E5.2
4 // Compute the drain current and differences in
    current sharing
5 // page-174-175
6 clear;
7 clc;
8 // given
9 I_T=30; // in A (total current)
10 V_DS1=4; // in V (drain to source voltage of MOSFET
    1)
11 V_DS2=4.5; // in V (drain to source voltage of
    MOSFET 2)
12 R_S1_a=0.4, R_S2_a=0.3; // in ohm (current sharing
    series resistance for part-a)
13 R_S1_b=0.7, R_S2_b=0.7; // in ohm (current sharing
    series resistance for part-b)
14 // calculate
15 // Since  $I_T=I_{D1}+I_{D2}$  and  $V_{DS1}+I_{D1}R_{S1}=V_{DS2}+I_{D2}R_{S2}$ ,
    simplifying both equations for  $I_{D1}$ , we get
16 //  $I_{D1}=(V_{DS2}-V_{DS1}+R_{S2}I_T)/(R_{S1}+R_{S2})$ 
17  $I_{D1\_a}=(V_{DS2}-V_{DS1}+R_{S2\_a}I_T)/(R_{S1\_a}+R_{S2\_a});$  //
    calculation of drain current of MOSFET 1 for part
    -a

```

```

18 I_D1_a_percent=I_D1_a*100/I_T; // equivalent value
    in terms of percentage of total current
19 I_D2_a=I_T-I_D1_a; // calculation of drain current
    of MOSFET 2 for part-a
20 I_D2_a_percent=I_D2_a*100/I_T; // equivalent value
    in terms of percentage of total current
21 dI_a=abs(I_D2_a-I_D1_a); // calculation of
    difference in current for part-a
22 dI_a_percent=abs(I_D2_a_percent-I_D1_a_percent); //
    equivalent value in terms of percentage of total
    current
23 printf("\npart-a\n");
24 printf("\nThe drain current of MOSFET 1 is \t I_D1=%g
    .2f A or %.2f %%", I_D1_a, I_D1_a_percent);
25 printf("\nThe drain current of MOSFET 2 is \t I_D2=%g
    .2f A or %.2f %%", I_D2_a, I_D2_a_percent);
26 printf("\n\nThe difference in current sharing is \t%
    .2f A or %.2f %%", dI_a, dI_a_percent);
27 I_D1_b=(V_DS2-V_DS1+R_S2_b*I_T)/(R_S1_b+R_S2_b); //
    calculation of drain current of MOSFET 1 for part
    -a
28 I_D1_b_percent=I_D1_b*100/I_T; // equivalent value
    in terms of percentage of total current
29 I_D2_b=I_T-I_D1_b; // calculation of drain current
    of MOSFET 2 for part-a
30 I_D2_b_percent=I_D2_b*100/I_T; // equivalent value
    in terms of percentage of total current
31 dI_b=abs(I_D2_b-I_D1_b); // calculation of
    difference in current for part-a
32 dI_b_percent=abs(I_D2_b_percent-I_D1_b_percent); //
    equivalent value in terms of percentage of total
    current
33 printf("\n\npart-b\n");
34 printf("\nThe drain current of MOSFET 1 is \t I_D1=%g
    .2f A or %.1f %%", I_D1_b, I_D1_b_percent);
35 printf("\nThe drain current of MOSFET 2 is \t I_D2=%g
    .2f A or %.1f %%", I_D2_b, I_D2_b_percent);
36 printf("\n\nThe difference in current sharing is \t%

```

```

    .2f A    or    %.1f %%",dI_b,dI_b_percent);
37 // Note: the answers for some of the quantity may
    vary slightly due to precise calculation

```

Scilab code Exa 5.3 Determine series resistance and safe highest frequency

```

1 // chapter 5
2 // example 5.3
3 // Determine series resistance and safe highest
  frequency
4 // page-175
5 clear;
6 clc;
7 // given
8 I_T=120; // in A (total current)
9 C_gs1=2200; // in pF (gate to source capacitance of
  MOSFET 1)
10 C_gd1=390; // in pF (gate to drain capacitance of
  MOSFET 1)
11 L_g1=2; // in nH (stray inductance of MOSFET 1)
12 C_gs2=2700; // in pF (gate to source capacitance of
  MOSFET 2)
13 C_gd2=330; // in pF (gate to drain capacitance of
  MOSFET 2)
14 L_g2=2.3; // in nH (stray inductance of MOSFET 2)
15 // calculate
16 C_gs1=C_gs1*1E-12; // changing unit from pF to F
17 C_gd1=C_gd1*1E-12; // changing unit from pF to F
18 L_g1=L_g1*1E-9; // changing unit from nF to F
19 C_gs2=C_gs2*1E-12; // changing unit from pF to F
20 C_gd2=C_gd2*1E-12; // changing unit from pF to F
21 L_g2=L_g2*1E-9; // changing unit from nF to F
22 f1=1/(2*%pi*sqrt(L_g1*(C_gs1+C_gd1))); //
  calculation of oscillating frequency of MOSFET 1
23 f2=1/(2*%pi*sqrt(L_g2*(C_gs2+C_gd2))); //

```

```

    calculation of oscillating frequency of MOSFET 1
24 f_h=min(f1,f2)/10; // calculation of safe highest
    frequency
25 Rg=1/(2*%pi*(C_gs1+C_gd1)*f_h); // calculation of
    series resistance in the gate
26 f_h=f_h*1E-6; // changing unit from Hz to MHz
27 printf("\nThe oscillating frequency of MOSFET 1 is \
    t f1=%0.2E Hz",f1);
28 printf("\nThe oscillating frequency of MOSFET 2 is \
    t f2=%0.2E Hz",f2);
29 printf("\n\n Since the safe highest frequency should
    be at least 1 decade lower than oscillating
    frequency , therefore the safe highest frequency
    is \t %.f MHz",f_h);
30 printf("\n\nThe series resistance in the gate
    terminal of both MOSFET is \t Rg=%0.2f ohm",Rg);
31 // Note: The answer for the series resistance varies
    due to precise calculation

```

Scilab code Exa 5.4 Determine the power dissipated by each MOSFET

```

1 // chapter 5
2 // example 5.4
3 // fig. E5.4
4 // Determine the power dissipated by each MOSFET
5 // page-175-176
6 clear;
7 clc;
8 // given
9 I_T=12; // in A (total current)
10 R1=0.2, R2=0.1 // in ohm
11 // calculate
12 I1=(R2/(R1+R2))*I_T; // applying current divider
    rule to calculate current through MOSFET 1
13 I2=I_T-I1; // calculation of current through MOSFET

```

```

2
14 P1=I1^2*R1; // calculation of power dissipated by
    MOSFET 1
15 P2=I2^2*R2; // calculation of power dissipated by
    MOSFET 2
16 printf("\nThe power dissipated by MOSFET 1 is \t P1=
    %.1f W",P1);
17 printf("\nThe power dissipated by MOSFET 2 is \t P2=
    %.1f W",P2);

```

Scilab code Exa 5.5 Calculate the rise time of driving waveform

```

1 // chapter 5
2 // example 5.5
3 // Calculate the rise time of driving waveform
4 // page-178
5 clear;
6 clc;
7 // given
8 C_iss=470; /// in pf (input capacitance)
9 Rg=200; // in ohm
10 R_L=2.2; // in k-ohm
11 // calculate
12 C_iss=C_iss*1E-12; // changing unit from pF to F
13 // Since  $R_g = t_r / (2.2 * C_{iss})$  therefore
14  $t_r = 2.2 * R_g * C_{iss}$ ; // calculation of current through
    MOSFET 2
15  $t_r = t_r * 1E9$ ; // changing unit from s to ns
16 printf("\nThe rise time is \t  $t_r = %.1f$  ns",t_r);

```

Scilab code Exa 5.6 Determine power loss

```

1 // chapter 5

```

```

2 // example 5.6
3 // fig. E 5.6
4 // Determine power loss
5 // page-182-183
6 clear;
7 clc;
8 // given
9 t_r=2; // in us (rise time)
10 R_DS_on=0.2; // in ohm (drain to source resistance
    when MOSFET is ON)
11 D=0.7; // duty cycle
12 f=30; // in kHz (frequency)
13 V_DS=100; // in V (DC power supply)
14 R_L=12; // in ohm (load resistance)
15 // calculate
16 I_D=V_DS/(R_L+R_DS_on); // calculation of drain
    current
17 f=f*1E3; // changing unit from kHz to Hz
18 T=1/f; // calculation of switching period
19 t_on=D*T; // calculation of on-time
20 W_on=I_D^2*R_DS_on*t_on; // calculation of energy
    loss during on-time
21 P_on=W_on*f; // calculation of power loss during on-
    time
22 printf("\nThe power loss in the on-state is \t\t
    P_on=%0.2 f W",P_on);
23 t_r=t_r*1E-6; // changing unit from us to s
24 W_ON=V_DS*I_D*t_r/6; // calculation of energy loss
    during turn-on interval
25 P_ON=W_ON*f; // calculation of power loss during
    turn-on interval
26 printf("\nThe power loss during the turn-on interval
    is \t P_ON=%0.1 f W",P_ON);

```

Scilab code Exa 5.7 Calculate the total power loss

```

1 // chapter 5
2 // example 5.7
3 // Calculate the total power loss
4 // page-183
5 clear;
6 clc;
7 // given
8 V_DS=120; // in V (DC power supply)
9 I_D=4; // in A (drain current)
10 t_r=80; // in ns (rise time)
11 t_f=120; // in ns (fall time)
12 I_DSS=2; // in mA (drain current at saturation)
13 R_DS_on=0.2; // in ohm (drain to source resistance
    when MOSFET is ON)
14 D=50; // in percentage (duty cycle)
15 f=45; // in kHz (switching frequency)
16 // calculate
17 f=f*1E3; // changing unit from kHz to Hz
18 I_DSS=I_DSS*1E-3; // changing unit from mA to A
19 t_r=t_r*1E-9; // changing unit from ns to s
20 t_f=t_f*1E-9; // changing unit from ns to s
21 T=1/f; // calculation of total period
22 t_on=D*T/100; // calculation of on-time
23 t_off=(100-D)*T/100; // calculation of off-time
24 P_on=I_D^2*R_DS_on*t_on/T; // calculation of on-
    state power loss
25 P_off=V_DS*I_DSS*t_off/T; // calculation of off-
    state power loss
26 Pw_on=(V_DS*I_D*t_r/6)*f; // calculation of turn-on
    switching power loss
27 Pw_off=(V_DS*I_D*t_f/6)*f; // calculation of turn-
    off switching power loss
28 P_T=P_on+P_off+Pw_on+Pw_off; // calculation of total
    power loss
29 printf("\n\nThe total power loss is \t P_T=%.2f W",P_T
    );

```

Scilab code Exa 5.8 Determine avg load current and power losses

```
1 // chapter 5
2 // example 5.8
3 // Fig. E 5.8
4 // Determine avg load current and power losses
5 // page-201
6 clear;
7 clc;
8 // given
9 t_ON=3; // in us (turn-on time)
10 t_OFF=1.2; // in us (turn-off time)
11 D=0.7; // duty cycle
12 V_CE_sat=2; // in V (collector to emitter voltage at
    saturation)
13 f=1; // in kHz (switching frequency)
14 R_L=10; // in ohm (load resistance)
15 V_CC=200; // in V (collector to emitter voltage)
16 // calculate
17 t_ON=t_ON*1E-6; // changing unit from us to s
18 t_OFF=t_OFF*1E-6; // changing unit from us to s
19 f=f*1E3; // changing unit from kHz to Hz
20 V_CE_max=V_CC;
21 I_C_max=(V_CC-V_CE_sat)/R_L; // calculation of
    maximum collector(load) current
22 I_C_avg=D*I_C_max; // calculation of average
    collector(load) current
23 P_con=V_CE_sat*I_C_avg; // calculation of conduction
    power loss
24 Pw_ON=(V_CE_max*I_C_max*t_ON/6)*f; // calculation of
    switching power loss during turn-on
25 Pw_OFF=(V_CE_max*I_C_max*t_OFF/6)*f; // calculation
    of switching power loss during turn-off
26 printf("\n\nThe average load current is \t\t\t I_C_avg
```



```
    =%.2f A", I_C_avg);
27 printf("\nThe conduction power loss is \t\t\t %.2f W
    ", P_con);
28 printf("\nThe switching power loss during turn-on is
    \t %.2f W", Pw_ON);
29 printf("\nThe switching power loss during turn-off
    is \t %.3f W", Pw_OFF);
```

Chapter 6

Phase Controlled Convertors

Scilab code Exa 6.2 Determine the heater power

```
1 // chapter 6
2 // example 6.2
3 // Determine the heater power
4 // page-270
5 clear;
6 clc;
7 // given
8 P=1; // in kW (power rating)
9 E=230; // in V (voltage rating)
10 f=50; // in Hz (supply frequency)
11 alpha1=45, alpha2=90; // in degree (delay angle)
12 // calculate
13 P=P*1E3; // changing unit from kW to W
14 Em=E*sqrt(2); // calculation of maximum value of
    supply voltage
15 alpha1_rad=(%pi/180)*alpha1; // changing from degree
    to radian
16 alpha2_rad=(%pi/180)*alpha2; // changing from degree
    to radian
17 Erms1=Em*sqrt(((%pi-alpha1_rad)/(4*%pi))+((sin(2*
    alpha1_rad))/(8*%pi))); // calculation of rms
```

```

        value of E
18 R=E^2/P; // calculation of resistance
19 W=Erms1^2/R; // calculation of heater power at 45
    degree
20 Erms2=Em*sqrt(((%pi-alpha2_rad)/(4*%pi))+((sin(2*
    alpha2_rad))/(8*%pi))); // calculation of rms
    value of E
21 W2=Erms2^2/R; // calculation of heater power at 45
    degree
22 printf("\nThe heater power at %.f degree is \t W1=%
    .2f W",alpha1,W);
23 printf("\nThe heater power at %.f degree is \t W2=%
    f W",alpha2,W2);

```

Scilab code Exa 6.3 Determine various parameters

```

1 // chapter 6
2 // example 6.3
3 // Determine various parameters
4 // page-270-271
5 clear;
6 clc;
7 // given
8 E=120; // in V (voltage supply)
9 f=50; // in Hz (supply frequency)
10 R=10; // in ohm
11 neta=25; // in percentage
12 // calculate
13 Em=E*sqrt(2); // calculation of maximum value of
    supply voltage
14 Edc=(neta/100)*(Em/%pi); // calculation of dc value
    of voltage
15 // since Edc=(Em/(2*%pi))*(1+cos(alpha)) solving for
    alpha, we get
16 alpha=acosd(Edc*(2*%pi/Em)-1); // calculation of

```

```

    firing angle
17 Idc=Edc/R; // calculation of average output current
18 alpha_rad=(%pi/180)*alpha; // calculation of firing
    angle in radian
19 Erms=Em*sqrt(((%pi-alpha_rad)/(4*%pi))+((sin(2*
    alpha_rad))/(8*%pi))); // calculation of rms
    voltage
20 Irms=Erms/R; // calculation of rms output current
21 Idc_SCR=Idc; // calculation of average SCR current
22 Irms_SCR=Irms; // calculation of rms SCR current
23 printf("\nThe firing angle is \t%.f",alpha);
24 printf("\nThe average output current is \tIdc=%.2f A
    ",Idc);
25 printf("\nThe rms output current is \tIrms=%.2f A",
    Irms);
26 printf("\nThe average SCR current is \t%.2f A",
    Idc_SCR);
27 printf("\nThe rms output current is \t%.2f A",
    Irms_SCR);
28 // Note: There is calculation mistake in the book
    for alpha due to which other values are also
    coming different.That's why all the answer vary

```

Scilab code Exa 6.4 Determine average current power supplied and dissipated and po

```

1 // chapter 6
2 // example 6.4
3 // Determine average current , power supplied and
    dissipated and power factor
4 // page-271-272
5 clear;
6 clc;
7 // given
8 Erms=230; // in V (voltage supply)
9 f=50; // in Hz (supply frequency)

```

```

10 R=5; // in ohm
11 Eb=150; // in V
12 // calculate
13 Em=Erms*sqrt(2); // calculation of maximum value of
    supply voltage
14 alpha1=asin(Eb/Em); // calculation of firing angle
15 Id=(1/(2*pi*R))*(2*Em*cos(alpha1)-Eb*(pi-2*alpha1)
    ); // calculation of average charging current
16 P_s=Eb*Id; // calculation of power supplied to
    battery
17 Irms=sqrt((1/(2*pi*R^2))*((Eb^2+Erms^2)*(pi-2*
    alpha1)+(Erms^2*sin(2*alpha1))-(4*Em*Eb*cos(
    alpha1)))); // calculation of rms current
18 P_d=Irms^2*R; // calculation of power dissipated in
    resistor
19 pf=(P_d+P_s)/(Erms*Irms); // calculation of supply
    power factor
20 printf("\nThe average charging current is \tId=%0.2f
    A", Id);
21 printf("\nThe power supplied to battery is \t%.2f W
    or \t %.2f kW", P_s, P_s*1E-3);
22 printf("\nThe rms current is \tIrms=%0.2f A", Irms);
23 printf("\nThe power dissipated in resistor is \t%.2f
    W or \t %.2f kW", P_d, P_d*1E-3);
24 printf("\nThe supply power factor is \t%.3f", pf);
25 // Note: 1. There is calculation mistake in the book
    for P_s .
26 //      2. The formula used in the book to
    calculate Irms has little printing error for Em.
    It should be Erms for the first two Em used
27 //      3. The answer slightly vary due to precise
    calculations

```

Scilab code Exa 6.5 Determine design details

```

1 // chapter 6
2 // example 6.5
3 // fig. 6.14
4 // Determine design details
5 // page-287-288
6 clear;
7 clc;
8 // given
9 E_supply=230; // in V (voltage supply)
10 Im=12; // in A
11 Edc=150; // in V
12 alpha=30; // in degree
13 V_drop=1.5; // in V (voltage drop across SCR)
14 // calculate
15 // Since  $E_{dc}=(2*E_m/\pi)*\cos(\alpha)-V_{drop}$ ,
    evaluating it for  $E_m$  we get
16  $E_m=(\pi*(E_{dc}+V_{drop}))/2*\cosd(\alpha)$ ; //
    calculation of peak voltage
17 Erms= $E_m/\sqrt{2}$ ; // calculation of rms voltage
18 Irms= $I_m/\sqrt{2}$ ; // calculation of rms current
19 TSR=2*Erms*Irms; // calculation of Transformer
    secondary rating
20 K=E_supply/Erms; // calculation of Transformer
    voltage ratio
21 I_P= $I_m*(1/K)$ ; // calculation of Transformer primary
    current
22 PIV=2*Em; // calculation of PIV for each SCR
23 printf("\nFor M-2 connection\n")
24 printf("\n\tThe peak voltage is \t\t\tEm=%0.1f V", Em)
    ;
25 printf("\n\tThe rms volatge is \t\t\tErms=%0.2f V",
    Erms);
26 printf("\n\tThe rms current is \t\t\tIrms=%0.2f A",
    Irms);
27 printf("\n\tThe Transformer secondary rating is \t %
    .1f kVA", TSR*1E-3);
28 printf("\n\tThe Transformer voltage ratio is \tK=%0.2
    f", K);

```

```

29 printf("\n\tThe Transformer primary current is \tI_P
    =%.2f A", I_P);
30 printf("\n\tThe PIV for each SCR is \t\tPIV=%.f V",
    PIV);
31 Em=(%pi*(Edc+2*V_drop))/(2*cosd(alpha)); //
    calculation of peak voltage
32 Erms=Em/sqrt(2); // calculation of rms voltage
33 Irms=Im; // calculation of rms current
34 TSR=Erms*Irms; // calculation of Transformer
    secondary rating
35 K=E_supply/Erms; // calculation of Transformer
    voltage ratio
36 I_P=Im*(1/K); // calculation of Transformer primary
    current
37 PIV=Em; // calculation of PIV for each SCR
38 I_rms_SCR=Im/sqrt(2); // calculation of rms current
    for each SCR
39 printf("\nFor B-2 connection\n")
40 printf("\n\tThe peak voltage is \t\t\tEm=%.2f V", Em)
    ;
41 printf("\n\tThe rms volatge is \t\t\tErms=%.2f V",
    Erms);
42 printf("\n\tThe rms current is \t\t\tIrms=%.f A",
    Irms);
43 printf("\n\tThe Transformer secondary rating is \t %
    .2f kVA", TSR*1E-3);
44 printf("\n\tThe Transformer voltage ratio is \tK=%.2
    f", K);
45 printf("\n\tThe Transformer primary current is \tI_P
    =%.2f A", I_P);
46 printf("\n\tThe PIV for each SCR is \t\tPIV=%.2f V",
    PIV);
47 printf("\n\tThe rms current for each SCR is \t%.1f A
    ", I_rms_SCR);
48 SCR_loss_M2=(V_drop/Edc)*100; // SCR loss in M2
    connection
49 SCR_loss_B2=(2*V_drop/Edc)*100; // SCR loss in B2
    connection

```

```

50 printf("\n\nThe SCR loss in M2 connection is \t%.f
    percent of the load power",SCR_loss_M2);
51 printf("\n\nThe SCR loss in B2 connection is \t%.f
    percent of the load power",SCR_loss_B2);

```

Scilab code Exa 6.6 Determine variuos parameters

```

1 // chapter 6
2 // example 6.6
3 // fig. 6.21
4 // Determine variuos parameters
5 // page-288-290
6 clear;
7 clc;
8 // given
9 Erms=230; // in V (voltage supply)
10 alpha=%pi/3; // in degree (firing angle)
11 Id=4; // in A (load current)
12 // calculate
13 Em=Erms*sqrt(2); // calculation of rms voltage
14 Edc=(2*Em/%pi)*cos(alpha); // calculation of dc
    output voltage
15 Pi=(2*Em/%pi)*Id*cos(alpha); // calculation of
    active power input
16 Qi=(2*Em/%pi)*Id*sin(alpha); // calculation of
    reactive power input
17 R=Edc/Id; // calculation of load resistance
18 Edc_1=(Em/%pi)*(1+cos(alpha)); // calculation of dc
    output voltage when free wheeling diode is
    connected
19 Id_1=Edc_1/R;
20 I1=(2*sqrt(2)*Id_1/%pi)*cos(alpha/2); // calculation
    of fundamental value of alternating current
21 Pi_1=(Erms*I1)*cos(alpha/2); // calculation of
    active input power input when free wheeling diode

```



```

        is connected
22  Qi_1=(Erms*I1)*sin(alpha/2); // calculation of
    reactive power input when free wheeling diode is
    connected
23  Edc_2=Em/(2*pi)*(1+cos(alpha)); // calculation of
    dc output voltage when SCR3 is damaged
24  Id_2=Edc_2/R; // calculation of dc output current
    when SCR3 is damaged
25  printf("\nThe dc output voltage is \tEdc=%0.2f V",Edc
    );
26  printf("\nThe active power input is \tPi=%0.2f W",Pi)
    ;
27  printf("\nThe reactive power input is \tQi=%0.2f Vars
    ",Qi);
28  printf("\nThe load resistance is \t\tR=%0.2f ohm",R);
29  printf("\n\nWhen free wheeling diode is connected\n"
    );
30  printf("\n\tThe dc output voltage is \tEdc=%0.2f V",
    Edc_1);
31  printf("\n\tThe dc output current is \tIdc=%0.f V",
    Id_1);
32  printf("\n\tThe fundamental value of alternating
    current is \tI1=%0.2f A",I1);
33  printf("\n\tThe active power input is \tPi=%0.2f W",
    Pi_1);
34  printf("\n\tThe reactive power input is \tQi=%0.f
    Vars",Qi_1);
35  printf("\n\nWhen SCR3 is damaged\n");
36  printf("\n\tThe dc output voltage is \tEdc=%0.2f V",
    Edc_2);
37  printf("\n\tThe dc output current is \tIdc=%0.f A",
    Id_2);

```

Scilab code Exa 6.7 Determine the firing angle

```

1 // chapter 6
2 // example 6.7
3 // fig. E6.7
4 // Determine the firing angle
5 // page-290-291
6 clear;
7 clc;
8 // given
9 Erms=220; // in V (voltage supply)
10 R=0.5; // in ohm (load resistance)
11 Idc=10; // in A (output current)
12 Ec_a=135; Ec_b=-145; // in V (capacitor voltage)
13 // calculate
14 Em=Erms*sqrt(2); // calculation of rms voltage
15 Edc_a=Idc*R+Ec_a; // calculation of dc output
    voltage
16 alpha_a=acosd(%pi/(2*Em)*Edc_a); // calculation of
    firing angle when Vc=135 V
17 Edc_b=Idc*R+Ec_b; // calculation of dc output
    voltage
18 alpha_b=acosd(%pi/(2*Em)*Edc_b); // calculation of
    firing angle when Vc=-145 V
19 printf("\n\nThe firing angle when Ec= %.f V is \t= %.f
    degree",Ec_a,alpha_a);
20 printf("\n\nThe firing angle when Ec= %.f V is \t= %
    .f degree",Ec_b,alpha_b);

```

Scilab code Exa 6.8 Determine firing angle output current and thyristor current

```

1 // chapter 6
2 // example 6.8
3 // Determine firing angle, output current and
    thyristor current
4 // page-298-299
5 clear;

```

```

6  clc;
7  // given
8  E=120; // in V (voltage supply)
9  f=50; // supply frequency
10 R=10; // in ohm (load resistance)
11 neta=25; // in percent
12 alpha_min=0; // angle for which average output
    voltage will be maximum
13 // calculate
14 Em=E*sqrt(2); // calculation of rms voltage
15 Edc_max=(Em/%pi)*(1+cos(alpha_min)); // calculation
    of maximum average output voltage
16 Edc=(neta/100)*Edc_max; // calculation of average
    output voltage
17 // Since Edc=(Em/%pi)*(1+cos(alpha)) , therefore we
    get
18 alpha=acos((%pi/Em)*Edc-1); // calculation of firing
    angle in radian
19 Erms=Em*sqrt(((%pi-alpha)/(2*%pi))+((sin(2*alpha))
    /(4*%pi))); // calculation of rms load voltage
20 Irms=Erms/R; // calculation of rms load current
21 Idc=Edc/R; // calculation of average load current
22 Im=Em/R; // calculation of maximum thyristor current
23 I_TH_avg=(Im/(2*%pi))*(integrate('sin(wt)', 'wt',
    alpha,%pi)); // calculation of average thyristor
    current
24 I_TH_rms=sqrt((Im^2/(2*%pi))*(integrate('(sin(wt))^2
    ', 'wt', alpha,%pi))); // calculation of rms
    thyristor current
25 printf("\nThe firing angle is \t\t\t %.f degree",
    alpha*(180/%pi));
26 printf("\nThe average output voltage is \t\t Edc=%f
    V", Edc);
27 printf("\nThe rms load voltage is \t\t Erms=%f V",
    Erms);
28 printf("\nThe average output current is \t\t Idc=%f.1
    f A", Idc);
29 printf("\nThe rms load current is \t\t Irms=%f.1 f A",

```

```

    I_rms);
30 printf("\nThe average thyristor current is \t
    I_TH_avg=%.2f A", I_TH_avg);
31 printf("\nThe rms thyristor current is \t\t I_TH_rms
    =%.2f A", I_TH_rms);

```

Scilab code Exa 6.9 Find average output current and power delivered

```

1 // chapter 6
2 // example 6.9
3 // fig. Ex.6.9
4 // Find average output current and power delivered
5 // page-299-300
6 clear;
7 clc;
8 // given
9 E=230; // in V (voltage supply)
10 f=50; // supply frequency
11 alpha=%pi/4; // in radian (firing angle)
12 R=10; // in ohm (load resistance)
13 L=10; // in mH
14 Ec=120; // in V (capacitor voltage)
15 // calculate
16 Em=E*sqrt(2); // calculation of peak voltage
17 Edc=(Em/(2*%pi))*(integrate('sin(wt)', 'wt', alpha, %pi
    )+abs(integrate('(sin(wt))', 'wt', %pi, 2*%pi))); //
    The formula used in the book has little mistake
18 Idc=(Edc-Ec)/R; // calculation of average output
    current
19 P=Ec*Idc; // calculation of power delivered
20 printf("\nThe average output current is \t Idc=%.2f
    A", Idc);
21 printf("\nThe power delivered is \t\t P=%.2f W", P);
22 // Note: 1. The integrating formula used in the book
    has little mistake but the answer is same

```

because they have mistake in calculation. I have used the correct formula

23 // 2. The answers vary slightly due to precise calculation upto 6 decimal digit. In the book, the calculation is upto 2 decimal digit

Scilab code Exa 6.10 Determine various parameters

```

1 // chapter 6
2 // example 6.10
3 // Determine various parameters
4 // page-300-301
5 clear;
6 clc;
7 // given
8 E=230; // in V (voltage supply)
9 alpha=%pi/6; // in radian (firing angle)
10 // calculate
11 Em=E*sqrt(2); // calculation of peak output voltage
12 Edc=(2*Em/%pi)*cos(alpha); // calculation of average
    output voltage
13 Irms_supply='Id'; // Supply RMS current
14 Irms_fundamental='(2*sqrt(2)/%pi)*Id'; // Supply
    fundamental RMS current
15 pf_fundamental=cos(alpha); // calculation of
    fundamental power factor
16 pf_supply=(2*sqrt(2)/%pi)*cos(alpha); // calculation
    of supply power factor
17 hf_supply=sqrt(%pi^2/8-1); // calculation of
    fundamental harmonic factor
18 KV=sqrt(%pi^2/(8*(cos(alpha))^2)-1); // calculation
    of voltage ripple factor
19 printf("\nThe average output voltage is \t\t Edc=%f.2
    f V",Edc);
20 printf("\nThe supply RMS current is \t\t Irms_supply

```

```

    =%s", Irms_supply);
21 printf("\nThe supply fundamental RMS current is \t
    Irms_fundamental=%s", Irms_fundamental);
22 printf("\nThe fundamental power factor is \t
    pf_fundamental=%.2 f", pf_fundamental);
23 printf("\nThe supply power factor is \t\t pf_supply=
    %.2 f", pf_supply);
24 printf("\nThe fundamental harmonic factor is \t
    hf_supply=%.3 f", hf_supply);
25 printf("\nThe voltage ripple factor is \t\t KV=%.3 f"
    ,KV);

```

Scilab code Exa 6.11 Find displacement factor harmonic factor and input power factor

```

1 // chapter 6
2 // example 6.11
3 // Find displacement factor , harmonic factor and
    input power factor
4 // page-301
5 clear;
6 clc;
7 // given
8 E=120; // in V (voltage supply)
9 f=50; // supply frequency
10 alpha=%pi/6; // in radian (firing angle)
11 // calculate
12 DF=cos(-alpha/2); // calculation of displacement
    factor
13 // Since HF=sqrt((Irms/Irms1)^2-1) where Irms=Idc*
    sqrt(1-(alpha/%pi)) and Irms1=(2*sqrt(2)*Idc/%pi)
    *cos(alpha/2)
14 //putting both value in formula for HF, we get HF=
    sqrt((sqrt(1-(alpha/%pi)))/((2*sqrt(2)/%pi)*cos(
    alpha/2)))^2-1)
15 HF=sqrt((sqrt(1-(alpha/%pi)))/((2*sqrt(2)/%pi)*cos(

```

```

        alpha/2)))^2-1); // calculation of harmonic
        factor of input current
16 // since pf=(Irms1/Irms)*cos(alpha/2) , putting the
    value of both we get pf=(2*sqrt(2)/%pi)*cos(alpha
        /2)/(qrt(1-(alpha/%pi)))
17 PF=(2*sqrt(2)/%pi)*cos(alpha/2)/(sqrt(1-(alpha/%pi))
    ); // calculation of input power factor
18 printf("\nThe displacement factor is \t\t DF=%0.4f",
    DF);
19 printf("\nThe harmonic factor of input current is
    HF=%0.2f percent",HF*100);
20 printf("\nThe input power factor is \t\t PF=%0.3f ",
    PF);
21 if PF>0 then
22     printf("(lagging)");
23 else
24     printf("(leading)");
25 end
26 // Note: The answer for DF, HF, PF varies slightly
    due to precise calculation upto 6 decimal digit
    where as there is 2 decimal digit calculation in
    the book

```

Scilab code Exa 6.12 Determine average output voltage

```

1 // chapter 6
2 // example 6.12
3 // Determine average output voltage
4 // page-319-320
5 clear;
6 clc;
7 // given
8 E=200; // in V (voltage supply per phase)
9 alpha1=0, alpha2=30, alpha3=60; // in degree (firing
    angle)

```

```

10 V_drop=1.5; // in V (voltage drop across SCR)
11 // calculate
12 Em=E*sqrt(2); // calculation of peak value of
    voltage
13 Edc1=(3*sqrt(3)/(2*pi))*Em*cosd(alpha1)-V_drop; //
    calculation of average load voltage for alpha=0
    degree
14 Edc2=(3*sqrt(3)/(2*pi))*Em*cosd(alpha2)-V_drop; //
    calculation of average load voltage for alpha=30
    degree
15 Edc3=(3*sqrt(3)/(2*pi))*Em*cosd(alpha3)-V_drop; //
    calculation of average load voltage for alpha=60
    degree
16 printf("\nThe average load voltage for alpha=%f
    degree\ is t Edc1=%f V",alpha1,Edc1);
17 printf("\n\nThe average load voltage for alpha=%f
    degree\ is t Edc1=%f V",alpha2,Edc2);
18 printf("\n\nThe average load voltage for alpha=%f
    degree\ is t Edc1=%f V",alpha3,Edc3);

```

Scilab code Exa 6.13 Determine average load voltage current PIV and power dssipati

```

1 // chapter 6
2 // example 6.13
3 // Determine average load voltage , current , PIV and
    power dssipation
4 // page-320-321
5 clear;
6 clc;
7 // given
8 E_line=380; // in V (voltage line supply)
9 I=32; // in A (load-current)
10 alpha1=0, alpha2=45; // in degree (firing angle)
11 Vt=1.2; // in V (voltage drop across SCR)
12 // calculate

```



```

13 Em=E_line*sqrt(2/3); // calculation of peak value of
    voltage
14 Edc1=(3*sqrt(3)/(2*pi))*Em*cosd(alpha1)-Vt; //
    calculation of average load voltage for alpha=0
    degree
15 Edc2=(3*sqrt(3)/(2*pi))*Em*cosd(alpha2)-Vt; //
    calculation of average load voltage for alpha=30
    degree
16 Irms=I/sqrt(3); // calculation of rms current
17 PIV=sqrt(2)*E_line; // calculation of peak inverse
    voltage
18 Pavg=(1/(2*pi))*(Vt*I)*integrate('1','wt',alpha1,(
    alpha1+(2*pi/3))); // calculation of average
    power dissipation in each thyristor
19 printf("\nThe average load voltage for alpha=%f
    degree is \t\t Edc1=%f V",alpha1,Edc1);
20 printf("\nThe average load voltage for alpha=%f
    degree is \t Edc1=%f V",alpha2,Edc2);
21 printf("\nThe rms current is \t\t\t\t Irms=%f A"
    ,Irms);
22 printf("\nThe Peak Inverse Voltage is \t\t\t\t PIV=%f
    .1 f V",PIV);
23 printf("\nThe average power dissipation in each
    thyristor is \t Pavg=%f W",Pavg);

```

Scilab code Exa 6.14 Calculate thyristor current ratings

```

1 // chapter 6
2 // example 6.14
3 // Calculate thyristor current ratings
4 // page-321
5 clear;
6 clc;
7 // given
8 E_line=415; // in V (voltage line supply) The value

```

```

        is used in the solution but not mentioned
9  R_L=10; // in ohm
10 alpha=30; // in degree (firing angle)
11 // calculate
12 Em=E_line*sqrt(2/3); // calculation of peak value of
    voltage
13 Edc=(3*sqrt(3)/(2*pi))*Em*cosd(alpha); //
    calculation of average load voltage
14 Idc=Edc/R_L; // calculation of average load current
15 I_T_rms=Idc/sqrt(3); // calculation of thyristor rms
    current
16 I_T_dc=Idc/3; // calculation of thyristor average
    load current
17 I_T_peak=Idc; // calculation of thyristor peak
    current
18 PIV=E_line*sqrt(2); // calculation of thyristor peak
    inverse voltage
19 printf("\nThe average load current \t\t Idc=%0.1f A",
    Idc);
20 printf("\nThe thyristor average load current is \t
    I_T_dc=%0.1f A",I_T_dc);
21 printf("\nThe thyristor rms current is \t\t I_T_rms=
    %0.1f A",I_T_rms);
22 printf("\nThe thyristor peak current is \t\t
    I_T_peak=%0.1f A",I_T_peak);
23 printf("\nThe thyristor peak inverse voltage is \t
    PIV=%0.1f V",PIV);

```

Scilab code Exa 6.15 Determine various parameters

```

1 // chapter 6
2 // example 6.15
3 // Determine various parameters
4 // page-322-323
5 clear;

```

```

6  clc;
7  // given
8  E_L=220; // in V (line voltage)
9  f=50; // in Hz (supply frequency)
10 R_L=10; // in ohm
11 neta=25; // in percent
12 // calculate
13 Es=E_L/sqrt(3); // calculation of phase voltage
14 Em=sqrt(2)*Es; // calculation of peak voltage
15 Edc_max=(3*sqrt(3)/(2*pi))*Em; // calculation of
    maximum average load voltage
16 Edc=(neta/100)*Edc_max; // calculation of average
    load voltage
17 if neta>86.6 then
18     alpha=acosd((2*pi/(3*sqrt(3)*Em))*Edc);
19 else
20     alpha=acosd((2*pi/(3*Em))*Edc-1)-30;
21
22 end
23 printf("\nThe delay angle \t\t\t %.1f degree",alpha)
    ;
24 Idc=Edc/R_L; // calculation of average load current
25 alpha=alpha*pi/180; // changing from degree to
    radian
26 Erms=sqrt((Em^2/(2*pi/3))*integrate('(sin(wt))^2',
    wt',0.691*pi,%pi)); // calculation of rms
    voltage
27 Irms=Erms/R_L; // calculation of rms current
28 I_T_dc=Idc/3; // calculation of thyristor average
    load current
29 I_T_rms=Irms/sqrt(3); // calculation of thyristor
    rms current
30 Pdc=Idc^2*R_L; // calculation of dc power
31 Pac=Irms^2*R_L; // calculation of ac power
32 neta=(Pdc/Pac)*100; // calculation of rectification
    efficiency
33 Input_VA=3*Es*I_T_rms; // calculation of input volt-
    ampere rating

```

```

34 TUF=(Pdc/Input_VA)*100; // calculation of
    transformer utilisation factor
35 pf=Pac/Input_VA; // calculation of input power
    factor
36 printf("\nThe average output current is \t\t Idc=%0.3
    f A",Idc);
37 printf("\nThe rms output current is \t\t Irms=%0.2f A
    ",Irms);
38 printf("\nThe thyristor average current is \t I_T_dc
    =%0.2f A",I_T_dc);
39 printf("\nThe thyristor rms current is \t\t I_T_rms=
    %0.2f A",I_T_rms);
40 printf("\nThe rectification efficiency is \t %0.2f
    percent",neta);
41 printf("\nThe transformer utilisation factor is \t
    TUF=%0.2f percent",TUF);
42 printf("\nThe input power factor is \t\t pf=%0.2f",pf
    );
43 if pf>0 then
44     printf(" (lagging)");
45 else
46     printf(" (leading)");
47 end
48 // Note: The answer for Erms, Irms, I_T_rms, neta,
    TUF, pf vary slightly due to precise calculation

```

Scilab code Exa 6.17 Calculate firing angle and supply power factor

```

1 // chapter 6
2 // example 6.17
3 // Calculate firing angle and supply power factor
4 // page-341-342
5 clear;
6 clc;
7 // given

```

```

8 Vs=230; // in V (voltage supply)
9 f=50; // supply frequency
10 E_batt=200; // in V (battery emf)
11 r=0.5; // in ohm (internal resistance of battery)
12 Id=20; // in A (load current)
13 // calculate
14 Edc=E_batt+Id*r; // calculation of battery terminal
    voltage
15 Em=Vs*sqrt(2/3); // calculation of peak voltage
16 // Since Edc=(3*sqrt(3)*Em/%pi)*cos(alpha) we get
17 alpha=acosd(%pi/(3*sqrt(3)*Em)*Edc); // calculation
    of firing angle
18 Is=sqrt((1/%pi)*Id^2*(2*%pi/3)); // calculation of
    supply current over one-half cycle
19 Idc_rms=Id; // calculation of rms value of output
    current
20 Pd=Edc*Id+Idc_rms^2*r; // calculation of power
    delivere to the load
21 // Since Pd=sqrt(3)*Vs*Is*cos1(alpha1) where cos(
    alpha1) is supply power factor therefore we get
22 pf=Pd/(sqrt(3)*Vs*Is); // calculation of supply
    power factor
23 Edc_batt=E_batt-Id*r; // calculation of dc voltage
    when battery is delivering power
24 // since (-)Edc_batt=(3*sqrt(3)/%pi*Emph*cosd(alpha)
    ) therefore we get
25 alpha2=acosd((%pi/(3*sqrt(3)))*(-Edc_batt)/Em); //
    calculation of firing angle
26 printf("\nThe firing angle is \t\t %.2f degree",
    alpha);
27 printf("\nThe supply power factor is \t %.2f",pf);
28 if pf>0 then
29     printf(" (lagging)");
30 else
31     printf(" (leading)");
32 end
33 printf("\n\nWhen battery is delivering the power,
    the firing angle is \t%.3f degree",alpha2);

```

34 // Note: The answers for all required values varies slightly due to precise calculation upto 6 digit

Scilab code Exa 6.19 Find out SCR rating

```
1 // chapter 6
2 // example 6.19
3 // Find out SCR rating
4 // page-343-344
5 clear;
6 clc;
7 // given
8 Es=415; // in V (voltage supply)
9 f=50; // supply frequency
10 R=100; // in ohm (load resistance)
11 alpha=0; // in radian
12 // calculate
13 Em=Es*sqrt(2/3); // calculation of peak voltage
14 Edc=(3*sqrt(3)*Em/%pi)*cos(alpha); // calculation of
    average voltage
15 Idc=Edc/R; // calculation of average output current
16 I_T_av=(1/(2*%pi))*Idc*integrate('1','wt',(alpha+%pi
    /6),(alpha+5*%pi/6)); // calculation of SCR
    average current
17 I_T_rms=sqrt((1/(2*%pi))*Idc^2*integrate('1','wt',(
    alpha+%pi/6),(alpha+5*%pi/6))); // calculation of
    SCR rms current
18 I_T_peak=Idc; // calculation of SCR peak current
19 PIV=sqrt(3)*Em; // calculation of peak inverse
    voltage of SCR
20 printf("\nThe SCR average current is \t I_T_av=%0.3f
    A",I_T_av);
21 printf("\nThe SCR rms current is \t\t I_T_rms=%0.3f A
    ",I_T_rms);
22 printf("\nThe SCR peak current is \t I_T_peak=%0.3f A
```

```

    ", I_T_peak);
23 printf("\n\nThe peak inverse voltage of SCR is \t
    PIV>=%.f A", PIV);
24 // Note: The answers vary slightly due to precise
    calculations upto 6 decimal digit

```

Scilab code Exa 6.20 Determine fundamental and various harmonics for various angle

```

1 // chapter 6
2 // example 6.20
3 // Determine fundamental and various harmonics for
    various angle
4 // page-344-345
5 clear;
6 clc;
7 clf;
8 // given
9 Es=415; // in V (voltage supply)
10 f=50; // supply frequency
11 R_L=100; // in ohm (load resistance)
12 alpha=0:30:180; // in radian
13 n1=1, n5=5, n7=7, n11=11, n13=13;
14 // calculate
15 Em=Es*sqrt(2/3); // calculation of peak voltage
16 printf("\nThe angles are\t\t\t\t")
17 for alpha=0:30:180
18     printf("\t%.f\t", alpha);
19
20 end
21 printf("\nFundamental component of the supply
    current is");
22 for alpha=0:30:180
23     Edc=(3*sqrt(3)*Em/%pi)*cosd(alpha); //
        calculation of average voltage
24     Idc=Edc/R_L; // calculation of average output

```

```

                current
25     Isn1=abs((2*sqrt(2)*Idc/%pi)*cosd(30*n1)/n1);
26     printf("\t%.3f\t",Isn1);
27
28 end
29 printf("\n%.fth harmonics component is\t\t",n5);
30 for alpha=0:30:180
31     Edc=(3*sqrt(3)*Em/%pi)*cosd(alpha); //
        calculation of average voltage
32     Idc=Edc/R_L; // calculation of average output
        current
33     Isn5=abs((2*sqrt(2)*Idc/%pi)*cosd(30*5)/n5);
34     printf("\t%.3f\t",Isn5);
35 end
36 printf("\n%.fth harmonics component is\t\t",n7);
37 for alpha=0:30:180
38     Edc=(3*sqrt(3)*Em/%pi)*cosd(alpha); //
        calculation of average voltage
39     Idc=Edc/R_L; // calculation of average output
        current
40     Isn7=abs((2*sqrt(2)*Idc/%pi)*cosd(30*n7)/n7);
41     printf("\t%.3f\t",Isn7);
42 end
43 printf("\n%.fth harmonics component is\t\t",n11);
44 for alpha=0:30:180
45     Edc=(3*sqrt(3)*Em/%pi)*cosd(alpha); //
        calculation of average voltage
46     Idc=Edc/R_L; // calculation of average output
        current
47     Isn11=abs((2*sqrt(2)*Idc/%pi)*cosd(30*n11)/n11);
48     printf("\t%.3f\t",Isn11);
49 end
50 printf("\n%.fth harmonics component is\t\t",n13);
51 for alpha=0:30:180
52     Edc=(3*sqrt(3)*Em/%pi)*cosd(alpha); //
        calculation of average voltage
53     Idc=Edc/R_L; // calculation of average output
        current

```



```

54     Isn13=abs((2*sqrt(2)*Idc/%pi)*cosd(30*n13)/n13);
55     printf("\t%.3f\t",Isn13);
56 end
57 // plotting
58 // since to obtain a smooth graph alpha has been
    chosen as given below
59 alpha=[0:5:180]';
60 Edc=(3*sqrt(3)*Em/%pi)*cosd(alpha);
61 Idc=Edc/R_L;
62 Isn1=abs((2*sqrt(2)*Idc/%pi)*cosd(30*n1)/n1);
63 Isn5=abs((2*sqrt(2)*Idc/%pi)*cosd(30*5)/n5);
64 Isn7=abs((2*sqrt(2)*Idc/%pi)*cosd(30*n7)/n7);
65 Isn11=abs((2*sqrt(2)*Idc/%pi)*cosd(30*n11)/n11);
66 Isn13=abs((2*sqrt(2)*Idc/%pi)*cosd(30*n13)/n13);
67 plot2d(alpha,[Isn1 Isn5 Isn7 Isn11 Isn13
    ],[1,2,3,4,5],leg="Isn1@Isn5@Isn7@Isn11@Isn13",
    nax=[2,7,2,10],rect=[0,0,180,5]);
68 xlabel("alpha (degrees)");
69 title("Fundamental and harmonic current with alpha");
    ;
70 // Note: The answers vary slightly due to precise
    calculations upto 6 decimal digit

```

Scilab code Exa 6.21 Determine average voltage

```

1 // chapter 6
2 // example 6.21
3 // Determine average voltage
4 // page-345
5 clear;
6 clc;
7 clf;
8 // given
9 Es=415; // in V (voltage supply)
10 f=50; // supply frequency

```

```

11 alpha=[0:30:120]; // in degree
12 // calculate
13 Em=Es*sqrt(2/3); // calculation of peak voltage
14 for alpha=[0:30:120];
15     if alpha<=60 then
16         Edc=(3*sqrt(3)*Em/%pi)*cosd(alpha); //
            calculation of average voltage for alpha
            <=60
17     else
18         Edc=(3*sqrt(3)*Em/%pi)*(1+cosd(alpha+60)); //
            calculation of average voltage for alpha
            >60
19     end
20     printf("\nFor alpha=%f,\tEdc=%f",alpha,Edc);
21 end
22 // plot
23 alpha=[0:5:60];
24 Edc1=(3*sqrt(3)*Em/%pi)*cosd(alpha);
25 plot2d(alpha,Edc1);
26 alpha=[60:5:120];
27 Edc2=(3*sqrt(3)*Em/%pi)*(1+cosd(alpha+60));
28 plot2d(alpha,Edc2);
29 xlabel("alpha (degrees)");
30 ylabel("Edc (avg) (in V)");
31 title("Average output voltage with alpha");

```

Scilab code Exa 6.22 Determine the minimum width of gate pulse

```

1 // chapter 6
2 // example 6.22
3 // Determine the minimum width of gate pulse
4 // page-345-346
5 clear;
6 clc;
7 // given

```

```

8 I_H=0.2; // in A (holding current)
9 td=2.5; // in us (delay time)
10 wt=%pi/3; // in radian (delay angle)
11 L1=8, L2=0; // in mH
12 R=2; // in ohm
13 E_line=208; // in V (line voltage)
14 f=50; // supply frequency
15 // calculate
16 L1=L1*1E-3; // changing unit from mH to H
17 td=td*1E-6; // changing unit from us to s
18 Ep=E_line/sqrt(3); // calculation of phase voltage
19 Em=Ep*sqrt(2); // calculation of peak voltage
20 e=sqrt(3)*Em*sin(wt+%pi/6);
21 di_dt_1=e/L1; // calculation of rate of rise of
    anode current when L=8 mH
22 // Since I_H=t1*(di_dt), therefore we get
23 t1=I_H/di_dt_1; // calculation of time required for
    anode current to rise to holding value when L=8
    mH
24 tp1=t1+td; // calculation of minimum width of gate
    pulse when L=8 mH
25 //di_dt_2=e/L2; // rate of rise of anode current
    when L=0
26 t2=I_H/e*L2; // calculation of time required for
    anode current to rise to holding value when L=0
27 tp2=t2+td; // calculation of minimum width of gate
    pulse when L=0
28 printf("\nThe minimum width of gate pulse when L=8
    mH is \t tp1=%0.3f us",tp1*1E6);
29 printf("\nThe minimum width of gate pulse when L=0 H
    is \t tp2=%0.1f us",tp2*1E6);

```

Scilab code Exa 6.23 Plot average voltage and load voltage

```
1 // chapter 6
```

```

2 // example 6.23
3 // Plot average voltage and load voltage
4 // page-356-357
5 clear;
6 clc;
7 clf;
8 // given
9 Es=415; // in V (voltage supply)
10 f=50; // supply frequency
11 alpha=[0:30:120]; // in degree
12 // calculate
13 Em=Es*sqrt(2/3); // calculation of peak voltage
14 // plot
15 alpha=[0:5:60];
16 Edc1=(3*sqrt(3)*Em/%pi)*cosd(alpha);
17 plot2d(alpha,Edc1);
18 alpha=[60:5:120];
19 Edc2=(3*sqrt(3)*Em/%pi)*(1+cosd(alpha+60));
20 plot2d(alpha,Edc2);
21 xlabel("alpha (degrees)");
22 ylabel("Edc (avg) (in V)");
23 title("Average output voltage with alpha");
24 // since 3-phase waveform can not be plotted, so i
    have only plotted the average voltage

```

Scilab code Exa 6.24 Determine various parameters

```

1 // chapter 6
2 // example 6.24
3 // Determine various parameters
4 // page-358-359
5 clear;
6 clc;
7 // given
8 E_line=220; // in V (line voltage)

```

```

9 f=50; // supply frequency
10 R_L=10; // in ohm
11 ratio=25; // in percent (ratio of given to maximum
    average output voltage)
12 alpha_min=0; // in radian (firing angle for max
    average output voltage)
13 // calculate
14 Ep=E_line/sqrt(3); // calculation of phase voltage
15 Em=Ep*sqrt(2); // calculation of peak voltage
16 Edc_max=(3*sqrt(3)*Em/(2*pi))*(1+cos(alpha_min));
    // calculation of maximum average output voltage
17 Edc=(ratio/100)*Edc_max; // calculation of average
    output voltage
18 // since Edc=(3*sqrt(3)*Em/(2*pi))*(1+cos(alpha));,
    therefore we get
19 alpha=acosd((2*pi/(3*sqrt(3)*Em))*Edc-1); //
    calculation of firing angle
20 printf("\nThe firing angle is \t\t\t %.f degree",
    alpha);
21 Idc=Edc/R_L; // calculation of average output
    current
22 alpha=alpha*(pi/180); // changing unit from degree
    to radian
23 Erms=(3*Em/2)*sqrt((pi-alpha+0.5*sin(2*alpha))/pi)
    ; // calculation of rms voltage
24 Irms=Erms/R_L; // calculation of rms current
25 I_T_avg=Idc/3; // calculation of SCR average current
26 I_T_rms=Irms*sqrt(2)/3; // calculation of SCR rms
    current
27 neta=(Edc*Idc)/(Erms*Irms)*100; // calculation of
    Rectification efficiency
28 Is=Irms*sqrt(2/3);
29 Es=3*Ep;
30 TUF=(Edc*Idc)/(Es*Is); // calculation of Transformer
    Utilisation Factor
31 printf("\nThe average output current is \t\t Idc=%.2
    f A", Idc);
32 printf("\nThe rms current is \t\t\t Irms=%.2 f A",

```

```

    I_rms);
33 printf("\nThe thyristor average current is \t
    I_T_avg=%.2f A", I_T_avg);
34 printf("\nThe thyristor rms current is \t\t I_T_rms=
    %.2f A", I_T_rms);
35 printf("\nThe Rectification efficiency is \t neta=%
    .1f percent", neta);
36 printf("\nThe Transformer Utilisation Factor is \t
    TUF=%.3f", TUF);
37 // Note : The formula written in the book to
    calculate Erms and Is is wrong but the answer in
    the book is according to the correct formula. I
    have used the correct formula.

```

Scilab code Exa 6.25 Determine DPF DF HF and PF

```

1 // chapter 6
2 // example 6.25
3 // Determine DPF, DF, HF and PF
4 // page-361
5 clear;
6 clc;
7 // given
8 Es=415; // in V (supply voltage)
9 f=50; // supply frequency
10 alpha=0:30:180; // in degree
11 // calculate
12 // Since  $I_{s_n} = (2 \cdot \sqrt{2} \cdot I_{dc} / \pi) \cdot (\cos(30 \cdot n) / n)$ 
    = 0.9 * I_dc * (cos(30 * n) / n)
13 // and  $I_{s\_fund} = 0.9 \cdot I_{dc} \cdot \cos(30) = 0.78 \cdot I_{dc}$  and  $I_{s\_rms} =$ 
    sqrt(2/3) * I_dc ,
14 // Since DF = I_s_fund / I_s_rms therefore we get
15 DF = (0.78 / sqrt(2/3)); // calculation of distortion
    factor
16 HF = sqrt((1/DF)^2 - 1); // calculation of harmonic

```



```

    from a conducting thyristor to the commutating
    diode is \t u1=%0.3f degree",u1);
20 printf("\nThe overlap angle for transfer of current
    from the commutating diode to a thyristor is \t\t
    \t u2=%0.3f degree",u2);
21 // Note: The answers for u1 and u2 vary slightly due
    to precise calculation upto 6 decimal digit

```

Scilab code Exa 6.27 Find the mean voltage at the load

```

1 // chapter 6
2 // example 6.27
3 // fig. Ex. 6.27
4 // Find the mean voltage at the load
5 // page-371-372
6 clear;
7 clc;
8 // given
9 E_line=415; // in V (line voltage)
10 Beta=18; // in degree (advance angle)
11 u=3.8; // in degree (overlap angle)
12 // calculate
13 Em=E_line*sqrt(2/3); // calculation of peak voltage
14 Edc=(3*sqrt(3)/(4*pi))*Em*(cosd(Beta)+cosd(Beta-u))
    ; // calculation of mean voltage at the load
15 printf("\nThe mean voltage at the load is \t Edc=%0.1
    f V",Edc);

```

Scilab code Exa 6.28 Compute source inductance load resistance and overlap angle

```

1 // chapter 6
2 // example 6.28

```



```

3 // Compute source inductance , load resistance and
  overlap angle
4 // page-371-372
5 clear;
6 clc;
7 // given
8 E=400; // in V (supply voltage)
9 f=50; // in Hz (supply frequency)
10 alpha=%pi/4; // in radian (firing angle)
11 Id=10; // in A (load current)
12 Edc=360; // in V (load voltage)
13 // calculate
14 alpha=alpha*(180/%pi);
15 disp(alpha);
16 Emph=E*sqrt(2/3); // calculation of peak voltage
17 // Since Edc=(3*sqrt(3)*Emph/%pi)*cosd(alpha)-(3*2*
  %pi*f*Ls/%pi)*Id, we get
18 Ls=(%pi/(3*2*%pi*f*Id))*((3*sqrt(3)*Emph/%pi)*cosd(
  alpha)-Edc); // calculation of source inductance
19 R=Edc/Id; // calculation of load resistance
20 // since Edc=(3*sqrt(3)*Emph/%pi)*cosd(alpha+u)
  -(3*2*%pi*f*Ls/%pi)*Id, we get
21 u=acosd((%pi/(3*sqrt(3)*Emph))*(Edc-(3*2*%pi*f*Ls/
  %pi)*Id))-alpha; // calculation of overlap angle
22 printf("\nThe source inductance is \t Ls=%0.1f mH",Ls
  *1E3);
23 printf("\nThe load resistance is \t\t R=%0.1f ohm",R)
  ;
24 printf("\nThe overlap angle is \t\t u=%0.f degree",u)
  ;

```

Scilab code Exa 6.29 Compute the average load voltage

```

1 // chapter 6
2 // example 6.29

```

```

3 // Compute the average load voltage
4 // page-372-373
5 clear;
6 clc;
7 // given
8 Eph=150; // in V (supply voltage per phase)
9 f=50; // in Hz (supply frequency)
10 Ls=1.2; // in mH (source inductance)
11 R=0.07; // in ohm
12 V_drop_Thyristor=1.5; // in V (voltage drop across
    Thyristor)
13 Id=30; // in A (continuous load current)
14 alpha=0:30:60; // in degree (firing angles)
15 // calculate
16 Ls=Ls*1E-3; // changing unit from mH to H
17 V_drop_reactance=(3*2*pi*f*Ls/(2*pi))*Id; //
    voltage drop due to source reactance
18 Em=Eph*sqrt(2); // calculation of peak voltage
19 for alpha=0:30:60
20     Edc=((3*sqrt(3)/(2*pi))*Em*cosd(alpha))-
        V_drop_Thyristor-V_drop_reactance;; //
        calculation of average load voltage
21     printf("\nFor %.f degree, the average load
        voltage is Edc=%.1f V",alpha,Edc);
22 end
23 // Note: The answers vary slightly due to precise
    calculation upto 6 decimal digits

```

Scilab code Exa 6.30 Compute the average generator voltage

```

1 // chapter 6
2 // example 6.30
3 // Compute the average generator voltage
4 // page-373
5 clear;

```

```

6  clc;
7  // given
8  E=415; // in V (supply voltage per phase)
9  f=50; // in Hz (supply frequency)
10 X_L=0.3; // in ohm (source reactance)
11 R=0.05; // in ohm (resistance per phase)
12 V_drop_Thyristor=1.5; // in V (voltage drop across
    Thyristor)
13 Id=60; // in A (continuous load current)
14 Beta=35; // in degree (firing advance angle)
15 u=0; // in degree (overlap angle at no load)
16 // calculate
17 V_drop_reactance=(3*X_L/%pi)*Id; // voltage drop due
    to overlap
18 V_drop_Thyristors=2*V_drop_Thyristor; // voltage
    drop due to SCRs
19 V_drop_resistance=2*R*Id; // voltage drop due to
    supply resistance
20 Emph=E*sqrt(2/3); // calculation of peak voltage
21 Edc_noload=-((3*sqrt(3)/%pi)*Emph*cosd(u-Beta)); //
    calculation of average voltage at no load
22 Edc=abs(Edc_noload-V_drop_Thyristors-
    V_drop_reactance-V_drop_resistance); //
    calculation of average generator voltage
23 printf("\n\nThe average generator voltage is Edc=%0.2 f
    V",Edc);
24 // Note: The answers vary slightly due to precise
    calculation upto 6 decimal digits

```

Scilab code Exa 6.32 Compute the firing angle and overlap angle

```

1 // chapter 6
2 // example 6.32
3 // Compute the firing angle and overlap angle
4 // page-373-375

```

```

5 clear;
6 clc;
7 // given
8 Eph=230; // in V (supply voltage per phase)
9 f=50; // in Hz (supply frequency)
10 Ls=0.3; // in mH (source inductance)
11 Id=15; // in A (load current)
12 R=1; // ohm (internal resistance)
13 E_loadsource=400; // in V (dc source voltage)
14 // calculate
15 Ls=Ls*1E-3; // changing unit from mH to H
16 Edc=E_loadsource+Id*R; // calculation of average
    voltage
17 Emph=Eph*sqrt(2); // calculation of peak voltage
18 // Since Edc=(3*sqrt(3)/%pi)*Emph*cosd(alpha)-(3*2*
    %pi*f*Ls/%pi)*Id, therefore we get
19 alpha=acosd((%pi/(3*sqrt(3)*Emph))*(Edc+(3*2*%pi*f*
    Ls/%pi)*Id)); // calculation of firing angle
20 // Since Edc=(3*sqrt(3)/%pi)*Emph*cosd(alpha+u)
    +(3*2*%pi*f*Ls/%pi)*Id, therefore we get
21 u=acosd(%pi/(3*sqrt(3)*Emph)*(Edc-(3*2*%pi*f*Ls/%pi)
    *Id))-alpha; // calculation of overlap angle
22 printf("\nThe firing angle is \t%.2f degree",alpha);
23 printf("\nThe overlap angle is \t%.3f degree",u);
24 // Note: The answers vary slightly due to precise
    calculation upto 6 decimal digits.In the book,
    the calculation is done upto 2 decimal digit

```

Scilab code Exa 6.33 Design the 3 phase bridge convertor

```

1 // chapter 6
2 // example 6.33
3 // Design the 3-phase bridge convertor
4 // page-375-377
5 clear;

```

```

6  clc;
7  // given
8  E=2.3; // in kV (supply voltage)
9  n=10; // delta-star transformer ratio
10 f=50; // in Hz (supply frequency)
11 Id=90; // in A (load current)
12 Edc1=500, Edc2=-500; // in V (range of varying DC
    voltage)
13 Ls=50; // in uH (commutating inductance per phase)
14 V_T=1.5; // in V (assumption for voltage drop across
    SCR as done in the book)
15 Tc_max=104; // in degree C (assumption for maximum
    temperature as done in the book)
16 T_A=25; // in degree C (assumption as done in the
    book)
17 theta_CS=0.675; // in degree C/W (assumption as done
    in the book)
18 Pav=43; // in W (assumption as done in the book)
19 // calculate
20 Ls=Ls*1E-6; //changing unit from uH to H
21 E=E*1E3; //changing unit from kV to V
22 Edc_red=(3*2*%pi*f*Ls/%pi)*Id; // calculation of
    reduction in output voltage due to overlap
23 Edc=Edc1+Edc_red+2*V_T; // calculation of average
    output voltage
24 E_L=(E/n)*sqrt(3); // calculation of line rms voltage
25 // Since Edc=1.35*E_L*cosd(alpha), therefore we get
26 alpha=acosd(Edc/(1.35*E_L)); // calculation of firing
    angle
27 E_DRM=E_L*sqrt(2)*V_T; // calculation of voltage
    ratings of SCR
28 ERRM=E_DRM; // calculation of voltage ratings of SCR
29 Iavg=Id/3; // calculation of average output current
30 Irms=Id/sqrt(3); // calculation of rms current
31 printf("\\n\\nThe average output voltage is \\t\\tEdc=%0.2 f
    V", Edc);
32 printf("\\n\\nThe line rms voltage is \\t\\tE_L=%0.1 f V",
    E_L);

```

```

33 printf("\nThe firing angle is \t\t\t%.1f degree",
    alpha);
34 printf("\nThe minimum voltage rating of SCR are \
    tE_DRM=ERRM=%.f V",E_DRM);
35 printf("\nThe average output current is \t\tIavg=%.f
    A",Iavg);
36 printf("\nThe rms current is \t\t\tIrms=%.2f A",Irms
    );
37 printf("\n\nTherefore we can select SCRs with rating
    900 V and 63 A (rms)");
38 Edc_2=(Edc2+Edc_red+2*V_T);// calculation of average
    output voltage in inverting mode. Here minus
    sign indicates inverting mode
39 PF=Edc_2/(1.35*E_L);// calculation of cos(alpha) in
    inverting mode
40 // since cosd(alpha+u)=cosd(alpha)-(2*pi*f*Ls*Id*
    sqrt(3/2)/E_L), therefore we get
41 alpha_mu=acosd(PF-(2*pi*f*Ls*Id*sqrt(3/2)/E_L));//
    calculation of (alpha+mu)
42 gama=180-alpha_mu;// calculation of gama
43 t_off=gama/(2*pi*f*(180/pi));// calculation of off
    time
44 printf("\n\nThe off time is \t t_off=%.3f ms",t_off
    *1E3);
45 theta_CA=(Tc_max-T_A)/Pav;
46 // since theta_CA=theta_CS+theta_SA, therefore we
    get
47 theta_SA=theta_CA-theta_CS;
48 printf("\n\nThe heat sink parameters is \t theta_SA=
    %.2f degree C/W", theta_SA);
49 Irms_secondary=sqrt(2/3)*Id;// calculation of rms
    secondary current
50 Irms_primary=sqrt(2/3)*Id/n;// calculation of rms
    primary current
51 VA_rating=3*E_L*Irms_secondary/sqrt(3);//
    calculation of transformer VA rating
52 I_Lf=(3/pi)*(2*Id/n)*(1/sqrt(2));// calculation of
    lin rms fundamental current

```

```

53 I_L=sqrt(2)*Id/n; // calculation of rms current
54 printf("\n\nThe rms secondary current is \t\t%.2f A"
, Irms_secondary);
55 printf("\n\nThe rms primary current is \t\t%.2f A",
, Irms_primary);
56 printf("\n\nThe tranformer VA rating is \t\t%.1f kVA",
, VA_rating*1E-3);
57 printf("\n\nThe line rms fundamental current is \tI_Lf
= %.2f A", I_Lf);
58 printf("\n\nThe rms current is \t\t\tI_L= %.2f A", I_L);
59 DPF=cosd(alpha); // calculation of displacement power
factor
60 DF=I_Lf/I_L; // calculation of distortion factor
61 PF=DPF*DF; // calculation of supply power factor
62 Pi=sqrt(3)*E*I_Lf*DPF; // calculation of fundamental
input power
63 Po=Edc1*Id; // calculation of output power
64 neta=(Po/Pi)*100; // calculation of efficiency
65 printf("\n\nThe displacement power factor is \tDPF= %
.2f", DPF);
66 printf("\n\nThe distortion factor is \t\tDF= %.2f", DF);
67 printf("\n\nThe power factor is \t\t\tPF= %.2f ", PF);
68 printf("\n\nThe efficiency is \t\t\t%.1f percent", neta
);
69 // Note: The answers vary slightly due to precise
calculation upto 6 decimal digits. In the book,
the calculation is done upto 2 decimal digit

```

Scilab code Exa 6.34 Calculate delay angle power delivered and fundamental reactive

```

1 // chapter 6
2 // example 6.34
3 // Calculate delay angle , power delivered and
fundamental reactive power
4 // page-377-378

```



```

7 // given
8 E_line=400; // in V (line to line supply voltage)
9 alpha=30; // in degree (control angle)
10 r=15; // in degree (overlap angle)
11 alpha_inv_mode=120; // in degree (control angle in
    inverting mode)
12 P=6; // number of pulses
13 // calculate
14 Emax=sqrt(2/3)*E_line;// calculation of peak voltage
15 Edc_with_overlap=(P/(2*pi))*Emax*sin(pi/P)*(cosd(
    alpha)+cosd(alpha+r));// calculation of average
    output voltage with overlap
16 Edc_without_overlap=(P/pi)*Emax*(pi/P)*cosd(alpha)
    ;// calculation of average output voltage without
    overlap
17 Edc_drop=Edc_without_overlap-Edc_with_overlap;//
    calculation of reduction in dc output voltage
18 Beta=180-alpha_inv_mode;// calculation of beta
19 r=Beta-acosd((25/(Emax*sin(pi/P)))-cosd(Beta));//
    calculation of overlpa angle
20 printf("\nThe reduction in dc output voltage due to
    overlap is \t %.2f V",Edc_drop);
21 printf("\nThe overlap angle in the inverting mode is
    \t\t r= %.f degree",r);
22 // Note: The answers vary slightly due to precise
    calculation upto 6 decimal digits.In the book,
    the calculation is done upto 2 decimal digit

```

Scilab code Exa 6.36 Calculate various parameters

```

1 // chapter 6
2 // example 6.36
3 // Calculate various parameters
4 // page-393-395
5 clear;

```

```

6  clc;
7  // given
8  E=230; // in V (supply voltage)
9  f=50; // in Hz (supply frequency)
10 Ia=10; // in A
11 Edc=175; // in V (average output voltage)
12 alpha1=33, alpha2=78; // in degree
13 Beta1=62; // in degree
14 // calculate
15 Em=sqrt(2)*E; // calculation of peak voltage
16 // EAC control
17 // Since Edc=(Em/%pi)*(1-cosd(Beta)), therefore we
   get
18 Beta=acosd(1-(%pi/Em)*Edc); // calculation of
   extinction angle
19 Is_rms=Ia*sqrt(Beta/180); // calculation of rms
   supply current
20 Is_fund=(2*sqrt(2)*Ia/%pi)*sind(Beta/2); //
   calculation of rms fundamental current
21 DPF=sind(Beta/2); // calculation of displacement
   factor
22 DF=Is_fund/Is_rms; // calculation of distortion
   factor
23 HF=sqrt(1/DF^2-1); // calculation of harmonic factor
24 PF=DF*DPF; // calculation of power factor
25 printf("\nEAC Control");
26 printf("\n\t\tThe extinction angle is \t Beta=%0.2 f
   degree",Beta);
27 printf("\n\t\tThe rms supply current is \t Is_rms=%0
   .2 f A",Is_rms);
28 printf("\n\t\tThe rms fundamental current is \t
   Is_fund=%0.2 f A",Is_fund);
29 printf("\n\t\tThe displacement factor is \t DPF=%0.2 f
   ",DPF);
30 if DPF>=0 then
31     printf(" (lagging)");
32 else
33     printf(" (leading)");

```

```

34 end
35 printf("\n\t\tThe distortion factor is \t DF=%0.2 f
    percent",DF*100);
36 printf("\n\t\tThe harmonic factor is \t\t HF=%0.2 f
    percent",HF*100);
37 printf("\n\t\tThe power factor is \t\t PF=%0.4 f",PF);
38 if PF>=0 then
39     printf(" (lagging)");
40 else
41     printf(" (leading)");
42 end
43 // SAC control
44 // Since  $E_{dc}=(2*E_m/\pi)*\cos(\alpha)$ , therefore we
    get
45  $\alpha=\arccos(\pi/(2*E_m)*E_{dc})$ ; // calculation of
    trigger angle
46  $I_{s\_rms}=I_a*\sqrt{1-(2*\alpha/180)}$ ; // calculation of
    rms supply current
47  $I_{s\_fund}=(2*\sqrt{2}*I_a/\pi)*\cos(\alpha)$ ; //
    calculation of rms fundamental current
48 DPF=1; // calculation of displacement factor
49  $DF=I_{s\_fund}/I_{s\_rms}$ ; // calculation of distortion
    factor
50  $HF=\sqrt{1/DF^2-1}$ ; // calculation of harmonic factor
51  $PF=DF*DPF$ ; // calculation of power factor
52 printf("\n\nSAC Control");
53 printf("\n\t\tThe trigger angle is \t\t  $\alpha$ =%0.2 f
    degree",alpha);
54 printf("\n\t\tThe rms supply current is \t  $I_{s\_rms}$ =%0.
    f A", $I_{s\_rms}$ );
55 printf("\n\t\tThe rms fundamental current is \t
     $I_{s\_fund}$ =%0.1 f A", $I_{s\_fund}$ );
56 printf("\n\t\tThe displacement factor is \t DPF=%0.f"
    ,DPF);
57 printf("\n\t\tThe distortion factor is \t DF=%0.f
    percent",DF*100);
58 printf("\n\t\tThe harmonic factor is \t\t HF=%0.1 f
    percent",HF*100);

```

```

59 printf("\n\t\tThe power factor is \t\t PF=%0.2 f",PF);
60 // PWM control
61 Beta3=180-alpha1;
62 Beta2=180-alpha2;
63 alpha3=180-Beta1;
64 Edc=(Em/%pi)*(cosd(alpha1)-cosd(Beta1)+cosd(alpha2)-
        cosd(Beta2)+cosd(alpha3)-cosd(Beta3));//
        calculation of average output voltage
65 Is_rms=(Ia/sqrt(180))*sqrt(Beta1-alpha1+Beta2-alpha2
        +Beta3-alpha3);// calculation of rms supply
        current
66 Is_fund=(sqrt(2)*Ia/%pi)*(cosd(alpha1)-cosd(Beta1)+
        cosd(alpha2)-cosd(Beta2)+cosd(alpha3)-cosd(Beta3)
        );// calculation of rms fundamental current
67 DPF=1;// calculation of displacement factor
68 DF=Is_fund/Is_rms;// calculation of distortion
        factor
69 HF=sqrt(1/DF^2-1);// calculation of harmonic factor
70 PF=DF*DPF;// calculation of power factor
71 printf("\n\nPWM Control");
72 printf("\n\t\tThe average output voltage is \t Edc=%0
        .2 f V",Edc);
73 printf("\n\t\tThe rms supply current is \t Is_rms=%0
        .2 f A",Is_rms);
74 printf("\n\t\tThe rms fundamental current is \t
        Is_fund=%0.1 f A",Is_fund);
75 printf("\n\t\tThe displacement factor is \t DPF=%0.f"
        ,DPF);
76 printf("\n\t\tThe distortion factor is \t DF=%0.f
        percent",DF*100);
77 printf("\n\t\tThe harmonic factor is \t\t HF=%0.2 f
        percent",HF*100);
78 printf("\n\t\tThe power factor is \t\t PF=%0.2 f",PF);
79 // Note: The answers vary slightly due to precise
        calculation upto 6 decimal digits.In the book,
        the calculation is done upto 2 decimal digit

```

Chapter 7

Dual Converters

Scilab code Exa 7.1 Compute the peak value of circulating current

```
1 // chapter 7
2 // example 7.1
3 // Compute the peak value of circulating current
4 // page-431
5 clear;
6 clc;
7 // given
8 Erms=230; // in V (per phase voltage supply)
9 w=315; // in rad/s
10 L=12; // in mH
11 alpha1=60, alpha2=120; // in degree
12 // calculate
13 L=L*1E-3; // changing unit from mH to H
14 i_cp=(3*sqrt(2)*Erms/(w*L))*(1-cosd(30)); //
    calculation of peak value of circulating current
15 printf("\nThe peak value of circulating current is \
    t i_cp=%0.2f A",i_cp);
16 // Note: The answer varies slightly due to precise
    calculation
```

Scilab code Exa 7.2 Design dual convertor

```
1 // chapter 7
2 // example 7.2
3 // Design dual convertor
4 // page-432
5 clear;
6 clc;
7 // given
8 Ea=220; // in V
9 Ia=30; // in A
10 N=1500; // in rpm (speed of motor)
11 Eac=400; // in V (3-phase supply)
12 f=50; // in Hz (supply frequency)
13 drop=15; // in percent (drop in the circuit)
14 // calculate
15 E_drop=(drop/100)*Ea; // calculation of total drop in
    the system
16 Edc_alpha=Ea+E_drop; // calculation of total dc
    voltage
17 // since  $E_{dc\_alpha}=1.35 \cdot E_{ac} \cdot \cos(\alpha)$ , therefore
    we get
18 alpha1=acosd(Edc_alpha/(1.35*Eac)); // calculation of
    firing angle
19 Iac=0.817*Ia; // calculation of AC line current
20 Pac=sqrt(3)*Eac*Iac; // calculation of AC terminal
    power
21 // since  $P_{ac}=1.35 \cdot P_{dc}$ , therefore we get
22 Pdc=Pac/1.35; // calculation of DC average power
23 I_ripple=Ia/5; // calculation of ripple current
24 w=2*%pi*f; // calculation of angular velocity
25 Lc=(2*1.35*Eac/(6*w*I_ripple))*(1/7+1/5); //
    calculation of current limiting inductance
26 alpha2=180-alpha1; // calculation of firing angle
```

```

27 PIV=2*sqrt(2)*Eac; // calculation of peak inverse
    voltage of SCR
28 I_T=2*sqrt(2)*Iac; // calculation of current rating
    of SCR
29 printf("\nThe total drop in the system is \t E_drop=
    %.f V",E_drop);
30 printf("\nThe total dc voltage is \t\t Edc_alpha=%.f
    V",Edc_alpha);
31 printf("\nThe firing angle is \t\t\t alpha1=%.f
    degree",alpha1);
32 printf("\nThe AC line current is \t\t\t Iac=%.2f A",
    Iac);
33 printf("\nThe AC terminal power is \t\t Pac=%.2f kW"
    ,Pac*1E-3);
34 printf("\nThe DC average power is \t\t Pdc=%.2f kW",
    Pdc*1E-3);
35 printf("\nThe current limiting inductance is \t Lc=%
    .f mH",Lc*1E3);
36 printf("\nThe firing angle is \t\t\t alpha2=%.f
    degree",alpha2);
37 printf("\nThe peak inverse voltage of SCR is \t PIV=
    %.f V",PIV);
38 printf("\nThe current rating of SCR is \t\t I_T=%.f
    A",I_T);

```

Chapter 8

Choppers

Scilab code Exa 8.1 Determine time ratio of the chopper

```
1 // chapter 8
2 // example 8.1
3 // Determine time ratio of the chopper
4 // page-439
5 clear;
6 clc;
7 // given
8 Edc=100; // in V
9 L=40; // in mH
10 R=5; // in ohm
11 I1=10, I2=12; // in A (current limits)
12 // calculate
13 Iavg=(I1+I2)/2; // calculation of average value of
    load current
14 Imax=Edc/R; // calculation of maximum value of load
    current
15 E0_av=Edc*(Iavg/Imax); // calculation of average
    value of voltage
16 // since  $T_{on}/(T_{on}+T_{off})=E0\_av/Edc$ , therefore we get
17  $T_{on}/T_{off}=E0\_av/(Edc-E0\_av)$ ; // calculation of time
    ratio of the chopper
```



```

18 printf("\n\nThe time ratio of the chopper is \t Ton/
    Toff=%.3 f ",Ton_Toff);

```

Scilab code Exa 8.3 Determine average and rms output voltage chopper efficiency and

```

1 // chapter 8
2 // example 8.3
3 // Determine average and rms output voltage , chopper
    efficiency and effective input resistance
4 // page-440-441
5 clear;
6 clc;
7 // given
8 Edc=200; // in V (input voltage)
9 R=15; // in ohm
10 Ed=2.5; // in V (voltage drop when the chopper is ON
    )
11 f=1; // in KHz (chopper frequency)
12 alpha=50; // in percent (duty cycle)
13 // calculate
14 f=f*1E3;
15 T=1/f; // calculation of time period of chopper
16 E0=(alpha/100)*(Edc-Ed); // calculation of average
    output voltage
17 E0_rms=sqrt(alpha/100)*(Edc-Ed); // calculation of
    rms output voltage
18 IO_rms=E0_rms/R; // calculation of rms output current
19 Po=E0_rms*IO_rms; // calculation of output power
20 Is=(Edc-Ed)/R; // calculation of average output
    current
21 Pi=(1/T)*Edc*Is*integrate('1','t',0,((alpha/100)*T))
    ; // calculation of input power
22 neta=Po/Pi; // calculation of chopper efficiency
23 printf("\n\nThe average output voltage is \t E0=%.2 f V
    ",E0);

```

```

24 printf("\nThe rms output voltage is \t E0_rms=%0.3f V
    ",E0_rms);
25 printf("\nThe chopper efficiency is \t neta=%0.2f
    percent",neta*100);

```

Scilab code Exa 8.4 Calculate the required pulse width

```

1 // chapter 8
2 // example 8.4
3 // Calculate the required pulse width
4 // page-442
5 clear;
6 clc;
7 // given
8 Edc=220; // in V (dc source)
9 E0=500; // in V (load voltage)
10 Toff=80; // in us (blocking period of thyristor)
11 // calculate
12 // since  $E0 = Edc * (Ton + Toff) / Toff$ , therefore we get
13  $Ton = (E0 / Edc) * Toff - Toff$ ; // calculation of required
    pulse width
14 printf("\nThe time required pulse width is \t Ton=%
    .1f us",Ton);
15 // Note: the answer varies slightly due to precise
    calculation

```

Scilab code Exa 8.5 Calculate the conduction and blocking period of the thyristor

```

1 // chapter 8
2 // example 8.5
3 // Calculate the conduction and blocking period of
    the thyristor
4 // page-446

```

```

5 clear;
6 clc;
7 // given
8 Edc=220; // in V (dc source)
9 f=2; // in Khz (chopper frequency)
10 E0=170; // in V (load voltage)
11 // calculate
12 f=f*1E3;
13 // since  $E0=E_{dc} \cdot T_{on} \cdot f$ , therefore we get
14  $T_{on}=E0/(E_{dc} \cdot f)$ ; // calculation of conduction period
    of the thyristor
15  $T=1/f$ ; // calculation of chopping period
16  $T_{off}=T-T_{on}$ ; // calculation of blocking period of
    the thyristor
17 printf("\nThe conduction period of the thyristor is
    \t  $T_{on}=%0.3f$  s",Ton*1E3);
18 printf("\nThe blocking period of the thyristor is \t
     $T_{off}=%0.3f$  s",Toff*1E3);
19 // Note: the answer varies slightly due to precise
    calculation

```

Scilab code Exa 8.6 Calculate limit of current pulsation chopping frequency duty c

```

1 // chapter 8
2 // example 8.6
3 // Calculate limit of current pulsation , chopping
    frequency , duty cycle and output voltage
4 // page-446
5 clear;
6 clc;
7 // given
8 Edc=110; // in V (dc source)
9 Ton=15; // in ms (conduction period of the thyristor
    )
10 Toff=12; // in ms (blocking period of the thyristor)

```

```

11 IO_max=300; // in A (maximum possible accelerating
    current)
12 IO_min=140; // in A (lower limit of current
    pulsation)
13 // calculate
14 limit=IO_max-IO_min; // calculation of limit of
    current pulsation
15 T=Ton+Toff; // calculation of chopping period
16 f=1/(T*1E-3); // calculation of chopping frequency
17 alpha=Ton/T; // calculation of duty cycle
18 E0=alpha*Edc; // calculation of output voltage
19 printf("\nThe limit of current pulsation is \t %.f A
    ",limit);
20 printf("\nThe chopping frequency is \t\t f=%.f Hz",f
    );
21 printf("\nThe duty cycle is \t\t\t alpha=%.2f ",
    alpha);
22 printf("\nThe output voltage is \t\t\t E0=%.2f V",E0
    );
23 // Note: the answer varies slightly due to precise
    calculation

```

Scilab code Exa 8.7 Compute following quantities

```

1 // chapter 8
2 // example 8.7
3 // Compute following quantities
4 // whether load current is continuous, Average
    output current, maximum & minimum values of
    steady-state output current, rms values of 1st, 2
    nd, 3rd harmonics of load current, Average value
    of source current, input power, power absorbed by
    the back emf Eb and power loss in the resistor,
    RMS value of uoutput current
5 // page-459-460

```

```

6 clear;
7 clc;
8 // given
9 Edc=220; // in V (dc source)
10 f=500; // in Hz (chopping frequency)
11 alpha=0.3; // duty cycle
12 R=1; // in ohm
13 L=3; // in mH
14 Eb=23; // in V (back emf)
15 // calculate
16 L=L*1E-3; // changing unit from mH to H
17 tou=L/R;
18 T=1/f;
19 g=Eb/Edc;
20 w=2*pi*f;
21 alpha_1=(tou/T)*log(1+g*(exp(T/tou)-1));
22 if alpha>alpha_1 then
23     printf("\nThe load current is continuous.");
24 else
25     printf("\nThe load current is discontinuous.");
26 end
27 IO_avg=(alpha*Edc-Eb)/R;
28 printf("\n\nThe average output current is \t\t\t\t
        IO_avg=%0.1 f A", IO_avg);
29 // Since alpha=Ton/T, therefore we get
30 Ton=alpha*T;
31 IO_max=(Edc/R)*((1-exp(-Ton/tou))/(1-exp(-T/tou)))-
        Eb/R;
32 printf("\n\nThe maximum steady-state output current
        is \t\t IO_max=%0.2 f A", IO_max);
33 IO_min=(Edc/R)*((exp(Ton/tou)-1)/(exp(T/tou)-1))-Eb/
        R;
34 printf("\n\nThe minimum steady-state output current
        is \t\t IO_min=%0.2 f A", IO_min);
35 Value=0; // a temporary variable to calculate few
        variables
36 for n=1:3
37     Z=sqrt(R^2+(w*n*L)^2);

```

```

38     I=(2*Edc*sin(n*pi*alpha))/(n*sqrt(2)*pi)/Z;
39     printf("\n\nThe %.fth harmonic of steady-state
          output current is \t I_%.f=%.3f A",n,n,I);
40     Value=Value+I^2;
41 end
42 I_TAV=(Edc-Eb)*alpha/R-(L/(R*T))*(IO_max-IO_min);
43 printf("\n\nThe average value of source current is \
          \t\t\t I_TAV=%.f3 A",I_TAV);
44 Pin=Edc*I_TAV;
45 P_absorbed=Eb*IO_avg;
46 P_loss=Pin-P_absorbed;
47 printf("\n\nThe input power is \t\t\t\t\t Pin=%.1f W
          ",Pin);
48 printf("\n\nThe power absorbed by load emf is \t\t\t
          P_absorbed=%.f W",P_absorbed);
49 printf("\n\nThe power loss in the resistor is \t\t\t
          P_loss=%.1f W",P_loss);
50 Irms_2_3=sqrt(IO_avg^2+Value);
51 printf("\n\nThe rms current using the result of (ii)
          and (iii) is \t Irms=%.2f A",Irms_2_3);
52 Irms_4=sqrt(P_loss/R);
53 printf("\n\nThe rms current using the result of (iv)
          is \t\t Irms=%.2f A",Irms_4);
54 // Note: the answer varies slightly due to precise
          calculation

```

Scilab code Exa 8.8 Calculate the mean values of load voltage and current

```

1 // chapter 8
2 // example 8.8
3 // Calculate the mean values of load voltage and
          current
4 // page-460-462
5 clear;
6 clc;

```

```

7 // given
8 Edc=80; // in V (dc source)
9 T=2; // in ms (chopping period)
10 L=8; // in mH
11 R=4; // in ohm
12 Ton_Toff_1= 1/1;
13 Ton_Toff_2= 4/1;
14 Ton_Toff_3= 1/4;
15 // calculate
16 L=L*1E-3; // changing unit from mH to H
17 tou=L/R;
18 T=T*1E-3;
19 //part-a
20 // since Ton/Toff=1/1 therefore Ton=Toff or
21 Ton=T/2;
22 Toff=Ton;
23 IO_max=(Edc/R)*((1-exp(-Ton/tou))/(1-exp(-T/tou)));
24 IO_min=IO_max*exp(-Toff/tou);
25 E0=Edc*(Ton/T);
26 IO_av=E0/R;
27 printf("\nWhent Ton/Toff=1/1,")
28 printf("\n\t\tThe maximum output current is \t\t
          IO_max=%0.2 f A", IO_max);
29 printf("\n\t\tThe minimum output current is \t\t
          IO_min=%0.2 f A", IO_min);
30 printf("\n\t\tThe mean value of load voltage is \t
          E0=%0. f V", E0);
31 printf("\n\t\tThe mean value of load current is \t
          IO_av=%0. f A", IO_av);
32 //part-b
33 // since Ton/Toff=4/1 therefore Ton=4Toff and Ton+
          Toff=T or 5*Toff=T therefore we get
34 Toff=T/5;
35 Ton=4*Toff;
36 IO_max=(Edc/R)*((1-exp(-Ton/tou))/(1-exp(-T/tou)));
37 IO_min=IO_max*exp(-Toff/tou);
38 E0=Edc*(Ton/T);
39 IO_av=E0/R;

```

```

40 printf("\nWhent Ton/Toff=4/1,")
41 printf("\n\t\tThe maximum output current is \t\t
      IO_max=%0.2 f A", IO_max);
42 printf("\n\t\tThe minimum output current is \t\t
      IO_min=%0.2 f A", IO_min);
43 printf("\n\t\tThe mean value of load voltage is \t
      E0=%0. f V", E0);
44 printf("\n\t\tThe mean value of load current is \t
      IO_av=%0. f A", IO_av);
45 //part-c
46 // since Ton/Toff=1/4 therefore Toff=4*Toff and Ton+
      Toff=T or 5*Ton=T therefore we get
47 Ton=T/5;
48 Toff=5*Ton;
49 IO_max=(Edc/R)*((1-exp(-Ton/tou))/(1-exp(-T/tou)));
50 IO_min=IO_max*exp(-Toff/tou);
51 E0=Edc*(Ton/T);
52 IO_av=E0/R;
53 printf("\nWhent Ton/Toff=1/4,")
54 printf("\n\t\tThe maximum output current is \t\t
      IO_max=%0.2 f A", IO_max);
55 printf("\n\t\tThe minimum output current is \t\t
      IO_min=%0.2 f A", IO_min);
56 printf("\n\t\tThe mean value of load voltage is \t
      E0=%0. f V", E0);
57 printf("\n\t\tThe mean value of load current is \t
      IO_av=%0. f A", IO_av);
58
59 // Note: 1 The answer for IO_min of part-b is wrong
      in the book due to calculation mistake.
60 //      2.the answers varies slightly due to
      precise calculation

```

Scilab code Exa 8.9 Find the chopping frequency


```

1 // chapter 8
2 // example 8.9
3 // fig. Ex. 8.9
4 // Find the chopping frequency
5 // page-463
6 clear;
7 clc;
8 // given
9 Edc=400; // in V (dc source)
10 L=0.05; // in H
11 R=0; // in ohm
12 alpha=0.3; // duty cycle
13 dI0=8; // in A (load current excursion)
14 // calculate
15 E0=alpha*Edc;
16 Eb=E0;
17 // Since VT_area=L*dI0 and VT_area=(Edc-Eb)*Ton,
    therefore we get
18 // (Edc-Eb)*Ton=L*dI0 or
19 Ton=L*dI0/(Edc-Eb); // calculation of ON period of
    chopper
20 // Since alpha=Ton/T, therefore
21 T=Ton/alpha; // calculation of chopping period
22 f=1/T; // calculation of chopping frequency
23 printf("\nThe chopping frequency to limit the load
    current excursion to %.f A is \t f=%.2f Hz",dI0,f
    );
24 // Note: The answer varies slightly due to precise
    calculation

```

Scilab code Exa 8.10 Find the on period average load current magnitude of ripple c

```

1 // chapter 8
2 // example 8.10
3 // Find the on period , average load current ,

```

```

        magnitude of ripple current and its rms value
4 // page-464
5 clear;
6 clc;
7 // given
8 f=2; // in Khz (chopping frequency)
9 Edc=96; // in V (dc source)
10 R=8; // in ohm
11 tou=6; // in ms (time constant)
12 E0=57.6; // in V (average load voltage)
13 // calculate
14 f=f*1E3; // changing unit from Khz to Hz
15 tou=tou*1E-3; // changing unit from ms to s
16 T=1/f; // calculation of chopping period
17 // Since tou=L/R, therefore we get
18 L=tou*R; // calculation of Inductance
19 // Since Eo=Edc*(Ton/T), therefore we get
20 Ton=(E0/Edc)*T; // calculation of ON period of
    chopper
21 Toff=T-Ton; // calculation of OFF period of chopper
22 F_L_rms=Edc*sqrt(Ton/T); // calculation of rms value
    of load voltage
23 IO=E0/R; // calculation of average load current
24 del_i=(Edc-E0)*Ton/L; // calculation of current
    ripple
25 IO_max=(Edc/R)*((1-exp(-Ton/tou))/(1-exp(-T/tou)));
    // calculation of maximum output current
26 IO_min=IO_max*exp(-Toff/tou); // calculation of
    minimum output current
27 Ir_rms=(IO_max-IO_min)/(2*sqrt(3)); // calculation
    of rms value of ripple current
28 printf("\nThe ON period of chopper is \t\t Ton=%0.1f
    ms",Ton*1E3);
29 printf("\nThe rms value of load voltage is \t %0.2f V
    ",F_L_rms);
30 printf("\nThe average load current is \t\t IO=%0.1f A
    ",IO);
31 printf("\nThe magnitude of ripple current is \t %0.2f

```

```

    A",del_i);
32 printf("\nThe maximum load current is \t\t I0_max=%
    .2f A",I0_max);
33 printf("\nThe minimum load current is \t\t I0_min=%
    .2f A",I0_min);
34 printf("\nThe RMS value of ripple current is \t
    Ir_rms=%0.4f A",Ir_rms);
35 // Note: The answer varies slightly due to precise
    calculation

```

Scilab code Exa 8.11 Compute the current in the motor

```

1 // chapter 8
2 // example 8.11
3 // Compute the current in the motor
4 // page-464-465
5 clear;
6 clc;
7 // given
8 Edc=180; // in V (dc source)
9 Ra=0.4; // in ohm(armature resistance)
10 Eb=80; // in V (back emf)
11 i_a=80; // in A(armature current)
12 La=8; // in mH (armature inductance)
13 t=8; // in ms
14 t_off=1; // in ms
15 // calculate
16 La=La*1E-3; // changing unit from mH to H
17 tou=La/Ra; // calculation of time constant
18 t_off=t_off*1E-3; // changing unit from ms to s
19 t=t*1E-3; // changing unit from ms to s
20 i_t=((Edc-Eb)/Ra)*(1-exp(-t_off/tou))+i_a*exp(-t_off
    /tou);
21 t8=t_off+t; // time instant 8ms after SCR turns off
22 i_f=i_t*exp(-t8/tou);

```

```

23 printf("\nThe current at the instant of Thyristor
    turns OFF is \t %.3f A",i_t);
24 printf("\nThe current %.f ms after Thyristor turns
    OFF is \t %.2f A",t*1E3,i_f);
25 // Note: The value of tou has been calculated wrong
    in the book due to which answer in the book are
    wrong

```

Scilab code Exa 8.12 Determine the ON time of the chopper

```

1 // chapter 8
2 // example 8.12
3 // Determine the ON time of the chopper
4 // page-465
5 clear;
6 clc;
7 // given
8 Edc=230; // in V (dc source)
9 F=400; // in Hz (chopping frequency)
10 E0=150; // in V
11 // calculate
12 // Since E0=alpha*Edc, therefore we get ,
13 alpha=E0/Edc;
14 T=1/F;
15 // Since alpha=Ton/T, therefore we get ,
16 Ton=alpha*T;
17 printf("\nThe ON time of chopper is \t Ton=%.4f ms",
    Ton*1E3);
18 // Note: The answer varies slightly due to precise
    calculation upto 6 decimal digit

```

Scilab code Exa 8.13 Determine average and rms output voltage and form and ripple

```

1 // chapter 8
2 // example 8.13
3 // Determine average and rms output voltage and form
   and ripple factor
4 // page-465
5 clear;
6 clc;
7 // given
8 Edc=220; // in V (dc source)
9 Ton=1; // in ms (ON period of chopper)
10 Toff=1.5; // in ms (OFF period of chopper)
11 // calculate
12 T=Ton+Toff; // calculation of chopping period
13 alpha=Ton/T; // calculation of duty cycle
14 E0=alpha*Edc; // calculation of average output
   voltage
15 E0_rms=sqrt(alpha)*Edc; // calculation of rms output
   voltage
16 FF=E0_rms/E0; // calculation of form factor
17 RF=sqrt(FF^2-1); // calculation of ripple factor
18 printf("\nThe average output voltage is \t E0=%f V"
   ,E0);
19 printf("\nThe rms output voltage is \t E0_rms=%f V
   ",E0_rms);
20 printf("\nThe form factor is \t\t FF=%f ",FF);
21 printf("\nThe ripple factor is \t\t RF=%f ",RF);
22
23 // Note: The answer varies slightly due to precise
   calculation upto 6 decimal digit

```

Scilab code Exa 8.14 Determine duty cycle for motoring regenerating mode and to ac

```

1 // chapter 8
2 // example 8.14
3 // Determine duty cycle for motoring, regenerating

```

```

mode and to achieve regenerating mode and power
returned
4 // page-477
5 clear;
6 clc;
7 // given
8 Edc=220; // in V (dc source)
9 R=0.1; // in ohm
10 L=10; // in mH
11 Eb=100; // in V (back emf)
12 I0=10; // in A
13 // calculate
14 L=L*1E-3; // changing unit from mH to H
15 // since  $I_0=(E_0-E_b)/R$  therefore we get,
16  $E_0=I_0*R+E_b$ ; // calculation of average load voltage
in motoring mode
17 // since  $E_0=\alpha*E_{dc}$ , therefore we get
18  $\alpha_1=E_0/E_{dc}$ ; // calculation of duty cycle for
motoring mode
19  $\alpha_2=E_b/E_{dc}$ ; // calculation of duty cycle for
generating mode
20  $\alpha_3=(E_b-I_0*R)/E_{dc}$ ; // calculation of duty cycle
to achieve regenerating mode
21  $P=E_b*I_0-I_0^2*R$ ; // calculation of power returned to
source during braking
22 printf("\nThe duty cycle for motoring mode is \t\t %
.3f ",alpha_1);
23 printf("\nThe critical duty cycle for generating
mode is \t %.4f ",alpha_2);
24 printf("\nThe duty cycle to achieve regenerating
mode is \t %.2f ",alpha_3);
25 printf("\nThe power returned to source during
braking is \t %.f W",P);

```

Scilab code Exa 8.15 Determine duty cycle for motoring regenerating mode and to ac

```

1 // chapter 8
2 // example 8.14
3 // Determine duty cycle for motoring, regenerating
   mode and to achieve regenerating mode, power
   returned and switching frequency
4 // page-478
5 clear;
6 clc;
7 // given
8 Edc=220; // in V (dc source)
9 R=0.1; // in ohm
10 L=10; // in mH
11 Eb=100; // in V (back emf)
12 I0=10; // in A
13 f=5; // in KHz (output frequency)
14 // calculate
15 L=L*1E-3; // changing unit from mH to H
16 // since  $I_0=(E_0-E_b)/R$  therefore we get,
17  $E_{0\_m}=I_0*R+E_b$ ; // calculation of average load voltage
   in motoring mode
18 // since  $E_0=(2*\alpha-1)*E_{dc}$ , therefore we get
19  $\alpha_m=(E_{0\_m}/E_{dc}+1)/2$ ; // calculation of duty cycle
   for motoring mode
20  $\alpha_c=1-\alpha_m$ ; // calculation of duty cycle for
   generating mode
21 // since  $I_0=(E_b-E_0)/R$  during regeneration mode,
   therefore we get
22  $E_{0\_r}=E_b-I_0*R$ ;
23 // since  $E_0=-(2*\alpha_r-1)*E_{dc}$ 
24  $\alpha_r=(1-E_{0\_r}/E_{dc})/2$ ;
25  $P=E_b*I_0-I_0^2*R$ ; // calculation of power returned to
   source during braking
26  $f_s=f/2$ ;
27 printf("\nThe duty cycle for motoring mode is \t\t
   alpha_m=%0.2 f ",alpha_m);
28 printf("\nThe critical duty cycle for generating
   mode is \t alpha_c=%0.2 f ",alpha_c);
29 printf("\nThe duty cycle to achieve regenerating

```

```

    mode is \t alpha_r=%0.3f ",alpha_r);
30 printf("\n\nThe power returned to source during
    braking is \t P=%0.f W",P);
31 printf("\n\nThe switching frequency of the device is \
    t fs=%0.1f KHz",f_s);

```

Scilab code Exa 8.16 Determine duty cycle of chopper

```

1 // chapter 8
2 // example 8.16
3 // Determine duty cycle of chopper
4 // page-480
5 clear;
6 clc;
7 // given
8 Edc=200; // in V (dc source)
9 R=0.1; // in ohm
10 L=10; // in mH
11 Eb1=150, Eb2=-110; // in V (back emf)
12 I0=10; // in A
13 // calculate
14 L=L*1E-3; // changing unit from mH to H
15 // since  $I_0=(E_0-E_b)/R$  therefore we get,
16 E01=I0*R+Eb1; // calculation of average load voltage
    when Eb=150 V
17 E02=I0*R+Eb2; // calculation of average load voltage
    when Eb=-110 V
18 // since  $E_0=2*E_{dc}(\alpha-0.5)$ , therefore we get
19 alpha1=(E01/(2*Edc))+0.5; // calculation of duty
    cycle when Eb=150 V
20 alpha2=(E02/(2*Edc))+0.5; // calculation of duty
    cycle when Eb=-110 V
21 printf("\n\nThe duty cycle when Eb=%0.f V is \t %0.3f ",
    Eb1,alpha1);
22 if alpha1>0.5 then

```



```

23     printf("\t\t It is forwarding mode");
24 else
25     printf("\t\t It is reversing motoring mode");
26 end
27 printf("\n\nThe duty cycle when Eb=%f V is \t %.3f ",
        Eb2,alpha2);
28 if alpha2>0.5 then
29     printf("\t\t It is forwarding mode");
30 else
31     printf("\t\t It is reversing motoring mode");
32 end
33 // Note : the answer vary slightly due to precise
        calculation

```

Scilab code Exa 8.17 Compute the value of commutating capacitor and inductor

```

1 // chapter 8
2 // example 8.17
3 // fig. 8.26
4 // Compute the value of commutating capacitor and
        inductor
5 // page-483-484
6 clear;
7 clc;
8 // given
9 Edc=80; // in V (dc source)
10 Toff=20; // in us (turn off time of SCR)
11 T=2000; // in us (chopping period)
12 IO_m=80; // in A (starting current)
13 // calculate
14 Toff=Toff*1E-6;
15 T=T*1E-6;
16 dt=Toff; // assumption as done in the book
17 t_q=Toff+dt;
18 C=IO_m*(t_q)/Edc; // calculation of commutating

```

```

    capacitance
19 L_min=C*(Edc/IO_m); // calculation of minimum
    commutating inductance
20 L_max=0.01*T^2/(%pi^2*C); // calculation of maximum
    commutating inductance
21 printf("\nThe commutating capacitance is \t C=%f uF
    ",C*1E6);
22 printf("\nThe commutating inductance lies in the
    range \t %.f uH <= L <= %.2f uH",L_min*1E6,L_max
    *1E6);

```

Scilab code Exa 8.18 Compute the value of commutating capacitor and inductor Maximum

```

1 // chapter 8
2 // example 8.18
3 // Compute the value of commutating capacitor and
    inductor , Maximum capacitor voltage , and peak
    commutating current
4 // page-491
5 clear;
6 clc;
7 // given
8 Edc=220; // in V (dc source)
9 Toff=20; // in us (turn off time of SCR)
10 IO_m=180; // in A (starting current)
11 x=3
12 // calculate
13 Toff=Toff*1E-6;
14 dt=Toff; // assumption as done in the book
15 t_q=Toff+dt;
16 L=(Edc*t_q)/(x*IO_m*(%pi-2*asin(1/x))); //
    calculation of commutating inductance
17 C=x*IO_m*t_q/(Edc*(%pi-2*asin(1/x))); // calculation
    of commutating capacitance
18 V_cp=Edc+IO_m*sqrt(L/C); // calculation of Maximum

```

```

    capacitor voltage
19 i_cp=x*I0_m; // calculation of peak commutating
    current
20 printf("\nThe commutating inductance is \t\t L=%0.2f
    uH",L*1E6);
21 printf("\nThe commutating capacitance is \t\t C=%0.2f
    uF",C*1E6);
22 printf("\nThe maximum capacitor voltage is \t V_cp=%
    .2f V",V_cp);
23 printf("\nThe peak commutating current is \t i_cp=%0.
    f A",i_cp);
24 // Note: the answer for i_cp is wrong in the book
    due to use of wrong value in the calculation

```

Scilab code Exa 8.19 Compute the value of commutating capacitance average output v

```

1 // chapter 8
2 // example 8.19
3 // Compute the value of commutating capacitance ,
    average output voltage , circuit off-time , total
    commutation interval
4 // page-495
5 clear;
6 clc;
7 // given
8 Edc=230; // in V (dc source)
9 I0=50; // in A (load current)
10 alpha=0.4; // duty cycle
11 f=2; // in KHz (chopping frequency)
12 // calculate
13 f=f*1E3; // changing unit from KHz to Hz
14 T=1/f; // calculation of chopping period
15 // since alpha=Ton/T, therefore we get
16 Ton=alpha*T; // calculation of ON period of chopper
17 C=Ton*I0/(2*Edc); // calculation of commutating

```

```

    capacitance
18 E0=2*Edc^2*C*f/I0; // calculation of average output
    voltage
19 t_q=Ton/2; // calculation of circuit off-time
20 T_interval=2*C*Edc/I0; // calculation of total
    commutation interval
21 printf("\nThe commutating capacitance is \t\t\t C=%
    .2f uF",C*1E6);
22 printf("\nThe average output voltage is \t\t\t E0=%
    f V",E0);
23 printf("\nThe circuit turn-off time for one SCR pair
    is \t t_q=%f us",t_q*1E6);
24 printf("\nThe total commutation interval is \t\t %f
    us",T_interval*1E6);

```

Scilab code Exa 8.20 Compute the value of commutating capacitance and transformer

```

1 // chapter 8
2 // example 8.20
3 // Compute the value of commutating capacitance and
    transformer inductances
4 // page-499
5 clear;
6 clc;
7 // given
8 Edc=60; // in V (dc source)
9 IO_m=140; // in A (load current)
10 t_q=20; // in us
11 g=4;
12 // calculate
13 t_q=t_q*1E-6; // changing unit from us to s
14 Rm=Edc/IO_m;
15 // since  $g=(1/R_m)*\sqrt{L_1/C}$  and  $t_q=\sqrt{L_1*C}$ ,
16 // Multiplying both these equations we get  $g*t_q=(1/
    R_m)*L_1$  or we get

```

```

17 L1=g*t_q*Rm; // calculation of transformer
    inductance L1
18 C=t_q^2/L1; // calculation of commutating
    capacitance
19 L2=L1; // calculation of transformer inductance L2
20 printf("\nThe commutating capacitance is \t C=%0.2f
    uF",C*1E6);
21 printf("\nThe transformer inductances is \t L1=%0.1f
    uH \t L2=%0.1f uH",L1*1E6, L2*1E6);
22 // Note: the answers vary slightly due to precise
    calculation

```

Scilab code Exa 8.21 Compute the inductance steady state speed and current swing

```

1 // chapter 8
2 // example 8.21
3 // fig. 8.32
4 // Compute the inductance , steady-state speed and
    current swing
5 // page-499-500
6 clear;
7 clc;
8 // given
9 di_a=6; // in A
10 n=1750; // in rpm (rated speed of motor)
11 HP=150; // in HP (horse power rating)
12 Ra=0.0099; // in ohm (armature resistance)
13 Eff=90; // in percent
14 Ea=1200; // in V (armature voltage)
15 Edc=Ea;
16 T=2500; // in us (chopping period)
17 alpha=0.10; // duty cycle
18 L1=125; // in mH
19 // calculate
20 T=T*1E-6; // changing unit from us to s

```

```

21 // since  $dI_a/d(\alpha)=(E_{dc}/L)*T*(1-2*\alpha)$ , and  $dI_a$ 
    //  $/d(\alpha)=0$  therefore we get
22 //  $1-2*\alpha_{worst}=0$ 
23  $\alpha_{worst}=1/2$ ; // calculation of duty cycle for
    // worst case of motor
24 // since  $di_a=(E_{dc}-\alpha_{worst}*E_{dc})/L$ , therefore we
    // get
25  $L=(E_{dc}-\alpha_{worst}*E_{dc})/di_a*\alpha_{worst}*T$ ; //
    // calculation of inductance
26  $P_{in}=HP*746/(Eff/100)$ ; // calculation of power input
    // to the motor
27  $I_a=P_{in}/E_{dc}$ ; // calculation of rated current in the
    // armature
28  $E_{a\_rated}=E_{dc}-I_a*R_a$ ; // calculation of armature
    // voltage under rated torque
29  $V_a=\alpha*E_{dc}-I_a*R_a$ ; // calculation of voltage at the
    // armature
30  $N=(V_a/E_{a\_rated})*n$ ; // calculation of steady-state
    // speed
31  $del\_i\_a=(E_{dc}-\alpha*E_{dc})/L*\alpha*T$ ; // calculation of
    // current swing
32 printf("\\n\\nThe inductance is \\t\\t  $L=$ %.f mH", $L*1E3$ );
33 printf("\\n\\nThe steady-state speed is \\t  $N=$ %.2f rpm", $N$ 
    );
34 printf("\\n\\nThe current swing is \\t\\t  $del\_i\_a=$ %.2f A",
     $del\_i\_a$ );
35 // Note: the answers vary slightly due to precise
    // calculation

```

Scilab code Exa 8.22 Design the jones chopper

```

1 // chapter 8
2 // example 8.22
3 // Design the jones chopper
4 // page-500-501

```

```

5 clear;
6 clc;
7 // given
8 Edc=200; // in V (source voltage)
9 I0=50; // in A (load current)
10 t_q=200; // in us
11 safety_factor=1.5;
12 // calculate
13 t_q=t_q*1E-6; // changing unit from us to s
14 C=(%pi/2)*(t_q/Edc)*I0; // calculation of
    commutating capacitance
15 V_C=safety_factor*Edc; // calculation of capacitor
    voltage rating
16 // since t_q=sqrt(L1*C), therefore we get
17 L1=t_q^2/C; // calculation of commutating inductance
    L1
18 L2=L1; // calculation of commutating inductance L2
19 V_B0=safety_factor*Edc; // for SCR 1
20 I_T=safety_factor*I0; // for SCR 1
21 t_q2=(%pi/2)*sqrt(L1*C); // for SCR 1
22 PIV=V_B0; // calculation of Peak inverse voltage for
    diode D1
23 I_D=I_T; // calculation of diode current for diode
    D1
24 dV_dt_1=I0/C; // dynamic characteristics for SCR 1
25 di_dt_1=safety_factor*Edc/L1; // dynamic
    characteristics for SCR 1
26 E_peak=safety_factor*Edc;
27 dV_dt_2=E_peak/sqrt(L1*C); // dynamic
    characteristics for SCR 2
28 L=2; // in uH (assumption as done in the book)
29 di_dt_2=E_peak/L; // dynamic characteristics for SCR
    2
30 printf("\n\nThe commutating capacitance is \t\t C=%0.2f
    uF",C*1E6);
31 printf("\n\nThe capacitor voltage rating is \t V_C=%
    .f V",V_C);
32 printf("\n\nThe commutating inductances are \t L1=%

```

```

    .2 f mH \t or L2=%0.2 f mH",L1*1E3,L2*1E3);
33 printf("\n\nThe characteristics of SCR1 are \t V_BO=
    %.f V \t I_T=%0.f A",V_BO,I_T);
34 printf("\n\nThe characteristics of SCR2 are \t t_q<=
    %.f us or t_q=250 us \t V_BO=%0.f V \t I_T=%0.f A",
    t_q2*1E6,V_BO,I_T);
35 printf("\n\nThe characteistics of diode D1 are \t
    PIV=%0.f V \t I_D=%0.f A",V_BO,I_D);
36 printf("\n\nThe dynamic characteistics of SCR1 are \
    t dV/dt=%0.2 f V/us \t di/dt=%0.2 f A/us",dV_dt_1*1E
    -6,di_dt_1*1E-6);
37 printf("\n\nThe dynamic characteistics of SCR2 are \
    t dV/dt=%0.2 f V/us \t di/dt=%0.f A/us",dV_dt_2*1E
    -6,di_dt_2*1E-6);
38 // Note: the answers vary slightly due to precise
    calculation

```

Scilab code Exa 8.23 Find duty cycle filter inductance and filter capacitance

```

1 // chapter 8
2 // example 8.23
3 // fig 8.43
4 // Find duty cycle , filter inductance and filter
    capacitance
5 // page-514-515
6 clear;
7 clc;
8 // given
9 Edc=14; // in V (dc source)
10 E0=6; // in V (average output voltage)
11 del_Vc=15; // mV (peak to peak ripple voltage)
12 del_I=0.6; // in A (peak to peak ripple current)
13 f=30; // in KHz (switching frequency)
14 // calculate
15 del_Vc=del_Vc*1E-3; // changing unit from mV to V

```



```

16 f=f*1E3; // changing unit from KHz to Hz
17 alpha=E0/Edc; // calculation of duty cycle
18 L=E0*(Edc-E0)/(f*Edc*del_I); // calculation of
    filter inductance
19 C=del_I/(8*f*del_Vc); // calculation of filter
    capacitance
20
21 printf("\nThe duty cycle is \t\t alpha=%0.4f \t or %
    .2f percent",alpha,alpha*100);
22 printf("\nThe filter inductance is \t L=%0.2f uH",L*1
    E6);
23 printf("\nThe filter capacitance is \t C=%0.2f uF",C
    *1E6);
24 // Note: the answers vary slightly due to precise
    calculation

```

Scilab code Exa 8.24 Determine maximum ON period of MOSFET Battery drain current a

```

1 // chapter 8
2 // example 8.24
3 // Determine maximum ON-period of MOSFET, Battery
    drain current and the value of choke required
4 // page-515
5 clear;
6 clc;
7 // given
8 Edc=12; // in V
9 Edc_max=13.5; // in V (maximum dc source)
10 Edc_min=10; // in V (minimum dc source)
11 E0=5; // in V (average output voltage)
12 IO=10; // in A (load current)
13 f=50; // in KHz
14 del_I=500; // in mA (ripple current)
15 // calculate
16 f=f*1E3; // changing unit from KHz to Hz

```

```

17 del_I=del_I*1E-3; // changing unit from mA to A
18 T=1/f; // calculation of time period
19 alpha_max=E0/Edc_min; // calculation of duty cycle
20 // since alpha=Ton/T, therefore we get
21 Ton_max=alpha_max*T; // calculation of maximum ON-
    period of MOSFET
22 // since Edc*Is=E0*I0, therefore we get
23 Is=E0*I0/Edc; // calculation of Battery drain
    current
24 L=E0*(Edc_min-E0)/(f*Edc_min*del_I); // calculation
    of the value of choke required
25 printf("\nThe maximum ON-period of MOSFET is \t
    Ton_max=%f us",Ton_max*1E6);
26 printf("\nThe Battery drain current is \t\t Is=%f
    A",Is);
27 printf("\nThe value of choke required is \t\t L=%f
    uH",L*1E6);
28 // Note: the answers vary slightly due to precise
    calculation

```

Scilab code Exa 8.25 Determine duty cycle ripple and peak current of inductor ripple

```

1 // chapter 8
2 // example 8.25
3 // fig. 8.44
4 // Determine duty cycle, ripple and peak current of
    inductor, ripple voltage
5 // page-518
6 clear;
7 clc;
8 // given
9 Edc=6; // in V (dc source)
10 E0=18; // in V (average output voltage)
11 I0=0.4; // in A (average load current)
12 f=20; // in KHz (switching frequency)

```

```

13 L=250; // in uH
14 C=420; // in uH
15 // calculate
16 f=f*1E3; // changing unit from KHz to Hz
17 L=L*1E-6; // changing unit from uH to H
18 C=C*1E-6; // changing unit from uF to F
19 // since  $E_0 = E_{dc}/(1-\alpha)$ , therefore we get
20  $\alpha = 1 - E_{dc}/E_0$ ; // calculation of duty cycle
21  $\Delta I = E_{dc} * (E_0 - E_{dc}) / (f * L * E_0)$ ; // calculation of
    ripple current of inductor
22  $I_s = I_0 / (1 - \alpha)$ ;
23  $I_2 = I_s + \Delta I / 2$ ; // calculation of peak current of
    inductor
24  $\Delta V_c = I_0 * \alpha / (f * C)$ ; // calculation of ripple
    voltage
25 printf("\nThe duty cycle is \t\t\t alpha=%0.4f \t
    or \t %0.2f percent",alpha,alpha*100);
26 printf("\nThe ripple current of inductor is \t\t
     $\Delta I = %0.2f$  A", $\Delta I$ );
27 printf("\nThe peak current of inductor is \t\t  $I_2 = %
    .1f$  A", $I_2$ );
28 printf("\nThe ripple voltage of filter capacitor is
    \t  $\Delta V_c = %0.2f$  mV", $\Delta V_c * 1E3$ );
29 // Note: the answers vary slightly due to precise
    calculation

```

Scilab code Exa 8.26 Compute average output voltage peak to peak output ripple vol

```

1 // chapter 8
2 // example 8.26
3 // fig. 8.45
4 // Compute average output voltage , peak-to-peak
    output ripple voltage , peak-to-peak current of
    the inductor and peak current of the device
5 // page-522-523

```

```

6 clear;
7 clc;
8 // given
9 Edc=14; // in V (dc source)
10 alpha=0.6; // duty cycle
11 f=25; // in KHz (switching frequency)
12 L=180; // in uH
13 C=220; // in uH
14 I0=1.5; // in A (average load current)
15 // calculate
16 f=f*1E3; // changing unit from KHz to Hz
17 L=L*1E-6; // changing unit from uH to H
18 C=C*1E-6; // changing unit from uF to F
19 E0=-Edc*alpha/(1-alpha); // calculation of average
    output voltage
20 del_Vc=I0*alpha/(f*C); // calculation of peak-to-
    peak output ripple voltage
21 del_I=Edc*alpha/(f*L); // calculation of ripple
    current of inductor
22 Is=I0*alpha/(1-alpha); // calculation of average
    input current
23 Ip=Is/alpha+del_I/2; // calculation of peak current
    of the device
24 printf("\nThe average output voltage is \t\t\t E0=%f
    V",E0);
25 printf("\nThe peak-to-peak output ripple voltage is
    \t del_Vc=%f V",del_Vc);
26 printf("\nThe peak-to-peak ripple current of
    inductor is \t del_I=%f A",del_I);
27 printf("\nThe peak current of the device is \t\t Ip=
    %f A",Ip);
28 // Note: the answers vary slightly due to precise
    calculation

```

Scilab code Exa 8.27 Determine range of duty cycle peak to peak choke ripple current

calculation

Scilab code Exa 8.28 Compute average output voltage average input current peak to

```
1 // chapter 8
2 // example 8.28
3 // fig. 8.46
4 // Compute average output voltage , average input
   current , peak-to-peak current of the inductors ,
   peak-to-peak output ripple voltages and peak
   current of the device
5 // page-529-530
6 clear;
7 clc;
8 // given
9 Edc=15; // in V (dc source)
10 alpha=0.4; // duty cycle
11 f=25; // in KHz (switching frequency)
12 L1=250; // in uH
13 C1=400; // in uH
14 L2=380; // in uH
15 C2=220; // in uH
16 I0=1.25; // in A (average load current)
17 // calculate
18 f=f*1E3; // changing unit from KHz to Hz
19 L1=L1*1E-6; // changing unit from uH to H
20 C1=C1*1E-6; // changing unit from uF to F
21 L2=L2*1E-6; // changing unit from uH to H
22 C2=C2*1E-6; // changing unit from uF to F
23 E0=-Edc*alpha/(1-alpha); // calculation of average
   output voltage
24 Is=I0*alpha/(1-alpha); // calculation of average
   input current
25 del_I1=Edc*alpha/(f*L1); // calculation of ripple
   current of inductor L1
```

```

26 del_Vc1=Is*(1-alpha)/(f*C1); // calculation of peak-
    to-peak output ripple voltage of capacitor C1
27 del_I2=Edc*alpha/(f*L2); // calculation of ripple
    current of inductor L2
28 del_Vc2=alpha*Edc/(8*C2*L2*f^2); // calculation of
    peak-to-peak output ripple voltage of capacitor
    C2
29 V_DF=E0; // calculation of average voltage across
    diode
30 I_L2=I0*E0/V_DF; // calculation of average current
    in inductor L2
31 Ip=Is+del_I1/2+I_L2+del_I2/2; // calculation of peak
    current of the device
32 printf("\nThe average output voltage is \t\t\t\t\t
    E0=%.2f V",E0);
33 printf("\nThe average input voltage is \t\t\t\t\t Is
    =%.2f A",Is);
34 printf("\nThe peak-to-peak ripple current of
    inductor L1 is \t\t del_I1=%.2f A",del_I1);
35 printf("\nThe peak-to-peak output ripple voltage of
    capacitor C1 is \t del_Vc1=%.2f mV",del_Vc1*1E3);
36 printf("\nThe peak-to-peak ripple current of
    inductor L2 is \t\t del_I2=%.2f A",del_I2);
37 printf("\nThe peak-to-peak output ripple voltage of
    capacitor C2 is \t del_Vc2=%.2f mV",del_Vc2*1E3)
    ;
38 printf("\nThe peak current of the device is \t\t\t\t\t
    Ip=%.2f A",Ip);
39 // Note: the answers vary slightly due to precise
    calculation

```

Chapter 9

Inverters

Scilab code Exa 9.1 Compute rms value of output voltage fundamental component of t

```
1 // chapter 9
2 // example 9.1
3 // Compute rms value of output voltage , fundamental
  component of the output-voltage waveform , first
  five harmonics of the output voltage , fundamental
  power consumed ,rms power consumed , rms value by
  harmonic summation method
4 // page-544
5 clear;
6 clc;
7 // given
8 Edc_2=96; // in V (dc source at center tapped)
9 R=10; // in ohm
10 // calculate
11 Edc=2*Edc_2;
12 E0_rms=Edc/2; // calculation of rms value of output
  voltage
13 printf("\n\nThe rms value of output voltage is \t\t\t
  E0_rms=%0. f V" ,E0_rms);
14 E1_fund=sqrt(2)/%pi*Edc; // calculation of
  fundamental component of the output-voltage
```



```

    waveform
15 printf("\n\nThe fundamental component of the output
    voltage is \t E1_fund=%0.2f V\n",E1_fund);
16 PO_fund=E1_fund^2/R; // calculation of fundamental
    power consumed
17 PO_rms=E0_rms^2/R; // calculation of rms power
    consumed
18 E0_rms_H=E1_fund^2;
19 for n=3:2:11
20     E0=E1_fund/n;
21     printf("\n The %f harmonic voltage is \t %0.2f V
        ",n,E0); // calculation of rms value of
        voltage by harmonic summation method
22     E0_rms_H=E0_rms_H+E0^2;
23 end
24 E0_rms_H=sqrt(E0_rms_H); // calculation of rms value
    by harmonic summation method
25 printf("\n\nThe fundamental power consumed is \t\t\t
    \t P0_fund=%0.2f W",PO_fund);
26 printf("\n\nThe rms power consumed is \t\t\t\t\t
    P0_rms=%0.2f W",PO_rms);
27 printf("\n\nThe rms value determined by harmonic
    summation method is \t E0_rms=%0.2f V",E0_rms_H);
28 printf("\n\n The two values of rms voltages as
    determined are almost equal.");
29 // Note: The answer varies slightly due to precise
    calculation

```

Scilab code Exa 9.2 Compute fundamental output voltage first five harmonics of the

```

1 // chapter 9
2 // example 9.2
3 // Compute fundamental output-voltage , first five
    harmonics of the output voltage ,rms value by
    direct integration and harmonic summation method

```

```

        ,output rms and fundamental power and transistor
        switch ratings
4 // page-547
5 clear;
6 clc;
7 // given
8 Edc=48; // in V (dc source)
9 R=10; // in ohm
10 // calculate
11 E1_fund=2*sqrt(2)/%pi*Edc; // calculation of
    fundamental component of the output-voltage
    waveform
12 printf("\n\nThe fundamental component of the output
    voltage is \t E1_fund=%0.2f V\n",E1_fund);
13 E0_rms=Edc; // calculation of rms value of output
    voltage
14 printf("\n\nThe rms value of output voltage is \t\t\t
    E0_rms=%0.f V\n",E0_rms);
15 E0_rms_H=E1_fund^2;
16 for n=3:2:11
17     E0=E1_fund/n;
18     printf("\n The %0.f harmonic voltage is \t %0.2f V
    ",n,E0); // calculation of rms value of
    voltage by harmonic summation method
19     E0_rms_H=E0_rms_H+E0^2;
20 end
21 E0_rms_H=sqrt(E0_rms_H); // calculation of rms value
    by harmonic summation method
22 printf("\n\nThe rms value determined by harmonic
    summation method is \t E0_rms=%0.2f V",E0_rms_H);
23 P0_rms=E0_rms^2/R; // calculation of rms power
    consumed
24 printf("\n\nThe rms power consumed is \t\t\t\t\t
    P0_rms=%0.2f W",P0_rms);
25 P0_fund=E1_fund^2/R; // calculation of fundamental
    power consumed
26 printf("\n\nThe fundamental power consumed is \t\t\t\t
    \t P0_fund=%0.2f W",P0_fund);

```

```

27 V_CE0=Edc;
28 I_T_peak=Edc/R;
29 I_T_rms=Edc/(sqrt(2)*R);
30 I_T_avg=Edc/(2*R);
31 printf("\n\nThe transistor switch ratings are \t
      VCE0=%f V \t I_T_peak=%f A \t I_T_rms=%f A \
      \t I_T_avg=%f A",V_CE0,I_T_peak,I_T_rms,I_T_avg)
      ;
32 // Note: The answer varies slightly due to precise
      calculation

```

Scilab code Exa 9.3 Determine rms load current at fundamental frequency rms value

```

1 // chapter 9
2 // example 9.3
3 // fig. 9.5
4 // Determine rms load current at fundamental
      frequency, rms value of load current, power
      output and average supply current
5 // page-550
6 clear;
7 clc;
8 // given
9 Edc=220; // in V (dc source)
10 R=10; // in ohm
11 L=10; // in mH
12 C=52; // in uF
13 f=400; // in Hz
14 // calculate
15 L=L*1E-3; // changing unit from mH to H
16 C=C*1E-6; // changing unit from uF to F
17 X_L=2*pi*f*L; // calculation of inductive reactance
18 X_C=1/(2*pi*f*C); // calculation of inductive
      reactance
19 I=0; // intialisation of variable for rms load

```

```

    current
20 // since Impedence offered to the nth harmonic
    component Zn=sqrt(R^2+(n*X_L-X_C/n)^2)
21 printf("\n\n\t\tZn\t\t\tIn");
22 for n=1:2:9
23     Zn=sqrt(R^2+(n*X_L-X_C/n)^2); // calculation of
        Impedence offered to the nth harmonic
        component
24     En=0.9*Edc/n; // calculation of rms value of the
        nth harmonic component of the output voltage
25     In=En/Zn; // calculation of rms value of nth
        harmonic component of the current
26     printf("\n%.f\t\t%.2f ohm\t\t%.3f A",n,Zn,In);
27     I=I+In^2;
28 end
29 I=sqrt(I);
30 printf("\n\nThe rms value of load current is \t I=%
    .2f A",I);
31 P0=I^2*R; // calculation of output power
32 Iav=P0/Edc; // calculation of average supply current
33 printf("\n\nThe output power is \t\t\t P0=%0.2f W",P0
    );
34 printf("\n\nThe average supply current is \t\t Iav=%
    .2f A",Iav);
35 // Note: The answer varies slightly due to precise
    calculation

```

Scilab code Exa 9.4 Determine IGBT ratings THD DF and HF and DF of the lowest order

```

1 // chapter 9
2 // example 9.4
3 // fig. 9.5
4 // Determine IGBT ratings , THD, DF and HF and DF of
    the lowest order harmonic
5 // page-552-554

```

```

6 clear;
7 clc;
8 // given
9 Edc=24; // in V (dc source)
10 R=3; // in ohm
11 // calculate
12 I_peak=(Edc/2)/R; // calculation of IGBT peak
    current
13 V_BR=2*(Edc/2); // calculation of peak reverse
    voltage of each IGBT
14 printf("\nThe IGBT ratings are \t I_peak=%f A \t
    V_BR=%f V",I_peak,V_BR);
15 E1_rms=2*Edc/(sqrt(2)*%pi);
16 E0_rms=(Edc/2);
17 THD=sqrt(E0_rms^2-E1_rms^2)/E1_rms; // calculation
    of total harmonic distortion
18 printf("\nThe total harmonic distortion is \t THD=%
    .3f or \t %.1f percent",THD,THD*100);
19 K=0;
20 for n=3:2:13
21     En_rms=2*Edc/(n*%pi*sqrt(2));
22     En_rms_n2=(En_rms/n^2)^2;
23     K=K+En_rms_n2;
24 end
25 K=sqrt(K);
26 DF=K/E1_rms; // calculation of distortion factor
27 printf("\nThe distortion factor is \t\t DF=%f or \
    t %.1f percent",DF,DF*100);
28 E3_rms=2*Edc/(3*%pi*sqrt(2));
29 HF3=E3_rms/E1_rms; // calculation of lowest order of
    harmonic distortion
30 printf("\nThe lowest order harmonic factor is \t HF3
    =%f or \t %.2f percent",HF3,HF3*100);
31 DF3=(E3_rms/3^2)/E1_rms; // calculation of lowest
    order distortion factor
32 printf("\nThe lowest order distortion factor is \t
    DF3=%f or \t %.2f percent",DF3,DF3*100);
33 // Note: The answer varies slightly due to precise

```

calculation

Scilab code Exa 9.5 Determine transistor ratings THD DF and HF and DF of the lowest

```
1 // chapter 9
2 // example 9.5
3 // Determine transistor ratings , THD, DF and HF and
  DF of the lowest order harmonic
4 // page-554
5 clear;
6 clc;
7 // given
8 Edc=48; // in V (dc source)
9 R=3; // in ohm
10 // calculate
11 Ip=Edc/R; // calculation of transistor peak current
12 I_avg=Ip/2; // calculation of transistor average
  current
13 V_BR=Edc; // calculation of peak reverse voltage of
  each IGBT
14 printf("\nThe transistor ratings are \t Ip=%f A \t
  I_avg=%f A \t V_BR=%f V",Ip,I_avg,V_BR);
15 E1_rms=2*Edc/(sqrt(2)*%pi);
16 E0_rms=(Edc/2);
17 THD=sqrt(E0_rms^2-E1_rms^2)/E1_rms; // calculation
  of total harmonic distortion
18 printf("\nThe total harmonic distortion is \t THD=%f
  .3f or \t %.1f percent",THD,THD*100);
19 K=0;
20 for n=3:2:13
21     En_rms=2*Edc/(n*%pi*sqrt(2));
22     En_rms_n2=(En_rms/n^2)^2;
23     K=K+En_rms_n2;
24 end
25 K=sqrt(K);
```

```

26 DF=K/E1_rms; // calculation of distortion factor
27 printf("\n\nThe distortion factor is \t\t DF=%0.3f
    or \t %0.1f percent",DF,DF*100);
28 E3_rms=2*Edc/(3*pi*sqrt(2));
29 HF3=E3_rms/E1_rms; // calculation of lowest order of
    harmonic distortion
30 printf("\n\nThe lowest order harmonic factor is \t
    HF3=%0.3f or \t %0.2f percent",HF3,HF3*100);
31 DF3=(E3_rms/3^2)/E1_rms; // calculation of lowest
    order distortion factor
32 printf("\n\nThe lowest order distortion factor is \t
    DF3=%0.4f or \t %0.3f percent",DF3,DF3*100);
33 // Note: The answer varies slightly due to precise
    calculation

```

Scilab code Exa 9.6 Determine carrier ratio and the number of pulses per cycle Fun

```

1 // chapter 9
2 // example 9.6
3 // Determine carrier ratio and the number of pulses
    per cycle, Fundamental output voltage, DF and HF
    of the output voltage and the order of first five
    significant harmonics
4 // page-569-570
5 clear;
6 clc;
7 // given
8 Edc_2=240; // in V (dc source)
9 fm=50; // in Hz (fundamental output frequency)
10 fc=1.2; // in KHz (carrier frequency)
11 M=0.8; // modulation index
12 // calculate
13 fc=fc*1E3;
14 Mf=fc/fm; // calculation of carrier ratio
15 p=Mf; // calculation of number of pulses per cycle

```

```

16 E0_fund=(1/sqrt(2))*M*Edc_2; // calculation of
    Fundamental output voltage
17 E0_rms=Edc_2;
18 DF=E0_fund/E0_rms; // calculation of DF of the
    output voltage
19 HF=sqrt(1/DF^2-1); // calculation of HF of the
    output voltage
20 printf("\nThe carrier ratio is \t\t\t\t Mf=%f",Mf);
21 printf("\nThe number of pulses per cycle is \t\t p=%
    .f",p);
22 printf("\nThe distortion factor of the output
    voltage is \t DF=%2f percent",DF*100);
23 printf("\nThe harmonic factor of the output voltage
    is \t HF=%1f percent",HF*100);
24 printf("\n\n The order of first five harmonics are \
    n\nn=");
25 for n=0:2:2
26     N1=Mf-n;
27     N2=Mf+n;
28     printf("%f, %f, ",N1,N2);
29 end
30 printf(" etc\n\nn=");
31 for n=1:2:3
32     N1=2*Mf-n;
33     N2=2*Mf+n;
34     printf("%f, %f, ",N1,N2);
35 end
36 printf(" etc\n\nn=");
37 for n=0:2:2
38     N1=3*Mf-n;
39     N2=3*Mf+n;
40     printf("%f, %f, ",N1,N2);
41 end
42 printf(" etc\n\nn=");
43 for n=1:2:3
44     N1=4*Mf-n;
45     N2=4*Mf+n;
46     printf("%f, %f, ",N1,N2);

```



```

47 end
48 printf(" etc\n\n=");
49 for n=0:2:4
50     N1=5*Mf-n;
51     N2=5*Mf+n;
52     printf("%.f, %.f, ",N1,N2);
53 end
54 printf(" etc");
55 // Note: 1. The answer varies slightly due to
    precise calculation
56 //      2. The calculation of order of first five
    significant harmonics is wrong in the book due to
    calculation mistake

```

Scilab code Exa 9.7 Compute DC and switch voltage ratings

```

1 // chapter 9
2 // example 9.7
3 // Compute DC and switch voltage ratings
4 // page-570
5 clear;
6 clc;
7 // given
8 E0_rms=220; // in V (Fundamental output voltage)
9 M=0.8; // modulation index
10 // calculate
11 // since  $E0_{rms} = \sqrt{1/2} * M * (E_{dc\_2})$ , therefore we
    get
12 Edc_2=E0_rms/(sqrt(1/2)*M); // calculation of DC
    voltage ratings
13 V_CEO=2*Edc_2; // calculation of switch voltage
    ratings
14 printf("\nThe DC voltage ratings is \t %.2f V",Edc_2
    );
15 printf("\nThe switch voltage ratings is \t %.f V",

```

```

V_CEO);
16 // Note: The answer varies slightly due to precise
    calculation

```

Scilab code Exa 9.8 Compute Total rms output voltage fundamental output voltage DF

```

1 // chapter 9
2 // example 9.8
3 // Compute Total rms output voltage , fundamental
    output voltage , DF and HF and gain of the
    inverter
4 // page-572
5 clear;
6 clc;
7 // given
8 Edc=240; // in V (battery voltage)
9 M=0.8; // modulation index
10 // calculate
11 E0_rms=Edc; // calculation of rms output voltage
12 E0_fund=M*Edc/sqrt(2); // calculation of Fundamental
    output voltage
13 DF=M/sqrt(2); // calculation of distortion factor
14 HF=sqrt(2/M^2-1); // calculation of harmonic factor
15 G=M/sqrt(2); // calculation of gain of the inverter
16
17 printf("\nThe rms output voltage is \t\t E0_rms=%0.1f
    V",E0_rms);
18 printf("\nThe Fundamental output voltage is \t
    E0_fund=%0.1f V",E0_fund);
19 printf("\nThe distortion factor is \t\t DF=%0.4f ",DF
    );
20 printf("\nThe harmonic factor is \t\t\t HF=%0.3f ",HF
    );
21 printf("\nThe gain of the inverter is \t\t G=%0.4f ",
    G);

```

```
22 // Note: The answer varies slightly due to precise
    calculation
```

Scilab code Exa 9.9 What should be the amplitude of modulation index

```
1 // chapter 9
2 // example 9.9
3 // What should be the amplitude of modulation index
4 // page-572
5 clear;
6 clc;
7 // given
8 Edc=120; // in V (battery voltage)
9 K=1/3; // transformer turn ratio
10 E01_rms=210; // in V (Fundamental output voltage of
    secondary)
11 // calculate
12 E0_fund=E01_rms*K; // calculation of Fundamental
    voltage component at primary of the transformer
13 // since  $E0\_fund=M*Edc/\sqrt{2}$ , therefore we get
14  $M=E0\_fund*\sqrt{2}/Edc$ ; // calculation of amplitude
    of modulation index
15 printf("\nThe amplitude of modulation index is \t M=
    %.2f",M);
16 // Note: The answer varies slightly due to precise
    calculation
```

Scilab code Exa 9.10 Determine fundamental output voltage and first five dominant

```
1 // chapter 9
2 // example 9.10
3 // Determine fundamental output voltage and first
    five dominant harmonics
```

```

4 // page-574
5 clear;
6 clc;
7 // given
8 Edc=280; // in V (battery voltage)
9 M=0.8; // modulation index
10 Mf=24; // carrier ratio
11 // calculate
12 E0_fund=M*Edc/sqrt(2); // calculation of Fundamental
    output voltage
13 printf("\nThe Fundamental output voltage is \t
    E0_rms=%0.2f V",E0_fund);
14 printf("\n\nThe first five dominant harmonics are \t
    n= ")
15 for n=2:2:6
16     N1=n*Mf-1;
17     N2=n*Mf+1;
18     printf("%0.f, %0.f, ",N1,N2);
19 end
20 printf(" ... etc");
21 // Note: The answer varies slightly due to precise
    calculation

```

Scilab code Exa 9.12 Determine rms value of the output line and phase voltages rms

```

1 // chapter 9
2 // example 9.12
3 // Determine rms value of the output line and phase
    voltages, rms value of the fundamental component
    of the line and phase voltage
4 // page-582
5 clear;
6 clc;
7 // given
8 Edc=500; // in V (source voltage)

```

```

9 // calculate
10 E_line_rms=sqrt(2/3)*Edc; // calculation of rms
    value of the output line voltage
11 E_phase_rms=E_line_rms/sqrt(3); // calculation of
    rms value of the phase voltage
12 E_line_fund=4*Edc*cosd(30)/(sqrt(2)*%pi); //
    calculation of rms value of the fundamental
    component of the line voltage
13 E_phase_fund=E_line_fund/sqrt(3); // calculation of
    rms value of the fundamental component of the
    phase voltage
14 printf("\nThe rms value of the output line voltage
    is \t\t\t\t E_line_rms=%f V",E_line_rms);
15 printf("\nThe rms value of the phase voltage is \t\t
    \t\t\t\t E_phase_rms=%f V",E_phase_rms);
16 printf("\nThe rms value of the fundamental component
    of the line voltage is \t E_line_fund=%f V",
    E_line_fund);
17 printf("\nThe rms value of the fundamental component
    of the line voltage is \t E_phase_fund=%f V",
    E_phase_fund);
18 // Note: The answer varies slightly due to precise
    calculations and the answer in the book is
    rounded off

```

Scilab code Exa 9.14 Determine various parameters

```

1 // chapter 9
2 // example 9.14
3 // Determine rms line and phase voltage, rms line
    and phase voltage at fundamental frequency, THD,
    DR, HF and DF of lowest order harmonic, load
    power and average and rms switch current
4 // page-584-585
5 clear;

```

```

6  clc;
7  // given
8  Edc=200; // in V (source voltage)
9  R=10; // in ohm
10 L=20; // in mH
11 f0=50; // in Hz (invertor frequency)
12 // calculate
13 L=L*1E-3; // changing unit from mH to H
14 w=2*pi*f0; // calculation of angular velocity
15 E_L=sqrt(2/3)*Edc; // calculation of rms value of
    the output line voltage
16 E_P=E_L/sqrt(3); // calculation of rms value of the
    phase voltage
17 E_L1=4*Edc*cosd(30)/(sqrt(2)*pi); // calculation of
    rms value of the fundamental component of the
    line voltage
18 E_P1=E_L1/sqrt(3); // calculation of rms value of
    the fundamental component of the phase voltage
19 printf("\n\nThe rms value of the output line voltage
    is \t\t\t\t E_L=%.2f V",E_L);
20 printf("\n\nThe rms value of the phase voltage is \t\t
    \t\t\t\t E_P=%.2f V",E_P);
21 printf("\n\nThe rms value of the fundamental component
    of the line voltage is \t E_L1=%.2f V",E_L1);
22 printf("\n\nThe rms value of the fundamental component
    of the line voltage is \t E_P1=%.2f V",E_P1);
23 E1_rms=2*Edc/(sqrt(2)*pi);
24 E0_rms=(Edc/2);
25 THD=sqrt(E_L^2-E_L1^2)/E_L1; // calculation of total
    harmonic distortion
26 printf("\n\n\nThe total harmonic distortion is \t THD=
    %.4f or \t %.2f percent",THD,THD*100);
27 K=0;
28 for n=5:2:11
29     E_Ln=4*Edc*cos(n*pi/6)/(n*pi*sqrt(2));
30     E_Ln_n2=(E_Ln/n^2)^2;
31     K=K+E_Ln_n2;
32 end

```

```

33 K=sqrt(K);
34 DF=K/E_L1; // calculation of distortion factor
35 printf("\nThe distortion factor is \t\t DF=%f or \t
    %.3f percent",DF,DF*100);
36 E_L5=4*Edc*cos(5*pi/6)/(5*pi*sqrt(2));
37 HF5=abs(E_L5/E_L1); // calculation of lowest order
    of harmonic factor
38 DF5=abs((E_L5/5^2)/E_L1); // calculation of lowest
    order of distortion factor
39 printf("\nThe lowest order harmonic factor is \t HF5
    =%.3f or \t %.2f percent",HF5,HF5*100);
40 printf("\nThe lowest order distortion factor is \t
    DF5=%.3f or \t %.2f percent",DF5,DF5*100);
41 I=0; // initialisation
42 for n=1:2:17
43     Z_L=sqrt(R^2+(n*w*L)^2);
44     theta=atand(n*w*L/R);
45     I_L=4*Edc*cos(n*pi/6)/(n*pi*Z_L);
46     I=I+I_L^2;
47 end
48 I=sqrt(I)/sqrt(2); // calculation of load current
49 P0=3*I^2*R; // calculation of load power
50 Is=P0/Edc; // calculation of average supply current
51 I_T_avg=Is/3; // calculation of average switch
    current
52 I_T_rms=I/sqrt(2); // calculation of rms switch
    current
53 printf("\n\nThe load power is \t\t P0=%.2f kW",P0*1E
    -3);
54 printf("\nThe average switch current is \t I_T_avg=%
    .2f A",I_T_avg);
55 printf("\nThe rms switch current is \t I_T_rms=%.2f
    A",I_T_rms);
56 // Note: 1. There is calculation mistake while
    calculating load current and hence the answers
    for P0, I_T_avg, I_T_rms are wrong in the book
57 //     2.The answer varies slightly due to precise
    calculations and the answer in the book is

```

rounded off

Scilab code Exa 9.17 Determine dc voltage rms line and phase voltages and Device v

```
1 // chapter 9
2 // example 9.17
3 // Determine dc voltage , rms line and phase voltages
  and Device voltage ratings
4 // page-591
5 clear;
6 clc;
7 // given
8 E1_line=415; // fundamental line voltage
9 // calculate
10 // since  $E1\_line = (\sqrt{2}/\pi) * E_{dc} * 1.5$ , therefore we
  get
11  $E_{dc} = E1\_line * (\pi / (\sqrt{2} * 1.5))$ ; // calculation of
  dc voltage
12  $E_{rms\_line} = E_{dc} / \sqrt{2}$ ; // calculation of rms line
  voltage
13  $E_{rms\_phase} = E_{rms\_line} / \sqrt{3}$ ; // calculation of
  rms phase voltage
14  $V_{CEO} = 1.5 * E_{dc}$ ; // calculation of Device voltage
  ratings
15 printf("\n\nThe dc voltage is \t\t  $E_{dc} = %.1f$  V", E_dc);
16 printf("\n\nThe rms line voltage is \t  $E_{rms\_line} = %.2f$ 
  V", E_rms_line);
17 printf("\n\nThe rms phase voltage is \t  $E_{rms\_phase} = %.2f$ 
  V", E_rms_phase);
18 printf("\n\nThe Device voltage ratings is \t  $V_{CEO} = %.1f$ 
  V", V_CEO);
19 // Note: The answer varies slightly due to precise
  calculations
```

Scilab code Exa 9.18 Design a series inverter circuit

```
1 // chapter 9
2 // example 9.18
3 // Desig a series inverter circuit
4 // page-606
5 clear;
6 clc;
7 // given
8 f0=1, fr=5; // in KHz (range of frequency of
   operation)
9 Rmin=25, Rmax=100; // in ohm (range of load
   resistance)
10 Ip=3; // in A
11 Edc=100; // in V (dc source)
12 AF=0.5; // attenuation factor (assumption as done in
   the book)
13 // calculate
14 f0=f0*1E3; // changing unit from KHz to Hz
15 fr=fr*1E3; // changing unit from KHz to Hz
16 wr=2*%pi*fr; // calculation of upper limit of
   angular velocity
17 w0=2*%pi*f0; // calculation of lower limit of
   angular velocity
18 L=-Rmax/(8*fr*log(AF)); // calculation of inductance
19 C=(1/L)*(1/(wr^2+(Rmax/(2*L))^2)); // calculation of
   capacitance
20 Ec=Edc*(exp(-Rmin*%pi/(2*wr*L))/(1-exp(-Rmin*%pi/(2*
   wr*L)))); // calculation of capacitor voltage
21 I_peak=(Ec+Edc)/(wr*L)*exp(-Rmin*%pi/(4*wr*L)); //
   calculation of peak current
22 // since  $V_{BO} \geq Ec + Edc$ , therefore
23 V_BO=Ec+Edc; // calculation of forward blocking
   voltage rating
```

```

24 // since I_T>=I-peak, therefore
25 I_T=(I_peak+1); // calculation of Thyristor current
26 Toff=%pi*((1/w0)-(1/wr)); // calculation of
    Thyristor off-time
27 // since I_T>=I-peak, therefore
28 tq=Toff*1E3-0.1; // calculation of inverter turn off
    -time
29 printf("\nThe inductance \t\t\t L=%0.1f mH",L*1E3);
30 printf("\nThe capacitance \t\t\t C=%0.2f uF",C*1E6);
31 printf("\nThe capacitor voltage \t\t\t Ec=%0.2f V",Ec);
32 printf("\nThe peak current \t\t\t I-peak=%0.2f A",
    I_peak);
33 printf("\nThe forward blocking voltage \t\t V_BO>=%0.f
    V",V_BO);
34 printf("\nThe Thyristor current \t\t\t I-T=%0.f A",I_T)
    ;
35 printf("\nThe Thyristor turn-off time \t\t Toff=%0.1f
    ms",Toff*1E3);
36 printf("\nThe inverter turn-off time \t\t tq=%0.1f ms",
    tq);
37 // Note: The answer varies slightly due to precise
    calculations and round off as done in the book

```

Scilab code Exa 9.19 Design a self commutated inverter circuit and compute output

```

1 // chapter 9
2 // example 9.19
3 // Design a self-commutated inverter circuit and
    compute output power
4 // page-608-609
5 clear;
6 clc;
7 // given
8 f0=3; // in KHz
9 R=5; // in ohm (load resistance)

```

```

10 L=5; // in mH
11 Edc=100; // in V (dc source)
12 // calculate
13 f0=f0*1E3; // changing unit from KHz to Hz
14 fr=1.35*f0; // calculation of resonant frequency
15 L=L*1E-3; // changing unit from mH to H
16 w0=2*%pi*f0; // calculation of normal angular
    frequency
17 wr=2*%pi*fr; // calculation of resonant angular
    velocity
18 // since L/L1=200, therefore we get
19 L1=L/200; // calculation of inductance L1
20 // since fr=1/(2*%pi*sqrt(2*L1*C)), therefore we
    get
21 C=(1/(2*%pi*fr))^2/(2*L1); // calculation of
    capacitance
22 tou=R*C; // calculation of time constant
23 T=1/f0; // calculation of time period
24 K=exp(-T/(2*tou)); // calculation of attenuation
    factor
25 Z0=(R*%i*w0*L)/((R+(%i*w0*L))); // calculation of
    output impedance
26 Z0_magnitude=abs(Z0);
27 I=(Edc/Z0_magnitude)*(1/(1-4*tou*((1-K)/(1+K)))); //
    calculation of current flowing through Thyristor
28 E0_max=I*Z0_magnitude*(1-2*K/(1+K)); // calculation
    of maximum output vltage
29 E0_rms=E0_max/sqrt(2); // calculation of rms output
    voltage
30 V_BO=2*(Edc+E0_max); // calculation of forward
    blocking voltage rating
31 I_T=2*I; // calculation of Thyristor current
32 tq=tou*log(2/(1+K)); // calculation of invertor trun
    off-time
33 Vc=2*E0_max; // calculation of capacitor voltage
34 P0=(E0_max*E0_rms/R)*cosd(atan2(imag(Z0),real(Z0)));
    // calculation of output power
35 printf("\nThe resonant frequency is \t\t\t fr=%0.2f

```

```

    KHz",fr*1E-3);
36 printf("\nThe inductance L1 is \t\t\t L1=%f uH",
    L1*1E6);
37 printf("\nThe capacitance is \t\t\t C=%f uF",C*1
    E6);
38 printf("\nThe current flowing through Thyristor is \
    t I=%f A",I);
39 printf("\nThe maximum output voltage is \t\t\t
    E0_max=%f V",E0_max);
40 printf("\nThe rms output voltage is \t\t\t E0_rms=%
    .2 f V",E0_rms);
41 printf("\nThe forward blocking voltage is \t\t V_BO
    >=%f V",V_BO);
42 printf("\nThe Thyristor current is \t\t\t I_T=%f A"
    ,I_T);
43 printf("\nThe inverter turn-off time is \t\t\t tq=%
    .1 f us",tq*1E6);
44 printf("\nThe output power is \t\t\t P0=%f W",P0
    );
45 // Note: The answer varies slightly due to precise
    calculations and round off as done in the book

```

Scilab code Exa 9.20 Design a parallel inverter

```

1 // chapter 9
2 // example 9.20
3 // Design a parallel inverter
4 // page-614
5 clear;
6 clc;
7 // given
8 f=50; // in Hz
9 E=200; // in V
10 Edc=40; // in V
11 I_L=2; // in A

```

```

12 tq=40; // in us (assumption as done in the book)
13 E_amplitude=415; // in V (fundamental frequency
    amplitude of voltage assumption as done in the
    book)
14 Bmax=1; // in Wb/m^2 (assumption for flux density as
    done in the book)
15 A=25; // in cm^2 (assumption for cross-section area
    as done in the book)
16 // calculate
17 tq=tq*1E-6; // changing unit from us to s
18 A=A*1E-4; // changing unit from cm^2 to m^2
19 // since Edc*sqrt(C/L)=I_L and sqrt(C*L)=3*tq/%pi,
    therefore multiplying both we get
20 // Edc*C=I_L*3*tq/%pi, therefore we get
21 C=(I_L*3*tq/%pi)/Edc; // calculation of capacitance
22 L=(1/(I_L/Edc)^2)*C; // calculation of inductance
23 Vc=2*Edc; // calculation of capacitor voltage
24 N2=E_amplitude/(sqrt(2)*4.44*f*A); // calculation of
    number of turns in secondary winding
25 // since N2/(1/2*N1)=6, therefore we get
26 N1=2*N2/6; // calculation of number of turns in
    primary winding
27 V_BO=2*Edc; // calculation of forward blocking
    voltage rating
28 I_T=2*E/Edc*I_L; // calculation of Thyristor current
29 printf("\nThe inductance is \t\t\t L=%0.1f uH",L*1
    E6);
30 printf("\nThe capacitance is \t\t\t C=%0.1f uF",C*1
    E6);
31 printf("\nThe capacitor voltage is \t\t\t Vc=%0.f V",
    Vc)
32 printf("\nThe number of turns in secondary winding
    is \t N2=%0.f",N2);
33 printf("\nThe number of turns in primary winding is
    \t N1=%0.f",N1);
34 printf("\nThe forward blocking voltage is \t\t V_BO
    >=%0.f V",V_BO);
35 printf("\nThe Thyristor current is \t\t\t I_T>=%0.f A

```

```

    ",I_T);
36 // Note: 1. The answer for L and C is wrong in the
    book due to calculation mistake.
37 //      2 The answer vary slightly due to precise
    calculations and round off as done in the book

```

Scilab code Exa 9.21 Calculate rms output voltage at fundamental frequency output

```

1 // chapter 9
2 // exapmle 9.21
3 // Calculate rms output voltage at fundamental
    frequency , output power, average and peak current
    and peak reverse-blocking voltage
4 // page-618
5 clear;
6 clc;
7 // given
8 Edc=50; // in V (source voltage)
9 R=3; // in ohm
10 D=50; // in percent (universal for the circuit used)
11 // calculate
12 E1=2*Edc/(sqrt(2)*%pi); // calculation of rms output
    voltage at fundamental frequency
13 E_L=Edc/2; // calculation of rms line voltage
14 P0=E_L^2/R; // calculation of output power
15 I_peak=(Edc/2)/R; // calculation of peak current
16 I_av=(D/100)*I_peak; // calculation of average
    current
17 V_BR=2*Edc/2; // calculation of peak reverse-
    blocking voltage
18 printf("\nThe rms output voltage at fundamental
    frequency is \t E1=%0.1f V",E1);
19 printf("\nThe output power is \t\t\t\t P0=%0.2 f W",
    P0);
20 printf("\nThe peak current is \t\t\t\t I_peak=%0.2 f

```

```

    A", I_peak);
21 printf("\nThe average current is \t\t\t\t I_av=%.3
    f A", I_av);
22 printf("\nThe peak reverse-blocking voltage is \t\t\t
    t V_BR=%.f V", V_BR);
23 // Note: The answer vary slightly due to precise
    calculations and round off as done in the book

```

Scilab code Exa 9.22 Calculate rms output voltage at fundamental frequency output

```

1 // chapter 9
2 // example 9.22
3 // fig. 9.43 (a)
4 // Calculate rms output voltage at fundamental
    frequency, output power, average and peak current
    and peak reverse-blocking voltage
5 // page-620
6 clear;
7 clc;
8 // given
9 Edc=50; // in V (source voltage)
10 R=3; // in ohm
11 D=50; // in percent (universal for the circuit used)
12 // calculate
13 E1=4*Edc/(sqrt(2)*%pi); // calculation of rms output
    voltage at fundamental frequency
14 E_L=sqrt(2*Edc^2*integrate('1','t',0,1/2)); //
    calculation of rms line voltage
15 P0=Edc^2/R; // calculation of output power
16 I_peak=Edc/R; // calculation of peak current
17 I_av=(D/100)*I_peak; // calculation of average
    current
18 V_BR=Edc; // calculation of peak reverse-blocking
    voltage
19 printf("\nThe rms output voltage at fundamental

```

```

    frequency is \t E1=%0.1f V" ,E1);
20 printf("\nThe output power is \t\t\t\t\t P0=%0.2f W" ,
    P0);
21 printf("\nThe peak current is \t\t\t\t\t I_peak=%0.2f
    A" ,I_peak);
22 printf("\nThe average current is \t\t\t\t\t I_av=%0.3
    f A" ,I_av);
23 printf("\nThe peak reverse-blocking voltage is \t\t\t
    t V_BR=%0.f V" ,V_BR);
24 // Note: The answer vary slightly due to precise
    calculations and round off as done in the book

```

Scilab code Exa 9.23 What value of C should the load have in order to obtain load

```

1 // chapter 9
2 // example 9.23
3 // What value of C should the load have in order to
    obtain load commutation of SCR
4 // page-620
5 clear;
6 clc;
7 // given
8 Edc=50; // in V (source voltage)
9 R=3; // in ohm
10 wL=12; // in ohm
11 T=0.2; // in ms (time period)
12 tq=12; // in us
13 Toff=1.5*tq;
14 // calculate
15 T=T*1E-3; // changing unit from ms to s
16 Toff=Toff*1E-6; // changing unit from us to s
17 phi_w=Toff; // calculation of phi/w
18 f=1/T; // calculation of frequency
19 w=2*%pi*f; // calculation of angular velocity
20 phi=phi_w*w; // calculation of phase angle

```



```

21 X_L=wL;
22 // since  $\tan(\phi)=(X_C-X_L)/R$ , therefore we get
23 X_C=(tan(phi)*R)+X_L; // calculation of capacitive
    reactance
24 // since  $X_c=1/(w*C)$ , therefore we get
25 C=1/(X_C*w); // calculation of required capacitance
26 printf("\nThe value of C that the load sholud have
    in order to obtain load commutation of SCR is \t
    C=%0.2 f uF",C*1E6);
27 // Note: The answer in the book is wrong due to
    calculation mistake in calculating the variable
    phi_w

```

Scilab code Exa 9.24 Obtain the value of commutating components L and C

```

1 // chapter 9
2 // example 9.24
3 // fig. 9.45
4 // Obtain the value of commutating components L and
    C
5 // page-626
6 clear;
7 clc;
8 // given
9 I_L_max=80; // in A (maximum load current)
10 Edc_min=200; // in V (minimum source voltage)
11 tq=40; // in us (turn-off time of SCRs)
12 // calculate
13 tq=tq*1E-6; // changing unit from us to s
14 Toff=1.5*tq; // calculation of circuit turn-off time
15 C=0.893*Toff*I_L_max/Edc_min; // calculation of the
    value of commutating capacitance
16 L=0.397*Edc_min*Toff/I_L_max; // calculation of the
    value of commutating inductance
17 printf("\nThe value of commutating capacitance is \t

```

```

    C=%0.2 f uF",C*1E6);
18 printf("\nThe value of commutating inductance is \t\
    t L=%0.2 f uH",L*1E6);
19 // Note: The answer in the book for C and L is wrong
    due to calculation mistake

```

Scilab code Exa 9.25 Obtain the value of commutating components and the value of r

```

1 // chapter 9
2 // example 9.25
3 // fig. 9.47
4 // Obtain the value of commutating components and
    the value of resistance
5 // page-628
6 clear;
7 clc;
8 // given
9 Edc=300; // in V (source voltage)
10 neta=15; // in percent (variation of maximum and
    minimum dc voltage from dc source voltage)
11 I_L_max=100; // in A (maximum load current)
12 I_L_min=20; // in A (minimum load current)
13 tq=20; // in us (turn-off time of SCRs)
14 safety_factor=2; // assumption
15 // calculate
16 tq=tq*1E-6; // changing unit from us to s
17 Toff=2*tq; // calculation of circuit turn-off time
18 Edc_min=Edc*(1-neta/100); // calculation of minimum
    dc voltage
19 Edc_max=Edc*(1+neta/100); // calculation of maximum
    dc voltage
20 C=0.893*Toff*I_L_max/Edc_min; // calculation of the
    value of commutating capacitance
21 L=0.397*Edc_min*Toff/I_L_max; // calculation of the
    value of commutating inductance

```

```

22 R=2*sqrt(L/C); // calculation of the value of
    resistance
23 printf("\nThe value of commutating capacitance is \t
    C=%0.1f uF",C*1E6);
24 printf("\nThe value of commutating inductance is \t\
    t L=%0.1f uH",L*1E6);
25 printf("\nthe value of resistance is \t\t\t R=%0.1f
    ohm",R);
26 // Note: The answer in the book for C and L is wrong
    due to calculation mistake

```

Scilab code Exa 9.26 Find the rms load current load power and thyristor ratings

```

1 // chapter 9
2 // example 9.26
3 // fig. Ex.9.26(a) and Ex. 9.26(b)
4 // Find the rms load current , load-power and
    thyristor ratings
5 // page-628-630
6 clear;
7 clc;
8 // given
9 Edc=600; // in V (source voltage)
10 R=15; // in ohm (resistance per phase)
11 alpha1=120, alpha2=180; // in degree
12 // calculate
13 // part-a
14 Ip=Edc/(2*R); // calculation of load current
    amplitude
15 Irms=sqrt((1/(2*pi))*Ip^2*(integrate('1','theta',
    ,0,(alpha1*(pi/180)))+integrate('1','theta',(
    alpha2*(pi/180)),(5*pi/3)))); // calculation of
    rms load current
16 P0=3*Irms^2*R; // calculation of load-power
17 I_T_rms=sqrt(Ip^2/3); // calculation of thyristor

```

```

    rms current
18 printf("\nFor %.f degree conduction , \n",alpha1);
19 printf("\nThe rms load current is \t Irms=%.2f A",
    Irms);
20 printf("\nThe load-power is \t\t P0=%.f kW",P0*1E-3)
    ;
21 printf("\nThe thyristor rms current is \t I_T_rms=%
    .1f A",I_T_rms);
22 // part-b
23 R0=R+R/2; // calculation of load on inverter
24 I1=Edc/R0; // calculation of current I1
25 I2=I1/2; // calculation of current I2
26 Irms1=sqrt((1/(2*pi))*(I2^2*integrate('1','theta',
    ,0,(alpha1*pi/180))+I1^2*integrate('1','theta',(
    alpha1*pi/180),(4*pi/3))+I2^2*integrate('1','
    theta',(4*pi/3),(2*pi))))); // calculation of
    rms load current Irms1
27 Irms2=I1/2; // calculation of rms load current Irms2
28 P0=3*Irms1^2*R; // calculation of load-power
29 printf("\n\nFor %.f degree conduction , \n",alpha2);
30 printf("\nThe rms load currents are \t Irms1=%.2f A
    \t Irms2=%.2f A",Irms1,Irms2);
31 printf("\nThe load-power is \t\t P0=%.2f kW",P0*1E
    -3);
32 // Note: 1. The wrong values of angle theta has been
    used in the book for calculating the rms load
    current in both cases. But the answer in the book
    is right. So I have used correct values and the
    answer is same as in the book with little
    variation due to precise calculation

```

Scilab code Exa 9.27 Determine commutating capacitor load current $F_{critical}$ and $R_{critical}$

```

1 // chapter 9
2 // example 9.27

```

```

3 // Determine commutating capacitor , load current ,
   Fcritical and Rcritical
4 // page-649-650
5 clear;
6 clc;
7 // given
8 f=50; // in Hz
9 tq=62; // in us (Thyristor turn-off time)
10 R=5; // in ohm
11 I=1; // in A (let us assume this value for current
   source for calculation of load current)
12 // calculate
13 tq=tq*1E-6; // changing unit from us to s
14 Toff=5*tq; // calculation of circuit turn-off time
15 T=1/f; // calculation of time period
16 // since Toff=0.69*R*C, therefore we get
17 C=Toff/(0.69*R); // calculation of commutating
   capacitor
18 I1=I*((1-exp(-T/(2*R*C)))/(1+exp(-T/(2*R*C)))); //
   calculation of load current
19 Toff_critical=1.5*tq; // calculation of critical
   circuit turn-off time
20 // since Toff=R*C*log(2/(1+exp(-T/(2*R*C)))) ,
   therefore we get
21 Tcritical=2*R*C*log(2/(exp(Toff_critical/(R*C))-1));
   // calculation of critical time period
22 Fcritical=1/Tcritical; // calculation of critical
   frequency
23 // since Toff=0.69*R*C, therefore we get
24 Rcritical=Toff_critical/(0.69*C); // calculation of
   critical resistance
25 printf("\nThe commutating capacitor is \t C=%0.2f uF"
   ,C*1E6);
26 printf("\nThe load current is \t\t I1=I=%0.f A",I1);
27 printf("\nThe critical frequency is \t Fcritical=%0.1
   f Hz",Fcritical);
28 printf("\nThe critical resistance is \t Rcritical=%
   .2f ohm",Rcritical);

```

```

29 // Note: 1.The answer varies slightly as from
    calculated from the book due to precise
    calculation .
30 //      2. for calculating other variables , author
    has use standard value of C (100 uF) for further
    calculation but I have used the value which is
    calculated .

```

Scilab code Exa 9.28 Design an OTT filter

```

1 // chapter 9
2 // example 9.28
3 // Design an OTT-filter
4 // page-662
5 clear;
6 clc;
7 // given
8 E_L=230; // in V (output voltage)
9 f=50; // in Hz
10 I_L=1.5; // in A (load current)
11 Edc=40; // in V (source voltage)
12 // calculate
13 W_D=2*%pi*f; // calculation of design radian
    frequency
14 Z_L=E_L/I_L; // calculation of load impedance
15 Z_D=abs(Z_L)/2; // calculation of filter design
    impedance
16 C1=1/(6*Z_D*W_D); // calculation of capacitance C1
17 C2=1/(3*Z_D*W_D); // calculation of capacitance C2
18 L1=9*Z_D/(2*W_D); // calculation of inductance L1
19 L2=Z_D/W_D; // calculation of inductance L1
20 printf("\nThe design radian frequency is \t W_D=%f
    rad/s",W_D);
21 printf("\nThe load impedance is \t\t Z_L=%f ohm",
    Z_L);

```

```

22 printf("\nThe filter design impedance is \t Z_D=%0.2 f
    ohm",Z_D);
23 printf("\nThe capacitance C1 is \t\t C1=%0.2 f uF",C1
    *1E6);
24 printf("\nThe capacitance C2 is \t\t C2=%0.2 f uF",C2
    *1E6);
25 printf("\nThe capacitance L1 is \t\t L1=%0.3 f H",L1);
26 printf("\nThe capacitance L2 is \t\t L1=%0.3 f H",L2);
27 // Note: The answer varies slightly due to precise
    calculation

```

Scilab code Exa 9.29 Design a 400 Hz parallel inverter

```

1 // chapter 9
2 // example 9.29
3 // Design a 400 Hz parallel inverter
4 // page-663-664
5 clear;
6 clc;
7 // given
8 P0=360; // in W (output power)
9 E_L=120; // in V (output voltage)
10 f=400; // in Hz
11 PF=0.7; // (lagging) (power factor)
12 Edc=28; // in V (source voltage)
13 Zin=80-23*i; // filter input impedance (assumption
    as done in the book)
14 neta=85; // in percent (assumption as done in the
    book)
15 Toff=12; // in us (assumption for circuit turn-off
    time as done in the book)
16 Ip_SCR=14; // in A (assumption for SCR peak current
    as done in the book)
17 // calculate
18 R_L=E_L^2*PF^2/P0; // calculation of load resistance

```

```

19 X_L=(R_L/PF)*sqrt(1-PF^2); // calculation of load
    reactance
20 Z_L_magnitude=sqrt(R_L^2+X_L^2); // calculation of
    load impedance
21 Z_L_phase=acosd(PF); // calculation of load
    impedance phase
22 Z_D=abs(Z_L_magnitude)/2; // calculation of filter
    design impedance
23 W_D=2*pi*f; // calculation of dsign radian
    frequency
24 C1=1/(6*Z_D*W_D); // calculation of capacitance C1
25 C2=1/(3*Z_D*W_D); // calculation of capacitance C2
26 L1=9*Z_D/(2*W_D); // calculation of inductance L1
27 L2=Z_D/W_D; // calculation of inductance L1
28 Rin=real(Zin); // calculation of filter input
    resistance
29 Xin=abs(imag(Zin)); // calculation of filter input
    reactance
30 Zin_magnitude=abs(Zin); // calculation of filter
    input impedance magnitude
31 E_SQ=(sqrt(2)/4)*pi*Zin_magnitude*(P0/Rin)^0.5 //
    calculation of input voltage to filter
32 n=E_SQ/Edc; // calculation of transfromer turns
    ratio
33 Pi=P0/(neta/100); // calculation of input power
34 I_T_av=P0*Zin_magnitude/(2*Edc*Rin); // calculation
    of average thyristor current
35 V_B0=2.5*Edc; // calculation of blocking voltage
36 L=6*Edc*Toff/(pi*Ip_SCR); // calculation of
    commutating inductance
37 C=3*Toff*Ip_SCR/(8*pi*Edc); // calculation of
    commutating capacitance
38 di_dt=2*Edc/L; // calculation of rate of change of
    current
39 printf("\nThe load resistance is \t\t\t R_L=%f
    ohm",R_L);
40 printf("\nThe load reactance is \t\t\t X_L=%f ohm
    ",X_L);

```



```

41 printf("\nThe magnitude of load impedance is \t\t
    Z_L_magnitude=%0.1f ohm",Z_L_magnitude);
42 printf("\nThe phase of load impedance is \t\t\t
    Z_L_phase=%0.f degree",Z_L_phase);
43 printf("\nThe filter design impedance is \t\t\t Z_D=
    %0.2f ohm",Z_D);
44 printf("\nThe design radian frequency is \t\t\t W_D=
    %0.f rad/s",W_D);
45 printf("\nThe capacitance C1 is \t\t\t\t C1=%0.1f uF"
    ,C1*1E6);
46 printf("\nThe capacitance C2 is \t\t\t\t C2=%0.1f uF"
    ,C2*1E6);
47 printf("\nThe capacitance L1 is \t\t\t\t L1=%0.1f mH"
    ,L1*1E3);
48 printf("\nThe capacitance L2 is \t\t\t\t L1=%0.f mH" ,
    L2*1E3);
49 printf("\nThe filter input resistance is \t\t\t Rin=
    %0.f ohm",Rin);
50 printf("\nThe filter input reactance is \t\t\t Xin=%
    0.f ohm",Xin);
51 printf("\nThe magnitude of filter input impedance is
    \t Zin_magnitude=%0.f ohm",Zin_magnitude);
52 printf("\nThe input voltage to filter is \t\t\t E_SQ
    =%0.f V",E_SQ);
53 printf("\nThe transformer turns ratio is \t\t\t n=%0.
    f",n);
54 printf("\nThe input power is \t\t\t\t Pin=%0.f W",Pi)
    ;
55 printf("\nThe average thyristor current is \t\t
    I_T_av=%0.1f A",I_T_av);
56 printf("\nThe blocking voltage is \t\t\t V_BO=%0.f V"
    ,V_BO);
57 printf("\nThe commutating inductance is \t\t\t L=%0.1
    f uH",L);
58 printf("\nThe commutating capacitance is \t\t\t C=%
    0.2f uF",C);
59 printf("\nThe rate of change of current at t=0 s is
    \t di/dt=%0.2f A/us",di_dt);

```

60 // Note: 1. The answer varies slightly due to
precise calculation.
61 // 2. Most of the answers have been rounded
off in the book and then used for further
calculation. I have used the exact values for the
calculations

Chapter 10

Cycloconverters

Scilab code Exa 10.1 Determine required supply voltage thyristor rating and power

```
1 // chapter 10
2 // example 10.1
3 // Determine required supply voltage , thyristor
  rating and power factor of the supply current
4 // page-698-699
5 clear;
6 clc;
7 // given
8 m=3; // number of phases
9 PF=0.7; // power factor (lagging)
10 Edc=190; // in V (load voltage)
11 I_L=45; // in A
12 // calculate
13 // since  $E_{dc} = (m/\pi) * E_{ph} * \sin(\pi/m)$ , therefore we
  get
14 Eph=Edc/((m/%pi)*sin(%pi/m)); // calculation of
  required supply voltage
15 Eph_max=Eph*sqrt(2); // calculation of required
  supply voltage maximum value
16 Imax=I_L*sqrt(2); // calculation of maximum value of
  cycloconvertor current
```

```

17 Irms=Imax/sqrt(3); // calculation of thyristor rms
    current
18 PIV=sqrt(3)*Eph_max; // calculation of peak inverse
    voltage
19 Irms_1_3=sqrt(I_L^2/3); // calculation of rms
    current for one-third cycle
20 Pin=(1/3)*Edc*I_L*PF; // calculation of input power
    per phase
21 pf=Pin/(Eph*Irms_1_3); // calculation of power
    factor of the supply current
22 printf("\nThe required supply voltage is \t\t\t Eph=
    %.2f V",Eph);
23 printf("\nThe thyristor ratings are \t\t\t Irms==%.2
    f A \t PIV=%.2f V",Irms,PIV);
24 printf("\nThe power factor of the supply current is
    \t pf=%.2f",pf);
25 // Note: 1. The answers vary slightly due to precise
    calculation.

```

Scilab code Exa 10.2 Estimate peak and rms value of load voltage

```

1 // chapter 10
2 // example 10.2
3 // Estimate peak and rms value of load voltage
4 // page-699-700
5 clear;
6 clc;
7 // given
8 E=600; // in V (line voltage)
9 f=50; // in Hz (supply frequency)
10 Ls=1.46; // in mH (inductance per phase)
11 I_L=28; // in A (load current)
12 p=6; // number of pulses
13 alpha1=0,alpha2=30, alpha3=60; // in degrees (firing
    angles)

```

```

14 // calculate
15 Ls=Ls*1E-3; // changing unit from mH to H
16 Em=E*sqrt(2); // calculation of peak value of supply
    voltage
17 w=2*pi*f; // calculation of angular frequency in
    radian
18 // since Epeak=(p/pi)*Em*sin(pi/p)*cosd(alpha)-(p*
    w*Ls*I_L/(2*pi)), therefore we get
19 for alpha=0:30:60
20     Epeak=(p/pi)*Em*sin(pi/p)*cosd(alpha)-(p*w*Ls*
        I_L/(2*pi)); // calculation of peak value of
        load voltage
21     Erms=Epeak/sqrt(2); // calculation of rms value
        of load voltage
22     printf("\n\nFor alpha=%f degree,",alpha);
23     printf("\nThe peak value of load voltage is \t
        Epeak=%f V",Epeak);
24     printf("\nThe rms value of load voltage is \t
        Erms=%f V",Erms);
25 end
26 // Note: 1. The value of E used in calculation in
    the book is 660 V while the value given is 600 V.
    So i have used 600 V for the calculations as given
    in the question statement. Therefore the answers
    do not match.
27 //      2. The answers vary slightly due to precise
    calculation.

```

Scilab code Exa 10.3 Determine the value of fundamental rms output voltage rms out

```

1 // chapter 10
2 // example 10.3
3 // Determine the value of fundamental rms output
    voltage, rms output current and output power
4 // page-700

```

```

5 clear;
6 clc;
7 // given
8 n=3/1; // transformer turn ratio
9 wL=3; // in ohm (inductive reactance)
10 R_L=4; // in ohm (load resistance)
11 alpha=160; // in degree (firing angle)
12 E=410; // in V (input voltage per phase)
13 f=50; // in Hz (supply frequency)
14 m=3; // number of phases
15 // calculate
16 Eph=E/2; // calculation of per phase voltage to
    convertor
17 r=cosd(180-alpha); // calculation of voltage
    reduction factor
18 Eor=r*Eph*(m/%pi)*sin(%pi/m); // calculation of
    fundamental rms output voltage ,
19 Ior_magnitude=Eor/sqrt(R_L^2+wL^2); // calculation
    of rms output current magnitude
20 Ior_phase=-atand(wL/R_L); // calculation of rms
    output current phase
21 P0=Ior_magnitude^2*R_L; // calculation of output
    power
22 printf("\nThe fundamental rms output voltage is \t
    Eor=%0.2f V",Eor);
23 printf("\nThe rms output current is \t Ior=%0.2f A \
    t and phase is \t %0.2f degree",Ior_magnitude,
    Ior_phase);
24 printf("\nThe output power is \t P0=%0.2f W",P0);
25 // Note: The answers vary slightly due to precise
    calculation.

```

Scilab code Exa 10.4 Determine the value of fundamental rms output voltage rms out

```
1 // chapter 10
```

```

2 // example 10.4
3 // Determine the value of fundamental rms output
   voltage , rms output current and output power
4 // page-700-701
5 clear;
6 clc;
7 // given
8 n=3/1; // transformer turn ratio
9 wL=3; // in ohm (inductive reactance)
10 R_L=4; // in ohm (load resistance)
11 alpha=160; // in degree (firing angle)
12 E=410; // in V (input voltage per phase)
13 f=50; // in Hz (supply frequency)
14 m=6; // number of pulses
15 // calculate
16 Eph=E/2; // calculation of per phase voltage to
   convertor
17 E_line=Eph*sqrt(3); // calculation of input to
   bridge inverter
18 r=cosd(180-alpha); // calculation of voltage
   reduction factor
19 Eor=r*E_line*(m/%pi)*sin(%pi/m); // calculation of
   fundamental rms output voltage ,
20 Ior_magnitude=Eor/sqrt(R_L^2+wL^2); // calculation
   of rms output current magnitude
21 Ior_phase=-atand(wL/R_L); // calculation of rms
   output current phase
22 P0=Ior_magnitude^2*R_L; // calculation of output
   power
23 printf("\nThe fundamental rms output voltage is \t
   Eor=%0.2f V",Eor);
24 printf("\nThe rms output current is \t Ior=%0.2f A \
   \t and phase is \t %0.2f degree",Ior_magnitude,
   Ior_phase);
25 printf("\nThe output power is \t P0=%0.2f W",P0);
26 // Note: The answers vary slightly due to precise
   calculation .

```

Scilab code Exa 10.5 Determine the input current to the convertors

```
1 // chapter 10
2 // example 10.5
3 // Determine the input current to the convertors
4 // page-701
5 clear;
6 clc;
7 // given
8 m=6; // number of pulses
9 Pi=50; // in kVA ()power of cycloconverter)
10 E=415; // in V
11 theta=45; // in degree (firing angle)
12 alpha0=0.8; // power factor
13 // calculate
14 Pi=Pi*1E3; // changing unit from kVA to VA
15 // since  $P_i=3*E*I_m\cos(\theta)=3*E*I*(\cos(\theta)/\sqrt{2})*\alpha_0$ , therefore we get
16  $I=Pi/(3*E*(\cos(\theta)/\sqrt{2})*\alpha_0)$ ; //
    calculation of input current to the convertors
17 printf("\n\nThe input current to the convertors is \t
    I=%0.2 f A",I);
```

Chapter 11

A C Regulators

Scilab code Exa 11.1 Determine various parameters

```
1 // chapter 11
2 // example 11.1
3 // Determine the peak values of average and rms
  thyristor currents , minimum circuit turn-off time
  , the ratio of third harmonic voltage to
  fundamental voltage , maximum value of di/dt and
  the angle at which greatest forward or reverse
  voltage is applied.
4 // page-718-719
5 clear;
6 clc;
7 // given
8 R=4; // in ohm
9 E=230; // in V (supply voltage)
10 f=50; // in Hz
11 alpha=%pi/3; // in degree
12 n=3
13 // calculate
14 Em=E*sqrt(2); // calculation of peak input voltage
15 I_T_av_m=Em/(%pi*R); // calculation of peak value of
  average thyristor current
```

```

16 I_T_rms_m=Em/(2*R); // calculation of peak value rms
    thyristor current
17 w=2*pi*f; // calculation of angular frequency
18 Toff=%pi/w; // calculation of minimum circuit turn-
    off time
19 A3=(Em/pi)*(sin((n+1)*alpha)/(n+1)-sin((n-1)*alpha)
    /(n-1));
20 B3=(Em/pi)*((cos((n+1)*alpha)-1)/(n+1)-(cos((n-1)*
    alpha)-1)/(n-1));
21 E_3m=sqrt(A3^2+B3^2);
22 E_1m=(Em/pi)*sqrt((sin((n-1)*alpha)/2+(pi-alpha))
    ^2+((cos((n-1)*alpha)-1)/(n-1))^2); // calculation
    of
23 ratio=E_3m/E_1m; // calculation of the ratio of third
    harmonic voltage to fundamental voltage
24 di_dt=%inf // calculation of maximum value of di/dt
25 alpha2=%pi/2; // calculation of the angle at which
    greatest forward or reverse voltage is applied.
26 Em_max=sqrt(2)*E; // calculation of magnitude of
    maximum voltage
27 printf("\nThe peak value of average thyristor
    current is \t\t\t I_T_av_m=%.2f A",I_T_av_m);
28 printf("\nThe peak value rms thyristor current is \t
    \t\t\t I_T_rms_m=%.2f A",I_T_rms_m);
29 printf("\nThe minimum circuit turn-off time is \t\t\t
    \t\t\t Toff_m=%.f ms",Toff*1E3);
30 printf("\nThe ratio of third harmonic voltage to
    fundamental voltage is \t\t %.3f ",ratio);
31 printf("\nThe maximum value of di/dt is \t\t\t\t\t\t\t
    di/dt=%f A/s",di_dt);
32 printf("\nThe angle at which greatest forward or
    reverse voltage is applied is \t alpha=%.2f
    radian",alpha2);
33 printf("\nThe magnitude of maximum voltage is \t\t\t\t
    \t\t\t Em_max=%.2f V",Em_max);

```

Scilab code Exa 11.2 Determine rms value of output voltage input power factor and

```
1 // chapter 11
2 // example 11.2
3 // fig. Ex. 11.2
4 // Determine rms value of output voltage , input
   power factor and average input current
5 // page-719-721
6 clear;
7 clc;
8 // given
9 R=6; // in ohm
10 Es=230; // in V (supply voltage)
11 f=50; // in Hz
12 alpha=%pi/2; // in degree
13 n=3
14 // calculate
15 E0_rms=sqrt((2*Es^2/(4*%pi))*(integrate('1-cos(2*wt)
   ','wt',alpha,%pi)+integrate('1-cos(2*wt)', 'wt',
   %pi,(2*%pi)))); // calculation of rms value of
   output voltage
16 IO_rms=E0_rms/R; // calculation of rms value of
   output current
17 P0=IO_rms^2*R; // calculation of load power
18 Ea=Es*IO_rms; // calculation of input voltage-ampere
   rating
19 pf=P0/Ea; // calculation of input power factor
20 Edc=(1/(2*%pi))*(sqrt(2)*Es*integrate('sin(wt)', 'wt',
   ,alpha,%pi)+sqrt(2)*Es*integrate('sin(wt)', 'wt',
   %pi,(2*%pi)))); // calculation of average output
   voltage
21 Idc=Edc/R; // calculation of average input current
22 printf("\n\nThe rms value of output voltage is \t
   E0_rms=%.2 f V",E0_rms);
```

```

23 printf("\nThe input power factor is \t\t pf=%0.3f ",
    pf);
24 if pf>0 then
25     printf(" (lagging)");
26 else
27     printf(" (leading)");
28 end
29 printf("\nThe average input current is \t\t Idc=%0.2f
    A", Idc);

```

Scilab code Exa 11.3 Determine various parameters

```

1 // chapter 11
2 // example 11.3
3 // Determine control range of firing angle , maximum
    value of rms load current , maximum power and
    power factor , maximum values of average and rms
    thyristor current , maximum possible of di/dt and
    the conduction angle for alpha=0 and alpha=120
4 // page-721-722
5 clear;
6 clc;
7 // given
8 R=4; // in ohm
9 Es=230; // in V (supply voltage)
10 f=50; // in Hz
11 wL=3; // in ohm (inductive reactance)
12 alpha1=0, alpha2=120; // in degree
13 // calculate
14 w=2*pi*f; // calculation of angular frequency
15 Em=Es*sqrt(2); // calculation of peak value of input
    voltage
16 alpha_min=atan(wL/R); // calculation of minimum
    firing angle
17 alpha_max=180; // calculation of maximum firing angle

```

```

18 Z=sqrt(R^2+wL^2); // calculation of impedance
19 IO_rms_m=Es/Z; // calculation of maximum value of rms
    load current
20 P0=IO_rms_m^2*R; // calculation of maximum power
21 pf=P0/(Es*IO_rms_m); // calculation of power factor
22 I_T_av=(Em/(%pi*Z)); // calculation of maximum values
    of average thyristor current
23 I_T_rms=Em/(2*Z); // calculation of maximum values of
    rms thyristor current
24 di_dt=w*Em/Z; // calculation of maximum possible of
    di/dt
25 gama1=180; // calculation of the conduction angle for
    alpha=0
26 gama2=95; // calculation of the conduction angle for
    alpha=120
27 printf("\nThe control range of firing angle is \t %
    .2f degree <= alpha <= %.2f degree",alpha_min
    ,alpha_max);
28 printf("\nThe maximum value of rms load current is \
    t\t IO_rms_m=%.f A",IO_rms_m);
29 printf("\nThe maximum power is \t\t\t\t\t P0=%.f W",
    P0);
30 printf("\nThe power factor is \t\t\t\t\t pf=%.1f",pf
    );
31 printf("\nThe maximum values of average thyristor
    current is \t I_T_av=%.3f A",I_T_av);
32 printf("\nThe maximum values of rms thyristor
    current is \t\t I_T_rms=%.3f A",I_T_rms);
33 printf("\nThe maximum possible of di/dt is \t\t\t di
    /dt=%1E A/s",di_dt);
34 printf("\nThe conduction angle for alpha=0 is \t\t\t
    gama1=%.f degree",gama1);
35 printf("\nThe conduction angle for alpha=120 is \t\t
    \t gama2=%.f degree",gama2);

```

Scilab code Exa 11.4 Plot a curve of load power against firing delay angle and det

```
1 // chapter 11
2 // example 11.4
3 // Plot a curve of load power against firing delay
   angle and determine required thyristor rating
4 // page-722
5 clear;
6 clc;
7 clf;
8 // given
9 R=10; // in ohm
10 E1=100; // in V
11 E2=70.7; // in V
12 f=50; // in Hz (used by the author)
13 // calculate
14 w=2*%pi*f;
15 alpha=[0:0.1:%pi];
16 P0=1000-(500*alpha-250*sin(2*alpha))/%pi;
17 plot2d(alpha,P0,max=[2,3,2,3],rect=[0,0,%pi,1000]);
18 PRV_12=E1*sqrt(2);
19 PRV_34=E2*sqrt(2);
20 printf("\nThe peak reverse voltage for thyristor T1
   and T2 is \t PRV=%0.1f V",PRV_12);
21 printf("\nThe peak reverse voltage for thyristor T3
   and T3 is \t PRV=%0.1f V",PRV_34);
22 I_T_max_12=E1*sqrt(2)/R;
23 I_T_max_34=E2*sqrt(2)/R;
24 I_T_rms_12=I_T_max_12/2;
25 I_T_rms_34=I_T_max_34/2;
26 printf("\nThe maximum current for thyristor T1 and
   T2 is \t I_T_12=%0.1f A",I_T_max_12);
27 printf("\nThe maximum current for thyristor T3 and
   T3 is \t I_T_34=%0.1f A",I_T_max_34);
28 printf("\nThe rms current for thyristor T1 and T2 is
   \t I_T_12=%0.1f A",I_T_rms_12);
29 printf("\nThe rms current for thyristor T3 and T3 is
   \t I_T_34=%0.1f A",I_T_rms_34);
```

Scilab code Exa 11.5 Determine rms current of thyristor T1 and T2 rms current of Th

```
1 // chapter 11
2 // example 11.5
3 // fig. 11.9
4 // Determine rms current of thyristor T1 and T2, rms
   current of Thyristor T3 and T4 and input power
   factor
5 // page-722-723
6 clear;
7 clc;
8 // given
9 e1=130; // in V
10 e2=130; // in V
11 Ep=260; // in V
12 E0=195; // in V
13 R=6; // in ohm
14 alpha=%pi/2; // in radian (firing angle)
15 // calculate
16 I1=sqrt((1/(2*pi*R^2))*2*(e1+e2)^2*integrate('(sin(
   wt))^2','wt',alpha,%pi)); // calculation of rms
   current of thyristor T1 and T2
17 I2=sqrt((1/(2*pi*R^2))*2*(e1^2)*integrate('(sin (wt
   ))^2','wt',0,alpha)); // calculation of rms
   current of Thyristor T3 and T4
18 Iw2=sqrt(2)*I1; // calculation of rms current of
   second winding
19 Iw1=sqrt((sqrt(2)*I1)^2+(sqrt(2)*I2)^2); //
   calculation of rms current of first winding
20 Ea=e1*Iw1+e2*Iw2; // calculation of volt-ampere
   rating
21 P0=E0^2/R; // calculation of maximum power
22 PF=P0/Ea; // calculation of power factor
23 printf("\n\nThe rms current of thyristor T1 and T2 is \
```

```

    t I1=%0.2f A",I1);
24 printf("\nThe rms current of Thyristor T3 and T4 is
    \t I2=%0.2f A",I2);
25 printf("\nThe power factor is \t\t\t pf=%0.3f",PF);
26 if PF>0 then
27     printf(" (lagging)");
28 else
29     printf(" (laeding)");
30 end

```

Scilab code Exa 11.6 Determine rms output phase voltage input power factor

```

1 // chapter 11
2 // example 11.6
3 // Determine rms output phase voltage , input power
  factor
4 // page-741-742
5 clear;
6 clc;
7 // given
8 E_L=210; // in V
9 R=5; // in ohm
10 alpha=%pi/3; // in radian (firing angle)
11 // calculate
12 Es=E_L/sqrt(3);
13 E0=sqrt((2*Es^2/(4*pi))* (integrate('1-cos(2*wt)',
    wt',alpha,%pi)+integrate('1-cos(2*wt)',
    'wt',%pi,(2*pi)))); // calculation of rms output pahse
  voltage
14 Ia=E0/R; // calculation of rms current
15 P0=3*Ia^2*R; // calculation of maximum power
16 I_L=Ia; // calculation of load current
17 EA=3*Es*I_L; // calculation of volt-ampere rating
18 pf=P0/EA; // calculation of power factor
19 printf("\nThe rms output phase voltage is \t E0=%0.3f

```



```

    V",E0);
20 printf("\nThe power factor is \t\t\t pf=%.3f",pf);
21 if pf>0 then
22     printf(" (lagging)");
23 else
24     printf(" (laeding)");
25 end
26 // Note part-c of this question is a derivation type
    which i havenot done

```

Scilab code Exa 11.7 Determine required ratings of triacs and thyristors

```

1 // chapter 11
2 // example 11.7
3 // Determine required ratings of triacs and
    thyristors
4 // page-742
5 clear;
6 clc;
7 // given
8 Es=415; // in V
9 P0=15; // in kW
10 // calculate
11 P0=P0*1E3; // changing unit from kW to W
12 E_line=Es*sqrt(3); // calculation of line voltage
13 I_line_rms=P0/E_line; // calculation of rms line
    current for traics
14 V_offstate=Es*sqrt(2); // calculation of peak
    offstate voltage for traics
15 I_rms=I_line_rms/sqrt(2); // calculation of required
    rms current rating for thyristor
16 printf("\n For Traics");
17 printf("\n\t\tThe rms line current is \t I_line_rms=
    %.1f A",I_line_rms);
18 printf("\n\t\tThe peak offstate voltage is \t

```

```
    V_offstate=%f V",V_offstate);
19 printf("\n\n For thyristors");
20 printf("\n\t\tThe required rms current rating is \t\t\t
    \t I_rms=%f A",I_rms);
21 printf("\n\t\tThe voltage requirement will be same
    as that of triacs %f V",V_offstate);
```

Chapter 12

Resonant Convertors

Scilab code Exa 12.1 Determine circuit turn off time maximum possible output frequ

```
1 // chapter 12
2 // example 12.1
3 // Determine circuit turn-off time, maximum possible
   output frequency, capacitor voltage, rms load
   current, output power and average and rms SCR
   currents
4 // page-755-756
5 clear;
6 clc;
7 // given
8 Edc=200; // in V (dc input)
9 Lr=40; // in uH (resonant inductor)
10 Cr=6.8; // in uF (resonant capacitor)
11 F=6; // in Khz (frequency of output voltage)
12 t_q=15; // in us (SCR turn-off time)
13 R=3; // in ohm
14 // calculate
15 Lr=Lr*1E-6; // changing unit from uH to H
16 Cr=Cr*1E-6; // changing unit from uF to F
17 t_q=t_q*1E-6; // changing unit from us to s
18 F=F*1E3; // changing unit from KHz to Hz
```

```

19 wr=sqrt((1/(Lr*Cr))-R^2/(4*Lr^2));
20 // since wr=2*pi*fr, therefore we get,
21 fr=wr/(2*pi);
22 w0=2*pi*F;
23 Toff=(pi/w0)-(pi/wr); // calculation of circuit
    turn-off time
24 Fmax=1/(2*(t_q+(pi/wr))); // calculation of maximum
    possible output frequency
25 Ec=Edc*((exp(R*pi/(2*Lr*wr))+1)/(exp(R*pi/(2*Lr*wr)
    ))-1)); // calculation of capacitor voltage
26 I_L_rms=((Edc+Ec)/(wr*Lr))*sqrt(F*(1-exp(-R*pi/(2*
    wr*Lr)))*((Lr/R)-(R/Lr)*(1/((2*wr)^2+(R/Lr)^2))))
    ; // calculation of rms load current
27 P0=I_L_rms^2*R; // calculation of output power
28 I_rms_SCR=I_L_rms/sqrt(2); // calculation of rms SCR
    current
29 I_L_avg=(2*F*(Edc+Ec)/((wr^2+(R/(2*Lr)^2))*Lr))*1+
    exp(-R*pi/(4*wr*Lr)); // calculation of average
    load current
30 I_avg_SCR=I_L_avg/2; // calculation of average SCR
    current
31 printf("\nThe circuit turn-off time is \t\t\t Toff=%
    .1f us",Toff*1E6);
32 printf("\nThe maximum possible output frequency is \
    t Fmax=%0.3f KHZ",Fmax*1E-3);
33 printf("\nThe capacitor voltage is \t\t\t Ec=%0.2f V"
    ,Ec);
34 printf("\nThe rms load current is \t\t\t I_L_rms=%0.2
    f A",I_L_rms);
35 printf("\nThe output power is \t\t\t\t P0=%0.2f W",P0
    );
36 printf("\nThe rms SCR current is \t\t\t\t I_rms_SCR=
    %0.2f A",I_rms_SCR);
37 printf("\nThe average SCR current is \t\t\t
    I_avg_SCR=%0.3f A",I_avg_SCR);
38 // Note : The answers vary slightly due to precise
    calculation

```

Scilab code Exa 12.2 Determine resonant frequency maximum operating frequency Peak

```
1 // chapter 12
2 // example 12.2
3 // fig. 12.8
4 // Determine resonant frequency , maximum operating
   frequency , Peak thyristor current , average
   thyristor current , rms thyristor current , rms
   load current and average supply current
5 // page-760-762
6 clear;
7 clc;
8 // given
9 C1=4; // in uF
10 C2=4; // in uF
11 Lr=40; // in uH
12 R=2; // in ohm
13 Edc=120; // in V (input voltage)
14 t_q=20; // in us (SCR turn-off time)
15 // calculate
16 Lr=Lr*1E-6; // changing unit from uH to H
17 t_q=t_q*1E-6; // changing unit from us to s
18 Ceq=C1+C2;
19 Ceq=Ceq*1E-6; // changing unit from uF to F
20 wr=sqrt((1/(Lr*Ceq))-R^2/(4*Lr^2)); // calculation
   of resonant angular frequency
21 fr=wr/(2*%pi); // calculation of resonant frequency
22 tr=1/fr; // calculation of resonant time-period
23 fr_max=1/(2*t_q); // calculation of maximum
   frequency
24 f0=0.4*fr; // calculation of output frequency
25 T0=1/f0; // calculation of output period
26 td=T0/2-tr; // calculation of delay time
27 tp=(1/wr)*atan(2*wr*Lr/R); // calculation of time at
```

```

    which peak current is obtained
28 Ec1=Edc/(exp(R*2*pi/(2*Lr*wr))+1); // calculation
    of initial capacitor voltage
29 Ip=(Edc+Ec1)/(wr*Lr)*sin(wr*tp)*exp(-R*tp/(2*Lr));
    // calculation of peak current
30 I_av_SCR=(Edc+Ec1)/(wr*Lr)*(1/T0)*integrate('sin(wr*
    t)*exp(-R*t/(2*Lr))','t',0,tr/2); // calculation
    of average thyristor current
31 I_rms_SCR=(Edc+Ec1)/(wr*Lr)*sqrt((1/T0)*(integrate('
    (sin(wr*t))^2*exp(-R*t/Lr)','t',0,tr/2))); //
    calculation of rms thyristor current
32 IO=2*I_rms_SCR; // calculation of rms load current
33 PO=IO^2*R; // calculation of output power
34 Is=PO/Edc; // calculation of average supply current
35 printf("\nThe resonant frequency is \t\t\t fr=%0.3f
    KHz",fr*1E-3);
36 printf("\nThe maximum possible operating frequency
    is \t fr_max=%0.f KHz",fr_max*1E-3);
37 printf("\nThe Peak thyristor current is \t\t\t Ip=%0
    .2f A",Ip);
38 printf("\nThe average thyristor current is \t\t
    I_av_SCR=%0.3f A",I_av_SCR);
39 printf("\nThe rms thyristor current is \t\t\t
    I_rms_SCR=%0.2f A",I_rms_SCR);
40 printf("\nThe rms load current is \t\t\t IO=%0.1f A",
    IO);
41 printf("\nThe average supply current is \t\t\t Is=%0
    .2f A",Is);
42 // Note : The answers vary slightly due to precise
    calculation

```

Scilab code Exa 12.3 Determine resonant frequency maximum operating frequency Peak

```

1 // chapter 12
2 // example 12.3

```

```

3 // Determine resonant frequency , maximum operating
   frequency , Peak thyristor current , average
   thyristor current , rms thyristor current , rms
   load current and average supply current
4 // page-765-767
5 clear;
6 clc;
7 // given
8 Cr=8; // in uF
9 Lr=40; // in uH
10 R=2; // in ohm
11 Edc=120; // in V (input voltage)
12 t_q=20; // in us (SCR turn-off time)
13 // calculate
14 Lr=Lr*1E-6; // changing unit from uH to H
15 t_q=t_q*1E-6; // changing unit from us to s
16 Cr=Cr*1E-6; // changing unit from uF to F
17 wr=sqrt((1/(Lr*Cr))-R^2/(4*Lr^2)); // calculation of
   resonant angular frequency
18 fr=wr/(2*pi); // calculation of resonant frequency
19 f0=0.4*fr; // calculation of output frequency
20 tr=1/fr; // calculation of resonant time-period
21 T0=1/f0; // calculation of output period
22 td=T0/2-tr; // calculation of delay time
23 fr_max=1/(2*t_q); // calculation of maximum
   frequency
24 f0_max=fr_max/2; // calculation of maximum foutput
   frequency
25 tp=(1/wr)*atan(2*wr*Lr/R); // calculation of time at
   which peak current is obtained
26 Ec1=Edc*((1-exp(-R*pi/(Lr*wr)))/(1+exp(-R*pi/(Lr*
   wr))))); // calculation of initial capacitor
   voltage
27 Ip=(Edc+Ec1)/(wr*Lr)*sin(wr*tp)*exp(-R*tp/(2*Lr));
   // calculation of peak current
28 I_avg_SCR=(Edc+Ec1)/(wr*Lr)*(1/T0)*integrate('sin(wr
   *t)*exp(-R*t/(2*Lr))', 't', 0, tr/2); // calculation
   of average thyristor current

```

```

29 I_rms_SCR=(Edc+Ec1)/(wr*Lr)*sqrt((1/T0)*(integrate('
    (sin(wr*t))^2*exp(-R*t/Lr)', 't', 0, tr/2))); //
    calculation of rms thyristor current
30 IO=2*I_rms_SCR; // calculation of rms load current
31 PO=IO^2*R; // calculation of output power
32 Is=PO/Edc; // calculation of average supply current
33 printf("\nThe resonant frequency is \t\t\t fr=%0.2f
    KHz", fr*1E-3);
34 printf("\nThe maximum possible operating frequency
    is \t fr_max=%0.f KHz", fr_max*1E-3);
35 printf("\nThe maximum possible output frequency is \
    t f0_max=%0.1f KHz", f0_max*1E-3);
36 printf("\nThe Peak thyristor current is \t\t\t Ip=%
    .3f A", Ip);
37 printf("\nThe average thyristor current is \t\t
    Lavg_SCR=%0.3f A", I_avg_SCR);
38 printf("\nThe rms thyristor current is \t\t\t
    I_rms_SCR=%0.2f A", I_rms_SCR);
39 printf("\nThe rms load current is \t\t\t I0=%0.1f A",
    IO);
40 printf("\nThe average supply current is \t\t\t Is=%
    .2f A", Is);
41 // Note : 1. The answer for Lavg_SCR, I_rms_SCR, IO
    , PO and Is are wrong in the book due to the use
    of wrong value of Ec1 in the calculation
42 //          2.The answers vary slightly due to precise
    calculation

```

Scilab code Exa 12.4 Design E class resonant inverter

```

1 // chapter 12
2 // example 12.4
3 // Design E-class resonant inverter
4 // page-769-770
5 clear;

```



```

6  clc;
7  // given
8  R=12; // in ohm
9  Edc=24; // in V (DC voltage)
10 fs=20; // in KHz (switching frequency)
11 Q=7; // assumption for quality factor as done in the
      book
12 // calculate
13 fs=fs*1E3; // changing unit from KHz to Hz
14 ws=2*pi*fs; // calculation of switching angular
      frequency
15 Ldc=0.4*R/ws; // calculation of source inductance
16 C1=2.165/(R*ws); // calculation of resonance element
17 // since  $Q=ws*L_r/R$ , therefore we get,
18 Lr=Q*R/ws; // calculation of inductance from series
      resonance
19 // since  $ws*L_r-1/(ws*C_r)=0.353*R$ , therefore we get,
20 Cr=(1/(ws*Lr-0.353*R))/ws; // calculation of
      capacitance from series resonance
21 e=(R/2)*sqrt(Cr/Lr); // calculation of damping
      factor
22 f0=1/(2*pi*sqrt(Lr*Cr)); // calculation of
      resonance frequency
23 printf("\\n\\nThe source inductance is \\t\\t\\t Ldc=%0.1f
      uH",Ldc*1E6);
24 printf("\\n\\nThe resonance element is \\t\\t\\t C1=%0.1f uF
      ",C1*1E6);
25 printf("\\n\\nThe inductance from series resonance is \\t
      Lr=%0.1f uH",Lr*1E6);
26 printf("\\n\\nThe capacitance from series resonance is \\
      t Cr=%0.2f uF",Cr*1E6);
27 printf("\\n\\nThe resonance frequency is \\t\\t\\t f0=%0.2f
      KHz",f0*1E-3);
28 // Note :The answers vary slightly due to precise
      calculation

```

Scilab code Exa 12.5 Determine values of resonant components Lr and Cr peak switch

```
1 // chapter 12
2 // example 12.5
3 // Determine values of resonant components Lr and
   Cr, peak switching current, peak voltage rating
   of the resonant capacitor
4 // page-778-780
5 clear;
6 clc;
7 // given
8 Edc=18; // in V (unregulated DC voltage)
9 E0=12; // in V (output voltage)
10 fr=1; // in MHz
11 P0=12; // in W
12 // calculate
13 fr=fr*1E6; // changing unit from MHz to Hz
14 // since P0=E0*I0, therefore we get,
15 I0=P0/E0; // calculation of load current
16 Zr=Edc/I0; // calculation of load impedance
17 // since Zr=sqrt(Lr/Cr) and fr=1/(2*pi*sqrt(Lr*Cr))
   , multiplying two equations, we get
18 // Zr*fr=1/(2*pi*Cr), therefore
19 Cr=1/(2*pi*Zr*fr); // calculation of resonant
   capacitance
20 Lr=Zr^2*Cr; // calculation of resonant inductance
21 is_p=I0+Edc*sqrt(Cr/Lr); // calculation of peak
   switch current
22 Vc_peak=2*Edc; // calculation of peak voltage rating
   of capacitor
23 printf("\nThe resonant capacitance is \t\t\t Cr=%0.5f
   uF",Cr*1E6);
24 printf("\nThe resonant inductance is \t\t\t Lr=%0.2f
   uH",Lr*1E6);
```

```

25 printf("\nThe peak switch current is \t\t\t is_p=%0.2
    f A",is_p);
26 printf("\nThe peak voltage rating of capacitor is \t
    Vc_peak=%0.f V",Vc_peak);
27 // Note :The answer in the book are wrong due to
    calculation mistake while calculating Cr and
    hence all other answer are also wrong

```

Scilab code Exa 12.6 Determine values of resonant components Lr and Cr peak voltage

```

1 // chapter 12
2 // example 12.6
3 // Determine values of resonant components Lr and Cr
    , peak voltage rating of the resonant capacitor
    and charging and discharging period of capacitor
4 // page-785-786
5 clear;
6 clc;
7 // given
8 Edc=35; // in V
9 E0=24; // in V (output voltage)
10 fr=500; // in KHz
11 P0=24; // in W
12 // calculate
13 fr=fr*1E3; // changing unit from KHz to Hz
14 // since P0=E0*I0, therefore we get,
15 I0=P0/E0; // calculation of load current
16 Zr=Edc/I0; // calculation of load impedance
17 // since Zr=sqrt(Lr/Cr) and fr=1/(2*pi*sqrt(Lr*Cr))
    , multiplying two equations, we get
18 // Zr*fr=1/(2*pi*Cr), therefore
19 Cr=1/(2*pi*Zr*fr); // calculation of resonant
    capacitance
20 Lr=Zr^2*Cr; // calculation of resonant inductance
21 Vs_p=Edc+I0*Zr; // calculation of peak voltage

```

```

        rating of capacitor
22 t1=Edc*Cr/I0; // calculation of charging period of
    capacitor
23 t3=sqrt(Lr*Cr)*asin(Edc*sqrt(Cr/Lr)/I0); //
    calculation of discharging period of capacitor
24 printf("\nThe resonant capacitance is \t\t\t Cr=%0.4f
    uF",Cr*1E6);
25 printf("\nThe resonant inductance is \t\t\t Lr=%0.2f
    uH",Lr*1E6);
26 printf("\nThe peak voltage rating of capacitor is \t
    Vs_p=%0.f V",Vs_p);
27 printf("\nThe charging period of capacitor is \t\t
    t1=%0.3f us",t1*1E6);
28 printf("\nThe discharging period of capacitor is \t\
    t t3=%0.3f us",t3*1E6);
29 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 12.7 Design a ZVS three level PWM convertor

```

1 // chapter 12
2 // example 12.7
3 // Design a ZVS three-level PWM convertor
4 // page-791-792
5 clear;
6 clc;
7 // given
8 Edc=300; // in V
9 E0=60; // in V (output voltage)
10 I0=10; // in A
11 fs=120; // in KHz
12 Deff=0.5; // effective duty ratio
13 del_D=25; // assumption for reduction in duty ratio
    in percentage of duty ratio as done in the book
14 TLI=3.46; // in uH (assuming transformer leakage

```

```

    inductance as done in the book)
15 C=500; // in pF (assuming intrinsic capacitance of
    MOSFET as done in the book)
16 // calculate
17 fs=fs*1E3; // changing unit from KHz to Hz
18 TLI=TLI*1E-6; // changing unit from uH to H
19 C=C*1E-12; // changing unit from pF to F
20 // since  $D_{eff}=2*n*E_0/E_{dc}$ , therefore we get,
21 n=Deff*Edc/(2*E0); // calculation of transformer
    turns ratio
22 // since  $D_{eff}=D-d_{l\_D}*D$ , therefore we get,
23 D=Deff/(1-d_{l\_D}/100); // calculation of duty ratio
24 Lr=((d_{l\_D}*D/100)*Edc/2)/(4*(I0/n)*fs); //
    calculation of resonant inductance
25 Lr_eff=Lr+TLI; // calculation of effective inductance
26 I0_min=(n*Edc/2)*sqrt(1.5*C/Lr_eff); // calculation
    of minimum load current
27 I_Lr=I0/n; // calculation of inductor current
28 X_Lr=2*pi*fs*Lr_eff; // calculation of inductive
    reactance
29 V_Lr=I_Lr*X_Lr; // calculation of voltage drop
    across Lr
30 // since  $E_0=D_{eff}*E_s$ , therefore we get
31 Es=E0/Deff; // calculation of secondary voltage
32 Ep=n*Es; // calculation of primary voltage
33 VA=Ep*I_Lr; // calculation of transformer volt-
    ampere
34 printf("\nThe duty ratio is \t\t D=%0.2 f",D);
35 printf("\nThe resonant inductance is \t Lr=%0.2 f uH",
    Lr*1E6);
36 printf("\nThe effective inductance is \t Lr_eff=%0. f
    uH",Lr_eff*1E6);
37 printf("\nThe minimum load current is \t I0_min=%0.2 f
    A", I0_min);
38 printf("\nThe inductor current is \t I_Lr=%0. f A",
    I_Lr);
39 printf("\nThe voltage drop across Lr is \t V_Lr=%0.2 f
    V",V_Lr);

```

```
40 printf("\nThe secondary voltage is \t Es=%f V",Es);
41 printf("\nThe primary voltage is \t\t Ep=%f V",Ep);
42 printf("\nThe transformer volt-ampere is \t VA=%f
    VA",VA);
43 // Note :The answer vary slightly due to precise
    calculation
```

Chapter 13

Protection and Cooling of Power Switching Devices

Scilab code Exa 13.1 Compute the values of di/dt inductor and the snubber circuit

```
1 // chapter 13
2 // example 13.1
3 // fig. 13.11
4 // Compute the values of  $di/dt$  inductor and the
   snubber circuit component  $R_s$  and  $C_s$ 
5 // page-807-808
6 clear;
7 clc;
8 // given
9 E=400; // in V
10 di_dt=50; // in A/us
11 dv_dt=200; // in V/us
12 // calculate
13 // since  $di/dt=E/L$ , therefore we get
14 L=E/di_dt; // calculation of
15 // since  $dV/dt=R_s*di/dt$ , therefore we get
16  $R_s=dv\_dt/di\_dt$ ; // calculation of
17  $R_s=10$ ; // assuming the desired values
18  $C_s=0.1$ ; // in  $\mu F$  assuming the desired value
```

```

19 L=E*Rs/(dv_dt);
20 printf("\nThe value of di/dt inductor is \t\t L=%f
    uH",L);
21 printf("\nThe snubber circuit component are \t Rs=%f.
    f ohm \t Cs=%f uF",Rs,Cs);

```

Scilab code Exa 13.2 Compute the required parameters snubber circuit

```

1 // chapter 13
2 // example 13.2
3 // Compute the required parameters snubber circuit
4 // page-809
5 clear;
6 clc;
7 // given
8 Em=380; // in V
9 dv_dt=50; // in V/us
10 L=0.1; // in mH
11 sigma=0.65; // assumption for damping factor as done
    in the book
12 // calculate
13 dv_dt=dv_dt/1E-6; // changing unit from V/us to V/s
14 L=L*1E-3; // changing unit from mH to H
15 C=(1/(2*L))*(0.564*Em/dv_dt)^2;
16 R=2*sigma*sqrt(L/C);
17 printf("\nThe capacitance is \t C=%f uF",C*1E6);
18 printf("\nThe resistance is \t R=%f ohm",R);
19 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 13.3 Design a snubber circuit

```

1 // chapter 13

```



```

2 // example 13.3
3 // Design a snubber circuit
4 // page-809
5 clc;
6 clear;
7 // given
8 VA=5; // in kVA
9 Es=120; // in V (secondary voltage)
10 f=400; // in Hz (switching frequency)
11 L=100; // in uH
12 Ep=200; // in V (peak transient voltage)
13 sigma=0.75; // assumption for damping factor as done
    in the book
14 // calculate
15 VA=VA*1E3; // changing unit from kVA to VA
16 L=L*1E-6; // changing unit from uH to H
17 C=10*VA*60/(Es^2*f); // calculation of capacitance
    in uF
18 Esp=Es*sqrt(2); // calculation of peak switching
    voltage ratio
19 Ep_Esp=Ep/Esp; // calculation of peak transient
    voltage Vs peak switching voltage ratio
20 R=2*sigma*sqrt(L/(C*1E-6)); // calculation
    resistance
21 printf("\nThe capacitance is \t C=%0.2f uF",C);
22 printf("\nThe peak transient voltage Vs peak
    switching voltage ratio is \t %0.2f",Ep_Esp);
23 printf("\nThe resistance is \t R=%0.1f ohm",R);
24 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 13.4 Compute initial capacitor voltage magnetizing current and cap

```

1 // chapter 13
2 // example 13.4

```



```

1 // chapter 13
2 // example 13.5
3 // fig. 13.14
4 // Determine the snubber component values for
   critical damping, value of R and power loss
5 // page-810-811
6 clear;
7 clc;
8 // given
9 Edc=30; // in V
10 fs=40; // in kHz
11 i_L=30; // in A (load current)
12 t_r=80; // in ns (rise time)
13 t_f=30; // in ns (fall time)
14 neta=10; // in % (ratio of maximum discharge current
   to load current)
15 // calculate
16 fs=fs*1E3; // changing unit from kHz to Hz
17 t_r=t_r*1E-9; // changing unit from ns to s
18 t_f=t_f*1E-9; // changing unit from ns to s
19 L=Edc*t_r/i_L; // calculation of inductance
20 C=i_L*t_f/Edc; // calculation of capacitance
21 R=sqrt(4*L/C); // calculation of resistance for
   critical damping
22 R1=Edc/((neta/100)*i_L); // calculation of
   resistance if maximum discharge current is
   limited to 10 % of load current
23 Ploss=(1/2)*C*Edc^2*fs; // calculation of power loss
24 printf("\nThe inductance is \t L=%f nH",L*1E9);
25 printf("\nThe capacitance is \t C=%f nF",C*1E9);
26 printf("\nThe resistance is \t R=%f ohm",R);
27 printf("\nThe resistance if maximum discharge
   current is limited to 10 %% of load current is \t
   R=%f ohm",R1);
28 printf("\nThe power loss due to RC snubber circuit
   is \t Ploss=%f W",Ploss);
29 // Note :The answer vary slightly due to precise
   calculation

```

Scilab code Exa 13.6 Design a suitable selenium voltage protection circuit and com

```
1 // chapter 13
2 // example 13.6
3 // Design a suitable selenium voltage protection
  circuit and compute energy dissipated per plate
4 // page-814
5 clear;
6 clc;
7 // given
8 Edc=440; // in V
9 Imax=120; // in A
10 R=0.175; // in ohm
11 T=25; // in ms (time constant)
12 V=40; // in V
13 // calculate
14 T=T*1E-3; // changing unit from ms to s
15 n=Edc/V; // calculation of number of plates in each
  branch
16 N=3*n; // calculation of total number of plates
17 L=T*R; // calculation of armature circuit inductance
18 E_stored=(1/2)*L*Imax^2; // calculation of energy
  stored in armature
19 E_dissipated=E_stored/11; // calculation of energy
  dissipated per plate
20 printf("\nThe number of plates in each branch is \t
  n=%f",n);
21 printf("\nThe total number of plates is \t N=%f",N)
  ;
22 printf("\nThe armature circuit inductance is \t L=%
  .2f mH",L*1E3);
23 printf("\nThe energy stored in armature is \t
  E_stored=%f W",E_stored);
24 printf("\nThe energy dissipated per plate is \t
```

```

    E_dissipated=%0.2f W",E_dissipated);
25 // Note : The value of time constant given in the
    book is 25 ms but in calculation the author has
    used 30 ms. Thats why answers in the book are
    wrong

```

Scilab code Exa 13.7 Design a suitable circuit

```

1 // chapter 13
2 // example 13.7
3 // Design a suitable circuit
4 // page-814
5 clear;
6 clc;
7 // given
8 Edc=200; // in V
9 V=30; // in V
10 // calculate
11 n=Edc/V; // calculation of number of plates in each
    branch
12 printf("\nThe number of plates is \t n=%0.f is series
    ",n);
13 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 13.8 Calculate the peak value of the fault current

```

1 // chapter 13
2 // example 13.8
3 // Calculate the peak value of the fault current
4 // page-825-826
5 clear;
6 clc;

```

```

7 // given
8 I_2_t=150; // in A^2 sec
9 f=50; // in Hz
10 tc=6; // in ms
11 // calculate
12 tc=tc*1E-3; // changing unit from ms to s
13 // since  $tc=3*I^2*t/I_p^2$ , therefore we get,
14 Ip=sqrt(3*I_2_t/tc); // calculation of peak value of
    the fault current
15 printf("\nThe peak value of the fault current is \t
    Ip=%0.2f A",Ip);
16 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 13.9 Compute the required fusing time

```

1 // chapter 13
2 // example 13.9
3 // Compute the required fusing time
4 // page-826-827
5 clear;
6 clc;
7 // given
8 I=250; // in A (non-repetitive surge current)
9 f=50; // in Hz
10 Ip=400; // in A (peak short circuit current)
11 // calculate
12 t=1/f; // calculation of time period
13 I_subcycle=sqrt(I^2*(1/100)/t); // calculation of
    subcycle surge current rating
14 tc=3*I_subcycle^2/Ip^2; // calculation of required
    fusing time
15 printf("\nThe required fusing time is \t tc=%0.2f ms"
    ,tc*1E3);
16 // Note :The formula used in the book is wrong. The

```



```

1 // chapter 13
2 // example 13.11
3 // Compute the values of RF filter components
4 // page-833
5 clear;
6 clc;
7 // given
8 R_L=120; // in ohm
9 f0=50; // in KHz
10 // calculate
11 f0=f0*1E3; // changing unit from KHz to Hz
12 L=R_L/(2*pi*f0); // calculation of inductance
13 C=1/(2*pi*R_L*f0); // calculation of capacitance
14 printf("\nThe inductance is \t L=%.2f uH",L*1E6);
15 printf("\nThe capacitance is \t C=%.3f uF",C*1E6);
16 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 13.12 Determine the value of thermal resistance heat sink and temp

```

1 // chapter 13
2 // example 13.12
3 // Determine the value of thermal resistance , heat
    sink and temperature at base
4 // page-840
5 clear;
6 clc;
7 // given
8 Pa=30; // in W (power loss)
9 Tc=125; // in degree C (junction temperature)
10 Ta=40; // in degree C (ambient temperature)
11 theta_CJ=0.7; // in degree C/W (junction to heat-
    sink thermal resistance)
12 // calculate
13 theta_CA=(Tc-Ta)/Pa; // calculation of total thermal

```



```

        resistance
14 theta_CS=theta_CA-theta_CJ; // calculation of
    thermal resistance of heat sink
15 T_base=Ta+(Pa*theta_CS); // calculation of
    temperature at base
16 printf("\nThe total thermal resistance is \t\t
    theta_CA=%0.2f degree C/W",theta_CA);
17 printf("\nThe thermal resistance of heat sink is \t
    theta_CS=%0.2f degree C/W",theta_CS);
18 printf("\nThe temperature at base is \t\t\t T_base=%0
    .f degree C",T_base);
19 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 13.13 Determine junction temperature

```

1 // chapter 13
2 // example 13.13
3 // Determine junction temperature
4 // page-840
5 clear;
6 clc;
7 // given
8 E=440; // in V
9 IO=960; // in A
10 Ta=80; // in ambient temperature
11 Pa=150; // in W (on state power loss)
12 Q_JC=0.15; // in degree C/W
13 Q_CS=0.075; // in degree C/W
14 Q_SA=0.45; // in degree C/W
15 // calculate
16 T_J=Ta+Pa*(Q_JC+Q_CS+Q_SA); // calculation of
    junction temperature
17 printf("\nThe junction temperature is \t T_J=%0.2f
    degree C",T_J);

```

```
18 // Note :The answer vary slightly due to precise
    calculation
```

Scilab code Exa 13.14 Determine total average power loss and percentage increase i

```
1 // chapter 13
2 // example 13.14
3 // Determine total average power loss and percentage
    increase in deivce rating
4 // page-840-841
5 clear;
6 clc;
7 // given
8 T_J=150; // in degree C (maximum junction
    temperature)
9 Q_JC=0.015; // in degree C/W
10 Q_CS=0.08; // in degree C/W
11 Ta_1=60; // in degree (heat sink temperature1)
12 Ta_2=50 // in degree (heat sink temperature2)
13 // calculate
14 Pav1=(T_J-Ta_1)/(Q_JC+Q_CS);
15 Pav2=(T_J-Ta_2)/(Q_JC+Q_CS);
16 percent_increase=((sqrt(Pav2)-sqrt(Pav1))/sqrt(Pav1)
    )*100;
17 printf("\nThe total average power loss is \t\t\t
    Pav1=%0.2f W",Pav1);
18 printf("\nThe required percentage increase in deivce
    rating is \t %0.2f %%",percent_increase);
19
20 // Note :The answer vary slightly due to precise
    calculation
```

Scilab code Exa 13.15 Plot instantaneous junction temperature

```

1 // chapter 13
2 // example 13.15
3 // fig. 13.40
4 // Plot instantaneous junction temperature
5 // page-841-842
6 clear;
7 clc;
8 clf;
9 // given
10 P2=0, P4=0, P6=0; // in W
11 P1=1000, P3=1400, P5=700; // in W
12 t1=1, t3=1, t5=1; // in ms
13 theta1=0.035, theta3=0.035, theta5=0.035; // in
    degree C/W
14 t2=0.5, t4=0.5, t6=0.5; // in ms
15 theta2=0.025, theta4=0.025, theta6=0.025; // in
    degree C/W
16 // calculate
17 del_TJ1=theta1*P1;
18 del_TJ1_5=del_TJ1-theta2*P1;
19 del_TJ2_5=del_TJ1_5+theta3*P3;
20 del_TJ3=del_TJ2_5-theta4*P3;
21 del_TJ4=del_TJ3+theta5*P5;
22 del_TJ4_5=del_TJ4-theta6*P5;
23 printf("\n\ndel_TJ1=%f degree C",del_TJ1);
24 printf("\n\ndel_TJ1_5=%f degree C",del_TJ1_5);
25 printf("\n\ndel_TJ2_5=%f degree C",del_TJ2_5);
26 printf("\n\ndel_TJ3=%f degree C",del_TJ3);
27 printf("\n\ndel_TJ4=%f degree C",del_TJ4);
28 printf("\n\ndel_TJ4_5=%f degree C",del_TJ4_5);
29 del_TJ=[del_TJ1 del_TJ1_5 del_TJ2_5 del_TJ3 del_TJ4
    del_TJ4_5];
30 plot2d(del_TJ,nax=[1,6,1,7],rect=[0,0,5,60]);
31 xlabel("t (ms)");
32 ylabel("del_TJ (degree C)");
33 title("Junction temperature rise plot");
34 // Note :There is calculation mistake in the book
    while calculating del_TJ_3 and hence all other

```

values are also affected. That's why answers in the book are wrong

Scilab code Exa 13.16 Determine the heat sink required

```
1 // chapter 13
2 // example 13.16
3 // Determine the heat-sink required
4 // page-841-842
5 clear;
6 clc;
7 // given
8 Vcc=100; // in V
9 V_CE_on=1; // in V
10 I_on=20; // in A
11 t_on=1; // in us
12 t_off=2; // in us
13 fs=10; // in kHz
14 del=0.9; // duty cycle
15 T_A=35; // in degree C
16 T_J_max=125; // in degree C
17 theta_JC=0.7; // in degree C/W
18 theta_CS=0.1; // in degree C/W
19 // calculate
20 t_on=t_on*1E-6; // changing unit from us to s
21 t_off=t_off*1E-6; // changing unit from us to s
22 fs=fs*1E3; // changing unit from kHz to Hz
23 P_cond=V_CE_on*I_on*del; // calculation of average
    power
24 P_loss=Vcc*I_on*(t_on+t_off)*fs/2; // calculation of
    switching power loss
25 P_diss=P_cond+P_loss; // calculation of total power
    loss
26 // since  $P_{diss}=(T_{J\_max}-T_A)/(\theta_{JC}+\theta_{CS}+\theta_{SA})$ , therefore we get
```

```

27 theta_SA=((T_J_max-T_A)/P_diss)-theta_JC-theta_CS;
    // calculation of heat-sink required
28 printf("\nThe required heat sink is \t theta_SA=%0.1f
    degree C/W",theta_SA);
29
30 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 13.17 Determine the thermal resistance of the heat sink

```

1 // chapter 13
2 // example 13.17
3 // Determine the thermal resistance of the heat sink
4 // page-842-843
5 clear;
6 clc;
7 // given
8 I_D=20; // in A
9 t_on=10; // in us
10 del=0.1; // in % (duty cycle)
11 T_A=40; // in degree C
12 T_J_max=150; // in degree C
13 theta_JC=1.5; // in degree C/W
14 R_ds_on=5; // in ohm
15 T_pr=0.03; // assumption as done in the book
16 // calculate
17 t_on=t_on*1E-6; // changing unit from us to s
18 P_cond=I_D^2*R_ds_on;
19 P_peak=P_cond;
20 // since P_peak=(T_J_max-T_C)/(T_pr*theta_JC),
    therefore we get
21 T_C=T_J_max-P_peak*T_pr*theta_JC;
22 P_diss=(del/100)*P_peak;
23 // since P_diss=(T_C-T_A)/theta_CA, therefore we get
24 theta_CA=(T_C-T_A)/P_diss;

```

```

25 printf("\nThe thermal resistance of the heat sink is
    \t theta_CA=%f degree C/W",theta_CA);
26
27 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 13.18 Determine the maximum power dissipation

```

1 // chapter 13
2 // example 13.18
3 // Determine the maximum power dissipation
4 // page-843
5 clear;
6 clc;
7 // given
8 Cs=0.2; // in J/degree C (thermal capacity)
9 theta=0.7; // in degree C/W (thermal resistance)
10 T_J=40; // in degree C (junction temperature)
11 t=0.1; // in s
12 // calculate
13 power_diss_per_degreeC=1/theta; // calculation of
    power dissipation per degree Celsius rise
14 tou=Cs/power_diss_per_degreeC; // calculation of
    thermal time constant
15 // since  $T_J = T_{J\_max} * (1 - \exp(-t/tou))$ , therefore we
    get
16 T_J_max=T_J/(1-exp(-t/tou)); // calculation of
    maximum junction temperature
17 P_max_diss=T_J_max*power_diss_per_degreeC; //
    calculation of maximum power dissipation
18 printf("\nThe maximum power dissipation is \t
    P_max_diss=%f W",P_max_diss);
19 // Note :The answer vary slightly due to precise
    calculation

```

Chapter 14

Control of D C Drives

Scilab code Exa 14.1 Determine motor terminal voltage and the value of flux as a p

```
1 // chapter 14
2 // example 14.1
3 // Determine motor terminal voltage and the value of
   flux as a percentage of rated flux
4 // page-862-863
5 clear;
6 clc;
7 // given
8 E=220; // in V
9 N1=960; // in rpm
10 Ia=80; // in A (armature current)
11 Ra=0.06; // in ohm (armature resistance)
12 N2=620; // in rpm
13 N3=1200; // in rpm
14 // calculate
15 Eb1=E-Ia*Ra; // calculation of back emf at 960 rpm
16 w1=N1*2*%pi/60; // calculation of rated speed
17 // since  $K1*\phi1*w1=Eb1$ , therefore we get
18 K1_phi1=Eb1/w1;
19 // since  $Eb1/Eb2=N1/N2$ , therefore we get
20 Eb2=(N2/N1)*Eb1; // calculation of back emf at 620
```

```

21 Em=Eb2+Ia*Ra; // calculation of motor terminal
    voltage
22 w3=N3*2*%pi/60;
23 // since Eb3=Ka*phi2*w3 and phi2=k*phi1, therefore
    we get
24 // Eb3=K*phi1*w3 (i)
25 // since T1=T2 or Ka*phi1*Ia1=Ka*phi2*Ia2 or Ia2=(
    phi1/phi2)*Ia1 or
26 // Ia2=Ia1/K (ii)
27 // since E=Eb3+Ia2*Ra, therefore Ia2=(E-Eb3)/Ra
    (iii)
28 // from (i) (ii) and (iii), we get E=K*K1_phi1*w3+(
    Ia1/K)*Ra
29 // and hence solving for K we get a quadratic
    equation (K1_phi1*w3)K^2-(E)K+Ia*Ra=0
30 // solving the quadratic equation
31 K1=(-(-E)+sqrt((-E)^2-4*K1_phi1*w3*Ia*Ra))/(2*
    K1_phi1*w3); // calculation of value of flux1
32 K2=(-(-E)-sqrt((-E)^2-4*K1_phi1*w3*Ia*Ra))/(2*
    K1_phi1*w3); // calculation of value of flux2
33 printf("\nThe motor terminal voltage is \t Em=%0.2f V
    ",Em);
34 printf("\nThe value of flux is \t K1=%0.1f ",K1);
35 printf("\nThe value of flux is \t K2=%0.3f ",K2);
36 printf("\nThe feasible value of K is %0.1f",K1)
37 // Note :The answer vary slightly due to precise
    calculation

```

Scilab code Exa 14.2 Compute the speed at which motor can hold the load by regenerative

```

1 // chapter 14
2 // example 14.2
3 // Compute the speed at which motor can hold the
    load by regenerative braking
4 // page-863-864

```



```

5 clear;
6 clc;
7 // given
8 T=100; // in Nm (torque)
9 E=220; // in V
10 N1=960; // in rpm
11 Ia=80; // in A (armature current)
12 Ra=0.06; // in ohm (armature resistance)
13 // calculate
14 Eb1=E-Ia*Ra; // calculation of back emf at 960 rpm
15 w1=N1*2*%pi/60; // calculation of rated speed
16 T1=Eb1*Ia/w1; // calculation of rated motor torque
17 // since  $T=K_a\phi I_a$ , therefore we get
18 Ka_phi=T1/Ia;
19 Ia2=T/Ka_phi; // calculation of armature current at
    T=100 Nm
20 Eb2=E+Ia2*Ra; // calculation of corresponding back
    emf
21 w2=(Eb2/Eb1)*w1; // calculation of speed at which
    motor can hold the load by regenerative braking
22 N2=w2*(60/(2*%pi));
23 printf("\n\nThe speed at which motor can hold the load
    by regenerative braking is \t w2=%0.2f rad/s or \
    t N2=%0.f rpm",w2,N2)
24 // Note :The value of torque given is T=100 Nm but
    the author has used T=1000 Nm in the calculation.
    Thats why the answer in the book is wrong

```

Scilab code Exa 14.3 Compute the field current firing angle of the convertor and t

```

1 // chapter 14
2 // example 14.3
3 // Compute the field current , firing angle of the
    convertor and the input power factor
4 // page-864-865

```

```

5 clear;
6 clc;
7 // given
8 E=230; // in V
9 f=50; // in Hz
10 La=0.06; // in H (armature inductance)
11 Ra=0.3; // in ohm (armature resistance)
12 Ka=0.9; // in V/A rad/s (motor voltage constant)
13 Rf=104; // in ohm (field resistance)
14 T_L=50; // in Nm (load torque)
15 N=800; // in rpm (speed)
16 alpha0=0; // in radian (firing angle for maximum
    field voltage)
17 // calculate
18 Em=E*sqrt(2); // calculation of peak voltage
19 Ef=(Em/%pi)*(1+cos(alpha0)); // calculation of
    maximum field voltage
20 If=Ef/Rf; // calculation of field current
21 Ia=T_L/(Ka*If); // calculation of armature current
22 w=N*(2*%pi/60); // calculation of angular speed
23 Eb=Ka*w*If; // calculation of back emf
24 Ea=Eb+Ia*Ra; // calculation of armature voltage
25 // since Ea=(Em/%pi)*(1+cos(alpha)), therefore we
    get
26 alpha=acosd(Ea*(%pi/Em)-1); // calculation of firing
    angle
27 P0=Ea*Ia; // calculation of output power
28 Pa=P0; // calculation of power from supply
29 Irms=sqrt((2/(2*%pi))*Ia^2*integrate('1','wt',alpha
    *(%pi/180),%pi)); // calculation of rms current
30 EI=E*Irms; // calculation of volt-ampere rating
31 Pf=Pa/(EI); // calculation of power factor
32 printf("\nThe field current is \t\t\t If=%0.2f A",If)
    ;
33 printf("\nThe firing angle of the convertor is \t
    alpha=%0.f degree",alpha);
34 printf("\nThe power factor is \t\t\t Pf=%0.2f",Pf);
35 if Pf>0 then

```

```

36     printf(" (lagging)");
37 else
38     printf(" (leading)");
39 end

```

Scilab code Exa 14.4 Determine motor torque speed of the motor supply power factor

```

1 // chapter 14
2 // example 14.4
3 // fig. 14.13
4 // Determine motor torque, speed of the motor,
   supply power factor, firing angle and power fed
   back to the supply
5 // page-865-866
6 clear;
7 clc;
8 // given
9 HP=10; // in HP (power of motor)
10 E=210; // in V
11 N=1000; // in rpm (speed)
12 Ia=30; // in A (armature current)
13 Ra=0.25; // in ohm (armature resistance)
14 Es=230; // in V (supply voltage)
15 Ka_phi=0.172; // in V/rpm (motor voltage constant)
16 alpha=45; // in degree
17 // calculate
18 Em=Es*sqrt(2); // calculation of peak voltage
19 // part- (a)
20 Ka_phi_rad=Ka_phi*(60/(2*%pi)); // changing unit
   from V/rpm to V/rad/s
21 T=Ka_phi_rad*Ia; // calculation of motor torque
22 Ea=(2*Em/%pi)*cosd(alpha); // calculation of
   armature voltage
23 Eb=Ea-Ia*Ra; // calculation of back emf
24 N=Eb/Ka_phi; // calculation of speed

```

```

25 EI=Es*Ia; // calculation of volt-ampere rating
26 Ps=Ea*Ia; // calculation of supplied power
27 Pf=Ps/EI; // calculation of power factor
28 printf("\nThe motor torque is \t\t T=%0.1f Nm",T);
29 printf("\nThe speed of the motor is \t N=%0.2f rpm",N
);
30 printf("\nThe supply power factor is \t Pf=%0.2f",Pf)
;
31 // part (b)
32 Ea2=-Eb+Ia*Ra; // calculation of back emf when in
regenerative action Here minus sign indicates
regenerative action
33 // since Ea=(2*Em/%pi)*cosd(alpha), therefore we get
34 alpha2=acosd(Ea2*(%pi/(2*Em))); // calculation of
corresponding firing angle
35 Pg=Eb*Ia; // calculation of power from dc machine
36 Pr=Ia^2*Ra; // calculation of power lost in armature
resistance
37 Ps=Pg-Pr; // calculation of supplied power
38 printf("\n\nThe firing angle to keep the motor
current at its rated value is \t alpha2=%0.2f
degree",alpha2);
39 printf("\nThe fpower fed back from the supply is \t
Ps=%0.1f W",Ps);
40 // Note :The answers vary due to precise
calculations

```

Scilab code Exa 14.5 What should be firing angle different speeds and calculate th

```

1 // chapter 14
2 // example 14.5
3 // What should be firing angle different speeds and
calculate the motor speed
4 // page-866-867
5 clear;

```

```

6  clc;
7  // given
8  Ea=210; // in V
9  N=1200; // in rpm (speed)
10 Ia=10; // in A (armature current)
11 Ra=1.5; // in ohm (armature resistance)
12 Es=230; // in V (supply voltage)
13 N1=800; // in rpm (rated torque)
14 N2=1200; // in rpm (braking torque)
15 alpha3=165; // in degree
16 // calculate
17 Em=Es*sqrt(2); // calculation of peak voltage
18 Eb=Ea-Ia*Ra; // calculation of rated back emf
19 w=abs(N2)*(2*%pi/60); // calculation of rated
    angular speed
20 Ka_phi=Eb/w; // calculation of motor voltage
    constant
21 Eb1=(N1/N2)*Eb; // calculation of back emf at speed
    N1
22 Ea1=Eb1+Ia*Ra; // calculation of armature voltage at
    speed N1
23 // since  $E_a = (2 \cdot E_m / \pi) \cdot \cos(\alpha)$ , therefore we get
24 alpha1=acosd(Ea1*(%pi/(2*Em))); // calculation of
    firing angle at speed N1
25 Ea2=-Eb+Ia*Ra; // calculation of armature voltage at
    speed N2
26 alpha2=acosd(Ea2*(%pi/(2*Em))); // calculation of
    firing angle at speed N2
27 Ea3=(2*Em/%pi)*cosd(alpha3); // calculation of
    armature voltage at alpha3
28 Eb3=Ea3-Ia*Ra; // calculation of back emf at alpha3
29 w3=abs(Eb3/Ka_phi); // calculation of speed at
    alpha3
30 N3=w3*(60/(2*%pi)); // calculation of speed in rpm
31 printf("\nThe firing angle at N1=%f rpm is \t
    alpha1=%f degree",N1,alpha1);
32 printf("\nThe firing angle at N2=%f rpm is \t
    alpha2=%f degree",N2,alpha2);

```

```

33 printf("\n\nThe speed of the motor is \t w3=%0.2f rad
    /s or \t N3=%0.1f rpm",w3,N3);
34 // Note : The answers vary slightly due to precise
    calculations

```

Scilab code Exa 14.6 Determine the motor speed

```

1 // chapter 14
2 // example 14.6
3 // Determine the motor speed
4 // page-867-868
5 clear;
6 clc;
7 // given
8 E=240; // in V
9 alpha1=110; // in degree (triggering angle)
10 alpha2=50; // in degree
11 T=1.8; // in Nm (torque)
12 Ka_phi=1; // in Nm/A (torque motor characteristics)
13 Ra=6; // in ohm (armature resistance)
14 // calculate
15 Em=E*sqrt(2); // calculation of peak voltage
16 Ia=T/Ka_phi;
17 VARIABLE=(1/%pi)*Em*integrate('sin(wt)', 'wt', alpha1
    *(%pi/180),%pi);
18 // since Ea=(VARIABLE+Eb*%pi*(alpha1-alpha2)/(%pi
    *180)) and Eb=Ea-Ia*Ra, putting the value in it,
    we get
19 // Eb=VARIABLE+Eb*(alpha1-alpha2)/180-Ia*Ra, or
20 // Eb-Eb*(alpha1-alpha2)/180=VARIABLE/%pi-Ia*Ra or
21 Eb=(VARIABLE-Ia*Ra)/(1-(alpha1-alpha2)/180); //
    calculation of back emf
22 w=Eb/Ka_phi; // calculation of motor speed in rad/s
23 N=w*(60/(2*%pi)); // calculation of motor speed in
    rpm

```

```

24 printf("\n\nThe motor speed is \t w=%0.2f rad/s or \t
      N=%0. f rpm",w,N);

```

Scilab code Exa 14.7 Determine the triggering angle of the convertor

```

1 // chapter 14
2 // example 14.7
3 // Determine the triggering angle of the convertor
4 // page-868
5 clear;
6 clc;
7 // given
8 P=80; // in kW (power rating of motor)
9 E=440; // in V
10 N1=800; // in rpm
11 N2=600; // in rpm
12 neta=75; // in % (% torque with respect to rated
      torque)
13 Eb1=410; // in V (back emf)
14 Eac=415; // in V (three-phase input)
15 // calculate
16 P=P*1E3; // changing unit from kW to W
17 Em=sqrt(2/3)*Eac; // calculation of peak value of
      input voltage
18 // since Eb1/Eb2=N1/N2, therefore we get
19 Eb2=Eb1*(N2/N1); // calculation of back emf
      corresponding to N2=600 rpm
20 Ia=P/E; // calculation of armature current
21 // since Eb1=E-Ia*Ra, therefore we get
22 Ra=(E-Eb1)/Ia; // calculation of armature resistance
23 Ea=Eb2+((neta/100)*Ia*Ra); // calculation of
      armature volage
24 // since Ea=(3*sqrt(3)/%pi)*Em*cosd(alpha),
      therefore we get
25 alpha=acosd((Ea/Em)*(%pi/(3*sqrt(3)))); //

```

```

    calculation of triggering angle of the convertor
26 printf("\n\nThe triggering angle of the convertor
    is \t alpha=%0.2f rdegree",alpha);
27 // Note: The answer varies slightly due to precise
    calculations

```

Scilab code Exa 14.8 Determine no load speeds firing angle supply power factor and

```

1 // chapter 14
2 // example 14.8
3 // Determine no load speeds , firing angle , supply
    power factor and the speed regulation
4 // page-868-870
5 clear;
6 clc;
7 // given
8 P=150; // in HP (power rating of motor)
9 E0=650; // in V (voltage rating of motor)
10 N1=1750; // in rpm
11 Eac=460; // in V (three-phase input)
12 Ia=170; // in A (rated armature current)
13 Ra=0.099; // in ohm (armature resistance)
14 La=0.73; // in mH (armature inductance)
15 Ka_phi=0.33; // in V/rpm (motor voltage constant)
16 alpha1=0, alpha2=30; // in degrees (firing angle)
17 neta=10; // in % (armature current at no load as a
    percentage of rated armature current)
18 // calculate
19 E=Eac/sqrt(3);
20 Em=E*sqrt(2);
21 Ea1=(3*sqrt(3)/%pi)*Em*cosd(alpha1);
22 Eb1=Ea1-Ia*Ra;
23 N_NL1=Eb1/Ka_phi;
24 Ea2=(3*sqrt(3)/%pi)*Em*cosd(alpha2);
25 Eb2=Ea2-Ia*Ra;

```



```

26 N_NL2=Eb2/Ka_phi;
27 Eb3=Ka_phi*N1;
28 Ea3=Eb3+Ia*Ra;
29 // since Ea=(3*sqrt(3)/%pi)*Em*cosd(alpha),
    therefore we get
30 alpha3=acosd((Ea3/Em)*(%pi/(3*sqrt(3))));
31 I_A=sqrt((1/%pi)*Ia^2*(2*%pi/3));
32 VA=3*E*I_A;
33 Ps=Ea3*Ia;
34 PF=Ps/VA;
35 Eb4=Ea3-((neta/100)*Ia*Ra);
36 N_NL3=Eb4/Ka_phi;
37 SR=((N_NL3-N1)/N1)*100;
38 printf("\nThe no load speeds are");
39 printf("\n\t\t\t For alpha=%f degree , N_NL= %.2 f
    rpm",alpha1,N_NL1);
40 printf("\n\t\t\t For alpha=%f degree , N_NL= %.2 f
    rpm",alpha2,N_NL2);
41 printf("\n\nThe firing angle to obtain a speed of N=
    %f rpm is \t alpha= %.2 f degree",N1,alpha3);
42 printf("\nThe supply power factor is \t\t\t\t PF= %
    .2 f",PF);
43 printf("\nThe speed regulation is \t\t\t\t\t SR= %.2
    f %%",SR);
44 // Note: The answer varies slightly due to precise
    calculations

```

Scilab code Exa 14.9 Determine motor torque motor current and supply power factor

```

1 // chapter 14
2 // example 14.9
3 // Determine motor torque , motor current and supply
    power factor
4 // page-878-879
5 clear;

```

```

6  clc;
7  // given
8  P=20; // in HP (power rating of motor)
9  E0=650; // in V (voltage rating of motor)
10 N=1000; // in rpm
11 Ra=0.25; // in ohm (armature resistance)
12 K_af=0.03; // in Nm/A^2
13 K_res=0.075; // in Vs/rad
14 Es=230; // in V (supply voltage)
15 alpha=30; // in degree (firing angle)
16 // calculate
17 Em=sqrt(2)*Es; // calculation of peak value of
    supply voltage
18 // part- (a) // semiconverter controlled dc drive
19 w=N*(2*pi/60); // calculation of angular speed
20 T=K_af*(((Em/pi)*(1+cosd(alpha)))-K_res*w)/(Ra+
    K_af*w))^2; // calculation of motor torque
21 Ia=sqrt(T/K_af); // calculation of motor current
22 Ea=(sqrt(2)*Es/pi)*(1+cosd(alpha)); // calculation
    of motor terminal voltage
23 Ps=Ea*Ia; // calculation of input power
24 VA=Es*Ia*sqrt(5/6); // calculation of input volt-
    ampere
25 PF=Ps/VA; // calculation of supply power factor
26 printf("\nFor semiconverter controlled DC drives");
27 printf("\nThe motor torque is \t\t T= %.2f Nm",T);
28 printf("\nThe motor current is \t\t Ia= %.2f A",Ia);
29 printf("\nThe supply power factor is \t PF= %.2f",PF
    );
30 // part (b)
31 T=K_af*(((2*Em/pi)*cosd(alpha))-K_res*w)/(Ra+K_af*
    w))^2; // calculation of motor torque
32 Ia=sqrt(T/K_af); // calculation of motor current
33 Ea=(2*sqrt(2)*Es/pi)*cosd(alpha); // calculation of
    motor terminal voltage
34 Ps=Ea*Ia; // calculation of input power
35 VA=Es*Ia; // calculation of input volt-ampere
36 PF=Ps/VA; // calculation of supply power factor

```

```

37 printf("\n\nFor fullconvertor controlled DC drives")
    ;
38 printf("\nThe motor torque is \t\t T= %.2f Nm",T);
39 printf("\nThe motor current is \t\t Ia= %.2f A",Ia);
40 printf("\nThe supply power factor is \t PF= %.2f",PF
    );
41 // Note: The answer varies slightly due to precise
    calculations

```

Scilab code Exa 14.10 Determine the firing angle of the armature convertor speed of

```

1 // chapter 14
2 // example 14.10
3 // Determine the firing angle of the armature
    convertor , speed of the motor and firing angle of
    the field convertor
4 // page-885-886
5 clear;
6 clc;
7 // given
8 P=25; // in HP (power rating of motor)
9 E0=320; // in V (voltage rating of motor)
10 N=960; // in rpm
11 Eac=210; // in V (ac input voltage)
12 Ra=0.2; // in ohm (armature resistance)
13 Rf=130; // in ohm (field resistance)
14 K_a=1.2; // in V/A rad/s (motor voltage constant)
15 T=110; // in Nm (torque developed)
16 alpha_a=0; // in degree (firing angle for armature
    convertor)
17 N2=1750; // in rpm
18 // calculate
19 Ep=Eac/sqrt(3);
20 Em=sqrt(2)*Ep; // calculation of peak value of phase
    voltage

```

```

21 Ef=(3*sqrt(3)*Em/%pi)*cosd(alpha_a);
22 If=Ef/Rf;
23 // since T=Ia*Ka*If, therefore we get
24 Ia=T/(K_a*If);
25 w=N*(2*%pi/60);
26 Eb=K_a*If*w;
27 Ea=Eb+Ia*Ra;
28 // since Ea=(3*sqrt(3)*Em/%pi)*cosd(alpha),
    therefore we get
29 alpha=acosd((Ea/Em)*(%pi/(3*sqrt(3))));
30 Ea1=(3*sqrt(3)*Em/%pi)*cosd(alpha_a);
31 Eb1=Ea1-Ia*Ra;
32 w1=Eb1/(K_a*If);
33 N1=w1*(60/(2*%pi));
34 w2=N2*(2*%pi/60);
35 // since Eb=K_a*If*w, therefore we get
36 If=Eb1/(K_a*w2);
37 Ef=If*Rf;
38 // since Ef=(3*sqrt(3)*Em/%pi)*cosd(alpha_f),
    therefore we get
39 alpha_f=acosd((Ef/Em)*(%pi/(3*sqrt(3))));
40 printf("\nThe firing angle of the armature convertor
    is \talpha= %.2f degree",alpha);
41 printf("\nThe speed of the motor is \t\t\t N1= %.2f
    rpm",N1);
42 printf("\nThe firing angle of the field convertor is
    \t alpha_f= %.2f",alpha_f);
43 // Note: The answer varies slightly due to precise
    calculations

```

Scilab code Exa 14.11 Determine the firing angle power factor active power and rea

```

1 // chapter 14
2 // example 14.11
3 // Determine the firing angle, power factor, active

```

```

        power and reactive power at rated speed and its
        10 % and their ratio
4 // page-886-887
5 clear;
6 clc;
7 // given
8 P=100; // in kW (power rating of motor)
9 N=1000; // in rpm
10 Ea=460; // in V
11 I=300; // in A
12 E=415; // in V (3 phase input voltage)
13 neta=10; // in % (% of rated speed for new speed)
14 // calculate
15 P=P*1E3;
16 Em=sqrt(2/3)*E; // calculation of peak value of
    phase voltage
17 // since Ea=(3*sqrt(3)*Em/%pi)*cosd(alpha),
    therefore we get
18 alpha1=acosd((Ea/Em)*(%pi/(3*sqrt(3))));
19 PF1=cosd(alpha1);
20 Ea_alpha=(neta/100)*Ea;
21 alpha2=acosd((Ea_alpha/Em)*(%pi/(3*sqrt(3))));
22 PF2=cosd(alpha2);
23 Ia=P/Ea;
24 I=sqrt(2/3)*Ia;
25 P_active1=sqrt(3)*E*I*cosd(alpha1);
26 P_reactive1=sqrt(3)*E*I*sind(alpha1);
27 P_active2=sqrt(3)*E*I*cosd(alpha2);
28 P_reactive2=sqrt(3)*E*I*sind(alpha2);
29 ratio=P_reactive2/P_reactive1;
30 printf("\nAt rated speed, the firing angle is \t
    alpha=%0.2f degree and the power factor is \t PF=%0.2f",alpha1,PF1);
31 printf("\n\nAt %0.f%% rated speed, the firing angle
    is \t alpha=%0.2f degree and the power factor is \t
    PF=%0.3f",neta,alpha2,PF2);
32 printf("\n\nAt rated speed, the active power is \t
    P_active=%0.1f kW and reactive power is \t

```

```

    P_reactive=%0.2f kVAR",P_active1*1E-3,P_reactive1
    *1E-3);
33 printf("\n\nAt %.f %% rated speed, the active power
    is \t P_active=%0.2f kW and reactive power is \t
    P_reactive=%0.2f kVAR",neta,P_active2*1E-3,
    P_reactive2*1E-3);
34 printf("\n\nThe ratio of reactive power at %.f %%
    rated speed and rated speed is %.2f",neta,ratio);
35 // Note: The answer vary slightly due to precise
    calculations

```

Scilab code Exa 14.12 Determine the range of frequencies of the chopper

```

1 // chapter 14
2 // example 14.12
3 // Determine the range of frequencies of the chopper
4 // page-893
5 clear;
6 clc;
7 // given
8 I=80; // in A
9 E=480; // in V
10 N=960; // in rpm
11 Ra=0.25; // in ohm (armature resistance)
12 Rf=120; // in ohm (field resistance)
13 N1=400, N2=750; // in rpm (range of speed)
14 Ton=3; // in ms
15 Ef=480; // in V
16 // calculate
17 Ton=Ton*1E-3; // changing unit from ms to s
18 If=E/Rf; // calculation of field current
19 Ia=I-If; // calculation of armature current
20 Eb=E-Ia*Ra; // calculation of back emf
21 Eb1=(N1/N)*Eb; // calculation of back emf
    corresponding to N1=400 rpm

```

```

22 Ea1=Eb1+Ia*Ra; // calculation of terminal voltage
    corresponding to N1=400 rpm
23 T1=(E/Ea1)*Ton; // calculation of chopping period
    corresponding to N1=400 rpm
24 F1=1/T1; // calculation of frequency corresponding
    to N1=400 rpm
25 Eb2=(N2/N)*Eb; // calculation of back emf
    corresponding to N2=400 rpm
26 Ea2=Eb2+Ia*Ra; // calculation of terminal voltage
    corresponding to N2=400 rpm
27 T2=(E/Ea2)*Ton; // calculation of chopping period
    corresponding to N2=400 rpm
28 F2=1/T2; // calculation of frequency corresponding
    to N2=400 rpm
29 printf("\n\nThe range of frequencies of the chopper
    is \t %.2f Hz <= f <= %.2f Hz",F1,F2);
30 // Note: The answer vary slightly due to precise
    calculations

```

Chapter 15

Control of A C Drives

Scilab code Exa 15.1 Determine the new value of torque developed by motor

```
1 // chapter 15
2 // example 15.1
3 // Determine the new value of torque developed by
  motor
4 // page-912
5 clear;
6 clc;
7 // given
8 T1=1500; // in sync Watts
9 f1=50; // in Hz
10 N=1440; // in rpm
11 NS=1500; // in rpm (synchronous speed)
12 f2=75; // in Hz
13 // calculate
14 // since  $T1/T2=f2/f1$ , therefore we get
15  $T2=(f1/f2)*T1$ ;
16 printf("\n\nThe new value of torque developed by
  motor is \t T2=%0.2f sync. watts",T2);
17 // Note: The answer vary slightly due to precise
  calculations
```

Scilab code Exa 15.2 Determine the angle of firing advance in different cases volt

```
1 // chapter 15
2 // example 15.2
3 // Determine the angle of firing advance in
  different cases , voltage ratio and power flow
4 // page-958-959
5 clear;
6 clc;
7 // given
8 P=6; // number of poles
9 f=50; // in Hz
10 N1=600, N2=800; // in rpm
11 E=600; // in V open circuit standstill slip-ring
    voltage
12 Es=415; // in V (supply voltage)
13 gama1=10; // in degree (overlap angle in rectifier)
14 gama2=5; // in degree (overlap angle in inverter)
15 V_diode=1.5; // in V (voltage drop across SCR)
16 V_SCR=0.7; // in V (voltage drop across SCR)
17 alpha=0; // in degree (used by the author in the
    book)
18 Pin=100; // assumption as done in the book
19 // calculate
20 Ns=(f/P)*120; // calculation of synchronous speed
21 S1=(Ns-N1)/Ns; // calculation of slip corresponding
    to N1=600
22 Er1=N1*S1; // calculation of rotor voltage
    corresponding to N1=600
23 Edc1=(P*Er1*sqrt(2)/%pi)*sin(%pi/P); // calculation
    of dc link voltage corresponding to N1=600
24 Edc_inv1=Edc1;
25 Emax=Es*sqrt(2);
26 // since Edc_inv=(P*Emax/(2*%pi))*sin(%pi/P)*(cos(
```

```

    Beta)+cos(Beta-gama)), and gama=0, therefore we
    get
27 Beta1=(acosd((2*%pi/(P*Emax*sin(%pi/P)))*Edc_inv1/2)
    ); // calculation of angle of firing advance
    corresponding to N1=600
28 S2=(Ns-N2)/Ns; // calculation of slip corresponding
    to N2=800
29 Er2=N2*S2; // calculation of rotor voltage
    corresponding to N2=800
30 Edc2=(P*Er2*sqrt(2)/%pi)*sin(%pi/P); // calculation
    of dc link voltage corresponding to N2=800
31 Edc_inv2=Edc2;
32 // since Edc_inv=(P*Emax/(2*%pi))*sin(%pi/P)*(cos(
    Beta)+cos(Beta-gama)), and gama=0, therefore we
    get
33 Beta2=(acosd((2*%pi/(P*Emax*sin(%pi/P)))*Edc_inv2/2)
    ); // calculation of angle of firing advance
    corresponding to N2=800
34 Edc3=(P*Emax/(2*%pi))*sin(%pi/P)*(cos(alpha)+cos(
    alpha+gama1))-2*V_SCR;
35 Beta3=acosd(((2*%pi/(P*Emax*sin(%pi/P)))*(Edc3-2*
    V_diode))/(2*cosd(gama2/2)))+gama2/2;
36 K=Es/Er1;
37 P0_rotor=Pin*S1;
38 P0_shaft=Pin-P0_rotor;
39 printf("\n\nThe angle of firing advance
    corresponding to N1=%f rpm is \t Beta1=%f
    degree",N1,Beta1);
40 printf("\n\nThe angle of firing advance corresponding
    to N2=%f rpm is \t Beta2=%f degree",N2,Beta2);
41 printf("\n\nThe angle of firing advance in overlapping
    case is \t\t Beta3=%f degree",Beta3);
42 printf("\n\nThe transfromer ratio is \t K=%f",K);
43 printf("\n\nThe power out of the rotor is \t
    P0_rotor=%f %% of power input to the stator",
    P0_rotor);
44 printf("\n\nThe shaft output power is \t P0_shaft=%f
    %% of power input to the stator",P0_shaft);

```

45 // Note: The answer in the book is wrong for Beta3
due to use of wrong values of Emax and gamal in
the calculation. I have used the correct values

Scilab code Exa 15.3 Determine the input voltage armature current excitation volta

```
1 // chapter 15
2 // example 15.3
3 // Determine the input voltage , armature current ,
  excitation voltage , torque angle and pull-out
  torque
4 // page-977-978
5 clear;
6 clc;
7 // given
8 P=6; // number of poles
9 f=50; // in Hz
10 E=400; // in V
11 Xs=%i*2; // in ohm (reactance per phase)
12 T_L=300; // in Nm
13 N=1000; // in rpm
14 f_inv=40; // in Hz (invertor frequency)
15 Nm=560; // in rpm (motor speed)
16 phi=0; // in degree (used in the book)
17 // calculate
18 Pf=cosd(phi);
19 Es=E/sqrt(3);
20 Eb=Es;
21 Ea_rated=Es;
22 w=2*%pi*f;
23 ws=2*w/P;
24 wb=ws;
25 Ns=(60/(2*%pi))*ws;
26 K=Eb/wb;
27 T_L1=T_L*(Nm/N)^2;
```

```

28  wm1=Nm*(2*pi/60);
29  ws1=wm1;
30  P0=T_L1*wm1;
31  Ea=K*ws1;
32  // since P0=3*Ea*Ia*Pf, therefore we get
33  Ia=P0/(3*Ea*Pf);
34  Ef=Ea-Ia*(Xs);
35  Ef_abs=abs(Ef);
36  Ef_phase=atand(imag(Ef)/real(Ef));
37  del=Ef_phase;
38  T_P=3*Ea*Ef_abs/(2*wm1);
39  printf("\nThe input voltage is \t\t Ea=%0.2f V",Ea);
40  printf("\nThe armature current is \t Ia=%0.2f A",Ia);
41  printf("\nThe excitation voltage is \t Ef=%0.2f V <%
    .2f degree",Ef_abs,Ef_phase);
42  printf("\nThe torque angle is \t\t %0.2f degree",del)
    ;
43  printf("\nThe pull-out torque is \t\t T_P=%0.2f Nm",
    T_P);
44  // Note: 1. In the book, the value of N given is N
    =100 rpm, but hte author hase used N=1000 rpm
    while solving. I have also used N=1000 rpm to
    make the answers to have practical values.
45  //      2. The answers in the book vary slightly
    due to precise calculations

```

Chapter 16

Power Electronic Applications

Scilab code Exa 16.1 Determine kVA rating of inverter Wattage of the rectifier and

```
1 // chapter 16
2 // example 16.1
3 // Determine kVA rating of inverter , Wattage of the
  rectifier and A-H rating of battery
4 // page-996
5 clear;
6 clc;
7 // given
8 Load=600; // in W
9 PF=0.8; // (lagging power factor)
10 efficiency=80; // in %
11 Edc=24; // in V
12 backup_time=30; // in min
13 // calculate
14 // since  $PF = \text{Load} / \text{kVA\_rating}$ , therefore we get
15 kVA_rating=Load/PF; // calculation of kVA rating of
  inverter
16 wattage=kVA_rating*PF/(efficiency/100); //
  calculation of Wattage of the rectifier
17 Idc=kVA_rating/Edc; // calculation of dc current
18 AH_rating=Idc*backup_time/60; // calculation of A-H
```

```

        rating of battery
19 printf("\nThe kVA rating of invertor is \t\t %.2f kW
    ",kVA_rating*1E-3);
20 printf("\nThe Wattage of the rectifier is \t %.2f kW
    ",wattage*1E-3);
21 printf("\nThe A-H rating of battery is \t\t %.2f AH
    ",AH_rating);
22 // The battery voltage is given as Edc=24 V but the
    author has used Edc=48 V. Thats why the answer
    in the book for AH_rating is wrong.

```

Scilab code Exa 16.2 Select a suitable battery

```

1 // chapter 16
2 // example 16.2
3 // Select a suitable battery
4 // page-996-997
5 clear;
6 clc;
7 // given
8 UPS_rating=20; // in kVA
9 backup_time=15; // in min
10 efficiency=85; // in %
11 PF=0.8; // (lagging power factor)
12 Edc1=147, Edc2=190; // in V (Battery voltage range)
13 V_cell=1.75; // in V (voltage per cell)
14 N=6; // in cell groups per jar
15 // calculate
16
17 Battery_kW=UPS_rating*PF/(efficiency/100); //
    calculation of battery power
18 num_cell=Edc1/V_cell; // calculation of number of
    cells
19 num_jar=num_cell/N; // calculation of number of jars
20 cell_size_kW=Battery_kW/num_cell // calculation of

```

```

    cell_size
21 printf("\nThe battery power is \t %.2f kW",
    Battery_kW);
22 printf("\nThe number of cells is \t %.f",num_cell);
23 printf("\nThe number of jars is \t %.f",num_jar);
24 printf("\nThe cell size is \t %.3f kW",cell_size_kW)
    ;
25 printf("\n\nBased on this data, we can choose 90 A–H
    battery which has 0.255 kW discharge rate at %.f
    min back–up time",backup_time);

```

Scilab code Exa 16.3 Determine AH efficiency and WH efficiency

```

1 // chapter 16
2 // example 16.3
3 // Determine AH efficiency and WH efficiency
4 // page–997
5 clear;
6 clc;
7 // given
8 V_cell=2; // in V (voltage of lead acid cell)
9 I_discharge=35; // in A (discharge current)
10 T_discharge=5; // in Hrs
11 Eavg=1.95; // in V
12 I_charge=45; // in A (4charge current)
13 T_charge=4; // in Hrs
14 // calculate
15 AH_efficiency=((I_discharge*T_discharge)/(I_charge*
    T_charge))*100; // calculation of AH efficiency
16 WH_efficiency=AH_efficiency*Eavg/V_cell; //
    calculation of WH efficiency
17
18 printf("\nThe AH efficiency is \t %.2f %%",
    AH_efficiency);
19 printf("\nThe WH efficiency is \t %.2f %%",

```

```
    WH_efficiency);
```

Scilab code Exa 16.4 Determine dc supply voltage and charging current

```
1 // chapter 16
2 // example 16.4
3 // Determine dc supply voltage and charging current
4 // page-997
5 clear;
6 clc;
7 // given
8 num_cell=18; // number of cells
9 AH_output=90; // in AH (AH output per cell)
10 T=10; // in Hrs
11 charging_time=8; // in Hrs
12 AH_efficiency=85; // in %
13 V_cell=2.4; // in V (voltage per cell)
14 r=0.1; // in ohm (internal resistance of battery)
15 // calculate
16 // since AH_efficiency=AH_output/AH_input, therefore
    we get
17 AH_input=AH_output/(AH_efficiency/100); //
    calculation of input AH per cell
18 // since AH_input=charging_current*charging_time,
    therefore we get
19 charging_current=AH_input/charging_time; //
    calculation of charging current
20 V_total=num_cell*V_cell; // calculation of total
    terminal voltage of 18 cells
21 V_drop=r*charging_current; // calculation of voltage
    drop across internal resistance
22 Edc=V_total+V_drop; // calculation of dc supply
    voltage
23 printf("\nThe charging current is \t %.2f A",
    charging_current);
```



```

24 printf("\nThe dc supply voltage is \t %.3f V",Edc);
25 // Note: the answers vary slightly due to precise
    calculation

```

Scilab code Exa 16.5 Calculate back up time and charger peak output power

```

1 // chapter 16
2 // example 16.5
3 // Calculate back-up time and charger peak output
    power
4 // page-997-998
5 clear;
6 clc;
7 // given
8 VA_rating=6; // in kVA
9 V=230; // in V
10 E=144; // in V
11 PF=0.8;
12 neta=0.85; // inverter efficiency
13 AH_rating=500; // in AH
14 E1=10.6, E2=13.4; // in V (range of battery voltage)
15 E_normal=12; // in V (normal battery voltage)
16 T=4; // in Hrs (charging time)
17 t=8; // in Hrs
18 capacity_derating=0.5;
19 // calculate
20 VA_rating=VA_rating*1E3;
21 Battery_kW=VA_rating*PF/neta; // calculation of
    battery power
22 num_Battery=E/E_normal; // calculation of number of
    batteries
23 // considering worst case for calculation of
    discharge current
24 Total_battery_voltage=E1*num_Battery; // calculation
    of total battery voltage

```

```

25 // since Battery_kW=Total_battery_voltage*I_dc ,
    therefore we get ,
26 I_dc=Battery_kW/Total_battery_voltage; //
    calculation of battery discharge current
27 T_backup=AH_rating*capacity_derating/I_dc; //
    calculation of back-up time
28 Ic=AH_rating*capacity_derating/T; // calculation of
    charging current
29 P_peak=E*Ic; // calculation of charging peak power
30 printf("\nThe back-up time is \t\t %.3f hours",
    T_backup);
31 printf("\nThe charging peak power is \t %.f kW",
    P_peak*1E-3);
32 // Note : There is calculation mistake in the book
    while calculating T_backup. Thats why answer in
    the book is wrong

```

Scilab code Exa 16.6 Determine maximum duty cycle and flyback convertor turns ratio

```

1 // chapter 16
2 // example 16.6
3 // Determine maximum duty cycle and flyback
    convertor turns ratio
4 // page-1007
5 clear;
6 clc;
7 // given
8 fs=60; // in kHz (switching frequency)
9 Esp=180; // in V (spike voltage)
10 Mains=230; // in V (mains supply)
11 f=50; // in Hz (supply frequency)
12 E0=12; // in V
13 E_DS=1200; // in V (used in the book, voltage across
    MOSFET)
14 // calculate

```

```

15 Edc=Mains*sqrt(2); // calculation of peak mains
    voltage
16 // since E_DS=(Edc/(1-alpha_max)+Esp, therefore we
    get
17 alpha_max=1-(Edc/(E_DS-Esp)); // calculation of
    maximum duty cycle
18 // since E0=(alpha_max/(1-alpha_max))*(N2/N1)*Edc,
    therefore we get
19 K=(Edc/E0)*(alpha_max/(1-alpha_max)); // calculation
    of flyback convertor turns ratio
20 printf("\nThe maximum duty cycle is \t\t alpha_max=%
    .2 f", alpha_max);
21 printf("\nThe flyback convertor turns ratio is \t N2
    /N1=%0.1 f", K);
22 // Note : the answer vary slightly due to precise
    calculations

```

Scilab code Exa 16.7 Determine average input power and current ratings of the tras

```

1 // chapter 16
2 // example 16.7
3 // Determine average input power and current ,
    ratings of the transistor , primary winding
    inductance and number of turns, and ratings of the
    diode
4 // page-1007-1009
5 clear;
6 clc;
7 // given
8 Edc_min=14, Edc_max=30; // in V (range of supply
    voltage)
9 V1=12, V2=-12, // in V (output voltages)
10 I1=0.6, I2=0.6; // in A (output current)
11 i_1=0.1, i_2=0.5; // in A (range of load current)
12 neta=80; // in % (efficiency of the convertor)

```

```

13 fs=50; // in kHz (switching frequency)
14 alpha_max=0.5; // assumption as done in the book
15 L0=80; // in mH (assumption as done in the book)
16 N0=1100; // (assumption as done in the book)
17 // calculate
18 fs=fs*1E3; // changing unit from kHz to Hz
19 L0=L0*1E-3; // changing unit from mH to H
20 P0=(V1*I1)+(-V2*I2); // calculation of full-load
    power
21 Pi=P0/(neta/100); // calculation of input power
22 I_avg_max=Pi/Edc_min; // calculation of maximum
    average input current
23 I_avg_min=Pi/Edc_max; // calculation of minimum
    average input current
24 Ic_max=2*P0/((neta/100)*Edc_min*alpha_max); //
    calculation of transistor current rating
25 V_CE_max=Edc_max/(1-alpha_max); // calculation of
    transistor voltage rating
26 Pd_max=V_CE_max*Ic_max; // calculation of transistor
    power rating
27 L_prim=Edc_min*alpha_max/(Ic_max*fs); // calculation
    of primary inductance
28 N_prim=N0*sqrt(L_prim/L0); // calculation of number
    of turns in primary winding
29 // since  $E_0=(\alpha_{max}/(1-\alpha_{max}))*(N_2/N_1)*E_{dc}$ ,
    therefore we get
30 N_sec=(V1/Edc_min)*N_prim*((1-alpha_max)/alpha_max);
    // calculation of number of turns in secondary
    winding
31 Id=(N_prim/N_sec)*Ic_max; // calculation of peak
    diode current
32 PIV=V1+(Edc_max/(N_prim/N_sec)); // calculation of
    peak inverse voltage
33 printf("\nThe average input power is \t Pi=%f W",Pi
    );
34 printf("\nThe maximum average input current is \t
    I_avg_max=%f A",I_avg_max);
35 printf("\nThe minimum average input current is \t

```

```

    I_avg_min=%.3f A",I_avg_min);
36 printf("\n\nThe ratings of the transistor are \t
    Ic_max=%.2f A \t V_CE_max=%.f V \t Pd_max=%.f W",
    Ic_max,V_CE_max,Pd_max);
37 printf("\n\nThe number of turns in primary winding
    is \t N_prim=%.f",N_prim);
38 printf("\n\nThe number of turns in secondary winding
    is \t N_sec=%.f",N_sec);
39 printf("\n\nThe ratings of the diode are \t Id>=%.1f
    A \t PIV>= %.2f V",Id,PIV);
40 // Note : 1.There is calculation mistake while
    calculating Id. Thats why answer in the book is
    wrong.
41 //      2. The answers vary slightly due to
    precise calculations

```

Scilab code Exa 16.8 Determine turn ratio of demagnetizing winding with primary winding

```

1 // chapter 16
2 // example 16.8
3 // Determine turn ratio of demagnetizing winding
    with primary winding, switch voltage rating and
    dc supply current
4 // page-1015
5 clear;
6 clc;
7 // given
8 E0=12; // in V
9 IO=12; // in A
10 fs=60; // in kHz (switching frequency)
11 E=230; // in V (rectified ac mains)
12 alpha_max=0.6; // maximum duty cycle
13 neta1=50; // in % (spike voltage percentage)
14 neta2=20; // in %
15 // calculate

```



```

12 e=80; // in % (efficiency)
13 E=230; // in V (used in the book)
14 alpha_max=0.8; // assumption for duty cycle as done
    in the book
15 tolerance=20; // assumption for voltage tolerance as
    done in the book
16 // calculate
17 fs=fs*1E3; // changing unit from kHz to Hz
18 L=L*1E-6; // changing unit from uH to H
19 L_R=n^2*L; // calculation of resonant inductance
20 f_R=0.25*fs; // calculation of resonant frequency
21 Cc=1/(4*(%pi*f_R)^2*L_R); // calculation of coupling
    capacitor
22 Edc=E*sqrt(2); // calculation of dc voltage
23 Ic=2*P0/((e/100)*alpha_max*Edc); // calculation of
    coupling current
24 I=Ic+(tolerance/100)*Ic; // calculation of worst case
    coupling current
25 dt=alpha_max/(2*fs);
26 Vc=(I/Cc)*dt; // calculation of coupling capacitor
    charge voltage
27 // since the range of Vc is 6 to 32 V,
28 // let us assume dVc=30 V therefore, the new value
    of capacitor is C=I*(dt/dVc);
29 dVc=30; // in V
30 C=I*(dt/dVc); // calculation of new coupling
    capacitance
31 printf("\nThe value of coupling capacitor is \t\t Cc
    =%.2f uF",Cc*1E6);
32 printf("\nThe peak coupling capacitor charge voltage
    is \t vc=%.1f V",Vc);
33 if Vc>=6 & Vc<=32 then
34     printf("\n\nThe value of Vc is acceptable.");
35 else
36     C=I*dt/dVc;
37     printf("\nThe new value of coupling capacitor is
    \t\t C=%.1f uF",C*1E6);
38 end

```

39 // Note : the answer vary slightly due to round off

Scilab code Exa 16.10 Determine rms current and peak reverse voltage

```
1 // chapter 16
2 // example 16.10
3 // fig. 16.20
4 // Determine rms current and peak reverse voltage
5 // page-1028-1029
6 clear;
7 clc;
8 // given
9 P0=500; // in MW
10 E=250; // in kV
11 // calculate
12 P0=P0*1E6; // changing unit from MW to W
13 E=E*1E3; // changing unit from kV to V
14 Id=P0/(2*E); // calculation of direct current
15 Irms=Id/sqrt(3); // calculation of rms current
16 E_line_max=E/2; // calculation of maximum line
    voltage
17 for 6 pulse group
18 PIV=E_line_max*(%pi/3); // calculation of peak
    reverse voltage
19 printf("\nThe rms current is \t\t Irms=%0.2f A",Irms)
    ;
20 printf("\nThe peak reverse voltage is \t PIV=%0.f kV"
    ,PIV*1E-3);
```

Scilab code Exa 16.11 Determine depth of heating and heat generated per unit surface

```
1 // chapter 16
2 // example 16.11
```



```

3 // Determine depth of heating and heat generated per
  unit surface area
4 // page-1036
5 clear;
6 clc;
7 // given
8 L=10; // in cm (length)
9 d=1; // in cm (diameter)
10 N=15; // number of turns
11 I=80; // in A
12 f=200; // in kHz
13 ur=1; // relative permeability
14 rho=5E-8; // in ohm-m (resistivity)
15 // calculate
16 L=L*1E-2; // changing unit from cm to m
17 d=d*1E-2; // changing unit from cm to m
18 f=f*1E3; // changing unit from KHz to Hz
19 del=503*sqrt(rho/(ur*f)); // calculation of depth of
  heating
20 H=2*pi*(N*I/L)^2*sqrt(rho*ur*f/1E7); // calculation
  of heat generated per unit surface area
21 printf("\nThe depth of heating is \t\t\t del=%0.3f mm
  ",del*1E3);
22 printf("\nThe heat generated per unit surface area
  is \t H=%0.2f kW/m^2",H*1E-3);
23 // Note : The value of L given is L=10 cm but the
  author has used L=1 cm in the calculation. That's
  why answer in the book is wrong.

```

Scilab code Exa 16.12 Determine supply frequency

```

1 // chapter 16
2 // example 16.12
3 // Determine supply frequency
4 // page-1037

```

```

5 clear;
6 clc;
7 // given
8 del=2.5; // in mm (depth of heating)
9 rho=5E-5; // in ohm-cm (resistivity)
10 ur=1; // relative permeability
11 // calculate
12 del=del*1E-3; // changing unit from mm to m
13 rho=rho*1E-2; // changing unit from ohm-cm to ohm-m
14 f=(rho/ur)*(503/del)^2; // calculation of supply
    frequency
15 printf("\nThe supply frequency is \t f=%0.2f kHz",f*1
    E-3);

```

Scilab code Exa 16.13 Determine voltage and current

```

1 // chapter 16
2 // example 16.13
3 // Determine voltage and current
4 // page-1041
5 clear;
6 clc;
7 // given
8 l=25, b=15, t=1; // in cm (dimensions of piece)
9 P=1; // in kW
10 Er=4; // relative permittivity
11 PF=0.6; // power factor
12 f=40; // in MHz
13 Eo=8.854E-12; // absolute permittivity
14 // calculate
15 l=l*1E-2; // changing unit from cm to m
16 b=b*1E-2; // changing unit from cm to m
17 t=t*1E-2; // changing unit from cm to m
18 P=P*1E3; // changing unit from kW to W
19 f=f*1E6; // changing unit from MHz to Hz

```

```

20 A=l*b; // calculation of area
21 C=EO*Er*A/t; // calculation of capacitance
22 // since  $P=2*\pi*f*C*V^2*PF$ , therefore we get
23 V=sqrt(P/(2*pi*f*C*PF)); // calculation of voltage
24 Xc=1/(2*pi*f*C); // calculation of capacitive
    reactance
25 I=V/Xc; // calculation of current
26 printf("\nThe voltage is \t V=%0.2f V",V);
27 printf("\nThe current is \t I=%0.2f A",I);

```

Scilab code Exa 16.14 Determine supply frequency

```

1 // chapter 16
2 // example 16.14
3 // Determine supply frequency
4 // page-1041
5 clear;
6 clc;
7 // given
8 C=5.3; // in uF
9 V=600; // in V
10 I=100; // in A
11 // calculate
12 C=C*1E-6; // changing unit from uF to F
13 Xc=V/I;
14 // since  $Xc=1/(2*\pi*f*C)$ , therefore we get
15 f=1/(2*pi*C*Xc); // calculation of supply frequency
16 printf("\nThe supply frequency is \t f=%0.f kHz",f*1E
    -3);

```

Scilab code Exa 16.15 Calculate the value of load resistance commutating capacitor

```

1 // chapter 16

```

```

2 // example 16.15
3 // fig. Ex 16.15
4 // Calculate the value of load resistance ,
   commutating capacitor and resistance connected in
   series
5 // page-1046
6 clear;
7 clc;
8 // given
9 Edc=50; // in V (supply voltage)
10 I_L=10; // in A (load current)
11 Toff=20; // in us (turn-off time)
12 I_H=5; // in mA (holding current)
13 // calculate
14 Toff=Toff*1E-6; // changing unit from us to s
15 I_H=I_H*1E-3; // changing unit from mA to A
16 R2=Edc/I_H; // calculation of resistance connected
   in series
17 R1=Edc/I_L; // calculation of load resistance
18 C=1.5*Toff*I_L/Edc; // calculation of ommutating
   capaitor
19 printf("\nThe value of resistance connected in
   series is \t R2=%f k-ohm",R2*1E-3);
20 printf("\nThe value of load resistance is \t R1=%f
   ohm",R1);
21 printf("\nThe value of commutating capacitor is \t C
   >=%f uF",C*1E6);

```

Scilab code Exa 16.16 What will be the firing angle and output power available

```

1 // chapter 16
2 // example 16.16
3 // What will be the firing angle and output power
   available
4 // page-1051

```

```

5 clear;
6 clc;
7 // given
8 f=50; // in Hz
9 neta=60; // in %
10 T=0.24; // in s (repetition period)
11 // calculate
12 // part (i) can not be solved
13 // since T=0.24 s represents 12 cycles at 50 Hz or T
    =24 half cycles, therefore
14 T=24;
15 // since Pload/Pmax=N/24, therefore
16 N1=1, N2=24
17 Pload1=N1/T;
18 Pload2=N2/T;
19 printf("The available power range from %.2f %% of
    Pmax (N=%.f) to %.f %% of Pmax (N=%.f) varying in
    steps of %.2f %% of Pmax",Pload1*1E2,N1,Pload2*1
    E2,N2,Pload1*1E2);

```
