Scilab Textbook Companion for Electrical Circuit Theory And Technology by J. O. Bird[1]

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October 4, 2013

Book Description

Title: Electrical Circuit Theory And Technology

Author: J. O. Bird

Publisher: Routledge

Edition: 2

Year: 2003

ISBN: 0-7506-5784-7

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Units associated with basic electrical quantities

Scilab code Exa 1.01 Example 1

```
1  //Problem 1.01: If a current of 5 A flows for 2
       minutes, find the quantity of electricity
       transferred.
2
3  //initializing the variables:
4  I = 5; // in Ampere
5  t = 120; // in sec
6
7  //calculation:
8  Q = I*t
9
10 printf("\n\nResult\n\n")
11 printf("\nQ: %.0f coulomb(C)\n",Q)
```

Scilab code Exa 1.02 Example 2

```
1 //Problem 1.02: A mass of 5000 g is accelerated at 2
     m/s2 by a force. Determine the force needed.
2
3 //initializing the variables:
4 M = 5; // in Kg
5 a = 2; // in m/s2
6
7 //calculation:
8 F = M*a
9
10 printf("\n\nResult\n\n")
11 printf("\nForce: %.0f Newton(N)\n",F)
```

Scilab code Exa 1.03 Example 3

```
1 //Problem 1.03: Find the force acting vertically
     downwards on a mass of 200 g attached to a wire.
2
3 //initializing the variables:
4 M = 0.2; // in Kg
5 g = 9.81; // in m/s2
6
7 //calculation:
8 F = M*g
9
10 printf("\n\nResult\n\n")
11 printf("\nForce: %.3f Newton(N)\n",F)
```

Scilab code Exa 1.04 Example 4

```
1 //Problem 1.04: A portable machine requires a force
     of 200 N to move it. How much work is done if the
```

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```
        machine  is  moved  20 m and  what  average  power  is
          utilized  if  the  movement  takes  25  s?
 2
 3  // initializing  the  variables :
 4  F  =  200;  //  in  Newton
 5  d  =  20;  //  in  m
 6  t  =  25;  //  in  sec
 7
 8  // calculation :
 9  W  =  F*d
10  P  =  W/t
11
12  printf ( "\n\ nResult \n\n" )
13  printf ( "\nPower :  %.0 f  watt (W)\n" ,P )
```

Scilab code Exa 1.05 Example 5

```
 1  // Problem  1.05:  A  mass  of  1000  kg  is  raised  through
          a  height  of  10m  in  20 s .  What  is  (a)  the  work  done
           and  (b)  the  power  developed ?
 2
 3  // initializing  the  variables :
 4  M  =  1000;  //  in  Kg
 5  h  =  10;  //  in  m
 6  t  =  20;  //  in  sec
 7  g  =  9.81  //  in  m/s2
 8
 9  // calculation :
10  W  =  M*g*h
11  P  =  W/t
12
13  printf ( "\n\ nResult \n\n" )
14  printf ( "\nWork  Done :  %.0 f  Joule ( J )\n" ,W )
15  printf ( "\nPower :  %.0 f  watt (W)\n" ,P )
```

Scilab code Exa 1.06 Example 6

```
1  //Problem 1.06: Find the conductance of a conductor
      of resistance (a) 10 ohm , (b) 5 kohm and (c) 100
      ohm.
2
3  //initializing the variables:
4  R1 = 10; // in ohm
5  R2 = 5000; // in ohm
6  R3 = 0.1; // in ohm
7  //calculation:
8  G1 = 1/R1
9  G2 = 1/R2
10  G3 = 1/R3
11
12  printf("\n\nResult\n\n")
13  printf("\nconductance(G1): %.1f seimen(S)n",G1)
14  printf("\nconductance(G2): %.4f seimen(S)n",G2)
15  printf("\nconductance(G3): %.0f seimen(S)n",G3)
```

Scilab code Exa 1.07 Example 7

```
1  //Problem 1.07: A source e.m.f. of 5 V supplies a
      current of 3 A for 10 minutes. How much energy is
      provided in this time?
2
3  //initializing the variables:
4  V = 5; // in Volts
5  I = 3; // in Ampere
6  t = 600; // in sec
7  //calculation:
8  P = V*I
```

```
9  E = P*t
10
11 printf("\n\nResult\n\n")
12 printf("\nEnergy(E): %.0f Joule(J)\n",E)
```

Scilab code Exa 1.08 Example 8

```
1  //Problem 1.08: An electric heater consumes 1.8 MJ
      when connected to a 250 V supply for 30 minutes.
      Find the power rating of the heater and the
      current taken from the supply.
2
3  //initializing the variables:
4  E = 18E5; // in Joule
5  V = 250; // in Volts
6  t = 1800; // in sec
7
8  //calculation:
9  P = E/t
10 I = P/V
11
12 printf("\n\nResult\n\n")
13 printf("\nPower(P): %.0f Watt(W)",P)
14 printf("\nCurrent(I): %.0f Ampere(A)\n",I)
```

Chapter 2

An introduction to electric circuits

Scilab code Exa 2.01 Example 1

```
1 //Problem 2.01: What current must flow if 0.24
     coulombs is to be transferred in 15 ms?
2
3 //initializing the variables:
4 Q = 0.24; // in Coulomb
5 t = 0.015; // in sec
6
7 //calculation:
8 I = Q/t
9
10 printf("\n\nResult\n\n")
11 printf("\nCurrent(I): %.0f Ampere(A)\n",I)
```

Scilab code Exa 2.02 Example 2

```
1 //Problem 2.02: If a current of 10 A flows for four
```

```
      minutes, find the quantity of electricity
      transferred.
 2
 3  //initializing the variables:
 4  I = 10; // in Ampere
 5  t = 240; // in sec
 6
 7  //calculation:
 8  Q = I*t
 9
10  printf("\n\nResult\n\n")
11  printf("\nCharge(Q): %.0f Coulomb(C)\n",Q)
```

Scilab code Exa 2.03 Example 3

```
 1  //Problem 2.03: The current flowing through a
      resistor is 0.8 A when a p.d. of 20 V is applied.
      Determine the value of the resistance.
 2
 3  //initializing the variables:
 4  I = 0.8; // in Ampere
 5  V = 20; // in Volts
 6
 7  //calculation:
 8  R = V/I
 9
10  printf("\n\nResult\n\n")
11  printf("\nResistance(R): %.0f Ohms\n",R)
```

Scilab code Exa 2.04 Example 4

```
1 //Problem 2.04: Determine the p.d. which must be
      applied to a 2 kohm resistor in order that a
      current of 10 mA may flow.
2
3 //initializing the variables:
4 I = 0.010; // in Ampere
5 R = 2000; // in ohms
6
7 //calculation:
8 V = I*R
9
10 printf("\n\nResult\n\n")
11 printf("\np.d.(V): %.0f Volts(V)\n",V)
```

Scilab code Exa 2.05 Example 5

```
1 //Problem 2.05: A coil has a current of 50 mA
      flowing through it when the applied voltage is 12
       V. What is the resistance of the coil?
2
3 //initializing the variables:
4 I = 0.050; // in Ampere
5 V = 12; // in Volts
6
7 //calculation:
8 R = V/I
9
10 printf("\n\nResult\n\n")
11 printf("\nResistance(R): %.0f Ohms\n",R)
```

Scilab code Exa 2.06 Example 6

```
1  //Problem  2.06:  A 100 V  battery  is  connected  across
       a  resistor  and  causes  a  current  of 5 mA to  flow.
       Determine  the  resistance  of  the  resistor.  If  the
       voltage  is  now  reduced  to  25 V,  what  will  be  the
       new  value  of  the  current  flowing?
2
3  //initializing  the  variables:
4  I = 0.005; // in  Ampere
5  V1 = 100; // in  Volts
6  V2 = 25; // in  Volts
7
8  //calculation:
9  //resistance
10 R = V1/I
11 //Current  when  voltage  is  reduced  to  25 V,
12 I = V2/R
13
14 printf("\n\nResult\n\n")
15 printf("\nResistance(R): %.0f  Ohms",R)
16 printf("\n Current  when  voltage  is  reduced  to  25 V
       is  %.2E A",I)
```

Scilab code Exa 2.07 Example 7

```
1  //Problem  2.07:  What  is  the  resistance  of  a  coil
       which  draws  a  current  of (a) 50 mA and (b) 200
        A  from  a  120 V  supply?
2
3  //initializing  the  variables:
4  I1 = 0.050; // in  Ampere
5  I2 = 200E-6; // in  Ampere
6  V = 120; // in  Volts
7
8  //calculation:
9  R1 = V/I1
```

```
10  R2 = V/ I2
11
12  printf(" \n\ nResult \n\n")
13  printf(" \ nResistance (R1 ) : %.0 f  Ohms" , R1)
14  printf(" \ nResistance (R2 ) : %.0 f  Ohms\n" , R2)
```

Scilab code Exa 2.08 Example 8

```
1  //Problem  2.08: A 100 W electric light bulb is
       connected to a 250 V supply. Determine (a) the
       current flowing in the bulb, and (b) the
       resistance of the bulb.
2
3  // initializing  the variables:
4  P = 100;  //  in Watt
5  V = 250;  //  in Volts
6
7  // calculation:
8  I = P/V
9  R = V/ I
10
11  printf(" \n\ nResult \n\n")
12  printf(" \ nCurrent ( I ) : %.1 f  Ampere (A)" , I)
13  printf(" \ nResistance (R) : %.0 f  Ohms\n" , R)
```

Scilab code Exa 2.09 Example 9

```
1  //Problem  2.09: Calculate the power dissipated when
       a current of 4 mA flows through a resistance of 5
        k
2
3  // initializing  the variables:
4  I = 0.004;  //  in ampere
```

```
5  R = 5000; // in ohms
6
7  //calculation :
8  P = I*I*R
9
10 printf("\n\nResult\n\n")
11 printf("\nPower(P): %.2f Watt(W)\n",P)
```

Scilab code Exa 2.10 Example 10

```
1  //Problem 2.10: An electric kettle has a resistance
       of 30. What current will flow when it is
       connected to a 240 V supply? Find also the power
       rating of the kettle .
2
3  //initializing the variables :
4  V = 240; // in Volts
5  R = 30; // in ohms
6
7  //calculation :
8  I = V/R
9  P = V*I
10
11 printf("\n\nResult\n\n")
12 printf("\nCurrent(I): %.0f Ampere(A)",I)
13 printf("\nPower(P): %.0f Watt(W)\n",P)
```

Scilab code Exa 2.11 Example 11

```
1  //Problem 2.11: A current of 5 A flows in the
       winding of an electric motor, the resistance of
       the winding being 100. Determine (a) the p.d.
```

```
   across the winding, and (b) the power dissipated
   by the coil.
2
3  //initializing the variables:
4  I = 5; // in ampere
5  R = 100; // in ohms
6
7  //calculation:
8  V = I*R
9  P = I*R*I
10
11 printf("\n\nResult\n\n")
12 printf("\np.d(V): %.0f Volts(V)",V)
13 printf("\nPower(P): %.0f Watt(W)\n",P)
```

Scilab code Exa 2.12 Example 12

```
1  //Problem 2.12: The current/voltage relationship for
       two resistors A and B is as shown in Figure 2.5.
       Determine the value of the resistance of each
       resistor.
2
3  //initializing the variables:
4  I1 = 0.020; // in ampere
5  V1 = 20; // in Volts
6  I2 = 0.005; // in ampere
7  V2 = 16; // in Volts
8
9  //calculation:
10 R1 = V1/I1
11 R2 = V2/I2
12
13 printf("\n\nResult\n\n")
14 printf("\nResistance(R1): %.0f Ohms",R1)
15 printf("\nResistance(R2): %.0f Ohms\n",R2)
```

Scilab code Exa 2.13 Example 13

```
1 //Problem 2.13: The hot resistance of a 240 V
       filament lamp is 960. Find the current taken by
       the lamp and its power rating.
2
3 //initializing the variables:
4 V = 240; // in Volts
5 R = 960; // in ohms
6
7 //calculation:
8 I = V/R
9 P = I*V
10
11 printf("\n\nResult\n\n")
12 printf("\nCurrent(I): %.2f Ampere(A)",I)
13 printf("\nPower(P): %.0f Watt(W)\n",P)
```

Scilab code Exa 2.14 Example 14

```
1 //Problem 2.14: A 12 V battery is connected across a
       load having a resistance of 40ohms. Determine
       the current flowing in the load, the power
       consumed and the energy dissipated in 2 minutes.
2
3 //initializing the variables:
4 V = 12; // in Volts
5 R = 40; // in ohms
6 t = 120; // in sec
7
8 //calculation:
```

```
 9  I = V/R
10  P = I*V
11  E = P*t
12
13  printf("\n\nResult\n\n")
14  printf("\nCurrent(I): %.1f Ampere(A)",I)
15  printf("\nPower(P): %.1f Watt(W)",P)
16  printf("\nEnergy(E): %.0f Joule(J)\n",E)
```

Scilab code Exa 2.15 Example 15

```
 1  //Problem 2.15: A source of e.m.f. of 15 V supplies
        a current of 2 A for six minutes. How much energy
         is provided in this time?
 2
 3  //initializing the variables:
 4  V = 15; // in Volts
 5  I = 2; // in ampere
 6  t = 360; // in sec
 7
 8  //calculation:
 9  E = V*I*t
10
11  printf("\n\nResult\n\n")
12  printf("\nEnergy(E): %.0f Joule(J)\n",E)
```

Scilab code Exa 2.16 Example 16

```
 1  //Problem 2.16: Electrical equipment in an office
        takes a current of 13 A from a 240 V supply.
        Estimate the cost per week of electricity if the
        equipment is used for 30 hours each week and 1
        kWh of energy costs 7p?
```

```
 2
 3  //initializing the variables:
 4  V = 240; // in Volts
 5  I = 13; // in ampere
 6  t = 30; // in hours
 7  p = 7; // in paise per kWh
 8
 9  //calculation:
10  P = V*I
11  E = P*t/1000 // in kWh
12  C = E*p
13
14  printf("\n\nResult\n\n")
15  printf("\nCost per week: %.1f Paise(p)\n",C)
```

Scilab code Exa 2.17 Example 17

```
 1  //Problem 2.17: An electric heater consumes 3.6 MJ
         when connected to a 250 V supply for 40 minutes.
         Find the power rating of the heater and the
         current taken from the supply.
 2
 3  //initializing the variables:
 4  V = 250; // in Volts
 5  E = 3.6E6; // energy in J
 6  t = 2400; // in sec
 7
 8  //calculation:
 9  P = E/t
10  I = P/V
11
12  printf("\n\nResult\n\n")
13  printf("\nPower(P): %.0f Watt(W)",P)
14  printf("\nCurrent(I): %.0f Ampere(A)\n",I)
```

Scilab code Exa 2.18 Example 18

```
1  //Problem 2.18: Determine the power dissipated by
       the element of an electric fire of resistance 20
       ohms when a current of 10 A flows through it. If
       the fire is on for 6 hours determine the energy
       used and the cost if 1 unit of electricity costs
       7p.
2
3  //initializing the variables:
4  R = 20; // in ohms
5  I = 10; // in ampere
6  t = 6; // in hours
7  p = 7; // in paise per kWh
8
9  //calculation:
10 P = I*I*R
11 E = P*t/1000 // in kWh
12 C = E*p
13
14 printf("\n\nResult\n\n")
15 printf("\nPower(P): %.0f Watt(W)",P)
16 printf("\nCost per week: %.0f Paise(p)\n",C)
```

Scilab code Exa 2.19 Example 19

```
1  //Problem 2.19: A business uses two 3 kW fires for
       an average of 20 hours each per week, and six 150
        W lights for 30 hours each per week. If the cost
        of electricity is 7p per unit, determine the
       weekly cost of electricity to the business.
2
```

```
3  //initializing the variables:
4  P1 = 3; // in kW
5  P2 = 150; // in Watt
6  n1 = 2; // no. of P1 Equips
7  n2 = 6; // no. of P2 Equips
8  t1 = 20; // in hours each per week
9  t2 = 30; // in hours each per week
10 p = 7; // in paise per kWh
11
12 //calculation:
13 E1 = P1*t1*n1 // in kWh by two P1 eqips
14 E2 = P2*t2*n2/1000 // in kWh by six P2 eqips
15 Et = E1 + E2
16 C = Et * 7
17 printf("\n\nResult\n\n")
18 printf("\nCost per week: %.0f Paise(p)\n",C)
```

Chapter 3

Resistance variation

Scilab code Exa 3.01 Example 1

```
1 //Problem 3.01: The resistance of a 5 m length of
      wire is 600 ohms. Determine (a) the resistance of
       an 8 m length of the same wire, and (b) the
      length of the same wire when the resistance is
      420 ohms.
2
3 //initializing the variables:
4 R = 600; // in ohms
5 L = 5; // in meter
6 L1 = 8; // in meter
7 R2 = 420; // in ohms
8
9 //calculation:
10 R1 = R*L1/L
11 L2 = R2*L/R
12
13 printf("\n\nResult\n\n")
14 printf("\n(a)Resistance %.0f Ohms",R1)
15 printf("\n(b)Length: %.1f meters(m)\n",L2)
```

Scilab code Exa 3.02 Example 2

```
1  //Problem 3.02: A piece of wire of cross−sectional
       area 2 mm2 has a resistance of 300 ohms. Find (a)
        the resistance of a wire of the same length and
       material if the cross−sectional area is 5 mm2, (b
       ) the cross−sectional area of a wire of the same
       length and material of resistance 750 ohms.
2
3  //initializing the variables:
4  R = 300; // in ohms
5  A = 2; // in mm2
6  A1 = 5; // in mm2
7  R2 = 750; // in ohms
8
9  //calculation:
10 R1 = R*A/A1
11 A2 = R*A/R2
12
13 printf("\n\nResult\n\n")
14 printf("\n(a)Resistance %.0f Ohms",R1)
15 printf("\n(b)C.S.A: %.1f mm2\n",A2)
```

Scilab code Exa 3.03 Example 3

```
1  //Problem 3.03: A wire of length 8 m and cross−
       sectional area 3 mm2 has a resistance of 0.16
       ohms. If the wire is drawn out until its
       crosssectional area is 1 mm2, determine the
       resistance of the wire.
2
3  //initializing the variables:
```

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```
4  R = 0.16; // in ohms
5  A = 3; // in mm2
6  L = 8; // in m
7  A1 = 1; // in mm2
8
9  //calculation:
10 L1 = L*3
11 R1 = R*A*L1/(A1*L)
12
13 printf("\n\nResult\n\n")
14 printf("\nResistance %.2f Ohms\n",R1)
```

Scilab code Exa 3.04 Example 4

```
1  //Problem 3.04: Calculate the resistance of a 2 km
      length of aluminium overhead power cable if the
      cross-sectional area of the cable is 100 mm2.
      Take the resistivity of aluminium to be 0.03E-6
      ohm m.
2
3  //initializing the variables:
4  A = 100E-6; // in m2
5  L = 2000; // in m
6  p = 0.03E-6; // in ohm m
7
8  //calculation:
9  R = p*L/A
10
11 printf("\n\nResult\n\n")
12 printf("\nResistance %.1f Ohms\n",R)
```

Scilab code Exa 3.05 Example 5

```
1 //Problem 3.05: Calculate the cross-sectional area,
      in mm2, of a piece of copper wire, 40 m in length
       and having a resistance of 0.25 ohms. Take the
      resistivity of copper as 0.02E-6ohm m.
2
3 //initializing the variables:
4 R = 0.25; // in ohms
5 L = 40; // in m
6 p = 0.02E-6; // in ohm m
7
8 //calculation:
9 A = p*L*1E6/R
10
11 printf("\n\nResult\n\n")
12 printf("\nC.S.A %.1f Ohms\n",A)
```

Scilab code Exa 3.06 Example 6

```
1 //Problem 3.06: The resistance of 1.5 km of wire of
      cross-sectional area 0.17 mm2 is 150 ohms.
      Determine the resistivity of the wire.
2
3 //initializing the variables:
4 R = 150; // in ohms
5 L = 1500; // in m
6 A = 0.17E-6; // in m2
7
8 //calculation:
9 p = R*A/L
10
11 printf("\n\nResult\n\n")
12 printf("\nresistivity %.3E Ohm m\n",p)
```

Scilab code Exa 3.07 Example 7

```
1 //Problem 3.07: Determine the resistance of 1200 m
      of copper cable having a diameter of 12 mm if the
       resistivity of copper is 1.7E-8 ohm m.
2
3 //initializing the variables:
4 d = 0.012; // in m
5 L = 1200; // in m
6 p = 1.7E-8; // in ohm m
7 pi = 3.14;
8
9 //calculation:
10 A = pi*d*d/4
11 R = p*L/A
12
13 printf("\n\nResult\n\n")
14 printf("\nresistance %.3f Ohm\n",R)
```

Scilab code Exa 3.08 Example 8

```
1 //Problem 3.08: A coil of copper wire has a
      resistance of 100 ohms when its temperature is 0
       C . Determine its resistance at 70 C if the
      temperature coefficient of resistance of copper
      at 0 C is 0.0043/ C
2
3 //initializing the variables:
4 R0 = 100; // in ohms
5 T0 = 0; // in   C
6 T1 = 70; // in   C
7 a0 = 0.0043; // in per C
8 pi = 3.14;
9
10 //calculation:
```

```
11  R70 = R0*[1 + (a0*T1)]
12
13  printf("\n\nResult\n\n")
14  printf("\nresistance %.1f Ohm\n",R70)
```

Scilab code Exa 3.09 Example 9

```
1  //Problem 3.09: An aluminium cable has a resistance
       of 27 ohms at a temperature of 35 C. Determine
       its resistance at 0 C. Take the temperature
       coefficient of resistance at 0 C to be 0.0038/
       C
2
3  //initializing the variables:
4  R1 = 27; // in ohms
5  T0 = 0; // in  C
6  T1 = 35; // in  C
7  a0 = 0.0038; // in per C
8  pi = 3.14;
9
10  //calculation:
11  R0 = R1/[1 + (a0*T1)]
12
13  printf("\n\nResult\n\n")
14  printf("\nresistance %.2f Ohm\n",R0)
```

Scilab code Exa 3.10 Example 10

```
1  //Problem 3.10: A carbon resistor has a resistance
       of 1 kohms at 0 C. Determine its resistance at
       80 C. Assume that the temperature coefficient of
       resistance for carbon at 0 C is 0.0005/ C
2
```

```
3  // initializing the variables :
4  R0 = 1000; // in ohms
5  T0 = 0; // in  C
6  T1 = 80; // in  C
7  a0 = -0.0005; // in per C
8  pi = 3.14;
9
10 // calculation :
11 R80 = R0*[1 + (a0*T1)]
12
13 printf("\n\nResult\n\n")
14 printf("\nresistance %.0f Ohm\n",R80)
```

Scilab code Exa 3.11 Example 11

```
1  // Problem 3.11: A coil of copper wire has a
      resistance of 10 ohms at 20 C. If the
      temperature coefficient of resistance of copper
      at 20 C is 0.004/ C determine the resistance of
      the coil when the temperature rises to 100 C.
2
3  // initializing the variables :
4  R20 = 10; // in ohms
5  T0 = 20; // in  C
6  T1 = 100; // in  C
7  a20 = 0.004; // in per C
8  pi = 3.14;
9
10 // calculation :
11 R100 = R20*[1 + (a20)*(T1 - T0)]
12
13 printf("\n\nResult\n\n")
14 printf("\nresistance %.1f Ohm\n",R100)
```

Scilab code Exa 3.12 Example 12

```
1  //Problem 3.12: The resistance of a coil of
       aluminium wire at 18 C is 200 ohms. The
       temperature of the wire is increased and the
       resistance rises to 240 ohms. If the temperature
       coefficient of resistance of aluminium is 0.0039/
        C at 18 C determine the temperature to which
       the coil has risen.
2
3  //initializing the variables:
4  R18 = 200; // in ohms
5  R1 = 240; // in ohms
6  T0 = 18; // in  C
7  a18 = 0.0039; // in per C
8  pi = 3.14;
9
10 //calculation:
11 T1 = (((R1/R18)-1)/a18) + T0
12
13 printf("\n\nResult\n\n")
14 printf("\nTemperature %.2f  C \n",T1)
```

Scilab code Exa 3.13 Example 13

```
1  //Problem 3.13: Some copper wire has a resistance of
        200 ohms at 20 C. A current is passed through
       the wire and the temperature rises to 90 C.
       Determine the resistance of the wire at 90 C,
       correct to thenearest ohm, assuming that the
       temperature coefficient of resistance is 0.004/
        C at 0 C.
```

```
2
3  //initializing the variables:
4  R20 = 200; // in ohms
5  T0 = 20; // in   C
6  T1 = 90; // in   C
7  a0 = 0.004; // in per C
8  pi = 3.14;
9
10 //calculation:
11 R90 = R20*[1 + (a0*T1)]/[1 + (a0*T0)]
12
13 printf("\n\nResult\n\n")
14 printf("\nResistance %.0f ohms\n",R90)
```

Chapter 4

Chemical effects of electricity

Scilab code Exa 4.01 Example 1

```
1 //Problem 4.01: Eight cells, each with an internal
      resistance of 0.2 ohms and an e.m.f. of 2.2 V are
       connected (a) in series, (b) in parallel.
      Determine the e.m.f. and the internal resistance
      of the batteries so formed.
2
3 //initializing the variables:
4 R = 0.2; // in ohms
5 n = 8; // no. of cells
6 e = 2.2; // in volts
7
8 //calculation:
9 es = n*e
10 ep = e
11 Rs = n*R
12 Rp = R/n
13
14 printf("\n\nResult\n\n")
15 printf("\n(a)Resistance %.1f ohms",Rs)
16 printf("\n(a)e.m.f %.1f Volts(V)",es)
17 printf("\n(b)Resistance %.3f ohms",Rp)
```

```
18  printf("\n(b)e.m.f %.1f Volts(V)",ep)
```

Scilab code Exa 4.02 Example 2

```
1  //Problem 4.02: A cell has an internal resistance of
       0.02 ohms and an e.m.f. of 2.0 V. Calculate its
       terminal p.d. if it delivers (a) 5 A, (b) 50 A
2
3  //initializing the variables:
4  r = 0.02; // in ohms
5  e = 2; // in volts
6  I1 = 5; // in Amperes
7  I2 = 50; // in Amperes
8
9  //calculation:
10 pd1 = e - (I1*r)
11 pd2 = e - (I2*r)
12
13 printf("\n\nResult\n\n")
14 printf("\n(a)p.d %.1f Volts(V)",pd1)
15 printf("\n(b)p.d %.1f Volts(V)\n",pd2)
```

Scilab code Exa 4.03 Example 3

```
1  //Problem 4.03: The p.d. at the terminals of a
       battery is 25 V when no load is connected and 24
       V when a load taking 10 A is connected. Determine
       the internal resistance of the battery.
2
3  //initializing the variables:
4  e1 = 25; // in volts
5  e2 = 24; // in volts
6  I2 = 10; // in Amperes
```

```
 7
 8  //calculation :
 9  r = (e1 - e2)/I2
10
11  printf("\n\nResult\n\n")
12  printf("\n Resistance %.1f Ohms\n",r)
```

Scilab code Exa 4.04 Example 4

```
 1  //Problem 4.04: Ten 1.5 V cells , each having an
        internal resistance of 0.2 ohms, are connected in
         series to a load of 58 ohms . Determine(a) the
        current flowing in the circuit and (b) the p.d.
        at the battery terminals .
 2
 3  //initializing the variables :
 4  r = 0.2; // in ohms
 5  n = 10; // no. of cells
 6  e = 1.5; // in volts
 7  R = 58; // in ohms
 8
 9  //calculation :
10  es = n*e
11  rs = n*r
12  I = es/(rs + R)
13  pd = es - (I*rs)
14
15  printf("\n\nResult\n\n")
16  printf("\n (a)Current %.2f Amperes(A)",I)
17  printf("\n (b)p.d %.1f Volts(V)\n",pd)
```

Chapter 5

Series and parallel networks

Scilab code Exa 5.01 Example 1

```
1  //Problem 5.01: For the circuit shown in Figure 5.2,
        determine (a) the battery voltage V, (b) the
     total resistance of the circuit, and (c) the
     values of resistance of resistors R1, R2 and R3,
     given that the p.d.  s  across R1, R2 and R3 are
     5 V, 2 V and 6 V respectively.
2
3  //initializing the variables:
4  V1 = 5; // in volts
5  V2 = 2; // in volts
6  V3 = 6; // in volts
7  I = 4; // in Amperes
8
9  //calculation:
10 Vt = V1 + V2 + V3
11 Rt = Vt/I
12 R1 = V1/I
13 R2 = V2/I
14 R3 = V3/I
15
16 printf(" \n\nResult\n\n")
```

```
17  printf("\n  (a)  Total  Voltage  %.0f  Volts (V)",Vt)
18  printf("\n  (b) Total  Resistance  %.2f  Ohms",Rt)
19  printf("\n  (c) Resistance (R1)  %.2f  Ohms",R1)
20  printf("\n  (c) Resistance (R2)  %.1f  Ohms",R2)
21  printf("\n  (c) Resistance (R3)  %.1f  Ohms",R3)
```

Scilab code Exa 5.02 Example 2

```
1  //Problem  5.02:  For  the  circuit  shown  in  Figure  5.3 ,
        determine  the  p.d.  across  resistor  R3.  If  the
        total  resistance  of  the  circuit  is  100  ohms,
        determine  the  current  flowing  through  resistor  R1
        .  Find  also  the  value  of  resistor  R2
2
3  //initializing  the  variables :
4  V1 = 10;  //  in  volts
5  V2 = 4;  //  in  volts
6  Vt = 25;  //  in  volts
7  Rt = 100;  //  in  ohms
8
9  //calculation :
10  V3 = Vt - V1 - V2
11  I = Vt/Rt
12  R2 = V2/I
13
14  printf("\n\nResult\n\n")
15  printf("\n  (a) Voltage (V3)  %.0f  Volts (V)",V3)
16  printf("\n  (b) current  %.2f  Amperes (A)",I)
17  printf("\n  (c) Resistance (R2)  %.0f  Ohms",R2)
```

Scilab code Exa 5.03 Example 3

```
1  //Problem 5.03: A 12 V battery is connected in a
       circuit having three series−connected resistors
       having resistances of 4 ohms, 9 ohms and 11 ohms.
        Determine the current flowing through, and the p
       .d. across the 9 ohms resistor. Find also the
       power dissipated in the 11 ohms resistor.
2
3  //initializing the variables:
4  Vt = 12; // in volts
5  R1 = 4; // in ohms
6  R2 = 9; // in ohms
7  R3 = 11; // in ohms
8
9  //calculation:
10  Rt = R1 + R2 + R3
11  I = Vt/Rt
12  V9 = I*R2
13  P11 = I*I*R3
14
15  printf("\n\nResult\n\n")
16  printf("\n (a)current %.1f Amperes(A)",I)
17  printf("\n (b)Voltage(V2) %.1f Volts(V)",V9)
18  printf("\n (c)Power %.2f Watt(W)",P11)
```

Scilab code Exa 5.04 Example 4

```
1  //Problem 5.04:Determine the value of voltage V
       shown in Figure 5.6.
2
3  //initializing the variables:
4  Vt = 50; // in volts
5  R1 = 4; // in ohms
6  R2 = 6; // in ohms
7
8  //calculation:
```

```
9   Rt = R1 + R2
10  I = Vt/Rt
11  V2 = I*R2
12
13  printf("\n\nResult\n\n")
14  printf("\n Voltage(V) %.0f Volts(V)\n",V2)
```

Scilab code Exa 5.05 Example 5

```
1  //Problem 5.05:Two resistors are connected in series
        across a 24 V supply and a current of 3 A flows
       in the circuit. If one of the resistors has a
       resistance of 2 ohms determine (a) the value of
       the other resistor, and (b) the p.d. across the 2
         resistor. If the circuit is connected for 50
       hours, how much energy is used?
2
3  //initializing the variables:
4  Vt = 24; // in volts
5  R1 = 2; // in ohms
6  I = 3; // in Amperes
7  t = 50; // in hrs
8
9  //calculation:
10  V1 = I*R1
11  R2 = [Vt-(I*R1)]/I
12  E = Vt*I*t
13
14  printf("\n\nResult\n\n")
15  printf("\n (a)Voltage(V1) %.0f Volts(V)",V1)
16  printf("\n (b)Resistance(R2) %.0f Ohms",R2)
17  printf("\n (a)Energy(E) %.2E Wh",E)
```

Scilab code Exa 5.06 Example 6

```
1  //Problem 5.06:For the circuit shown in Figure 5.10,
      determine (a) the reading on the ammeter, and (b
      ) the value of resistor R2
2
3  //initializing the variables:
4  R1 = 5; // in ohms
5  R3 = 20; // in ohms
6  I1 = 8; // in Amperes
7  It = 11; // in Amperes
8
9  //calculation:
10 Vt = I1*R1
11 I3 = Vt/R3
12 R2 = Vt/[It - I1 - I3]
13
14 printf("\n\nResult\n\n")
15 printf("\n (a)Ammeter Reading %.0f Amperes(A)",I3)
16 printf("\n (b)Resistance(R2) %.0f Ohms\n",R2)
```

Scilab code Exa 5.07 Example 7

```
1  //Problem 5.07: Two resistors, of resistance 3 ohms
      and 6 ohms, are connected in parallel across a
      battery having a voltage of 12 V. Determine (a)
      the total circuit resistance and (b) the current
      flowing in the 3 ohms resistor.
2
3  //initializing the variables:
4  R1 = 3; // in ohms
5  R2 = 6; // in ohms
6  Vt = 12; // in volts
7
8  //calculation:
```

```
9   Rt = R1*R2/[R1 + R2]
10  I1 = [Vt/R1]
11
12  printf("\n\nResult\n\n")
13  printf("\n (a)Total Resistance %.0f Ohms",Rt)
14  printf("\n (b)Current(I1) %.0f Amperes(A)\n",I1)
```

Scilab code Exa 5.08 Example 8

```
1  //Problem 5.08: For the circuit shown in Figure
       5.12, find (a) the value of the supply voltage V
       and (b) the value of current I.
2
3  //initializing the variables:
4  R1 = 10; // in ohms
5  R2 = 20; // in ohms
6  R3 = 60; // in ohms
7  I2 = 3; // in Amperes
8
9  //calculation:
10 Vt = I2*R2
11 I1 = Vt/R1
12 I3 = Vt/R3
13 I = I1 +I2 + I3
14
15 printf("\n\nResult\n\n")
16 printf("\n (a)Voltage(V) %.0f Volts(V)",Vt)
17 printf("\n (b)Total Current(I) %.0f Amperes(A)",I)
```

Scilab code Exa 5.10 Example 10

```
1  //Problem 5.10: Find the equivalent resistance for
       the circuit shown in Figure 5.17.
```

```
 2
 3  //initializing the variables:
 4  R1 = 1; // in ohms
 5  R2 = 2.2; // in ohms
 6  R3 = 3; // in ohms
 7  R4 = 6; // in ohms
 8  R5 = 18; // in ohms
 9  R6 = 4; // in ohms
10
11
12  //calculation:
13  R0 = 1/[(1/3) + (1/6) + (1/18)]
14  Rt = R1 + R2 + R0 + R6
15
16  printf("\n\nResult\n\n")
17  printf("\n Equivalent Resistance %.0f Ohms\n",Rt)
```

Scilab code Exa 5.11 Example 11

```
 1  //Problem 5.11: For the series−parallel arrangement
        shown in Figure 5.19, find (a) the supply current
        , (b) the current flowing through each resistor
        and (c) the p.d. across each resistor.
 2
 3  //initializing the variables:
 4  R1 = 2.5; // in ohms
 5  R2 = 6; // in ohms
 6  R3 = 2; // in ohms
 7  R4 = 4; // in ohms
 8  Vt = 200; // in volts
 9
10  //calculation:
11  R0 = 1/[(1/R2) + (1/R3)]
12  Rt = R1 + R0 + R4
13  It = Vt/Rt
```

```
14  I1 = It
15  I4 = It
16  I2 = R3*It/(R3+R2)
17  I3 = It - I2
18  V1 = I1*R1
19  V2 = I2*R2
20  V3 = I3*R3
21  V4 = I4*R4
22
23  printf("\n\nResult\n\n")
24  printf("\n (a)Total Current Supply %.0f Amperes(A)",
        It)
25  printf("\n (b)Current through resistors (R1, R2, R3,
        R4)%.0f, %.2f, %.2f, %.0f Amperes(A)
        respectively",I1, I2, I3, I4)
26  printf("\n (c)voltage across resistors (R1, R2, R3,
        R4)%.1f, %.1f, %.1f, %.0f Volts(V) respectively",
        V1, V2, V3, V4)
```

Scilab code Exa 5.12 Example 12

```
1  //Problem 5.12: For the circuit shown in Figure 5.21
       calculate (a) the value of resistor Rx such that
       the total power dissipated in the circuit is 2.5
       kW, and (b) the current flowing in each of the
       four resistors.
2
3  //initializing the variables:
4  R1 = 15; // in ohms
5  R2 = 10; // in ohms
6  R3 = 38; // in ohms
7  Vt = 250; // in volts
8  P = 2500; // in Watt
9
10 //calculation:
```

```
11  It = P/Vt
12  I2 = R1*It/(R1+R2)
13  I1 = It - I2
14  Re1 = 1/[(1/R1) + (1/R2)]
15  Rt = Vt/It
16  Re2 = Rt - Re1
17  Rx = 1/[(1/Re2) - (1/R3)]
18  I4 = R3*It/(R3+Rx)
19  I3 = It - I4
20
21  printf("\n\nResult\n\n")
22  printf("\n (a)Resistance (Rx) %.0f Ohms",Rx)
23  printf("\n (b)Current through resistors (R1, R2, R3,
        R4): %.0f, %.0f, %.0f, %.0f Amperes(A)
        respectively",I1, I2, I3, I4)
```

Scilab code Exa 5.13 Example 13

```
1  //Problem 5.13: For the arrangement shown in Figure
       5.22, find the current Ix
2
3  //initializing the variables:
4  R1 = 8; // in ohms
5  R2 = 2; // in ohms
6  R3 = 1.4; // in ohms
7  R4 = 9; // in ohms
8  R5 = 2; // in ohms
9  Vt = 17; // in volts
10
11  //calculation:
12  R01 = R1*R2/(R1 + R2)
13  R02 = R01 + R3
14  R03 = R4*R02/(R4 +R02)
15  Rt = R5 + R03
16  It = Vt/Rt
```

```
17  I1 = R4*It/(R4 + R02)
18  Ix = R2*I1/(R1 + R2)
19
20  printf("\n\nResult\n\n")
21  printf("\n Current(Ix) %.1f Amperes(A)\n",Ix)
```

Scilab code Exa 5.14 Example 14

```
1  //Problem 5.14: If three identical lamps are
       connected in parallel and the combined resistance
        is 150 ohms, find the resistance of one lamp.
2
3  //initializing the variables:
4  Rt = 150; // in ohms
5  n = 3; // no. of identical lamp
6
7  //calculation:
8  R = Rt*3 // (1/Rt)=(1/R)+(1/R)+(1/R)
9
10  printf("\n\nResult\n\n")
11  printf("\n Resistance %.0f Ohms\n",R)
```

Scilab code Exa 5.15 Example 15

```
1  //Problem 5.15: Three identical lamps A, B and C are
       connected in series across a 150 V supply. State
        (a) the voltage across each lamp, and (b) the
       effect of lamp C failing.
2
3  //initializing the variables:
4  //series connection
5  n = 3; // no. of identical lamp
6  Vt = 150; // in volts
```

```
7
8  // calculation:
9  V = Vt/3  // Since each lamp is identical, then V
       volts across each.
10
11  printf("\n\nResult\n\n")
12  printf("\n Voltage across each resistor = %.0f Volts
       (V)",V)
```

Chapter 6

Capacitors and capacitance

Scilab code Exa 6.01 Example 1

```
1 //Problem 6.01:(a) Determine the p.d. across a 4  F
       capacitor when charged with 5 mC. (b) Find the
      charge on a 50 pF capacitor when the voltage
      applied to it is 2 kV.
2
3 //initializing the variables:
4 C1 = 4E-6; // in Farad
5 C2 = 50E-12; // in Farad
6 Q1 = 5E-3; // in Coulomb
7 V2 = 2000; // in volts
8
9 //calculation:
10 V1 = Q1/C1
11 Q2 = C2*V2
12
13 printf("\n\nResult\n\n")
14 printf("\n (a)P.d %.0f  Volts(V)",V1)
15 printf("\n (b)Charge(Q) %.2E Coulomb(C)",Q2)
```

Scilab code Exa 6.02 Example 2

```scilab
1  //Problem  6.02: A  direct  current  of 4 A flows  into  a
        previously  uncharged  20   F  capacitor  for  3 ms.
      Determine  the  pd  between  the  plates.
2
3  //initializing  the  variables:
4  I = 4; // in  amperes
5  C = 20E-6; // in  Farad
6  t = 3E-3; // in  sec
7
8  //calculation:
9  Q = I*t
10 V = Q/C
11
12 printf(")\n\nResult\n\n")
13 printf(")\n  (a)P.d %.0f  Volts(V)\n",V)
```

Scilab code Exa 6.03 Example 3

```scilab
1  //Problem  6.03:A 5   F  capacitor  is  charged  so  that
        the  pd  between  its  plates  is  800 V.  Calculate  how
         long  the  capacitor  can  provide  an  average
        discharge  current  of 2 mA.
2
3  //initializing  the  variables:
4  I = 2E-3; // in  amperes
5  C = 5E-6; // in  Farad
6  V = 800; // in  volts
7
8  //calculation:
9  Q = C*V
10 t = Q/I
11
12 printf(")\n\nResult\n\n")
```

```
13  printf("\n capacitor can provide an average
        discharge current of 2mA for %.0f Sec\n",t)
```

Scilab code Exa 6.04 Example 4

```
1  //Problem 6.04: Two parallel rectangular plates
       measuring 20 cm by 40 cm carry an electric charge
        of 0.2  C. Calculate the electric flux density.
        If the plates are spaced 5 mm apart and the
       voltage between them is 0.25 kV determine the
       electric field strength.
2
3  //initializing the variables:
4  Q = 0.2E-6; // in Coulomb
5  A = 800E-4; // in m2
6  d = 0.005; // in m
7  V = 250; // in Volts
8
9  //calculation:
10  D = Q/A
11  E = V/d
12
13  printf("\n\nResult\n\n")
14  printf("\n (a)Electric flux density D %.2E C/m2",D)
15  printf("\n (b)Electric field strength E %.2E V/m\n",
       E)
```

Scilab code Exa 6.05 Example 5

```
1  //Problem 6.05: The flux density between two plates
       separated by mica of relative permittivity 5 is 2
        C /m2. Find the voltage gradient between the
       plates.
```

```
2
3  // initializing the variables :
4  D = 2E-6; // in   C /m2
5  e0 = 8.85E-12; // in F/m
6  er = 5;
7
8  // calculation :
9  E = D/(e0*er)
10
11 printf("\n\nResult\n\n")
12 printf("\n Electric field strength E %.2E V/m\n",E)
```

Scilab code Exa 6.06 Example 6

```
1  //Problem 6.06: Two parallel plates having a pd of
      200 V between them are spaced 0.8 mm apart. What
      is the electric field strength? Find also the
      flux density when the dielectric between the
      plates is (a) air, and (b) polythene of relative
      permittivity 2.3
2
3  // initializing the variables :
4  d = 0.8E-3; // in m
5  e0 = 8.85E-12; // in F/m
6  era = 1; // for air
7  erp = 2.3; // for polythene
8  V =200; // in Volts
9
10 // calculation :
11 E = V/d
12 //for air
13 Da = E*e0*era
14 //for polythene
15 Dp = E*e0*erp
16 printf("\n\nResult\n\n")
```

```
17  printf("\n (a) Electric  flux  density  for  air %.2E C/
        m2",Da)
18  printf("\n (b) Electric  flux  density  for  polythene  %
        .2E  C/m2\n",Dp)
```

Scilab code Exa 6.07 Example 7

```
1  //Problem  6.07:  (a) A  ceramic  capacitor  has  an
        effective  plate  area  of  4 cm2  separated  by  0.1 mm
         of  ceramic  of  relative  permittivity  100.
        Calculate  the  capacitance  of  the  capacitor  in
        picofarads. (b) If  the  capacitor  in  part  (a) is
        given  a  charge  of  1.2  C  what  will  be  the  pd
        between  the  plates?
2
3  //initializing  the  variables:
4  A = 4E-4; // in  m2
5  d = 0.1E-3; // in  m
6  e0 = 8.85E-12; // in  F/m
7  er = 100;
8  Q = 1.2E-6; // in  coulomb
9
10 //calculation:
11 C = e0*er*A/d
12 V = Q/C
13
14 printf("\n\nResult\n\n")
15 printf("\n (a) Capacitance  %.2E F",C)
16 printf("\n (b)P.d.= %.0f  Volts(V)\n",V)
```

Scilab code Exa 6.08 Example 8

```
1  //Problem 6.08: A waxed paper capacitor has two
       parallel plates, each of effective area 800 cm2.
       If the capacitance of the capacitor is 4425 pF
       determine the effective thickness of the paper if
       its relative permittivity is 2.5
2
3  //initializing the variables:
4  A = 800E-4; // in m2
5  C = 4425E-12; // in Farads
6  e0 = 8.85E-12; // in F/m
7  er = 2.5;
8
9  //calculation:
10 d = e0*er*A/C
11
12 printf("\n\nResult\n\n")
13 printf("\n Thickness  %.2E m\n",d)
```

Scilab code Exa 6.09 Example 9

```
1  //Problem 6.09: A parallel plate capacitor has
       nineteen interleaved plates each 75 mm by 75 mm
       separated by mica sheets 0.2 mm thick. Assuming
       the relative permittivity of the mica is 5,
       calculate the capacitance of the capacitor.
2
3  //initializing the variables:
4  n = 19; // no. of plates
5  L = 75E-3; // in m
6  B = 75E-3; // in m
7  d = 0.2E-3; // in m
8  e0 = 8.85E-12; // in F/m
9  er = 5;
10
11 //calculation:
```

```
12  A = L*B
13  C = e0*er*A*(n-1)/d
14
15  printf("\n\nResult\n\n")
16  printf("\n Capacitance %.2E F\n",C)
```

Scilab code Exa 6.10 Example 10

```
1  //Problem 6.10: Calculate the equivalent capacitance
        of two capacitors of 6  F and 4  F connected (
     a) in parallel and (b) in series
2
3  //initializing the variables:
4  C1 = 6E-6; // in Farads
5  C2 = 4E-6; // in Farads
6
7  //calculation:
8  // in Parallel
9  Cp = C1 +C2
10 // in Series
11 Cs = 1/[(1/C1) + (1/C2)]
12
13 printf("\n\nResult\n\n")
14 printf("\n (a)Capacitance in  parallel %.2E F",Cp)
15 printf("\n (b)Capacitance in  Series %.2E F\n",Cs)
```

Scilab code Exa 6.11 Example 11

```
1  //Problem 6.11: What capacitance must be connected
     in series with a 30  F capacitor for the
     equivalent capacitance to be 12  F ?
2
3  //initializing the variables:
```

```
4  C1 = 30E-6; // in Farads
5  Cs = 12E-6; // in Farads
6
7  //calculation :
8  // in Series
9  C2 = 1/[(1/Cs) - (1/C1)]
10
11 printf("\n\nResult\n\n")
12 printf("\n (a)Capacitance in series %.2E F\n",C2)
```

Scilab code Exa 6.12 Example 12

```
1  //Problem 6.12: Capacitances of 1  F , 3  F , 5   F
      and 6   F  are connected in parallel to a direct
      voltage supply of 100 V. Determine (a) the
      equivalent circuit capacitance , (b) the total
      charge and (c) the charge on each capacitor .
2
3  //initializing the variables :
4  C1 = 1E-6; // in Farads
5  C2 = 3E-6; // in Farads
6  C3 = 5E-6; // in Farads
7  C4 = 6E-6; // in Farads
8  Vt = 100; // in Volts
9
10 //calculation :
11 // in Parallel
12 Cp = C1 + C2 + C3 + C4
13 Qt = Vt*Cp
14 Q1 = C1*Vt
15 Q2 = C2*Vt
16 Q3 = C3*Vt
17 Q4 = C4*Vt
18
19 printf("\n\nResult\n\n")
```

```
20  printf("\n (a)Equivalent Capacitance in Parallel %.2
       E F",Cp)
21  printf("\n (b)Total charge %.2E C",Qt)
22  printf("\n (c)Charge on each capacitors (C1, C2, C3,
       C4) %.2E C, %.2E C, %.2E C, %.2E C respectively"
       ,Q1,Q2,Q3,Q4)
```

Scilab code Exa 6.13 Example 13

```
1  //Problem 6.13: Capacitances of 3 F , 6  F and 12
        F  are connected in series across a 350 V supply
       . Calculate (a) the equivalent circuit
      capacitance , (b) the charge on each capacitor and
       (c) the pd across each capacitor .
2
3  //initializing the variables :
4  C1 = 3E-6; // in Farads
5  C2 = 6E-6; // in Farads
6  C3 = 12E-6; // in Farads
7  Vt = 350; // in Volts
8
9  //calculation :
10 // in series
11 Cs = 1/[(1/C1) + (1/C2) + (1/C3)]
12 Qt = Vt*Cs
13 V1 = Qt/C1
14 V2 = Qt/C2
15 V3 = Qt/C3
16
17 printf("\n\nResult\n\n")
18 printf("\n (a)Equivalent Capacitance in Series %.2E
       F",Cs)
19 printf("\n (b)Charge on each capacitors (C1, C2, C3)
        %.2E C",Qt)
20 printf("\n (b)P.d Across each capacitors (C1, C2, C3
```

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```
    ) %.0 f  V,  %.0 f  V,  %.0 f  V  respectively",V1,  V2,  V3
    )
```

Scilab code Exa 6.14 Example 14

```
1  //Problem  6.14:  A  capacitor  is  to  be  constructed  so
     that  its  capacitance  is  0.2   F  and  to  take  a  p.d
     .  of  1.25  kV  across  its  terminals.  The  dielectric
      is  to  be  mica  which,  after  allowing  a  safety
     factor  of  2,  has  a  dielectric  strength  of  50  MV/m
     .  Find  (a)  the  thickness  of  the  mica  needed,  and
     (b)  the  area  of  a  plate  assuming  a  two-plate
     construction.  (Assume  r  for  mica  to  be  6)
2
3  //initializing  the  variables:
4  C  =  0.2E-6;  //  in  Farads
5  V  =  1250;  //  in  Volts
6  E   =  50E6;  //  in  V/m
7  e0  =  8.85E-12;  //  in  F/m
8  er  =  6;
9
10 //calculation:
11 d  =  V/E
12 A  =  C*d/e0/er
13
14 printf("\n\nResult\n\n")
15 printf("\n  (a)Thickness  %.2E  m",d)
16 printf("\n  (b)Area  of  plate  is  %.2E  m2  \n",A)
```

Scilab code Exa 6.15 Example 15

```
1 //Problem 6.15: (a) Determine the energy stored in a
      3  F capacitor when charged to 400 V. (b) Find
      also the average power developed if this energy
      is dissipated in a time of 10   s
2
3 //initializing the variables:
4 C = 3E-6; // in Farads
5 V = 400; // in Volts
6 t = 10E-6; // in secs
7
8 //calculation:
9 W = C*V*V/2
10 P = W/t
11
12 printf("\n\nResult\n\n")
13 printf("\n (a)Energy stored %.2f J",W)
14 printf("\n (b)Power developed %.2E W ",P)
```

Scilab code Exa 6.16 Example 16

```
1 //Problem 6.16: A 12   F capacitor is required to
      store 4 J of energy. Find the pd to which the
      capacitor must be charged.
2
3 //initializing the variables:
4 C = 12E-6; // in Farads
5 W = 4; // in Joules
6
7 //calculation:
8 V = (2*W/C)^0.5
9
10 printf("\n\nResult\n\n")
11 printf("\n P.d %.1f V\n",V)
```

Scilab code Exa 6.17 Example 17

```
1  //Problem  6.17:  A  capacitor  is  charged  with  10  mC.
       If  the  energystored  is  1.2  J  find  (a)  the  voltage
        and  (b)  the  capacitance.
2
3  //initializing  the  variables:
4  W  =  1.2;  //  in  Joules
5  Q  =  10E-3;  //  in  Coulomb
6
7  //calculation:
8  V  =  2*W/Q
9  C  =  Q/V
10
11  printf("\n\nResult\n\n")
12  printf("\n  (a)P.d  %.0f  V",V)
13  printf("\n  (b)Capacitance  %.2E  F\n",C)
```

Chapter 7

Magnetic circuits

Scilab code Exa 7.01 Example 1

```
1 //Problem 7.01: A magnetic pole face has a
      rectangular section having dimensions 200 mm by
      100 mm. If the total flux emerging from the pole
      is 150 Wb, calculate the flux density.
2
3 //initializing the variables:
4 Phi = 150E-6; // in Wb
5 l = 200E-3; // in m
6 b = 100E-3; // in m
7
8 //calculation:
9 A = l*b
10 B = Phi/A
11
12 printf("\n\nResult\n\n")
13 printf("\n Flux density %.2E T\n",B)
```

Scilab code Exa 7.02 Example 2

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```
1  //Problem 7.02: The maximum working flux density of
       a lifting electromagnet is 1.8 T and the
       effective area of a pole face is circular in
       cross-section. If the total magnetic flux
       produced is 353 mWb, determine the radius of the
       pole face.
2
3  //initializing the variables:
4  Phi = 353E-3; // in Wb
5  B = 1.8; // in tesla
6  Pi = 3.14;
7
8  //calculation:
9  A = Phi/B
10 r = (A/Pi)^0.5
11
12 printf("\n\nResult\n\n")
13 printf("\n radius of the pole face is %.2E m\n",r)
```

Scilab code Exa 7.03 Example 3

```
1  //Problem 7.03: A magnetizing force of 8000 A/m is
       applied to a circular magnetic circuit of mean
       diameter 30 cm by passing a current through a
       coil wound on the circuit. If the coil is
       uniformly wound around the circuit and has 750
       turns, find the current in the coil.
2
3  //initializing the variables:
4  H = 8000; // in A/m
5  d = 0.30; // in m
6  N = 750; // no. of turns
7  Pi = 3.14;
8
9  //calculation:
```

```
10  l = Pi*d
11  I = H*l/N
12
13  printf("\n\nResult\n\n")
14  printf("\n current I = %.2f Ampere(A)\n",I)
```

Scilab code Exa 7.04 Example 4

```
1  //Problem 7.04: A flux density of 1.2 T is produced
      in a piece of cast steel by a magnetizing force
      of 1250 A/m. Find the relative permeability of
      the steel under these conditions.
2
3  //initializing the variables:
4  B = 1.2; // in Tesla
5  H = 1250; // in A/m
6  Pi = 3.14;
7  u0 = 4*Pi*1E-7;
8
9  //calculation:
10  ur = B/(u0*H)
11
12  printf("\n\nResult\n\n")
13  printf("\n relative permeability of the steel = %.0f
      \n",ur)
```

Scilab code Exa 7.05 Example 5

```
1  //Problem 7.05: Determine the magnetic field
      strength and the mmf required to produce a flux
      density of 0.25 T in an air gap of length 12 mm.
2
3  //initializing the variables:
```

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```
4 B = 0.25; // in Tesla
5 u0 = 4*%pi*1E-7;
6 l = 12E-3; // in m
7
8 //calculation:
9 H = B/u0
10 mmf = H*l
11
12 printf("\n\nResult\n\n")
13 printf("\n (a)Magnetic field strength H = %.0f A/m",
    H)
14 printf("\n (b)mmf = %.0f A\n",mmf)
```

Scilab code Exa 7.06 Example 6

```
1 //Problem 7.06: A coil of 300 turns is wound
    uniformly on a ring of non−magnetic material. The
     ring has a mean circumference of 40 cm and a
    uniform cross sectional area of 4 cm2. If the
    current in the coil is 5 A, calculate (a) the
    magnetic field strength, (b) the flux density and
     (c) the total magnetic flux in the ring.
2
3 //initializing the variables:
4 N = 300; // no. of turns
5 l = 0.40; // in m
6 A = 4E-4; // in m2
7 I = 5; // in Amperes
8 u0 = 4*%pi*1E-7;
9 ur = 1
10 //calculation:
11 H = N*I/l
12 B = u0*ur*H
13 Phi = B*A
14
```

```
15  printf("\n\nResult\n\n")
16  printf("\n (a)Magnetic field strength H = %.0f A/m
        \",H)
17  printf("\n (b)Flux Density = %.2E T",B)
18  printf("\n (c)total magnetic flux = %.2E Wb",Phi)
```

Scilab code Exa 7.07 Example 7

```
1  //Problem 7.07: An iron ring of mean diameter 10 cm
       is uniformly wound with 2000 turns of wire. When
        a current of 0.25 A is passed through the coil a
        flux density of 0.4 T is set up in the iron. Find
        (a) the magnetizing force and (b) the relative
        permeability of the iron under these conditions.
2
3  //initializing the variables:
4  N = 2000; // no. of turns
5  d = 0.10; // in m
6  B = 0.4; // in Tesla
7  I = 0.25; // in Amperes
8  u0 = 4*%pi*1E-7;
9
10 //calculation:
11 l = %pi*d
12 H = N*I/l
13 ur = B/(u0*H)
14
15 printf("\n\nResult\n\n")
16 printf("\n (a)Magnetic field strength H = %.0f A/m",
       H)
17 printf("\n (b)relative permeability of the iron = %
       .0f ",ur)
```

Scilab code Exa 7.08 Example 8

```scilab
1  //Problem 7.08: A uniform ring of cast iron has a
       cross-sectional area of 10 cm2 and a mean
       circumference of 20 cm. Determine the mmf
       necessary to produce a flux of 0.3 mWb in the
       ring.
2
3  //initializing the variables:
4  A = 10E-4; // in m2
5  l = 0.20; // in m
6  Phi = 0.3E-3; // in Wb
7  u0 = 4*%pi*1E-7;
8
9  //calculation:
10  B = Phi/A
11  // from the magnetisation curve, corresponding the
       value of B
12  H = 1000
13  mmf = H*l
14  printf("\n\nResult\n\n")
15  printf("\n (a)mmf = %.0f A\n",mmf)
```

Scilab code Exa 7.09 Example 9

```scilab
1  //Problem 7.09: Determine the reluctance of a piece
       of mumetal of  length 150 mm and cross-sectional
       area 1800 mm2 when the relative permeability is
       4000. Find also the absolute permeability of the
       mumetal.
2
3  //initializing the variables:
4  A = 18E-4; // in m2
5  l = 0.15; // in m
6  u0 = 4*%pi*1E-7;
```

```
7  ur = 4000;
8
9  //calculation:
10 S = l/(u0*ur*A)
11 u = u0*ur
12
13 printf("\n\nResult\n\n")
14 printf("\n (a)Reluctance  S = %.0f  /H",S)
15 printf("\n (b)Absolute  permeability,      = %.2E H/m\n
      ",u)
```

Scilab code Exa 7.10 Example 10

```
1  //Problem  7.10: A mild  steel  ring  has  a radius  of 50
       mm and  a crosssectional  area  of 400 mm2. A
       current  of 0.5 A flows  in  a coil  wound  uniformly
       around  the  ring  and  the  flux  produced  is 0.1 mWb.
        If  the  relative  permeability  at  this  value  of
       current  is 200 find  (a)  the  reluctance  of  the
       mild  steel  and  (b)  the  number  of  turns  on  the
       coil.
2
3  //initializing  the  variables:
4  A = 4E-4;  // in m2
5  r = 0.05;  // in m
6  I = 0.5;  // in Amperes
7  Phi = 0.1E-3;  // in Wb
8  u0 = 4*%pi*1E-7;
9  ur = 200;
10
11 //calculation:
12 l = 2*%pi*r
13 S = l/(u0*ur*A)
14 N = S*Phi/I
15
```

```
16  printf("\n\nResult\n\n")
17  printf("\n (a)Reluctance S = %.2E /H",S)
18  printf("\n (b)number of turns on the coil = %.0f ",N
        )
```

Scilab code Exa 7.11 Example 11

```
1  //Problem 7.11: A closed magnetic circuit of cast
       steel contains a 6 cm long path of cross−
       sectional area 1 cm2 and a 2 cm path of cross−
       sectional area 0.5 cm2. A coil of 200 turns is
       wound around the 6 cm length of the circuit and a
        current of 0.4 A flows. Determine the flux
       density in the 2 cm path, if the relative
       permeability of the cast steel is 750.
2
3  //initializing the variables:
4  A1 = 1E-4; // in m2
5  A2 = 0.5E-4; // in m2
6  l1 = 0.06; // in m
7  l2 = 0.02; // in m
8  N1 = 200; // no. of turns about 6 cm coil
9  I = 0.4; // in Amperes
10 u0 = 4*%pi*1E-7;
11 ur = 750;
12
13 //calculation:
14 //Reluctance
15 S1 = l1/(u0*ur*A1) // for 6 cm
16 S2 = l2/(u0*ur*A2) // for 2 cm
17 St = S1 + S2
18 Phi = N1*I/St
19 B2 = Phi/A2
20
21 printf("\n\nResult\n\n")
```

```
22  printf("\n flux density in the 2 cm path = %.2f T\n"
       ,B2)
```

Scilab code Exa 7.12 Example 12

```
1  //Problem 7.12: A silicon iron ring of cross-
       sectional area 5 cm2 has a radial air gap of 2 mm
        cut into it. If the mean length of the silicon
       iron path is 40 cm, calculate the magnetomotive
       force to produce a flux of 0.7 mWb.
2
3  //initializing the variables:
4  A = 5E-4; // in m2
5  l = 0.4; // in m
6  r = 2E-3; // in m
7  u0 = 4*%pi*1E-7;
8  Phi = 0.7E-3; // in Wb
9
10  //calculation:
11  //For the silicon iron:
12  B = Phi/A
13  //From the B H curve for silicon iron,
       corresponding to value of B
14  Hs = 1650
15  mmfs = Hs*l
16  //For the air gap:
17  Ha = B/u0
18  mmfa = Ha*r
19  mmft = mmfs + mmfa
20
21  printf("\n\nResult\n\n")
22  printf("\n Total mmf to produce a flux of 0.7 mWb =
       %.0f A\n",mmft)
```

Scilab code Exa 7.13 Example 13

```
1  //Problem 7.13: Figure 7.4 shows a ring formed with
       two differentmaterials cast steel and mild
       steel. The dimensions are:
2  //                             mean length          cross-
       sectional area
3  //    Mild steel              400 mm
       500 mm2
4  //    Cast steel              300 mm
       312.5 mm2
5  //Find the total mmf required to cause a flux of 500
        Wb in the magnetic circuit. Determine also the
        total circuit reluctance.
6
7  //initializing the variables:
8  A1 = 5E-4; // in m2
9  A2 = 3.125E-4; // in m2
10 l1 = 0.4; // in m
11 l2 = 0.3; // in m
12 u0 = 4*%pi*1E-7;
13 Phi = 0.5E-3; // in Wb
14
15 //calculation:
16 //For the mild steel:
17 B1 = Phi/A1
18 //From the B H curve for Mild steel, corresponding
        to value of B
19 Hm = 1400
20 mmfm = Hm*l1
21 //For the cast steel:
22 B2 = Phi/A2
23 //From the B H curve for cast steel steel,
       corresponding to value of B
```

```
24  Hc = 4800
25  mmfc = Hc*l2
26  mmft = mmfm + mmfc
27  //Reluctance
28  S = mmft/Phi
29
30  printf("\n\nResult\n\n")
31  printf("\n Total mmf to produce a flux of 0.5 mWb =
        %.0f A",mmft)
32  printf("\n Total circuit reluctance = %.2E /H",S)
```

Scilab code Exa 7.14 Example 14

```
1  //Problem 7.14: A section through a magnetic circuit
        of uniform cross-sectional area 2 cm2 is shown
      in Figure 7.5. The cast steel core has a mean
      length of 25 cm. The air gap is 1 mm wide and the
       coil has 5000 turns. The B H curve for cast
      steel is shown on page 78. Determine the current
      in the coil to produce a flux density of 0.80 T
      in the air gap, assuming that all the flux passes
       through both parts of the magnetic circuit.
2
3  //initializing the variables:
4  A = 2E-4; // in m2
5  l1 = 0.25; // in m
6  l2 = 0.001; // in m
7  u0 = 4*%pi*1E-7;
8  N = 5000; // no. of turns
9  B = 0.8; // in tesla
10 ua = 1; // for air
11
12 //calculation:
13 //for the core
14 //From the B H curve for Mild steel, corresponding
```

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```scilab
       to value of B = 0.8
15  H = 750
16  ur = B/(u0*H)
17  S1 = l1/(u0*ur*A)
18  //For the air gap:
19  S2 = l2/(u0*ua*A)
20  St = S1 + S2
21  //flux
22  Phi = B*A
23  //current
24  I = St*Phi/N
25
26  printf("\n\nResult\n\n")
27  printf("\n current = %.3f A",I)
```

Chapter 8

Electromagnetism

Scilab code Exa 8.02 Example 2

```
1  //Problem  8.02:  A  conductor  carries  a  current  of  20
      A  and  is  at  rightangles  to  a  magnetic  field
      having  a  flux  density  of  0.9  T.  If  the  length  of
      the  conductor  in  the  field  is  30  cm,  calculate
      the  force  acting  on  the  conductor.  Determine  also
       the  value  of  the  force  if  the  conductor  is
      inclined  at  an  angle  of  30   to  the  direction  of
      the  field.
2
3  //initializing  the  variables:
4  B = 0.9;  //  in  tesla
5  I = 20;  //  in  Amperes
6  l = 0.30;  //  in  m
7  alpha = 30;  //  in  degree
8  u0 = 4*%pi*1E-7;
9
10 //calculation:
11 F1 = B*I*l
12 F2 = B*I*l*sin(alpha*%pi/180)
13
14 printf("\n\nResult\n\n")
```

```
15  printf("\n (a) Force when the conductor is at right
        angles to the field = %.1f N",F1)
16  printf("\n (b) Force when the conductor is at 30
        angle to the field = %.1f N",F2)
```

Scilab code Exa 8.03 Example 3

```
1  //Problem 8.03: Determine the current required in a
       400 mm length of conductor of an electric motor,
       when the conductor is situated at right−angles to
        a magnetic field of flux density 1.2 T, if a
       force of 1.92 N is to be exerted on the conductor
        .
2
3  //initializing the variables:
4  F = 1.92; // in newton
5  B = 1.2; // in tesla
6  l = 0.40; // in m
7  u0 = 4*%pi*1E-7;
8
9  //calculation:
10  I = F/(B*l)
11
12  printf("\n\nResult\n\n")
13  printf("\n (a) Current I = %.0f Amperes(A)",I)
```

Scilab code Exa 8.04 Example 4

```
1  //Problem 8.04: A conductor 350 mm long carries a
       current of 10 A and is at right−angles to a
       magnetic field lying between two circular pole
       faces each of radius 60 mm. If the total flux
```

```
          between the pole faces is 0.5 mWb, calculate the
          magnitude of the force exerted on the conductor.
2
3  //initializing the variables:
4  r = 0.06; // in m
5  I = 10; // in Amperes
6  l = 0.35; // in m
7  Phi = 0.5E-3; // in Wb
8  u0 = 4*%pi*1E-7;
9
10 //calculation:
11 A = %pi*r*r
12 B = Phi/A
13 F = B*I*l
14
15 printf("\n\nResult\n\n")
16 printf("\n (a)Force F = %.3f N\n",F)
```

Scilab code Exa 8.06 Example 6

```
1  //Problem 8.06: A coil is wound on a rectangular
          former of width 24 mm and length 30 mm. The
          former is pivoted about an axis passing through
          the middle of the two shorter sides and is placed
           in a uniform magnetic field of flux density 0.8
          T, the axis being perpendicular to the field. If
          the coil carries a current of 50 mA, determine
          the force on each coil side (a) for a single-turn
           coil, (b) for a coil wound with 300 turns.
2
3  //initializing the variables:
4  N1 = 1; // for a single-turn coil
5  N2 = 300; // no. of turns
6  b = 0.024; // in m
7  B = 0.8; // in Tesla
```

```
8  I = 0.05; // in Amperes
9  l = 0.030; // in m
10 u0 = 4*%pi*1E-7;
11
12 //calculation:
13 //For a single-turn coil,
14 F1 = N1*B*I*l
15 //for a coil wound with 300 turns.
16 F2 = N2*B*I*l
17
18 printf("\n\nResult\n\n")
19 printf("\n (a)For a single-turn coil, force on each
       coil side = %.4f N",F1)
20 printf("\n (b)For a 300-turn coil, force on each
       coil side = %.2f N",F2)
```

Scilab code Exa 8.07 Example 7

```
1  //Problem 8.07: An electron in a television tube has
       a charge of 1.6    1019 coulombs and travels at
       3     107 m/s perpendicular to a field of flux
       density 18.5   T. Determine the force exerted on
       the electron in the field.
2
3  //initializing the variables:
4  Q = 1.6E-19; // in Coulomb
5  v = 3E7; // in m/s
6  B = 18.5E-6; // in Tesla
7  u0 = 4*%pi*1E-7;
8
9  //calculation:
10 F = Q*v*B
11
12 printf("\n\nResult\n\n")
13 printf("\n Force exerted on the electron in the
```

field . = %.2E N",F)

Chapter 9

Electromagnetic induction

Scilab code Exa 9.01 Example 1

```
1 //Problem 9.01: A conductor 300 mm long moves at a
      uniform speed of 4 m/s at right-angles to a
      uniform magnetic field of flux density 1.25 T.
      Determine the current flowing in the conductor
      when (a) its ends are open-circuited, (b) its
      ends are connected to a load of 20 ohm resistance
      .
2
3 //initializing the variables:
4 l = 0.3; // in m
5 v = 4; // in m/s
6 B = 1.25; // in Tesla
7 R = 20; // in ohms
8 u0 = 4*%pi*1E-7;
9
10 //calculation:
11 E = B*l*v
12 I2 = E/R
13
14 printf("\n\nResult\n\n")
15 printf("\n (a)If the ends of the conductor are open
```

```
          circuited  no  current  will  flow  even  though  %.1f V
             has  been  induced",E)
16  printf("\n  (b)From  O h m  s  law ,  I  = %.3 f  Ampere",I2)
```

Scilab code Exa 9.02 Example 2

```
1  //Problem  9.02:  At  what  velocity  must  a  conductor  75
       mm long  cut  a  magnetic  field  of  flux  density  0.6
        T  if  an  e.m.f.  of  9 V  is  to  be  induced  in  it ?
       Assume  the  conductor ,  the  field  and  the  direction
        of  motion  are  mutually  perpendicular .
2
3  // initializing  the  variables :
4  l = 0.075;  //  in  m
5  E = 9;  //  in  Volts
6  B = 0.6;  //  in  Tesla
7  R = 20;  //  in  ohms
8  u0 = 4*%pi*1E-7;
9
10  // calculation :
11  v = E/(B*l)
12
13  printf("\n\nResult\n\n")
14  printf("\n  velocity  v  = %.0 f  m/s\n",v)
```

Scilab code Exa 9.03 Example 3

```
1  //Problem  9.03:  A  conductor  moves  with  a  velocity  of
        15  m/s  at  an  angle  of  (a)  90   ,  (b)  60     and  (c)
        30     to  a  magnetic  field  produced  between  two
       square-faced  poles  of  side  length  2  cm.  If  the
       flux  leaving  a  pole  face  is  5  Wb ,  find  the
       magnitude  of  the  induced  e.m.f.  in  each  case .
```

```
2
3  //initializing the variables:
4  l = 0.02; // in m
5  b = 0.02; // in m
6  v = 15; // in m/s
7  R = 20; // in ohms
8  Phi = 5E-6; // in Wb
9  u0 = 4*%pi*1E-7;
10 a1 = 90; // in degrees
11 a2 = 60; // in degrees
12 a3 = 30; // in degrees
13
14 //calculation:
15 A = l*b
16 B = Phi/A
17 E90 = B*l*v*sin(a1*%pi/180)
18 E60 = B*l*v*sin(a2*%pi/180)
19 E30 = B*l*v*sin(a3*%pi/180)
20
21 printf("\n\nResult\n\n")
22 printf("\n Induced e.m.f. at angles 90  , 60  , 30
       are %.2E V, %.2E V, %.3E V respectively\n",E90,
     E60,E30)
```

Scilab code Exa 9.04 Example 4

```
1  //Problem 9.04: The wing span of a metal aeroplane
      is 36 m. If the aeroplane is flying at 400 km/h,
      determine the e.m.f. induced between its wing
      tips. Assume the vertical component of the
      earth s magnetic field is 40  T
2
3  //initializing the variables:
4  s = 36; // in m
5  v = 400; // in km/h
```

```
6   u0 = 4*%pi*1E-7;
7   B = 40E-6; // in Tesla
8
9   // calculation :
10  v0 = v*5/18
11  E = B*s*v0
12
13  printf("\n\nResult\n\n")
14  printf("\n Induced e.m.f. = %.2f V\n",E)
```

Scilab code Exa 9.06 Example 6

```
1   // Problem 9.06: Determine the e.m.f. induced in a
        coil of 200 turns when there is a change of flux
        of 25 mWb linking with it in 50 ms
2
3   // initializing the variables :
4   N = 200; // no. of turns
5   dt = 0.050; // change of time in sec
6   u0 = 4*%pi*1E-7;
7   dPhi = 0.025; // change of flux in Wb
8
9   // calculation :
10  E = -1*N*dPhi/dt
11
12  printf("\n\nResult\n\n")
13  printf("\n Induced e.m.f. = %.0f V\n",E)
```

Scilab code Exa 9.07 Example 7

```
1   // Problem 9.07: A flux of 400  Wb passing through a
        150-turn coil is reversed in 40 ms. Find the
        average e.m.f. induced .
```

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```
2
3  //initializing the variables:
4  N = 150; // no. of turns
5  dt = 0.040; // change of time in sec
6  u0 = 4*%pi*1E-7;
7  dPhi = 800E-6; // change of flux in Wb
8
9  //calculation:
10 //Since the flux reverses, the flux changes from
       C400  Wb to 400  Wb, a total change of flux of
       800  Wb
11 E = -1*N*dPhi/dt
12
13 printf("\n\nResult\n\n")
14 printf("\n Induced e.m.f. = %.0f V\n",E)
```

Scilab code Exa 9.08 Example 8

```
1  //Problem 9.08: Calculate the e.m.f. induced in a
       coil of inductance 12 H by a current changing at
       the rate of 4 A/s
2
3  //initializing the variables:
4  L = 12; // in Henry
5  u0 = 4*%pi*1E-7;
6  dIdt = 4; // change of current with change in time
       in A/s
7
8  //calculation:
9  E = -1*L*dIdt
10
11 printf("\n\nResult\n\n")
12 printf("\n Induced e.m.f. = %.0f V\n",E)
```

Scilab code Exa 9.09 Example 9

```
1  //Problem 9.09: An e.m.f. of 1.5 kV is induced in a
       coil when a current of 4 A reduced to 0 A in a 8
       ms. find the inductance of the coil.
2
3  //initializing the variables:
4  E = 1500; // in Volts
5  dt = 0.008; // Change of time in sec
6  dI = 4; // change of current in A/s
7
8  //calculation:
9  L = abs(E)*dt/dI
10
11 printf("\n\n Result \n\n")
12 printf("\n Inductance L = %.0f H\n",L)
```

Scilab code Exa 9.10 Example 10

```
1  //Problem 9.10: An 8 H inductor has a current of 3 A
       flowing through it. How much energy is stored in
       the magnetic field of the inductor?
2
3  //initializing the variables:
4  L = 8; // in Henry
5  I = 3; // in Amperes
6
7  //calculation:
8  W = L*I*I/2
9
10 printf("\n\n Result \n\n")
11 printf("\n Energy stored , W = %.0f J\n",W)
```

Scilab code Exa 9.11 Example 11

```
1  //Problem 9.11: Calculate the coil inductance when a
        current of 4 A in a coil of 800 turns produces a
        flux of 5 mWb linking with the coil.
2
3  //initializing the variables:
4  I = 4; // in Amperes
5  N = 800; //turns
6  Phi = 0.005; // in Wb
7
8  //calculation:
9  L = N*Phi/I
10
11 printf("\n\n Result \n\n")
12 printf("\n Inductance L = %.0f H\n",L)
```

Scilab code Exa 9.12 Example 12

```
1  //Problem 9.12: A flux of 25 mWb links with a 1500
        turn coil when a current of 3 A passes through
        the coil. Calculate (a) the inductance of the
        coil, (b) the energy stored in the magnetic field
        , and (c) the average e.m.f. induced if the
        current falls to zero in 150 ms.
2
3  //initializing the variables:
4  I1 = 3; // in Amperes
5  I2 = 0; // in Amperes
6  dt = 0.150; // in secs
7  N = 1500; //turns
```

```
8  Phi = 0.025; // in Wb
9
10 //calculation:
11 L = N*Phi/I1
12 W = L*I1*I1/2
13 dI = I1 - I2
14 E = -1*L*dI/dt
15
16 printf(" \n\n Result \n\n")
17 printf(" \n (a)Inductance L = %.1f H",L)
18 printf(" \n (b)energy stored W = %.2f J",W)
19 printf(" \n (c)e.m.f. induced = %.0f V",E)
```

Scilab code Exa 9.13 Example 13

```
1  //Problem 9.13: A 750 turn coil of inductance 3 H
       carries a current of 2 A. Calculate the flux
       linking the coil and the e.m.f. induced in the
       coil when the current collapses to zero in 20 ms
2
3  //initializing the variables:
4  I1 = 2; // in Amperes
5  I2 = 0; // in Amperes
6  dt = 0.020; // in secs
7  N = 750; //turns
8  L = 3; // in Henry
9
10 //calculation:
11 Phi = L*I1/N
12 dI = I1 - I2
13 E = -1*L*dI/dt
14
15 printf(" \n\n Result \n\n")
16 printf(" \n (a)Flux = %.3f Wb",Phi)
17 printf(" \n (b)e.m.f. induced = %.0f V",E)
```

Scilab code Exa 9.14 Example 14

```
1  //Problem 9.14: Calculate the mutual inductance
      between two coils when a current changing at 200
      A/s in one coil induces an e.m.f. of 1.5 V in the
       other.
2
3  //initializing the variables:
4  dI1dt = 200; // change of current with change in
      time in A/s
5  N = 2; // no. of coils
6  E2 = 1.5; // in Volts
7
8  //calculation:
9  M = abs(E2)/dI1dt
10
11 printf(" \n\n Result \n\n")
12 printf(" \n mutual inductance , M = %.4f H\n", M)
```

Scilab code Exa 9.15 Example 15

```
1  //Problem 9.15: The mutual inductance between two
      coils is 18 mH. Calculate the steady rate of
      change of current in one coil to induce an e.m.f.
       of 0.72 V in the other.
2
3  //initializing the variables:
4  M = 0.018; // in Henry
5  N = 2; // no. of coils
6  E2 = 0.72; // in Volts
7
```

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```
8   // calculation :
9   dI1dt = abs(E2)/M
10
11  printf("\n\n Result \n\n")
12  printf("\n rate of change of current dI1/dt = %.0f A
        /s\n", dI1dt)
```

Scilab code Exa 9.16 Example 16

```
1   // Problem 9.16: Two coils have a mutual inductance
        of 0.2 H. If the current in one coil is changed
        from 10 A to 4 A in 10 ms, calculate (a) the
        average induced e.m.f. in the second coil, (b)
        the change of flux linked with the second coil if
         it is wound with 500 turns.
2
3   // initializing the variables :
4   M = 0.2; // in Henry
5   I1 = 10; // in Amperes
6   I2 = 4; // in Amperes
7   dt = 0.010; // in secs
8   N = 500; // turns
9
10  // calculation :
11  dI1dt = (I1 -I2)/dt
12  E2 = -1*dI1dt*M
13  dPhi = abs(E2)*dt/N
14
15  printf("\n\n Result \n\n")
16  printf("\n (a)Induced e.m.f. E2 = %.0f V", E2)
17  printf("\n (b)change of flux = %.4f Wb", dPhi)
```

Chapter 10

Electrical measuring instruments and measurements

Scilab code Exa 10.01 Example 1

```
1  //Problem 10.01: A moving-coil instrument gives a f.
       s.d. when the current is 40 mA and its resistance
        is 25 ohms. Calculate the value of the shunt to
       be connected in parallel with the meter to enable
        it to be used as an ammeter for measuring
       currents up to 50 A.
2
3  //initializing the variables:
4  Ia = 0.040; // in Amperes
5  I = 50; // in Amperes
6  ra = 25; // in ohms
7
8
9  //calculation:
10 Is = I - Ia
11 V = Ia*ra
12 Rs = V/Is
13
14 printf("\n\n Result \n\n")
```

```
15  printf(”\n   value  of  the  shunt  to  be  connected  in
        parallel  =  %.3E  ohms”,Rs)
```

Scilab code Exa 10.02 Example 2

```
1  //Problem  10.02:  A  moving−coil  instrument  having  a
        resistance  of  10  ohms,  gives  a  f.s.d.  when  the
        current  is  8  mA.  Calculate  the  value  of  the
        multiplier  to  be  connected  in  series  with  the
        instrument  so  that  it  can  be  used  as  a  voltmeter
        for  measuring  p.d.s.  up  to  100  V.
2
3  //initializing  the  variables:
4  V  =  100;  //  in  volts
5  I  =  0.008;  //  in  Amperes
6  ra  =  10;  //  in  ohms
7
8
9  //calculation:
10  Rm  =  (V/I)  -  ra
11
12  printf(”\n\n  Result  \n\n”)
13  printf(”\n  value  of  the  multiplier  to  be  connected
        in  series  =  %.3Eohms\n”,  Rm)
```

Scilab code Exa 10.03 Example 3

```
1  //Problem  10.03:  Calculate  the  power  dissipated  by
        the  voltmeter  and  by  resistor  R  in  Figure  10.9
        when  (a)  R  =  250  ohms  (b)  R  =  2  Mohms.  Assume
        that  the  voltmeter  sensitivity  (sometimes  called
        figure  of  merit)  is  10  kohms/V.
2
```

```
3  // initializing  the  variables :
4  fsd = 200;  //  in  volts
5  R1 = 250;  //  in  ohms
6  R2 = 2E6;  //  in  ohms
7  sensitivity = 10000;  //  in  ohms/V
8
9  // calculation :
10 Rv = sensitivity * fsd
11 Iv = V/Rv
12 Pv = V * Iv
13 I1 = V/R1
14 P1 = V * I1
15 I2 = V/R2
16 P2 = V * I2
17
18 printf ("\n\n  Result  \n\n")
19 printf ("\n  (a) the  power  dissipated  by  the  voltmeter
       = %.2E W",  Pv)
20 printf ("\n  (b) the  power  dissipated  by  resistor  250
       ohm = %.0 f W",  P1)
21 printf ("\n  (c) the  power  dissipated  by  resistor  2
       Mohm = %.2E W",  P2)
```

Scilab code Exa 10.04 Example 4

```
1  // Problem  10.04:  An  ammeter  has  a  f.s.d.  of  100 mA
       and  a  resistance  of  50  ohms.  The  ammeter  is  used
       to  measure  the  current  in  a  load  of  resistance
       500  ohms  when  the  supply  voltage  is  10 V.
       Calculate  (a)  the  ammeter  reading  expected  (
       neglecting  its  resistance ),  (b)  the  actual
       current  in  the  circuit ,  (c)  the  power  dissipaed
       in  the  ammeter ,  and  (d)  the  power  dissipated  in
       the  load .
2
```

```
 3  //initializing the variables:
 4  V = 10; // in volts
 5  fsd = 0.1; // in Amperes
 6  ra = 50; // in ohms
 7  R = 500; // in ohms
 8
 9  //calculation:
10  Ie = V/R
11  Ia = V/(R + ra)
12  Pa = Ia*Ia*ra
13  PR = Ia*Ia*R
14
15  printf("\n\n Result \n\n")
16  printf("\n (a)expected ammeter reading = %.2E A\",
       Ie)
17  printf("\n (b)Actual ammeter reading = %.2E A",Ia)
18  printf("\n (c)Power dissipated in the ammeter = %.2E
        W", Pa)
19  printf("\n (d)Power dissipated in the load resistor
       = %.2E W",PR)
```

Scilab code Exa 10.05 Example 5

```
 1  //Problem 10.05: A voltmeter having a f.s.d. of 100
       V and a sensitivity of 1.6 kohms/V is used to
       measure voltage V1 in the circuit of Figure
       10.11. Determine (a) the value of voltage V1 with
        the voltmeter not connected, and (b) the voltage
        indicated by the voltmeter when connected
       between A and B.
 2
 3  //initializing the variables:
 4  fsd = 100; // in volts
 5  R1 = 40E3; // in ohms
 6  R2 = 60E3; // in ohms
```

```
7  sensitivity = 1600; // in ohms/V
8
9  //calculation:
10 V1 = (R1/(R1 + R2))*fsd
11 Rv = fsd*sensitivity
12 Rep = R1*Rv/(R1 + Rv)
13 V1n = (Rep/(Rep + R2))*fsd
14
15 printf("\n\n Result \n\n")
16 printf("\n (a)the value of voltage V1 with the
       voltmeter6 not connected = %.0f V", V1)
17 printf("\n (b)the voltage indicated by the voltmeter
        when connected between A and B = %.2f V",V1n)
```

Scilab code Exa 10.06 Example 6

```
1  //Problem 10.06: (a) A current of 20 A flows through
        a load having a resistance of 2 ohms. Determine
        the power dissipated in the load. (b) A wattmeter
       , whose current coil has a resistance of 0.01 ohm
        is connected as shown in Figure 10.13. Determine
        the wattmeter reading.
2
3  //initializing the variables:
4  I = 20; // in amperes
5  R = 2; // in ohms
6  Rw = 0.01; // in ohms
7
8  //calculation:
9  PR = I*I*R
10 Rt = R + Rw
11 Pw = I*I*Rt
12
13 printf("\n\n Result \n\n")
14 printf("\n (a)the power dissipated in the load = %.0
```

```
    f W" , PR)
15  printf("\n (b)the wattmeter reading. = %.0f W\n",Pw)
```

Scilab code Exa 10.08 Example 8

```
1  //Problem 10.08: (For the c.r.o. square voltage
      waveform shown in Figure 10.15 determine (a) the
      periodic time, (b) the frequency and (c) the peak
      -to-peak voltage. The    time/cm    (or timebase
      control) switch is on 100   s/cm and the    volts
      /cm    (or signal amplitude control) switch is on
       20 V/cm.
2  //(In Figures 10.15 to 10.18 assume that the squares
       shown are 1 cm by 1 cm)
3
4  //initializing the variables:
5  tc = 100E-6; // in s/cm
6  Vc = 20; // in V/cm
7  w = 5.2; // in cm ( width of one complete cycle )
8  h = 3.6; // in cm ( peak-to-peak height of the
      display )
9
10  //calculation:
11  T = w*tc
12  f = 1/T
13  ptpv = h*Vc
14
15  printf("\n\n Result \n\n")
16  printf("\n (a)the periodic time, T = %.2E sec", T)
17  printf("\n (b)Frequency, f = %.0f Hz",f)
18  printf("\n (c)the peak-to-peak voltage = %.0f V",
      ptpv)
```

Scilab code Exa 10.09 Example 9

```
1  //Problem 10.09: (For the c.r.o. display of a pulse
       waveform shown in Figure 10.16 the  time/cm
       switch is on 50 ms/cm and the  volts/cm
       switch is on 0.2 V/cm. Determine (a) the periodic
        time, (b) the frequency, (c) the magnitude of
       the pulse voltage.
2  //(In Figures 10.15 to 10.18 assume that the squares
        shown are 1 cm by 1 cm)
3
4  //initializing the variables:
5  tc = 50E-3; // in s/cm
6  Vc = 0.2; // in V/cm
7  w = 3.5; // in cm ( width of one complete cycle )
8  h = 3.4; // in cm ( peak-to-peak height of the
       display )
9
10 //calculation:
11 T = w*tc
12 f = 1/T
13 ptpv = h*Vc
14
15 printf("\n\n Result \n\n")
16 printf("\n (a)the periodic time, T = %.2E sec ",T)
17 printf("\n (b)Frequency, f = %.2f Hz",f)
18 printf("\n (c)the peak-to-peak voltage = %.2f V",
       ptpv)
```

Scilab code Exa 10.10 Example 10

```
1  //Problem 10.10: A sinusoidal voltage trace
       displayed by a c.r.o. is shown in Figure 10.17.
       If the  time/cm  switch is on 500  s/cm and
       the  volts/cm  switch is on 5 V/cm, find, for
```

```
         the  waveform ,  ( a )  the  frequency ,  ( b )  the  peak−to
         −peak  voltage ,  ( c )  the  amplitude ,  ( d )  the  r .m. s .
         value .
 2  // ( In  Figures  10.15  to  10.18  assume  that  the  squares
         shown  are  1  cm  by  1  cm)
 3
 4  // i n i t i a l i z i n g  the  v a r i a b l e s :
 5  tc  =  500E-6;  //  in  s/cm
 6  Vc  =  5;  //  in  V/cm
 7  w  =  4;  //  in  cm  (  width  of  one  complete  cycle  )
 8  h  =  5;  //  in  cm  (  peak−to−peak  height  of  the  display
         )
 9
10  // c a l c u l a t i o n :
11  T  =  w*tc
12  f  =  1/T
13  ptpv  =  h*Vc
14  Amp  =  ptpv/2
15  Vrms  =  Amp/(2^0.5)
16
17  printf ( ”\n\n  Result  \n\n” )
18  printf ( ”\n  ( a ) Frequency ,  f  =  %.0 f  Hz” , f )
19  printf ( ”\n  ( b ) the  peak−to−peak  voltage  =  %.0 f  V” ,
         ptpv )
20  printf ( ”\n  ( c ) Amplitude  =  %.1 f  V” , Amp)
21  printf ( ”\n  ( d ) r .m. s  voltage  =  %.2 f  V” , Vrms )
```

Scilab code Exa 10.11 Example 11

```
 1  // Problem  10.11:  For  the  double−beam  o s c i l l o s c o p e
         d i s p l a y s  shown  in  Figure  10.18  determine  ( a )
         their  frequency ,  ( b )  their  r .m. s .  values ,  ( c )
         their  phase  d i f f e r e n c e .  The  time /cm  switch
         is  on  100  s /cm  and  the  volts /cm  switch  on
         2  V/cm .
```

```
2  //( In Figures 10.15 to 10.18 assume that the squares
       shown are 1 cm by 1 cm)
3
4  // initializing the variables :
5  tc = 100E-6; // in s/cm
6  Vc = 2; // in V/cm
7  w = 5; // in cm ( width of one complete cycle for
      both waveform )
8  h1 = 2; // in cm ( peak-to-peak height of the
      display )
9  h2 = 2.5; // in cm ( peak-to-peak height of the
      display )
10
11  // calculation :
12  T = w*tc
13  f = 1/T
14  ptpv1 = h1*Vc
15  Vrms1 = ptpv1/(2^0.5)
16  ptpv2 = h2*Vc
17  Vrms2 = ptpv2/(2^0.5)
18  phi = 0.5*360/w
19
20  printf("\n\n Result \n\n")
21  printf("\n (a)Frequency , f = %.0f Hz",f)
22  printf("\n (b1)r.m.s voltage of 1st waveform = %.2f
      V",Vrms1)
23  printf("\n (b2)r.m.s voltage of 2nd waveform = %.2f
      V",Vrms2)
24  printf("\n (c)Phase difference = %.0 f  ",phi)
```

Scilab code Exa 10.12 Example 12

```
1  //Problem 10.12: The ratio of two powers is (a) 3 (b
      ) 20 (c) 400 (d) 1/20. Determine the decibel
      power ratio in each case .
```

```
2
3 //initializing the variables:
4 rP1 = 3; // ratio of two powers
5 rP2 = 20; // ratio of two powers
6 rP3 = 400; // ratio of two powers
7 rP4 = 1/20; // ratio of two powers
8
9 //calculation:
10 X1 = 10*log10(3)
11 X2 = 10*log10(20)
12 X3 = 10*log10(400)
13 X4 = 10*log10(1/20)
14
15 printf("\n\n Result \n\n")
16 printf("\n (a)decibel power ratio for power ratio 3
       = %.2f dB ",X1)
17 printf("\n (b)decibel power ratio for power ratio 20
        = %.1f dB ",X2)
18 printf("\n (c)decibel power ratio for power ratio
       400 = %.1f dB ",X3)
19 printf("\n (d)decibel power ratio for power ratio
       1/20 = %.1f dB ",X4)
```

Scilab code Exa 10.13 Example 13

```
1 //Problem 10.13: The current input to a system is 5
     mA and the current output is 20 mA. Find the
     decibel current ratio assuming the input and load
      resistances of the system are equal.
2
3 //initializing the variables:
4 I2 = 0.020; // in ampere
5 I1 = 0.005; // in ampere
6
7 //calculation:
```

```
8  X = 20*log10(I2/I1)
9
10 printf(")"\n\n Result \n\n")
11 printf(")"\n decibel current ratio = %.0f dB\n",X)
```

Scilab code Exa 10.14 Example 14

```
1  //Problem 10.14: 6% of the power supplied to a cable
       appears at the output terminals. Determine the
     power loss in decibels.
2
3  //initializing the variables:
4  rP = 0.06; // power ratios rP = P2/P1
5
6  //calculation:
7  X = 10*log10(rP)
8
9  printf(")"\n\n Result \n\n")
10 printf(")"\n decibel Power ratios = %.2f dB\n",X)
```

Scilab code Exa 10.15 Example 15

```
1  //Problem 10.15: An amplifier has a gain of 14 dB.
     Its input power is 8 mW. Find its output power.
2
3  //initializing the variables:
4  X = 14; // decibal power ratio in dB
5  P1 = 0.008; // in Watt
6
7  //calculation:
8  rP = 10^(X/10)
9  P2 = rP*P1
10
```

```
11  printf(" \n\n  Result  \n\n")
12  printf(" \n  output  power  P2 = %.3f W\n",P2)
```

Scilab code Exa 10.16 Example 16

```
1  //Problem  10.16:  The  output  voltage  from  an
        amplifier  is  4 V.  If  the  voltage  gain  is  27 dB,
        calculate  the  value  of  the  input  voltage  assuming
         that  the  amplifier  input  resistance  and  load
        resistance  are  equal.
2
3  //initializing  the  variables:
4  X = 27;  // Voltage  gain  in  decibels
5  V2 = 4;  // output  voltage  in  Volts
6
7  //calculation:
8  V1 = V2/(10^(27/20))
9
10 printf(" \n\n  Result  \n\n")
11 printf(" \n  input  Voltage  V1 = %.3f V\n",V1)
```

Scilab code Exa 10.17 Example 17

```
1  //Problem  10.17:  In  a  Wheatstone  bridge  ABCD,  a
        galvanometer  is  connected  between  A  and  C,  and  a
        battery  between  B  and  D.  A  resistor  of  unknown
        value  is  connected  between  A  and  B.  When  the
        bridge  is  balanced,  the  resistance  between  B  and
        C  is  100  ohms,  that  between  C  and  D  is  10  ohms
        and  that  between  D  and  A  is  400  ohms.  calculate
        the  value  of  the  unknown  resistance.
2
3  //initializing  the  variables:
```

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```
4  R2 = 100; // in ohms
5  R3 = 400; // in ohms
6  R4 = 10; // in ohms
7
8  // calculation :
9  R1 = R2*R3/R4
10
11  printf("\n\n Result \n\n")
12  printf("\n unknown resistance , R1 = %.0f Ohms\n",R1)
```

Scilab code Exa 10.18 Example 18

```
1  //Problem 10.18: In a d.c. potentiometer , balance is
        obtained at a length of 400 mm when using a
      standard cell of 1.0186 volts. Determine the e.m.
      f. of a dry cell if balance is obtained with a
      length of 650 mm
2
3  // initializing the variables :
4  E1 = 1.0186; // in Volts
5  l1 = 0.400; // in m
6  l2 = 0.650; // in m
7
8  // calculation :
9  E2 = (l2/l1)*E1
10
11  printf("\n\n Result \n\n")
12  printf("\n the e.m.f. of a dry cell = %.3f Volts\n",
      E2)
```

Scilab code Exa 10.19 Example 19

```
1  //Problem 10.19: The current flowing through a
      resistor of 5 kohm(+-)0.4% is measured as 2.5 mA
      with an accuracy of measurement of (+-)0.5%.
      Determine the nominal value of the voltage across
       the resistor and its accuracy.
2
3  //initializing the variables:
4  I = 0.0025; // in Amperes
5  R = 5000; // in ohms
6  e1 = 0.4; // in %
7  e2 = 0.5; // in %
8
9  //calculation:
10 V = I*R
11 em = e1 + e2
12 Ve = em*V/100
13
14 printf("\n\n Result \n\n")
15 printf("\n voltage V = %.1fV(+-)%.2fV\n",V,Ve)
```

Scilab code Exa 10.20 Example 20

```
1  //Problem 10.20: The current I flowing in a resistor
      R is measured by a 0  10 A ammeter which gives
     an indication of 6.25 A. The voltage V across the
      resistor is measured by a 0  50 V voltmeter,
     which gives an indication of 36.5 V. Determine
     the resistance of the resistor, and its accuracy
     of measurement if both instruments have a limit
     of error of 2% of f.s.d. Neglect any loading
     effects of the instruments.
2
3  //initializing the variables:
4  I = 6.25; // in Amperes
5  Im = 10; // max in Amperes
```

```
6  V = 36.5; // in volts
7  Vm = 50; // max in volts
8  e = 2; // in %
9
10 // calculation :
11 R = V/I
12 Ve = e*Vm/100
13 Ve1 = Ve*100/V   // in  %
14 Ie = e*Im/100
15 Ie1 = Ie*100/I   // in %
16 em = Ve1 + Ie1
17 Re = em*R/100
18
19 printf("\n\n Result \n\n")
20 printf("\n Resistance R = %.2f ohms(+-)%.2f ohms\n",
      R,Re)
```

Scilab code Exa 10.21 Example 21

```
1 //Problem 10.21: The arms of a Wheatstone bridge
     ABCD have the following resistances : AB: R1 =
     1000 ohms (+-) 1.0% ; BC: R2 = 100 ohm (+-) 0.5%;
      CD: unknown resistance Rx; DA: R3 = 432.5 ohms
     (+-)0.2%. Determine the value of the unknown
     resistance and its accuracy of measurement.
2
3 // initializing the variables :
4 R1 = 1000; // in ohms
5 R2 = 100; // in ohms
6 R3 = 432.5; // in ohms
7 e1 = 1; // in %
8 e2 = 0.5; // in %
9 e3 = 0.2; // in %
10
11 // calculation :
```

```
12  Rx = R2*R3/R1
13  em = e1 + e2 + e3
14  Re = em*Rx/100
15
16  printf("\n\n Result \n\n")
17  printf("\n Resistance R = %.2f ohms(+-)%.2f ohms\n",
        Rx,Re)
```

Chapter 13

DC circuit theory

Scilab code Exa 13.01 Example 1

```
 1  //Problem  13.01:  (a)  Find  the  unknown  currents
        marked  in  Figure  13.3(a).  (b)  Determine  the  value
         of  e.m.f.  E  in  Figure  13.3(b).
 2
 3  //initializing  the  variables:
 4  Iab  =  50;  //  in  ampere
 5  Ibc  =  20;  //  in  ampere
 6  Iec  =  15;  //  in  ampere
 7  Idf  =  120;  //  in  ampere
 8  Ifg  =  40;  //  in  ampere
 9  Iab  =  50;  //  in  ampere
10  I  =  2;  //  in  ampere
11  V1  =  4;  //  in  volts
12  V2  =  3;  //  in  volts
13  V3  =  6;  //  in  volts
14  R1  =  1;  //  in  ohms
15  R2  =  2;  //  in  ohms
16  R3  =  2.5;  //  in  ohms
17  R4  =  1.5;  //  in  ohms
18
19  //calculation:
```

```
20  I1 = Iab - Ibc
21  I2 = Ibc + Iec
22  I3 = I1 - Idf
23  I4 = Iec - I3
24  I5 = Idf - Ifg
25  // Applying Kirchhoff s voltage law and moving
        clockwise around the loop of Figure 13.3(b)
        starting at point A:
26  E = I*R2 + I*R3 + I*R4 + I*R1 - V2 - V3 + V1
27
28  printf("\n\n Result \n\n")
29  printf("\n (a) unknown currents I1, I2, I3, I4, I5
        are %.0fA, %.0fA, %.0fA, %.0fA, %.0fA respetively
        ",I1, I2, I3, I4, I5)
30  printf("\n (b) value of e.m.f. E = %.0f Volts",E)
```

Scilab code Exa 13.06 Example 6

```
1  //Problem 13.06: For the circuit shown in Figure
        13.16, find, using the superposition theorem, (a)
         the current flowing in and the pd across the 18
        ohm resistor, (b) the current in the 8 V battery
        and (c) the current in the 3 V battery.
2
3  //initializing the variables:
4  E1 = 8; // in volts
5  E2 = 3; // in volts
6  R1 = 3; // in ohms
7  R2 = 2; // in ohms
8  R3 = 18; // in ohms
9
10  //calculation:
11  //Removing source E2 gives the circuit of Figure
        13.17(a).
12  //The current directions are labelled as shown in
```

```
      Figure 13.17(a), I1 flowing from the positive
          terminal of E1.
13  //From Figure 13.17(b), I1
14  r1 = 1/(1/R2 + 1/R3)
15  I1 = E1/(R1 + r1)
16  //From Figure 13.17(a), I2
17  I2 = (R3/(R3 + R2))*I1
18  I3 = (R2/(R3 + R2))*I1
19  //Removing source E1 gives the circuit of Figure
          13.18(a)
20  //The current directions are labelled as shown in
          Figures 13.18(a) and 13.18(b), I4 flowing from
          the positive terminal of E2
21  //From Figure 13.18(c), I4
22  r2 = 1/(1/R3 + 1/R1)
23  I4 = E2/(r2 + R2)
24  //From Figure 13.18(b), I5
25  I5 = (R3/(R1 + R3))*I4
26  I6 = (R1/(R1 + R3))*I4
27  //Resultant current in the R3 resistor
28  I18 = I3 - I6
29  //P.d. across the R3
30  V3 = I18*R3
31  //Resultant current in the E1
32  Ie1 = I1 + I5
33  //Resultant current in the E2
34  Ie2 = I2 + I4
35
36  printf("\n\n Result \n\n")
37  printf("\n Resultant current in the 18 ohm resistor
          is %.3f A",I18)
38  printf("\n P.d. across the 18 ohm resistor is %.3f V
          ",V3)
39  printf("\n Resultant current in the E1 is %.3f A",
          Ie1)
40  printf("\n Resultant current in the E2 is %.3f A",
          Ie2)
```

Scilab code Exa 13.07 Example 7

```
1  //Problem 13.07: Use Th evenin s theorem to find
       the current flowing in the 10 ohm resistor for
       the circuit shown in Figure 13.28(a).
2
3  //initializing the variables:
4  V = 10; // in volts
5  R1 = 2; // in ohms
6  R2 = 8; // in ohms
7  R3 = 5; // in ohms
8  R = 10; // in ohms
9
10 //calculation:
11 //The 10 ohm resistance branch is short-circuited as
        shown in Figure 13.28(b).
12 //Current I1
13 I1 = V/(R1 + R2)
14 //p.d. across AB, E
15 E = R2*I1
16 //the resistance  looking-in   at a break made
       between A and B is given by
17 r = R3 + (R1*R2)/(R2 + R1)
18 //The equivalent Th evenin s circuit is shown in
       Figure 13.28(d), the current in the 10 ohm
       resistance is given by:
19 I = E/(r + R)
20
21 printf("\n\n Result \n\n")
22 printf("\n the current in the 10 ohm resistance is
       given by %.3 f A",I)
```

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Scilab code Exa 13.08 Example 8

```
1  //Problem  13.08:  For  the  network  shown  in  Figure
       13.29(a)  determine  the  current  in  the  0.8  ohm
       resistor  using  Th  e v e n i n  s  theorem .
2
3  //initializing  the  variables :
4  V = 12;  //  in  volts
5  R1 = 5;  //  in  ohms
6  R2 = 1;  //  in  ohms
7  R3 = 4;  //  in  ohms
8  R = 0.8;  //  in  ohms
9
10  //calculation :
11  //The  0.8  ohm  resistance  branch  is  short−circuited
        as  shown  in  Figure  13.29(b) .
12  //Current  I1
13  I1 = V/(R1 + R2 + R3)
14  //p.d.  across  AB,  E
15  E = R3*I1
16  //the  resistance  looking−in  at  a  break  made
       between  A  and  B  is  given  by
17  r = R3*(R1 + R2)/(R2 + R1 + R3)
18  //The  equivalent  Th  e v e n i n  s  circuit  is  shown  in
        Figure  13.29(d) ,  the  current  in  the  0.8  ohm
        resistance  is  given  by :
19  I = E/(r + R)
20
21  printf("\n\n  Result  \n\n")
22  printf("\n  the  current  in  the  0.8  ohm  resistance  is
        given  by  %.1 f  A",I)
```

Scilab code Exa 13.09 Example 9

```
1  //Problem  13.09:  Use  Th  e v e n i n  s  theorem  to
```

```
      determine the current I flowing in the 4 ohm
      resistor shown in Figure 13.30(a). Find also the
      power dissipated in the 4 ohm resistor.
2
3  //initializing the variables:
4  E1 = 4; // in volts
5  E2 = 2; // in volts
6  R1 = 2; // in ohms
7  R2 = 1; // in ohms
8  R3 = 4; // in ohms
9
10 //calculation:
11 //The 4 ohm resistance branch is short−circuited as
      shown in Figure 13.30(b).
12 //Current I1
13 I1 = (E1 - E2)/(R1 + R2)
14 //p.d. across AB, E
15 E = E1 - I1*R1
16 //the resistance   looking−in   at a break made
      between A and B is given by
17 r = R2*R1/(R2 + R1)
18 //The equivalent Th evenin s circuit is shown in
      Figure 13.30(d), the current in the 4ohm
      resistance is given by:
19 I = E/(r + R3)
20 //Power dissipated in R3
21 P3 = R3*I^2
22
23 printf("\n\n Result \n\n")
24 printf("\n the current in the 4 ohm resistance is
      given by %.3f A",I)
25 printf("\n power disipated in 4 ohm resistor is
      given by %.3f W",P3)
```

Scilab code Exa 13.10 Example 10

```
1  //Problem 13.10: Use Th evenin s theorem to
      determine the current flowing in the 3 ohm
      resistance of the network shown in Figure 13.31(a
      ). The voltage source has negligible internal
      resistance.
2
3  //initializing the variables:
4  V = 24; // in volts
5  R1 = 20; // in ohms
6  R2 = 5; // in ohms
7  R3 = 10; // in ohms
8  R4 = 5/3; // in ohms
9  R5 = 3; // in ohms
10
11 //calculation:
12 //The 3 ohm resistance branch is short−circuited as
      shown in Figure 13.31(b).
13 //P.d. across R3
14 V3 = (R3/(R3 + R2))*V
15 //p.d. across AB, E
16 E = V3
17 //the resistance looking−in at a break made
      between A and B is given by
18 r = R4 + R2*R3/(R2 + R3)
19 //The equivalent Th evenin s circuit is shown in
      Figure 13.31(e), the current in the 32 ohm
      resistance is given by:
20 I = E/(r + R5)
21
22 printf("\n\n Result \n\n")
23 printf("\n the current in the 3 ohm resistance is
      given by %.0f A",I)
```

Scilab code Exa 13.11 Example 11

```
1  //Problem 13.11: A Wheatstone Bridge network is
       shown in Figure 13.32(a). Calculate the current
       flowing in the 32 ohm resistor, and its direction
       , using Th evenin s theorem. Assume the source
        of e.m.f. to have negligible resistance.
2
3  //initializing the variables:
4  E = 54; // in volts
5  R1 = 2; // in ohms
6  R2 = 14; // in ohms
7  R3 = 3; // in ohms
8  R4 = 11; // in ohms
9  R5 = 32; // in ohms
10
11 //calculation:
12 //The 32ohm resistance branch is short-circuited as
       shown in Figure 13.32(b).
13 //The p.d. between A and C,
14 Vac = (R1/(R1 + R4))*E
15 //The p.d. between B and C,
16 Vbc = (R2/(R2 + R3))*E
17 //Hence the p.d. between A and B
18 Vab = Vbc - Vac
19 //the resistance  looking-in  at a break made
       between A and B is given by
20 r = R1*R4/(R1 + R4) + R2*R3/(R2 + R3)
21 //The equivalent Th evenin s circuit is shown in
       Figure 13.32(f), the current in the 32 ohm
       resistance is given by:
22 I = E/(r + R5)
23
24 printf("\n\n Result \n\n")
25 printf("\n the current in the 32 ohm resistance is
       given by %.0f A",I)
```

Scilab code Exa 13.12 Example 12

```
1  //Problem 13.12: Use Norton s theorem to determine
        the current flowing in the 10 ohm resistance for
        the circuit shown in Figure 13.34(a).
2
3  //initializing the variables:
4  V = 10; // in volts
5  R1 = 2; // in ohms
6  R2 = 8; // in ohms
7  R3 = 5; // in ohms
8  R4 = 10; // in ohms
9
10 //calculation:
11 //The 10ohm resistance branch is short-circuited as
        shown in Figure 13.34(b).
12 //Figure 13.34(c) is equivalent to Figure 13.34(b).
        Hence
13 Isc = V/R1
14 //the resistance  looking-in   at a break made
        between A and B is  given by
15 r = R1*R2/(R1 + R2)
16 //From the Norton equivalent network shown in Figure
        13.34(d) the current in the 10 ohm resistance is
        given by:
17 I = (r/(r + R3 + R4))*Isc
18
19 printf("\n\n Result \n\n")
20 printf("\n the current in the 10 ohm resistance is
        given by %.3f A",I)
```

Scilab code Exa 13.13 Example 13

```
1  //Problem 13.13: Use Norton s theorem to determine
        the current I flowing in the 4 ohm resistance
```

```
        shown  in  Figure  13.35( a ) .
 2
 3  // initializing  the  variables :
 4  V1  =  4;  //  in  volts
 5  V2  =  2;  //  in  volts
 6  R1  =  2;  //  in  ohms
 7  R2  =  1;  //  in  ohms
 8  R3  =  4;  //  in  ohms
 9
10  // calculation :
11  //The  4ohm  resistance  branch  is  short−circuited  as
        shown  in  Figure  13.35( b ) .
12  // Figure  13.35( b )
13  Isc  =  V1/R1  +  V2/R2
14  // the  resistance   looking −in   at  a  break  made
        between  A  and  B  is  given  by
15  r  =  R1∗R2/(R1  +  R2)
16  //From  the  Norton  equivalent  network  shown  in  Figure
         13.35( c )  the  current  in  the  4ohm  resistance  is
        given  by :
17  I  =  (r/(r  +  R3))∗Isc
18
19  printf ( ”\n\n  Result  \n\n” )
20  printf ( ”\n  the  current  in  the  4ohm  resistance  is
        given  by  %.3 f  A” ,I )
```

Scilab code Exa 13.14 Example 14

```
 1  //Problem  13.14:  Use  N o r t o n  s  theorem  to  determine
        the  current  flowing  in  the  3  ohm  resistance  of
       the  network  shown  in  Figure  13.36( a ) .  The  voltage
        source  has  negligible  internal  resistance .
 2
 3  // initializing  the  variables :
 4  V  =  24;  //  in  volts
```

```
5  R1 = 20; // in ohms
6  R2 = 5; // in ohms
7  R3 = 10; // in ohms
8  R4 = 5/3; // in ohms
9  R5 = 3; // in ohms
10
11 //calculation:
12 //The 3ohm resistance branch is short−circuited as
       shown in Figure 13.36(b).
13 //Figure 13.36(c) is equivalent to Figure 13.36(b).
14 Isc = V/R2
15 //the resistance   looking−in   at a break made
       between A and B is given by
16 r = R3*R2/(R3 + R2)
17 //From the Norton equivalent network shown in Figure
        13.36(f) the current in the 3ohm resistance is
       given by:
18 I = (r/(r + R4 + R5))*Isc
19
20 printf("\n\n Result \n\n")
21 printf("\n the current in the 3ohm resistance is
       given by %.0f A",I)
```

Scilab code Exa 13.15 Example 15

```
1 //Problem 13.15: Determine the current flowing in
      the 2ohm resistance in the network shown in
      Figure 13.37(a).
2
3 //initializing the variables:
4 I = 15; // in amperes
5 R1 = 6; // in ohms
6 R2 = 4; // in ohms
7 R3 = 8; // in ohms
8 R4 = 2; // in ohms
```

```
9  R5 = 7; // in ohms
10
11 //calculation:
12 //The 2ohm resistance branch is short−circuited as
       shown in Figure 13.37(b).
13 //Figure 13.37(c) is equivalent to Figure 13.37(b).
14 Isc = (R1/(R1 + R2))*I
15 //the resistance   looking−in   at a break made
       between A and B is given by
16 r = ((R1 + R2)*(R3 + R5)/(R1 + R2 + R3 + R5))
17 //From the Norton equivalent network shown in Figure
        13.37(e) the current in the 2ohm resistance is
       given by:
18 I = (r/(r + R4))*Isc
19
20 printf(”\n\n Result \n\n”)
21 printf(”\n the current in the 2ohm resistance is
       given by %.2f A”,I)
```

Scilab code Exa 13.18 Example 18

```
1 //Problem 13.18: (a) Convert the circuit to the left
        of terminals AB in Figure 13.45(a) to an
       equivalent Th evenin circuit by initially
       converting to a Norton equivalent circuit. (b)
       Determine the current flowing in the 1.8 ohm
       resistor.
2
3 //initializing the variables:
4 E1 = 12; // in volts
5 E2 = 24; // in volts
6 R1 = 3; // in ohms
7 R2 = 2; // in ohms
8 R3 = 1.8; // in ohms
9
```

```
10  //calculation:
11  //For the branch containing the V1 source,
        converting to a Norton equivalent network gives
12  Isc1 = E1/R1
13  r1 = R1
14  //For the branch containing the V2 source,
        converting to a Norton equivalent network gives
15  Isc2 = E2/R2
16  r2 = R2
17  //Thus the network of Figure 13.46(a) converts to
        Figure 13.46(b).
18  //total short−circuit current
19  Isct = Isc1 + Isc2
20  //the resistance is
21  z = r1*r2/(r1 + r2)
22  //Both of the Norton equivalent networks shown in
        Figure 13.46(c) may be converted to Th evenin
        equivalent circuits. The open−circuit voltage
        across CD is
23  Vcd = Isct*z
24  //the current I flowing in a 1.8 ohm resistance
        connected between A and B is given by:
25  I = Vcd/(z + R3)
26
27  printf("\n\n Result \n\n")
28  printf("\n the current I flowing in a 1.8 ohm
        resistance connected between A and B is given by
        %.2f A",I)
```

Scilab code Exa 13.19 Example 19

```
1  //Problem 13.19: Determine by successive conversions
        between Th evenin and Norton equivalent
        networks a Th evenin equivalent circuit for
        terminals AB of Figure 13.46(a). Hence determine
```

```
        the  current  flowing  in  the  200  ohm  resistance .
 2
 3  // initializing  the  variables :
 4  V1 = 10;  //  in  volts
 5  V2 = 6;  //  in  volts
 6  R1 = 2000;  //  in  ohms
 7  R2 = 3000;  //  in  ohms
 8  R3 = 600;  //  in  ohms
 9  R4 = 200;  //  in  ohms
10  i = 0.001;  //  in  amperes
11
12  // calculation :
13  // For  the  branch  containing  the  V1  source ,
        converting  to  a  Norton  equivalent  network  gives
14  Isc1 = V1/R1
15  r1 = R1
16  // For  the  branch  containing  the  V2  source ,
        converting  to  a  Norton  equivalent  network  gives
17  Isc2 = V2/R2
18  r2 = R2
19  // Thus  the  network  of  Figure  13.46( a )  converts  to
        Figure  13.46( b ) .
20  // total  short−circuit  current
21  Isct = Isc1 + Isc2
22  // the  resistance  is
23  z = r1*r2/(r1 + r2)
24  // Both  of  the  Norton  equivalent  networks  shown  in
        Figure  13.46( c )  may  be  converted  to  Th evenin
        equivalent  circuits .  The  open−circuit  voltage
        across  CD  is
25  Vcd = Isct*z
26  // The  open−circuit  voltage  across  EF  is
27  Vef = i*R3
28  // the  resistance    looking −in     at  EF  is
29  r3 = R3
30  // Thus  Figure  13.46( c )  converts  to  Figure  13.46( d ) .
        Combining  the  two  Th evenin  circuits  gives
31  E = Vcd - Vef
```

graph of (RL) against power(P)
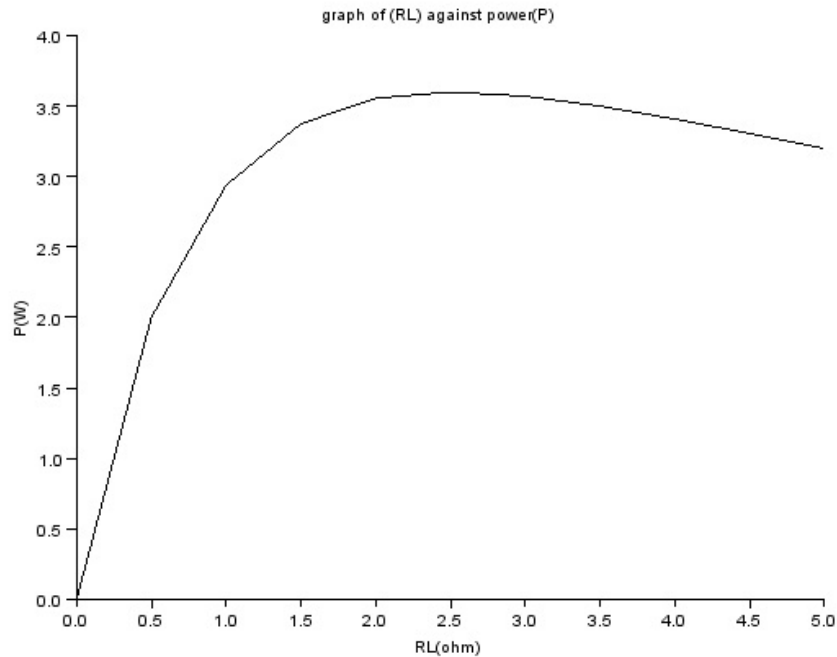
Figure 13.1: Example 20

```
32  r = z + r3
33  //the current I flowing in a 200 ohm resistance
        connected between A and B is given by:
34  I = E/(r + R4)
35
36  printf(”\n\n Result \n\n”)
37  printf(”\n the current I flowing in a 200ohm
        resistance connected between A and B is given by:
        is %.2E A”,I)
```

Scilab code Exa 13.20 Example 20

```
1 //Problem 13.20: The circuit diagram of Figure 13.48
      shows dry cells of source e.m.f. 6 V, and
      internal resistance 2.5 ohm. If the load
      resistance RL is varied from 0 to 5 ohm in 0.5
      ohm steps, calculate the power dissipated by the
      load in each case. Plot a graph of RL (
      horizontally) against power (vertically) and
      determine the maximum power dissipated.
2
3 //initializing the variables:
4 V = 6; // in volts
5 r = 2.5; // in ohms
6
7 //calculation:
8 RL=(0:0.5:5)';
9 function [y]=f(RL)
10     y = RL*(V/(r + RL))^2;
11 endfunction
12 fplot2d(RL, f)
13 xtitle("graph of (RL) against power(P)", "RL(ohm)",
      "P(W)")
```

Scilab code Exa 13.21 Example 21

```
1 //Problem 13.21: A d.c. source has an open−circuit
      voltage of 30 V and an internal resistance of 1.5
      ohm. State the value of load resistance that
      gives maximum power dissipation and determine the
      value of this power.
2
3 //initializing the variables:
4 V = 30; // in volts
5 r = 1.5; // in ohms
6
7 //calculation:
```

```
8  //current  I  =  E/( r  +  RL)
9  //For  maximum  power ,  RL  =  r
10 RL  =  r
11 I  =  V/( r  +  RL)
12 //Power ,  P,  dissipated  in  load  RL,  P
13 P  =  RL* I ^2
14
15 printf ( " \n\n  Result  \n\n " )
16 printf ( " \n  ( a )  the  value  of  the  load  resistor  RL  is
       %.1 f  ohm" ,RL)
17 printf ( " \n  (b)  maximum  power  dissipation  =  %.0 f  W" ,P
       )
```

Scilab code Exa 13.22 Example 22

```
1  //Problem  13.22:  Find  the  value  of  the  load  resistor
        RL  shown  in  Figure  13.51( a )  that  gives  maximum
       power  dissipation  and  determine  the  value  of  this
        power .
2
3  //initializing  the  variables :
4  V  =  15;  //  in  volts
5  R1  =  3;  //  in  ohms
6  R2  =  12;  //  in  ohms
7
8  //calculation :
9  //Resistance  RL  is  removed  from  the  circuit  as  shown
        in  Figure  13.51(b ).
10 //The  p.d.  across  AB  is  the  same  as  the  p.d.  across
       the  12  ohm  resistor .
11 E  =  (R2/(R1  +  R2))*V
12 //Removing  the  source  of  e.m.f.  gives  the  circuit  of
        Figure  13.51( c ) ,
13 //from  which  resistance ,  r
14 r  =  R1*R2/(R1  +  R2)
```

```
15  //The equivalent Th evenin s circuit supplying
       terminals AB is shown in Figure 13.51(d), from
       which, current I = E/(r + RL)
16  //For maximum power, RL = r
17  RL = r
18  I = E/(r + RL)
19  //Power, P, dissipated in load RL, P
20  P = RL*I^2
21
22  printf("\n\n Result \n\n")
23  printf("\n (a) the value of the load resistor RL is
        %.1f ohm",RL)
24  printf("\n (b) maximum power dissipation = %.0f W",P
        )
```

Chapter 14

Alternating voltages and currents

Scilab code Exa 14.01 Example 1

```
1 //Problem 14.01: Determine the periodic time for
     frequencies of (a) 50 Hz and (b) 20 kHz
2
3 //initializing the variables:
4 f1 = 50; // in Hz
5 f2 = 20000; // in Hz
6
7 //calculation:
8 T1 = 1/f1
9 T2 = 1/f2
10
11 printf("\n\n Result \n\n")
12 printf("\n (a) Periodic time T = %.2f secs",T1)
13 printf("\n (b) Periodic time T = %.2E secs\n",T2)
```

Scilab code Exa 14.02 Example 2

```
1  //Problem 14.02: Determine the frequencies for
       periodic times of (a) 4 ms, (b) 4   s
2
3  //initializing the variables:
4  T1 = 0.004; // in secs
5  T2 = 4E-6; // in secs
6
7  //calculation:
8  f1 = 1/T1
9  f2 = 1/T2
10
11 printf("\n\n Result \n\n")
12 printf("\n (a) Frequency f = %.0f Hz",f1)
13 printf("\n (b) Frequency f = %.2E secs",f2)
```

Scilab code Exa 14.03 Example 3

```
1  //Problem 14.03: An alternating current completes 5
       cycles in 8 ms. What is its frequency?
2
3  //initializing the variables:
4  T = (8E-3)/5; // in secs
5
6  //calculation:
7  f = 1/T
8
9  printf("\n\n Result \n\n")
10 printf("\n Frequency f = %.0f Hz\n",f)
```

Scilab code Exa 14.04 Example 4

```scilab
1  //Problem 14.04: For the periodic waveforms shown in
       Figure 14.5 determine for each: (i) frequency (
     ii) average value over half a cycle (iii) rms
     value (iv) form factor and (v) peak factor
2
3  //initializing the variables:
4  Ta = 0.02; // Time for 1 complete cycle in secs
5  Vamax = 200; // in volts
6  Va1 = 25; // in volts
7  Va2 = 75; // in volts
8  Va3 = 125; // in volts
9  Va4 = 175; // in volts
10 Tb = 0.016; // Time for 1 complete cycle in secs
11 Ibmax = 10; // in Amperes
12
13 //calculation:
14 //for Triangular waveform (Figure 14.5(a))
15 fa = 1/Ta
16 Aaw = Ta*Vamax/4
17 Vaavg = Aaw*2/Ta
18 Varms = (((Va1^2) + (Va2^2) + (Va3^2) + (Va4^2))/4)
     ^0.5 //Note that the greater the number of
     intervals chosen, the greater the accuracy of the
      result
19 Ffa = Varms/Vaavg
20 Pfa = Vamax/Varms
21
22 //for Rectangular waveform (Figure 14.5(b))
23 fb = 1/Tb
24 Abw = Tb*Ibmax/2
25 Ibavg = Abw*2/Tb
26 Ibrms = 10
27 Ffb = Ibrms/Ibavg
28 Pfb = Ibmax/Ibrms
29
30 printf("\n\n Result \n\n")
31 printf("\n (a1)Frequency f = %.0f Hz",fa)
32 printf("\n (a2)average value over half a cycle = %.0
```

```
       f V" ,Vaavg )
33  printf (" \n  ( a3 ) rms  value  = %.1 f  V" ,Varms )
34  printf (" \n  ( a4 ) Form  factor  = %.2 f " ,Ffa )
35  printf (" \n  ( a5 ) Peak  factor  = %.2 f " ,Pfa )
36  printf (" \n  ( b1 ) Frequency  f  = %.1 f  Hz" ,fb )
37  printf (" \n  ( b2 ) average  value  over  half  a  cycle  = %.0
       f  A" ,Ibavg )
38  printf (" \n  ( b3 ) rms  value  = %.0 f  A" ,Ibrms )
39  printf (" \n  ( b4 ) Form  factor  = %.0 f " ,Ffb )
40  printf (" \n  ( b5 ) Peak  factor  = %.0 f " ,Pfb )
```

Scilab code Exa 14.06 Example 6

```
1  //Problem  14.06:  Calculate  the  rms  value  of  a
       sinusoidal  current  of  maximum  value  20  A
2
3  // initializing  the  variables :
4  Imax  = 20;  //  in  Amperes
5
6  // calculation :
7  // for  a  sine  wave
8  Irms  =  Imax /(2^0.5)
9
10  printf (" \n\n  Result  \n\n" )
11  printf (" \n  Rms  value  = %.2 f  A\n" ,Irms )
```

Scilab code Exa 14.07 Example 7

```
1  //Problem  14.07:  Determine  the  peak  and  mean  values
       for  a  240  V  mains  supply .
2
3  // initializing  the  variables :
4  Vrms  = 240;  //  in  Volts
```

```
5
6  //calculation :
7  //for a sine wave
8  Vmax = Vrms *(2^0.5)
9  Vmean = 0.637* Vmax
10
11 printf("\n\n Result \n\n")
12 printf("\n peak value = %.1f V",Vmax)
13 printf("\n mean value = %.1f V",Vmean)
```

Scilab code Exa 14.08 Example 8

```
1  //Problem 14.08: A supply voltage has a mean value
       of 150 V. Determine its maximum value and its rms
        value
2
3  //initializing the variables :
4  Vmean = 150; // in Volts
5
6  //calculation :
7  //for a sine wave
8  Vmax = Vmean/0.637
9  Vrms = 0.707* Vmax
10
11 printf("\n\n Result \n\n")
12 printf("\n peak value = %.1f V",Vmax)
13 printf("\n rms value = %.1f V",Vrms)
```

Scilab code Exa 14.09 Example 9

```
1  //Problem 14.09: An alternating voltage is given by
       v = 282.8 sin 314t volts. Find (a) the rms
```

```
     voltage, (b) the frequency and (c) the
     instantaneous value of voltage when t = 4 ms
2
3 //initializing the variables:
4 Vmax = 282.8; // in Volts
5 w = 314; // in rad/sec
6 t = 0.004; // in sec
7
8 //calculation:
9 //for a sine wave
10 Vrms = 0.707*Vmax
11 f = w/(2*%pi)
12 v = Vmax*sin(w*t)
13
14 printf("\n\n Result \n\n")
15 printf("\n (a)rms value = %.0f V",Vrms)
16 printf("\n (b)frequency f = %.0f Hz",f)
17 printf("\n (c)instantaneous value of voltage at 4 ms
        = %.1f V",v)
```

Scilab code Exa 14.10 Example 10

```
1 //Problem 14.10: An alternating voltage is given by
     v = 75 sin(200*pi*t −0.25) volts. Find (a) the
     amplitude, (b) the peak−to−peak value, (c) the
     rms value, (d) the periodic time, (e) the
     frequency, and (f) the phase angle (in degrees
     and minutes) relative to 75 sin 200t
2
3 //initializing the variables:
4 Vmax = 75; // in Volts
5 w = 200*%pi; // in rad/sec
6 t = 0.004; // in sec
7 phi = 0.25; // in radians
8
```

```
9  //calculation :
10 //for a sine wave
11 Vptp = 2*Vmax
12 Vrms = 0.707*Vmax
13 f = w/(2*%pi)
14 T = 1/f
15 v = Vmax*sin(w*t)
16 phid = phi*180/%pi
17
18 printf(" \n\n Result \n\n")
19 printf(" \n (a) Amplitude , or peak value = %.0 f V" ,
      Vmax)
20 printf(" \n (b) Peak−to−peak value = %.0 f V" ,Vptp)
21 printf(" \n (c)rms value = %.0 f V" ,Vrms)
22 printf(" \n (d) periodic time , T = %.2 f sec" ,T)
23 printf(" \n (e) frequency f = %.0 f Hz" ,f)
24 printf(" \n (f) phase angle = %.2 f " ,phid)
```

Scilab code Exa 14.12 Example 12

```
1 //Problem 14.12: The current in an a.c. circuit at
      any time t seconds is given by: i = 120 sin (100*
      pit +0.36) amperes. Find : (a) the peak value , the
      periodic time , the frequency and phase angle
      relative to 120 sin 100 pit (b) the value of the
      current when t = 0 (c) the value of the current
      when t = 8 ms (d) the time when the current first
       reaches 60 A, and (e) the time when the current
      is first a maximum
2
3 //initializing the variables :
4 Imax = 120; // in Amperes
5 w = 100*%pi; // in rad/sec
6 phi = 0.36; // in rad
7 t1 = 0; // in secs
```

140

```
8  t2 = 0.008; // in secs
9  i = 60; // in amperes
10
11 //calculation:
12 //for a sine wave
13 f = w/(2*%pi)
14 T = 1/f
15 phid = phi*180/%pi
16 i0 = Imax*sin((w*t1) + phi)
17 i8 = Imax*sin((w*t2)+phi)
18 ti = (asin(i/Imax) - phi)/w
19 tm1 = (asin(Imax/Imax) - phi)/w
20
21 printf("\n\n Result \n\n")
22 printf("\n (a)Peak value = %.0f A, Periodic time T =
        %.2f sec, Frequency, f = %.0f Hz Phase angle = %
        .1f ", Imax, T, f, phid)
23 printf("\n (b) When t = 0, i = %.1f A",i0)
24 printf("\n (c)When t = 8 ms = %.1f A", i8)
25 printf("\n (d)When i is 60 A, then time t = %.2E s",
        ti)
26 printf("\n (e)When the current is a maximum, time, t
        = %.2E s",tm1)
```

Chapter 15

Single phase series ac circuits

Scilab code Exa 15.01 Example 1

```
1  //Problem 15.01: (a) Calculate the reactance of a
        coil of inductance 0.32 H when it is connected to
        a 50 Hz supply. (b) A coil has a reactance of
        124 ohm in a circuit with a supply of frequency 5
        kHz. Determine the inductance of the coil.
2
3  //initializing the variables:
4  L = 0.32; // in Henry
5  f1 = 50; // in Hz
6  f2 = 5000; // in Hz
7  Z = 124; // in ohms
8
9  //calculation:
10 XL = 2*%pi*f1*L
11 L = Z/(2*%pi*f2)
12
13 printf("\n\n Result \n\n")
14 printf("\n (a)Inductive reactance, XL = %.1f ohms ",
        XL)
15 printf("\n (b)Inductance L = %.2E H",L)
```

Scilab code Exa 15.02 Example 2

```
1  //Problem 15.02: A coil has an inductance of 40 mH
       and negligible resistance. Calculate its
       inductive reactance and the resulting current if
       connected to (a) a 240 V, 50 Hz supply, and (b) a
        100 V, 1 kHz supply.
2
3  //initializing the variables:
4  L = 0.040; // in Henry
5  V1 = 240; // in volts
6  V2 = 100; // in volts
7  f1 = 50; // in Hz
8  f2 = 1000; // in Hz
9
10  //calculation:
11  XL1 = 2*%pi*f1*L
12  I1 = V1/XL1
13  XL2 = 2*%pi*f2*L
14  I2 = V2/XL2
15
16  printf("\n\n Result \n\n")
17  printf("\n (a)Inductive reactance, XL = %.2f ohms
       and current I = %.2f A", XL1, I1)
18  printf("\n (b)Inductive reactance, XL = %.1f ohms
       and current I = %.3f A", XL2, I2)
```

Scilab code Exa 15.03 Example 3

```
1  //Problem 15.03: Determine the capacitive reactance
       of a capacitor of 10   F when connected to a
       circuit of frequency (a) 50 Hz (b) 20 kHz
```

```
 2
 3  //initializing the variables:
 4  C = 10E-6; // in Farads
 5  f1 = 50; // in Hz
 6  f2 = 20000; // in Hz
 7
 8  //calculation:
 9  Xc1 = 1/(2*%pi*f1*C)
10  Xc2 = 1/(2*%pi*f2*C)
11
12  printf("\n\n Result \n\n")
13  printf("\n (a)Capacitive reactance, Xc = %.1f ohms "
        , Xc1)
14  printf("\n (b)Capacitive reactance, Xc = %.3f ohms "
        , Xc2)
```

Scilab code Exa 15.04 Example 4

```
 1  //Problem 15.04: A capacitor has a reactance of 40
       ohms when operated on a 50 Hz supply. Determine
       the value of its capacitance.
 2
 3  //initializing the variables:
 4  Z = 40; // in ohms
 5  f = 50; // in Hz
 6
 7  //calculation:
 8  C = 1/(2*%pi*f1*Z)
 9
10  printf("\n\n Result \n\n")
11  printf("\n Capacitance ,C = %.2E F ", C)
```

Scilab code Exa 15.05 Example 5

```
1  //Problem 15.05: Calculate the current taken by a 23
        F capacitor when connected to a 240 V, 50 Hz
      supply.
2
3  //initializing the variables:
4  C = 23E-6; // in Farads
5  f = 50; // in Hz
6  V = 240; // in volts
7
8  //calculation:
9  Xc = 1/(2*%pi*f1*C)
10 I = V/Xc
11
12 printf("\n\n Result \n\n")
13 printf("\n current I = %.2f A ",I)
```

Scilab code Exa 15.06 Example 6

```
1  //Problem 15.06: In a series R L circuit the p.d.
      across the resistance R is 12 V and the p.d.
      across the inductance L is 5 V. Find the supply
      voltage and the phase angle between current and
      voltage.
2
3  //initializing the variables:
4  Vr = 12; // in volts
5  Vl = 5; // in volts
6
7  //calculation:
8  V = (Vr^2 + Vl^2)^0.5
9  phi = atan(Vl/Vr)
10 phid = phi*180/%pi
11
12 printf("\n\n Result \n\n")
13 printf("\n supply voltage V = %.0f V, phase angle
```

```
     between current and voltage is %.2 f    ",V, phid)
```

Scilab code Exa 15.07 Example 7

```
1  //Problem 15.07: A coil has a resistance of 4 ohms
       and an inductance of 9.55 mH. Calculate (a) the
       reactance, (b) the impedance, and (c) the current
        taken from a 240 V, 50 Hz supply. Determine also
        the phase angle between the supply voltage and
       current.
2
3  //initializing the variables:
4  V = 240; // in volts
5  R = 4; // in ohms
6  L = 0.00955; // in Henry
7  f = 50; // in Hz
8
9  //calculation:
10 XL = 2*%pi*f*L
11 Z = (R^2 + XL^2)^0.5
12 I = V/Z
13 phid = atan(XL/R)*180/%pi
14
15 printf("\n\n Result \n\n")
16 printf("\n (a)Inductive reactance, XL = %.0 f ohms",
       XL)
17 printf("\n (b)Impedance, Z = %.0 f ohms",Z)
18 printf("\n (c)Current, I = %.0 f A",I)
19 printf("\n (d)phase angle between the supply voltage
        and current is %.2 f   ",phid)
```

Scilab code Exa 15.08 Example 8

```
1  //Problem 15.08: A coil takes a current of 2 A from
       a 12 V d.c. supply. When connected to a 240 V, 50
        Hz supply the current is 20 A. Calculate the
       resistance, impedance, inductive reactance and
       inductance of the coil.
2
3  //initializing the variables:
4  Vdc = 12; // in volts
5  Vac = 240; // in volts
6  Iac = 20; // in Amperes
7  Idc = 2; // in Amperes
8  f = 50; // in Hz
9
10 //calculation:
11 R = Vdc/Idc
12 Z = Vac/Iac
13 XL = (Z^2 - R^2)^0.5
14 L = XL/(2*%pi*f)
15
16 printf("\n\n Result \n\n")
17 printf("\n (a)Resistance, R = %.0f ohms",R)
18 printf("\n (b)Impedance, Z = %.0f ohms",Z)
19 printf("\n (c)Inductive reactance, XL = %.2f ohms",
       XL)
20 printf("\n (d)Inductance, L = %.4f H",L)
```

Scilab code Exa 15.09 Example 9

```
1  //Problem 15.09: A coil of inductance 318.3 mH and
       negligible resistance is connected in series with
        a 200 ohms resistor to a 240 V, 50 Hz supply.
       Calculate (a) the inductive reactance of the coil
       , (b) the impedance of the circuit, (c) the
       current in the circuit, (d) the p.d. across each
       component, and (e) the circuit phase angle
```

```
2
3  //initializing the variables:
4  R = 200; // in ohms
5  L = 0.3183; // in henry
6  Vac = 240; // in volts
7  f = 50; // in Hz
8
9  //calculation:
10 XL = 2*%pi*f*L
11 Z = (R^2 + XL^2)^0.5
12 I = V/Z
13 VL = I*XL
14 VR = I*R
15 phid = atan(XL/R)*180/%pi
16
17 printf("\n\n Result \n\n")
18 printf("\n (a)Inductive reactance, XL = %.0f ohms",
      XL)
19 printf("\n (b)Impedance, Z = %.1f ohms",Z)
20 printf("\n (c)current, I = %.3f A",I)
21 printf("\n (d)p.d. across Inductor, VL = %.1f V and
      p.d. across resistance, VR = %.1f V",VL, VR)
22 printf("\n (e)circuit phase angle is %.2f ",phid)
```

Scilab code Exa 15.10 Example 10

```
1  //Problem 15.10: A coil consists of a resistance of
      100 ohms and an inductance of 200 mH. If an
      alternating voltage, v, given by v = 200 sin500t
      volts is applied across the coil, calculate (a)
      the circuit impedance, (b) the current flowing, (
      c) the p.d. across the resistance, (d) the p.d.
      across the inductance and (e) the phase angle
      between voltage and current.
2
```

```
3  //initializing the variables:
4  R = 100; // in ohms
5  L = 0.2; // in henry
6  Vmax = 200; // in volts
7  w = 500; // in rad/sec
8
9  //calculation:
10 Vrms = 0.707*Vmax
11 f = w/(2*%pi)
12 XL = 2*%pi*f*L
13 Z = (R^2 + XL^2)^0.5
14 I = Vrms/Z
15 VL = I*XL
16 VR = I*R
17 phid = atan(XL/R)*180/%pi
18
19 printf("\n\n Result \n\n")
20 printf("\n (a)Impedance, Z = %.1f ohms",Z)
21 printf("\n (b)current, I = %.0f A",I)
22 printf("\n (c)p.d. across resistance, VR = %.0f V",
       VR)
23 printf("\n (d)p.d. across Inductor, VL = %.0f V",VL)
24 printf("\n (e)circuit phase angle is %.0f ",phid)
```

Scilab code Exa 15.11 Example 11

```
1  //Problem 15.11: A pure inductance of 1.273 mH is
      connected in series with a pure resistance of 30
      ohms. If the frequency of the sinusoidal supply
      is 5 kHz and the p.d. across the 30 ohm resistor
      is 6 V, determine the value of the supply voltage
       and the voltage across the 1.273 mH inductance.
      Draw the phasor diagram.
2
3  //initializing the variables:
```

```
4  R = 30; // in ohms
5  L = 1.2273E-3; // in henry
6  f = 5000; // in Hz
7  VR = 6; // in volts
8
9  // calculation :
10 I =VR/R
11 XL = 2*%pi*f*L
12 Z = (R^2 + XL^2)^0.5
13 V = I*Z
14 VL = I*XL
15
16 printf("\n\n Result \n\n")
17 printf("\n (a)supply voltage = %.0f Volts",V)
18 printf("\n (b)p.d. across Inductor , VL = %.0f V",VL)
```

Scilab code Exa 15.12 Example 12

```
1  //Problem 15.12: A coil of inductance 159.2 mH and
       resistance 20 ohms is connected in series with a
       60 ohms resistor to a 240 V, 50 Hz supply.
       Determine (a) the impedance of the circuit , (b)
       the current in the circuit , (c) the circuit phase
        angle , (d) the p.d. across the 60 ohms resistor
       and (e) the p.d. across the coil. (f) Draw the
       circuit phasor diagram showing all voltages .
2
3  // initializing the variables :
4  R = 60; // in ohms
5  Rc = 20; // in ohms
6  L = 159.2E-3; // in henry
7  f = 50; // in Hz
8  V = 240; // in volts
9
10 // calculation :
```

```
11  XL = 2*%pi*f*L
12  Rt = R + Rc
13  Z = (Rt^2 + XL^2)^0.5
14  I = V/Z
15  phid = atan(XL/Rt)*180/%pi
16  VR = I*R
17  Zc = (Rc^2 + XL^2)^0.5
18  Vc = I*Zc
19  VL = I*XL
20  VRc = I*Rc
21
22  printf(" \n\n Result \n\n")
23  printf(" \n (a)Impedance, Z = %.2f ohms",Z)
24  printf(" \n (b)current, I = %.3f A",I)
25  printf(" \n (c)circuit phase angle is %.0f ",phid)
26  printf(" \n (d)p.d. across resistance, VR = %.1f V",
        VR)
27  printf(" \n (e)p.d. across coil, Vc = %.0f V",Vc)
28  printf(" \n (f1)p.d. across Inductor, VL = %.1f V",VL
        )
29  printf(" \n (f2)p.d. across coil resistance, VRc = %
        .2f V",VRc)
```

Scilab code Exa 15.13 Example 13

```
1 //Problem 15.13: A resistor of 25 ohms is connected
      in series with a capacitor of 45  F. Calculate (
      a) the impedance, and (b) the current taken from
      a 240 V, 50 Hz supply. Find also the phase angle
      between the supply voltage and the current.
2
3 //initializing the variables:
4 R = 25; // in ohms
5 C = 45E-6; // in Farads
6 f = 50; // in Hz
```

```
7  V = 240; // in volts
8
9  // calculation:
10 Xc = 1/(2*%pi*f*C)
11 Z = (R^2 + Xc^2)^0.5
12 I = V/Z
13 phid = atan(Xc/R)*180/%pi
14
15 printf("\n\n Result \n\n")
16 printf("\n (a)Impedance, Z = %.2f ohms",Z)
17 printf("\n (b)current, I = %.2f A",I)
18 printf("\n (c)phase angle between the supply voltage
          and current is %.2f ",phid)
```

Scilab code Exa 15.14 Example 14

```
1  //Problem 15.14: A capacitor C is connected in
      series with a 40 ohm resistor across a supply of
      frequency 60 Hz. A current of 3 A flows and the
      circuit impedance is 50 ohms. Calculate: (a) the
      value of capacitance, C, (b) the supply voltage,
      (c) the phase angle between the supply voltage
      and current, (d) the p.d. across the resistor,
      and (e) the p.d. across the capacitor. Draw the
      phasor diagram.
2
3  // initializing the variables:
4  R = 40; // in ohms
5  f = 60; // in Hz
6  I = 3; //in amperes
7  Z = 50; // in ohms
8
9  // calculation:
10 Xc = (Z^2 - R^2)^0.5
11 C = 1/(2*%pi*f*Xc)
```

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```
12  V = I*Z
13  phid = atan(Xc/R)*180/%pi
14  VR = I*R
15  Vc = I*Xc
16
17  printf("\n\n Result \n\n")
18  printf("\n (a)capacitance , C = %.2E F",C)
19  printf("\n (b)Voltage , V = %.0f Volts",V)
20  printf("\n (c)phase angle between the supply voltage
         and current is %.2f ",phid)
21  printf("\n (d)p.d. across resistance , VR = %.0f V",
         VR)
22  printf("\n (e)p.d. across Capacitor , Vc = %.0f V",Vc
         )
```

Scilab code Exa 15.15 Example 15

```
1  //Problem 15.15: A coil of resistance 5 ohms and
         inductance 120 mH in series with a 100   F
         capacitor , is connected to a 300 V, 50 Hz supply.
          Calculate (a) the current flowing , (b) the phase
          difference between the supply voltage and
         current , (c) the voltage across the coil and (d)
         the voltage across the capacitor.
2
3  //initializing the variables:
4  R = 5; // in ohms
5  C = 100E-6; // in Farads
6  L = 0.12; // in Henry
7  f = 50; // in Hz
8  V = 300; // in volts
9
10 //calculation:
11 XL = 2*%pi*f*L
12 Xc = 1/(2*%pi*f*C)
```

```
13  X = XL - Xc
14  //Since XL is greater than Xc, the circuit is
        inductive.
15  Z = (R^2 + (XL-Xc)^2)^0.5
16  I = V/Z
17  phid = atan((XL-Xc)/R)*180/%pi
18  Zcl = (R^2 + XL^2)^0.5
19  Vcl = I*Zcl
20  phidc = atan(XL/R)*180/%pi
21  Vc = I*Xc
22
23  printf("\n\n Result \n\n")
24  printf("\n (a)Current, I = %.2f A",I)
25  printf("\n (b)phase angle between the supply voltage
        and current is %.2f  ",phid)
26  printf("\n (c)Voltage across the coil, Vcoil = %.0f
        Volts",Vcl)
27  printf("\n (d)p.d. across Capacitor, Vc = %.0f V",Vc
        )
```

Scilab code Exa 15.16 Example 16

```
1  //Problem 15.16: The following three impedances are
       connected in series across a 40 V, 20 kHz supply:
        (i) a resistance of 8 ohms, (ii) a coil of
       inductance 130  H and 5 ohms resistance, and (
       iii) a 10 ohms  resistor in series with a 0.25
        F capacitor. Calculate (a) the circuit current,
        (b) the circuit phase angle and (c) the voltage
       drop across each impedance.
2
3  //initializing the variables:
4  R1 = 8; // in ohms
5  C = 0.25E-6; // in Farads
6  L = 130E-6; // in Henry
```

```
7  Rc = 5; // in ohms
8  R2 = 10; // in ohms
9  f = 20000; // in Hz
10 V = 40; // in volts
11
12 // calculation :
13 XL = 2*%pi*f*L
14 Xc = 1/(2*%pi*f*C)
15 X = Xc - XL
16 R = R1 + R2 + Rc
17 // Since Xc is greater than XL, the circuit is
       capacitive .
18 Z = (R^2 + (Xc-XL)^2)^0.5
19 I = V/Z
20 phid = atan((Xc-XL)/R)*180/%pi
21 V1 = I*R1
22 V2 = I*((Rc^2 + XL^2)^0.5)
23 V3 = I*((R2^2 + Xc^2)^0.5)
24
25 printf("\n\n Result \n\n")
26 printf("\n (a)Current ,I = %.3f A",I)
27 printf("\n (b)circuit phase angle is %.2f ",phid)
28 printf("\n (c1)Voltage across the Resistance of 8
      ohms = %.2f Volts",V1)
29 printf("\n (c2)Voltage across the coil , Vcoil = %.2f
       Volts",V2)
30 printf("\n (c3)p.d. across Capacitor resistance
      circuit = %.2f Volts",V3)
```

Scilab code Exa 15.17 Example 17

```
1 //Problem 15.17: Determine the p.d.   s V1 and V2
      for the circuit shown in Figure 15.17 if the
      frequency of the supply is 5 kHz. Draw the phasor
       diagram and hence determine the supply voltage V
```

```
        and the circuit phase angle.
2
3  //initializing the variables:
4  R1 = 4; // in ohms
5  C = 1.273E-6; // in Farads
6  L = 286E-6; // in Henry
7  R2 = 8; // in ohms
8  f = 5000; // in Hz
9  I = 5; // in amperes
10
11 //calculation:
12 XL = 2*%pi*f*L
13 phid1 = atan(XL/R)*180/%pi
14 V1 = I*((R1^2 + XL^2)^0.5)
15 Xc = 1/(2*%pi*f*C)
16 V2 = I*((R2^2 + Xc^2)^0.5)
17 phid2 = atan(Xc/R)*180/%pi
18 Z = ((R1+R2)^2 + (Xc-XL)^2)^0.5
19 V = I*Z
20 phid = atan((Xc-XL)/(R1+R2))*180/%pi
21
22 printf("\n\n Result \n\n")
23 printf("\n Voltage V1 = %.2f V and V2 = %.1f V",V1,
      V2)
24 printf("\n Voltage supply, V = %.0f V",V)
25 printf("\n circuit phase angle is %.2f ",phid)
```

Scilab code Exa 15.18 Example 18

```
1  //Problem 15.18: A coil having a resistance of 10
      ohms and an inductanc of 125 mH is connected in
      series with a 60   F capacitor across a 120 V
      supply. At what frequency does resonance occur?
      Find the current flowing at the resonant
      frequency.
```

```
 2
 3  //initializing the variables:
 4  R = 10; // in ohms
 5  C = 60E-6; // in Farads
 6  L = 125E-3; // in Henry
 7  V = 120; // in Volts
 8
 9  //calculation:
10  fr = 1/(2*%pi*(L*C)^0.5)
11  //At resonance, XL = Xc and impedance Z = R
12  I = V/R
13
14  printf("\n\n Result \n\n")
15  printf("\n (a)Resonance frequency, Fr = %.2 f Hz",fr)
16  printf("\n (b)Current, I = %.0 f",I)
```

Scilab code Exa 15.19 Example 19

```
 1  //Problem 15.19: The current at resonance in a
        series L C R circuit is 100 A. If the
        applied voltage is 2 mV at a frequency of 200 kHz
        , and the circuit inductance is 50 H, find (a)
        the circuit resistance, and (b) the circuit
        capacitance.
 2
 3  //initializing the variables:
 4  L = 0.05E-3; // in Henry
 5  fr = 200000; // in Hz
 6  V = 0.002; // in Volts
 7  I = 0.1E-3; // in amperes
 8
 9  //calculation:
10  // L–C–R
11  //At resonance, XL = Xc and impedance Z = R
12  R = V/I
```

```
13  C = 1/(L*(2*%pi*fr)^2)
14
15  printf("\n\n Result \n\n")
16  printf("\n (a)Resistance , R = %.0f ohms",R)
17  printf("\n (b)Capacitance , C = %.2E F",C)
```

Scilab code Exa 15.20 Example 20

```
1  //Problem 15.20: A coil of inductance 80 mH and
       negligible resistance is connected in series with
        a capacitance of 0.25  F and a resistor of
       resistance 12.5 ohms across a 100 V, variable
       frequency supply. Determine (a) the resonant
       frequency , and (b) the current at resonance. How
       many times greater than the supply voltage is the
        voltage across the reactances at resonance?
2
3  //initializing the variables:
4  L = 80E-3; // in Henry
5  C = 0.25E-6; // in Farads
6  R = 12.5; // in ohms
7  V = 100; // in Volts
8
9  //calculation:
10  fr = 1/(2*%pi*((L*C)^0.5))
11  //At resonance , XL = Xc and impedance Z = R
12  I = V/R
13  VL = I*(2*%pi*fr*L)
14  Vc = I/(2*%pi*fr*C)
15  Vm = VL/V
16
17  printf("\n\n Result \n\n")
18  printf("\n (a)the resonant frequency = %.1f Hz",fr)
19  printf("\n (b)Current , I = %.0f A",I)
20  printf("\n (b)Voltage magnification at resonance = %
```

```
.3f V",Vm)
```

Scilab code Exa 15.21 Example 21

```
1 //Problem 15.21: A series circuit comprises a coil
      of resistance 2 ohms and inductance 60 mH, and a
      30   F capacitor. Determine the Qfactor of the
      circuit at resonance.
2
3 //initializing the variables:
4 L = 60E-3; // in Henry
5 C = 30E-6; // in Farads
6 R = 2; // in ohms
7
8 //calculation:
9 Q = ((L/C)^0.5)/R
10
11 printf("\n\n Result \n\n")
12 printf("\n At resonance, Q-factor = %.2f",Q)
```

Scilab code Exa 15.22 Example 22

```
1 //Problem 15.22: A coil of negligible resistance and
       inductance 100 mH is connected in series with a
      capacitance of 2   F and a resistance of 10
      across a 50 V, variable frequency supply.
      Determine (a) the resonant frequency, (b) the
      current at resonance, (c) the voltages across the
       coil and the capacitor at resonance, and (d) the
      Q-factor of the circuit.
2
3 //initializing the variables:
4 L = 100E-3; // in Henry
```

```
5  C = 2E-6; // in Farads
6  R = 10; // in ohms
7  V = 50; // in Volts
8
9  // calculation :
10 fr = 1/(2*%pi*((L*C)^0.5))
11 //At resonance , XL = Xc and impedance Z = R
12 I = V/R
13 VL = I*(2*%pi*fr*L)
14 Vc = I/(2*%pi*fr*C)
15 Q = VL/V
16
17 printf(" \n\n Result \n\n")
18 printf(" \n (a)the resonant frequency = %.1f Hz",fr)
19 printf(" \n (b)Current , I = %.0f A",I)
20 printf(" \n (c)Voltage across coil at resonance is %
        .0fV and Voltage across capacitance at resonance
        is %.0fV",VL , Vc)
21 printf(" \n (d)At resonance , Q-factor = %.2f",Q)
```

Scilab code Exa 15.23 Example 23

```
1  //Problem 15.23: A filter in the form of a series
        L  R  C circuit is designed to operate at a
       resonant frequency of 5 kHz. Included within the
       filter is a 20 mH inductance and 10 ohm
       resistance . Determine the bandwidth of the filter
        .
2
3  // initializing the variables :
4  L = 20E-3; // in Henry
5  R = 10; // in ohms
6  fr = 5000; // in Hz
7
8  // calculation :
```

```
9  Qr = (2*%pi*fr)*L/R
10 bw = fr/Qr
11
12 printf("\n\n Result \n\n")
13 printf("\n Bandwidth, (f2-f1) = %.1f Hz",bw)
```

Scilab code Exa 15.24 Example 24

```
1 //Problem 15.24: An instantaneous current, i = 250
     sin w

2 t mA flows through a pure resistance of 5 kohm. Find
       the power dissipated in the resistor.
3
4 //initializing the variables:
5 R = 5000; // in ohms
6 Imax = 0.250; // in Amperes
7
8 //calculation:
9 Irms = 0.707*Imax
10 P = Irms*Irms*R
11
12 printf("\n\n Result \n\n")
13 printf("\n Power, P = %.1f Watts",P)
```

Scilab code Exa 15.25 Example 25

```
1 //Problem 15.25: A series circuit of resistance 60
     ohm and inductance 75 mH is connected to a 110 V,
      60 Hz supply. Calculate the power dissipated.
2
3 //initializing the variables:
4 R = 60; // in ohms
```

```
5  L = 75E-3; // in Henry
6  V = 110; // in Volts
7  f = 60; // in Hz
8
9  // calculation :
10 XL = 2*%pi*f*L
11 Z = (R^2 + XL^2)^0.5
12 I = V/Z
13 P = I*I*R
14
15 printf("\n\n Result \n\n")
16 printf("\n Power, P = %.0f Watts",P)
```

Scilab code Exa 15.26 Example 26

```
1  // Problem 15.26: A pure inductance is connected to a
       150 V, 50 Hz supply, and the apparent power of
     the circuit is 300 VA. Find the value of the
     inductance.
2
3  // initializing the variables :
4  VI = 300; // in VA
5  V = 150; // in Volts
6  f = 50; // in Hz
7
8  // calculation :
9  I = VI/V
10 XL = V/I
11 L = XL/(2*%pi*f)
12
13 printf("\n\n Result \n\n")
14 printf("\n Inductance = %.3f H",L)
```

Scilab code Exa 15.27 Example 27

```
1  //Problem 15.27: A transformer has a rated output of
        200 kVA at a power factor of 0.8. Determine the
       rated power output and the corresponding reactive
        power.
2
3  //initializing the variables:
4  VI = 200000; // in VA
5  pf = 0.8; // power factor
6
7  //calculation:
8  P = VI*pf
9  Q = VI*sin(acos(pf))
10
11  printf("\n\n Result \n\n")
12  printf("\n rated power output is %.0fW and the
        corresponding reactive power is %.0f var",P,Q)
```

Scilab code Exa 15.28 Example 28

```
1  //Problem 15.28: The power taken by an inductive
        circuit when connected to a 120 V, 50 Hz supply
        is 400 W and the current is 8 A. Calculate (a)
        the resistance, (b) the impedance, (c) the
        reactance, (d) the power factor, and (e) the
        phase angle between voltage and current.
2
3  //initializing the variables:
4  V = 120; // in Volts
5  f = 50; // in Hz
6  P = 400; // in Watt
7  I = 8; // in Amperes
8
9  //calculation:
```

```
10  R = P/(I*I)
11  Z = V/I
12  XL = (Z^2 - R^2)^0.5
13  pf = P/(V*I)
14  phi = acos(pf)*180/%pi
15
16  printf("\n\n Result \n\n")
17  printf("\n (a) resistance = %.2f ohm ",R)
18  printf("\n (b) Impedance Z = %.0f Ohm ",Z)
19  printf("\n (c) reactance = %.2f ohm ",XL)
20  printf("\n (d) Power factor = %.4f",pf)
21  printf("\n (e) phase angle = %.2f  ",phi)
```

Scilab code Exa 15.29 Example 29

```
1  //Problem 15.29: A circuit consisting of a resistor
       in series with a capacitor takes 100 watts at a
       power factor of 0.5 from a 100 V, 60 Hz supply.
       Find (a) the current flowing, (b) the phase angle
       , (c) the resistance, (d) the impedance, and (e)
       the capacitance.
2
3  //initializing the variables:
4  V = 100; // in Volts
5  f = 60; // in Hz
6  P = 100; // in Watt
7  pf = 0.5; // power factor
8
9  //calculation:
10  I = P/(pf*V)
11  phi = acos(pf)*180/%pi
12  R = P/(I*I)
13  Z = V/I
14  Xc = (Z^2 - R^2)^0.5
15  C = 1/(2*%pi*f*Xc)
```

```
16
17  printf("\n\n Result \n\n")
18  printf("\n (a)Current I = %.0f A ",I)
19  printf("\n (b)phase angle = %.0f ",phi)
20  printf("\n (c)resistance = %.0f ohm ",R)
21  printf("\n (d)Impedance Z = %.0f Ohm ",Z)
22  printf("\n (e)capacitance = %.2E F ",C)
```

Chapter 16

Single phase parallel ac circuits

Scilab code Exa 16.01 Example 1

```scilab
1  //Problem 16.01: A 20 ohm resistor is connected in
      parallel with an inductance of 2.387 mH across a
      60 V, 1 kHz supply. Calculate (a) the current in
      each branch, (b) the supply current, (c) the
      circuit phase angle, (d) the circuit impedance,
      and (e) the power consumed.
2
3  //initializing the variables:
4  R = 20; // in Ohms
5  L = 2.387E-3; // in Henry
6  V = 60; // in Volts
7  f = 1000; // in Hz
8
9  //calculation:
10 IR = V/R
11 XL = 2*%pi*f*L
12 IL = V/XL
13 I = (IR^2 + IL^2)^0.5
14 phi = atan(IL/IR)
15 phid = phi*180/%pi
16 Z = V/I
```

```
17  P = V*I*cos(phi)
18
19  printf("\n\n Result \n\n")
20  printf("\n (a)Current through resistor is %.0f A
        and current through Inductor is %.0f A",IR, IL)
21  printf("\n (b)current, I = %.0f A ",I)
22  printf("\n (c)phase angle = %.2f  ",phid)
23  printf("\n (d)Impedance Z = %.0f Ohm ",Z)
24  printf("\n (e)Power consumed = %.0f Watt ",P)
```

Scilab code Exa 16.02 Example 2

```
1  //Problem 16.02: A 30  F capacitor is connected in
       parallel with an 80 ohms resistor across a 240 V,
        50 Hz supply. Calculate (a) the current in each
       branch, (b) the supply current, (c) the circuit
       phase angle, (d) the circuit impedance, (e) the
       power dissipated, and (f) the apparent power.
2
3  //initializing the variables:
4  R = 80; // in Ohms
5  C = 30E-6; // in Farads
6  V = 240; // in Volts
7  f = 50; // in Hz
8
9  //calculation:
10 IR = V/R
11 Xc = 1/(2*%pi*f*C)
12 Ic = V/Xc
13 I = (IR^2 + Ic^2)^0.5
14 phi = atan(Ic/IR)
15 phid = phi*180/%pi
16 Z = V/I
17 P = V*I*cos(phi)
18 S = V*I
```

```
19
20  printf("\n\n Result \n\n")
21  printf("\n (a)Current through resistor is %.0f A
          and current through capacitor is %.3f A",IR, Ic)
22  printf("\n (b)current , I = %.3f A ",I)
23  printf("\n (c)phase angle = %.2f  ",phid)
24  printf("\n (d)Impedance Z = %.2f Ohm ",Z)
25  printf("\n (e)Power consumed = %.0f Watt ",P)
26  printf("\n (f)apparent Power = %.1f VA ",S)
```

Scilab code Exa 16.03 Example 3

```
1  //Problem 16.03: A capacitor C is connected in
          parallel with a resistor R across a 120 V, 200 Hz
           supply. The supply current is 2 A at a power
          factor of 0.6 leading. Determine the values of C
          and R.
2
3  //initializing the variables:
4  pf = 0.6; // power factor
5  V = 120; // in Volts
6  f = 200; // in Hz
7  I = 2; // in Amperes
8
9  //calculation:
10 phi = acos(pf)
11 phid = phi*180/%pi
12 IR = I*cos(phi)
13 Ic = I*sin(phi)
14 R = V/IR
15 C = Ic/(2*%pi*f*V)
16
17 printf("\n\n Result \n\n")
18 printf("\n (a)Resistance R = %.0f Ohm ",R)
19 printf("\n (b)Capacitance ,C = %.2E F ",C)
```

Scilab code Exa 16.04 Example 4

```
1  //Problem 16.04: A pure inductance of 120 mH is
       connected in parallel with a 25  F capacitor and
        the network is connected to a 100 V, 50 Hz
       supply. Determine (a) the branch currents, (b)
       the supply current and its phase angle, (c) the
       circuit impedance, and (d) the power consumed.
2
3  //initializing the variables:
4  C = 25E-6; // in Farads
5  L = 120E-3; // in Henry
6  V = 100; // in Volts
7  f = 50; // in Hz
8
9  //calculation:
10 XL = 2*%pi*f*L
11 IL = V/XL
12 Xc = 1/(2*%pi*f*C)
13 Ic = V/Xc
14 //IL and Ic are anti-phase. Hence supply current,
15 I = IL - Ic
16 //the current lags the supply voltage V by 90
17 phi = %pi/2
18 phid = phi*180/%pi
19 Z = V/I
20 P = V*I*cos(phi)
21
22 printf("\n\n Result \n\n")
23 printf("\n (a)Current through Inductor is %.3f A
       and current through capacitor is %.3f A",IL, Ic)
24 printf("\n (b)current, I = %.3f A ",I)
25 printf("\n (c)phase angle = %.0 f  ",phid)
26 printf("\n (d)Impedance Z = %.2 f Ohm ",Z)
```

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```
27  printf("\n (e)Power  consumed  = %.0 f  Watt  ",P)
```

Scilab code Exa 16.05 Example 5

```
1  //Problem  16.05:  Repeat  Problem  16.04  for  the
       condition  when  the  frequency  is  changed  to  150  Hz
       .
2
3  //initializing  the  variables :
4  C = 25E-6;  // in  Farads
5  L = 120E-3;  // in  Henry
6  V = 100;  // in  Volts
7  f = 150;  // in  Hz
8
9  //calculation :
10  XL = 2*%pi*f*L
11  IL = V/XL
12  Xc = 1/(2*%pi*f*C)
13  Ic = V/Xc
14  //IL and  Ic  are  anti-phase .  Hence  supply  current ,
15  I = Ic - IL
16  //the  current  leads  the  supply  voltage  V by  90
17  phi = %pi/2
18  phid = phi*180/%pi
19  Z = V/I
20  P = V*I*cos(phi)
21
22  printf("\n\n Result  \n\n")
23  printf("\n (a)Current  through  Inductor  is  %.3 f  A
       and  current  through  capacitor  is  %.3 f  A",IL, Ic)
24  printf("\n (b)current ,  I = %.3 f  A ",I)
25  printf("\n (c)phase  angle  = %.0 f   ",phid)
26  printf("\n (d)Impedance  Z = %.2 f  Ohm  ",Z)
27  printf("\n (e)Power  consumed  = %.0 f  Watt  ",P)
```

Scilab code Exa 16.06 Example 6

```
1  //Problem 16.06: A coil of inductance 159.2 mH and
       resistance 40 ohm is connected in parallel with a
        30   F capacitor across a 240 V, 50 Hz supply.
       Calculate (a) the current in the coil and its
       phase angle, (b) the current in the capacitor and
        its phase angle, (c) the supply current and its
       phase angle,(d) the circuit impedance, (e) the
       power consumed, (f) the apparent power, and (g)
       the reactive power. Draw the phasor diagram.
2
3  //initializing the variables:
4  C = 30E-6; // in Farads
5  R = 40; // in Ohms
6  L = 159.2E-3; // in Henry
7  V = 240; // in Volts
8  f = 50; // in Hz
9
10 //calculation:
11 XL = 2*%pi*f*L
12 Z1 = (R^2 + XL^2)^0.5
13 ILR = V/Z1
14 phi1 = atan(XL/R)
15 phi1d = phi1*180/%pi
16 Xc = 1/(2*%pi*f*C)
17 Ic = V/Xc
18 phi2 = %pi/2
19 phi2d = phi2*180/%pi
20 Ih = ILR*cos(phi1) + Ic*cos(phi2)
21 Iv = -1*ILR*sin(phi1) + Ic*sin(phi2)
22 I = (Ih^2 + Iv^2)^0.5
23 phi = atan(abs(Iv)/Ih)
24 Z = V/I
```

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```
25  P = V*I*cos(phi)
26  phid = phi*180/%pi
27  S = V*I
28  Q = V*I*sin(phi)
29
30  printf("\n\n Result \n\n")
31  printf("\n (a)Current through coil is %.3f A and
         lagged by phase angle is %.2 f  ",ILR,phi1d)
32  printf("\n (b)Current through capacitor is %.3f A
         and lead by phase angle is %.0 f  ",Ic,phi2d)
33  printf("\n (c)supply Current is %.3f A and lagged by
            phase angle is %.2 f  ",I,phid)
34  printf("\n (d)Impedance Z = %.2f Ohm ",Z)
35  printf("\n (e)Power consumed = %.0 f Watt ",P)
36  printf("\n (f)apparent Power = %.1 f VA ",S)
37  printf("\n (g)reactive Power = %.1 f var ",Q)
```

Scilab code Exa 16.07 Example 7

```
1  //Problem 16.07: A coil of inductance 0.12 H and
      resistance 3 kohm is connected in parallel with a
       0.02   F capacitor and is supplied at 40 V at a
      frequency of 5 kHz. Determine (a) the current in
      the coil, and (b) the current in the capacitor. (
      c) Draw to scale the phasor diagram and measure
      the supply current and its phase angle; check the
      answer by calculation. Determine (d) the circuit
      impedance and (e) the power consumed.
2
3  //initializing the variables:
4  C = 0.02E-6; // in Farads
5  R = 3000; // in Ohms
6  L = 120E-3; // in Henry
7  V = 40; // in Volts
8  f = 5000; // in Hz
```

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```
 9
10  //calculation:
11  XL = 2*%pi*f*L
12  Z1 = (R^2 + XL^2)^0.5
13  ILR = V/Z1
14  phi1 = atan(XL/R)
15  phi1d = phi1*180/%pi
16  Xc = 1/(2*%pi*f*C)
17  Ic = V/Xc
18  phi2 = %pi/2
19  phi2d = phi2*180/%pi
20  Ih = ILR*cos(phi1) + Ic*cos(phi2)
21  Iv = -1*ILR*sin(phi1) + Ic*sin(phi2)
22  I = (Ih^2 + Iv^2)^0.5
23  phi = atan((Iv)/Ih)
24  phid = phi*180/%pi
25  Z = V/I
26  P = V*I*cos(phi)
27
28  printf("\n\n Result \n\n")
29  printf("\n (a)Current through coil is %.5f A and
          lagged by phase angle is %.2f ",ILR,phi1d)
30  printf("\n (b)Current through capacitor is %.5f A
          and lead by phase angle is %.0f ",Ic,phi2d)
31  printf("\n (c)supply Current is %.5f A and lagged by
           phase angle is %.2f ",I,phid)
32  printf("\n (d)Impedance Z = %.2f Ohm ",Z)
33  printf("\n (e)Power consumed = %.4f Watt ",P)
```

Scilab code Exa 16.08 Example 8

```
 1  //Problem 16.08: A pure inductance of 150 mH is
        connected in parallel with a 40   F capacitor
        across a 50 V, variable frequency supply.
        Determine (a) the resonant frequency of the
```

```
        circuit and (b) the current circulating in the
        capacitor and inductance at resonance.
2
3 //initializing the variables:
4 C = 40E-6; // in Farads
5 R = 0; // in Ohms
6 L = 150E-3; // in Henry
7 V = 50; // in Volts
8
9 //calculation:
10 fr = ((1/(L*C) - R*R/(L*L))^0.5)/(2*%pi)
11 Xc = 1/(2*%pi*fr*C)
12 Icirc = V/Xc
13
14 printf("\n\n Result \n\n")
15 printf("\n (a)Parallel resonant frequency, fr = %.2f
        Hz ",fr)
16 printf("\n (b)Current circulating in L and C at
        resonance = %.3f A ",Icirc)
```

Scilab code Exa 16.09 Example 9

```
1 //Problem 16.09: A coil of inductance 0.20 H and
      resistance 60 ohm is connected in parallel with a
       20  F capacitor across a 20 V, variable
      frequency supply. Calculate (a) the resonant
      frequency, (b) the dynamic resistance, (c) the
      current at resonance and (d) the circuit Q-factor
       at resonance.
2
3 //initializing the variables:
4 C = 20E-6; // in Farads
5 R = 60; // in Ohms
6 L = 200E-3; // in Henry
7 V = 20; // in Volts
```

```
 8
 9 //calculation:
10 fr = ((1/(L*C) - R*R/(L*L))^0.5)/(2*%pi)
11 Rd = L/(R*C)
12 Ir = V/Rd
13 Q = 2*%pi*fr*L/R
14
15 printf(”\n\n Result \n\n”)
16 printf(”\n (a)Parallel resonant frequency, fr = %.2f
       Hz ”,fr)
17 printf(”\n (b)the dynamic resistance ,RD = %.1f ohm ”
       ,Rd)
18 printf(”\n (c)Current at resonance = %.2f A ”,Ir)
19 printf(”\n (d)Q−factor = %.2f”,Q)
```

Scilab code Exa 16.10 Example 10

```
 1 //Problem 16.10: A coil of inductance 100 mH and
       resistance 800 ohm is connected in parallel with
       a variable capacitor across a 12 V, 5 kHz supply.
        Determine for the condition when the supply
       current is a minimum: (a) the capacitance of the
       capacitor, (b) the dynamic resistance, (c) the
       supply current, and (d) the Q−factor.
 2
 3 //initializing the variables:
 4 fr = 5000; // in ohm
 5 R = 800; // in Ohms
 6 L = 100E-3; // in Henry
 7 V = 12; // in Volts
 8
 9 //calculation:
10 C = 1/(L*{(2*%pi*fr)^2 + R*R/(L*L)})
11 Rd = L/(R*C)
12 Ir = V/Rd
```

```
13  Q = 2*%pi*fr*L/R
14
15  printf("\n\n Result \n\n")
16  printf("\n (a)capacitance , C = %.3E F ",C)
17  printf("\n (b)the dynamic resistance ,RD = %.0f ohm "
        ,Rd)
18  printf("\n (c)Current at resonance = %.3E A ",Ir)
19  printf("\n (d)Q-factor = %.2f ",Q)
```

Scilab code Exa 16.11 Example 11

```
1  //Problem 16.11: A single−phase motor takes 50 A at
       a power factor of 0.6 lagging from a 240 V, 50 Hz
        supply. Determine (a) the current taken by a
       capacitor connected in parallel with the motor to
        correct the power factor to unity , and (b) the
       value of the supply current after power factor
       correction.
2
3  //initializing the variables:
4  f = 50; // in ohm
5  V = 240; // in Volts
6  pf = 0.6// power factor
7  Im = 50; // in amperes
8
9  //calculation:
10  phi = acos(pf)
11  phid = phi*180/%pi
12  Ic = Im*sin(phi)
13  I = Im*cos(phi)
14
15  printf("\n\n Result \n\n")
16  printf("\n (a)the capacitor current Ic must be %.0f
       A for the power factor to be unity. ",Ic)
17  printf("\n (b)Supply current I = %.0f A ",I)
```

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Scilab code Exa 16.12 Example 12

```
1  //Problem 16.12: A motor has an output of 4.8 kW, an
         efficiency of 80% and a power factor of 0.625
      lagging when operated from a 240 V, 50 Hz supply.
       It is required to improve the power factor to
      0.95 lagging by connecting a capacitor in
      parallel with the motor. Determine (a) the
      current taken by the motor, (b) the supply
      current after power factor correction, (c) the
      current taken by the capacitor, (d) the
      capacitance of the capacitor, and (e) the kvar
      rating of the capacitor.
2
3  //initializing the variables:
4  Pout = 4800; // in Watt
5  eff = 0.8;// effficiency
6  f = 50; // in ohm
7  V = 240; // in Volts
8  pf1 = 0.625// power factor
9  pf2 = 0.95// power factor
10
11 //calculation:
12 Pin = Pout/eff
13 Im = Pin/(V*pf1)
14 phi1 = acos(pf1)
15 phi1d = phi1*180/%pi
16 //When a capacitor C is connected in parallel with
      the motor a current Ic flows which leads V by 90
       .
17 phi2 = acos(pf2)
18 phi2d = phi2*180/%pi
19 Imh = Im*cos(phi1)
20 //Ih = I*cos(phi2)
```

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```
21  Ih = Imh
22  I = Ih/cos(phi2)
23  Imv = Im*sin(phi1)
24  Iv = I*sin(phi2)
25  Ic = Imv - Iv
26  C = Ic/(2*%pi*f*V)
27  kvar = V*Ic/1000
28
29  printf("\n\n Result \n\n")
30  printf("\n (a) current taken by the motor, Im = %.0f
        A", Im)
31  printf("\n (b) supply current after p.f. correction,
        I = %.2f A ", I)
32  printf("\n (c) magnitude of the capacitor current Ic
        = %.0f A", Ic)
33  printf("\n (d) capacitance, C = %.0f   F ", (C/1E-6))
34  printf("\n (d) kvar rating of the capacitor = %.2f
        kvar ", kvar)
```

Scilab code Exa 16.13 Example 13

```
1  //Problem 16.13: A 250 V, 50 Hz single-phase supply
       feeds the following loads (i) incandescent lamps
       taking a current of 10 A at unity power factor, (
       ii) fluorescent lamps taking 8 A at a power
       factor of 0.7 lagging, (iii) a 3 kVA motor
       operating at full load and at a power factor of
       0.8 lagging and (iv) a static capacitor.
       Determine, for the lamps and motor, (a) the total
        current, (b) the overall power factor and (c)
       the total power. (d) Find the value of the static
        capacitor to improve the overall power factor to
        0.975 lagging.
2
3  //initializing the variables:
```

```scilab
 4  S = 3000; // in VA
 5  f = 50; // in ohm
 6  V = 250; // in Volts
 7  Iil = 10; // in Amperes
 8  Ifl = 8; // in Amperes
 9  pfil = 1// power factor
10  pffl = 0.7// power factor
11  pfm = 0.8// power factor
12  pf0 = 0.975// power factor
13
14  // calculation :
15  phiil = acos(pfil)
16  phiild = phiil*180/%pi
17  phifl = acos(pffl)
18  phifld = phifl*180/%pi
19  phim = acos(pfm)
20  phimd = phim*180/%pi
21  phi0 = acos(pf0)
22  phi0d = phi0*180/%pi
23  Im = S/V
24  Ih = Iil*cos(phiil) + Ifl*cos(phifl) + Im*cos(phim)
25  Iv = Iil*sin(phiil) - Ifl*sin(phifl) - Im*sin(phim)
26  Il = (Ih^2 + Iv^2)^0.5
27  phi = atan(abs(Iv)/Ih)
28  phid = phi*180/%pi
29  pf = cos(phi)
30  P = V*Il*pf
31  I = Il*cos(phi)/cos(phi0)
32  Ic = Il*sin(phi) - I*sin(phi0)
33  C = Ic/(2*%pi*f*V)
34
35  printf(" \n\n Result  \n\n")
36  printf(" \n (a) total current ,  Il = %.2 f A", Il)
37  printf(" \n (b) Power factor = %.3 f", pf)
38  printf(" \n (c) Total power ,  P = %.3 f Watt", P)
39  printf(" \n (d) capacitance ,  C = %.2E F ", C)
```

Chapter 17

DC transients

Scilab code Exa 17.01 Example 1

```
1 //Problem 17.01: A 15   F uncharged capacitor is
      connected in series with a 47 kohm resistor
      across a 120 V, d.c. supply. Use the tangential
      graphical method to draw the capacitor voltage/
      time characteristic of the circuit. From the
      characteristic, determine the capacitor voltage
      at a time equal to one time constant after being
      connected to the supply, and also two seconds
      after being connected to the supply. Also, find
      the time for the capacitor voltage to reach one
      half of its steady state value.
2
3 //initializing the variables:
4 C = 15E-6; // in Farads
5 R = 47000; // in ohms
6 V = 120; // in Volts
7
8 //calculation:
9 tou = R*C
```
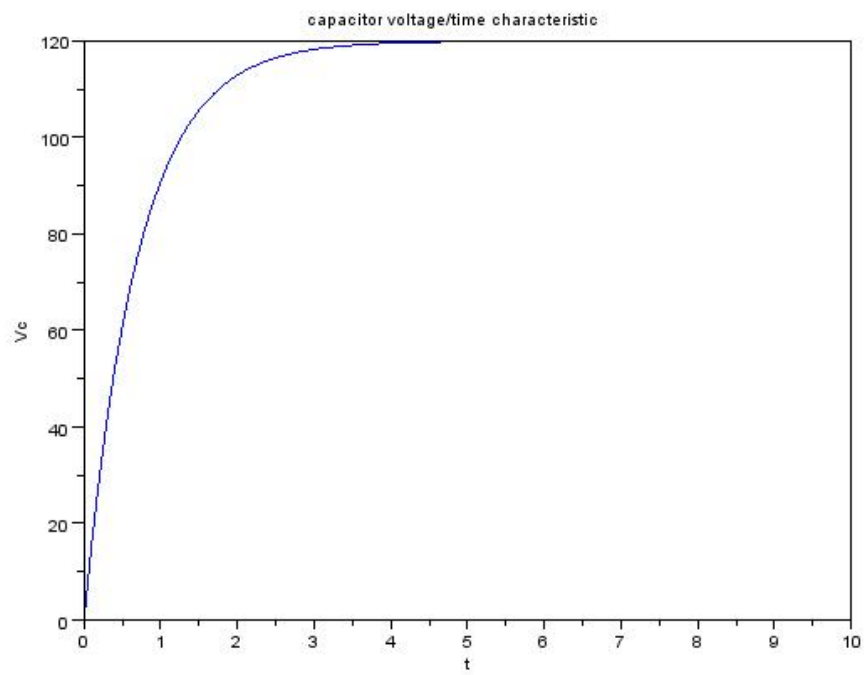
Figure 17.1: Example 1

```
10  t1 = tou
11  Vctou = V*(1-%e^(-1*t1/tou))
12  Vct = V/2
13  t = 0:0.1:10
14  Vc = V*(1-%e^(-1*t/tou));
15  plot(t,Vc)
16  xtitle("capacitor voltage/time characteristic", "t",
        "Vc")
17  t = -1*tou*log(1 - Vct/V)
18
19  printf("\ = \n\n Result \n\n")
20  printf("\n (a)the capacitor voltage at a time equal
        to one time constant = %.2f V",Vctou)
21  printf("\n (b)the time for the capacitor voltage to
        reach one half of its steady state value = %.1f
        sec",t)
```

Scilab code Exa 17.02 Example 2

```
1  //Problem 17.02: A 4  F capacitor is charged to 24
      V and then discharged through a 220 kohms
      resistor. Use the  initial slope and three
      point  method to draw: (a) the capacitor
      voltage/time characteristic, (b) the resistor
      voltage/time characteristic and (c) the current/
      time characteristic, for the transients which
      occur. From the characteristics determine the
      value of capacitor voltage, resistor voltage and
      current one and a half seconds after discharge
      has started.
2
3  //initializing the variables:
4  C = 4E-6; // in Farads
```
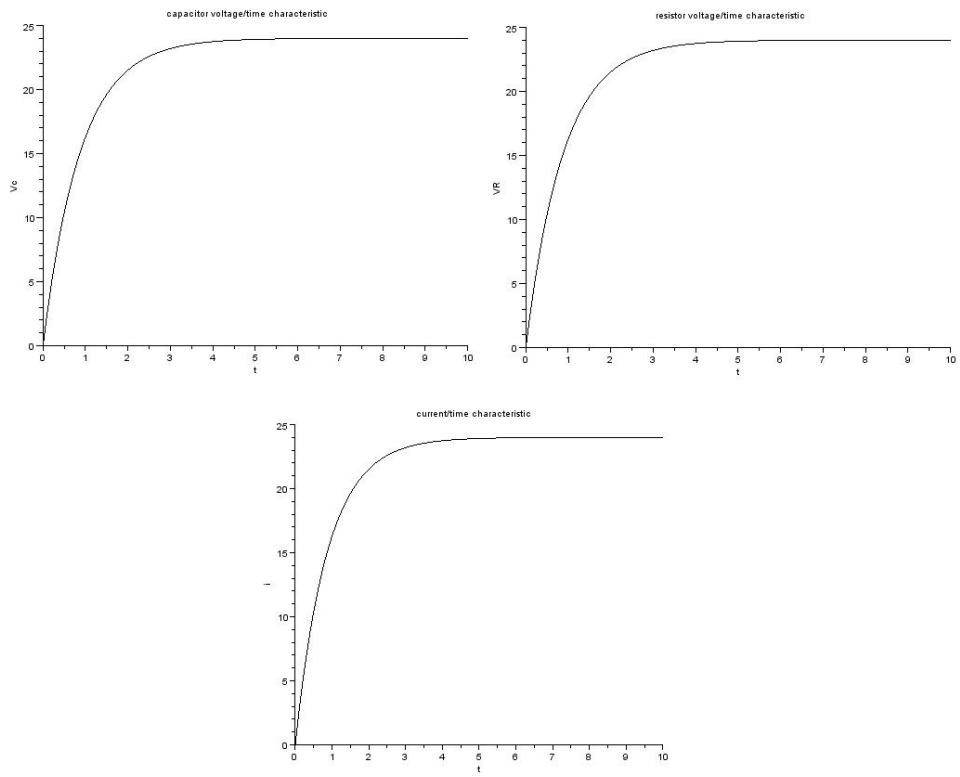
Figure 17.2: Example 2

```
5   R = 220000; // in ohms
6   V = 24; // in Volts
7   t1 = 1.5; // in secs
8
9   // calculation :
10  tou = R*C
11  t = 0:0.1:10
12  Vc = V*(1-%e^(-1*t/tou));
13  plot2d(t,Vc)
14  xtitle("capacitor voltage/time characteristic", "t",
        "Vc")
15  xset('window',1)
16  VR = V*(1-%e^(-1*t/tou));
17  plot2d(t,VR)
18  xtitle("resistor voltage/time characteristic", "t",
        "VR")
19  xset('window',2)
20  I = V/R
21  i = I*%e^(-1*t/tou)
22  plot2d(t,i)
23  xtitle("current/time characteristic", "t", "i")
24  Vct1 = V*%e^(-1*t1/tou)
25  VRt1 = V*%e^(-1*t1/tou)
26  it1 = I*%e^(-1*t1/tou)
27
28  printf("\ = \n\n Result \n\n")
29  printf("\n the value of capacitor voltage is %.2f V,
        resistor voltage is %.2f V, current is %.1E A at
        one and a half seconds after discharge has
        started.",Vct1, VRt1,it1)
```

Scilab code Exa 17.03 Example 3

```
1   //Problem 17.03: A 20   F capacitor is connected in
        series with a 50 kohm resistor and the circuit is
```

```
    connected to a 20 V, d.c. supply. Determine (a)
    the initial value of the current flowing, (b) the
     time constant of the circuit, (c) the value of
    the current one second after connection, (d) the
    value of the capacitor voltage two seconds after
    connection, and (e) the time after connection
    when the resistor voltage is 15 V
2
3  //initializing the variables:
4  C = 20E-6; // in Farads
5  R = 50000; // in ohms
6  V = 20; // in Volts
7  t1 = 1; // in secs
8  t2 = 2; // in secs
9  VRt = 15; // in Volts
10
11 //calculation:
12 tou = R*C
13 I = V/R
14 Vct1 = V*(1-%e^(-1*t2/tou))
15 t3 = -1*tou*log(VRt/V)
16 it1 = I*%e^(-1*t1/tou)
17
18 printf("\ = \n\n Result \n\n")
19 printf("\n (a)initial value of the current flowing
       is %.4f A",I)
20 printf("\n (b)time constant of the circuit %.0f Sec"
       ,tou)
21 printf("\n (c)the value of the current one second
       after connection, %.3f mA",(it1/1E-3))
22 printf("\n (d)the value of the capacitor voltage two
        seconds after connection %.1f V",Vct1)
23 printf("\n (e)the time after connection when the
       resistor voltage is 15 V is %.3f sec",t3)
```

Scilab code Exa 17.04 Example 4

```
1  //Problem 17.04: A circuit consists of a resistor
       connected in series with a 0.5   F capacitor and
       has a time constant of 12 ms. Determine (a) the
       value of the resistor , and (b) the capacitor
       voltage 7 ms after connecting the circuit to a 10
        V supply
2
3  //initializing the variables:
4  C = 0.5E-6; // in Farads
5  V = 10; // in Volts
6  tou = 0.012; // in secs
7  t1 = 0.007; // in secs
8
9  //calculation:
10 R = tou/C
11 Vc = V*(1-%e^(-1*t1/tou))
12
13 printf("\ = \n\n Result \n\n")
14 printf("\n (a)value of the resistor is %.0f ohm",R)
15 printf("\n (b)capacitor voltage is %.2f V",Vc)
```

Scilab code Exa 17.05 Example 5

```
1  //Problem 17.05: A capacitor is charged to 100 V and
        then discharged through a 50 kohm resistor. If
       the time constant of the circuit is 0.8 s,
       determine: (a) the value of the capacitor , (b)
       the time for the capacitor voltage to fall to 20
       V, (c) the current flowing when the capacitor has
        been discharging for 0.5 s, and (d) the voltage
       drop across the resistor when the capacitor has
       been discharging for one second.
2
```

```
3  //initializing the variables:
4  R = 50000; // in ohms
5  V = 100; // in Volts
6  Vc1 = 20; // in Volts
7  tou = 0.8; // in secs
8  t1 = 0.5; // in secs
9  t2 = 1; // in secs
10
11 //calculation:
12 C = tou/R
13 t = -1*tou*log(Vc1/V)
14 I = V/R
15 it1 = I*%e^(-1*t1/tou)
16 Vc = V*%e^(-1*t2/tou)
17
18 printf("\ = \n\n Result \n\n")
19 printf("\n (a)the value of the capacitor is %.2E F",
       C)
20 printf("\n (b)the time for the capacitor voltage to
       fall to 20 V is %.2f sec",t)
21 printf("\n (c)the current flowing when the capacitor
        has been discharging for 0.5 s is %.5f A",it1)
22 printf("\n (d)the voltage drop across the resistor
       when the capacitor has been discharging for one
       second is %.1f V",Vc)
```

Scilab code Exa 17.06 Example 6

```
1  //Problem 17.06: A 0.1   F capacitor is charged to
       200 V before being connected across a 4 kohm
       resistor. Determine (a) the initial discharge
       current, (b) the time constant of the circuit,
       and (c) the minimum time required for the voltage
        across the capacitor to fall to less than 2 V
2
```

```
3  //initializing the variables:
4  C = 0.1E-6; // in Farads
5  R = 4000; // in ohms
6  V = 200; // in Volts
7  Vc1 = 2; // in Volts
8
9  //calculation:
10 tou = R*C
11 I = V/R
12 t = -1*tou*log(Vc1/V)
13
14 printf("\ = \n\n Result \n\n")
15 printf("\n (a) initial discharge current is %.2f A",
       I)
16 printf("\n (b)Time constant tou is %.4f sec",tou)
17 printf("\n (c)minimum time required for the voltage
       across the capacitor to fall to less than 2 V is
       %.3f sec",t)
```

Scilab code Exa 17.07 Example 7

```
1  //Problem 17.07: A relay has an inductance of 100 mH
       and a resistance of 20 ohm. It is connected to a
       60 V, d.c. supply. Use the   initial slope and
       three point   method to draw the current/time
       characteristic and hence determine the value of
       current flowing at a time equal to two time
       constants and the time for the current to grow to
       1.5 A.
2
3  //initializing the variables:
4  L = 0.1; // in Henry
5  R = 20; // in ohms
```
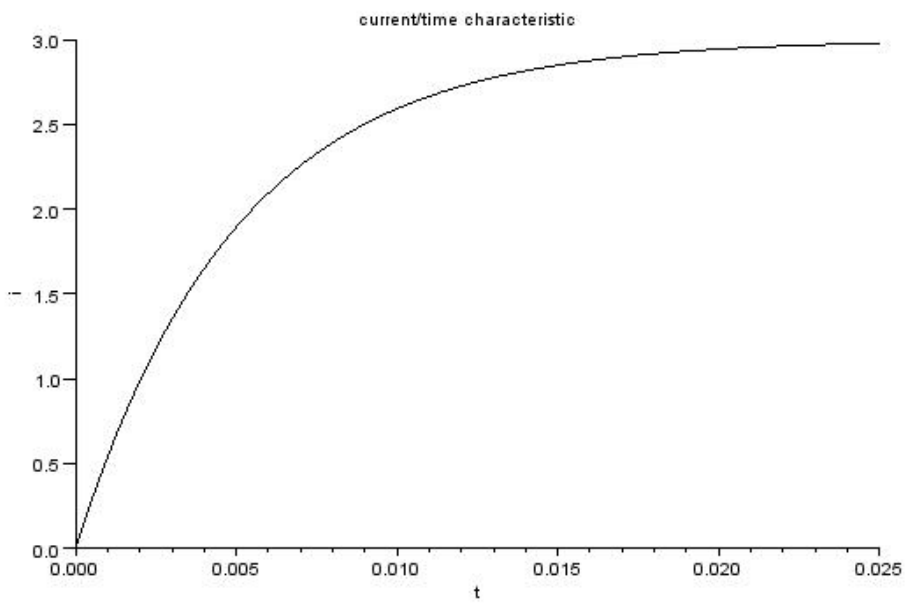
Figure 17.3: Example 7

```
6  V = 60; // in Volts
7  i2 = 1.5; // in Amperes
8
9  // calculation :
10 tou = L/R
11 t1 = 2*tou
12 t = 0:0.0001:0.025
13 I = V/R
14 i = I*(1 - %e^(-1*t/tou))
15 plot2d(t,i)
16 xtitle("current/time characteristic", "t", "i")
17 i1 = I*(1 - %e^(-1*t1/tou))
18 t2 = -1*tou*log(1 - i2/I)
19
20 printf("\ = \n\n Result \n\n")
21 printf("\n (a) the value of current flowing at a
       time equal to two time constants is %.3f A",i1)
22 printf("\n (b)the time for the current to grow to
       1.5 A is %.7f sec",t2)
```

Scilab code Exa 17.08 Example 8

```
1  //Problem 17.08: A coil of inductance 0.04 H and
       resistance 10 ohm is connected to a 120 V, d.c.
       supply. Determine (a) the final value of current,
        (b) the time constant of the circuit, (c) the
       value of current after a time equal to the time
       constant from the instant the supply voltage is
       connected, (d) the expected time for the current
       to rise to within 1% of its final value.
2
3  // initializing the variables :
4  L = 0.04; // in Henry
5  R = 10; // in ohms
6  V = 120; // in Volts
```

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```
 7  i2 = 0.01*I; // in amperes
 8
 9  //calculation:
10  tou = L/R
11  t1 = tou
12  I = V/R
13  i1 = I*(1 - %e^(-1*t1/tou))
14  i2 = 0.01*I
15  t2 = -1*tou*log(i2/I)
16
17  printf(")\ = \n\n Result \n\n")
18  printf(")\n (a) the final value of current is %.0f A"
        ,I)
19  printf(")\n (b)time constant of the circuit is %.3f
        sec",tou)
20  printf(")\n (c) value of current after a time equal
        to the time constant is %.2f A",i1)
21  printf(")\n (d)the expected time for the current to
        rise to within 0.01 times of its final value is %
        .2f sec",t2)
```

Scilab code Exa 17.09 Example 9

```
1  //Problem 17.09: The winding of an electromagnet has
       an inductance of 3 H and a resistance of 15 ohm.
       When it is connected to a 120 V, d.c. supply,
      calculate: (a) the steady state value of current
      flowing in the winding, (b) the time constant of
      the circuit, (c) the value of the induced e.m.f.
      after 0.1 s, (d) the time for the current to rise
       to 85% of its final value, and (e) the value of
      the current after 0.3 s.
2
3  //initializing the variables:
4  L = 3; // in Henry
```

```
5  R = 15; // in ohms
6  V = 120; // in Volts
7  t1 = 0.1; // in secs
8  t3 = 0.3; // in secs
9
10 //calculation:
11 tou = L/R
12 I = V/R
13 i2 = 0.85*I
14 VL = V*%e^(-1*t1/tou)
15 t2 = -1*tou*log(1 - (i2/I))
16 i3 = I*(1 - %e^(-1*t3/tou))
17
18 printf("\ = \n\n Result \n\n")
19 printf("\n (a) steady state value of current is %.0f
        A",I)
20 printf("\n (b)time constant of the circuit is %.3f
        sec",tou)
21 printf("\n (c)value of the induced e.m.f. after 0.1
        s is %.2f V",VL)
22 printf("\n (d) time for the current to rise to 0.85
        times of its final values is %.3f sec",t2)
23 printf("\n (e)value of the current after 0.3 s is %
        .3f A",i3)
```

Scilab code Exa 17.10 Example 10

```
1 //Problem 17.10: The field winding of a 110 V, d.c.
      motor has a resistance of 15 ohms and a time
      constant of 2 s. Determine the inductance and use
       the tangential method to draw the current/time
      characteristic when the supply is removed and
      replaced by a shorting link. From the
```

current/time characteristic
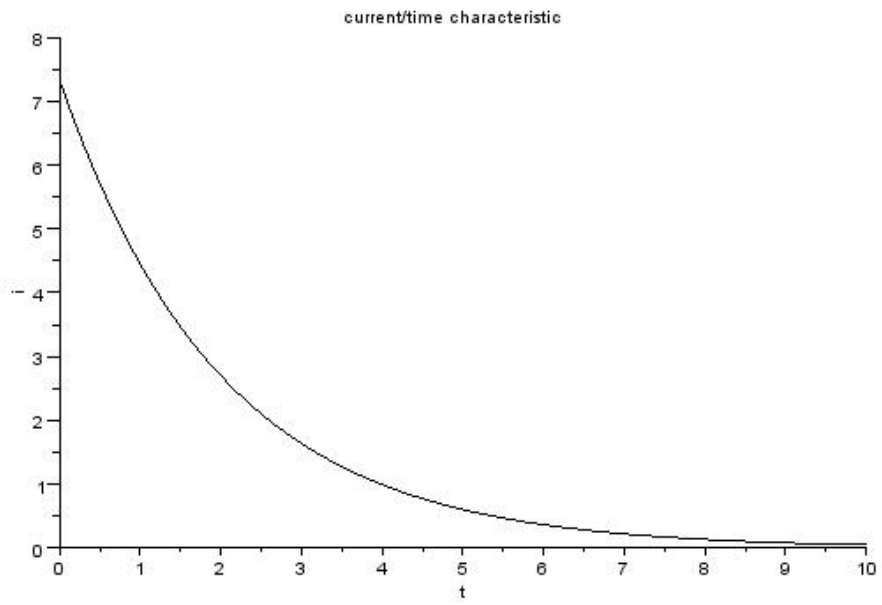
Figure 17.4: Example 10

```
      characteristic determine (a) the current flowing
      in the winding 3 s after being shorted−out and (b
      ) the time for the current to decay to 5 A.
2
3  // initializing the variables:
4  R = 15;  // in ohms
5  V = 110;  // in Volts
6  tou = 2;  // in secs
7  t1 = 3;  // in secs
8  i2 =5;  // in amperes
9
10  // calculation:
11  L = tou*R
12  t = 0:0.1:10
13  I = V/R
14  i = I*(%e^(-1*t/tou))
15  plot2d(t,i)
16  xtitle("current/time characteristic", "t", "i")
17  i1 = I*(%e^(-1*t1/tou))
18  t2 = -1*tou*log((i2/I))
19
20  printf("\ = \n\n Result \n\n")
21  printf("\n inductance is %.0f H",L)
22  printf("\n (a)the current flowing in the winding 3 s
         after being shorted−out is %.2f A",i1)
23  printf("\n (b)the time for the current to decay to 5
         A is %.3f sec",t2)
```

Scilab code Exa 17.11 Example 11

```
1  //Problem 17.11 A coil having an inductance of 6 H
      and a resistance of R  is connected in series
      with a resistor of 10  to a 120 V, d.c. supply.
      The time constant of the circuit is 300 ms. When
      steady−state conditions have been reached, the
```

```
          supply is replaced instantaneously by a short−
          circuit. Determine: (a) the resistance of the
          coil ,(b) the current flowing in the circuit one
          second after the shorting link has been placed in
           the circuit , and (c) the time taken for the
          current to fall to 10% of its initial value.
 2
 3  //initializing the variables:
 4  L = 6; // in Henry
 5  r = 10; // in ohms
 6  V = 120; // in Volts
 7  tou = 0.3; // in secs
 8  t1 = 1; // in secs
 9
10  //calculation:
11  R = (L/tou) - r
12  Rt = R + r
13  I = V/Rt
14  i2 = 0.1*I
15  i1 = I*(%e^(-1*t1/tou))
16  t2 = -1*tou*log((i2/I))
17
18  printf("\ = \n\n Result \n\n")
19  printf("\n (a) resistance of the coil is %.0f ohm",R
        )
20  printf("\n (b) current flowing in the circuit one
          second after the shorting link has been placed is
          %.3f A",i1)
21  printf("\n (c)the time for the current to decay to
          0.1 times of initial value is %.3f sec",t2)
```

Scilab code Exa 17.12 Example 12

```
 1  //Problem 17.12: An inductor has a negligible
        resistance and an inductance of 200 mH and is
```

```scilab
      connected in series with a 1 kohm resistor to a
      24 V, d.c. supply. Determine the time constant of
       the circuit and the steady-state value of the
      current flowing in the circuit. Find (a) the
      current flowing in the circuit at a time equal to
       one time constant, (b) the voltage drop across
      the inductor at a time equal to two time
      constants and (c) the voltage drop across the
      resistor after a time equal to three time
      constants.
 2
 3  //initializing the variables:
 4  L = 0.2; // in Henry
 5  R = 1000; // in ohms
 6  V = 24; // in Volts
 7
 8  //calculation:
 9  tou = L/R
10  t1 = 1*tou // in secs
11  t2 = 2*tou // in secs
12  t3 = 3*tou // in secs
13  I = V/R
14  i1 = I*(1 - %e^(-1*t1/tou))
15  VL = V*(%e^(-1*t2/tou))
16  VR = V*(1 - %e^(-1*t3/tou))
17
18  printf("\ = \n\n Result \n\n")
19  printf("\n time constant of the circuit is %.4f sec,
         and  the steady-state value of the current is %
        .3f A",tou, I)
20  printf("\n (a) urrent flowing in the circuit at a
        time equal to one time constant is %.5f A",i1)
21  printf("\n (b) voltage drop across the inductor at a
         time equal to two time constants is %.3f V",VL)
22  printf("\n (c)the voltage drop across the resistor
        after a time equal to three time constants is %.2
        f V",VR)
```

Chapter 18

Operational amplifiers

Scilab code Exa 18.01 Example 1

```
1 //Problem 18.01: A differential amplifier has an
      open−loop voltage gain of 120. The input signals
      are 2.45 V and 2.35 V. Calculate the output
      voltage of the amplifier
2
3 //initializing the variables:
4 Vi2 = 2.45; // in Volts
5 Vi1 = 2.35; // in Volts
6 A0 = 120; // open−loop voltage gain
7
8 //calculation:
9 Vo = A0*(Vi2 - Vi1)
10
11 printf("\n\n Result \n\n")
12 printf("\n the output voltage is %.0f V",Vo)
```

Scilab code Exa 18.02 Example 2

```
1 //Problem 18.02: Determine the common−mode gain of
      an op amp that has a differential voltage gain of
       150E3 and a CMRR of 90 dB.
2
3 //initializing the variables:
4 Vg = 150E3; // differential voltage gain
5 CMRR = 90; // in dB
6
7 //calculation:
8 CMG = Vg/(10^(CMRR/20))
9
10 printf("\n\n Result \n\n")
11 printf("\n common−mode gain is %.2f",CMG)
```

Scilab code Exa 18.03 Example 3

```
1 //Problem 18.03: A differential amplifier has an
      open−loop voltage gain of 120 and a common input
       signal of 3.0 V to both terminals. An output
       signal of 24 mV results. Calculate the common−
       mode gain and the CMRR.
2
3 //initializing the variables:
4 Vg = 120; // differential voltage gain
5 Vi = 3; // in Volts
6 Vo = 0.024; // in Volts
7
8 //calculation:
9 CMG = Vo/Vi
10 CMRR = 20*log10(Vg/CMG)
11
12 printf("\n\n Result \n\n")
13 printf("\n common−mode gain is %.3f and CMRR is %.2f
       dB",CMG, CMRR)
```

Scilab code Exa 18.04 Example 4

```
1  //Problem 18.04: In the inverting amplifier of
       Figure 18.5, Ri = 1 kohm and Rf = 2 kohm.
       Determine the output voltage when the input
       voltage is: (a)+0.4 V (b) −1.2 V
2
3  //initializing the variables:
4  Rf = 2000; // in ohms
5  Ri = 1000; // in ohms
6  Vi1 = 0.4; // in Volts
7  Vi2 = -1.2; // in Volts
8
9  //calculation:
10 Vo1 = -1*Rf*Vi1/Ri
11 Vo2 = -1*Rf*Vi2/Ri
12
13 printf("\n\n Result \n\n")
14 printf("\n output voltage when the input voltage is
       0.4V is %.1f V and when the input voltage is −1.2
       V is %.1f V",Vo1, Vo2)
```

Scilab code Exa 18.05 Example 5

```
1  //Problem 18.05: The op amp shown in Figure 18.6 has
       an input bias current of 100 nA at 20 C.
       Calculate (a) the voltage gain, and (b) the
       output offset voltage due to the input bias
       current. (c) How can the effect of input bias
       current be minimised?
2
3  //initializing the variables:
```

```
4 Ii = 100E-9; // in Amperes
5 T = 20; // in  C
6 Rf = 1E6; // in ohms
7 Ri = 10000; // in ohms
8
9 //calculation:
10 A = -1*Rf/Ri
11 Vos = Ii*Ri*Rf/(Ri+Rf)
12
13 printf("\n\n Result \n\n")
14 printf("\n (a)the voltage gain is %.0f",A)
15 printf("\n (b)output offset voltage is %.5f V",Vos)
```

Scilab code Exa 18.06 Example 6

```
1 //Problem 18.06: Design an inverting amplifier to
       have a voltage gain of 40 dB, a closed−loop
       bandwidth of 5 kHz and an input resistance of 10
       kohm.
2
3 //initializing the variables:
4 Vg = 40; // in dB
5 bf = 5000; // in Hz
6 Ri = 10000; // in ohms
7
8 //calculation:
9 A = 10^(Vg/20)
10 Rf = A*Ri
11 f = A*bf
12
13 printf("\n\n Result \n\n")
14 printf("\n the voltage gain is %.0f, Rf = %.0f ohm
       and frequency = %.0f Hz",A, Rf, f)
```

Scilab code Exa 18.07 Example 7

```
1  //Problem  18.07:  For  the  op  amp  shown  in  Figure
      18.8 ,  R1 = 4.7  kohm  and  R2 = 10  kohm .  If  the
      input  voltage  is− 0.4  V,  determine  ( a )  the
      voltage  gain  ( b )  the  output  voltage
2
3  //initializing  the  variables :
4  Vi = -0.4;  //  in  Volts
5  R1 = 4700;  //  in  ohms
6  R2 = 10000;  //  in  ohms
7
8  //calculation :
9  A = 1 + (R2/R1)
10 Vo = A*Vi
11
12 printf(" \n\n  Result  \n\n")
13 printf(" \n(a)  the  voltage  gain  is  %.2 f",A)
14 printf(" \n(b)  output  voltageis  %.2 f  V",Vo)
```

Scilab code Exa 18.08 Example 8

```
1  //Problem  18.08:  For  the  summing  op  amp  shown  in
       Figure  18.11 ,  determine  the  output  voltage ,  Vo
2
3  //initializing  the  variables :
4  V1 = 0.5;  //  in  Volts
5  V2 = 0.8;  //  in  Volts
6  V3 = 1.2;  //  in  Volts
7  R1 = 10000;  //  in  ohms
8  R2 = 20000;  //  in  ohms
9  R3 = 30000;  //  in  ohms
```

```
10  Rf = 50000; // in ohms
11
12  //calculation:
13  Vo = -1*Rf*(V1/R1 + V2/R2 + V3/R3)
14
15  printf("\n\n Result \n\n")
16  printf("\n output voltageis %.1f V",Vo)
```

Scilab code Exa 18.10 Example 10

```
1  //Problem 18.10: A steady voltage of -0.75V is
       applied to an op amp integrator having component
       values of R = 200 kohm and C = 2.5   F . Assuming
       that the initial capacitor charge is zero ,
       determine the value of the output voltage 100 ms
       after application of the input .
2
3  //initializing the variables:
4  Vs = -0.75; // in Volts
5  R = 200000; // in ohms
6  C = 2.5E-6; // in Farads
7  t = 0.1; // in secs
8
9  //calculation:
10  Vo = (-1/(C*R))*integrate('-0.75', 't', 0, 0.1)
11
12  printf("\n\n Result \n\n")
13  printf("\n output voltage is %.2f V",Vo)
```

Scilab code Exa 18.11 Example 11

```
 1  //Problem 18.11: In the differential amplifier shown
        in Figure 18.16, R1 = 10 kohm, R2 = 10 kohm, R3
        = 100 kohm and Rf = 100 kohm. Determine the
        output voltage Vo if:
 2  //(a) V1 = 5 mV and V2 = 0
 3  //(b) V1 = 0 and V2 = 5mV
 4  //(c) V1 = 50 mV and V2 = 25mV
 5  //(d) V1 = 25 mV and V2 = 50mV
 6
 7  //initializing the variables:
 8  V1a = 0.005; // in Volts
 9  V2a = 0; // in Volts
10  V1b = 0; // in Volts
11  V2b = 0.005; // in Volts
12  V1c = 0.05; // in Volts
13  V2c = 0.025; // in Volts
14  V1d = 0.025; // in Volts
15  V2d = 0.05; // in Volts
16  R1 = 10000; // in ohms
17  R2 = 10000; // in ohms
18  R3 = 100000; // in ohms
19  Rf = 100000; // in ohms
20
21  //calculation:
22  Vo1 = -1*Rf*V1a/R1
23  Vo2 = (R3/(R2+R3))*(1 + (Rf/R1))*V2b
24  Vo3 = -1*Rf*(V1c-V2c)/R1
25  Vo4 = (R3/(R2+R3))*(1 + (Rf/R1))*(V2d-V1d)
26
27  printf("\n\n Result \n\n")
28  printf("\n (a)output voltage is %.3f V",Vo1)
29  printf("\n (b)output voltage is %.3f V",Vo2)
30  printf("\n (c)output voltage is %.3f V",Vo3)
31  printf("\n (d)output voltage is %.3f V",Vo4)
```

Chapter 19

Three phase systems

Scilab code Exa 19.01 Example 1

```
1  //Problem 19.01: Three loads, each of resistance 30
      ohm
2  , are connected in star to a 415 V, 3-phase supply.
      Determine (a) the system phase voltage, (b) the
      phase current and (c) the line current.
3
4  //initializing the variables:
5  Vl = 415; // in Volts
6  Rp = 30; // in ohms
7
8  //calculation:
9  Vp = Vl/(3^0.5)
10 Ip = Vp/Rp
11 Il = Ip
12
13 printf("\n\n Result \n\n")
14 printf("\n (a)the system phase voltage is %.1f V",Vp
      )
15 printf("\n (b)phase current is %.0f A",Ip)
16 printf("\n (c)line current is %.0f A",Il)
```

Scilab code Exa 19.02 Example 2

```
1 //Problem 19.02: A star-connected load consists of
      three identical coils each of resistance 30
2 ohm and inductance 127.3 mH. If the line current is
      5.08 A, calculate the line voltage if the supply
      frequency is 50 Hz.
3
4 //initializing the variables:
5 R = 30; // in ohms
6 L = 0.1273; // in Henry
7 Ip = 5.08; // in Amperes
8 f = 50; // in Hz
9
10 //calculation:
11 XL = 2*%pi*f*L
12 Zp = (R*R + XL*XL)^0.5
13 Il = Ip
14 Vp = Ip*Zp
15 Vl = Vp*(3^0.5)
16
17 printf("\n\n Result \n\n")
18 printf("\n (a)line voltage is %.0f V",Vl)
```

Scilab code Exa 19.04 Example 4

```
1 //Problem 19.04: A 415 V, 3-phase, 4 wire, star-
      connected system supplies three resistive loads
      as shown in Figure 19.7. Determine (a) the
      current in each line and (b) the current in the
      neutral conductor.
2
```

```
 3  //initializing the variables:
 4  V = 415; // in Volts
 5  PR = 24000; // in Watt
 6  Py = 18000; // in Watt
 7  Pb = 12000; // in Watt
 8  VR = 240; // in Volts
 9  Vy = 240; // in Volts
10  Vb = 240; // in Volts
11
12  //calculation:
13  //For a star-connected system VL = Vp*(3^0.5)
14  Vp = Vl/(3^0.5)
15  phir = 90*%pi/180
16  phiy = 330*%pi/180
17  phib = 210*%pi/180
18  // I = P/V  for a resistive load
19  IR = PR/VR
20  Iy = Py/Vy
21  Ib = Pb/Vb
22  Inh = IR*cos(phir) + Ib*cos(phib) + Iy*cos(phiy)
23  Inv = IR*sin(phir) + Ib*sin(phib) + Iy*sin(phiy)
24  In = (Inh^2 + Inv^2)^0.5
25
26  printf("\n\n Result \n\n")
27  printf("\n (a)cuurnt in R line is %.0f A, cuurnt in
        Y line is %.0f A and cuurnt in B line is %.0f A",
        IR,Iy,Ib)
28  printf("\n (b)cuurnt in neutral line is %.1f A",In)
```

Scilab code Exa 19.05 Example 5

```
 1  //Problem 19.05: Three identical coils each of
        resistance 30 ohm
 2   and inductance 127.3 mH are connected in delta to a
        440 V, 50 Hz, 3-phase supply. Determine (a) the
```

```
         phase  current ,  and  ( b )  the  line  current .
 3
 4  // initializing  the  variables :
 5  R = 30;  //  in  ohms
 6  L = 0.1273;  //  in  Henry
 7  VL = 440;  //  in  Volts
 8  f = 50;  //  in  Hz
 9
10  // calculation :
11  XL = 2*%pi*f*L
12  Zp = (R*R + XL*XL)^0.5
13  Vp = VL
14  // Phase  current
15  Ip = Vp/Zp
16  // For  a  delta  connection ,
17  IL = Ip*(3^0.5)
18
19  printf ("\n\n  Result  \n\n")
20  printf ("\n  (a) the  phase  current  %.1 f  A",Ip)
21  printf ("\n  (b) line   current  %.2 f  A",IL)
```

Scilab code Exa 19.06 Example 6

```
 1  // Problem  19.06:  Three  identical  capacitors  are
        connected  in  delta  to  a  415  V,  50  Hz,  3−phase
        supply .  If  the  line  current  is  15  A,  determine
        the  capacitance  of  each  of  the  capacitors .
 2
 3  // initializing  the  variables :
 4  IL = 15;  //  in  Amperes
 5  VL = 415;  //  in  Volts
 6  f = 50;  //  in  Hz
 7
 8  // calculation :
 9  // For  a  delta  connection
```

```
10  Ip = IL/(3^0.5)    //phase current
11  Vp = VL
12  //Capacitive reactance per phase
13  Xc = Vp/Ip
14  C = 1/(2*%pi*f*Xc)
15
16  printf("\n\n Result \n\n")
17  printf("\n capacitance is %.3E F",C)
```

Scilab code Exa 19.07 Example 7

```
1  //Problem 19.07: Three coils each having resistance
       3
2  ohm and inductive reactance 4 ohm
3   are connected (i) in star and (ii) in delta to a
       415 V, 3-phase supply. Calculate for each
       connection (a) the line and phase voltages and (
       b) the phase and line currents.
4
5  //initializing the variables:
6  R = 3; // in ohms
7  XL = 4; // in ohms
8  VL = 415; // in Volts
9
10  //calculation:
11  //For a star connection:
12  //IL = Ip
13  //VL = Vp*(3^0.5)
14  VLs = VL
15  Vps = VLs/(3^0.5)
16  //Impedance per phase,
17  Zp = (R*R + XL*XL)^0.5
18  Ips = Vps/Zp
19  ILs = Ips
20  //For a delta connection:
```

```
21  //VL = Vp
22  //IL = Ip*(3^0.5)
23  VLd = VL
24  Vpd = VLd
25  Ipd = Vpd/Zp
26  ILd = Ipd*(3^0.5)
27
28  printf("\n\n Result \n\n")
29  printf("\n (a)the line voltage for star connection
        is %.0f V and the phase voltage for star
        connection is %.0f V and the line voltage for
        delta connection is %.0f V and the phase voltage
        for delta connection is %.0f V",VLs,Vps,VLd,Vpd)
30  printf("\n (b)the line current for star connection
        is %.0f A and the phase current for star
        connection is %.0f A and the line current for
        delta connection is %.0f A and the phase current
        for delta connection is %.0f A",ILs,Ips,ILd,Ipd)
```

Scilab code Exa 19.08 Example 8

```
1  //Problem 19.08: Three 12
2  ohms resistors are connected in star to a 415 V, 3-
       phase supply. Determine the total power
       dissipated by the resistors.
3
4  //initializing the variables:
5  Rp = 12; // in ohms
6  VL = 415; // in Volts
7
8  //calculation:
9  //Power dissipated, P = VL*IL*(3^0.5)*cos(phi)   or
       P = 3*Ip*Ip*Rp)
10 Vp = VL/(3^0.5)    // since the resistors are star−
       connected
```

```
11  //Phase current, Ip
12  Zp = Rp
13  Ip = Vp/Zp
14  //For a star connection
15  IL = Ip
16  // For a purely resistive load, the power factor cos
        (phi) = 1
17  pf = 1
18  P = VL*IL*(3^0.5)*pf
19
20  printf("\n\n Result \n\n")
21  printf("\n (a)total power dissipated by the
        resistors is %.0f W",P)
```

Scilab code Exa 19.09 Example 9

```
1  //Problem 19.09: The input power to a 3-phase a.c.
       motor is measured as 5 kW. If the voltage and
       current to the motor are 400 V and 8.6 A
       respectively, determine the power factor of the
       system.
2
3  //initializing the variables:
4  P = 5000; // in Watts
5  IL = 8.6; // in amperes
6  VL = 400; // in Volts
7
8  //calculation:
9  //Power dissipated, P = VL*IL*(3^0.5)*cos(phi)   or
       P = 3*Ip*Ip*Rp)
10 pf = P/(VL*IL*(3^0.5))
11
12 printf("\n\n Result \n\n")
13 printf("\n power factor is %.3f",pf)
```

Scilab code Exa 19.10 Example 10

```
1  //Problem 19.10: Three identical coils, each of
      resistance 10 ohm
2   and inductance 42 mH are connected (a) in star and
       (b) in delta to a 415 V, 50 Hz, 3-phase supply.
        Determine the total power dissipated in each
        case.
3
4  //initializing the variables:
5  R = 10; // in ohms
6  L = 0.042; // in Henry
7  VL = 415; // in Volts
8  f = 50; // in Hz
9
10  //calculation:
11  //For a star connection:
12  //IL = Ip
13  //VL = Vp*(3^0.5)
14  XL = 2*%pi*f*L
15  Zp = (R*R + XL*XL)^0.5
16  VLs = VL
17  Vps = VLs/(3^0.5)
18  //Impedance per phase,
19  Ips = Vps/Zp
20  ILs = Ips
21  //Power dissipated, P = VL*IL*(3^0.5)*cos(phi)   or
        P = 3*Ip*Ip*Rp)
22  pfs = R/Zp
23  Ps = VLs*ILs*(3^0.5)*pfs
24
25  //For a delta connection:
26  //VL = Vp
27  //IL = Ip*(3^0.5)
```

```
28  VLd = VL
29  Vpd = VLd
30  Ipd = Vpd/Zp
31  ILd = Ipd*(3^0.5)
32  //Power dissipated, P = VL*IL*(3^0.5)*cos(phi)   or
        P = 3*Ip*Ip*Rp)
33  pfd = R/Zp
34  Pd = VLd*ILd*(3^0.5)*pfd
35
36  printf("\n\n Result \n\n")
37  printf("\n total power dissipated in star is %.1E W
        and in delta is %.2E W",Ps, Pd)
```

Scilab code Exa 19.11 Example 11

```
1  //Problem 19.11: A 415 V, 3-phase a.c. motor has a
        power output of 12.75 kW and operates at a power
        factor of 0.77 lagging and with an efficiency of
        85%. If the motor is delta-connected, determine (
        a) the power input, (b) the line current and (c)
        the phase current.
2
3  //initializing the variables:
4  Po = 12750; // in Watts
5  pf = 0.77; // power factor
6  eff = 0.85;
7  VL = 415; // in Volts
8
9  //calculation:
10 //eff = power_out/power_in
11 Pi = Po/eff
12 //Power P = VL*IL*(3^0.5)*cos(phi)   or   P = 3*Ip*Ip*
        Rp)
13 IL = Pi/(VL*(3^0.5)*pf) // line current
14
```

```
15  //For a delta connection:
16  //IL = Ip*(3^0.5)
17  Ip = IL/(3^0.5)
18
19  printf("\n\n Result \n\n")
20  printf("\n (a)power input is %.2E W",Pi)
21  printf("\n (b)line current is %.2f A",IL)
22  printf("\n (c)phase current is %.2f A",Ip)
```

Scilab code Exa 19.13 Example 13

```
1  //Problem 19.13: A 400 V, 3-phase star connected
       alternator supplies a delta-connected load, each
       phase of which has a resistance of 30 ohm
2   and inductive reactance 40
3  ohm. Calculate (a) the current supplied by the
       alternator and (b) the output power and the kVA
       of the alternator, neglecting losses in the line
       between the alternator and load.
4
5  //initializing the variables:
6  R = 30; // in ohms
7  XL = 40; // in ohms
8  VL = 400; // in Volts
9
10 //calculation:
11 Zp = (R*R + XL*XL)^0.5
12 //a delta-connected load
13 Vp = VL
14 //Phase current
15 Ip = Vp/Zp
16 IL = Ip*(3^0.5)
17 //Alternator output power is equal to the power
       dissipated by the load.
18 //Power P = VL*IL*(3^0.5)*cos(phi)   or   P = 3*Ip*Ip*
```

```
        Rp)
19  pf = R/Zp
20  P = VL*IL*(3^0.5)*pf
21  //Alternator output kVA,
22  S = VL*IL*(3^0.5)
23
24  printf("\n\n Result \n\n")
25  printf("\n (a)the current supplied by the alternator
        is %.2f A",IL)
26  printf("\n (b)output power is %.2E W and kVA of the
        alternator is %.2E kVA",P, S)
```

Scilab code Exa 19.14 Example 14

```
1  //Problem 19.14: Each phase of a delta−connected
       load comprises a resistance of 30 ohm
2   and an 80   F capacitor in series. The load is
       connected to a 400 V, 50 Hz, 3-phase supply.
       Calculate (a) the phase current, (b) the line
       current, (c) the total power dissipated and (d)
       the kVA rating of the load. Draw the complete
       phasor diagram for the load.
3
4  //initializing the variables:
5  R = 30; // in ohms
6  C = 80E-6; // in Farads
7  f = 50; // in Hz
8  VL = 400; // in Volts
9
10  //calculation:
11  //Capacitive reactance
12  Xc = 1/(2*%pi*f*C)
13  Zp = (R*R + Xc*Xc)^0.5
14  pf = R/Zp
15  //a delta−connected load
```

```
16  Vp = VL
17  //Phase current
18  Ip = Vp/Zp
19  IL = Ip*(3^0.5)
20  //Power P = VL*IL*(3^0.5)*cos(phi)   or   P = 3*Ip*Ip*
        Rp)
21  P = VL*IL*(3^0.5)*pf
22  //Alternator output kVA,
23  S = VL*IL*(3^0.5)
24
25  printf("\n\n Result \n\n")
26  printf("\n (a)the phase current   is %.3f A",Ip)
27  printf("\n (b)the line current   is %.2f A",IL)
28  printf("\n (c) power is %.2E W and \n(d)kVA of the
        alternator is %.2E kVA",P, S)
```

Scilab code Exa 19.15 Example 15

```
1  //Problem 19.15: Two wattmeters are connected to
       measure the input power to a balanced 3-phase
       load by the two-wattmeter method. If the
       instrument readings are 8 kW and 4 kW, determine
       (a) the total power input and (b) the load power
       factor.
2
3  //initializing the variables:
4  Pi1 = 8000; // in Watts
5  Pi2 = 4000; // in Watts
6
7  //calculation:
8  //Total input power
9  Pi = Pi1 + Pi2
10 phi = atan((Pi1 - Pi2)*(3^0.5)/(Pi1 + Pi2))
11 //Power factor
12 pf = cos(phi)
```

```
13
14  printf("\n\n Result \n\n")
15  printf("\n (a)power input is %.1E W",Pi)
16  printf("\n (b)power factor is %.3f",pf)
```

Scilab code Exa 19.16 Example 16

```
1  //Problem 19.16: Two wattmeters connected to a 3-
        phase motor indicate the total power input to be
        12 kW. The power factor is 0.6. Determine the
        readings of each wattmeter.
2
3  //initializing the variables:
4  Pi = 12000; // in Watts
5  pf = 0.6; // power factor
6
7  //calculation:
8  //If the two wattmeters indicate Pi1 and Pi2
        respectively
9  // Pit = Pi1 + Pi2
10 Pit = Pi
11 // Pid = Pi1 - Pi2
12 //power factor = 0.6 = cos(phi)
13 phi = acos(pf)
14 Pid = Pit*tan(phi)/(3^0.5)
15 //Hence wattmeter 1 reads
16 Pi1 = (Pid + Pit)/2
17 //wattmeter 2 reads
18 Pi2 = Pit - Pi1
19
20 printf("\n\n Result \n\n")
21 printf("\n reading in each wattameter are %.2E W and
        %.2E W",Pi1,Pi2)
```

Scilab code Exa 19.17 Example 17

```
1  //Problem 19.17: Two wattmeters indicate 10 kW and 3
       kW respectively when connected to measure the
       input power to a 3-phase balanced load, the
       reverse switch being operated on the meter
       indicating the 3 kW reading. Determine (a) the
       input power and (b) the load power factor.
2
3  //initializing the variables:
4  Pi1 = 10000; // in Watts
5  Pi2 = -3000; // in Watts
6
7  //calculation:
8  //Total input power
9  Pi = Pi1 + Pi2
10 phi = atan((Pi1 - Pi2)*(3^0.5)/(Pi1 + Pi2))
11 //Power factor
12 pf = cos(phi)
13
14 printf("\n\n Result \n\n")
15 printf("\n (a)power input is %.2E W",Pi)
16 printf("\n (b)power factor is %.3f",pf)
```

Scilab code Exa 19.18 Example 18

```
1  //Problem 19.18: Three similar coils, each having a
       resistance of 8 ohm and an inductive reactance
       of 8 ohm are connected (a) in star and (b) in
       delta, across a 415 V, 3-phase supply. Calculate
       for each connection the readings on each of two
```

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```
        wattmeters  connected  to  measure  the  power  by  the
        two−wattmeter  method .
 2
 3  // initializing  the  variables :
 4  R = 8;  //  in  ohms
 5  XL = 8;  //  in  ohms
 6  VL = 415;  //  in  Volts
 7
 8  // calculation :
 9  //For  a  star  connection :
10  //IL = Ip
11  //VL = Vp*(3^0.5)
12  VLs = VL
13  Vps = VLs/(3^0.5)
14  //Impedance  per  phase ,
15  Zp = (R*R + XL*XL)^0.5
16  Ips = Vps/Zp
17  ILs = Ips
18  //Power  dissipated ,  P = VL*IL*(3^0.5)*cos(phi)   or
        P = 3*Ip*Ip*Rp)
19  pf = R/Zp
20  Ps = VLs*ILs*(3^0.5)*pf
21  //If  wattmeter  readings  are  P1  and  P2  then  P1 + P2 =
        Pst
22  Pst = Ps
23  //  Pid = Pi1 − Pi2
24  phi = acos(pf)
25  Psd = Pst*tan(phi)/(3^0.5)
26  //Hence  wattmeter  1  reads
27  Ps1 = (Psd + Pst)/2
28  //wattmeter  2  reads
29  Ps2 = Pst - Ps1
30
31  //For  a  delta  connection :
32  //VL = Vp
33  //IL = Ip*(3^0.5)
34  VLd = VL
35  Vpd = VLd
```

```
36  Ipd = Vpd/Zp
37  ILd = Ipd*(3^0.5)
38  //Power dissipated , P = VL*IL*(3^0.5)*cos(phi)   or
        P = 3*Ip*Ip*Rp)
39  Pd = VLd*ILd*(3^0.5)*pf
40  //If wattmeter readings are P1 and P2 then P1 + P2 =
        Pdt
41  Pdt = Pd
42  // Pid = Pi1 - Pi2
43  Pdd = Pdt*tan(phi)/(3^0.5)
44  //Hence wattmeter 1 reads
45  Pd1 = (Pdd + Pdt)/2
46  //wattmeter 2 reads
47  Pd2 = Pdt - Pd1
48
49  printf("\n\n Result \n\n")
50  printf("\n (a)When the coils are star-connected the
        wattmeter readings are %.3E W and %.3E W",Ps1,Ps2
        )
51  printf("\n (b)When the coils are delta-connected the
         wattmeter readings are are %.3E W and %.3E W",
        Pd1,Pd2)
```

Chapter 20

Transformers

Scilab code Exa 20.01 Example 1

```scilab
1 //Problem 20.01: A transformer has 500 primary turns
      and 3000 secondary turns. If the primary voltage
      is 240 V, determine the secondary voltage,
     assuming an ideal transformer.
2
3 //initializing the variables:
4 N1 = 500; // primary turns
5 N2 = 3000; // secondary turns
6 V1 = 240; // in Volts
7
8 //calculation:
9 //For an ideal transformer, voltage ratio = turns
      ratio
10 V2 = V1*N2/N1
11
12 printf(" \n\n Result \n\n")
13 printf(" \n secondary voltage %.2E V",V2)
```

Scilab code Exa 20.02 Example 2

```
1  //Problem 20.02: An ideal transformer with a turns
      ratio of 2:7 is fed from a 240 V supply.
      Determine its output voltage.
2
3  //initializing the variables:
4  tr = 2/7;   // turns ratio
5  V1 = 240; // in Volts
6
7  //calculation:
8  //A turns ratio of 2:7 means that the transformer
      has 2 turns on the primary for every 7 turns on
      the secondary
9  V2 = V1/tr
10
11 printf(")\n\n Result \n\n")
12 printf(")\n output voltage %.0f V",V2)
```

Scilab code Exa 20.03 Example 3

```
1  //Problem 20.03: An ideal transformer has a turns
      ratio of 8:1 and the primary current is 3 A when
      it is supplied at 240 V. Calculate the secondary
      voltage and current.
2
3  //initializing the variables:
4  tr = 8/1;   // turns ratio
5  I1 = 3; // in Amperes
6  V1 = 240; // in Volts
7
8  //calculation:
9  //A turns ratio of 8:1 means that the transformer
      has 28 turns on the primary for every 1turns on
      the secondary
10 V2 = V1/tr
11 //secondary current
```

```
12  I2 = I1*tr
13
14  printf("\n\n Result \n\n")
15  printf("\n secondary voltage is %.0f V and secondary
          current is %.0f A",V2, I2)
```

Scilab code Exa 20.04 Example 4

```
1  //Problem 20.04: An ideal transformer, connected to
       a 240 V mains, supplies a 12 V, 150 W lamp.
       Calculate the transformer turns ratio and the
       current taken from the supply.
2
3  //initializing the variables:
4  V1 = 240; // in Volts
5  V2 = 12; // in Volts
6  P = 150; // in Watts
7
8  //calculation:
9  I2 = P/V2
10  //A turns ratio = Vp/Vs
11  tr = V1/V2 // turn ratio
12  //   V1/V2 = I2/I1
13  //current taken from the supply
14  I1 = I2*V2/V1
15
16  printf("\n\n Result \n\n")
17  printf("\n turn ratio is %.0f and current taken from
          the supply is %.3f A",tr, I1)
```

Scilab code Exa 20.05 Example 5

```
1  // Problem  20.05:  A  5  kVA  single −phase  transformer
       has  a  turns  ratio  of  10:1  and  is  fed  from  a  2.5
       kV  supply .  Neglecting  losses ,  determine  (a)  the
       full −load  secondary  current ,  (b)  the  minimum  load
        resistance  which  can  be  connected  across  the
       secondary  winding  to  give  full  load  kVA,  (c)  the
       primary  current  at  full  load  kVA.
2
3  // initializing  the  variables :
4  S = 5000;  //  in  VA
5  tr = 10;  //  turn  ratio
6  V1 = 2500;  //  in  Volts
7
8  // calculation :
9  //A  turns  ratio  of  8:1  means  that  the  transformer
       has  28  turns  on  the  primary  for  every  1turns  on
       the  secondary
10  V2 = V1/tr
11  // transformer  rating  in  volt −amperes  = Vs∗Is
12  I2 = S/V2
13  // Minimum  value  of  load  resistance
14  RL = V2/I2
15  //   tr = I2/I1
16  I1 = I2/tr
17
18  printf (" \n\n  Result  \n\n")
19  printf (" \n  (a) full −load  secondary  current  is  %.0 f  A"
       ,I2)
20  printf (" \n  (b) minimum  load  resistance  is  %.1 f  ohm",
       RL)
21  printf (" \n  (c)  primary  current  is  %.0 f  A",I1)
```

Scilab code Exa 20.06 Example 6

```
1  // Problem  20.06:  A  2400  V/400  V  single −phase
```

```
        transformer  takes  a  no  load  current  of  0.5 A  and
        the  core  loss  is  400 W.  Determine  the  values  of
        the  magnetizing  and  core  loss  components  of  the
        no  load  current .  Draw  to  scale  the  no−load  phasor
         diagram  for  the  transformer .
2
3  // initializing  the  variables :
4  V1  =  2400;  //  in  Volts
5  V2  =  400;  //  in  Volts
6  I0  =  0.5;  //  in  Amperes
7  Pc  =  400;  //  in  Watts
8
9  // calculation :
10  //Core  loss  ( i . e .  iron  loss )  P  =  V1∗I0∗cos ( phi0 )
11  pf  =  Pc /( V1∗I0 )
12  phi0  =  acos ( pf )
13  //Magnetizing  component
14  Im  =  I0∗sin ( phi0 )
15  //Core  loss  component
16  Ic  =  I0∗cos ( phi0 )
17
18  printf (" \n\n  Result  \n\n")
19  printf (" \n  ( a ) magnetizing  component  is  %.3 f  A  and
         Core  loss  component  is  %.3 f  A", Im,  Ic )
```

Scilab code Exa 20.07 Example 7

```
1  // Problem  20.07:  A  transformer  takes  a  current  of
        0.8  A  when  its  primary  is  connected  to  a  240  volt
        ,  50  Hz  supply ,  the  secondary  being  on  open
        circuit .  If  the  power  absorbed  is  72  watts ,
        determine  ( a )  the  iron  loss  current ,  ( b )  the
        power  factor  on  no−load ,  and  ( c )  the  magnetizing
        current .
2
```

```
3  // initializing the variables :
4  V = 240; // in Volts
5  I0 = 0.8; // in Amperes
6  P = 72; // in Watts
7  f = 50; // in Hz
8
9  // calculation :
10 // Power absorbed = total core loss , P = V*I0*cos (
      phi0 )
11 // Ic = I0*cos ( phi0 )
12 Ic = P/V
13 pf = Ic/I0
14 // From the right-angled triangle in Figure 20.2( b)
      and using
15 // Pythagoras   theorem ,
16 Im = ( I0*I0 - Ic*Ic )^0.5
17
18 printf ("\n\n Result \n\n")
19 printf ("\n (a) Core loss component is %.2 f A", Ic)
20 printf ("\n (b) power factor is %.3 f", pf)
21 printf ("\n (c)magnetizing component is %.2 f A",Im)
```

Scilab code Exa 20.08 Example 8

```
1  // Problem 20.08: A 100 kVA, 4000 V/200 V, 50 Hz
      single-phase transformer has 100 secondary turns.
       Determine (a) the primary and secondary current ,
       (b) the number of primary turns , and (c) the
      maximum value of the flux .
2
3  // initializing the variables :
4  S = 100000; // in VA
5  V1 = 4000; // in Volts
6  V2 = 200; // in Volts
7  N2 = 100; // sec turns
```

```
8  f = 50; // in Hz
9
10 //calculation:
11 //Transformer rating = V1*I1 = V2*I2
12 //primary current
13 I1 = S/V1
14 //secondary current
15 I2 = S/V2
16 //primary turns
17 N1 = N2*V1/V2
18 //maximum flux
19 //assuming E2 = V2
20 Phim = V2/(4.44*f*N2)
21
22 printf(")\n\n Result \n\n")
23 printf(")\n (a)primary current is %.0f A and
      secondary current is %.0f A", I1, I2)
24 printf(")\n (b)number of primary turns is %.0f", N1)
25 printf(")\n (c)maximum value of the flux is %.2E Wb",
      Phim)
```

Scilab code Exa 20.09 Example 9

```
1  //Problem 20.09: A single-phase, 50 Hz transformer
       has 25 primary turns and 300 secondary turns. The
        cross-sectional area of the core is 300 cm2.
       When the primary winding is connected to a 250 V
       supply, determine (a) the maximum value of the
       flux density in the core, and (b) the voltage
       induced in the secondary winding.
2
3  //initializing the variables:
4  V1 = 250; // in Volts
5  A = 0.03; // in m2
6  N2 = 300; // sec turns
```

```
7  N1 = 25; // prim turns
8  f = 50; // in Hz
9
10 // calculation :
11 //e.m.f. E1 = 4.44*f*Phim*N1
12 //maximum flux density ,
13 Phim = V1/(4.44*f*N1)
14 //Phim = Bm*A, where Bm = maximum core flux density
      and A = cross−sectional area of the core
15 //maximum core flux density
16 Bm = Phim/A
17 //voltage induced in the secondary winding ,
18 V2 = V1*N2/N1
19
20 printf("\n\n Result \n\n")
21 printf("\n (a)maximum core flux density %.2f T", Bm)
22 printf("\n (b)voltage induced in the secondary
      winding is %.0f V", V2)
```

Scilab code Exa 20.10 Example 10

```
1  //Problem 20.10: A single−phase 500 V/100 V, 50 Hz
      transformer has a maximum core flux density of
      1.5 T and an effective core crosssectional area
      of 50 cm2. Determine the number of primary and
      secondary turns.
2
3  // initializing the variables :
4  V1 = 500; // in Volts
5  V2 = 100; // in Volts
6  Bm = 1.5; // in Tesla
7  A = 0.005; // in m2
8  f = 50; // in Hz
9
10 // calculation :
```

```
11  // Phim = Bm*A, where Bm = maximum core flux density
        and A = cross−sectional area of the core
12  // maximum core flux density
13  Phim = Bm*A
14  // e.m.f. E1 = 4.44*f*Phim*N1
15  // primary turns,
16  N1 = V1/(4.44*f*Phim)
17  // secondary turns,
18  N2 = V2*N1/V1
19
20  printf("\n\n Result \n\n")
21  printf("\n no. of primary and secondary turns are %
        .0f turns, and %.0f turns respectively", N1, N2)
```

Scilab code Exa 20.11 Example 11

```
1  // Problem 20.11: A 4500 V/225 V, 50 Hz single−phase
        transformer is to have an approximate e.m.f. per
        turn of 15 V and operate with a maximum flux of
        1.4 T. Calculate (a) the number of primary and
        secondary turns and (b) the cross−sectional area
        of the core.
2
3  // initializing the variables:
4  emfpt = 15; // in Volts
5  V1 = 4500; // in Volts
6  V2 = 225; // in Volts
7  Bm = 1.4; // in Tesla
8  f = 50; // in Hz
9
10  // calculation:
11  // E.m.f. per turn, V1/N1 = V2/N2 = emfpt
12  // primary turns,
13  N1 = V1/emfpt
14  // secondary turns,
```

```
15  N2 = V2/emfpt
16  //e.m.f. E1 = 4.44*f*Phim*N1
17  //maximum flux density,
18  Phim = V1/(4.44*f*N1)
19  //Phim = Bm*A, where Bm = maximum core flux density
        and A = cross-sectional area of the core
20  //cross-sectional area
21  A = Phim/Bm
22
23  printf("\n\n Result \n\n")
24  printf("\n (a)no. of primary and secondary turns are
        %.0f turns, and %.0f turns respectively", N1, N2
        )
25  printf("\n (b)cross-sectional area is %.2E m2", A)
```

Scilab code Exa 20.12 Example 12

```
1  //Problem 20.12: A single-phase transformer has 2000
        turns on the primary and 800 turns on the
      secondary. Its no-load current is 5 A at a power
      factor of 0.20 lagging. Assuming the volt drop in
       the windings is negligible, determine the
      primary current and power factor when the
      secondary current is 100 A at a power factor of
      0.85 lagging.
2
3  //initializing the variables:
4  N1 = 2000; // prim turns
5  N2 = 800; // sec turns
6  I0 = 5; // in Amperes
7  pf0 = 0.20; // power factor
8  I2 = 100; // in Amperes
9  pf2 = 0.85; // power factor
10
11  //calculation:
```

```
12  //Let I01 be the component of the primary current
        which provides the restoring mmf. Then I01*N1 =
        I2*N2
13  I01 = I2*N2/N1
14  //If the power factor of the secondary is 0.85
15  phi2 = acos(pf2)
16  //If the power factor on no-load is 0.20,
17  phi0 = acos(pf0)
18  I1h = I0*cos(phi0) + I01*cos(phi2)
19  I1v = I0*sin(phi0) + I01*sin(phi2)
20  //Hence the magnitude of I1
21  I1 = (I1h*I1h + I1v*I1v)^0.5
22  pf1 = cos(atan(I1v/I1h))
23
24  printf("\n\n Result \n\n")
25  printf("\n Primary currnt is %.2f A, and Power
        factor is %.2f", I1, pf1)
```

Scilab code Exa 20.13 Example 13

```
1  //Problem 20.13: A transformer has 600 primary turns
        and 150 secondary turns. The primary and
        secondary resistances are 0.25 ohm and 0.01 ohm
        respectively and the corresponding leakage
        reactances are 1.0 ohm and 0.04 ohm  respectively
        . Determine (a) the equivalent resistance
        referred to the primary winding, (b) the
        equivalent reactance referred to the primary
        winding, (c) the equivalent impedance referred to
         the primary winding, and (d) the phase angle of
        the impedance.
2
3  //initializing the variables:
4  N1 = 600; // prim turns
5  N2 = 150; // sec turns
```

```
6  R1 = 0.25; // in ohms
7  R2 = 0.01; // in ohms
8  X1 = 1.0; // in ohms
9  X2 = 0.04; // in ohms
10
11 //calculation:
12 tr = N1/N2 // turn ratio
13 vr = tr // voltage ratio = turn raio, vr = V1/V2
14 //equivalent resistance Re
15 Re = R1 + R2*(vr^2)
16 //equivalent reactance, Xe
17 Xe = X1 + X2*(vr^2)
18 //equivalent impedance, Ze
19 Ze = (Re*Re + Xe*Xe)^0.5
20 //cos(phie) = Re/Ze
21 pfe = Re/Ze
22 phie = acos(pfe)
23 phied = phie*180/%pi // in    (deg)
24
25 printf("\n\n Result \n\n")
26 printf("\n (a)the equivalent resistance referred to
       the primary winding is %.2 f ohm", Re)
27 printf("\n (b)the equivalent reactance referred to
       the primary winding is %.2 f ohm", Xe)
28 printf("\n (c)the equivalent impedance referred to
       the primary winding is %.2 f ohm", Ze)
29 printf("\n (d)phase angle is %.2 f  ", phied)
```

Scilab code Exa 20.14 Example 14

```
1 //Problem 20.14: A 5 kVA, 200 V/400 V, single−phase
       transformer has a secondary terminal voltage of
       387.6 volts when loaded. Determine the regulation
        of the transformer.
2
```

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```
3  // initializing the variables :
4  V1 = 200;  // in Volts
5  V2 = 400;  // in Volts
6  V2L = 387.6;  // in Volts
7  S = 5000;  // in VA
8
9  // calculation :
10 // regulation =(No−load secondary voltage − terminal
      voltage on load ) ∗100/no−load secondary voltage
      in %
11 reg = (V2 - V2L)∗100/ V2
12
13 printf ( " \n\n Result \n\n")
14 printf ( " \n the regulation of the transformer is %.1 f
        percent " , reg )
```

Scilab code Exa 20.15 Example 15

```
1  // Problem 20.15: The open circuit voltage of a
      transformer is 240 V. A tap changing device is
      set to operate when the percentage regulation
      drops below 2.5%. Determine the load voltage at
      which the mechanism operates .
2
3  // initializing the variables :
4  VnL = 240;  // in Volts
5  reg = 2.5;  // in percent
6
7  // calculation :
8  // regulation =(No−load secondary voltage − terminal
      voltage on load ) ∗100/no−load secondary voltage
      in %
9  VL = VnL - reg∗VnL/100
10
11 printf ( " \n\n Result \n\n")
```

```
12  printf("\n the load voltage at which the mechanism
        operates is %.0f V ", VL)
```

Scilab code Exa 20.16 Example 16

```
1  //Problem 20.16: A 200 kVA rated transformer has a
       full−load copper loss of 1.5 kW and an iron loss
       of 1 kW. Determine the transformer efficiency at
       full load and 0.85 power factor.
2
3  //initializing the variables:
4  S = 200000; // in VA
5  Pc = 1500; // in Watt
6  Pi = 1000; // in Watt
7  pf = 0.85; // power factor
8
9  //calculation:
10 //Efficiency = output power/input power = (input
       power losses)/input power
11 //Efficiency = 1 − losses/input power
12 //Full−load output power = V*I*pf
13 Po = S*pf
14 //Total losses
15 Pl = Pc + Pi
16 //Input power = output power + losses
17 PI = Po + Pl
18 //efficiency
19 eff = 1-(Pl/PI)
20
21 printf("\n\n Result \n\n")
22 printf("\n the transformer efficiency at full load
       is %.4f", eff)
```

Scilab code Exa 20.17 Example 17

```
1  //Problem 20.17: Determine the efficiency of the
       transformer in Problem 20.16 at half full-load
       and 0.85 power factor.
2
3  //initializing the variables:
4  S = 200000; // in VA
5  Pc = 1500; // in Watt
6  Pi = 1000; // in Watt
7  pf = 0.85; // power factor
8
9  //calculation:
10 //Efficiency = output power/input power = (input
       power losses)/input power
11 //Efficiency = 1 - losses/input power
12 //Half full-load power output = V*I*pf/2
13 Po = S*pf/2
14 //Copper loss (or I*I*R loss) is proportional to
       current squared
15 //Hence the copper loss at half full-load is
16 Pch = Pc/(2*2)
17 //Iron loss = 1000 W (constant)
18 //Total losses
19 Pl = Pch + Pi
20 //Input power at half full-load = output power at
       half full-load + losses
21 PI = Po + Pl
22 //efficiency
23 eff = (1-(Pl/PI))*100
24
25 printf("\n\n Result \n\n")
26 printf("\n the transformer efficiency at half full
       load is %.2f percent", eff)
```

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Scilab code Exa 20.18 Example 18

```
1  //Problem 20.18: A 400 kVA transformer has a primary
        winding resistance of 0.5 ohm and a secondary
        winding resistance of 0.001 ohm . The iron loss
        is 2.5 kW and the primary and secondary voltages
        are 5 kV and 320 V respectively . If the power
        factor of the load is 0.85 , determine the
        efficiency of the transformer (a) on full load ,
        and (b) on half load .
2
3  //initializing the variables :
4  S = 400000; // in VA
5  R1 = 0.5; // in Ohm
6  R2 = 0.001; // in Ohm
7  V1 = 5000; // in Volts
8  V2 = 320; // in Volts
9  Pi = 2500; // in Watt
10 pf = 0.85; // power factor
11
12 //calculation :
13 //Rating = 400 kVA = V1*I1 = V2*I2
14 //Hence primary current
15 I1 = S/V1
16 //secondary current
17 I2 = S/V2
18 //Total copper loss = I1*I1*R1 + I2*I2*R2,
19 Pcf = I1*I1*R1 + I2*I2*R2
20 //On full load , total loss = copper loss + iron loss
21 Plf = Pcf + Pi
22 // full-load power output = V2*I2*pf
23 Pof = S*pf
24 //Input power at full-load = output power at full-
        load + losses
25 PIf = Pof + Plf
26 //Efficiency = output power/input power = (input
        power losses )/input power
27 //Efficiency = 1 - losses/input power
```

```
28  efff = (1-(Plf/PIf))*100
29
30  //Half full-load power output = V*I*pf/2
31  Poh = S*pf/2
32  //Copper loss (or I*I*R loss) is proportional to
        current squared
33  //Hence the copper loss at half full-load is
34  Pch = Pcf/(2*2)
35  //Iron loss = 2500 W (constant)
36  //Total losses
37  Plh = Pch + Pi
38  //Input power at half full-load = output power at
        half full-load + losses
39  PIh = Poh + Plh
40  //efficiency
41  effh = (1-(Plh/PIh))*100
42
43  printf(" \n\n Result \n\n")
44  printf(" \n (a)the transformer efficiency at full
        load is %.2f percent", efff)
45  printf(" \n (b)the transformer efficiency at half
        full load is %.2f percent", effh)
```

Scilab code Exa 20.19 Example 19

```
1  //Problem 20.19: A 500 kVA transformer has a full
        load copper loss of 4 kW and an iron loss of 2.5
        kW. Determine (a) the output kVA at which the
        efficiency of the transformer is a maximum, and (
        b) the maximum efficiency, assuming the power
        factor of the load is 0.75.
2
3  //initializing the variables:
4  S = 500000; // in VA
5  Pcf = 4000; // in Watt
```

```
6  Pi = 2500; // in Watt
7  pf = 0.75; // power factor
8
9  // calculation :
10 // Let x be the fraction of full load kVA at which
      the efficiency is a maximum.
11 // The corresponding total copper loss = (4 kW)*(x^2)
12 // At maximum efficiency , copper loss = iron loss
      Hence
13 x = (Pi/Pcf)^0.5
14 // Hence the output kVA at maximum efficiency
15 So = x*S
16 // Total loss at maximum efficiency
17 Pl = 2*Pi
18 // Output power
19 Po = So*pf
20 // Input power = output power + losses
21 PI = Po + Pl
22 // Efficiency = output power/input power = (input
      power losses )/input power
23 // Efficiency = 1 - losses/input power
24 // Maximum efficiency
25 effm = (1 - Pl/PI)*100
26
27 printf("\n\n Result \n\n")
28 printf("\n the output kVA at maximum efficiency is %
      .2E VA", So)
29 printf("\n max. efficiency is %.2f pecent", effm)
```

Scilab code Exa 20.20 Example 20

```
1 // Problem 20.20: A transformer having a turns ratio
     of 4:1 supplies a load of resistance 100 ohm.
     Determine the equivalent input resistance of the
     transformer .
```

```
 2
 3 //initializing the variables:
 4 tr = 4; // turn ratio
 5 RL = 100; // in Ohms
 6
 7 //calculation:
 8 //the equivalent input resistance,
 9 Ri = RL*(tr^2)
10
11 printf("\n\n Result \n\n")
12 printf("\n the equivalent input resistance is %.0f
      ohm", Ri)
```

Scilab code Exa 20.21 Example 21

```
 1 //Problem 20.21: The output stage of an amplifier
      has an output resistance of 112 ohm. Calculate
      the optimum turns ratio of a transformer which
      would match a load resistance of 7 ohm to the
      output resistance of the amplifier.
 2
 3 //initializing the variables:
 4 R1 = 112; // in Ohms
 5 RL = 7; // in Ohms
 6
 7 //calculation:
 8 //The equivalent input resistance, R1 of the
      transformer needs to be 112 ohm for maximum power
       transfer.
 9 //R1 = RL*(tr^2)
10 // tr = N1/N2 turn ratio
11 tr = (R1/RL)^0.5
12
13 printf("\n\n Result \n\n")
14 printf("\n the optimum turns ratio is %.0f ", tr)
```

Scilab code Exa 20.22 Example 22

```
1 //Problem 20.22: Determine the optimum value of load
       resistance for maximum power transfer if the
      load is connected to an amplifier of output
      resistance 150 ohm through a transformer with a
      turns ratio of 5:1..
2
3 //initializing the variables:
4 tr = 5; // turn ratio
5 R1 = 150; // in Ohms
6
7 //calculation:
8 //The equivalent input resistance, R1 of the
       transformer needs to be 150 ohm for maximum power
        transfer.
9 //R1 = RL*(tr^2)
10 RL = R1/(tr^2)
11
12 printf("\n\n Result \n\n")
13 printf("\n the optimum value of load resistance is %
      .0f ohm", RL)
```

Scilab code Exa 20.23 Example 23

```
1 //Problem 20.23: A single−phase, 220 V/1760 V ideal
      transformer is supplied from a 220 V source
      through a cable of resistance 2 ohm. If the load
      across the secondary winding is 1.28 kohm
      determine (a) the primary current flowing and (b)
       the power dissipated in the load resistor.
```

```
 2
 3  // initializing the variables :
 4  V1 = 220; // in Volts
 5  V2 = 1760; // in Volts
 6  V = 220; // in Volts
 7  RL = 1280; // in Ohms
 8  R = 2; // in Ohms
 9
10  // calculation :
11  // Turns ratio , tr = N1/N2 = V1/V2
12  tr = V1/V2
13  // Equivalent input resistance of the transformer ,
14  //R1 = RL*(tr^2)
15  R1 = RL*(tr^2)
16  // Total input resistance
17  Rin = R + R1
18  // Primary current
19  I1 = V1/Rin
20  // For an ideal transformer V1/V2 = I2/I1 ,
21  I2 = I1*tr
22  // Power dissipated in load resistor RL
23  P = I2*I2*RL
24
25  printf (" \n\n Result \n\n")
26  printf (" \n (a) primary current flowing is %.0 f A" ,
        I1)
27  printf (" \n (b)  power dissipated in the load
        resistor is %.0 f W" , P)
```

Scilab code Exa 20.24 Example 24

```
 1  // Problem 20.24: An a.c. source of 24 V and internal
        resistance 15 kohm is matched to a load by a
        25:1 ideal transformer. Determine (a) the value
        of the load resistance and (b) the power
```

```
          dissipated in the load.
2
3  //initializing the variables:
4  tr = 25; // teurn ratio
5  V = 24; // in Volts
6  R1 = 15000; // in Ohms
7  Rin = 15000; // in ohms
8
9  //calculation:
10 //Turns ratio, tr = N1/N2 = V1/V2
11 //For maximum power transfer R1 needs to be equal to
       15 kohm
12 RL = R1/(tr^2)
13 //The total input resistance when the source is
      connected to the matching transformer is
14 Rt = Rin + R1
15 //Primary current,
16 I1 = V/Rt
17 //N1/N2 = I2/I1
18 I2 = I1*tr
19 //Power dissipated in load resistor RL
20 P = I2*I2*RL
21
22 printf(")\n\n Result \n\n")
23 printf(")\n (a) the load resistance is %.0f ohm", RL)
24 printf(")\n (b)  power dissipated in the load
      resistor is %.2E W", P)
```

Scilab code Exa 20.25 Example 25

```
1 //Problem 20.25: A single-phase auto transformer has
      a voltage ratio 320 V:250 V and supplies a load
     of 20 kVA at 250 V. Assuming an ideal transformer
     , determine the current in each section of the
     winding.
```

```
2
3  //initializing the variables:
4  V1 = 320; // in Volts
5  V2 = 250; // in Volts
6  S = 20000; // in VA
7
8  //calculation:
9  //Rating = 20 kVA = V1*I1 = V2*I2
10 //Hence primary current, I1
11 I1 = S/V1
12 //secondary current, I2
13 I2 = S/V2
14 //Hence current in common part of the winding
15 I = I2 - I1
16
17 printf("\n\n Result \n\n")
18 printf("\n current in common part of the winding is
       %.1f A", I)
19 printf("\n primary current and secondary current are
       %.1f A and %.0f A respectively",I1, I2)
```

Scilab code Exa 20.26 Example 26

```
1  //Problem 20.26: Determine the saving in the volume
      of copper used in an auto transformer compared
      with a double−wound transformer for (a) a 200 V
      :150 V transformer, and (b) a 500 V:100 V
      transformer.
2
3  //initializing the variables:
4  V1a = 200; // in Volts
5  V2a = 150; // in Volts
6  V1b = 500; // in Volts
7  V2b = 100; // in Volts
8
```

```
 9  // calculation :
10  // For a 200 V:150 V transformer , xa
11  xa = V2a/V1a
12  // volume of copper in auto transformer
13  vca = (1 - xa)*100 // of copper in a double-wound
       transformer
14  // the saving is
15  vsa = 100 - vca
16  // For a 500 V:100 V transformer , xb
17  xb = V2b/V1b
18  // volume of copper in auto transformer
19  vcb = (1 - xb)*100 // of copper in a double-wound
       transformer
20  // the saving is
21  vsb = 100 - vcb
22
23  printf("\n\n Result \n\n")
24  printf("\n (a)For a 200 V:150 V transformer , the
       saving is %.0f percent", vsa)
25  printf("\n (b)For a 500 V:100 V transformer , the
       saving is %.0f percent", vsb)
```

Scilab code Exa 20.27 Example 27

```
1  // Problem 20.27: A three-phase transformer has 500
      primary turns and 50 secondary turns. If the
      supply voltage is 2.4 kV find the secondary line
      voltage on no-load when the windings are
      connected a) star-delta , (b) delta-star .
2
3  // initializing the variables :
4  N1 = 500; // prim turns
5  N2 = 50; // sec turns
6  VL = 2400; // in Volts
7
```

```
8  //calculation:
9  //For a star−connection , VL = Vp∗(3^0.5)
10 VL1s = VL
11 //Primary phase voltage
12 Vp1s = VL1s/(3^0.5)
13 //For a delta−connection , VL = Vp
14 //N1/N2 = V1/V2, from which ,
15 //secondary phase voltage , Vp2s
16 Vp2s = Vp1s∗N2/N1
17 VL2d = Vp2s
18
19 //For a delta−connection , VL = Vp
20 VL1d = VL
21 //primary phase voltage Vp1d
22 Vp1d = VL1d
23 //Secondary phase voltage , Vp2d
24 Vp2d = Vp1d∗N2/N1
25 //For a star−connection , VL = Vp∗(3^0.5)
26 VL2s = Vp2d∗(3^0.5)
27
28 printf(”\n\n Result \n\n”)
29 printf(”\n the secondary line voltage for star and
       delta connection are %.0f V and %.1f V
       respectively”, VL2s , VL2d)
```

Scilab code Exa 20.28 Example 28

```
1  //Problem 20.28: A current transformer has a single
       turn on the primary winding and a secondary
       winding of 60 turns. The secondary winding is
       connected to an ammeter with a resistance of 0.15
        ohm. The resistance of the secondary winding is
       0.25 ohm. If the current in the primary winding
       is 300 A, determine (a) the reading on the
       ammeter, (b) the potential difference across the
```

```
       ammeter and (c) the total load (in VA) on the
       secondary.
 2
 3  //initializing the variables:
 4  N1 = 1; // prim turns
 5  N2 = 60; // sec turns
 6  I1 = 300; // in amperes
 7  Ra = 0.15; // in ohms
 8  R2 = 0.25; // in ohms
 9
10  //calculation:
11  //Reading on the ammeter,
12  I2 = I1*(N1/N2)
13  //P.d. across the ammeter = I2*RA, where RA is the
       ammeter resistance
14  pd = I2*Ra
15  //Total resistance of secondary circuit
16  Rt = Ra + R2
17  //Induced e.m.f. in secondary
18  V2 = I2*Rt
19  //Total load on secondary
20  S = V2*I2
21
22  printf("\n\n Result \n\n")
23  printf("\n (a)the reading on the ammeter is %.0f A "
       ,I2)
24  printf("\n (b)potential difference across the
       ammeter is %.2f V ",pd)
25  printf("\n (c)total load (in VA) on the secondary is
       %.0f VA ",S)
```

Chapter 21

DC machines

Scilab code Exa 21.01 Example 1

```
1 //Problem 21.01: An 8-pole, wave-connected armature
     has 600 conductors and is driven at 625 rev/min.
     If the flux per pole is 20 mWb, determine the
     generated e.m.f.
2
3 //initializing the variables:
4 Z = 600; // no. of conductors
5 c = 2; // for a wave winding
6 p = 4; // no. of pairs
7 n = 625/60; // in rev/sec
8 Phi = 20E-3; // in Wb
9
10 //calculation:
11 //Generated e.m.f., E = 2*p*Phi*n*Z/c
12 E = 2*p*Phi*n*Z/c
13
14 printf("\n\n Result \n\n")
15 printf("\n the generated e.m.f is %.0f V ",E)
```

Scilab code Exa 21.02 Example 2

```
1  //Problem 21.02: A 4-pole generator has a lap-wound
       armature with 50 slots with 16 conductors per
       slot. The useful flux per pole is 30 mWb.
       Determine the speed at which the machine must be
       driven to generate an e.m.f. of 240 V.
2
3  //initializing the variables:
4  Z = 50*16; // no. of conductors
5  p = 1; // let no. of pairs
6  c = 2*p; // for a lap winding
7  Phi = 30E-3; // in Wb
8  E = 240; // in Volts
9
10 //calculation:
11 //Generated e.m.f., E = 2*p*Phi*n*Z/c
12 //Rearranging gives, speed
13 n = E*c/(2*p*Phi*Z)
14
15 printf("\n\n Result \n\n")
16 printf("\n the speed at which the machine must be
       driven is %.0f rev/sec ",n)
```

Scilab code Exa 21.03 Example 3

```
1  //Problem 21.03: An 8-pole, lap-wound armature has
       1200 conductors and a flux per pole of 0.03 Wb.
       Determine the e.m.f. generated when running at
       500 rev/min.
2
3  //initializing the variables:
4  Z = 1200; // no. of conductors
5  p = 1; // let, no. of pairs
6  c = 2*p; // for a lap winding
```

```
7  Phi = 30E-3; // in Wb
8  n = 500/60; // in rev/sec
9
10 // calculation :
11 // Generated e.m.f., E = 2*p*Phi*n*Z/c
12 E = 2*p*Phi*n*Z/c
13
14 printf("\n\n Result \n\n")
15 printf("\n Generated e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.04 Example 4

```
1  // Problem 21.04: Determine the generated e.m.f. in
      problem 21.03 if the armature is wave-wound.
2
3  // initializing the variables :
4  Z = 1200; // no. of conductors
5  p = 4; // let , no. of pairs
6  c = 2; // for a wave winding
7  Phi = 30E-3; // in Wb
8  n = 500/60; // in rev/sec
9
10 // calculation :
11 // Generated e.m.f., E = 2*p*Phi*n*Z/c
12 E = 2*p*Phi*n*Z/c
13
14 printf("\n\n Result \n\n")
15 printf("\n Generated e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.06 Example 6

```
1  //Problem 21.06: A d.c. generator running at 30 rev/
       s generates an e.m.f. of 200 V. Determine the
       percentage increase in the flux per pole required
        to generate 250 V at 20 rev/s.
2
3  //initializing the variables:
4  n1 = 30; // in rev/sec
5  E1 = 200; // in Volts
6  n2 = 20; // in rev/sec
7  E2 = 250; // in Volts
8
9  //calculation:
10 //generated e.m.f., E proportional to phi*w and
       since w = 2*pi*n, then
11 // E proportional to phi*n
12 // E1/E2 = Phi1*n1/(Phi2*n2)
13 // let Phi2/Phi1 = Phi
14 Phi = E2*n1/(E1*n2)
15 Phi_inc = (Phi - 1)*100 ///in percent
16
17 printf("\n\n Result \n\n")
18 printf("\n percentage increase in the flux per pole
       is %.1f percent ",Phi_inc)
```

Scilab code Exa 21.07 Example 7

```
1  //Problem 21.07: Determine the terminal voltage of a
        generator which develops an e.m.f. of 200 V and
       has an armature current of 30 A on load. Assume
       the armature resistance is 0.30 ohm.
2
3  //initializing the variables:
4  Ra = 0.30; // in ohms
5  Ia = 30; // in Amperes
6  E = 200; // in Volts
```

```
7
8  //calculation:
9  //terminal voltage,
10 //V = E − Ia∗Ra
11 V = E - Ia*Ra
12
13 printf(")\n\n Result \n\n")
14 printf(")\n terminal voltage of a generator is %.0f V
       ",V)
```

Scilab code Exa 21.08 Example 8

```
1  //Problem 21.08: A generator is connected to a 60
       ohm load and a current of 8 A flows. If the
       armature resistance is 1 ohm determine (a) the
       terminal voltage, and (b) the generated e.m.f.
2
3  //initializing the variables:
4  RL = 60; // in ohms
5  Ia = 8; // in Amperes
6  Ra = 1; // in ohms
7
8  //calculation:
9  //terminal voltage,
10 //V = Ia∗RL
11 V = Ia*RL
12 //Generated e.m.f., E
13 E = V + Ia*Ra
14
15 printf(")\n\n Result \n\n")
16 printf(")\n (a)terminal voltage is %.0f V ",V)
17 printf(")\n (b)generated e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.09 Example 9

```
1  //Problem  21.09:  A  separately−excited  generator
       develops  a  no−load  e .m. f .  of  150  V  at  an  armature
        speed  of  20  rev/s  and  a  flux  per  pole  of  0.10  Wb
       .  Determine  the  generated  e .m. f .  when  (a)  the
       speed  increases  to  25  rev/s  and  the  pole  flux
       remains  unchanged ,  (b)  the  speed  remains  at  20
       rev/s  and  the  pole  flux  is  decreased  to  0.08  Wb,
       and  ( c )  the  speed  increases  to  24  rev/s  and  the
       pole  flux  is  decreased  to  0.07  Wb.
2
3  // initializing  the  variables :
4  E1  =  150;  //  in  Volts
5  n1  =  20;  //  in  rev/sec
6  Phi1  =  0.10;  //  in  Wb
7  n2  =  25;  //  in  rev/sec
8  Phi2  =  0.10;  //  in  Wb
9  n3  =  20;  //  in  rev/sec
10 Phi3  =  0.08;  //  in  Wb
11 n4  =  24;  //  in  rev/sec
12 Phi4  =  0.07;  //  in  Wb
13
14 // calculation :
15 //generated  e .m. f . ,  E  proportional  to  phi∗w  and
       since  w  =  2∗pi∗n ,  then
16 //  E  proportional  to  phi∗n
17 //  E1/E2  =  Phi1∗n1 /( Phi2∗n2)
18 E2  =  E1∗Phi2∗n2 /( Phi1∗n1)
19 E3  =  E1∗Phi3∗n3 /( Phi1∗n1)
20 E4  =  E1∗Phi4∗n4 /( Phi1∗n1)
21
22 printf ("\n\n  Result  \n\n")
23 printf ("\n  (a) the  generated  e .m. f  is  %.1 f  V  ",E2)
24 printf ("\n  (b) generated  e .m. f .  is  %.0 f  V  ",E3)
25 printf ("\n  ( c ) generated  e .m. f .  is  %.0 f  V  ",E4)
```

Scilab code Exa 21.10 Example 10

```
1  //Problem 21.10: A shunt generator supplies a 20 kW
      load at 200 V through cables of resistance, R =
      100 mohm. If the field winding resistance, Rf=D
      50ohm  and the armature resistance, Ra = 40 mohm,
      determine (a) the terminal voltage, and (b) the
      e.m.f. generated in the armature.
2
3  //initializing the variables:
4  Ps = 20000; // in Watts
5  Vs = 200; // in Volts
6  Rs = 0.1; // in ohms
7  Rf = 50; // in ohms
8  Ra = 0.04; // in ohms
9
10 //calculation:
11 //Load current, I
12 Is = Ps/Vs
13 //Volt drop in the cables to the load
14 Vd = Is*Rs
15 //Hence terminal voltage,
16 V = Vs + Vd
17 //Field current, If
18 If = V/Rf
19 //Armature current
20 Ia = If + Is
21 //Generated e.m.f. E
22 E = V + Ia*Ra
23
24 printf("\n\n Result \n\n")
25 printf("\n (a)terminal voltage is %.0f V ",V)
26 printf("\n (b)generated e.m.f. is %.2f V ",E)
```

Scilab code Exa 21.11 Example 11

```
1  //Problem 21.11: A short−shunt compound generator
       supplies 80 A at 200 V. If the field resistance,
       Rf = 40 ohm, the series resistance, Rse = 0.02
       ohms  and the armature resistance, Ra = 0.04 ohm,
        determin  the e.m.f. generated.
2
3  //initializing the variables:
4  Is = 80; // in amperes
5  Vs = 200; // in Volts
6  Rf = 40; // in ohms
7  Rse = 0.02; // in ohms
8  Ra = 0.04; // in ohms
9
10 //calculation:
11 //Volt drop in series winding
12 Vse = Is*Rse
13 //P.d. across the field winding = p.d. across
       armature
14 V1 = Vs + Vse
15 //Field current, If
16 If = V1/Rf
17 //Armature current
18 Ia = If + Is
19 //Generated e.m.f. E
20 E = V1 + Ia*Ra
21
22 printf("\n\n Result \n\n")
23 printf("\n generated e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.12 Example 12

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```
1  //Problem  21.12:  A  10  kW  shunt  generator  having  an
      armature  circuit  resistance  of  0.75  ohm  and  a
      field  resistance  of  125  ohms ,  generates  a
      terminal  voltage  of  250  V  at  full  load . Determine
       the  efficiency  of  the  generator  at  full  load ,
      assuming  the  iron ,  friction  and  windage  losses
      amount  to  600  W.
2
3  //initializing  the  variables :
4  Ps = 10000; // in Watt
5  Pl = 600; // in Watt
6  Ra = 0.75; // in ohms
7  Rf = 125; // in ohms
8  V = 250; // in Volts
9
10  //calculation :
11  //Output  power  Ps = V*I
12  //from  which ,  load  current  I
13  I = Ps/V
14  //Field  current ,  If
15  If = V/Rf
16  //Armature  current
17  Ia = If + I
18  //Efficiency ,
19  eff = Ps*100/((V*I) + (Ia*Ia*Ra) + (If*V) + (Pl)) //
      in  Percent
20
21  printf(" \n\n  Result  \n\n")
22  printf(" \n  Efficiency  is  %.2f  percent  ",eff)
```

Scilab code Exa 21.13 Example 13

```
1  //Problem  21.13:  A  d.c.  motor  operates  from  a  240  V
      supply .  The  armature  resistance  is  0.2  ohm.
      Determine  the  back  e.m.f.  when  the  armature
```

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```
      current is 50 A.
 2
 3  // initializing the variables :
 4  Ra = 0.2; // in ohms
 5  V = 240; // in Volts
 6  Ia = 50; // in Amperes
 7
 8  // calculation :
 9  // For a motor , V = E + Ia*Ra
10  E = V - Ia*Ra
11
12  printf ("\n\n Result \n\n")
13  printf ("\n back e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.14 Example 14

```
 1  // Problem 21.14: The armature of a d.c. machine has
        a resistance of 0.25 ohm and is connected to a
        300 V supply. Calculate the e.m.f. generated when
         it is running: (a) as a generator giving 100 A,
        and (b) as a motor taking 80 A.
 2
 3  // initializing the variables :
 4  Ra = 0.25; // in ohms
 5  V = 300; // in Volts
 6  Ig = 100; // in Amperes
 7  Im = 80; // in Amperes
 8
 9  // calculation :
10  // As a generator , generated e.m.f. ,
11  // E = V + Ia*Ra
12  Eg = V + Ig*Ra
13  // For a motor , generated e.m.f. (or back e.m.f.) ,
14  // E = V - Ia*Ra
15  E = V - Im*Ra
```

```
16
17  printf("\n\n Result \n\n")
18  printf("\n (a)As a generator, generated e.m.f. is %
        .0f V ",Eg)
19  printf("\n (b)back e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.15 Example 15

```
1  //Problem 21.15: An 8−pole d.c. motor has a wave−
       wound armature with 900 conductors. The useful
       flux per pole is 25 mWb. Determine the torque
       exerted when a current of 30 A flows in each
       armature conductor.
2
3  //initializing the variables:
4  p = 4;
5  c = 2; // for a wave winding
6  Phi = 25E-3; // Wb
7  Z = 900;
8  Ia = 30; // in Amperes
9
10 //calculation:
11 //torque T = p*Phi*Z*Ia/(pi*

12 c)
13 T = p*Phi*Z*Ia/(1*%pi*c)
14
15 printf("\n\n Result \n\n")
16 printf("\n the torque exerted is %.1f Nm ",T)
```

Scilab code Exa 21.16 Example 16

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```
1  //Problem 21.16: Determine the torque developed by a
      350 V d.c. motor having an armature resistance
      of 0.5 ohm and running at 15 rev/s. The armature
      current is 60 A.
2
3  //initializing the variables:
4  V = 350; // in Volts
5  Ra = 0.5; // in ohms
6  n = 15; // in rev/sec
7  Ia = 60; // in Amperes
8
9  //calculation:
10 //Back e.m.f. E = V - Ia*Ra
11 E = V - Ia*Ra
12 //torque T = E*Ia/(2*

13 n*pi)
14 T = E*Ia/(2*n*%pi)
15
16 printf("\n\n Result \n\n")
17 printf("\n the torque exerted is %.1f Nm ",T)
```

Scilab code Exa 21.17 Example 17

```
1  //Problem 21.17: A six-pole lap-wound motor is
      connected to a 250 V d.c. supply. The armature
      has 500 conductors and a resistance of 1 ohm. The
       flux per pole is 20 mWb. Calculate (a) the speed
       and (b) the torque developed when the armature
      current is 40 A
2
3  //initializing the variables:
4  p = 1; // let
5  c = 2*p; // for a lap winding
6  Phi = 20E-3; // Wb
```

```
7  Z = 500;
8  V = 250; // in Volts
9  Ra = 1; // in ohms
10 Ia = 40; // in Amperes
11
12 // calculation:
13 // Back e.m.f. E = V − Ia*Ra
14 E = V - Ia*Ra
15 //E.m.f. E = 2*p*Phi*n*Z/c
16 // rearrange,
17 n = E*c/(2*p*Phi*Z)
18 //torque T = E*Ia/(2*

19 n*pi)
20 T = E*Ia/(2*n*%pi)
21
22 printf("\n\n Result \n\n")
23 printf("\n (a)speed n is %.0f rev/sec ",n)
24 printf("\n (b)the torque exerted is %.2f Nm ",T)
```

Scilab code Exa 21.18 Example 18

```
1  //Problem 21.18: The shaft torque of a diesel motor
      driving a 100 V d.c. shunt−wound generator is 25
      Nm. The armature current of the generator is 16 A
       at this value of torque. If the shunt field
      regulator is adjusted so that the flux is reduced
       by 15%, the torque increases to 35 Nm. Determine
       the armature current at this new value of torque
       .
2
3  // initializing the variables:
4  T1 = 25; // in Nm
5  T2 = 35; // in Nm
6  Ia1 = 16; // in Amperes
```

```
7  V = 100;  // in Volts
8  x = 0.15;
9
10 //calculation:
11 //the shaft torque T of a generator is proportional
       to (phi*Ia), where Phi is the flux and Ia is the
       armature current. Thus, T = k*Phi*Ia, where k is
       a constant.
12 //The torque at flux phi1 and armature current Ia1
       is T1 = k*Phi1*Ia1.
13 //similarly T2 = k*Phi2*Ia2
14 Phi2 = (1 - x)*Phi1
15 Ia2 = T2*Ia1*Phi1/(Phi2*T1)
16
17 printf("\n\n Result \n\n")
18 printf("\n armature current at the new value of
       torque is %.2f A ",Ia2)
```

Scilab code Exa 21.19 Example 19

```
1  //Problem 21.19: A 100 V d.c. generator supplies a
       current of 15 A when running at 1500 rev/min. If
       the torque on the shaft driving the generator is
       12 Nm, determine (a) the efficiency of the
       generator and (b) the power loss in the generator
       .
2
3  //initializing the variables:
4  T = 12;  // in Nm
5  I = 15;  // in Amperes
6  V = 100;  // in Volts
7  n = 1500/60;  // in rev/sec
8
9  //calculation:
10 //the efficiency of a generator = (output power/
```

```
     input  power ) ∗100 %
11  //The  output  power  is  the  electrical  output ,  i.e.  VI
         watts.  The  input  power  to  a  generator  is  the
     mechanical  power  in  the  shaft  driving  the
     generator ,  i.e.  T∗w  or  T(2∗pi∗n)  watts ,  where  T
     is  the  torque  in  Nm and  n  is  speed  of  rotation  in
      rev/s.  Hence ,  for  a  generator
12  //efficiency  =  V∗I∗100/(T∗2∗pi∗

13  n)   %
14  eff  =  V∗I∗100/(T∗2∗%pi∗n)  //  in    Percent
15  //The  input  power  =  output  power  +  losses
16  //  hence ,  T∗2∗%pi∗n  =  V∗I  +  losses
17  Pl  =  T∗2∗%pi∗n  -  V∗I
18
19  printf ("\n\n  Result  \n\n")
20  printf ("\n  (a)  efficiency  is  %.2 f  percent  ",eff )
21  printf ("\n  (b)  power  loss  is  %.0 f  W ",Pl)
```

Scilab code Exa 21.20 Example 20

```
 1  //Problem  21.20:  A  240  V  shunt  motor  takes  a  total
       current  of  30  A.  If  the  field  winding  resistance
       Rf  =  150  ohm  and  the  armature  resistance  Ra  =  0.4
        ohm.  determine  (a)  the  current  in  the  armature ,
       and  (b)  the  back  e.m. f.
 2
 3  //initializing  the  variables :
 4  Rf  =  150;  //  in  Ohms
 5  Ra  =  0.4;  //  in  Ohms
 6  I  =  30;  //  in  Amperes
 7  V  =  240;  //  in  Volts
 8
 9  //calculation :
10  //Field  current  If
```

```
11  If = V/Rf
12  //Supply current I = Ia + If
13  //Hence armature current, Ia
14  Ia = I - If
15  //Back e.m.f. E = V - Ia*Ra
16  E = V - (Ia*Ra)
17
18  printf("\n\n Result \n\n")
19  printf("\n (a)   current in the armature is %.1f A ",
        Ia)
20  printf("\n (b) Back e.m.f. E is %.2f V ",E)
```

Scilab code Exa 21.21 Example 21

```
1  //Problem 21.21: A 200 V, d.c. shunt-wound motor has
        an armature resistance of 0.4 ohm and at a
        certain load has an armature current of 30 A and
        runs at 1350 rev/min. If the load on the shaft of
        the motor is increased so that the armature
        current increases to 45 A, determine the speed of
        the motor, assuming the flux remains constant.
2
3  //initializing the variables:
4  Ia1 = 30; // in Amperes
5  Ia2 = 45; // in Amperes
6  Ra = 0.4; // in ohm
7  n1 = 1350/60; // in Rev/sec
8  V = 200; // in Volts
9
10  //calculation:
11  //The relationship E proportional to (Phi*n) applies
        to both generators and motors. For a motor,
12  //E = V - (Ia*Ra)
13  E1 =   V - (Ia1*Ra)
14  E2 =   V - (Ia2*Ra)
```

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```
15 //The relationship, E1/E2 = Phi1*n1/Phi2*n2,
      applies to both generators and motors. Since the
      flux is constant, Phi1 = Phi2
16 Phi2 = Phi1
17 n2 = E2*Phi1*n1/(Phi2*E1)
18
19 printf("\n\n Result \n\n")
20 printf("\n the speed of the motor is %.2f rev/sec ",
      n2)
```

Scilab code Exa 21.22 Example 22

```
1 //Problem 21.22: A 220 V, d.c. shunt−wound motor
      runs at 800 rev/min and the armature current is
      30 A. The armature circuit resistance is 0.4 ohm.
       Determine (a) the maximum value of armature
      current if the flux is suddenly reduced by 10%
      and (b) the steady state value of the armature
      current at the new value of flux, assuming the
      shaft torque of the motor remains constant.
2
3 //initializing the variables:
4 Ia1 = 30; // in Amperes
5 Ra = 0.4; // in ohm
6 n = 800/60; // in Rev/sec
7 V = 220; // in Volts
8 x= 0.1;
9
10 //calculation:
11 //For a d.c. shunt−wound motor, E = V − (Ia*Ra),
      Hence initial generated e.m.f.,
12 E1 =  V - (Ia1*Ra)
13 //The generated e.m.f. is also such that E
      proportional to (Phi*n) so at the instant the
      flux is reduced, the speed has not had time to
```

```
         change , and
14  E = E1 *(1 - x )
15  // Hence , the voltage drop due to the armature
         resistance is
16  Vd = V - E
17  // The instantaneous value of the current is
18  Ia = Vd / Ra
19  // T proportional to ( Phi * Ia ) , since the torque is
         constant ,
20  // Phi1 * Ia1 = Phi2 * Ia2 ,  The flux 8 is reduced by 10%
         , hence
21  Phi2 = (1 - x )* Phi1
22  Ia2 = Phi1 * Ia1 / Phi2
23
24  printf ( "\n\n Result \n\n" )
25  printf ( "\n ( a ) instantaneous value of the current %.0
         f A " , Ia )
26  printf ( "\n ( b ) steady state value of armature current
         , %.2 f A " , Ia2 )
```

Scilab code Exa 21.23 Example 23

```
1  // Problem 21.23: A series motor has an armature
         resistance of 0.2 ohm and a series field
         resistance of 0.3 ohm . It is connected to a 240 V
         supply and at a particular load runs at 24 rev / s
         when drawing 15 A from the supply . ( a ) Determine
         the generated e . m . f . at this load . ( b ) Calculate
         the speed of the motor when the load is changed
         such that the current is increased to 30 A .
         Assume that this causes a doubling of the flux .
2
3  // initializing the variables :
4  Ia1 = 15;  //  in Amperes
5  Ia2 = 30;  //  in Amperes
```

```
6   Rf = 0.3; // in ohms
7   Ra = 0.2; // in ohm
8   n1 = 24; // in Rev/sec
9   V = 240; // in Volts
10  x= 2;
11
12  //calculation :
13  //generated e.m.f., E, at initial load, is given by
14  E1 =  V - Ia1*(Ra + Rf)
15  //When the current is increased to 30 A, the
        generated e.m.f. is given by:
16  E2 =  V - Ia2*(Ra + Rf)
17  //E proportional to (Phi*n)
18  //E1/E2 = Phi1*n1/Phi2*n2
19  Phi2 = x*Phi1
20  n2 = E2*Phi1*n1/(Phi2*E1)
21
22  printf("\n\n Result \n\n")
23  printf("\n (a)generated e.m.f., E is %.1f V ",E1)
24  printf("\n (b)speed of motor, n2, %.2f A ",n2)
```

Scilab code Exa 21.24 Example 24

```
1   //Problem 21.24: A 320 V shunt motor takes a total
        current of 80 A and runs at 1000 rev/min. If the
        iron , friction and windage losses amount to 1.5
        kW, the shunt field resistance is 40 ohm and the
        armature resistance is 0.2 ohm , determine the
        overall efficiency of the motor.
2
3   //initializing the variables :
4   I = 80; // in Amperes
5   C = 1500; // in Watt
6   Rf = 40; // in ohms
7   Ra = 0.2; // in ohm
```

```
8  n = 1000/60; // in Rev/sec
9  V = 320; // in Volts
10
11 // calculation :
12 // Field current , If
13 If = V/Rf
14 // Armature current Ia
15 Ia = I - If
16 // Efficiency =((V*I − Ia*Ia*Ra − If*V − C)/(V*I))
       *100%
17 eff = ((V*I - (Ia*Ia*Ra) - (If*V) - C)/(V*I))*100 //
       in percent
18
19 printf("\n\n Result \n\n")
20 printf("\n efficiency is %.1 f",eff)
```

Scilab code Exa 21.25 Example 25

```
1  // Problem 21.25: A 250 V series motor draws a
       current of 40 A. The armature resistance is 0.15
       ohm and the field resistance is 0.05ohm .
       Determine the maximum efficiency of the motor .
2
3  // initializing the variables :
4  I = 40; // in Amperes
5  Rf = 0.05; // in ohms
6  Ra = 0.15; // in ohm
7  V = 250; // in Volts
8
9  // calculation :
10 // However for a series motor, If = 0 and the Ia*Ia*
       Ra loss needs to be I*I*(Ra + Rf)
11 // For maximum efficiency I*I*(Ra + Rf) = C
12 // Efficiency =((V*I −2*Ia*Ia*Ra)/(V*I))*100%
13 eff = ((V*I - (2*I*I*(Ra + Rf)))/(V*I))*100 // in
```

```
      percent
14
15 printf("\n\n Result \n\n")
16 printf("\n efficiency is %.1f",eff)
```

Scilab code Exa 21.26 Example 26

```
1 //Problem 21.26: A 200 V d.c. motor develops a shaft
        torque of 15 Nm at 1200 rev/min. If the
      efficiency is 80%, determine the current supplied
        to the motor.
2
3 //initializing the variables:
4 T = 15; // in Nm
5 n = 1200/60; // in rev/sec
6 eff = 0.8;
7 V = 200; // in Volts
8
9 //calculation:
10 //The efficiency of a motor = (output power/input
      power)*100 %
11 //The output power of a motor is the power available
        to do work at its shaft and is given by Tw or T
       proportional to (2*pi*n) watts, where T is the
       torque in Nm and n is the speed of rotation in
       rev/s. The input power is the electrical power in
        watts supplied to the motor, i.e. VI watts.
12 //Thus for a motor, efficiency =(T*2*pi*

13 n/(V*I))%
14 I = T*2*%pi*n/(V*eff)
15
16 printf("\n\n Result \n\n")
17 printf("\n current supplied, I is %.1f A",I)
```

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Scilab code Exa 21.27 Example 27

```
1  //Problem 21.27: A d.c. series motor drives a load
       at 30 rev/s and takes a current of 10 A when the
       supply voltage is 400 V. If the total resistance
       of the motor is 2 ohm and the iron, friction and
       windage losses amount to 300 W, determine the
       efficiency of the motor.
2
3  //initializing the variables:
4  R = 2; // in ohm
5  n = 30; // in rev/sec
6  I = 10; // in A
7  C = 300; // in Watt
8  V = 400; // in Volts
9
10 //calculation:
11 //Efficiency =((V*I - I*I*R - C)/(V*I))*100%
12 eff = ((V*I - (I*I*R) - C)/(V*I))*100 // in percent
13
14 printf("\n\n Result \n\n")
15 printf("\n efficiency is %.1f percent",eff)
```

Scilab code Exa 21.28 Example 28

```
1  //Problem 21.28: A 500 V shunt motor runs at its
       normal speed of 10 rev/s when the armature
       current is 120 A. The armature resistance is 0.2
       ohm. (a) Determine the speed when the current is
       60 A and a resistance of 0.5 ohm is connected in
       series with the armature, the shunt field
       remaining constant. (b) Determine the speed when
```

```
      the  current  is  60 A and  the  shunt  field  is
      reduced  to  80% of  its  normal  value  by  increasin
      resistance  in  the  field  circuit .
 2
 3  // initializing  the  variables :
 4  Ia1 = 120;  // in A
 5  Ia2 = 60;  // in A
 6  Ra = 0.2;  // in ohm
 7  n1 = 10;  // in rev/sec
 8  R = 0.5;  // in ohm
 9  x = 0.8;
10  V = 500;  // in Volts
11
12  // calculation :
13  // back e.m.f.  at  Ia1
14  E1 = V - Ia1*Ra
15  // at Ia2
16  E2 = V - Ia2*(Ra + R)
17  //E1/E2 = Phi1*n1/Phi2*n2
18  Phi2 = Phi1
19  n2 = Phi1*n1*E2/(Phi2*E1)
20  // Back e.m.f.  when Ia2
21  E3 = V - Ia2*Ra
22  Phi3 = x*Phi1
23  n3 = Phi1*n1*E3/(Phi3*E1)
24
25  printf (" \n\n  Result  \n\n")
26  printf (" \n (a) speed  n2  is  %.2 f  rev/sec", n2)
27  printf (" \n (b) speed  n3  is  %.2 f  rev/sec", n3)
```

Scilab code Exa 21.29 Example 29

```
 1  // Problem  21.29:  On  full−load  a  300 V  series  motor
      takes  90 A  and  runs  at  15  rev/s.  The  armature
      resistance  is  0.1  ohm  and  the  series  winding
```

```
     resistance is 50 mohm. Determine the speed when
     developing full load torque but with a 0.2 ohm
     diverter in parallel with the field winding. (
     Assume that the flux is proportional to the field
      current.)
 2
 3  // initializing the variables:
 4  Ia1 = 90; // in Amperes
 5  Ra = 0.1; // in ohm
 6  Rse = 0.05; // in ohm
 7  Rd = 0.2; // in Ohm
 8  n1 = 15; // in rev/sec
 9  V = 300; // in Volts
10
11  // calculation:
12  // e.m.f. E1
13  E1 = V - Ia1*(Ra + Rse)
14  //With the Rd diverter in parallel with Rse
15  // equivalent resistance, Re
16  Re = Rd*Rse/(Rd+Rse)
17  //Torque, T proprtional to Ia*Phi and for full load
        torque, Ia1*Phi1 = Ia2*Phi2
18  //Since flux is proportional to field current Phi1
        proportional to Ta1 and Phi2 Proportional to I1
19  I1 =  (Ia1*Ia1*0.8)^0.5
20  //By current division, current I1
21  Ia2 = I1/(Rd/(Rd + Rse))
22  //Hence e.m.f. E2
23  E2 = V - Ia2*(Ra + Re)
24  //E1/E2 = Phi1*n1/Phi2*n2
25  n2 = E2*Ia1*n1/(I1*E1)
26
27  printf("\n\n Result \n\n")
28  printf("\n speed n2 is %.2f rev/sec", n2)
```

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Scilab code Exa 21.30 Example 30

```
1  //Problem 21.30: A series motor runs at 800 rev/min
        when the voltag is 400 V and the current is 25 A.
         The armature resistance is 0.4 ohm and the
        series field resistance is 0.2 ohm. Determine the
         resistance to be connected in series to reduce
        the speed to 600 rev/min with the same current.
2
3  //initializing the variables:
4  Ia1 = 25; // in Amperes
5  Ra = 0.4; // in ohm
6  Rse = 0.2; // in ohm
7  n1 = 800/60; // in rev/sec
8  n2 = 600/60; // in rev/sec
9  V = 400; // in Volts
10
11  //calculation:
12  //e.m.f. E1
13  E1 = V - Ia1*(Ra + Rse)
14  //At n2, since the current is unchanged, the flux is
        unchanged.
15  //E1/E2 = n1/n2
16  E2 = E1*n2/n1
17  //and E2 = V - Ia1(Ra + Rse + R)
18  R = (V - E2)/Ia1 - Ra - Rse
19
20  printf("\n\n Result \n\n")
21  printf("\n Resistance is %.2f ohm", R)
```

Chapter 22

Three phase induction motors

Scilab code Exa 22.01 Example 1

```
1  //Problem 22.01: A three-phase two-pole induction
       motor is connected to a 50 Hz supply. Determine
       the synchronous speed of the motor in rev/min.
2
3  //initializing the variables:
4  f = 50; // in Hz
5  p = 2/2; // number of pairs of poles
6
7  //calculation:
8  //ns is the synchronous speed, f is the frequency in
        hertz of the supply to the stator and p is the
       number of pairs of poles.
9  ns = f/p
10 nsrpm = ns*60
11
12 printf("\n\n Result \n\n")
13 printf("\nsynchronous speed of the motor is %.0f rev
       /min", nsrpm)
```

Scilab code Exa 22.02 Example 2

```
1 //Problem 22.02: A stator winding supplied from a
    three-phase 60 Hz system is required to produce a
    magnetic flux rotating at 900 rev/min. Determine
    the number of poles.
2
3 //initializing the variables:
4 f = 60; // in Hz
5 ns = 900/60; // in rev/sec
6
7 //calculation:
8 //ns is the synchronous speed, f is the frequency in
    hertz of the supply to the stator and p is the
    number of pairs of poles.
9 p = f/ns
10 np = p*2
11
12 printf("\n\n Result \n\n")
13 printf("\nnumber of poles is %.0f", np)
```

Scilab code Exa 22.03 Example 3

```
1 //Problem 22.03: A three-phase 2-pole motor is to
    have a synchronous speed of 6000 rev/min.
    Calculate the frequency of the supply voltage.
2
3 //initializing the variables:
4 p = 2/2; // number of pairs of poles
5 ns = 6000/60; // in rev/sec
6
7 //calculation:
8 //ns is the synchronous speed, f is the frequency in
    hertz of the supply to the stator and p is the
    number of pairs of poles.
```

```
9  f = p*ns
10
11  printf("\n\n Result \n\n")
12  printf("\nfrequency is %.0f Hz",f)
```

Scilab code Exa 22.04 Example 4

```
1  //Problem 22.04: The stator of a 3-phase, 4-pole
      induction motor is connected to a 50 Hz supply.
      The rotor runs at 1455 rev/min at full load.
      Determine (a) the synchronous speed and (b) the
      slip at full load.
2
3  //initializing the variables:
4  p = 4/2; // number of pairs of poles
5  f = 50; // in Hz
6  nr = 1455/60; // in rev/sec
7
8  //calculation:
9  //ns is the synchronous speed, f is the frequency in
       hertz of the supply to the stator and p is the
      number of pairs of poles.
10  ns = f/p
11  //The slip, s
12  s = ((ns - nr)/ns)*100 // in percent
13
14  printf("\n\n Result \n\n")
15  printf("\n(a) synchronous speed is %.0f rev/sec",ns)
16  printf("\n(b) slip is %.0f percent",s)
```

Scilab code Exa 22.05 Example 5

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```
1  //Problem 22.05: A 3-phase, 60 Hz induction motor
       has 2 poles. If the slip is 2% at a certain load,
        determine (a) the synchronous speed, (b) the
       speed of the rotor and (c) the frequency of the
       induced e.m.f.   s  in the rotor.
2
3  //initializing the variables:
4  p = 2/2; // number of pairs of poles
5  f = 60; // in Hz
6  s = 0.02; // slip
7
8  //calculation:
9  //ns is the synchronous speed, f is the frequency in
        hertz of the supply to the stator and p is the
       number of pairs of poles.
10 ns = f/p
11 //The the rotor runs at
12 nr = ns*(1 - s)
13 //frequency of the e.m.f.   s  induced in the rotor
       bars is
14 fr = ns - nr
15
16 printf("\n\n Result \n\n")
17 printf("\n(a) synchronous speed is %.0f rev/sec",ns)
18 printf("\n(b) rotor speed is %.1f rev/sec",nr)
19 printf("\n(c) frequency of the e.m.f.   s  induced in
        the rotor bars is is %.1f Hz",fr)
```

Scilab code Exa 22.06 Example 6

```
1  //Problem 22.06: A three-phase induction motor is
       supplied from a 50 Hz supply and runs at 1200 rev
       /min when the slip is 4%. Determine the
       synchronous speed.
2
```

```
3  // initializing the variables :
4  f = 50; // in Hz
5  nr = 1200/60; // in rev/min
6  s = 0.04; // slip
7
8  // calculation :
9  // the synchronous speed .
10 ns = nr/(1 - s)
11 nsrpm = ns*60
12 printf("\n\n Result \n\n")
13 printf("\n synchronous speed is %.0f rev/min",nsrpm)
```

Scilab code Exa 22.07 Example 7

```
1  // Problem 22.07: The frequency of the supply to the
       stator of an 8- pole induction motor is 50 Hz and
        the rotor frequency is 3 Hz. Determine (a) the
       slip , and (b) the rotor speed .
2
3  // initializing the variables :
4  p = 8/2; // number of pairs of poles
5  f = 50; // in Hz
6  fr = 3; // in Hz
7
8  // calculation :
9  // ns is the synchronous speed , f is the frequency in
         hertz of the supply to the stator and p is the
       number of pairs of poles .
10 ns = f/p
11 // fr = s*f
12 s = (fr/f)
13 // the rotor speed .
14 nr = ns*(1 - s)
15 nrrpm = nr*60
16
```

```
17  printf("\n\n Result \n\n")
18  printf("\n(a) slip is %.0f percent",s*100)
19  printf("\n (b) rotor speed is %.0f rev/min",nrrpm)
```

Scilab code Exa 22.08 Example 8

```
1  //Problem 22.08: The power supplied to a three-phase
        induction motor is 32 kW and the stator losses
       are 1200 W. If the slip is 5%, determine (a) the
        rotor copper loss, (b) the total mechanical power
         developed by the rotor, (c) the output power of
        the motor if friction and windage losses are 750
        W, and (d) the efficiency of the motor,
        neglecting rotor iron loss.
2
3  //initializing the variables:
4  Psi = 32000; // in Watts
5  Psl = 1200; // in Watts
6  s = 0.05; // slip
7  Pfl = 750; // in Watts
8
9  //calculation:
10 //Input power to rotor = stator input power - stator
        losses
11 Pi =  Psi - Psl
12 //slip = rotor copper loss/rotor input
13 Pl = s*Pi
14 //Total mechanical power developed by the rotor =
       rotor input power - rotor losses
15 Pr = Pi - Pl
16 //Output power of motor = power developed by the
       rotor - friction and windage losses
17 Po = Pr - Pfl
18 //Efficiency of induction motor = (output power/
       input power)*100
```

```
19 eff = (Po/Psi)*100 // in percent
20
21 printf("\n\n Result \n\n")
22 printf("\n(a) rotor copper loss is %.0f Watt",Pl)
23 printf("\n(b) Total mechanical power developed by
       the rotor is %.0f W",Pr)
24 printf("\n(c) Output power of motor is %.0f Watt",Po
       )
25 printf("\n(d) efficiency of induction motor is %.2f
       percent",eff)
```

Scilab code Exa 22.09 Example 9

```
1 //Problem 22.09: The speed of the induction motor of
        Problem 22.08 is reduced to 35% of its
     synchronous speed by using external rotor
     resistance. If the torque and stator losses are
     unchanged, determine (a) the rotor copper loss,
     and (b) the efficiency of the motor.
2
3 //initializing the variables:
4 Psi = 32000; // in Watts
5 Psl = 1200; // in Watts
6 Pfl = 750; // in Watts
7 x = 0.35;
8
9 //calculation:
10 nr = x*ns
11 //The slip, s
12 s = ((ns - nr)/ns)
13 //Input power to rotor = stator input power - stator
       losses
14 Pi =  Psi - Psl
15 //slip = rotor copper loss/rotor input
16 Pl = s*Pi
```

```
17 //Total mechanical power developed by the rotor =
      rotor input power − rotor losses
18 Pr = Pi - Pl
19 //Output power of motor = power developed by the
      rotor − friction and windage losses
20 Po = Pr - Pfl
21 //Efficiency of induction motor = (output power/
      input power)*100
22 eff = (Po/Psi)*100 // in percent
23
24 printf("\n\n Result \n\n")
25 printf("\n(a) rotor copper loss is %.0f Watt",Pl)
26 printf("\n(b) efficiency of induction motor is %.2f
      percent",eff)
```

Scilab code Exa 22.10 Example 10

```
1 //Problem 22.10: A 415 V, three−phase, 50 Hz, 4 pole
    , star−connected induction motor runs at 24 rev/s
     on full load. The rotor resistance and reactance
     per phase are 0.35 ohm and 3.5 ohm respectively,
     and the effective rotor−stator turns ratio is
     0.85:1. Calculate (a) the synchronous speed, (b)
     the slip, (c) the full load torque, (d) the power
     output if mechanical losses amount to 770 W, (e)
     the maximum torque, (f) the speed at which
     maximum torque occurs and (g) the starting torque
     .
2
3 //initializing the variables:
4 V = 415; // in Volts
5 f = 50 ; // in Hz
6 nr = 24; // in rev/sec
7 p = 4/2; // no. of pole pairs
8 R2 = 0.35; // in Ohms
```

```
 9  X2 = 3.5; // in Ohms
10  tr = 0.85; // turn ratio N2/N1
11  Pl = 770; // in Watt
12  m = 3; // no. of phases
13
14  // calculation:
15  //ns is the synchronous speed, f is the frequency in
         hertz of the supply to the stator and p is the
       number of pairs of poles.
16  ns = f/p
17  //The slip, s
18  s = ((ns - nr)/ns)*100 // in percent
19  //Phase voltage, E1 = V/(3^0.5)
20  E1 = V/(3^0.5)
21  //Full load torque
22  T = [m*(tr^2)/(2*%pi*ns)]*[(s/100)*E1*E1*R2/(R2*R2 +
       (X2*(s/100))^2)]
23  //Output power, including friction losses
24  Pm = 2*%pi*nr*T
25  //power output
26  Po = Pm - Pl
27  //Maximum torque occurs when R2 = Xr = 0.35 ohm
28  //Slip
29  sm = R2/X2
30  //maximum torque, Tm
31  Tm = [m*(tr^2)/(2*%pi*ns)]*[sm*E1*E1*R2/(R2*R2 + (X2
     *sm)^2)]
32  //speed at which maximum torque occurs
33  nrm = ns*(1 - sm)
34  nrmrpm = nrm*60
35  //At the start, i.e., at standstill, slip, s=1
36  ss = 1
37  //starting torque
38  Ts = [m*(tr^2)/(2*%pi*ns)]*[ss*E1*E1*R2/(R2*R2 + (X2
     *ss)^2)]
39
40  printf("\n\n Result \n\n")
41  printf("\n(a)Synchronous speed is %.0f rev/sec",ns)
```

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```
42  printf("\n(b)Slip  is  %.0f  percent",s)
43  printf("\n(c)Full  load  torque  is  %.2f Nm",T)
44  printf("\n(d)power  output  is  %.2E W",Po)
45  printf("\n(e)maximum  torque  is  %.2f Nm",Tm)
46  printf("\n(f)speed  at  which  maximum  torque  occurs  is
        %.0frev/min",nrmrpm)
47  printf("\n(g)starting  torque  is  %.2f Nm",Ts)
```

Scilab code Exa 22.11 Example 11

```
1  //Problem  22.11:  Determine  for  the  induction  motor
       in  problem  22.10  at  full  load ,  (a)  the  rotor
       current ,  (b)  the  rotor  copper  loss ,  and  (c)  the
       starting  current.
2
3  //initializing  the  variables:
4  V = 415;  // in  Volts
5  f = 50  ;  // in  Hz
6  nr = 24;  // in  rev/sec
7  p = 4/2;  // no.  of  pole  pairs
8  R2 = 0.35;  // in  Ohms
9  X2 = 3.5;  // in  Ohms
10  tr = 0.85;  // turn  ratio  N2/N1
11  m = 3;  // no.  of  phases
12
13  //calculation:
14  //ns  is  the  synchronous  speed ,  f  is  the  frequency  in
        hertz  of  the  supply  to  the  stator  and  p  is  the
       number  of  pairs  of  poles.
15  ns = f/p
16  //The  slip ,  s
17  s = ((ns - nr)/ns)*100  // in  percent
18  //Phase  voltage ,  E1 = V/(3^0.5)
19  E1 = V/(3^0.5)
20  //rotor  current ,
```

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```
21  Ir = (s/100)*E1*tr/((R2^2 + (X2*(s/100))^2)^0.5)
22  //Rotor copper loss
23  Pcl = m*R2*(Ir^2)
24  //starting current,
25  ss =1
26  I2 = ss*tr*E1/((R2^2 + (X2*ss)^2)^0.5)
27
28  printf("\n\n Result \n\n")
29  printf("\n(a)rotor current is %.2f A",Ir)
30  printf("\n(b)Total copper loss is %.2f W",Pcl)
31  printf("\n(c)starting current is %.2f A",I2)
```

Scilab code Exa 22.12 Example 12

```
1  //Problem 22.12: For the induction motor in problems
      22.10 and 22.11, if the stator losses are 650 W,
      determine (a) the power input at full load, (b)
     the efficiency of the motor at full load and (c)
     the current taken from the supply at full load,
     if the motor runs at a power factor of 0.87
     lagging.
2
3  //initializing the variables:
4  V = 415; // in Volts
5  Psl = 650; // in Watt
6  pf = 0.87; // power factor
7
8  //calculation:
9  Pm = 11770; // watts from part (d), Problem 22.10
10 Pcl = 490.35; // watts, Rotor copper loss, from part
      (b), Problem 22.11
11 //Stator input power
12 P1 = Pm + Pcl + Psl
13 Po = 11000 // watts, Net power output, from part (d)
     , Problem 22.10
```

```
14  // efficiency = (output/input) *100
15  eff = (Po/P1)*100 // in percent
16  //Power input, P1 = (3^0.5)*VL*IL*cos(phi)
17  // pf = cos(phi)
18  //supply current, IL
19  I = P1/((3^0.5)*V*pf)
20
21  printf("\n\n Result \n\n")
22  printf("\n(aStator input power is %.2E W",P1)
23  printf("\n(b)efficiency is %.2f percent",eff)
24  printf("\n(c)supply current is %.2f A",I)
```

Scilab code Exa 22.13 Example 13

```
1  //Problem 22.13: For the induction motor of Problems
        22.10 to 22.12, determine the resistance of the
       rotor winding required for maximum starting
       torque.
2
3  //initializing the variables:
4  V = 415; // in Volts
5  f = 50 ; // in Hz
6  nr = 24; // in rev/sec
7  p = 4/2; // no. of pole pairs
8  R2 = 0.35; // in Ohms
9  X2 = 3.5; // in Ohms
10
11  //calculation:
12  //At the moment of starting, slip,
13  s = 1
14  //Maximum torque occurs when rotor reactance equals
        rotor resistance
15  //for maximum torque
16  R2 = s*X2
17
```

```
18  printf("\n\n Result \n\n")
19  printf("\nresistance of the rotor is %.1f Ohm",R2)
```

Chapter 23

Revision of complex numbers

Scilab code Exa 23.01 Example 1

```
1 //Problem 23.01: In an electrical circuit the total
     impedance ZT is given by ZT = (Z1*Z2/(Z1 + Z2))+
     Z3.     Determine ZT in (a + jb) form, correct to
     two decimal places, when Z1 = 5 - j3, Z2 = 4 - i7
      and Z3 = 3.9 - i6.7.
2
3 //initializing the variables:
4 Z1 = 5 - 3*%i;
5 Z2 = 4 + 7*%i;
6 Z3 = 3.9 - 6.7*%i;
7
8 //calculation:
9 ZT = (Z1*Z2/(Z1 + Z2))+ Z3
10 y = imag(ZT)
11 x = real(ZT)
12
13 printf("\n\n Result \n\n")
14 printf("\n ZT is %.2f + (%.2f)i", x,y)
```

Scilab code Exa 23.02 Example 2

```scilab
1  //Problem 23.02: Given Z1 = 3 + i4, Z2 = 2 - i5
       determine in cartesian form correct to three
       decimal places:
2  //(a)1/Z1, (b)1/Z2,  (c)1/Z1 + 1/Z2,  (d)1/(1/Z1 +
       1/Z2)
3
4  //initializing the variables:
5  Z1 = 3 + 4*%i;
6  Z2 = 2 - 5*%i;
7
8  //calculation:
9  za = 1/Z1
10 zb = 1/Z2
11 zc = za + zb
12 zd = 1/zc
13 zax = real(za)
14 zay = imag(za)
15 zbx = real(zb)
16 zby = imag(zb)
17 zcx = real(zc)
18 zcy = imag(zc)
19 zdx = real(zd)
20 zdy = imag(zd)
21
22 printf("\n\n Result \n\n")
23 printf("\n (a)1/Z1 is %.3f + (%.3f)i", zax,zay)
24 printf("\n (b)1/Z2 is %.3f + (%.3f)i", zbx,zby)
25 printf("\n (c)1/Z1 + 1/Z2 is %.3f + (%.3f)i", zcx,
       zcy)
26 printf("\n (d)1/(1/Z1 + 1/Z2) is %.3f + (%.3f)i",
       zdx,zdy)
```

Scilab code Exa 23.03 Example 3

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```
1  //Problem 23.03: Solve the following complex
       equations :
2  //(a) 3(a + ib) = 9−i2
3  //(b) (2+i)(−2+i) = x+iy
4  //(c) (a−i(2b))+(b−i3a) = 5+i2
5
6  //initializing the variables :
7  Z1 = 9 - 2*%i;
8  Z2 = 2 + 1*%i;
9  Z3 = -2 + 1*%i;
10 Z4 = 5 + 2*%i;
11
12 //calculation :
13 za = Z1/3
14 zb = Z2*Z3
15 zca = (2*real(Z4) + imag(Z4))/-1
16 zcb = real(Z4) - zca
17 zaa = real(za)
18 zab = imag(za)
19 zbx = real(zb)
20 zby = imag(zb)
21
22 printf("\n\n Result \n\n")
23 printf("\n (a)a and b are %.0f and %.2f resp.", zaa,
       zab)
24 printf("\n (b)x and y are %.0f and %.0f resp.", zbx,
       zby)
25 printf("\n (c)a and b are %.0f and %.0f resp.", zca,
       zcb)
```

Scilab code Exa 23.05 Example 5

```
1  //Problem 23.05: Convert (5,−132 ) into a + ib form
       correct to four significant figures .
2
```

```
3  //initializing the variables:
4  r = 5; // magnitude
5  theta = -132; // in degree
6
7  //calculation:
8  x = r*sin(theta*%pi/180)
9  y = r*cos(theta*%pi/180)
10 z = x+%i*y
11
12 printf("\n\n Result \n\n")
13 printf("\n Z is %.3f + (%.3f)i", x,y)
```

Scilab code Exa 23.06 Example 6

```
1  //Problem 23.06: Two impedances in an electrical
      network are given by Z1 = (4.7,35  ) and Z2 =
      (7.3, -48)  . Determine in polar form the total
      impedance ZT given that ZT = Z1*Z2/(Z1 + Z2)
2
3  //initializing the variables:
4  r1 = 4.7; // magnitude
5  theta1 = 35; // in degree
6  r2 = 7.3; // magnitude
7  theta2 = -48; // in degree
8
9  //calculation:
10 x1 = r1*cos(theta1*%pi/180)
11 y1 = r1*sin(theta1*%pi/180)
12 z1 = x1+%i*y1
13 x2 = r2*cos(theta2*%pi/180)
14 y2 = r2*sin(theta2*%pi/180)
15 z2 = x2+%i*y2
16 z3 = z1*z2/(z1 + z2)
17 x3 = real(z3)
18 y3 = imag(z3)
```

```
19  r3 = (x3^2 + y3^2)^0.5
20  theta3 = atan(y3/x3)*180/%pi
21
22  printf("\n\n Result \n\n")
23  printf("\n ZT is (%.2f/_%.2f )", r3,theta3)
```

Scilab code Exa 23.07 Example 7

```
1  //Problem 23.07: Determine (-2 + i3)^5 in polar and
       in cartesian form.
2
3  //initializing the variables:
4  z = -2 + %i*3;
5
6  //calculation:
7  zc = z^5
8  x = real(zc)
9  y = imag(zc)
10 r = (x^2 + y^2)^0.5
11 theta = atan(y/x)*180/%pi
12 if ((x<0)&(y<0)) then
13     theta = theta -180;
14 elseif ((x<0)&(y>0)) then
15     theta = theta +180;
16 end
17
18 printf("\n\n Result \n\n")
19 printf("\n Z is %.0f + (%.0f)i", x,y)
20 printf("\n ZT is (%.1f/_%.2f )", r,theta)
```

Scilab code Exa 23.08 Example 8

```scilab
1  //Problem 23.08: Determine the two square roots of
      the complex number (12 + i5) in cartesian and
      polar form, correct to three significant figures.
      Show the roots on an Argand diagram.
2
3  //initializing the variables:
4  z = 12 + %i*5;
5
6  //calculation:
7  x = real(z)
8  y = imag(z)
9  r = (x^2 + y^2)^0.5
10 theta1 = atan(y/x)*180/%pi
11 if ((x<0)&(y<0)) then
12     theta1 = theta1 -180;
13 elseif ((x<0)&(y>0)) then
14     theta1 = theta1 +180;
15 end
16 theta2 = theta1 + 360
17 rtheta1 = theta1/2
18 rtheta2 = theta2/2
19 if (rtheta2 > 180) then
20     rtheta2 = rtheta2 -360;
21 elseif ((x<0)&(y>0)) then
22     rtheta2 = rtheta2 +360;
23 end
24 rr = r^0.5
25 x1 = rr*cos(rtheta1*%pi/180)
26 y1 = rr*sin(rtheta1*%pi/180)
27 z1 = x1 + %i*y1
28 x2 = rr*cos(rtheta2*%pi/180)
29 y2 = rr*sin(rtheta2*%pi/180)
30 z2 = x2 + %i*y2
31
32 printf("\n\n Result \n\n")
33 printf("\n two roots are (%.2f + (%.2f)i) and (%.2f
      + (%.2f)i)", x1,y1,x2,y2)
34 printf("\n two roots are (%.1f/_%.2f  ) and (%.1f/_%
```

```
.2 f  )", rr,rtheta1 , rr,rtheta2)
```

Chapter 24

Application of complex numbers to series ac circuits

Scilab code Exa 24.01 Example 1

```
1  //Problem 24.01: Determine the values of the
      resistance and the series-connected inductance or
       capacitance for each of the following impedances
      :(a)(12 + i5)ohm (b)-i40 ohm (c)30/_60   ohm (d)
      2.20 x 10^6 /_-30   ohm. Assume for each a
      frequency of 50 Hz.
2
3  //initializing the variables:
4  z1 = 12 + %i*5;
5  z2 = -40*%i;
6  r3 = 30;
7  theta3 = 60;  // in degrees
8  r4 = 2.20E6;
9  theta4 = -30; // in degrees
10 f = 50; // in Hz
11
12 //calculation:
13 //for an R L series circuit, impedance
14 // Z = R + iXL
```

```
15  Ra = real(z1)
16  XLa = imag(z1)
17  La = XLa/(2*%pi*f)
18  //for a purely capacitive circuit , impedance Z = −
        iXc
19  Xcb = abs(imag(z2))
20  Cb = 1/(2*%pi*f*Xcb)
21  z3 = r3*cos(theta3*%pi/180) + %i*(r3*sin(theta3*%pi
        /180))
22  Rc = real(z3)
23  XLc = imag(z3)
24  Lc = XLc/(2*%pi*f)
25  z4 = r4*cos(theta4*%pi/180) + %i*(r4*sin(theta4*%pi
        /180))
26  Rd = real(z4)
27  Xcd = abs(imag(z4))
28  Cd = 1/(2*%pi*f*Xcd)
29
30  printf("\n\n Result \n\n")
31  printf("\n (a)an impedance (12 + i5)ohm represents a
         resistance of %.0f ohm in series with an
        inductance of %.2E", Ra,La)
32  printf("\n (b)an impedance −i40 ohm represents a
        pure capacitor of capacitance %.2E", Cb)
33  printf("\n (c)an impedance 30/_60   ohm represents a
         resistance of %.0f ohm in series with an
        inductance of %.2E", Rc,Lc)
34  printf("\n (d)an impedance 2.20 x 10^6 /_−30    ohm
        represents a resistance of %.2E ohm in series
        with a capacitor of capacitance %.2E",Rd, Cd)
```

Scilab code Exa 24.02 Example 2

```
1  //Problem 24.02: Determine , in polar and rectangular
        forms , the current flowing in an inductor of
```

```
        negligible resistance and inductance 159.2 mH
        when it is connected to a 250 V, 50 Hz supply.
 2
 3  //initializing the variables:
 4  L = 0.1592 ; // in Henry
 5  V = 250; // in Volts
 6  f = 50; // in Hz
 7  R = 0; // in ohms
 8
 9  //calculation:
10  //for an R  L  series circuit, impedance
11  // Z = R + iXL
12  XL = 2*%pi*f*L
13  Z = R + %i*XL
14  I = V/Z
15  x = real(I)
16  y = imag(I)
17  r = (x^2 + y^2)^0.5
18  if ((x==0)&(y<0)) then
19      theta = -90
20  elseif ((x==0)&(y>0)) then
21      theta = +90
22  else
23      theta = atan(y/x)*180/%pi
24  end
25
26  printf("\n\n Result \n\n")
27  printf("\n current is (%.0f/_%.0f  ) A", r, theta)
```

Scilab code Exa 24.03 Example 3

```
1  //Problem 24.03: A 3  F capacitor is connected to a
        supply of frequency 1 kHz and a current of 2.83/
       _90  A flows. Determine the value of the supply
       p.d.
```

```
2
3  //initializing the variables:
4  C = 3E-6 ; // in farad
5  f = 1000; // in Hz
6  ri = 2.83;
7  thetai = 90; // in degrees
8
9  //calculation:
10 //Capacitive reactance Xc
11 Xc = 1/(2*%pi*f*C)
12 // circuit impedance Z
13 Z = -1*%i*Xc
14 I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
      /180)
15 V = I*Z
16 x = real(V)
17 y = imag(V)
18
19 printf("\n\n Result \n\n")
20 printf("\n supply p.d. is %.0f + (%.0f) V", x,y)
```

Scilab code Exa 24.04 Example 4

```
1  //Problem 24.04: The impedance of an electrical
      circuit is (30 − i50) ohms.Determine (a) the
      resistance, (b) the capacitance, (c) the modulus
      of the impedance, and (d) the current flowing and
       its phase angle, when the circuit is connected
      to a 240 V, 50 Hz supply.
2
3  //initializing the variables:
4  V = 240; // in Volts
5  f = 50; // in Hz
6  Z = 30 - %i*50;
7
```

```
8  //calculation:
9  //Since impedance Z = 30 − i50,
10 //resistance
11 R = real(Z)
12 //capacitive reactance
13 Xc = abs(imag(Z))
14 //capacitance
15 C = 1/(2*%pi*f*Xc)
16 //modulus of impedance
17 modZ = (R^2 + Xc^2)^0.5
18 I = V/Z
19 x = real(I)
20 y = imag(I)
21 r = (x^2 + y^2)^0.5
22 if ((x==0)&(y<0)) then
23     theta = -90
24 elseif ((x==0)&(y>0)) then
25     theta = +90
26 else
27     theta = atan(y/x)*180/%pi
28 end
29
30 printf("\n\n Result \n\n")
31 printf("\n (a)resistance is %.0f ohm", R)
32 printf("\n (b)capacitance is %.2E Farad", C)
33 printf("\n (c)modulus of impedance is %.2f ohm",
       modZ)
34 printf("\n (d)current flowing and its phase angle is
        (%.2f/_%.2f  ) A", r, theta)
```

Scilab code Exa 24.05 Example 5

```
1 //Problem 24.05: A 200 V, 50 Hz supply is connected
      across a coil of negligible resistance and
      inductance 0.15 H connected in series with a 32
```

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```
        ohm resistor. Determine (a) the impedance of the
        circuit, (b) the current and circuit phase angle,
        (c) the p.d. across the 32 ohm resistor, and (d)
        the p.d. across the coil.
2
3  //initializing the variables:
4  V = 200; // in Volts
5  f = 50; // in Hz
6  R = 32; // in ohms
7  L = 0.15; // in Henry
8
9  //calculation:
10 //Inductive reactance XL
11 XL = 2*%pi*f*L
12 //impedance, Z
13 Z = R + %i*XL
14 //Current I
15 I = V/Z
16 xi = real(I)
17 yi = imag(I)
18 ri = (xi^2 + yi^2)^0.5
19 if ((xi==0)&(yi<0)) then
20     thetai = -90
21 elseif ((xi==0)&(yi>0)) then
22     thetai = +90
23 else
24     thetai = atan(yi/xi)*180/%pi
25 end
26 //P.d. across the resistor
27 VR = I*R
28 xr = real(VR)
29 yr = imag(VR)
30 rr = (xr^2 + yr^2)^0.5
31 thetar = atan(yr/xr)*180/%pi
32 //P.d. across the coil, VL
33 VL = I*%i*XL
34 xl = real(VL)
35 yl = imag(VL)
```

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```
36  rl = (xl^2 + yl^2)^0.5
37  thetal = atan(yl/xl)*180/%pi
38
39  printf("\n\n Result \n\n")
40  printf("\n (a)impedance is %.0f + (%.1f)i ohm", real
        (Z), imag(Z))
41  printf("\n (b)current flowing and its phase angle is
         (%.2f/_%.2f ) A", ri, thetai)
42  printf("\n (c)P.d. across the resistor is (%.2f/_%.2
        f ) V", rr,thetar)
43  printf("\n (d)P.d. across the coil, VL is (%.2f/_%.2
        f ) V", rl, thetal)
```

Scilab code Exa 24.06 Example 6

```
1  //Problem 24.06: Determine the value of impedance if
        a current of (7+i16)A flows in a circuit when
       the supply voltage is (120+i200)V. If the
       frequency of the supply is 5 MHz, determine the
       value of the components forming the series
       circuit.
2
3  //initializing the variables:
4  V = 120 + %i*200; // in Volts
5  f = 5E6; // in Hz
6  I = 7 + %i*16;  // in amperes
7
8  //calculation:
9  //impedance, Z
10 Z = V/I
11 R = real(Z)
12 X = imag(Z)
13 if ((R>0)&(X<0)) then
14     printf("\n\n Result \n\n")
15     C = -1/(2*%pi*f*X)
```

```
16        printf(" \n The series circuit thus consists of a
              resistor of resistance %.2 f ohm and a
            capacitor of capacitance %.2E Farad \n",R,C)
17  elseif ((R>0)&(X>0)) then
18        printf(" \n\n Result \n\n")
19        L = 2*%pi*f*X
20        printf(" \n The series circuit thus consists of a
              resistor of resistance %.2 f ohm and a
            inductor of insuctance %.2E Henry \n",R,L)
21  end
```

Scilab code Exa 24.07 Example 7

```
1  //Problem 24.07: For the circuit shown in Figure
       24.11 , determine the value of impedance Z2.
2
3  //initializing the variables:
4  rv = 70; // in volts
5  thetav = 30; // in degrees
6  ri = 3.5; // in amperes
7  thetai = -20; // in degrees
8  //z1 consist of two resistance
9  R1 = 4.36; // in ohms
10 R2 = -2.1*%i; // in ohms
11
12 //calculation:
13 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
14 I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
       /180)
15 //impedance, Z
16 Z = V/I
17 //Total impedance Z = z1 + z2
18 Z1 = R1 + R2
19 Z2 = Z - Z1
```

```
20  x = real(Z2)
21  y = imag(Z2)
22
23  printf("\n\n Result \n\n")
24  printf("\n impedance Z2 is %.2f + (%.2f) ohm\n",x,y)
```

Scilab code Exa 24.08 Example 8

```
1  //Problem 24.08: A circuit comprises a resistance of
       90 ohm in series with an inductor of inductive
       reactance 150 ohm. If the supply current is (1.35/
       _0 )A, determine (a) the supply voltage, (b) the
       voltage across the 90 ohm resistance, (c) the
       voltage across the inductance, and (d) the
       circuit phase angle. Draw the phasor diagram.
2
3  //initializing the variables:
4  R = 90; // in ohms
5  XL = 150; // in ohms
6  ri = 1.35; // in amperes
7  thetai = 0; // in degrees
8
9  //calculation:
10 I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
       /180)
11 //Circuit impedance Z
12 Z = R + %i*XL
13 //Supply voltage, V
14 V = I*Z
15 //Voltage across 90 ohm resistor
16 VR = real(V)
17 //Voltage across inductance, VL
18 VL = imag(V)
19 xv = real(V)
20 yv = imag(V)
```

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```
21  rv = (xv^2 + yv^2)^0.5
22  thetav = atan(yv/xv)*180/%pi
23  phi = thetav - thetai
24
25  printf("\n\n Result \n\n")
26  printf("\n (a)Supply voltage, V is %.2f + (%.2f)i V"
        ,xv,yv)
27  printf("\n (b)Voltage across 90 ohm resistor, VR is
        %.2f V",VR)
28  printf("\n (c)Voltage across inductance, VL is %.2f
        V",VL)
29  printf("\n (d)Circuit phase angle is %.2f ",phi)
```

Scilab code Exa 24.09 Example 9

```
1  //Problem 24.09: A coil of resistance 25 ohm and
       inductance 20 mH has an alternating voltage given
        by v = 282.8 sin (628.4t + pi/3) volts applied
       across it. Determine (a) the rms value of voltage
        (in polar form), (b) the circuit impedance, (c)
       the rms current flowing, and (d) the circuit
       phase angle.
2
3  //initializing the variables:
4  R = 25; // in ohms
5  L = 0.02; // in henry
6  Vm = 282.8; // in volts
7  w = 628.4; // in rad/sec
8  phiv = %pi/3; // phase angle
9
10  //calculation:
11  //rms voltage
12  Vrms = 0.707*Vm*cos(phiv) + %i*0.707*Vm*sin(phiv)
13  //frequency
14  f = w/(2*%pi)
```

```
15  //Inductive reactance XL
16  XL = 2*%pi*f*L
17  //Circuit impedance Z
18  Z = R + %i*XL
19  //Rms current
20  Irms = Vrms/Z
21  phii = atan(imag(Irms)/real(Irms))*180/%pi
22  phi = phiv*180/%pi - phii
23
24  printf("\n\n Result \n\n")
25  printf("\n (a)the rms value of voltage is %.2f + (%
        .2f)i V ",real(Vrms), imag(Vrms))
26  printf("\n (b)the circuit impedance is %.2f + (%.2f)
        i ohm ",R, XL)
27  printf("\n (c)the rms current flowing is %.2f + (%.2
        f)i A ",real(Irms), imag(Irms))
28  printf("\n (d)Circuit phase angle is %.2f   ",phi)
```

Scilab code Exa 24.10 Example 10

```
1  //Problem 24.10: A 240 V, 50 Hz voltage is applied
       across a series circuit comprising a coil of
       resistance 12 ohm and inductance 0.10 H, and 120
        F capacitor. Determine the current flowing in
       the circuit.
2
3  //initializing the variables:
4  R = 12; // in ohms
5  L = 0.10; // in henry
6  C = 120E-6; // in Farads
7  f = 50; // in Hz
8  V = 240; // in volts
9
10 //calculation:
11 //Inductive reactance, XL
```

```
12  XL = 2*%pi*f*L
13  // Capacitive reactance , Xc
14  Xc = 1/(2*%pi*f*C)
15  // Circuit impedance Z
16  Z = R + %i*(XL - Xc)
17  I = V/Z
18  phii = atan(imag(I)/real(I))*180/%pi
19  phiv = 0  // in degrees
20  phi = phiv - phii
21
22  printf("\n\n Result \n\n")
23  printf("\n the current flowing is %.2f + (%.2f)i A\n
        ",real(I), imag(I))
24  printf("and Circuit phase angle is %.2f  \n",phi)
```

Scilab code Exa 24.11 Example 11

```
1  // Problem 24.11:A coil of resistance R ohms and
      inductance L henrys is connected in series with a
       50   F capacitor. If the supply voltage is 225 V
       at 50 Hz and the current flowing in the circuit
      is 1.56/ −30   A, determine the values of R and L
      . Determine also the voltage across the coil and
      the voltage across the capacitor .
2
3  // initializing the variables :
4  C = 50E-6; // in Farads
5  f = 50; // in Hz
6  V = 225; // in volts
7  ri = 1.5; // in Amperes
8  thetai = -30; // in degrees
9
10  // calculation :
11  I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
      /180)
```

```
12  //Capacitive reactance, Xc
13  Xc = 1/(2*%pi*f*C)
14  //Circuit impedance Z
15  Z = V/I
16  R = real(Z)
17  XL = imag(Z) + Xc
18  //inductance L
19  L = XL/(2*%pi*f)
20  //Voltage across coil
21  Zcoil = R + %i*XL
22  Vcoil = I*Zcoil
23  //Voltage across capacitor,
24  Vc = -1*I*Xc*%i
25
26  printf("\n\n Result \n\n")
27  printf("\n (a)resistance is %.2f ohm and inductance
        is %.2f H ",R, L)
28  printf("\n (b)voltage across the coil is %.2f + (%.2
        f)i V ",real(Vcoil), imag(Vcoil))
29  printf("\n (c)voltage across the capacitor is %.2f +
         (%.2f)i V ",real(Vc), imag(Vc))
```

Scilab code Exa 24.12 Example 12

```
1  //Problem 24.12: For the circuit shown in Figure
       24.17, determine the values of voltages V1 and V2
        if the supply frequency is 4 kHz. Determine also
        the value of the supply voltage V and the
       circuit phase angle. Draw the phasor diagram.
2
3  //initializing the variables:
4  C = 2.653E-6; // in Farads
5  R1 = 8; // in ohms
6  R2 = 5; // in ohms
7  L = 0.477E-3; // in Henry
```

```scilab
8  f = 4000; // in Hz
9  ri = 6; // in Amperes
10 thetai = 0; // in degrees
11
12 //calculation:
13 I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
      /180)
14 //Capacitive reactance, Xc
15 Xc = 1/(2*%pi*f*C)
16 //impedance Z1
17 Z1 = R1 - %i*Xc
18 //inductive reactance XL
19 XL = 2*%pi*f*L
20 //impedance Z2,
21 Z2 = R2 + %i*XL
22 //voltage V1
23 V1 = I*Z1
24 //voltage V2
25 V2 = I*Z2
26 //Supply voltage, V
27 V = V1 + V2
28 phiv = atan(imag(V)/real(V))*180/%pi
29 phi = phiv - thetai
30
31 printf("\n\n Result \n\n")
32 printf("\n supply voltage is %.2f + (%.2f)i V\n",
      real(V), imag(V))
33 printf("and Circuit phase angle is %.2f   \n",phi)
```

Chapter 25

Application of complex numbers to parallel ac networks

Scilab code Exa 25.01 Example 1

```
1 //Problem 25.01: Determine the admittance,
     conductance and susceptance of the following
     impedances: (a)-i5 ohm, (b)25+i40 ohm, (c)3-i2
     ohm, (d)50/_40 ohm.
2
3 //initializing the variables:
4 Z1 = 0 - %i*5; // in ohms
5 Z2 = 25 + %i*40; // in ohms
6 Z3 = 3 - %i*2; // in ohms
7 r4 = 50; // in ohms
8 theta4 = 40; // in degrees
9
10 //calculation:
11 //admittance Y
12 Y1 = 1/Z1
13 //conductance, G
14 G1 = real(Y1)
15 //Suspectance, Bc
16 Bc1 = abs(imag(Y1))
```

```
17  //admittance Y
18  Y2 = 1/Z2
19  //conductance, G
20  G2 = real(Y2)
21  //Suspectance, Bc
22  Bc2 = abs(imag(Y2))
23  //admittance Y
24  Y3 = 1/Z3
25  //conductance, G
26  G3 = real(Y3)
27  //Suspectance, Bc
28  Bc3 = abs(imag(Y3))
29  Z4 = r4*cos(theta4*%pi/180) + %i*r4*sin(theta4*%pi
        /180)
30  //admittance Y
31  Y4 = 1/Z4
32  //conductance, G
33  G4 = real(Y4)
34  //Suspectance, Bc
35  Bc4 = abs(imag(Y4))
36
37  printf(" \n\n Result \n\n")
38  printf(" \n (a)admittance Y is (%.0f + (%.1f)i) S,
        conductance, G is %.0f S, susceptance ,Bc is %.1f
        S ",real(Y1), imag(Y1),G1,Bc1)
39  printf(" \n (b)admittance Y is (%.4f + (%.4f)i) S,
        conductance, G is %.4f S, susceptance ,Bc is %.4f
        S ",real(Y2), imag(Y2),G2, Bc2)
40  printf(" \n (c)admittance Y is (%.3f + (%.3f)i) S,
        conductance, G is %.3f S, susceptance ,Bc is %.3f
        S ",real(Y3), imag(Y3),G3,Bc3)
41  printf(" \n (d)admittance Y is (%.4f + (%.4f)i) S,
        conductance, G is %.4f S, susceptance ,Bc is %.4f
        S ",real(Y4), imag(Y4),G4,Bc4)
```

Scilab code Exa 25.02 Example 2

```
1  //Problem 25.02: Determine expressions for the
       impedance of the following admittances: (a)0.004/
       _30 S  (b) (0.001-i0.002)S (c)(0.05 + i0.08)S
2
3  //initializing the variables:
4  Y2 = 0.001 - %i*0.002; // in S
5  Y3 = 0.05 + %i*0.08; // in S
6  r1 = 0.004; // in S
7  theta1 = 30; // in degrees
8
9  //calculation:
10 //impedance, Z
11 Z2 = 1/Y2
12 Z3 = 1/Y3
13 Y1 = r1*cos(theta1*%pi/180) + %i*r1*sin(theta1*%pi
       /180)
14 Z1 = 1/Y1
15
16 printf("\n\n Result \n\n")
17 printf("\n (a)Impedance,Z is (%.1f + (%.0f)i) ohm ",
       real(Z1), imag(Z1))
18 printf("\n (b)Impedance,Z is (%.0f + (%.0f)i) ohm ",
       real(Z2), imag(Z2))
19 printf("\n (c)Impedance,Z is (%.2f + (%.2f)i) ohm ",
       real(Z3), imag(Z3))
```

Scilab code Exa 25.03 Example 3

```
1  //Problem 25.03: The admittance of a circuit is
       (0.040 + i0.025) S. Determine the values of the
       resistance and the capacitive reactance of the
       circuit if they are connected (a) in parallel, (b
       ) in series. Draw the phasor diagram for each of
```

```
      the circuits.
 2
 3  //initializing the variables:
 4  Y = 0.040 - %i*0.025; // in S
 5
 6  //calculation:
 7  //impedance, Z
 8  Z = 1/Y
 9  //conductance, G
10  G = real(Y)
11  //Suspectance, Bc
12  Bc = abs(imag(Y))
13  //parallrl
14  //resistance, R
15  Rp = 1/G
16  //capacitive reactance
17  Xcp = 1/Bc
18  //series
19  //resistance, R
20  Rs = real(Z)
21  //capacitive reactance
22  Xcs = abs(imag(Z))
23
24  printf("\n\n Result \n\n")
25  printf("\n (a)for parallel, resistance,R is %.0f ohm
          and capacitive reactance, Xc is %.0f ohm ",Rp,
        Xcp)
26  printf("\n (b)forseries, resistance,R is %.2f ohm
          and capacitive reactance, Xc is %.2f ohm ",Rs,Xcs
        )
```

Scilab code Exa 25.04 Example 4

```
 1  //Problem 25.04: Determine the values of currents I,
        I1 and I2 shown in the network of Figure 25.5.
```

```
 2
 3  // initializing  the  variables :
 4  R1 = 8;  // in  ohm
 5  R = 5;  // in  ohm
 6  R2 = 6;  // ohm
 7  rv = 50;  // in  volts
 8  thetav = 0;  // in  degrees
 9
10  // calculation :
11  // voltage ,V
12  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
        /180)
13  // circuit  impedance ,  ZT
14  ZT = R + (R1*%i*R2/(R1 + %i*R2))
15  // Current  I
16  I = V/ZT
17  // current ,I1
18  I1 = I*(%i*R2/(R1 + %i*R2))
19  // current ,  I2
20  I2 = I*(R1/(R1 + %i*R2))
21
22  printf(" \n\n  Result  \n\n")
23  printf(" \n  current ,  I  is  (%.2 f  +  (%.2 f ) i )  A, current ,
        I1  is  (%.2 f  +  (%.2 f ) i )  A,  current ,  I2  is  (%.2 f  +
        (%.2 f ) i )  A  ",real(I),  imag(I),real(I1),  imag(I1),
        real(I2),  imag(I2))
```

Scilab code Exa 25.05 Example 5

```
1  // Problem  25.05:  For  the  parallel  network  shown  in
        Figure  25.6 ,  determine  the  value  of  supply
        current  I  and  its  phase  relative  to  the  40  V
        supply .
2
3  // initializing  the  variables :
```

```
4  R1 = 5; // in ohm
5  R2 = 3; // in ohm
6  R3 = 8; // ohm
7  Xc = 4; // in ohms
8  XL = 12; // in Ohms
9  V = 40; // in volts
10 f = 50; // in Hz
11
12 //calculation :
13 Z1 = R1 + %i*XL
14 Z2 = R2 - %i*Xc
15 Z3 = R3
16 //circuit admittance , YT = 1/ZT
17 YT = (1/Z1) + (1/Z2) + (1/Z3)
18 //Current I
19 I = V*YT
20 I1 = V/Z1
21 I2 = V/Z2
22 I3 = V/Z2
23 thetav = 0
24 thetai = atan(imag(I)/real(I))*180/%pi
25 phi = thetav - thetai
26 if (phi>0) then
27     a = "lagging"
28 else
29     a = "leading"
30 end
31
32 printf("\n\n Result \n\n")
33 printf("\n current , I is (%.2f + (%.2f)i) A,and its
       phase relative to the 40 V supply is %s by %.2 f
       \n",real(I), imag(I),a,abs(phi))
```

Scilab code Exa 25.06 Example 6

```
1  //Problem 25.06: An a.c. network consists of a coil,
        of inductance 79.58 mH and resistance 18 ohm, in
        parallel with a capacitor of capacitance 64.96
        F. If the supply voltage is 250/_0  V at 50 Hz
        , determine (a) the total equivalent circuit
        impedance, (b) the supply current, (c) the
        circuit phase angle, (d) the current in the coil,
        and (e) the current in the capacitor.
2
3  //initializing the variables:
4  L = 0.07958; // in Henry
5  R = 18; // in ohm
6  C = 64.96E-6; // in Farad
7  rv = 250; // in volts
8  thetav = 0; // in degrees
9  f = 50; // in Hz
10
11  //calculation:
12  //Inductive reactance
13  XL = 2*%pi*f*L
14  //capacitive reactance
15  Xc = 1/(2*%pi*f*C)
16  //impedance of the coil,
17  Zcoil = R + %i*XL
18  //impedance presented by the capacitor,
19  Zc = -1*%i*Xc
20  //Total equivalent circuit impedance,
21  ZT = Zcoil*Zc/(Zcoil + Zc)
22  //voltage
23  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
        /180)
24  //current, I
25  I = V/ZT
26  thetai = atan(imag(I)/real(I))*180/%pi
27  phi = thetav - thetai
28  if (phi>0) then
29      a = "lagging"
30  else
```

```
31       a = "leading"
32  end
33  //Current in the coil, ICOIL
34  Icoil = V/Zcoil
35  //Current in the capacitor, IC
36  Ic = V/Zc
37
38  printf("\n\n Result \n\n")
39  printf("\n (a)the circuit impedance is %.2f + (%.2f)
        i ohm ",real(ZT), imag(ZT))
40  printf("\n (b)supply current, I is %.2f + (%.2f)i A
        ",real(I), imag(I))
41  printf("\n (c)circuit phase relative is %s by %.2f
         ",a,abs(phi))
42  printf("\n (d)current in coil, Icoil is %.2f + (%.2f
        )i A ",real(Icoil), imag(Icoil))
43  printf("\n (e)current in capacitor, Ic is %.2f + (%
        .2f)i A ",real(Ic), imag(Ic))
```

Scilab code Exa 25.07 Example 7

```
1  //Problem 25.07: (a) For the network diagram of
       Figure 25.8, determine the value of impedance Z1
       (b) If the supply frequency is 5 kHz, determine
       the value of the components comprising impedance
       Z1.
2
3  //initializing the variables:
4  RL = %i*6; // in ohm
5  R2 = 8; // in ohm
6  Z3 = 10; // in ohm
7  rv = 50; // in volts
8  thetav = 30; // in degrees
9  ri = 31.4; // in amperes
10 thetai = 52.48; // in degrees
```

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```
11  f = 5000; // in Hz
12
13  //calculation :
14  //impedance , Z2
15  Z2 = R2 + RL
16  //voltage
17  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
        /180)
18  //current , I
19  I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
        /180)
20  //Total circuit admittance ,
21  YT = I/V
22  //admittance , Y3
23  Y3 = 1/Z3
24  //admittance , Y2
25  Y2 = 1/Z2
26  //admittance , Y1
27  Y1 = YT - Y2 - Y3
28  //impedance , Z1
29  Z1 = 1/Y1
30
31  printf("\n\n Result \n\n")
32  printf("\n (a)the impedance Z1 is %.2f + (%.2f)i ohm
        ",real(Z1), imag(Z1))
33
34  //resistance , R1
35  R1 = real(Z1)
36  X1 = imag(Z1)
37  if ((R1>0)&(X1<0)) then
38      C1 = -1/(2*%pi*f*X1)
39      printf("\n (b)The series circuit thus consists
            of a resistor of resistance %.2f ohm and a
            capacitor of capacitance %.2E Farad\n",R1,C1)
40  elseif ((R1>0)&(X1>0)) then
41      L1 = 2*%pi*f*X1
42      printf("\n (b)The series circuit thus consists
            of a resistor of resistance %.2f ohm and a
```

```
                   inductor  of  insuctance  %.2E  Henry\n",R1,L1)
43  end
```

Scilab code Exa 25.08 Example 8

```
 1  //Problem  25.08:  For  the  series−parallel  arrangement
        shown  in  Figure  25.9 ,  determine  (a)  the
        equivalent  series  circuit  impedance ,  (b)  the
        supply  current  I ,  (c)  the  circuit  phase  angle ,  (d
        )  the  values  of  voltages  V1  and  V2,  and  (e)  the
        values  of  currents  IA  and  IB .
 2
 3  //initializing  the  variables :
 4  RL1 = %i*1.02;  //  in  ohm
 5  R1 = 1.65;  //  in  ohm
 6  RLa = %i*7;  //  in  ohm
 7  Ra = 5;  //  in  ohm
 8  Rcb = -1*%i*15;  //  in  ohm
 9  Rb = 4;  //  in  ohm
10  rv = 91;  //  in  volts
11  thetav = 0;  //  in  degree
12
13  //calculation :
14  //voltage
15  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
        /180)
16  //impedance ,  Z1
17  Z1 = R1 + RL1
18  //impedance ,  Za
19  Za = Ra + RLa
20  //impedance ,  Zb
21  Zb = Rb + Rcb
22  //impedance ,  Z,  of  the  two  branches  connected  in
        parallel
23  Z = Za*Zb/(Za + Zb)
```

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```
24 //Total circuit impedance
25 ZT = Z1 + Z
26 //Supply current, I
27 I = V/ZT
28 thetai = atan(imag(I)/real(I))*180/%pi
29 phi = thetav - thetai
30 if (phi>0) then
31     a = "lagging"
32 else
33     a = "leading"
34 end
35 //Voltage V1
36 V1 = I*Z1
37 //Voltage V2
38 V2 = I*Z
39 //current Ia
40 Ia = V2/Za
41 //Current Ib
42 Ib = V2/Zb
43
44 printf("\n\n Result \n\n")
45 printf("\n (a)equivalent series circuit impedance is
       %.2f + (%.2f)i ohm ",real(ZT), imag(ZT))
46 printf("\n (b)supply current, I is %.2f + (%.2f)i A
       ",real(I), imag(I))
47 printf("\n (c)circuit phase relative is %s by %.2f
       ",a,abs(phi))
48 printf("\n (d)voltage, V1 is (%.2f + (%.2f)i) V and
       V2 is(%.2f + (%.2f)i) V ",real(V1), imag(V1),real
       (V2), imag(V2))
49 printf("\n (e)current, Ia is (%.2f + (%.2f)i) A and
       Ib is(%.2f + (%.2f)i) A ",real(Ia), imag(Ia),real
       (Ib), imag(Ib))
```

Chapter 26

Power in ac circuits

Scilab code Exa 26.01 Example 1

```
1 //Problem 26.01: A coil of resistance 5 ohm and
      inductive reactance 12 ohm is connected across a
      supply voltage of 526/_30 volts. Determine the
      active power in the circuit.
2
3 //initializing the variables:
4 RL = %i*12; // in ohm
5 R = 5; // in ohm
6 rv = 52; // in volts
7 thetav = 30; // in degree
8
9 //calculation:
10 //voltage
11 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
      /180)
12 //impedance, Z
13 Z = R + RL
14 //current
15 I = V/Z
16 //Active power, P
17 Pa = real(V)*real(I) + imag(V)*imag(I)
```

```
18
19 printf(" \n\n Result \n\n")
20 printf(" \nthe active power in the circuit %.0f W\n",
      Pa)
```

Scilab code Exa 26.02 Example 2

```
1 //Problem 26.02: A current of (15+i8)A flows in a
      circuit whose supply voltage is (120+i200)V.
      Determine (a) the active power, and (b) the
      reactive power.
2
3 //initializing the variables:
4 V = 120 + %i*200; // in volts
5 I = 15 + %i*8; // in amperes
6
7 //calculation:
8 //Active power, P
9 Pa = real(V)*real(I) + imag(V)*imag(I)
10 //Reactive power, Q
11 Q = imag(V)*real(I) - real(V)*imag(I)
12
13 printf(" \n\n Result \n\n")
14 printf(" \n (a) the active power in the circuit %.0f
      W",Pa)
15 printf(" \n (b) the reactive power in the circuit %.0
      f var ",Q)
```

Scilab code Exa 26.03 Example 3

```
1 //Problem 26.03: A series circuit possesses
      resistance R and capacitance C. The circuit
      dissipates a power of 1.732 kW and has a power
```

factor of 0.866 leading. If the applied voltage
is given by v = 141.4*sin(10000t + pi/9) volts,
determine (a) the current flowing and its phase,
(b) the value of resistance R, and (c) the value
of capacitance C.

```
 2
 3  //initializing the variables:
 4  Vm = 141.4; // in volts
 5  w = 10000; // in rad/sec
 6  phiv = %pi/9; // in radian
 7  Pd = 1732; // in Watts
 8  pf = 0.866; // power fctr
 9
10  //calculation:
11  //the rms voltage,
12  Vrms = 0.707*Vm
13  //Power P = V*I*cos(phi)
14  //current magnitude, Irms
15  Irms = Pd/(Vrms*pf)
16  phid = acos(pf)
17  //current phase angle
18  phii = phiv + phid
19  phiid = phii*180/%pi // in degrees
20  //Voltage, V
21  V = Vrms*cos(phiv) + %i*Vrms*sin(phiv)
22  //current, I
23  I = Irms*cos(phii) + %i*Irms*sin(phii)
24  //Impedance, Z
25  Z = V/I
26  //resistance, R
27  R = real(Z)
28  //capacitive reactance, Xc
29  Xc = abs(imag(Z))
30  //capacitance, C
31  C = 1/ (w*Xc)
32
33  printf("\n\n Result \n\n")
34  printf("\n (a)the current flowing and Circuit phase
```

```
        angle is %.0f/_%.2f    A ",Irms,phiid)
35  printf("\n (b) the resistance is %.2f ohm ",R)
36  printf("\n (c) the capacitance is %.2E farad ",C)
```

Scilab code Exa 26.04 Example 4

```
 1  //Problem 26.04:For the circuit shown in Figure
       26.8, determine the active power developed
       between points (a) A and B, (b) C and D, (c) E
       and F.
 2
 3  //initializing the variables:
 4  rv = 100; // in volts
 5  thetav = 0; // in degrees
 6  R = 5; // in ohm
 7  R1 = 3; // in ohms
 8  RL = %i*4; // in ohm
 9  Rc = -10*%i; // in ohms
10
11  //calculation:
12  //impedance, Z1
13  Z1 = R1 + RL
14  //impedance, Zc
15  Zc = Rc
16  //Circuit impedance, Z
17  Z = R + (Z1*Zc/(Z1 + Zc))
18  //voltage
19  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
20  I = V/Z
21  Imag = ((real(I))^2 + (imag(I))^2)^0.5
22  //Active power developed between points A and B
23  Pab = (Imag^2)*R
24  //Active power developed between points C and D
25  Pcd = (Imag^2)*real(Zc)
```

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```
26  //Current, I1
27  I1 = I*Zc/(Zc + Z1)
28  I1mag = ((real(I1))^2 + (imag(I1))^2)^0.5
29  //active power developed between points E and F
30  Pef = (I1mag^2)*real(Z1)
31
32  printf("\n\n Result \n\n")
33  printf("\n (a)Active power developed between points
        A and B is %.2f W ",Pab)
34  printf("\n (b)Active power developed between points
        C and D is %.2f W ",Pcd)
35  printf("\n (c)Active power developed between points
        E and F is %.2f W ",Pef)
```

Scilab code Exa 26.05 Example 5

```
1  //Problem 26.05:The circuit shown in Figure 26.9
       dissipates an active power of 400 Wand has a
       power factor of 0.766 lagging. Determine (a) the
       apparent power, (b) the reactive power, (c) the
       value and phase of current I, and (d) the value
       of impedance Z.
2
3  //initializing the variables:
4  Pa = 400; // in Watts
5  rv = 100; // in volts
6  thetav = 30; // in degrees
7  R = 4; // in ohm
8  pf = 0.766; // power factor
9
10 //calculation:
11 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
12 //magnitude of apparent power,S = V*I
13 S = Pa/pf
```

```
14  phi = acos(pf)
15  theta = phi*180/%pi // in degrees
16  //Reactive power Q
17  Q = S*sin(phi)
18  //magnitude of current
19  Imag = S/rv
20  thetai = thetav - theta
21  I = Imag*cos(thetai*%pi/180) + %i*Imag*sin(thetai*
       %pi/180)
22  //Total circuit impedance ZT
23  ZT = V/I
24  //impedance Z
25  Z = ZT - R
26
27  printf("\n\n Result \n\n")
28  printf("\n (a)apparent power is %.2f VA ",S)
29  printf("\n (b)reactive power is %.2f var ",Q)
30  printf("\n (c)the current flowing and Circuit phase
       angle is %.2f/_%.0f   A ",Imag,thetai)
31  printf("\n (d)impedance, Z is %.2f + (%.2f)i ohm ",
       real(Z), imag(Z))
```

Scilab code Exa 26.06 Example 6

```
1  //Problem 26.06: A 300 kVA transformer is at full
      load with an overall power factor of 0.70 lagging
      . The power factor is improved by adding
      capacitors in parallel with the transformer until
       the overall power factor becomes 0.90 lagging.
      Determine the rating (in kilovars) of the
      capacitors required.
2
3  //initializing the variables:
4  S = 300000; // in VA
5  pf1 = 0.70; // in power factor
```

```
6  pf2 = 0.90; // in power factor
7
8  //calculation:
9  //active power, P
10 Pa = S*pf1
11 phi1 = acos(pf1)
12 phi1d = phi1*180/%pi
13 //Reactive power, Q
14 Q = S*sin(phi1)
15 phi2 = acos(pf2)
16 phi2d = phi2*180/%pi
17 //The capacitor rating needed to improve the power
      factor to 0.90
18 //the capacitor rating,
19 Pr = Q - (Pa*tan(phi2))
20
21 printf("\n\n Result \n\n")
22 printf("\n the rating (in kilovars) of the
      capacitors is %.1f kvar\n",(Pr/1E3))
```

Scilab code Exa 26.07 Example 7

```
1 //Problem 26.07: A circuit has an impedance Z = (3+
     i4)ohm and a source p.d. of 50/_30   V at a
     frequency of 1.5 kHz. Determine (a) the supply
     current , (b) the active , apparent and reactive
     power , (c) the rating of a capacitor to be
     connected in parallel with impedance Z to improve
      the power factor of the circuit to 0.966 lagging
     , and (d) the value of capacitance needed to
     improve the power factor to 0.966 lagging.
2
3 //initializing the variables:
4 Z = 3 + %i*4; // in ohms
5 rv = 50; // in volts
```

```
6  thetav = 30; // in Degrees
7  f = 1500; // in Hz
8  pf1 = 0.966; // in power factor
9
10 //calculation:
11 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
12 //Supply current, I
13 I = V/Z
14 Istr = real(I) - %i*imag(I)
15 //Apparent power, S
16 S = V*Istr
17 //active power, Pa
18 Pa = real(S)
19 //reactive power, Q
20 Q = abs(imag(S))
21 //apparent power, S
22 S = (real(S)^2 + imag(S)^2)^0.5
23 phi1 = acos(pf1)
24 phi1d = phi1*180/%pi
25 //rating of the capacitor
26 Pr = Q - Pa*tan(phi1)
27 //Current in capacitor, Ic
28 Ic = Pr/rv
29 //Capacitive reactance, Xc
30 Xc = rv/Ic
31 C = 1/(2*%pi*f*Xc)
32
33 printf("\n\n Result \n\n")
34 printf("\n (a)supply current, I is %.2f + (%.2f)i A
       ",real(I), imag(I))
35 printf("\n (b)active power is %.0f W, apparent power
        is %.0f W and reactive power is %.0f W ",Pa, S,
     Q)
36 printf("\n (c)the rating of the capacitors is %.1f
       var\n",Pr)
37 printf(" (d)value of capacitance needed to improve
       the power factor to 0.966 lagging is %.3E F\n", C
```

)

Chapter 27

AC bridges

Scilab code Exa 27.02 Example 2

```
1  //Problem 27.02: For the Wien bridge shown in Figure
        27.9, R2 = R3 = 30 kohm, R4 = 1 kohm and C2 = C3
        = 1 nF. Determine, when the bridge is balanced,
        (a) the value of resistance R1, and (b) the
        frequency of the bridge.
2
3  //initializing the variables:
4  R2 = 30000; // in ohms
5  R3 = 30000; // in ohms
6  R4 = 1000; // in ohms
7  C2 = 1e-9; // IN fARADS
8  C3 = 1e-9; // IN fARADS
9
10 //calculation:
11 //the bridge is balanced
12 R1 = R4/((R3/R2) + (C2/C3))
13 //frequency, f
14 f = 1/(2*%pi*((C2*C3*R2*R3)^0.5))
15
16 printf("\n\n Result \n\n")
17 printf("\n (a)Resistance R1 = %.0f ohm",R1)
```

```
18  printf("\n (b)frequency , f is %.2E Hz ",f)
```

Scilab code Exa 27.03 Example 3

```
1  //Problem 27.03: A Schering bridge network is as
       shown in Figure 27.7. Given C2 = 0.2  F , R4 =
       200 ohm, R3 = 600 ohm, C3 = 4000 pF and the
       supply frequency is 1.5 kHz, determine , when the
       bridge is balanced , (a) the value of resistance
       Rx, (b) the value of capacitance Cx, (c) the
       phase angle of the unknown arm, (d) the power
       factor of the unknown arm and (e) its loss angle.
2
3  //initializing the variables :
4  R3 = 600; // in ohms
5  R4 = 200; // in ohms
6  C2 = 0.2e-6; // IN fARADS
7  C3 = 4000e-12; // IN fARADS
8  f = 1500; //in Hz
9
10 //calculation :
11 //the bridge is balanced
12 //Resistance , Rx
13 Rx = R4*C3/C2
14 //Capacitance , Cx
15 Cx = C2*R3/R4
16 //Phase angle
17 phi = atan(1/(2*%pi*f*Cx*Rx))
18 phid = phi*180/%pi // in degrees
19 //Power factor of capacitor
20 Pc = cos(phi)
21 //Loss angle ,
22 del = 90 - phid
23
24 printf("\n\n Result \n\n")
```

```
25  printf("\n (a)Resistance Rx = %.0f ohm ",Rx)
26  printf("\n (b)capacitance, Cx is %.2E Farad ",Cx)
27  printf("\n (c)phasor diagram = %.2f   ",phid)
28  printf("\n (d)power factor is %.4f ",Pc)
29  printf("\n (e)Loss angle = %.2f   ",del)
```

Chapter 28

Series resonance and Q factor

Scilab code Exa 28.01 Example 1

```scilab
1  //Problem 28.01: A coil having a resistance of 10
      ohm and an inductance of 75 mH is connected in
      series with a 40   F capacitor across a 200 V a.c
      . supply. Determine at what frequency resonance
      occurs, and (b) the current flowing at resonance.
2
3  //initializing the variables:
4  R = 10; // in ohms
5  C = 40e-6; // IN fARADS
6  L = 0.075; // IN Henry
7  V = 200; // in Volts
8
9  //calculation:
10 //Resonant frequency,
11 fr = 1/(2*%pi*((L*C)^0.5))
12 //Current at resonance, I
13 I = V/R
14
15 printf("\n\n Result \n\n")
16 printf("\n (a)Resonant frequency = %.1f Hz ",fr)
17 printf("\n (b)Current at resonance, I is %.0f A ",I)
```

Scilab code Exa 28.02 Example 2

```scilab
1  //Problem 28.02: An R  L  C series circuit is
       comprised of a coil of inductance 10 mH and
       resistance 8 ohm and a variable capacitor C. The
       supply frequency is 1 kHz. Determine the value of
        capacitor C for series resonance.
2
3  //initializing the variables:
4  R = 8; // in ohms
5  L = 0.010; // IN Henry
6  f = 1000; // in Hz
7
8  //calculation:
9  //At resonance
10 //capacitance C
11 C = 1/(L*(2*%pi*f)^2)
12
13 printf("\n\n Result \n\n")
14 printf("\n capacitance, C is %.2E F\n",C)
```

Scilab code Exa 28.03 Example 3

```scilab
1  //Problem 28.03: A coil having inductance L is
       connected in series with a variable capacitor C.
       The circuit possesses stray capacitance CS which
       is assumed to be constant and effectively in
       parallel with the variable capacitor C. When the
       capacitor is set to 1000 pF the resonant
       frequency of the circuit is 92.5 kHz, and when
       the capacitor is set to 500 pF the resonant
```

```
      frequency is 127.8 kHz Determine the values of (a
      ) the stray capacitance CS, and (b) the coil
      inductance L.
2
3  //initializing the variables:
4  C1 = 1000e-12; // IN fARADS
5  C2 = 500e-12; // IN fARADS
6  fr1 = 92500; // in Hz
7  fr2 = 127800; // in Hz
8
9  //calculation:
10 //For a series  R  L  C  circuit the resonant
      frequency fr is given by:
11 //fr = 1/(2 pi*(L*C)^2)
12 Cs = ((C1 - C2)/((fr2/fr1)^2 - 1)) - C2
13 L = 1/((C1 + Cs)*(2*%pi*fr1)^2)
14
15 printf("\n\n Result \n\n")
16 printf("\n (a)stray capacitance, Cs is %.2E F ",Cs)
17 printf("\n (b)inductance, L is %.2E H ",L)
```

Scilab code Exa 28.04 Example 4

```
1  //Problem 28.04: A series circuit comprises a 10 ohm
       resistance, a 5   F  capacitor and a variable
      inductance L. The supply voltage is 20/ _0   volts
       at a frequency of 318.3 Hz. The inductance is
      adjusted until the p.d. across the 10 ohm
      resistance is a maximum. Determine for this
      condition (a) the value of inductance L, (b) the
      p.d. across each component and (c) the Q−factor.
2
3  //initializing the variables:
4  R = 10; // in ohms
5  C = 5e-6; // IN fARADS
```

```
6  rv = 20; //in volts
7  thetav = 0; // in degrees
8  f = 318.3; // in Hz
9
10 //calculation:
11 wr = 2*%pi*f
12 //The maximum voltage across the resistance occurs
      at resonance when the current is a maximum. At
      resonance, L = 1/c*wr^2
13 L = 1/(C*wr^2)
14 //voltage
15 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
      /180)
16 //Current at resonance Ir
17 Ir = V/R
18 //p.d. across resistance, VR
19 VR = Ir*R
20 //inductive reactance, XL
21 XL = wr*L
22 //p.d. across inductance, VL
23 VL = Ir*(%i*XL)
24 //capacitive reactance, Xc
25 Xc = 1/(wr*C)
26 //p.d. across capacitor, Vc
27 Vc = Ir*(-1*%i*Xc)
28 //Q-factor at resonance, Qr
29 Qr = imag(VL)/V
30
31 printf("\n\n Result \n\n")
32 printf("\n (a)inductance, L is %.2E H ",L)
33 printf("\n (b)p.d. across resistance, VR is %.2f V,
       p.d. across inductance, VL %.0fi V and p.d.
       across capacitor, VC %.0fi V ",VR, imag(VL), imag
      (Vc))
34 printf("\n (c)Q-factor at resonance, Qr is %.0f ",
      Qr)
```

Scilab code Exa 28.05 Example 5

```
1  //Problem 28.05: A series  L   R   C  circuit  has a
       sinusoidal  input  voltage  of  maximum  value  12 V.
       If  inductance ,  L = 20 mH,  resistance ,  R = 80 ohm,
        and  capacitance ,  C = 400 nF,  determine  (a)  the
       resonant  frequency ,  (b)  the  value  of  the  p.d.
       across  the  capacitor  at  the  resonant  frequency , (
       c)  the  frequency  at  which  the  p.d.  across  the
       capacitor  is  a  maximum,  and  (d)  the  value  of  the
       maximum  voltage  across  the  capacitor .
2
3  //initializing  the  variables :
4  R = 80;  // in  ohms
5  C = 0.4e-6;  // IN  fARADS
6  L = 0.020;  // IN  Henry
7  Vm = 12;  //in  volts
8
9  //calculation :
10  //Resonant  frequency ,
11  fr = 1/(2*%pi*((L*C)^0.5))
12  wr = 2*%pi*fr
13  //Q = wr*L/R
14  Q = wr*L/R
15  Vc = Q*Vm
16  //the  frequency  f  at  which  VC  is  a  maximum  value ,
17  f = fr*(1 - (1/(2*Q*Q)))^0.5
18  //the  maximum  value  of  the  p.d.  across  the  capacitor
        is  given  by:
19  Vcm = Vc/(1 - (1/(2*Q))^2)^0.5
20
21  printf(" \n\n  Result  \n\n")
22  printf(" \n  (a)The  resonant  frequency  is  %.1f  Hz ",fr
       )
```

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```
23  printf("\n (b) the value of the p.d. across the
        capacitor at the resonant frequency %.2f V ",Vc)
24  printf("\n (c) the frequency f at which Vc is a
        maximum value, is %.1f Hz ",f)
25  printf("\n (d) the maximum value of the p.d. across
        the capacitor is %.1f V ",Vcm)
```

Scilab code Exa 28.06 Example 6

```
1  //Problem 28.06: An inductor of Q-factor 60 is
       connected in series with a capacitor having a Q-
       factor of 390. Determine the overall Q-factor of
       the circuit.
2
3  //initializing the variables:
4  QL = 60; // Q-factor
5  Qc = 390; // Q-factor
6
7  //calculation:
8  QT = QL*Qc/(QL + Qc)
9
10 printf("\n\n Result \n\n")
11 printf("\n the overall Q-factor is %.0f \n",QT)
```

Scilab code Exa 28.07 Example 7

```
1  //Problem 28.07: A filter in the form of a series
       L   R   C circuit is designed to operate at a
       resonant frequency of 10 kHz. Included within the
        filter is a 10 mH inductance and 5 ohm
       resistance. Determine the bandwidth of the filter
       .
2
```

```
 3  // initializing the variables :
 4  R = 5;  // in ohms
 5  L = 0.010;  // IN Henry
 6  fr = 10000;  // in Hz
 7
 8  // calculation :
 9  wr = 2*%pi*fr
10  //Q-factor at resonance is given by
11  Qr = wr*L/R
12  // Since Qr = fr /( f2 - f1 ) ,
13  bw = fr/Qr
14
15  printf ("\n\n Result \n\n")
16  printf ("\n bandwidth of the filter is %.1 f Hz\n",bw)
```

Scilab code Exa 28.08 Example 8

```
 1  //Problem 28.08: An R  L  C  series circuit has a
        resonant frequency of 1.2 kHz and a Q-factor at
        resonance of 30. If the impedance of the circuit
        at resonance is 50 ohm determine the values of (a
        ) the inductance , and (b) the capacitance . Find
        also (c) the bandwidth , (d) the lower and upper
        half-power frequencies and (e) the value of the
        circuit impedance at the half-power frequencies .
 2
 3  // initializing the variables :
 4  Zr = 50;  // in ohms
 5  fr = 1200;  // in Hz
 6  Qr = 30;  // Q-factor
 7
 8  // calculation :
 9  //At resonance the circuit impedance , Z
10  R = Zr
11  wr = 2*%pi*fr
```

```
12  //Q−factor  at  resonance  is  given  by  Qr = wr∗L/R,
        then  L  is
13  L = Qr*R/wr
14  //At  resonance  r∗L = 1/(wr∗C)
15  //capacitance, C
16  C = 1/(L*wr*wr)
17  //bandwidth ,.(f2      f1)
18  bw = fr/Qr
19  //upper  half−power  frequency, f2
20  f2 = (bw + ((bw^2) + 4*(fr^2))^0.5)/2
21  //lower  half−power  frequency, f1
22  f1 = f2 - bw
23  //At  the  half−power  frequencies, current  I
24  //I = 0.707∗Ir
25  //Hence  impedance
26  Z = (2^0.5)*R
27
28  printf("\n\n  Result  \n\n")
29  printf("\n (a)inductance, L is %.3f H ",L)
30  printf("\n (b)capacitance, C is %.2E F ",C)
31  printf("\n (c)bandwidth is %.0f Hz ",bw)
32  printf("\n (d)the  upper  half−power  frequency, f2  is
        %.0f  Hz and  the  lower  half−power  frequency, f1  is
         %.0f  Hz ",f2,f1)
33  printf("\n (e)impedance  at  the  half−power
        frequencies  is %.2f ohm ",Z)
```

Scilab code Exa 28.09 Example 9

```
1  //Problem  28.09: A  series  R  L  C  circuit  is
       connected  to  a  0.2  V  supply  and  the  current  is  at
        its  maximum  value  of  4 mA when  the  supply
       frequency  is  adjusted  to  3 kHz. The Q−factor  of
       the  circuit  under  these  conditions  is  100.
       Determine  the  value  of  (a)  the  circuit  resistance
```

```
     , ( b )  the  circuit  inductance ,  ( c )  the  circuit
       capacitance ,  and  ( d )  the  voltage  across  the
       capacitor
 2
 3  // initializing  the  variables :
 4  V = 0.2;  //  in  Volts
 5  I = 0.004;  //  in  Amperes
 6  fr = 3000;  //  in  Hz
 7  Qr = 100;  //  Q-factor
 8
 9  // calculation :
10  wr = 2*%pi*fr
11  //At  resonance ,  impedance
12  Z = V/I
13  //At  resonance  the  circuit  impedance ,  Z
14  R = Z
15  //Q-factor  at  resonance  is  given  by  Qr = wr*L/R,
        then  L  is
16  L = Qr*R/wr
17  //At  resonance  r*L = 1/(wr*C)
18  // capacitance ,  C
19  C = 1/(L*wr*wr)
20  //Q-factor  at  resonance  in  a  series  circuit
        represents  the  voltage  magnification  Qr = Vc/V,
        then  Vc  is
21  Vc = Qr*V
22
23  printf ("\n\n  Result  \n\n")
24  printf ("\n  (a) the  circuit  resistance  is  %.0 f  ohm  ",R
       )
25  printf ("\n  (b) inductance ,  L  is  %.3 f  H  ",L)
26  printf ("\n  (c) capacitance ,  C  is  %.2E  F  ",C)
27  printf ("\n  (d) the  voltage  across  the  capacitor  is  %
        .0 f  V  ",Vc)
```

Scilab code Exa 28.10 Example 10

```
1  //Problem 28.10: A coil of inductance 351.8 mH and
       resistance 8.84 ohm is connected in series with a
        20  F capacitor. Determine (a) the resonant
       frequency, (b) the Q-factor at resonance, (c) the
        bandwidth, and (d) the lower and upper -3dB
       frequencies.
2
3  //initializing the variables:
4  R = 8.84; // in ohms
5  L = 0.3518; // IN Henry
6  C = 20e-6; // IN fARADS
7
8  //calculation:
9  //Resonant frequency,
10 fr = 1/(2*%pi*((L*C)^0.5))
11 wr = 2*%pi*fr
12 //Q-factor at resonance, Q = wr*L/R
13 Qr = wr*L/R
14 //bandwidth,.(f2      f1)
15 bw = fr/Qr
16 //the lower   3  dB frequency
17 f1 = fr - bw/2
18 //the upper   3  dB frequency
19 f2 = fr + bw/2
20
21 printf("\n\n Result \n\n")
22 printf("\n (a)Resonant frequency, fr is %.0f Hz",fr)
23 printf("\n (b)Q-factor at resonance is %.0f",Qr)
24 printf("\n (c)Bandwidth is %.0f Hz ",bw)
25 printf("\n (d)the lower -3dB frequency, f1 is %.0f
       Hz and the upper -3dB frequency, f2 is %.0f Hz ",
       f1,f2)
```

Scilab code Exa 28.11 Example 11

```
1  //Problem 28.11: In an L  R  C  series network, the
       inductance, L = 8 mH, the capacitance, C = 0.3
       F, and the resistance, R = 15 ohm. Determine
      the current flowing in the circuit when the input
       voltage is 7.56/ _0  V and the frequency is (a)
      the resonant frequency, (b) a frequency 3% above
      the resonant frequency. Find also (c) the
      impedance of the circuit when the frequency is 3%
       above the resonant frequency.
2
3  //initializing the variables:
4  R = 15; // in ohms
5  L = 0.008; // IN Henry
6  C = 0.3e-6; // IN fARADS
7  rv = 7.56; //in volts
8  thetav = 0; // in degrees
9  x = 0.03;
10
11  //calculation:
12  //Resonant frequency,
13  fr = 1/(2*%pi*((L*C)^0.5))
14  wr = 2*%pi*fr
15  //At resonance,
16  Zr = R
17  //voltage
18  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
      /180)
19  //Current at resonance
20  Ir = V/Zr
21  //Q-factor at resonance, Q = wr*L/R
22  Qr = wr*L/R
23  //If the frequency is 3% above  fr, then
24  del = x
25  I = Ir/(1 + (2*del*Qr*%i))
26  Z = V/I
27
```

```
28  printf("\n\n Result \n\n")
29  printf("\n (a)Current at resonance, Ir is %.2f A ",
        Ir)
30  printf("\n (b)current flowing in the circuit when
        frequency 3 percent above the resonant frequency
        is %.4f + (%.4f)i A ",real(I), imag(I))
31  printf("\n (c)impedance of the circuit when the
        frequency is 3 percent above the resonant
        frequency is %.0f + (%.2f)i A ",real(Z), imag(Z))
```

Chapter 29

Parallel resonance and Q factor

Scilab code Exa 29.01 Example 1

```
1  //Problem 29.01: A coil of inductance 5 mH and
       resistance 10 ohm is connected in parallel with a
        250 nF capacitor across a 50 V variable-
       frequency supply. Determine (a) the resonant
       frequency, (b) the dynamic resistance, (c) the
       current at resonance, and (d) the circuit Q-
       factor at resonance.
2
3  //initializing the variables:
4  R = 10; // in ohms
5  L = 0.005; // IN Henry
6  C = 0.25e-6; // IN fARADS
7  V = 50; //in volts
8
9  //calculation:
10 //Resonant frequency, for parallel
11 fr = ((1/(L*C) - ((R^2)/(L^2)))^0.5)/(2*%pi)
12 //dynamic resistance
13 Rd = L/(C*R)
14 //Current at resonance
15 Ir = V/Rd
```

```
16  wr = 2*%pi*fr
17  //Q-factor at resonance, Q = wr*L/R
18  Qr = wr*L/R
19
20  printf("\n\n Result \n\n")
21  printf("\n (a)Resonance frequency is %.0f Hz ",fr)
22  printf("\n (b)dynamic resistance %.0f ohm ",Rd)
23  printf("\n (c)Current at resonance, Ir is %.3f A ",
        Ir)
24  printf("\n (d)Q-factor at resonance is %.1f ",Qr)
```

Scilab code Exa 29.02 Example 2

```
1  //Problem 29.02: In the parallel network of Figure
       29.6, inductance, L = 100 mH and capacitance, C =
        40   F . Determine the resonant frequency for the
        network if (a) RL = 0 and (b) RL = 30 ohm.
2
3  //initializing the variables:
4  RL1 = 0; // in ohms
5  RL2 = 30; // in ohms
6  L = 0.100; // IN Henry
7  C = 40e-6; // IN fARADS
8  V = 50; //in volts
9
10  //calculation:
11  //for RL1
12  //Resonant frequency,
13  wr1 = (1/(L*C))^0.5
14  fr1 = wr1/(2*%pi)
15  //for RL2
16  //Resonant frequency,
17  wr2 = (1/(L*C) - ((RL2^2)/(L^2)))^0.5
18  fr2 = wr2/(2*%pi)
19
```

```
20  printf("\n\n  Result  \n\n")
21  printf("\n  (a)Resonance  frequency  at  RL = 0  is  %.1f
        Hz",fr1)
22  printf("\n  (b)Resonance  frequency  at  RL = 30  ohm  is
        %.1f  Hz\n",fr2)
```

Scilab code Exa 29.03 Example 3

```
1  //Problem  29.03:  A  coil  of  inductance  120 mH and
       resistance  150 ohm is  connected  in  parallel  with
       a  variable  capacitor  across  a  20 V,  4 kHz supply.
        Determine  for  the  condition  when  the  supply
       current  is  a  minimum,  (a)  the  capacitance  of  the
       capacitor,  (b)  the  dynamic  resistance,  (c)  the
       supply  current,  (d)  the  Q-factor,  (e)  the  band-
       width,  (f)  the  upper  and  lower  -3 dB frequencies,
        and  (g)  the  value  of  the  circuit  impedance  at
       the  -3 dB frequencies.
2
3  //initializing  the  variables:
4  R = 150;  //  in  ohms
5  L = 0.120;  //  IN  Henry
6  V = 20;  //in  volts
7  fr = 4000;  //  in  Hz
8
9  //calculation:
10  //capacitance,  C
11  C = 1/(L*[(2*%pi*fr)^2 + ((R^2)/(L^2))])
12  Rd = L/(C*R)
13  //Current  at  resonance
14  Ir = V/Rd
15  wr = 2*%pi*fr
16  //Q-factor  at  resonance,  Q = wr*L/R
17  Qr = wr*L/R
18  //bandwidth,.(f2      f1)
```

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```
19  bw = fr/Qr
20  //upper half-power frequency, f2
21  f2 = (bw + ((bw^2) + 4*(fr^2))^0.5)/2
22  //lower half-power frequency, f1
23  f1 = f2 - bw
24  //impedance at the    3 dB frequencies
25  Z = Rd/(2^0.5)
26
27  printf("\n\n Result \n\n")
28  printf("\n (a)the capacitance of the capacitor,C is
        %.2E F",C)
29  printf("\n (b)dynamic resistance %.2E ohm ",Rd)
30  printf("\n (c)Current at resonance, Ir is %.3E A ",
        Ir)
31  printf("\n (d)Q-factor at resonance is %.2f ",Qr)
32  printf("\n (e)bandwidth is %.0f Hz ",bw)
33  printf("\n (f)the upper half-power frequency, f2 is
        %.0f Hz and the lower half-power frequency, f1 is
        %.0f Hz ",f2,f1)
34  printf("\n (g)impedance at the    3 dB frequencies
        is %.3E ohm",Z)
```

Scilab code Exa 29.04 Example 4

```
1  //Problem 29.03: A two-branch parallel network is
       shown in Figure 29.8. Determine the resonant
       frequency of the network.
2
3  //initializing the variables:
4  RL = 5; // in ohms
5  L = 0.002; // IN Henry
6  C = 25e-6; // IN fARADS
7  Rc = 3; // in ohms
8
9  //calculation:
```

```
10 //Resonant frequency, for parallel
11 fr = (1/(2*%pi*((L*C)^0.5)))*((RL^2 - (L/C))/(Rc^2 -
      (L/C)))^0.5
12
13 printf("\n\n Result \n\n")
14 printf("\n resonant frequency, fr is %.2f Hz",fr)
```

Scilab code Exa 29.05 Example 5

```
1 //Problem 29.05: Determine for the parallel network
      shown in Figure 29.9 the values of inductance L
      for which the network is resonant at a frequency
      of 1 kHz.
2
3 //initializing the variables:
4 RL = 3; // in ohms
5 fr = 1000; // in Hz
6 Xc = 10; // IN ohms
7 Rc = 4; // in ohms
8
9 //calculation:
10 XL1 = (((Rc^2 + Xc^2)/Xc) + ((((Rc^2 + Xc^2)/Xc)^2)
      - 4*(RL^2))^0.5)/2
11 XL2 = (((Rc^2 + Xc^2)/Xc) - ((((Rc^2 + Xc^2)/Xc)^2)
      - 4*(RL^2))^0.5)/2
12 wr = 2*%pi*fr
13 //inductance
14 L1 = XL1/wr
15 L2 = XL2/wr
16
17 printf("\n\n Result \n\n")
18 printf("\n inductance is either %.2E H or %.2E H",L1
      , L2)
```

Scilab code Exa 29.06 Example 6

```
1  //Problem 29.06: A capacitor having a Q-factor of
       300 is connected in parallel with a coil having a
        Q-factor of 60. Determine the overall Q-factor
       of the parallel combination.
2
3  //initializing the variables:
4  QL = 60; // Q-factor
5  Qc = 300; // Q-factor
6
7  //calculation:
8  QT = QL*Qc/(QL + Qc)
9
10  printf("\n\n Result \n\n")
11  printf("\n the overall Q-factor is %.0f \n",QT)
```

Scilab code Exa 29.07 Example 7

```
1  //Problem 29.07: In an L R  C  network, the
       capacitance is 10.61 nF, the bandwidth is 500 Hz
       and the resonant frequency is 150 kHz. Determine
       for the circuit (a) the Q-factor, (b) the dynamic
        resistance, and (c) the magnitude of the
       impedance when the supply frequency is 0.4%
       greater than the tuned frequency.
2
3  //initializing the variables:
4  C = 10.61E-9; // in Farad
5  bw = 500; // in Hz
6  fr = 150000; // in Hz
7  x = 0.004
```

```
8
9   //calculation:
10  //Q-factor
11  Q = fr/bw
12  wr = 2*%pi*fr
13  //dynamic resistance, RD
14  Rd = L*Q/(C*wr*L)
15  del = x
16  Z = Rd/(1 + (2*del*Q*%i))
17  Zmag = (real(Z)^2 + imag(Z)^2)^0.5
18
19  printf("\n\n Result \n\n")
20  printf("\n (a)Q-factor %.2f",Q)
21  printf("\n (b)dynamic resistance %.2E ohm",Rd)
22  printf("\n (c)magnitude of the impedance %.2E ohm",
        Zmag)
```

Chapter 30

Introduction to network analysis

Scilab code Exa 30.01 Example 1

```
1  //Problem 30.01: Use Kirchhoff s laws to find the
      current flowing in each branch of the network
      shown in Figure 30.3.
2
3  //initializing the variables:
4  rv1 = 100; // in volts
5  rv2 = 50; // in volts
6  thetav1 = 0; // in degrees
7  thetav2 = 90; // in degrees
8  R1 = 25; // in ohm
9  R2 = 20; // in ohm
10 R3 = 10; // in ohm
11
12 //calculation:
13 //voltage
14 V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
      %pi/180)
15 V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
      %pi/180)
```

```
16  //The branch currents and their directions are
        labelled as shown in Figure 30.4
17  //Two loops are chosen. loop ABEF, and loop BCDE
18  //using kirchoff rule in 3 loops
19  //two eqns obtained
20  //(R1 + R2)*I1 + R2*I2 = V1
21  //R2*I1 + (R2 + R3)*I2 = V2
22  I1 = (3*V1 - 2*V2)/(3*(R1 + R2) - 2*(R2))
23  I2 = (V2 - R2*I1)/(R2 + R3)
24  I = I1 + I2
25
26  printf("\n\n Result \n\n")
27  printf("\n current, I1 is %.2f + (%.2f)i A, current,
        I2 is  %.2f + (%.2f)i A and total current, I is
       %.2f + (%.2f)i A",real(I1), imag(I1),real(I2),
       imag(I2),real(I), imag(I))
```

Scilab code Exa 30.02 Example 2

```
1  //Problem 30.02: Determine the current flowing in
       the 2 ohm resistor of the circuit shown in Figure
        30.5 using Kirchhoff s laws. Find also the
       power dissipated in the 3 ohm resistance.
2
3  //initializing the variables:
4  V = 8; // in volts
5  R1 = 1; // in ohm
6  R2 = 2; // in ohm
7  R3 = 3; // in ohm
8  R4 = 4; // in ohm
9  R5 = 5; // in ohm
10 R6 = 6; // in ohm
11
12 //calculation:
13 //Currents and their directions are assigned as
```

```
        shown in Figure 30.6.
14  //Three loops are chosen since three unknown
        currents are required. The choice of loop
        directions is arbitrary. loop ABCDE, and loop
        EDGF and loop DCHG
15  //using kirchoff rule in 3 loops
16  //three eqns obtained
17  //R5*I1 + (R6 + R4)*I2 - R4*I3 = V
18  //-1*R1*I1 + (R6 + R1)*I2 + R2*I3 = 0
19  // R3*I1 - (R3 + R4)*I2 + (R2 + R3 + R4)*I3 = 0
20  //using determinants
21  d1 = [V (R6 + R4) -1*R4; 0 (R6 + R1) R2; 0 (-1*(R3 +
        R4)) (R2 + R3 + R4)]
22  D1 = det(d1)
23  d2 = [R5 V -1*R4; -1*R1 0 R2; R3 0 (R2 + R3 + R4)]
24  D2 = det(d2)
25  d3 = [R5 (R6 + R4) V; -1*R1 (R6 + R1) 0; R3 (-1*(R3
        + R4)) 0]
26  D3 = det(d3)
27  d = [R5 (R6 + R4) -1*R4; -1*R1 (R6 + R1) R2; R3
        (-1*(R3 + R4)) (R2 + R3 + R4)]
28  D = det(d)
29  I1 = D1/D
30  I2 = D2/D
31  I3 = D3/D
32  //Current in the 2 ohm resistance
33  I = I1 - I2 + I3
34  //power dissipated in the 3 ohm resistance
35  P3 = R3*I^2
36
37  printf("\n\n Result \n\n")
38  printf("\n (a)current through 2 ohm resistor is %.2f
        A",I2)
39  printf("\n (b)power dissipated in the 3 ohm resistor
        is %.2f W",P3)
```

Scilab code Exa 30.03 Example 3

```
1  //Problem 30.03: For the a.c. network shown in
        Figure 30.7, determine the current flowing in
        each branch using Kirchhoff s laws.
2
3  //initializing the variables:
4  E1 = 5 + %i*0; // in volts
5  E2 = 2 + %i*4; // in volts
6  Z1 = 3 + %i*4; // in ohm
7  Z2 = 2 - %i*5; // in ohm
8  Z3 = 6 + %i*8; // in ohm
9
10 //calculation:
11 //Currents I1 and I2 with their directions are shown
        in Figure 30.8.
12 //Two loops are chosen with their directions both
        clockwise.loop ABEF and loop BCDE,
13 //using kirchoff rule in 3 loops
14 //two eqns obtained
15 //(Z1 + Z3)*I1 - Z3*I2 = E1
16 //-1*Z3*I1 + (Z2 + Z3)*I2 = E2
17 I1 = ((Z2 + Z3)*E1 + Z3*E2)/((Z2 + Z3)*(Z1 + Z3) -
        Z3*Z3)
18 I2 = -1*(E1 - (Z1 + Z3)*I1)/Z3
19 I3 = I1 - I2
20
21 printf("\n\n Result \n\n")
22 printf("\n current , I1 is %.2 f + (%.2 f)i A, current ,
        I2 is  %.2 f + (%.2 f)i A and current in Z3, I3 is
        %.3 f + (%.3 f)i A",real(I1), imag(I1),real(I2),
        imag(I2),real(I3), imag(I3))
```

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Scilab code Exa 30.04 Example 4

```
1  //Problem 30.04: For the network shown in Figure
       30.9, use Kirchhoff s laws to determine the
       magnitude of the current in the (4 + i3)ohm
       impedance.
2
3  //initializing the variables:
4  rv1 = 10; // in volts
5  rv2 = 12; // in volts
6  rv3 = 15; // in volts
7  thetav1 = 0; // in degrees
8  thetav2 = 0; // in degrees
9  thetav3 = 0; // in degrees
10 R1 = 4; // in ohm
11 R2 = -1*5*%i; // in ohm
12 R3 = 8; // in ohm
13 R4 = 4; // in ohm
14 R5 = %i*3; // in ohm
15
16 //calculation:
17 //voltages
18 V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
       %pi/180)
19 V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
       %pi/180)
20 V3 = rv3*cos(thetav3*%pi/180) + %i*rv3*sin(thetav3*
       %pi/180)
21 //Currents I1, I2 and I3 with their directions are
       shown in Figure 30.10.
22 //Three loops are chosen. The choice of loop
       directions is arbitrary. loop ABGH, and loopBCFG
       and loop CDEF
23 Z4 = R4 + R5
```

```scilab
24  //using kirchoff rule in 3 loops
25  //three eqns obtained
26  //R1*I1 + R2*I2 = V1 + V2
27  //-1*R3*I1 + (R3 + R2)*I2 + R3*I3 = V2 + V3
28  // -1*R3*I1 + R3*I2 + (R3 + Z4)*I3 = V3
29  //using determinants
30  d1 = [(V1 + V2) R2 0; (V2 + V3) (R3 + R2) R3; V3 R3
       (R3 + Z4)]
31  D1 = det(d1)
32  d2 = [R1 (V1 + V2) 0; -1*R3 (V2 + V3) R3; -1*R3 V3 (
       R3 + Z4)]
33  D2 = det(d2)
34  d3 = [R1 R2 (V1 + V2); -1*R3 (R3 + R2) (V2 + V3);
       -1*R3 R3 V3]
35  D3 = det(d3)
36  d = [R1 R2 0; -1*R3 (R3 + R2) R3; -1*R3 R3 (R3 + Z4)
       ]
37  D = det(d)
38  I1 = D1/D
39  I2 = D2/D
40  I3 = D3/D
41  I3mag = (real(I3)^2 + imag(I3)^2)^0.5
42
43  printf("\n\n Result \n\n")
44  printf("\n magnitude of the current through (4 + i3)
        ohm impedance is %.2f A",I3mag)
```

Chapter 31

Mesh current and nodal analysis

Scilab code Exa 31.01 Example 1

```
1  //Problem 31.01: Use mesh−current analysis to
       determine the current flowing in (a) the 5 ohm
       resistance, and (b) the 1ohm  resistance of the d
       .c. circuit shown in Figure 31.2.
2
3  //initializing the variables:
4  V1 = 4; // in volts
5  V2 = 5; // in volts
6  R1 = 3; // in ohm
7  R2 = 5; // in ohm
8  R3 = 4; // in ohm
9  R4 = 1; // in ohm
10 R5 = 6; // in ohm
11 R6 = 8; // in ohm
12
13 //calculation:
14 //The mesh currents I1, I2 and I3 are shown in
       Figure 31.2. Using Kirchhoff s voltage law in 3
       loops
```

```
15  //three eqns obtained
16  //(R1 + R2)*I1 − R2*I2 = V1
17  //−1*R2*I1 + (R2 + R3 + R4 + R5)*I2 − R4*I3 = 0
18  // −1*R4*I2 + (R4 + R6)*I3 = −1*V2
19  //using determinants
20  d1 = [V1 -1*R2 0; 0 (R2 + R3 + R4 + R5) -1*R4; -1*V2
        -1*R4 (R4 + R6)]
21  D1 = det(d1)
22  d2 = [(R1 + R2) V1 0; -1*R2 0 -1*R4; 0 -1*V2 (R4 +
       R6)]
23  D2 = det(d2)
24  d3 = [(R1 + R2) -1*R2 V1; -1*R2 (R2 + R3 + R4 + R5)
       0; 0 -1*R4 -1*V2]
25  D3 = det(d3)
26  d = [(R1 + R2) -1*R2 0; -1*R2 (R2 + R3 + R4 + R5)
       -1*R4; 0 -1*R4 (R4 + R6)]
27  D = det(d)
28  I1 = D1/D
29  I2 = D2/D
30  I3 = D3/D
31  IR2 = I1 - I2
32  IR4 = I2 - I3
33
34  printf("\n\n Result \n\n")
35  printf("\n (a)current in the 5 ohm resistance is %.2
       f A",IR2)
36  printf("\n (b)current in the 1 ohm resistance is %.2
       f A",IR4)
```

Scilab code Exa 31.02 Example 2

```
1  //Problem 31.02: For the a.c. network shown in
       Figure 31.3 determine, using mesh−current
       analysis, (a) the mesh currents I1 and I2 (b) the
       current flowing in the capacitor, and (c) the
```

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```
        active  power  delivered  by  the  100/ _0    V  voltage
        source .
 2
 3   // initializing  the  variables :
 4   rv  =  100;  //  in  volts
 5   thetav  =  0;  //  in  degrees
 6   R1  =  5;  //  in  ohm
 7   R2  =  -1*4*%i;  //  in  ohm
 8   R3  =  4;  //  in  ohm
 9   R4  =  %i *3;  //  in  ohm
10
11   // calculation :
12   // voltages
13   V  =  rv* cos ( thetav *%pi /180)  +  %i*rv* sin ( thetav *%pi
        /180)
14   // Currents  I1 ,  I2  with  their  directions  are  shown  in
            Figure  31.03.
15   //Two  loops  are  chosen . The  choice  of  loop
        directions  is  arbitrary .
16   // using  kirchoff  rule  in  2  loops
17   //two  eqns  obtained
18   //( R1  +  R2 )* I1  −  R2* I2  =  V
19   //−1* R2* I1  +  ( R3  +  R2  +  R4 )* I2  =  0
20   // using  determinants
21   d1  =  [V  -1* R2 ;  0  ( R3  +  R2  +  R4 )]
22   D1  =  det ( d1 )
23   d2  =  [( R1  +  R2 )  V;  -1* R2  0]
24   D2  =  det ( d2 )
25   d  =  [( R1  +  R2 )  -1* R2 ;  -1* R2  ( R3  +  R2  +  R4 )]
26   D  =  det (d)
27   I1  =  D1 /D
28   I2  =  D2 /D
29   I1mag  =  ( real ( I1 )^2  +  imag ( I1 )^2)^0.5
30   // Current  flowing  in  capacitor
31   Ic  =  I1  -  I2
32   // Source  power  P
33   phi  =  atan ( imag ( I1 )/ real ( I1 ))
34   P  =  V* I1mag * cos ( phi )
```

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```
35  Icmag = (real(Ic)^2 + imag(Ic)^2)^0.5
36
37  printf("\n\n Result \n\n")
38  printf("\n (a) current, I1 is %.2f + (%.2f)i A,
        current, I2 is  %.2f + (%.2f)i A",real(I1), imag(
        I1),real(I2), imag(I2))
39  printf("\n (b) current in the capacitor is %.2f A",
        Icmag)
40  printf("\n (c) Source power P is %.2f W",P)
```

Scilab code Exa 31.03 Example 3

```
1  //Problem 31.03: A balanced star−connected 3−phase
       load is shown in Figure 31.4. Determine the value
        of the line currents IR, IY and IB using mesh−
       current analysis.
2
3  //initializing the variables:
4  rv1 = 415; // in volts
5  rv2 = 415; // in volts
6  thetav1 = 120; // in degrees
7  thetav2 = 0; // in degrees
8  R = 3 + %i*4; // in ohm
9
10  //calculation:
11  //voltages
12  V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
       %pi/180)
13  V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
       %pi/180)
14  //Two mesh currents I1 and I2 are chosen as shown in
        Figure 31.4.
15  //Two loops are chosen. The choice of loop
       directions is arbitrary.
16  //using kirchoff rule in 2 loops
```

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```
17  //two eqns obtained
18  //2*R*I1 - R*I2 = V1
19  //-1*R*I1 + 2*R*I2 = V2
20  //using determinants
21  d1 = [V1 -1*R; V2 2*R]
22  D1 = det(d1)
23  d2 = [2*R V1; -1*R V2]
24  D2 = det(d2)
25  d = [2*R -1*R; -1*R 2*R]
26  D = det(d)
27  I1 = D1/D
28  I2 = D2/D
29  I1mag = (real(I1)^2 + imag(I1)^2)^0.5
30  //line current IR
31  IR = I1
32  //line current IB
33  IB = -1*I2
34  //line current IY
35  IY = I2 - I1
36
37  printf("\n\n Result \n\n")
38  printf("\n current, IR is %.2f + (%.2f)i A, current,
        IB is  %.2f + (%.2f)i A and current, IY is %.2f
       + (%.2f)i A",real(IR), imag(IR),real(IB), imag(IB
       ),real(IY), imag(IY))
```

Scilab code Exa 31.04 Example 4

```
1  //Problem 31.04: For the network shown in Figure
      31.8, determine the voltage VAB, by using nodal
      analysis.
2
3  //initializing the variables:
4  ri = 20; // in amperes
5  thetai = 0; // in degrees
```

```
6  R1 = 10; // in ohm
7  R2 = %i*3; // in ohm
8  R3 = 4; // in ohm
9  R4 = 16; // in ohm
10
11 //calculation:
12 //current
13 I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
      /180)
14 //Figure 31.8 contains two principal nodes (at 1 and
       B) and thus only one nodal equation is required.
       B is taken as the reference node and the
      equation for node 1 is obtained as follows.
      Applying Kirchhoff s current law to node 1
      gives:
15 //IX + IY = I
16 V1 = I/((1/R4) +(1/(R2  +R3)))
17 IY = V1/(R2 + R3)
18 VAB = IY*R3
19
20 printf(" \n\n Result \n\n")
21 printf(" \n voltage VAB is %.2f + (%.2f)i V",real(VAB
      ), imag(VAB))
```

Scilab code Exa 31.05 Example 5

```
1 //Problem 31.05: Determine the value of voltage VXY
      shown in the circuit of Figure 31.9.
2
3 //initializing the variables:
4 rv1 = 8; // in volts
5 rv2 = 8; // in volts
6 thetav1 = 0; // in degrees
7 thetav2 = 90; // in degrees
8 R1 = 5; // in ohm
```

```
9   R2 = %i*6; // in ohm
10  R3 = 4; // in ohm
11  R4 = 3; // in ohm
12
13  //calculation :
14  //voltages
15  V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
        %pi/180)
16  V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
        %pi/180)
17  //The circuit contains no principal nodes. However,
        if point Y is chosen as the reference node then
        an equation may be written for node X assuming
        that current leaves point X by both branches
18  VX = [(V1/(R1 + R3) + V2/(R2 + R4))/(1/(R1 + R3) +
        1/(R2 + R4))]
19  VXY = VX
20
21  printf("\n\n Result \n\n")
22  printf("\n voltage VXY is %.2f + (%.2f)i V",real(VXY
        ), imag(VXY))
```

Scilab code Exa 31.06 Example 6

```
1  //Problem 31.06: Use nodal analysis to determine the
        current flowing in each branch of the network
        shown in Figure 31.10.
2
3  //initializing the variables :
4  rv1 = 100; // in volts
5  rv2 = 50; // in volts
6  thetav1 = 0; // in degrees
7  thetav2 = 90; // in degrees
8  R1 = 25; // in ohm
9  R2 = 20; // in ohm
```

```
10  R3 = 10;  // in ohm
11
12  // calculation :
13  // voltages
14  V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
        %pi/180)
15  V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
        %pi/180)
16  // There are only two principal nodes in Figure 31.10
         so only one nodal equation is required. Node 2
        is taken as the reference node.
17  // The equation at node 1 is I1 + I2 + I3 = 0
18  Vn1 = [(V1/R1 + V2/R3)/(1/R1 + 1/R2 + 1/R3)]
19  I1 = (Vn1 - V1)/R1
20  I2 = Vn1/R2
21  I3 = (Vn1 - V2)/R3
22
23  printf(" \n\n Result \n\n")
24  printf(" \n current , I1 is %.2 f + (%.2 f)i A, current ,
         I2 is  %.2 f + (%.2 f)i A and current , I3 is %.2 f
        + (%.2 f)i A",real(I1), imag(I1),real(I2), imag(I2
        ),real(I3), imag(I3))
```

Scilab code Exa 31.07 Example 7

```
1  // Problem 31.07: In the network of Figure 31.11 use
       nodal analysis to determine (a) the voltage at
       nodes 1 and 2, (b) the current in the j4 ohm
       inductance , (c) the current in the 5 ohm
       resistance , and (d) the magnitude of the active
       power dissipated in the 2.5 ohm resistance .
2
3  // initializing the variables :
4  rv1 = 25;  // in volts
5  rv2 = 25;  // in volts
```

```
 6  thetav1 = 0; // in degrees
 7  thetav2 = 90; // in degrees
 8  R1 = 2; // in ohm
 9  R2 = -1*%i*4; // in ohm
10  R3 = 5; // in ohm
11  R4 = %i*4; // in ohm
12  R5 = 2.5; // in ohm
13
14  //calculation:
15  //voltages
16  V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
       %pi/180)
17  V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
       %pi/180)
18  //The equation at node 1
19  //Vn1*(1/R1 + 1/R2 + 1/R3) − Vn2/R3 = V1/R1
20  //The equation at node 2
21  //Vn1*(−1/R3) + Vn2*(1/R4 + 1/R5 + 1/R3) = V2/R5
22  //using determinants
23  d1 = [V1/R1 -1/R3; V2/R5 (1/R4 + 1/R5 + 1/R3)]
24  D1 = det(d1)
25  d2 = [(1/R1 + 1/R2 + 1/R3) V1/R1; -1/R3 V2/R5]
26  D2 = det(d2)
27  d = [(1/R1 + 1/R2 + 1/R3) -1/R3; -1/R3 (1/R4 + 1/R5
       + 1/R3)]
28  D = det(d)
29  Vn1 = D1/D
30  Vn2 = D2/D
31  //current in the j4 ohm inductance is given by:
32  I4 = Vn2/R4
33  //current in the 5 ohm resistance is given by:
34  I3 = (Vn1 - Vn2)/R3
35  //active power dissipated in the 2.5 ohm resistor is
        given by
36  P5 = R5*((Vn2 - V2)/R5)^2
37  //magnitude of the active power dissipated
38  P5mag = (real(P5)^2 + imag(P5)^2)^0.5
39
```

```
40  printf("\n\n Result \n\n")
41  printf("\n (a) the voltage at nodes 1 and 2 is %.2f
        + (%.2f)i V and %.2f + (%.2f)i V",real(Vn1), imag
        (Vn1),real(Vn2), imag(Vn2))
42  printf("\n (b)the current in the j4 ohm inductance
        is %.2f + (%.2f)i A",real(I4), imag(I4))
43  printf("\n (c)the current in the 5 ohm resistance is
        %.2f + (%.2f)i A",real(I3), imag(I3))
44  printf("\n (d) magnitude of the active power
        dissipated in the 2.5 ohm resistance is %.2f W",
        P5mag)
```

Scilab code Exa 31.08 Example 8

```
1   //Problem 31.08: In the network shown in Figure
        31.12 determine the voltage VXY using nodal
        analysis
2
3   //initializing the variables:
4   ri = 25; // in amperes
5   thetai = 0; // in degrees
6   R1 = 4; // in ohm
7   R2 = %i*3; // in ohm
8   R3 = 5; // in ohm
9   R4 = %i*10; // in ohm
10  R5 = %i*20; // in ohm
11
12  //calculation:
13  //current
14  I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
        /180)
15  //Node 3 is taken as the reference node.
16  //At node 1,
17  //V1*(1/(R1 + R2) + 1/R3) - V2/R3 = I
18  //The equation at node 2
```

```
19  //V1*(-1/R3) + V2*(1/R4 + 1/R5 + 1/R3) = 0
20  //using determinants
21  d1 = [I -1/R3; 0 (1/R4 + 1/R5 + 1/R3)]
22  D1 = det(d1)
23  d2 = [(1/(R1 + R2) + 1/R3) I; -1/R3 0]
24  D2 = det(d2)
25  d = [(1/(R1 + R2) + 1/R3) -1/R3; -1/R3 (1/R4 + 1/R5
        + 1/R3)]
26  D = det(d)
27  V1 = D1/D
28  V2 = D2/D
29  //the voltage between point X and node 3 is
30  VX = V1*R2/(R1 + R2)
31  //Thus the voltage
32  VY = V2
33  VXY = VX - VY
34
35  printf("\n\n Result \n\n")
36  printf("\n voltage VXY is %.2f + (%.2f)i V",real(VXY
        ), imag(VXY))
```

Scilab code Exa 31.09 Example 9

```
1  //Problem 31.09: Use nodal analysis to determine the
        voltages at nodes 2 and 3 in Figure 31.13 and
       hence determine the current flowing in the 2 ohm
       resistor and the power dissipated in the 3 ohm
       resistor.
2
3  //initializing the variables:
4  V = 8; // in volts
5  R1 = 1; // in ohm
6  R2 = 2; // in ohm
7  R3 = 3; // in ohm
8  R4 = 4; // in ohm
```

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```scilab
 9  R5 = 5; // in ohm
10  R6 = 6; // in ohm
11
12  //calculation:
13  //In Figure 31.13, the reference node is shown at
        point A.
14  //At node 1,
15  //V1*(1/R1 + 1/R6 + 1/R5) - V2/R1 - V3/R5 = V/R5
16  //The equation at node 2
17  //V1*(-1/R1) + V2*(1/R2 + 1/R1 + 1/R3) - V3/R3 = 0
18  //At node 3
19  // - V1/R5 - V2/R3 + V3*(1/R4 + 1/R3 + 1/R5) = -1*V/
        R5
20  //using determinants
21  d1 = [V/R5 -1/R1 -1/R5; 0 (1/R2 + 1/R1 + 1/R3) -1/R3
        ; -1*V/R5 -1/R3 (1/R4 + 1/R3 + 1/R5)]
22  D1 = det(d1)
23  d2 = [(1/R1 + 1/R6 + 1/R5) V/R5 -1/R5; -1/R1 0 -1/R3
        ; -1/R5 -1*V/R5 (1/R4 + 1/R3 + 1/R5)]
24  D2 = det(d2)
25  d3 = [(1/R1 + 1/R6 + 1/R5) -1/R1 V/R5; -1/R1 (1/R2 +
         1/R1 + 1/R3) 0; -1/R5 -1/R3 -1*V/R5]
26  D3 = det(d3)
27  d = [(1/R1 + 1/R6 + 1/R5) -1/R1 -1/R5; -1/R1 (1/R2 +
         1/R1 + 1/R3) -1/R3; -1/R5 -1/R3 (1/R4 + 1/R3 +
        1/R5)]
28  D = det(d)
29  Vn1 = D1/D
30  Vn2 = D2/D
31  Vn3 = D3/D
32  //the current in the 2 ohm resistor
33  I2 = Vn2/R2
34  //power dissipated in the 3 ohm resistance
35  P3 = R3*((Vn2 - Vn3)/R3)^2
36
37  printf("\n\n Result \n\n")
38  printf("\n voltage at node 2 is %.2f V",Vn2)
39  printf("\n voltage at node 3 is %.2f V",Vn3)
```

```
40  printf("\n (a)current  through  2 ohm  resistor  is  %.2f
        A",I2)
41  printf("\n (b)power  dissipated  in  the  3 ohm  resistor
        is  %.2f W",P3)
```

Chapter 32

The superposition theorem

Scilab code Exa 32.01 Example 1

```scilab
1 //Problem 32.01:A.c. sources of 100/_0  V and
      internal resistance 25 ohm and 50/_90  V and
      internal resistance 10 ohm, are connected in
      parallel across a 20 ohm load. Determine using
      the superposition theorem, the current in the 20
      ohm load and the current in each voltage source
2
3 //initializing the variables:
4 rv1 = 100; // in volts
5 rv2 = 50; // in volts
6 thetav1 = 0; // in degrees
7 thetav2 = 90; // in degrees
8 r1 = 25; // in ohm
9 R = 20; // in ohm
10 r2 = 10; // in ohm
11
12 //calculation:
13 //voltage
14 V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
      %pi/180)
15 V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
```

```
     %pi /180)
16  //The circuit diagram is shown in Figure 32.7.
        Following the above procedure:
17  //The network is redrawn with the 50/ _90  V source
        removed as shown in Figure 32.8
18  //Currents I1, I2 and I3 are labelled as shown in
        Figure 32.8.
19  I1 = V1/(r1 + r2*R/(R + r2))
20  I2 = (r2/(r2 + R))*I1
21  I3 = (R/(r2 + R))*I1
22  //The network is redrawn with the 100/ _0  V source
        removed as shown in Figure 32.9
23  //Currents I4, I5 and I6 are labelled as shown in
        Figure 32.9.
24  I4 = V2/(r2 + r1*R/(r1 + R))
25  I5 = (r1/(r1 + R))*I4
26  I6 = (R/(r1 + R))*I4
27  //Figure 32.10 shows Figure 32.9 superimposed on
        Figure 32.8, giving the currents shown.
28  //Current in the 20 ohm load ,
29  I20 = I2 + I5
30  //Current in the 100/ _0  V source
31  IV1 = I1 - I6
32  //Current in the 50/ _90  V source
33  IV2 = I4 - I3
34
35  printf("\n\n Result \n\n")
36  printf("\n (a)current in the 20 ohm load is %.3f + (
        %.3f)i A",real(I20), imag(I20))
37  printf("\n (b)Current in the 100/ _0  V source is %
        .3f + (%.3f)i A",real(IV1), imag(IV1))
38  printf("\n (b)Current in the 50/ _90  V source is %
        .3f + (%.3f)i A",real(IV2), imag(IV2))
```

Scilab code Exa 32.02 Example 2

```
1  //Problem 32.02:Use the superposition theorem to
       determine the current in the 4 ohm resistor of
       the network shown in Figure 32.11.
2
3  //initializing the variables:
4  V1 = 12; // in volts
5  V2 = 20; // in volts
6  R1 = 5; // in ohm
7  R2 = 4; // in ohm
8  R3 = 2.5; // in ohm
9  R4 = 6; // in ohm
10 R5 = 2; // in ohm
11
12 //calculation:
13 //Removing the 20 V source gives the network shown
       in Figure 32.12.
14 //Currents I1 and I2 are shown labelled in Figure
       32.12
15 Re1 = (R4*R5/(R4 + R5)) + R3
16 Re2 = Re1*R2/(Re1  + R2) + R1
17 I1 = V1/Re2
18 I2 = (R2/(Re1 + R2))*I1
19 //Removing the 12 V source from the original network
        gives the network shown in Figure 32.14.
20 //Currents I3, I4 and I5 are shown labelled in
       Figure 32.14.
21 Re3 = (R1*R2/(R1 + R2)) + R3
22 Re4 = Re3*R4/(Re3 + R4) + R5
23 I3 = V2/Re4
24 I4 = (R4/(Re3 + R4))*I3
25 I5 = (R1/(R1 + R2))*I4
26 //Superimposing Figure 32.14 on Figure 32.12 shows
       that the current flowing in the 4 ohm resistor is
        given by
27 Ir4 = I5 - I2
28
29 printf("\n\n Result \n\n")
30 printf("\ncurrent in the 4 ohm resistor of the
```

```
network is %.3 f A" ,Ir4 )
```

Scilab code Exa 32.03 Example 3

```
1  //Problem 32.03: Use the superposition theorem to
       obtain the current flowing in the (4 + i3) ohm
       impedance of Figure 32.16.
2
3  // initializing the variables :
4  rv1 = 30; // in volts
5  rv2 = 30; // in volts
6  thetav1 = 45; // in degrees
7  thetav2 = -45; // in degrees
8  R1 = 4; // in ohm
9  R2 = 4; // in ohm
10 R3 = %i*3; // in ohm
11 R4 = -1*%i*10; // in ohm
12
13 // calculation :
14 // voltage
15 V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
       %pi/180)
16 V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
       %pi/180)
17 //The network is redrawn with V2 removed, as shown
        in Figure 32.17.
18 //Current I1 and I2 are shown in Figure 32.17. From
        Figure 32.17,
19 Re1 = R4*(R2 + R3)/(R4 + R3 + R2)
20 Re2 = Re1 + R1
21 // current
22 I1 = V1/Re2
23 I2 = (R4/(R2 + R3 + R4))*I1
24 //The original network is redrawn with V1 removed,
        as shown in Figure 32.18
```

```
25  // Currents I3 and I4 are shown in Figure 32.18. From
        Figure 32.18 ,
26  Re3 = R1*(R2 + R3)/(R1 + R3 + R2)
27  Re4 = Re3 + R4
28  I3 = V2/Re4
29  I4 = (R1/(R2 + R3 + R1))*I3
30  // If the network of Figure 32.18 is superimposed on
        the network of Figure 32.17 , it can be seen that
        the current in the (4+i3) ohm impedance is given
        by
31  Ir4i3 = I2 - I4
32
33  printf (" \n\n Result \n\n")
34  printf (" \ncurrent in the (4 + i3) ohm impedance of
        the network is %.3 f + (%.3 f)i A" ,real (Ir4i3) ,
        imag (Ir4i3))
```

Scilab code Exa 32.04 Example 4

```
1  // Problem 32.04: For the a.c. network shown in
       Figure 32.19 determine , using the superposition
       theorem , (a) the current in each branch , (b) the
       magnitude of the voltage across the(6 + i8) ohm
       impedance , and (c) the total active power
       delivered to the network .
2
3  // initializing the variables :
4  E1 = 5 + %i*0; // in volts
5  E2 = 2 + %i*4; // in volts
6  Z1 = 3 + %i*4; // in ohm
7  Z2 = 2 - %i*5; // in ohm
8  Z3 = 6 + %i*8; // in ohm
9
10 // calculation :
11 // The original network is redrawn with E2 removed ,
```

```
        as  shown  in  Figure  32.20.
12  // Currents  I1 ,  I2  and  I3  are  labelled  as  shown  in
        Figure  32.20.
13  Ze1  =  Z3*Z2/(Z3  +  Z2)
14  Ze2  =  Ze1  +  Z1
15  // current
16  I1  =  E1/Ze2
17  I2  =  (Z2/(Z3  +  Z2))*I1
18  I3  =  (Z3/(Z3  +  Z2))*I1
19  // The  original  network  is  redrawn  with  E1  removed ,
        as  shown  in  Figure  32.22
20  // Currents  I4 ,  I5  and  I6  are  shown  labelled  in
        Figure  32.22  with  I4  flowing  away  from  the
        positive  terminal  of  the  E2  source .
21  Ze3  =  Z3*Z1/(Z3  +  Z1)
22  Ze4  =  Ze3  +  Z2
23  I4  =  E2/Ze4
24  I5  =  (Z1/(Z3  +  Z1))*I4
25  I6  =  (Z3/(Z3  +  Z1))*I4
26  // If  the  network  of  Figure  32.18  is  superimposed  on
        the  network  of  Figure  32.17 ,  it  can  be  seen  that
        the  current  in  the  (4+i3)  ohm  impedance  is  given
        by
27  i1  =  I1  +  I6
28  i2  =  I3  +  I4
29  i3  =  I2  -  I5
30  // magnitude
31  i1mag  =  (real(i1)^2  +  imag(i1)^2)^0.5
32  i2mag  =  (real(i2)^2  +  imag(i2)^2)^0.5
33  E1mag  =  (real(E1)^2  +  imag(E1)^2)^0.5
34  E2mag  =  (real(E2)^2  +  imag(E2)^2)^0.5
35  // phase
36  phi1  =  atan(imag(i1)/real(i1))
37  phi2  =  atan(imag(i2)/real(i2))
38  // voltage  across  the(6  +  i8)  ohm  impedance
39  V6i8  =  i3*Z3
40  V6i8m  =  (real(V6i8)^2  +  imag(V6i8)^2)^0.5
41  // power
```

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```
42  P = (E1mag*i1mag*cos(phi1)) + (E2mag*i2mag*cos(phi2
        - atan(imag(E2)/real(E2))))
43
44  printf("\n\n Result \n\n")
45  printf("\n(b)current in the (6 + i8) ohm resistor of
        the network is %.3f V",V6i8m)
46  printf("\n(c)the total active power delivered to the
        network is %.3f W",P)
```

Scilab code Exa 32.05 Example 5

```
1  //Problem 32.05: Use the superposition theorem to
        determine, for the network shown in Figure 32.25,
        (a) the magnitude of the current flowing in the
        capacitor, (b) the p.d. across the 5 ohm
        resistance, (c) the active power dissipated in
        the 20 ohm resistance and (d) the total active
        power taken from the supply.
2
3  //initializing the variables:
4  rv1 = 50; // in volts
5  rv2 = 30; // in volts
6  thetav1 = 0; // in degrees
7  thetav2 = 90; // in degrees
8  R1 = 20; // in ohm
9  R2 = 5; // in ohm
10 R3 = -1*%i*3; // in ohm
11 R4 = 8; // in ohm
12 R5 = 8; // in ohm
13
14 //calculation:
15 //voltage
16 V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
        %pi/180)
17 V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
```

```
      %pi/180)
18  //The network is redrawn with the V2 source removed,
        as shown in Figure 32.26.
19  //Currents I1 to I5 are shown labelled in Figure
        32.26.
20  //current
21  Re1 = R4*R5/(R5 + R4) + R3
22  Re2 = Re1*R2/(R2 + Re1)
23  I1 = V1/(Re2 + R1)
24  I2 = (Re1/(R2 + Re1))*I1
25  I3 = (R2/(Re1 + R2))*I1
26  I4 = (R4/(R4 + R5))*I3
27  I5 = I3 - I4
28  //The original network is redrawn with the V1 source
        removed, as shown in Figure 32.27.
29  //Currents I6 to I10 are shown labelled in Figure
        32.27
30  Re3 = R1*R2/(R1 + R2)
31  Re4 = Re3 + R3
32  Re5 = Re4*R4/(Re4 + R4)
33  Re6 = Re5  + R5
34  I6 = V2/Re6
35  I7 = (Re4/(Re4 + R4))*I6
36  I8 = (R4/(Re4 + R4))*I6
37  I9 = (R1/(R1 + R2))*I8
38  I10 = (R2/(R1 + R2))*I8
39  //current flowing in the capacitor is given by
40  Ic = I3 - I8
41  //magnitude of the current in the capacitor
42  Icmag = (real(Ic)^2 + imag(Ic)^2)^0.5
43  //
44  i1 = I2 + I9
45  i1mag = (real(i1)^2 + imag(i1)^2)^0.5
46  //magnitude of the p.d. across the 5 ohm resistance
        is given by
47  Vr5m = i1mag*R2
48  //Active power dissipated in the 20 ohm resistance
        is given by
```

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```
49  i2 = I1 - I10
50  i2mag = (real(i2)^2 + imag(i2)^2)^0.5
51  phii2 = atan(imag(i2)/real(i2))
52  Pr20 = R1*(i2mag)^2
53  //Active power developed by the V1
54  P1 = rv1*i2mag*cos(phii2)
55  //Active power developed by V2 source
56  i3 = I6 - I5
57  i3mag = (real(i3)^2 + imag(i3)^2)^0.5
58  phii3 = atan(imag(i3)/real(i3))
59  if ((imag(i3)>0) & (real(i3)<0)) then
60      phii3 = phii3 + %pi
61  end
62  P2 = rv2*i3mag*cos(phii3 - (thetav2*%pi/180))
63  //Total power developed
64  P = P1 + P2
65
66  printf("\n\n Result \n\n")
67  printf("\n(a)the magnitude of the current flowing in
        the capacitor is %.2f A",Icmag)
68  printf("\n(b) the p.d. across the 5 ohm resistance
       is %.3f V",Vr5m)
69  printf("\n(c)the active power dissipated in the 20
       ohm resistance is %.0f W",Pr20)
70  printf("\n(d)the total active power taken from the
       supply is %.1f W",P)
```

Chapter 33

Thevenins and Nortons theorems

Scilab code Exa 33.01 Example 1

```
1  //Problem 33.01: For the circuit shown in Figure
       33.12, use Th evenin s theorem to determine (a
       ) the current flowing in the capacitor, and (b)
       the p.d. across the 150 kohm resistor.
2
3  //initializing the variables:
4  rv = 200; // in volts
5  thetav = 0; // in degrees
6  R1 = 5000; // in ohm
7  R2 = 20000; // in ohm
8  R3 = -1*%i*120000; // in ohm
9  R4 = 150000; // in ohm
10
11 //calculation:
12 //voltage
13 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
14 //Initially the (150-i120)kohm impedance is removed
       from the  circuit as shown in Figure 33.13.
```

```
15  //Note that, to find the current in the capacitor,
        only the capacitor need have been initially
        removed from the circuit. However, removing each
        of the components from the branch through which
        the current is required will often result in a
        simpler solution.
16  //From Figure 33.13,
17  //current, I1
18  I1 = V/(R1 + R2)
19  //The open-circuit e.m.f. E is equal to the p.d.
        across the 20 kohm resistor, i.e.
20  E = I1*R2
21  //Removing the V1 source gives the network shown in
        Figure 33.14.
22  //The impedance, z,  looking in  at the open-
        circuited terminals is given by
23  z = R1*R2/(R1 + R2)
24  //The Th evenin equivalent circuit is shown in
        Figure 33.15, where current iL is given by
25  ZL = R3 + R4
26  IL = E/(ZL + z)
27  ILmag = (real(IL)^2 + imag(IL)^2)^0.5
28  //current flowing in the capacitor
29  Ic = ILmag
30  //P.d. across the 150 kohm resistor,
31  Vr150 = ILmag*R4
32
33  printf("\n\n Result \n\n")
34  printf("\n(a)the current flowing in the capacitor is
        %.1E A",Ic)
35  printf("\n(b) the p.d. across the 150 ohm resistance
        is %.0f V",Vr150)
```

Scilab code Exa 33.02 Example 2

```scilab
1  //Problem 33.02: Determine, for the network shown in
        Figure 33.16, the value of current I. Each of
        the voltage sources has a frequency of 2 kHz.
2
3  //initializing the variables:
4  V1 = 20; // in volts
5  V2 = 10; // in volts
6  R1 = 2; // in ohm
7  R2 = 1.5; // in ohm
8  L = 235E-6; // in Henry
9  R4 = 3; // in ohm
10 f = 2000; // in Hz
11
12 //calculation:
13 //The impedance through which current I is flowing
        is initially removed from the network, as shown
        in Figure 33.17.
14 //From Figure 33.17,
15 //current, I1
16 I1 = (V1 - V2)/(R1 + R4)
17 //the open circuit e.m.f. E
18 E = V1 - I1*R1
19 //When the sources of e.m.f. are removed from the
        circuit, the impedance, z,  looking in   at
        the break is given by
20 z = R1*R4/(R1 + R4)
21 //The Th evenin equivalent circuit is shown in
        Figure 33.18, where inductive reactance,
22 XL = 2*%pi*f*L
23 R3 = %i*XL
24 //Hence current
25 I = E/(R2 + R3 + z)
26
27 printf("\n\n Result \n\n")
28 printf("\n the current I is %.2f + (%.2f)i A",real(I
        ), imag(I))
```

Scilab code Exa 33.03 Example 3

```scilab
1  //Problem 33.03: Use Th evenin s theorem to
       determine the power dissipated in the 48 ohm
       resistor of the network shown in Figure 33.19
2
3  //initializing the variables:
4  rv = 50; // in volts
5  thetav = 0; // in degrees
6  R1 = -1*%i*400; // in ohm
7  R2 = 300; // in ohm
8  R3 = %i*144; // in ohm
9  R4 = 48; // in ohm
10
11 //calculation:
12 //voltage
13 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
14 //The R3 and R4 impedance is initially removed from
       the network as shown in Figure 33.20.
15 //From Figure 33.20,
16 //current, I
17 i = V/(R1 + R2)
18 //the open circuit e.m.f. E
19 E = i*R2
20 //When the V is removed from the circuit, the
       impedance, z, looking in  at the break is
       given by
21 z = R1*R2/(R1 + R2)
22 //The Th evenin equivalent circuit is shown in
       Figure 33.21 connected to R# and R4,
23 //Hence current
24 I = E/(R4 + R3 + z)
25 Imag = (real(I)^2 + imag(I)^2)^0.5
```

```
26  //the power dissipated in the 48 ohm resistor
27  Pr48 = R4*Imag^2
28
29  printf("\n\n Result \n\n")
30  printf("\n the power dissipated in the 48 ohm
        resistor is %.2f W",Pr48)
```

Scilab code Exa 33.04 Example 4

```
 1  //Problem 33.04:For the network shown in Figure
        33.22, use Th evenin s theorem to determine
        the current flowing in the 80 ohm resistor.
 2
 3  //initializing the variables:
 4  V = 100; // in volts
 5  R1 = 5; // in ohm
 6  R2 = 20; // in ohm
 7  R3 = 46; // in ohm
 8  R4 = 50; // in ohm
 9  R5 = 15; // in ohm
10  R6 = 60; // in ohm
11  R7 = 16; // in ohm
12  R8 = 80; // in ohm
13
14  //calculation:
15  //One method of analysing a multi-branch network as
        shown in Figure 33.22 is to use Th evenin s
        theorem on one part of the network at a time. For
         example, the part of the circuit to the left of
        AA may be reduced to a Th evenin equivalent
        circuit.
16  //From Figure 33.23,
17  E1 = (R2/(R1 + R2))*V
18  z1 = R1*R2/(R1 + R2)
19  //Thus the network of Figure 33.22 reduces to that
```

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of Figure 33.24. The part of the network shown in
        Figure 33.24 to the left of BB may be reduced to
        a Th evenin equivalent circuit , where
20 E2 = (R4/(R3 + R4 + z1))*E1
21 z2 = R4*(z1 + R3)/(R4 + z1 + R3)
22 //Thus the original network reduces to that shown in
        Figure 33.25. The part of the network shown in
        Figure 33.25 to the left of CC may be reduced to
        a Th evenin equivalent circuit , where
23 E3 = (R6/(R5 + R6 + z2))*E2
24 z3 = R6*(z2 + R5)/(R5 + z2 + R6)
25 //Thus the original network reduces to that of
        Figure 33.26 , from which the current in the 80
        ohm resistor is given by
26 I = E3/(z3 + R7 + R8)
27
28 printf("\n\n Result \n\n")
29 printf("\n the current flowing in the 80 ohm
        resistor is %.2f A",I)

Scilab code Exa 33.05 Example 5

```
1  //Problem 33.05:Determine the Th evenin equivalent
       circuit with respect to terminals AB of the
       circuit shown in Figure 33.27. Hence determine (a
       ) the magnitude of the current flowing in a (3.75
       + i11) ohm impedance connected across terminals
       AB, and (b) the magnitude of the p.d. across the(
       3.75 + i11)ohm impedance.
2
3  //initializing the variables:
4  rv = 24; // in volts
5  thetav = 0; // in degrees
6  R1 = -1*%i*3; // in ohm
7  R2 = 4; // in ohm
```

```
8  R3 = %i*3; // in ohm
9
10 //calculation:
11 //voltage
12 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
      /180)
13 //Current I1 shown in Figure 33.27 is given by
14 I1 = V/(R1 + R2 + R3)
15 //The Th evenin equivalent voltage, i.e., the open−
      circuit voltage across terminals AB, is given by
16 E = I1*(R2 + R3)
17 //When the voltage source is removed, the impedance
      z looking in  at AB is given by
18 z = (R2 + R3)*R1/(R1 + R2 + R3)
19 //Thus the Th evenin equivalent circuit is as shown
       in Figure 33.28.
20 //when (3.75 + i11) ohm impedance connected across
      terminals AB, the current I flowing in the
      impedance is given by
21 R = 3.75 + %i*11;  // in ohms
22 I = E/(R + z)
23 Imag = (real(I)^2 + imag(I)^2)^0.5
24 //the p.d. across the( 3.75 + i11)ohm impedance.
25 VR = I*R
26 VRmag = (real(VR)^2 + imag(VR)^2)^0.5
27
28 printf("\n\n Result \n\n")
29 printf("\n (a) the current I flowing in the (3.75 +
      i11) impedance is given by is %.0f A",Imag)
30 printf("\n (b) the magnitude of the p.d. across the
      impedance is %.1f V",VRmag)
```

Scilab code Exa 33.06 Example 6

```
1 //Problem 33.06: Use Th evenin s theorem to
```

```
      determine the current flowing in the capacitor of
        the network shown in Figure 33.29.
 2
 3  //initializing the variables:
 4  rv = 16.55; // in volts
 5  thetav = -22.62; // in degrees
 6  R1 = 4; // in ohm
 7  R2 = %i*2; // in ohm
 8  R3 = %i*6; // in ohm
 9  R4 = 3; // in ohm
10  R5 = 5; // in ohm
11  R6 = -1*%i*8; // in ohm
12
13  //calculation:
14  //voltage
15  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
        /180)
16  //The capacitor is removed from branch AB, as shown
        in Figure 33.30.
17  //Impedance, Z
18  Z1 = R3 + R4 + R5
19  Z = R1 + (Z1*R2/(R2 + Z1))
20  I1 = V/Z
21  I2 = (R2/(R2 +Z1))*I1
22  //The open-circuit voltage, E
23  E = I2*R5
24  //If the voltage source is removed from Figure
        33.30, the impedance, z,   looking in    at AB
        is given by
25  z = R5*((R1*R2/(R1 + R2)) + R3 + R4)/(R5 + ((R1*R2/(
        R1 + R2)) + R3 + R4))
26  //The Th evenin equivalent circuit is shown in
        Figure 33.31, where the current flowing in the
        capacitor, I, is given by
27  I = E/(z + R6)
28  Imag = (real(I)^2 + imag(I)^2)^0.5
29  phiid = (atan(imag(I)/real(I)))*180/%pi
30  printf("\n\n Result \n\n")
```

```
31  printf("\n the  current  flowing  in  the  capacitor  of
        the  network  is  %.2 f /_%.2 f   A", Imag , phiid )
```

Scilab code Exa 33.07 Example 7

```
1  //Problem  33.07:  For  the  network  shown  in  Figure
      33.32 ,  derive  the  Th evenin  equivalent  circuit
      with  respect  to  terminals  PQ,  and  hence  determine
       the  power  dissipated  by  a  2  ohm  resistor
      connected  across  PQ.
2
3  //initializing  the  variables :
4  rv1  =  5;  //  in  volts
5  rv2  =  10;  //  in  volts
6  thetav1  =  45;  //  in  degrees
7  thetav2  =  0;  //  in  degrees
8  R1  =  8;  //  in  ohm
9  R2  =  5;  //  in  ohm
10  R3  =  %i*3;  //  in  ohm
11  R4  =  4;  //  in  ohm
12
13  //calculation :
14  //voltage
15  V1  =  rv1*cos( thetav1 *%pi /180)  +  %i*rv1*sin( thetav1 *
      %pi /180)
16  V2  =  rv2*cos( thetav2 *%pi /180)  +  %i*rv2*sin( thetav2 *
      %pi /180)
17  //Current  I1  shown  in  Figure  33.32  is  given  by
18  I1  =  V2 /( R2  +  R3  +  R4 )
19  //Hence  the  voltage  drop  across  the  5  ohm  resistor
      is  given  by  VX  is  in  the  direction  shown  in
      Figure  33.32 ,
20  Vx  =  I1*R2
21  //The  open−circuit  voltage  E  across  PQ  is  the  phasor
       sum  of  V1,  Vx  and  V2,  as  shown  in  Figure  33.33.
```

```
22  E = V2 - V1 - Vx
23  //The impedance , z ,   looking in    at terminals PQ
        with the voltage sources removed is given by
24  z = R1 + R2*(R3 + R4)/(R2 + R3 + R4)
25  //The Th evenin equivalent circuit is shown in
        Figure 33.34 with the 2 ohm resistance connected
        across terminals PQ.
26  //The current flowing in the 2 ohm resistance is
        given by
27  R = 2; // in ohms
28  I = E/(z + R)
29  Imag = (real(I)^2 + imag(I)^2)^0.5
30  //power P dissipated in the 2 ohm resistor is given
        by
31  Pr2 = R*Imag^2
32
33  printf("\n\n Result \n\n")
34  printf("\n power P dissipated in the 2 ohm resistor
        is %.4 f W", Pr2)
```

Scilab code Exa 33.08 Example 8

```
1  //Problem 33.08: For the a.c. bridge network shown
       in Figure 33.35 , determine the current flowing in
        the capacitor , and its direction , by using
        Th evenin s theorem . Assume the 306/_0  V
        source to have negligible internal impedance .
2
3  //initializing the variables :
4  rv = 30; // in volts
5  thetav = 0; // in degrees
6  R1 = 15; // in ohm
7  R2 = 40; // in ohm
8  R3 = %i*20; // in ohm
9  R4 = 20; // in ohm
```

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```
10  R5 = %i*5; // in ohm
11  R6 = 5; // in ohm
12  R7 = -1*%i*25; // in ohm
13
14  //calculation:
15  //voltage
16  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
17  //The R7 is initially removed from the network, as
        shown in Figure 33.36
18  Z1 = R1
19  Z2 = R2
20  Z3 = R3 + R4
21  Z4 = R5 + R6
22  //P.d. between A and C,
23  Vac = (Z1/(Z1 + Z4))*V
24  //P.d. between B and C,
25  Vbc = (Z2/(Z2 + Z3))*V
26  //Assuming that point A is at a higher potential
        than point B, then the p.d. between A and B is
27  Vab = Vac - Vbc
28  //the open-circuit voltage across AB is given by
29  E = Vab
30  //Point C is at a potential of V . Between C and A
         is a volt drop of Vac. Hence the voltage at point
         A is
31  Va = V - Vac
32  //Between points C and B is a voltage drop of Vbc.
        Hence the voltage at point B
33  Vb = V - Vbc
34  //Replacing the V source with a short-circuit (i.e.,
         zero internal impedance) gives the network shown
         in Figure 33.37(a). The network is shown redrawn
         in Figure 33.37(b) and simplified in Figure
        33.37(c). Hence the impedance, z,    looking
        in    at terminals AB is given by
35  z = Z1*Z4/(Z1 + Z4) + Z2*Z3/(Z2 + Z3)
36  //The Th evenin equivalent circuit is shown in
```

```
        Figure 33.38, where current I is given by
37  I = E/(z + R7)
38  Imag = (real(I)^2 + imag(I)^2)^0.5
39
40  printf("\n\n Result \n\n")
41  printf("\n  the current flowing in the capacitor is
        %.3f A in direction from B to A.",Imag)
```

Scilab code Exa 33.09 Example 9

```
1  //Problem 33.09: Use Norton s theorem to determine
       the value of current I in the circuit shown in
       Figure 33.47.
2
3  //initializing the variables:
4  V = 5; // in volts
5  R1 = 2; // in ohm
6  R2 = 3; // in ohm
7  R3 = -1*%i*3; // in ohm
8  R4 = 2.8; // in ohm
9
10  //calculation:
11  //The branch containing the R4 is short-circuited,
       as shown in Figure 33.48.
12  //The R2 in parallel with a short-circuit is the
       same as R2 in parallel with 0 ohm giving an
       equivalent impedance of
13  Z1 = R2*0/(R3 + 0)
14  //Hence the network reduces to that shown in Figure
       33.49, where
15  Isc = V/R1
16  //If the Voltage source is removed from the network
       the input impedance, z,  looking-in   at a
       break made in AB of Figure 33.48 gives
17  z = R1*R2/(R1 + R2)
```

```
18  //The  Norton  equivalent  network  is  shown  in  Figure
        33.51 ,  where  current  I  is  given  by
19  I  =  (z/(z  +  R4  +  R3))*Isc
20
21  printf("\n\n  Result  \n\n")
22  printf("\n   the  current  flowing  in  the  capacitor  is
        %.2f  +  (%.2f)i  A",real(I),  imag(I))
```

Scilab code Exa 33.10 Example 10

```
 1  //Problem  33.10:  For  the  circuit  shown  in  Figure
        33.52  determine  the  current  flowing  in  the
        inductive  branch  by  using  Norton  s  theorem .
 2
 3  //initializing  the  variables :
 4  V1  =  20;  //  in  volts
 5  V2  =  10;  //  in  volts
 6  R1  =  2;  //  in  ohm
 7  R2  =  1.5;  //  in  ohm
 8  R3  =  %i*2.95;  //  in  ohm
 9  R4  =  3;  //  in  ohm
10
11  //calculation :
12  //The  inductive  branch  is  initially  short−circuited ,
        as  shown  in  Figure  33.53.
13  //From  Figure  33.53 ,
14  I1  =  V1/R1
15  I2  =  V2/R4
16  Isc  =  I1  +  I2
17  //If  the  voltage  sources  are  removed ,  the  impedance ,
        z,   looking  in    at  a  break  made  in  AB  is
        given  by
18  z  =  R1*R4/(R1  +  R4)
19  //The  Norton  equivalent  network  is  shown  in  Figure
        33.54 ,  where  current  I  is  given  by
```

```
20  I = (z/(z + R2 + R3))*Isc
21
22  printf("\n\n  Result  \n\n")
23  printf("\n   the  current  flowing  in  the  inductive
        branch  is  %.2f  +  (%.2f)i  A",real(I),  imag(I))
```

Scilab code Exa 33.11 Example 11

```
1  //Problem  33.11:  Use  N o r t o n  s  theorem  to  determine
        the  magnitude  of  the  p.d.  across  the  1  ohm
       resistance  of  the  network  shown  in  Figure  33.55.
2
3  //initializing  the  variables:
4  V = 10;  //  in  volts
5  R1 = 4;  //  in  ohm
6  R2 = 4;  //  in  ohm
7  R3 = -1*%i*2;  //  in  ohm
8  R4 = 1;  //  in  ohm
9
10 //calculation:
11 //The  branch  containing  the  R4  is  initially  short-
        circuited ,  as  shown  in  Figure  33.56.
12 //R2  in  parallel  with  R3  in  parallel  with  0  ohm  (i.e
        .,  the  short-circuit)  is  equivalent  0  ohm  giving
       the  equivalent  circuit  of  Figure  33.57.  Hence  Isc
13 Isc = V/R1
14 //The  voltage  source  is  removed  from  the  network  of
        Figure  33.55,  as  shown  in  Figure  33.58,  and  the
        impedance  z,   looking  in   at  a  break  made  in
        AB  is  given  by
15 z = 1/(1/R1 + 1/R2 + 1/R3)
16 //The  Norton  equivalent  network  is  shown  in  Figure
        33.59,  from  which  current  I  is  given  by
17 I = (z/(z + R4))*Isc
18 Imag = (real(I)^2 + imag(I)^2)^0.5
```

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```
19  Vr1 = Imag*R4
20
21  printf (" \n\n  Result  \n\n")
22  printf (" \n  the  magnitude  of  the  p.d.  across  the  1
        ohm  resistor  is  %.2 f  V" , Vr1 )
```

Scilab code Exa 33.12 Example 12

```
1  //Problem  33.12: For  the  network  shown  in  Figure
       33.60 ,  obtain  the  Norton  equivalent  network  at
       terminals  AB.  Hence  determine  the  power
       dissipated  in  a  5  ohm  resistor  connected  between
       A  and  B.
2
3  //initializing  the  variables :
4  rv  =  20;  //  in  volts
5  thetav  =  0;  //  in  degrees
6  R1  =  2;  //  in  ohm
7  R2  =  4;  //  in  ohm
8  R3  =  %i*3;  //  in  ohm
9  R4  =  -1*%i*3;  //  in  ohm
10
11  //calculation :
12  //voltage
13  V  =  rv*cos(thetav*%pi/180)  +  %i*rv*sin(thetav*%pi
        /180)
14  //Terminals  AB  are  initially  short−circuited ,  as
        shown  in  Figure  33.61.
15  //The  circuit  impedance  Z  presented  to  the  voltage
         source  is  given  by
16  Z  =  R1  +  R4*(R2  +  R3)/(R2  +  R3  +  R4)
17  //Thus  current  I  in  Figure  33.61  is  given  by
18  I  =  V/Z
19  Isc  =  ((R2  +  R3)/(R2  +  R3  +  R4))*I
20  //Removing  the  voltage  source  of  Figure  33.60  gives
```

```
        the network Figure 33.62 of Figure 33.62.
        Impedance, z,   looking in   at terminals AB is
        given by
21  z = R4 + R1*(R2 + R3)/(R2 + R3 + R1)
22  //The Norton equivalent network is shown in Figure
        33.63.
23  R = 5; // in ohms
24  //Current IL
25  IL = (z/(z + R))*Isc
26  ILmag = (real(IL)^2 + imag(IL)^2)^0.5
27  //the power dissipated in the 5 ohm resistor is
28  Pr5 = R*ILmag^2
29
30  printf("\n\n Result \n\n")
31  printf("\n the power dissipated in the 5 ohm
        resistor is %.2f W", Pr5)
```

Scilab code Exa 33.13 Example 13

```
1  //Problem 33.13: Derive the Norton equivalent network
        with respect to terminals PQ for the network
        shown in Figure 33.64 and hence determine the
        magnitude of the current flowing in a 2 ohm
        resistor connected across PQ.
2
3  //initializing the variables:
4  rv1 = 5; // in volts
5  rv2 = 10; // in volts
6  thetav1 = 45; // in degrees
7  thetav2 = 0; // in degrees
8  R1 = 8; // in ohm
9  R2 = 5; // in ohm
10 R3 = %i*3; // in ohm
11 R4 = 4; // in ohm
12
```

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```
13  // calculation :
14  // voltage
15  V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
        %pi/180)
16  V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
        %pi/180)
17  //Terminals PQ are initially short−circuited , as
        shown in Figure 33.65.
18  //Currents I1 and I2 are shown labelled .
        Kirchhoff s laws are used .
19  //For loop ABCD, and moving anticlockwise ,
20  //I1*(R2 + R3 + R4) + I2*(R3 + R4) = V2
21  //For loop DPQC, and moving clockwise ,
22  //R2*I1 − R1*I2 = V2 − V1
23  //Solving Equations by using determinants gives
24  d1 = [V2 (R3 + R4); (V2 - V1) -1*R1]
25  D1 = det(d1)
26  d2 = [(R2 + R3 + R4) V2; R2 (V2 - V1)]
27  D2 = det(d2)
28  d = [(R2 + R3 + R4) (R3 + R4); R2 -1*R1]
29  D = det(d)
30  I1 = D1/D
31  I2 = D2/D
32  //the short−circuit current Isc
33  Isc = I2
34  //The impedance , z ,    looking in    at a break made
        between P and Q is given by
35  z = R1 + R2*(R3 + R4)/(R2 + R3 + R4)
36  //The Norton equivalent circuit is shown in Figure
        33.66 , where current I is given by
37  R = 2; //in ohm
38  I = (z/(z + R))*Isc
39  Imag = (real(I)^2 + imag(I)^2)^0.5
40
41  printf(" \n\n Result \n\n")
42  printf(" \n the magnitude of the current flowing 5
        ohm resistor is %.2f A", Imag)
```

Scilab code Exa 33.15 Example 15

```scilab
1  //Problem 33.15: (a) Convert the circuit to the left
       of terminals AB in Figure 33.72 to an equivalent
       Th evenin circuit by initially converting to a
      Norton equivalent circuit. (b) Determine the
      magnitude of the current flowing in the (1.8+i4)
      ohm impedance connected between terminals A and B
       of Figure 33.72.
2
3  //initializing the variables:
4  E1 = 12; // in volts
5  E2 = 24; // in volts
6  Z1 = 3; // in ohm
7  Z2 = 2; // in ohm
8  R1 = %i*4; // in ohm
9  R2 = 1.8; // in ohm
10
11 //calculation:
12 Z3 = R1 + R2
13 //For the branch containing the E1 source,
       conversion to a Norton equivalent network gives
14 Isc1 = E1/Z1
15 //For the branch containing the E2 source,
       conversion to a Norton equivalent circuit gives
16 Isc2 = E2/Z2
17 //Thus Figure 33.73 shows a network equivalent to
       Figure 33.72. From Figure 33.73, the total short-
       circuit current
18 Isc = Isc1 + Isc2
19 //the total impedance is given by
20 z = Z1*Z2/(Z1 + Z2)
21 //Thus Figure 33.73 simplifies to Figure 33.74.
22 //The open-circuit voltage across AB of Figure
```

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```
      33.74 , E
23  E = Isc*z
24  //the impedance    looking in     at AB,is z
25  //the Th evenin equivalent circuit is as shown in
        Figure 33.75.
26  R = 1.8 + %i*4; // in ohm
27  //when R impedance is connected to terminals AB of
        Figure 33.75, the current I flowing is given by
28  I = E/(z + R)
29  Imag = (real(I)^2 + imag(I)^2)^0.5
30
31  printf("\n\n Result \n\n")
32  printf("\n the magnitude of the current flowing (1.8
        + i4) ohm resistor is %.2f A", Imag)
```

Scilab code Exa 33.16 Example 16

```
1  //Problem 33.16: Determine, by successive
        conversions between Th evenin s and Norton s
         equivalent networks, a Th evenin equivalent
        circuit for terminals AB of Figure 33.76. Hence
        determine the magnitude of the current flowing in
         the capacitive branch connected to terminals AB.
2
3  //initializing the variables:
4  V1 = 5; // in volts
5  V2 = 10; // in volts
6  i = 0.001; // in Amperes
7  R1 = 1000; // in ohm
8  R2 = 4000; // in ohm
9  R3 = 2000; // in ohm
10  R4 = 200; // in ohm
11  R5 = -1*%i*4000; // in ohm
12
13  //calculation:
```

```
14 //For the branch containing the V1 source,
       conversion to a Norton equivalent network gives
15 Isc1 = V1/R1
16 z1 = R1
17 //For the branch containing the V2 source,
       conversion to a Norton equivalent circuit gives
18 Isc2 = V2/R2
19 z2 = R2
20 //Thus the circuit of Figure 33.76 converts to that
       of Figure 33.77.
21 //The above two Norton equivalent networks shown in
       Figure 33.77 may be combined, since the total
       short-circuit current is
22 Isc = Isc1 + Isc2
23 //the total impedance is given by
24 Z1 = z1*z2/(z1 + z2)
25 //Both of the Norton equivalent networks shown in
       Figure 33.78 may be converted to Th evenin
       equivalent circuits. Open-circuit voltage across
       CD is
26 Ecd = Isc*Z1
27 //the impedance   looking in    at CD is Z1
28 //Open-circuit voltage across EF
29 Eef = i*R3
30 //the impedance   looking in    Figure 33.79 at EF
31 Z2 = R3
32 //Thus Figure 33.78 converts to Figure 33.79.
33 //Combining the two Th evenin circuits gives e.m.f.
34 E = Ecd - Eef
35 //impedance z
36 z = Z1 + Z2
37 //the Th evenin equivalent circuit for terminals AB
       of Figure 33.76 is as shown in Figure 33.80.
38 Z3 = R4 + R5
39 //If an impedance Z3 is connected across terminals
       AB, then the current I flowing is given by
40 I = E/(z + Z3)
41 Imag = (real(I)^2 + imag(I)^2)^0.5
```

```
42
43  printf("\n\n Result \n\n")
44  printf("\n the current in the capacitive branch is %
        .2E A", Imag)
```

Scilab code Exa 33.17 Example 17

```
1  //Problem 33.17: (a) Determine an equivalent
       Th evenin circuit for terminals AB of the
       network shown in Figure 33.81. (b) Calculate the
       power dissipated in a (600 − i800)ohm impedance
       connected between A and B of Figure 33.81.
2
3  //initializing the variables:
4  V = 5; // in volts
5  i = 0.004; // in Amperes
6  R1 = 2000; // in ohm
7  R2 = %i*1000; // in ohm
8
9  //calculation:
10 //Converting the Th evenin circuit to a Norton
       network gives
11 Isc1 = V/R2
12 //Thus Figure 33.81 converts to that shown in Figure
        33.82. The two Norton equivalent networks may be
        combined, giving
13 Isc = Isc1 + i
14 z = R1*R2/(R1 + R2)
15 //This results in the equivalent network shown in
       Figure 33.83. Converting to an equivalent
       Th evenin circuit gives open circuit e.m.f.
       across AB,
16 E = Isc*z
17 //Thus the The venin equivalent circuit is as shown
       in Figure 33.84.
```

```
18  R = 600 - %i*800; // in ohms
19  //When a R impedance is connected across AB, the
        current I flowing is given by
20  I = E/(z + R)
21  Imag = (real(I)^2 + imag(I)^2)^0.5
22  //the power dissipated in the R resistor is
23  PR = R*Imag^2
24
25  printf(")\n\n Result \n\n")
26  printf(")\n the power dissipated in the (600 - i800)
        ohm resistor is %.2E W", PR)
```

Chapter 34

Delta star and star delta transformations

Scilab code Exa 34.02 Example 2

```
1  //Problem 34.02: For the network shown in Figure
       34.7, determine (a) the equivalent circuit
       impedance across terminals AB, (b) supply current
        I and (c) the power dissipated in the 10 ohm
       resistor.
2
3  //initializing the variables:
4  rv = 40; // in volts
5  thetav = 0; // in degrees
6  ZA = %i*10; // in ohm
7  ZB = %i*15; // in ohm
8  ZC = %i*25; // in ohm
9  ZD = -1*%i*8; // in ohm
10 ZE = 10; // in ohm
11
12 //calculation:
13 //voltage
14 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
```

```
15  //The network of Figure 34.7 is redrawn, as in
        Figure 34.8, showing more clearly the part of the
         network 1, 2, 3 forming a delta connection  This
         may he transformed into a star connection as
        shown in Figure 34.9.
16  Z1 = ZA*ZB/(ZA + ZB + ZC)
17  Z2 = ZC*ZB/(ZA + ZB + ZC)
18  Z3 = ZA*ZC/(ZA + ZB + ZC)
19  //The equivalent network is shown in Figure 34.10
        and is further simplified in Figure 34.11
20  //(ZE + Z3) in parallel with (Z1 + ZD) gives an
        equivalent impedance of
21  z = (ZE + Z3)*(Z1 + ZD)/(Z1 + ZD + ZE + Z3)
22  //Hence the total circuit equivalent impedance
        across terminals AB is given by
23  Zab = z + Z2
24  //Supply current I
25  I = V/Zab
26  I1 = ((Z1 + ZD)/(Z1 + ZD + ZE + Z3))*I
27  I1mag = (real(I1)^2 + imag(I1)^2)^0.5
28  //Power P dissipated in the 10 ohm resistance of
        Figure 34.7 is given by
29  Pr10 = ZE*I1mag^2
30
31  printf("\n\n Result \n\n")
32  printf("\n (a)the equivalent circuit impedance
        across terminals AB is %.2f + (%.2f)i ohm",real(
        Zab), imag(Zab))
33  printf("\n (b)supply current I is %.2f + (%.2f)i A",
        real(I), imag(I))
34  printf("\n (c)power P dissipated in the 10 ohm
        resistor is %.2f W",Pr10)
```

Scilab code Exa 34.03 Example 3

```
 1  //Problem 34.03: Determine, for the bridge network
        shown in Figure 34.12, (a) the value of the
        single equivalent resistance that replaces the
        network between terminals A and B, (b) the
        current supplied by the 52 V source, and (c) the
        current flowing in the 8 ohm resistance.
 2
 3  //initializing the variables:
 4  V = 52; // in volts
 5  ZA = 8; // in ohm
 6  ZB = 16; // in ohm
 7  ZC = 40; // in ohm
 8  ZD = 1; // in ohm
 9  ZE = 4; // in ohm
10
11  //calculation:
12  //In Figure 34.12, no resistances are directly in
        parallel or directly in series with each other.
        However, ACD and BCD are both delta connections
        and either may be converted into an equivalent
        star connection. The delta network BCD is redrawn
         in Figure 34.13(a) and is transformed into an
        equivalent star connection as shown in Figure
        34.13(b), where
13  Z1 = ZA*ZB/(ZA + ZB + ZC)
14  Z2 = ZC*ZB/(ZA + ZB + ZC)
15  Z3 = ZA*ZC/(ZA + ZB + ZC)
16  //The network of Figure 34.12 may thus be redrawn as
         shown in Figure 34.14. The Z1 and ZE are in
        series with each other, as are the ZD and Z3
        resistors. Hence the equivalent network is as
        shown in Figure 34.15. The total equivalent
        resistance across terminals A and B is given by
17  Zab = (Z1 + ZE)*(ZD + Z3)/(Z1 + ZE + ZD + Z3) + Z2
18  //Current supplied by the source, i.e., current I in
         Figure 34.15, is given by
19  I = V/Zab
20  //From Figure 34.15, current I1
```

```
21  I1 = ((ZD + Z3)/(Z1 + ZE + ZD + Z3))*I
22  //current I2
23  I2 = I - I1
24  //From Figure 34.14, p.d. across AC,
25  Vac = I1*ZE
26  //p.d. across AD
27  Vad = I2*ZD
28  //Hence p.d. between C and D is given
29  Vcd = Vac - Vad
30  //current in the 8 ohm resistance
31  Ir8 = Vcd/ZA
32
33  printf(")"\n\n Result \n\n")
34  printf(")"\n (a)the equivalent circuit impedance
        across terminals AB is %.2f  ohm",Zab)
35  printf(")"\n (b)the current supplied by the 52 V
        source is %.2f  A",I)
36  printf(")"\n (c)the current flowing in the 8 ohm
        resistance is %.2f A",Ir8)
```

Scilab code Exa 34.05 Example 5

```
1  //Problem 34.05: For the network shown in Figure
      34.20, determine (a) the current flowing in the
      (0+i10) ohm impedance, and (b) the power
      dissipated in the (20 + i0) ohm impedance.
2
3  //initializing the variables:
4  rv = 120; // in volts
5  thetav = 0; // in degrees
6  ZA = 25 - %i*5; // in ohm
7  ZB = 15 + %i*10; // in ohm
8  ZC = 20 - %i*30; // in ohm
9  ZD = 20 + %i*0; // in ohm
10 ZE = 0 + %i*10; // in ohm
```

```
11  ZF = 2.5 - %i*5; // in ohm
12
13  //calculation:
14  //voltage
15  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
        /180)
16  //The network may initially be simplified by
        transforming the delta PQR to its equivalent star
         connection as represented by impedances Z1, Z2
        and Z3 in Figure 34.21. From equation (34.7),
17  Z1 = ZA*ZB/(ZA + ZB + ZC)
18  Z2 = ZC*ZB/(ZA + ZB + ZC)
19  Z3 = ZA*ZC/(ZA + ZB + ZC)
20  //The network is shown redrawn in Figure 34.22 and
        further simplified in Figure 34.23, from which,
21  Zab = ((Z3 + ZE)*(ZD + Z2)/(Z2 + ZE + ZD + Z3)) + (
        Z1 + ZF)
22  //Current I1
23  I1 = V/Zab
24  //current I2
25  I2 = ((ZE + Z3)/(Z2 + ZE + ZD + Z3))*I1
26  //current I3
27  I3 = I1 - I2
28  //The power P dissipated in the ZD impedance of
        Figure 34.20 is given by
29  Pzd = ZD*I2^2
30
31  printf("\n\n Result \n\n")
32  printf("\n (a)the current flowing in the (0+i10) ohm
         impedance is %.2f  A",I3)
33  printf("\n (b) the power dissipated in the (20 + i0)
         ohm impedance is %.2f W",Pzd)
```

Chapter 35

Maximum power transfer theorems and impedance matching

Scilab code Exa 35.01 Example 1

```
1 //Problem 35.01: For the circuit shown in Figure
    35.2 the load impedance Z is a pure resistance.
    Determine (a) the value of R for maximum power to
    be transferred from the source to the load, and
    (b) the value of the maximum power delivered to R
    .
2
3 //initializing the variables:
4 rv = 120; // in volts
5 thetav = 0; // in degrees
6 Z = 15 + %i*20; // in ohm
7
8 //calculation:
9 //voltage
10 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
    /180)
11 //maximum power transfer occurs when R = mod(Z)
```

```
12  R = (real(Z)^2 + imag(Z)^2)^0.5
13  //the total circuit impedance
14  ZT = Z + R
15  //Current I flowing in the load is given by
16  I = V/ZT
17  Imag = (real(I)^2 + imag(I)^2)^0.5
18  //maximum power delivered
19  P = R*Imag^2
20
21  printf("\n\n Result \n\n")
22  printf("\n (a)maximum power transfer occurs when R
        is %.0f ohm",R)
23  printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.02 Example 2

```
1  //Problem 35.02: If the load impedance Z in Figure
       35.2 of problem 35.01 consists of variable
       resistance R and variable reactance X, determine
       (a) the value of Z that results in maximum power
       transfer, and (b) the value of the maximum power.
2
3  //initializing the variables:
4  rv = 120; // in volts
5  thetav = 0; // in degrees
6  Z = 15 + %i*20; // in ohm
7
8  //calculation:
9  //voltage
10 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
11 //maximum power transfer occurs when X = -1*imag(Z)
       and R = real(Z)
12 z = real(Z) - %i*imag(Z)
13 //Total circuit impedance at maximum power transfer
```

```
      condition ,
14  ZT = Z + z
15  //Current  I  flowing  in  the  load  is  given  by
16  I = V/ZT
17  Imag = (real(I)^2 + imag(I)^2)^0.5
18  //maximum  power  delivered
19  P =  real(Z)*I^2
20
21  printf("\n\n  Result  \n\n")
22  printf("\n  (a)maximum  power  transfer  occurs  when  Z
        is  %.0f + (%.0f)i  ohm",real(z),  imag(z))
23  printf("\n  (b)  maximum  power  delivered  is  %.0f W",P)
```

Scilab code Exa 35.03 Example 3

```
1  //Problem  35.03:  For  the  network  shown  in  Figure
       35.3,  determine  (a)  the  value  of  the  load
       resistance  R  required  for  maximum  power  transfer ,
        and  (b)  the  value  of  the  maximum  power
       transferred .
2
3  //initializing  the  variables :
4  rv = 200; // in  volts
5  thetav = 0; // in  degrees
6  R1 = 100; // in  ohm
7  C = 1E-6; // in  farad
8  f = 1000; // in  Hz
9
10 //calculation :
11 //voltage
12 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
13 //Capacitive  reactance ,  Xc
14 Xc = 1/(2*%pi*f*C)
15 //Hence  source  impedance ,
```

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```
16  z = R1*(%i*Xc)/(R1 + %i*Xc)
17  //maximum power transfer is achieved when R = mod(z)
18  R = (real(z)^2 + imag(z)^2)^0.5
19  //Total circuit impedance at maximum power transfer
        condition ,
20  ZT = z + R
21  //Current I flowing in the load is given by
22  I = V/ZT
23  Imag = (real(I)^2 + imag(I)^2)^0.5
24  //maximum power transferred ,
25  P = R*Imag^2
26
27  printf("\n\n Result \n\n")
28  printf("\n (a)maximum power transfer occurs when R
        is %.2f ohm",R)
29  printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.04 Example 4

```
1  //Problem 35.04: In the network shown in Figure 35.4
        the load consists of a fixed capacitive
        reactance of 7 ohm and a variable resistance R.
        Determine (a) the value of R for which the power
        transferred to the load is a maximum, and (b) the
        value of the maximum power.
2
3  //initializing the variables:
4  rv = 60; // in volts
5  thetav = 0; // in degrees
6  R1 = 4; // in ohm
7  XL = 10; // in ohm
8  Xc = 7; // in ohm
9  R2 = %i*XL; // in ohm
10 R3 = -1*%i*Xc; // in ohm
11
```

```
12  //calculation:
13  //voltage
14  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
        /180)
15  //maximum power transfer is achieved when
16  R = (R1^2 + (XL - Xc)^2)^0.5
17  //Hence source impedance,
18  ZT = R1 + R2 + R3 + R
19  //Current I flowing in the load is given by
20  I = V/ZT
21  Imag = (real(I)^2 + imag(I)^2)^0.5
22  //maximum power transferred,
23  P = R*Imag^2
24
25  printf("\n\n Result \n\n")
26  printf("\n (a)maximum power transfer occurs when R
        is %.2f ohm",R)
27  printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.05 Example 5

```
1  //Problem 35.05: Determine the value of the load
       resistance R shown in Figure 35.5 that gives
       maximum power dissipation and calculate the value
        of this power.
2
3  //initializing the variables:
4  V = 20; // in volts
5  R1 = 5; // in ohm
6  R2 = 15; // in ohm
7
8  //calculation:
9  //R is removed from the network as shown in Figure
       35.6
10 //P.d. across AB, E
```

```
11  E = (R2/(R1 + R2))*V
12  //Impedance    looking-in    at terminals AB with
       the source removed is given by
13  r = R1*R2/(R1 + R2)
14  //The equivalent Th evenin circuit supplying
       terminals AB is shown in Figure 35.7. From
       condition (2), for maximum power transfer
15  R = r
16  //Current I flowing in the load is given by
17  I = E/(R + r)
18  //maximum power transferred ,
19  P = R*I^2
20
21  printf("\n\n Result \n\n")
22  printf("\n (a)maximum power transfer occurs when R
       is %.2 f ohm",R)
23  printf("\n (b) maximum power delivered is %.0 f W",P)
```

Scilab code Exa 35.06 Example 6

```
1  //Problem 35.06: Determine , for the network shown in
       Figure 35.8 , (a) the values of R and X that will
       result in maximum power being transferred across
       terminals AB, and (b) the value of the maximum
     power .
2
3  //initializing the variables :
4  rv = 100; // in volts
5  thetav = 30; // in degrees
6  R1 = 5; // in ohm
7  R2 = 5; // in ohm
8  R3 = %i*10; // in ohm
9
10 //calculation :
11 //voltage
```

```
12  V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
        /180)
13  //Resistance R and reactance X are removed from the
        network as shown in Figure 35.9
14  //P.d. across AB,
15  E = ((R2 + R3)/(R1 + R2 + R3))*V
16  //With the source removed the impedance, z,
           looking in    at terminals AB is given by:
17  z = (R2 + R3)*R1/(R1 + R2 + R3)
18  //The equivalent Th evenin circuit is shown in
        Figure 35.10. From condition 3, maximum power
        transfer is achieved when X = -1*imag(z) and R =
        real(z)
19  X = -1*imag(z)
20  R = real(z)
21  Z = R + %i*X
22  //Current I flowing in the load is given by
23  I = E/(z + Z)
24  Imag = (real(I)^2 + imag(I)^2)^0.5
25  //maximum power transferred,
26  P = R*Imag^2
27
28  printf("\n\n Result \n\n")
29  printf("\n (a)maximum power transfer occurs when R
        is %.2f ohm and X is %.2f ohm",R, X)
30  printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.07 Example 7

```
1  //Problem 35.07: Determine the optimum value of load
        resistance for maximum power transfer if the
        load is connected to an amplifier of output
        resistance 448 ohm through a transformer with a
        turns ratio of 8:1.
2
```

```
3  //initializing the variables:
4  Ro = 448; // in ohm
5  tr = 8; // turn ratio N1/N2
6
7  //calculation:
8  //The equivalent input resistance r of the
       transformer must be Ro for maximum power transfer
       .
9  r = Ro
10 RL = r*(1/tr)^2
11
12 printf("\n\n Result \n\n")
13 printf("\n the optimum value of load resistance is %
       .0f ohm",RL)
```

Scilab code Exa 35.08 Example 8

```
1  //Problem 35.08: A generator has an output impedance
       of (450 + i60) ohm. Determine the turns ratio of
       an ideal transformer necessary to match the
       generator to a load of (40 + i19) ohm for maximum
       transfer of power.
2
3  //initializing the variables:
4  Zo = 450 + %i*60; // in ohm
5  ZL = 40 + %i*19; // in ohm
6
7  //calculation:
8  //transformer turns ratio tr = (N1/N2)
9  Zomag = (real(Zo)^2 + imag(Zo)^2)^0.5
10 ZLmag = (real(ZL)^2 + imag(ZL)^2)^0.5
11 tr = (Zomag/ZLmag)^0.5
12
13 printf("\n\n Result \n\n")
14 printf("\n the transformer turns ratio is %.2f",tr)
```

Scilab code Exa 35.09 Example 9

```
1  //Problem 35.09: A single-phase, 240 V/1920 V ideal
        transformer is supplied from a 240 V source
        through a cable of resistance 5 ohm. If the load
        across the secondary winding is 1.60 kohm
        determine (a) the primary current flowing, and (b
        ) the power dissipated in the load resistance.
2
3  //initializing the variables:
4  V1 = 240; // in volts
5  V2 = 1920; // in volts
6  R1 = 5; // in ohms
7  R2 = 1600; // in ohms
8
9  //calculation:
10 //The network is shown in Figure 35.12.
11 //turn ratio N1/N2 = V1/V2
12 tr = V1/V2
13 //Equivalent input resistance of the transformer,
14 RL = R2
15 r = RL*tr^2
16 //Total input resistance,
17 Rin = R1 + r
18 //primary current, I1
19 I1 = V1/Rin
20 //For an ideal transformer V1/V2 = I2/I1
21 I2 = I1*(V1/V2)
22 //Power dissipated in the load resistance
23 P = RL*I2^2
24
25 printf("\n\n Result \n\n")
26 printf("\n (a) primary current flowing is %.0f A",I1
        )
```

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```
27  printf("\n (b) Power dissipated in the load
         resistance is %.0fW",P)
```

Scilab code Exa 35.10 Example 10

```
1  //Problem 35.10: An ac. source of 30/_0   V and
       internal resistance 20 kohm is matched to a load
       by a 20:1 ideal transformer. Determine for
       maximum power transfer (a) the value of the load
       resistance, and (b) the power dissipated in the
       load.
2
3  //initializing the variables:
4  rv = 30; // in volts
5  thetav = 0; // in degrees
6  r = 20000; // in ohms
7  tr = 20; // turn ratio
8
9  //calculation:
10 //voltage
11 V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
       /180)
12 //The network diagram is shown in Figure 35.13.
13 //For maximum power transfer, r1 must be equal to
14 r1 = r
15 //load resistance RL
16 RL = r1/tr^2
17 //The total input resistance when the source is
       connected to the matching transformer is
18 RT = r + r1
19 //Primary current
20 I1 = V/RT
21 //N1/N2 = I2/I1
22 I2 = I1*tr
23 //Power dissipated in load resistance RL is given by
```

```
24  P = RL*I2^2
25
26  printf("\n\n Result \n\n")
27  printf("\n (a)the value of the load resistance is %
        .0f ohm",RL)
28  printf("\n (b) Power dissipated in the load
        resistance is %.2E W",P)
```

Chapter 36

Complex Waveforms

Scilab code Exa 36.03 Example 3

```
1  //Problem 36.03: Determine the rms value of the
        current waveform represented by i = 100 sinwt + 20
        sin(3wt + pi/6) + 10 sin(5wt + 2*pi/3) mA
2
3  //initializing the variables:
4  A1 = 0.100; // in amperes
5  A3 = 0.020; // in amperes
6  A5 = 0.010; // in amperes
7
8  //calculation:
9  //the rms value of current is given by
10 Irms = ((A1^2 + A3^2 + A5^2)/2)^0.5
11
12 printf("\n\n Result \n\n")
13 printf("\n the rms value of current is %.5f A",Irms)
```

Scilab code Exa 36.04 Example 4

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```
1  //Problem 36.04: A complex voltage is represented by
2  //  v = 10 sinwt + 3 sin (3wt) + 2 sin (5wt) Volts
3  //Determine for the voltage, (a) the rms value, (b)
      the mean value and (c) the form factor.
4
5  //initializing the variables:
6  A1 = 10;  // in volts
7  A3 = 3;  // in volts
8  A5 = 2;  // in volts
9
10  //calculation:
11  //the rms value of voltage is given by
12  Vrms = ((A1^2 + A3^2 + A5^2)/2)^0.5
13  //the mean value of voltage is given by
14  //x = wt
15  function [Y]=f(x)
16      Y = (10*sin(x) + 3*sin(3*x) + 2*sin(5*x));
17  endfunction
18  Vav = (1/%pi)*(integrate('f', 'x', 0, %pi))
19  //form factor is given by
20  ff = Vrms/Vav
21
22  printf("\n\n Result \n\n")
23  printf("\n (a)the rms value of voltage is %.2f V",
      Vrms)
24  printf("\n (b)the mean value of voltage is %.2f V",
      Vav)
25  printf("\n (c)form factor is %.3f ",ff)
```

Scilab code Exa 36.06 Example 6

```
1  //Problem 36.06: Determine the average power in a 20
      # resistance if the current i flowing through it
      is of the form
2  //  i = 12 sinwt + 5 sin (3wt) + 2 sin (5wt) A
```

```
 3
 4  // initializing  the  variables :
 5  A1 = 12;  //  in  amperes
 6  A3 = 5;  //  in  amperes
 7  A5 = 2;  //  in  amperes
 8  R = 20;  //  in  ohms
 9
10  // calculation :
11  // rms  current
12  Irms = ((A1^2 + A3^2 + A5^2)/2)^0.5
13  // average  power
14  P = R*Irms^2
15
16  printf("\n\n Result \n\n")
17  printf("\n average power %.0f W",P)
```

Scilab code Exa 36.07 Example 7

```
 1  // Problem  36.07:  A  complex  voltage  v  given  by
 2  //  v = 60 sinwt + 15 sin (3wt + pi/4) + 10 sin (5wt − pi
        /2)  Volts
 3  // is  applied  to  a  circuit  and  the  resulting  current
        i  is  given  by
 4  //  i = 2 sin (wt − pi/6) + 0.30 sin (3wt − pi/12) + 0.1
        sin (5wt − 8 pi/9) A
 5  // Determine  (a)  the  total  active  power  supplied  to
        the  circuit ,  and  (b)  the  overall  power  factor .
 6
 7  // initializing  the  variables :
 8  Ia1 = 2;  //  in  amperes
 9  Ia3 = 0.3;  //  in  amperes
10  Ia5 = 0.1;  //  in  amperes
11  Va1 = 60;  //  in  volts
12  Va3 = 15;  //  in  volts
13  Va5 = 10;  //  in  volts
```

```
14  Phii1 = -1*%pi/6; // in radians
15  Phii3 = -1*%pi/12; // in radians
16  Phii5 = -8*%pi/9; // in radians
17  Phiv1 = 0; // in radians
18  Phiv3 = %pi/4; // in radians
19  Phiv5 = -1*%pi/2; // in radians
20
21
22  //calculation:
23  //rms values;
24  I1 = Ia1/(2^0.5); // in amperes
25  I3 = Ia3/(2^0.5); // in amperes
26  I5 = Ia5/(2^0.5); // in amperes
27  V1 = Va1/(2^0.5); // in volts
28  V3 = Va3/(2^0.5); // in volts
29  V5 = Va5/(2^0.5); // in volts
30  //total power supplied,
31  P = V1*I1*cos(Phiv1 - Phii1) + V3*I3*cos(Phiv3 -
        Phii3) + V5*I5*cos(Phiv5 - Phii5)
32  //rms current
33  Irms = ((I1^2 + I3^2 + I5^2))^0.5
34  //rms voltage
35  Vrms = ((V1^2 + V3^2 + V5^2))^0.5
36  //overall power factor
37  pf = P/(Vrms*Irms)
38
39  printf("\n\n Result \n\n")
40  printf("\n(a)the total active power supplied to the
        circuit %.2f W",P)
41  printf("\n(b)overall power factor %.3f",pf)
```

Scilab code Exa 36.09 Example 9

```
1  //Problem 36.09: A supply voltage v given by
2  // v = 240 sin314t + 40 sin942t + 30 sin1570t Volts
```

```
 3  //is applied to a circuit comprising a resistance of
        12 ohm connected in series with a coil of
       inductance 9.55 mH. Determine (a) an expression
       to represent the instantaneous value of the
       current, (b) the rms voltage, (c) the rms current
       , (d) the power dissipated, and (e) the overall
       power factor.
 4
 5  //initializing the variables:
 6  V1m = 240; // in volts
 7  V3m = 40; // in volts
 8  V5m = 30; // in volts
 9  w1 = 314; // fundamental
10  R = 12; // in ohm
11  L = 0.00955; // in Henry
12
13  //calculation:
14  //fundamental or first harmonic
15  //inductive reactance,
16  XL1 = w1*L
17  //impedance at the fundamental frequency,
18  Z1 = R + %i*XL1
19  //Maximum current at fundamental frequency
20  I1m = V1m/Z1
21  I1mag = (real(I1m)^2 + imag(I1m)^2)^0.5
22  phii1 = atan(imag(I1m)/real(I1m))
23  //Third harmonic
24  XL3 = 3*XL1
25  //impedance at the third harmonic frequency,
26  Z3 = R + %i*XL3
27  //Maximum current at third harmonic frequency
28  I3m = V3m/Z3
29  I3mag = (real(I3m)^2 + imag(I3m)^2)^0.5
30  phii3 = atan(imag(I3m)/real(I3m))
31  //fifth harmonic
32  XL5 = 5*XL1
33  //impedance at the third harmonic frequency,
34  Z5 = R + %i*XL5
```

```
35  //Maximum current at third harmonic frequency
36  I5m = V5m/Z5
37  I5mag = (real(I5m)^2 + imag(I5m)^2)^0.5
38  phii5 = atan(imag(I5m)/real(I5m))
39  //rms voltage
40  Vrms = ((V1m^2 + V3m^2 + V5m^2)/2)^0.5
41  //rms current
42  Irms = ((I1mag^2 + I3mag^2 + I5mag^2)/2)^0.5
43  //power dissipated
44  P = R*Irms^2
45  //overall power factor
46  pf = P/(Vrms*Irms)
47
48  printf("\n\n Result \n\n")
49  printf("\n(b)the rms value of current is %.2f A",
        Irms)
50  printf("\n(c)the rms value of voltage is %.2f V",
        Vrms)
51  printf("\n(d)the total power dissipated %.0f W",P)
52  printf("\n(e)overall power factor %.3f",pf)
```

Scilab code Exa 36.10 Example 10

```
1  //Problem 36.10: An e.m.f. is represented by
2  // e = 50 + 200sinwt + 40sin(2wt - pi/2) + 5sin(4wt
        + pi/4) Volts
3  //the fundamental frequency being 50 Hz. The e.m.f.
        is applied across a circuit comprising a 100   F
        capacitor connected in series with a 50 ohm
        resistor. Obtain an expression for the current
        flowing and hence determine the rms value of
        current.
4
5  //initializing the variables:
6  Vom = 50; // in volts
```

```
 7  V1m = 200; // in volts
 8  V2m = 40; // in volts
 9  V4m = 5; // in volts
10  f = 50; // in Hz
11  R = 50; // in ohm
12  C = 100E-6; // in farad
13  phiv1 = 0; // in rad
14  phiv2 = -1*%pi/2; // in rad
15  phiv4 = %pi/4; // in rad
16
17  //calculation:
18  //voltage
19  V1 = V1m*cos(phiv1) + %i*V1m*sin(phiv1)
20  V2 = V2m*cos(phiv2) + %i*V2m*sin(phiv2)
21  V4 = V4m*cos(phiv4) + %i*V4m*sin(phiv4)
22  //Inductance has no effect on a steady current.
       Hence the d.c. component of the current, i0, is
       given by
23  Iom = 0
24  //fundamental or first harmonic
25  w1 = 2*%pi*f
26  //inductive reactance,
27  Xc1 = 1/(w1*C)
28  //impedance at the fundamental frequency,
29  Z1 = R + %i*Xc1
30  //Maximum current at fundamental frequency
31  I1m = V1/Z1
32  I1mag = (real(I1m)^2 + imag(I1m)^2)^0.5
33  phii1 = atan(imag(I1m)/real(I1m))
34  //second harmonic
35  Xc2 = Xc1/2
36  //impedance at the third harmonic frequency,
37  Z2 = R + %i*Xc2
38  //Maximum current at third harmonic frequency
39  I2m = V2/Z2
40  I2mag = (real(I2m)^2 + imag(I2m)^2)^0.5
41  phii2 = atan(imag(I2m)/real(I2m))
42  //fourth harmonic
```

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```
43  Xc4 = Xc1/4
44  //impedance  at  the  third  harmonic  frequency ,
45  Z4 = R + %i*Xc4
46  //Maximum  current  at  third  harmonic  frequency
47  I4m = V4/Z4
48  I4mag = (real(I4m)^2 + imag(I4m)^2)^0.5
49  phii4 = atan(imag(I4m)/real(I4m))
50  //rms  current
51  Irms = (Iom^2 + (I1mag^2 + I2mag^2 + I4mag^2)/2)^0.5
52
53  printf("\n\n  Result  \n\n")
54  printf("\n(b) the  rms  value  of  current  is  %.2f  A" ,
        Irms)
```

Scilab code Exa 36.11 Example 11

```
 1  //Problem  36.11:  A  supply  voltage  v  given  by
 2  //  v = 25 + 100 sinwt + 40 sin (3wt + pi/6) + 20 sin (5wt
        + pi/12) Volts
 3  //where  w = 10000  rad/s.  The  voltage  is  applied  to  a
         series  circuit  comprising  a  5.0  ohm  resistance
        and  a  500   H  inductance. Determine (a) an
        expression  to  represent  the  current  flowing  in
        the  circuit ,  (b)  the  rms  value  of  current ,
        correct  to  two  decimal  places ,  and  (c)  the  power
        dissipated  in  the  circuit ,  correct  to  three
        significant  figures.
 4
 5  //initializing  the  variables :
 6  Vom = 25;  //  in  volts
 7  V1m = 100;  //  in  volts
 8  V3m = 40;  //  in  volts
 9  V5m = 20;  //  in  volts
10  w1 = 10000;  //  fundamental
11  R = 5;  //  in  ohm
```

```
12  L = 500E-6; // in Henry
13  phiv1 = 0; // in rad
14  phiv3 = %pi/6; // in rad
15  phiv5 = %pi/12; // in rad
16
17  //calculation:
18  //voltage
19  V1 = V1m*cos(phiv1) + %i*V1m*sin(phiv1)
20  V3 = V3m*cos(phiv3) + %i*V3m*sin(phiv3)
21  V5 = V5m*cos(phiv5) + %i*V5m*sin(phiv5)
22  //Inductance has no effect on a steady current.
        Hence the d.c. component of the current, i0, is
        given by
23  Iom = Vom/R
24  //fundamental or first harmonic
25  //inductive reactance,
26  XL1 = w1*L
27  //impedance at the fundamental frequency,
28  Z1 = R + %i*XL1
29  //Maximum current at fundamental frequency
30  I1m = V1/Z1
31  I1mag = (real(I1m)^2 + imag(I1m)^2)^0.5
32  phii1 = atan(imag(I1m)/real(I1m))
33  //Third harmonic
34  XL3 = 3*XL1
35  //impedance at the third harmonic frequency,
36  Z3 = R + %i*XL3
37  //Maximum current at third harmonic frequency
38  I3m = V3/Z3
39  I3mag = (real(I3m)^2 + imag(I3m)^2)^0.5
40  phii3 = atan(imag(I3m)/real(I3m))
41  //fifth harmonic
42  XL5 = 5*XL1
43  //impedance at the third harmonic frequency,
44  Z5 = R + %i*XL5
45  //Maximum current at third harmonic frequency
46  I5m = V5/Z5
47  I5mag = (real(I5m)^2 + imag(I5m)^2)^0.5
```

```
48  phii5 = atan(imag(I5m)/real(I5m))
49  //rms current
50  Irms = (Iom^2 + (I1mag^2 + I3mag^2 + I5mag^2)/2)^0.5
51  //power dissipated
52  P = R*Irms^2
53
54  printf("\n\n Result \n\n")
55  printf("\n(b)the rms value of current is %.2f A",
        Irms)
56  printf("\n(c)the total power dissipated %.0f W",P)
```

Scilab code Exa 36.12 Example 12

```
1  //Problem 36.12: The voltage applied to a particular
        circuit comprising two components connected in
       series is given by
2  // v = 30 + 40sinwt + 25sin(2wt) + 15sin(4wt) Volts
3  //and the resulting current is given by
4  //  v = 0.743sin(wt + 1.19) + 0.78sin(2wt + 0.896) +
        0.636sin(4wt + 0.559) A
5  //Determine (a) the average power supplied, (b) the
       type of components present, and (c) the values of
       the components.
6
7  //initializing the variables:
8  Vom = 30; // in volts
9  V1m = 40; // in volts
10 V2m = 25; // in volts
11 V4m = 15; // in volts
12 Iom = 0; // in amperes
13 I1m = 0.743; // in Amperes
14 I2m = 0.781; // in Amperes
15 I4m = 0.636; // in Amperes
16 phii1 = 1.190; // in rad
17 phii2 = 0.896; // in rad
```

```
18  phii4 = 0.559; // in rad
19  w = 1000; // in rad
20
21  //calculation:
22  //the average power P is given by
23  P = Vom*Iom + (0.707*V1m)*(0.707*I1m)*cos(phii1) + +
         (0.707*V2m)*(0.707*I2m)*cos(phii2) + (0.707*V4m)
        *(0.707*I4m)*cos(phii4)
24  //rms current
25  Irms = (Iom^2 + (I1m^2 + I2m^2 + I4m^2)/2)^0.5
26  //resistance R
27  R = P/(Irms^2)
28  //impedance
29  Z1 = V1m/I1m
30  //Xc1
31  Xc1 = (Z1^2 - R^2)^0.5
32  //capacitance
33  C = 1/(w*Xc1)
34
35  printf("\n\n Result \n\n")
36  printf("\n(a)the average power P is %.2f W",P)
37  printf("\n(c)the resistance R %.0f ohm and
         capacitance %.2E F",R,C)
```

Scilab code Exa 36.13 Example 13

```
1  //Problem 36.13: In the circuit shown in Figure
      36.17 the supply voltage v is given by v = 300
      sin314t + 120 sin(942t + 0.698) Volts.Determine (a
      ) an expression for the supply current, i, (b)
      the percentage harmonic content of the supply
      current, (c) the total power dissipated, (d) an
      expression for the p.d. shown as v1, and (e) an
      expression for current ic.
2
```

```
3  //initializing the variables:
4  V1m = 300; // in volts
5  V3m = 120; // in volts
6  phiv1 = 0; // in rad
7  phiv2 = 0.698; // in rad
8  w1 = 314; // in rad
9  C = 2.123E-6; // in farads
10 R1 = 560; // in ohms
11 R2 = 2000; // in Ohm
12
13 //calculation:
14 //voltage
15 V1 = V1m*cos(phiv1) + %i*V1m*sin(phiv1)
16 V3 = V3m*cos(phiv3) + %i*V3m*sin(phiv3)
17 //capacitive reactance,
18 Xc1 = 1/(w1*C)
19 //impedance at the fundamental frequency,
20 Z1 = R1 + %i*Xc1*R2/(R2 + %i*Xc1)
21 //Maximum current at fundamental frequency
22 I1m = V1/Z1
23 I1mag = (real(I1m)^2 + imag(I1m)^2)^0.5
24 phii1 = atan(imag(I1m)/real(I1m))
25 //Third harmonic
26 Xc3 = Xc1/3
27 //impedance at the third harmonic frequency,
28 Z3 = R1 + %i*Xc3*R2/(R2 + %i*Xc3)
29 //Maximum current at third harmonic frequency
30 I3m = V3/Z3
31 I3mag = (real(I3m)^2 + imag(I3m)^2)^0.5
32 phii3 = atan(imag(I3m)/real(I3m))
33 //Percentage harmonic content of the supply current
       is given by
34 percent = I3mag*100/I1mag
35 //total active power
36 P = (0.707*V1m)*(0.707*I1mag)*cos(phiv1 - phii1) +
       (0.707*V3m)*(0.707*I3m)*cos(phiv3 - phii3)
37
38 printf("\n\n Result \n\n")
```

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```
39  printf("\n(b)Percentage  harmonic  content  of  the
        supply  current  is  %.0f  percent",percent)
40  printf("\n(c)total  active  power  is  %.2f W",P)
```

Scilab code Exa 36.14 Example 14

```
1  //Problem  36.14:  A  voltage  waveform  having  a
       fundamental  of  maximum  value  400 V  and  a  third
       harmonic  of  maximum  value  10 V  is  applied  to  the
       circuit  shown  in  Figure  36.18.  Determine  (a)  the
       fundamental  frequency  for  resonance  with  the
       third  harmonic ,  and  (b)  the  maximum  value  of  the
       fundamental  and  third  harmonic  components  of
       current .
2
3  //initializing  the  variables :
4  V1m = 400;  // in  volts
5  V3m = 10;  // in  volts
6  C = 0.2E-6;  // in  farads
7  R = 2;  // in  ohms
8  L = 0.5;  // in  Henry
9
10  //calculation :
11  //Resonance  with  the  third  harmonic  means  that
12  w = (1/(9*L*C))^0.5
13  //fundamental  frequency ,  f
14  f = w/(2*%pi)
15  //At  the  fundamental  frequency ,
16  //impedance  Z1
17  Z1 = R + %i*(w*L - 1/(w*C))
18  Z1mag = (real(Z1)^2 + imag(Z1)^2)^0.5
19  phiZ1 = atan(imag(Z1)/real(Z1))
20  //Maximum  value  of  current  at  the  fundamental
       frequency ,
21  I1m = V1m/Z1mag
```

```
22  //At the third harmonic frequency,
23  Z3 = R + %i*(3*w*L - 1/(3*w*C))
24  Z3mag = (real(Z3)^2 + imag(Z3)^2)^0.5
25  phiZ3 = atan(imag(Z3)/real(Z3))
26  //Maximum value of current at the third harmonic
        frequency,
27  I3m = V3m/Z3
28
29  printf("\n\n Result \n\n")
30  printf("\n(a)fundamental frequency for resonance
        with the third harmonic is %.2f Hz",f)
31  printf("\n(b)Maximum value of current at the
        fundamental frequency is %.3f A and at the third
        harmonic frequency %.2f A",I1m, I3m)
```

Scilab code Exa 36.15 Example 15

```
1  //Problem 36.15: A voltage wave has an amplitude of
        800 V at the fundamental frequency of 50 Hz and
        its nth harmonic has an amplitude 1.5% of the
        fundamental. The voltage is applied to a series
        circuit containing resistance 5 ohm, inductance
        0.369 H and capacitance 0.122   F. Resonance
        occurs at the nth harmonic. Determine (a) the
        value of n, (b) the maximum value of current at
        the nth harmonic, (c) the p.d. across the
        capacitor at the nth harmonic and (d) the maximum
         value of the fundamental current.
2
3  //initializing the variables:
4  V1m = 800; // in volts
5  f = 50; // in Hz
6  x = 0.015;
7  C = 0.122E-6; // in farads
8  R = 5; // in ohms
```

```
 9  L = 0.369; // in Henry
10
11  //calculation:
12  //voltage at nth harmonic
13  Vnm = x*V1m
14  w = 2*%pi*f
15  //For resonance at the nth harmonic nwL = 1/nwC
16  n = 1/(w*(L*C)^0.5)
17  //At resonance, impedance
18  Zn = R
19  //the maximum value of current at the nth harmonic
20  Inm = Vnm/Zn
21  //capacitive reactance, at nth harmonic
22  Xcn = 1/(n*w*C)
23  //the p.d. across the capacitor at the nth harmonic
24  Vcn = Inm*Xcn
25  //At the fundamental frequency, inductive reactance,
26  XL1 = w*L
27  //capacitive reactance
28  Xc1 = 1/(w*C)
29  //Impedance at the fundamental frequency,
30  Z1 = R + %i*(XL1 - Xc1)
31  Z1mag = (real(Z1)^2 + imag(Z1)^2)^0.5
32  phiZ1 = atan(imag(Z1)/real(Z1))
33  //Maximum value of current at the fundamental
        frequency,
34  I1m = V1m/Z1mag
35
36  printf("\n\n Result \n\n")
37  printf("\n(a)n = %.0f",n)
38  printf("\n(b)the maximum value of current at the nth
         harmonic %.2f A",Inm)
39  printf("\n(c)the p.d. across the capacitor at the
      nth harmonic is %.2f",Vcn)
40  printf("\n(d)the maximum value of the fundamental
      current. %.2f A",I1m)
```

Chapter 38

Magnetic materials

Scilab code Exa 38.01 Example 1

```
1 //Problem 38.01: The area of a hysteresis loop
     obtained from a ferromagnetic specimen is 12.5
     cm2. The scales used were: horizontal axis 1 cm =
      500 A/m; vertical axis 1 cm = 0.2 T. Determine (
     a) the hysteresis loss per m3 per cycle, and (b)
     the hysteresis loss per m3 at a frequency of 50
     Hz.
2
3 //initializing the variables:
4 A = 12.5; // in cm2
5 x = 500; // horizontal axis 1 cm = 500 A/m
6 y = 0.2; // vertical axis 1 cm = 0.2 T
7 f = 50; // in Hz
8
9 //calculation:
10 //hysteresis loss per cycle
11 HL = A*x*y
12 //At 50 Hz frequency, hysteresis loss
13 HLf = HL*f
14
15 printf("\n\n Result \n\n")
```

```
16  printf("\n(a) hysteresis loss per cycle is = %.0f J/
        m3",HL)
17  printf("\n(b)At 50 Hz frequency, hysteresis loss %.0
        f W/m3",HLf)
```

Scilab code Exa 38.02 Example 2

```
1  //Problem 38.02: If in problem 38.01, the maximum
       flux density is 1.5 T at a frequency of 50 Hz,
       determine the hysteresis loss per m3 for a
       maximum flux density of 1.1 T and frequency of 25
        Hz. Assume the Steinmetz index to be 1.6
2
3  //initializing the variables:
4  n = 1.6; // the Steinmetz index
5  f1 = 50; // in Hz
6  f2 = 25; // in Hz
7  Bm1 = 1.5; // in Tesla
8  Bm2 = 1.1; // in Tesla
9  Ph1 = 62500; // in W/m3
10 v = 1;
11
12 //calculation:
13 //hysteresis loss Ph = kh*v*f*(Bm)^n
14 kh = Ph1/(v*f1*(Bm1)^n)
15 //When f = 25 Hz and Bm = 1.1 T,
16 Ph2 = kh*v*f2*(Bm2)^n
17
18 printf("\n\n Result \n\n")
19 printf("\n hysteresis loss When f = 25 Hz and Bm =
       1.1 T, is = %.0f W/m3",Ph2)
```

Scilab code Exa 38.03 Example 3

```
1  //Problem 38.03: A ferromagnetic ring has a uniform
       cross-sectional area of 2000 mm2 and a mean
       circumference of 1000 mm. A hysteresis loop
       obtained for the specimen is plotted to scales of
        10 mm = 0.1 T and 10 mm = 400 A/m and is found
       to have an area of 104 mm2. Determine the
       hysteresis loss at a frequency of 80 Hz.
2
3  //initializing the variables:
4  csa = 0.002; // in m2
5  l = 1; // in m
6  a = 400/0.01; // 10 mm = 400 A/m
7  b = 0.1/0.01; // 10 mm = 0.1 T
8  A = 0.01; // in m2
9  f = 80; // in Hz
10
11 //calculation:
12 //hysteresis loss per cycle
13 HL = A*a*b
14 //At a frequency of 80 Hz,
15 //hysteresis loss
16 HLf = HL*f
17 //Volume of ring
18 v = csa*l
19 //hysteresis loss
20 Ph = HLf*v
21
22 printf("\n\n Result \n\n")
23 printf("\n the hysteresis loss at a frequency of 80
       Hz is %.0f W",Ph)
```

Scilab code Exa 38.04 Example 4

```
1  //Problem 38.04: The cross-sectional area of a
       transformer limb is 80 cm2 and the volume of the
```

transformer core is 5000 cm3. The maximum value of the core flux is 10 mWb at a frequency of 50 Hz. Taking the Steinmetz constant as 1.7, the hysteresis loss is found to be 100 W. Determine the value of the hysteresis loss when the maximum core flux is 8 mWb and the frequency is 50 Hz.

```
2
3  //initializing the variables:
4  Phi1 = 0.01; // in Wb
5  Phi2 = 0.008; // in Wb
6  csa = 0.008; // in m2
7  v = 0.005; // in m3
8  f = 50; // in Hz
9  n = 1.7; // the Steinmetz constant
10 Ph1 = 100; // in Watt
11
12 //calculation:
13 //maximum flux density
14 Bm1 = Phi1/csa
15 //hysteresis loss Ph1 = kh*v*f*(Bm1)^n
16 kh = Ph1/(v*f*(Bm1)^n)
17 //When the maximum core flux is 8 mWb,
18 Bm2 = Phi2/csa
19 //hysteresis loss, Ph2
20 Ph2 = kh*v*f*(Bm2)^n
21
22 printf("\n\n Result \n\n")
23 printf("\nthe value of the hysteresis loss when the
        maximum core flux is 8 mWb and the frequency is
        50 Hz is %.1f W",Ph2)
```

Scilab code Exa 38.05 Example 5

```
1  //Problem 38.05: The eddy current loss in a
        particular magnetic circuit is 10 W/m3. If the
```

```
        frequency  of  operation  is  reduced  from  50  Hz  to
        30  Hz  with  the  flux  density  remaining  unchanged,
        determine  the  new  value  of  eddy  current  loss  per
        cubic  metre.
 2
 3  //initializing  the  variables:
 4  Pe1 = 10;  //  in  W/m3
 5  f1 = 50;  //  in  Hz
 6  f2 = 30;  //  in  Hz
 7
 8  //calculation:
 9  //When  the  eddy  current  loss  is  10 W/m3,  frequency  f
        is  50  Hz.
10  //constant  k
11  k = Pe1/(f1^2)
12  //When  the  frequency  is  30  Hz,  eddy  current  loss,
13  Pe2 = k*(f2^2)
14
15  printf("\n\n  Result  \n\n")
16  printf("\neddy  current  loss  per  cubic  metre  is  %.1f
        W/m3",Pe2)
```

Scilab code Exa 38.06 Example 6

```
 1  //Problem  38.06:  The  core  of  a  transformer  operating
        at  50  Hz  has  an  eddy  current  loss  of  100 W/m3
        and  the  core  laminations  have  a  thickness  of  0.50
         mm.  The  core  is  redesigned  so  as  to  operate  with
         the  same  eddy  current  loss  but  at  a  different
        voltage  and  at  a  frequency  of  250  Hz.  Assuming
        that  at  the  new  voltage  the  maximum  flux  density
        is  one−third  of  its  original  value  and  the
        resistivity  of  the  core  remains  unaltered,
        determine  the  necessary  new  thickness  of  the
        laminations.
```

```
 2
 3  // initializing the variables :
 4  Pe = 100; // in W/m3
 5  f1 = 50; // in Hz
 6  t1 = 0.0005; // in m
 7  x = 1/3;
 8  f2 = 250; // in Hz
 9
10  // calculation :
11  //Pe = ke *(Bm1* f1 * t1 )^2
12  //Hence , at 50 Hz frequency
13  ke = Pe /(Bm1* f1 * t1 )^2
14  //At 250 Hz frequency
15  Bm2 = x* Bm1
16  t2 = (( Pe / ke )^0.5)/( Bm2 * f2 )
17
18  printf ("\n\n Result \n\n")
19  printf ("\nlamination thickness is %.2Em",t2)
```

Scilab code Exa 38.07 Example 7

```
 1  //Problem 38.07: The core of an inductor has a
        hysteresis loss of 40 W and an eddy current loss
        of 20 W when operating at 50 Hz frequency. (a)
        Determine the values of the losses if the
        frequency is increased to 60 Hz. (b) What will be
         the total core loss if the frequency is 50 Hz
        and the lamination are made one−half of their
        original thickness? Assume that the flux density
        remains unchanged in each case
 2
 3  // initializing the variables :
 4  Ph1 = 40; // in W
 5  Pe1 = 20; // in W
 6  f1 = 50; // in Hz
```

```
 7  x = 1/2;
 8  f2 = 60; // in Hz
 9  t1 = 1;
10  //calculation:
11  //hysteresis loss Ph = kh*v*f*(Bm)^n = k1*f
12  //Thus when the hysteresis is 40 W and the frequency
        50 Hz,
13  k1 = Ph1/f1
14  //If the frequency is increased to 60 Hz,
15  Ph2 = k1*f2
16  //eddy current loss, Pe = ke*(Bm1*f1*t1)^2 = k2*f^2
17  //since the flux density and lamination thickness
        are constant.
18  //When the eddy current loss is 20 W the frequency
        is 50 Hz. Thus
19  k2 = Pe1/(f1^2)
20  //If the frequency is increased to 60 Hz,
21  Pe2 = k2*(f2^2)
22  //hysteresis loss Ph = kh*v*f*(Bm)^n, is independent
        of the thickness of the laminations. Thus, if
        the thickness of the laminations is halved, the
        hysteresis loss remains at
23  Phb2 = Ph1
24  //eddy current loss, Pe = ke*(Bm1*f1*t1)^2 = k2*t^3
25  k3 = Pe1/(t1^3)
26  t2 = 0.5*t1
27  Peb2 = k3*t2^3
28  //total core loss when the thickness of the
        laminations is halved is given by
29  TL = Phb2 + Peb2
30
31  printf(" \n\n Result \n\n")
32  printf(" \n(a)If the frequency is increased to 60 Hz,
        hysteresis loss is %.0f W and eddy current loss %
        .1f W",Ph2, Pe2)
33  printf(" \n(b)the total core loss when the thickness
        of the laminations is halved %.1f W",TL)
```

Scilab code Exa 38.08 Example 8

```
1  //Problem 38.08: When a transformer is connected to
       a 500 V, 50 Hz supply, the hysteresis and eddy
       current losses are 400 Wand 150 W respectively.
       The applied voltage is increased to 1 kV and the
       frequency to 100 Hz. Assuming the Steinmetz index
        to be 1.6, determine the new total core loss.
2
3  //initializing the variables:
4  V1 = 500; // in Volts
5  V2 = 1000; // in Volts
6  Ph1 = 400; // in W
7  Pe1 = 150; // in W
8  f1 = 50; // in Hz
9  n = 1.6; // Steinmetz index
10 f2 = 100; // in Hz
11
12 //calculation:
13 //hysteresis loss Ph = k1*f*(E/f)^n
14 //At 500 V and 50 Hz
15 k1 = Ph1/(f1*(V1/f1)^1.6)
16 //At 1000 V and 100 Hz,
17 Ph2 = k1*f2*(V2/f2)^1.6
18 //eddy current loss, Pe = k2*E^2
19 //At 500 V,
20 k2 = Pe1/(V1^2)
21 //At 1000 V,
22 Pe2 = k2*(V2^2)
23 //the new total core loss
24 TL = Ph2 + Pe2
25
26 printf("\n\n Result \n\n")
27 printf("\n the new total core loss %.0f W",TL)
```

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Scilab code Exa 38.10 Example 10

```
1  //Problem 38.10: The core of a synchrogenerator has
       total losses of 400 W at 50 Hz and 498W at 60 Hz,
        the flux density being constant for the two
       tests. (a) Determine the hysteresis and eddy
       current losses at 50 Hz (b) If the flux density
       is increased by 25% and the lamination thickness
       is increased by 40%, determine the hysteresis and
        eddy current losses at 50 Hz. Assume the
       Steinmetz index to be 1.7.
2
3  //initializing the variables:
4  TL1 = 400; // in Watt
5  TL2 = 498; // in Watt
6  x = 0.25;
7  y = 0.4;
8  f1 = 50; // in Hz
9  n = 1.7; // Steinmetz index
10 f2 = 60; // in Hz
11
12 //calculation:
13 //if volume v and the maximum flux density are
       constant
14 //hysteresis loss Ph = kh*v*f*(Bm)^n = k1*f
15 //(if the maximum flux density and the lamination
       thickness are constant)
16 //eddy current loss, Pe = ke*(Bm1*f1*t1)^2 = k2*f^2
17 //At 50 Hz frequency, TL1 = k1*f1 + k2*f1^2
18 //At 60 Hz frequency, TL2 = k1*f2 + k2*f2^2
19 //Solving equations gives the values of k1 and k2.
20 k2 = (5*TL2 - 6*TL1)/(5*(f2^2) - 6*(f1^2))
21 k1 = (TL1 - k2*f1^2)/f1
22 //hysteresis loss Ph = k1*f
```

```
23  Ph1 = k1*f1
24  //eddy current loss
25  Pe1 = k2*f1^2
26  //Since at 50 Hz the flux density is increased by 25
        %, the new hysteresis loss is
27  Ph2 = Ph1*(1 + x)^1.7
28  //Since at 50 Hz the flux density is increased by 25
        %, and the lamination thickness is increased by
        40%, the new eddy current loss is
29  Pe2 = Pe1*((1 + x)^2)*(1 + y)^3
30
31  printf("\n\n Result \n\n")
32  printf("\n (a)the hysteresis and eddy current losses
         at 50 Hz are %.0 f W and %.0 f W resp.",Ph1, Pe1)
33  printf("\n (b)the hysteresis and eddy current losses
         at 50 Hz after increement are %.1 f W and %.1 f W
        resp.",Ph2, Pe2)
```

Chapter 39

Dielectrics and dielectric loss

Scilab code Exa 39.01 Example 1

```
1  //Problem 39.01: The equivalent series circuit for a
       particular capacitor consists of a 1.5 ohm
       resistance in series with a 400 pF capacitor.
       Determine for the capacitor, at a frequency of 8
       MHz, (a) the loss angle, (b) the power factor, (c
       ) the Q-factor, and (d) the dissipation factor.
2
3  //initializing the variables:
4  Rs = 1.5; // in ohms
5  Cs = 400E-12; // in Farads
6  f = 8E6; // in Hz
7
8  //calculation:
9  //for a series equivalent circuit,
10 //tan(del) = Rs*w*Cs
11 //loss angle,
12 del = atan(Rs*Cs*(2*%pi*f))
13 //power factor
14 pf = cos(del)
15 //the Q-factor
16 Q = 1/tan(del)
```

```
17  //dissipation factor,
18  D = 1/Q
19
20  printf("\n\n Result \n\n")
21  printf("\n (a)loss angle %.3f rad.",del)
22  printf("\n (b)power factor %.3f rad.",del)
23  printf("\n (c)Q-factor is %.2f ",Q)
24  printf("\n (d)dissipation factor %.3f rad.",D)
```

Scilab code Exa 39.02 Example 2

```
1  //Problem 39.02: A capacitor has a loss angle of
       0.025 rad, and when it is connected across a 5 kV
       , 50 Hz supply, the power loss is 20 .W Determine
        the component values of the equivalent parallel
       circuit.
2
3  //initializing the variables:
4  del = 0.025; // in rad.
5  V = 5000; // in Volts
6  PL = 20; // power loss
7  f = 50; // in Hz
8
9  //calculation:
10 //power loss = w*C*V^2*tan(del)
11 Cp = PL/(2*%pi*f*V*V*tan(del))
12 //for a parallel equivalent circuit,
13 //tan(del) = 1/(Rp*w*Cp)
14 Rp = 1/(2*%pi*f*Cp*tan(del))
15
16 printf("\n\n Result \n\n")
17 printf("\n capacitance C %.2E F and parallel
       resistance %.2E ohm.",Cp, Rp)
```

Scilab code Exa 39.03 Example 3

```scilab
1 //Problem 39.03: A 2000 pF capacitor has an
     alternating voltage of 20 V connected across it
      at a frequency of 10 kHz. If the power dissipated
       in the dielectric is 500  W , determine (a) the
      loss angle , (b) the equivalent series loss
      resistance , and (c) the equivalent parallel loss
      resistance.
2
3 //initializing the variables:
4 P = 500E-6; // in Watt
5 C = 2000E-12; // in Farads
6 V = 20; // in Volts
7 f = 10000; // in Hz
8
9 //calculation:
10 //power loss = w*C*V^2*tan(del)
11 //loss angle
12 del = atan(P/(2*%pi*f*V*V*C))
13 //for an equivalent series circuit ,
14 //tan(del) = (Rs*w*Cs)
15 Cs = C
16 Rs = (tan(del))/(2*%pi*f*Cp)
17 //for an equivalent parallel circuit
18 //tan(del) = 1/(Rp*w*Cp)
19 Cp = C
20 Rp = 1/(2*%pi*f*Cp*tan(del))
21
22 printf("\n\n Result \n\n")
23 printf("\n (a)loss angle %.6f rad.",del)
24 printf("\n (b)series resistance %.2f ohm.",Rs)
25 printf("\n (c)parallel resistance %.2E ohm.",Rp)
```

Chapter 40

Field theory

Scilab code Exa 40.01 Example 1

```
1  //Problem 40.01: A field plot between two metal
       plates is shown in Figure 40.9. The relative
       permeability of the dielectric is 2.8. Determine
       the capacitance per metre length of the system.
2
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 2.8;
6  l = 1; // in m
7
8  //calculation:
9  //From Figure 40.9
10 m = 16; // number of parallel squares measured along
       each equipotential
11 n = 6; // the number of series squares measured
       along each line of force
12 C = e0*er*l*m/n
13
14 printf(" \n\n Result \n\n")
15 printf(" \n capacitance is %.3E Farad.",C)
```

Scilab code Exa 40.02 Example 2

```
1  //Problem 40.02: A field plot for a cross-section of
      a concentric cable is shown in Figure 40.10. If
      the relative permeability of the dielectric is
      3.4, determine the capacitance of a 100 m length
      of the cable.
2
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 3.4;
6  l = 100; // in m
7
8  //calculation:
9  //From Figure 40.10
10 m = 13; // number of parallel squares measured along
      each equipotential
11 n = 4; // the number of series squares measured
      along each line of force
12 C = e0*er*l*m/n
13
14 printf("\n\n Result \n\n")
15 printf("\n capacitance is %.3E Farad.",C)
```

Scilab code Exa 40.03 Example 3

```
1  //Problem 40.03: A coaxial cable has an inner core
      radius of 0.5 mm and an outer conductor of
      internal radius 6.0 mm. Determine the capacitance
       per metre length of the cable if the dielectric
      has a relative permittivity of 2.7.
2
```

```
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 2.7;
6  ri = 0.0005; // in m
7  ro = 0.006; // in m
8
9  //calculation:
10 //capacitance C
11 C = 2*%pi*e0*er/(log(ro/ri))
12
13 printf("\n\n Result \n\n")
14 printf("\n capacitance is %.3E Farad.",C)
```

Scilab code Exa 40.04 Example 4

```
1  //Problem 40.04: A single-core concentric cable has
       a capacitance of 80 pF per metre length. The
       relative permittivity of the dielectric is 3.5
       and the core diameter is 8.0 mm. Determine the
       internal diameter of the sheath.
2
3  //initializing the variables:
4  C = 80E-12; // in Farads
5  e0 = 8.85E-12;
6  er = 3.5;
7  d0 = 0.008; // in m
8
9  //calculation:
10 //internal diameter
11 di = d0*(%e^(2*%pi*e0*er/C))
12
13 printf("\n\n Result \n\n")
14 printf("\n internal diameter is %.5f m.",di)
```

Scilab code Exa 40.05 Example 5

```
1  //Problem 40.05: A concentric cable has a core
       diameter of 32 mm and an inner sheath diameter of
        80 mm. The core potential is 40 kV and the
       relative permittivity of the dielectric is 3.5.
       Determine (a) the capacitance per kilometre
       length of the cable, (b) the dielectric stress at
        a radius of 30 mm, and (c) the maximum and
       minimum values of dielectric stress.
2
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 3.5;
6  di = 0.08; // in m
7  d0 = 0.032; // in m
8  r = 0.03; // in m
9  V = 40000; // in Volts
10
11  //calculation:
12  //capacitance C
13  C = 2*%pi*e0*er/(log(di/d0))
14  //dielectric stress at radius r,
15  E = V/(r*log(di/d0))
16  //maximum dielectric stress,
17  Emax = V/((d0/2)*(log((di/d0))))
18  //minimum dielectric stress,
19  Emin = V/((di/2)*(log((di/d0))))
20
21  printf("\n\n Result \n\n")
22  printf("\n capacitance is %.2E F/km",C*1E3)
23  printf("\n dielectric stress at radius r is %.2E V/m
       ",E)
24  printf("\n maximum dielectric stress, is %.2E V/m
```

Scilab code Exa 40.06 Example 6

```
1 //Problem 40.06: A single-core concentric cable is
      to be manufactured for a 60 kV, 50 Hz
      transmission system. The dielectric used is paper
       which has a maximum permissible safe dielectric
      stress of 10 MV/m rms and a relative permittivity
       of 3.5. Calculate (a) the core and inner sheath
      radii for the most economical cable, (b) the
      capacitance per metre length, and (c) the
      charging current per kilometre run.
2
3 //initializing the variables:
4 e0 = 8.85E-12;
5 er = 3.5;
6 V = 60000; // in Volts
7 f = 50; // in Hz
8 Em = 10E6; // in V/m
9
10
11 //calculation:
12 //core radius, a
13 a = V/Em
14 //internal sheath radius,
15 b = a*%e^1
16 //capacitance
17 C = 2*%pi*e0*er/(log(b/a))
18 //Charging current
19 I = V*2*%pi*f*C
20 //charging current per kilometre
21 Ipkm = I*1000
22
23 printf("\n\n Result \n\n")
```

```
24  printf("\n core radius is %.2E m and internal sheath
         radius %.2E m",a,b)
25  printf("\n capacitance is %.2E F/m",C)
26  printf("\n the charging current per kilometre %.2f A
         ",Ipkm)
```

Scilab code Exa 40.07 Example 7

```
1  //Problem 40.07: A concentric cable has a core
       diameter of 25 mm and an inside sheath diameter
       of 80 mm. The relative permittivity of the
       dielectric is 2.5, the loss angle is 3.5 x 10−3
       rad and the working voltage is 132 kV at 50 Hz
       frequency. Determine for a 1 km length of the
       cable (a) the capacitance, (b) the charging
       current and (c) the power loss.
2
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 2.5;
6  di = 0.08; // in m
7  d0 = 0.025; // in m
8  r = 1000; // in m
9  V = 132000; // in Volts
10 f = 50; // in Hz
11 del = 3.5E-3; // rad.
12
13 //calculation:
14 //core radius, a
15 a = d0/2
16 //internal sheath radius,
17 b = di/2
18 //capacitance
19 C = 2*%pi*e0*er*1E3/(log(b/a))
20 //Charging current
```

```
21  I = V*2*%pi*f*C
22  //power loss
23  P = (2*%pi*f*C*tan(del))*V^2
24
25  printf("\n\n Result \n\n")
26  printf("\n (a)capacitance for a 1 km length is %.2E
        F",C)
27  printf("\n (b)the charging current %.2E A/km",I)
28  printf("\n (c)power loss %.0f W",P)
```

Scilab code Exa 40.08 Example 8

```
1  //Problem 40.08: A concentric cable has a core
       diameter of 20 mm and a sheath inside diameter of
        60 mm. The permittivity of the dielectric is
       3.2. Using three equipotential surfaces within
       the dielectric , determine the capacitance of the
       cable per metre length by the method of
       curvilinear squares. Draw the field plot for the
       cable.
2
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 3.2;
6  di = 0.06; // in m
7  d0 = 0.020; // in m
8
9  //calculation:
10  //core radius , a
11  a = d0/2
12  //internal sheath radius ,
13  b = di/2
14  //capacitance
15  C = 2*%pi*e0*er/(log(b/a))
16
```

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```
17 printf("\n\n Result \n\n")
18 printf("\n capacitance per m of length is %.2E F",C)
```

Scilab code Exa 40.09 Example 9

```
1 //Problem 40.09: Two parallel wires, each of
      diameter 5 mm, are uniformly spaced in air at a
      distance of 50 mm between centres. Determine the
      capacitance of the line if the total length is
      200 m.
2
3 //initializing the variables:
4 e0 = 8.85E-12;
5 er = 1;
6 D = 0.05; // in m
7 d = 0.005; // in m
8 l = 200; // in m
9
10 //calculation:
11 //capacitance
12 C = %pi*e0*er/(log(D/(d/2)))
13 //capacitance of a 200 m length
14 C200 = C*l
15
16 printf("\n\n Result \n\n")
17 printf("\n capacitance of a 200 m length is %.2E F",
      C200)
```

Scilab code Exa 40.10 Example 10

```
1 //Problem 40.10: A single-phase circuit is composed
      of two parallel conductors, each of radius 4 mm,
      spaced 1.2 m apart in air. The p.d. between the
```

```scilab
2
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 1;
6  D = 1.2; // in m
7  r = 0.004; // in m
8  f = 50; // in Hz
9  V = 15000; // in Volts
10 l = 1000; // in m
11
12 //calculation:
13 //capacitance
14 C = %pi*e0*er/(log(D/r))
15 //capacitance of a 1 km length
16 Cpkm = C*l
17 //Charge Q
18 Q = Cpkm*V
19 //Charging current
20 I = V*2*%pi*f*Cpkm
21
22 printf("\n\n Result \n\n")
23 printf("\n capacitance per 1km length is %.2E F",
      Cpkm)
24 printf("\n Charge Q is %.2E C",Q)
25 printf("\n Charging current is %.3f A",I)
```

Scilab code Exa 40.11 Example 11

```scilab
1  //Problem 40.11:The charging current for an 800 m
      run of isolated twin line is not to exceed 15 mA.
```

```
2
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 1;
6  I = 0.015; // in Amperes
7  d = 1.25; // in m
8  r = 800; // in m
9  f = 50; // in Hz
10 V = 10000; // in Volts
11
12 //calculation:
13 //capacitance
14 C = I/(2*%pi*f*V)
15 //required maximum value of capacitance
16 Cmax = C/r
17 //maximum diameter of each conductor
18 D = 2*d/(%e^(%pi*e0*er/Cmax))
19
20 printf("\n\n Result \n\n")
21 printf("\n required maximum value of capacitance is
       %.2E F/m",Cmax)
22 printf("\nthe maximum diameter of each conductor is
       %.4f m",D)
```

Scilab code Exa 40.12 Example 12

```
1  //Problem 40.12: Determine the energy stored in a 10
       nF capacitor when charged to 1 kV, and the
       average power developed if this energy is
```

```
       dissipated  in  10     s .
 2
 3  // initializing  the  variables :
 4  e0  =  8.85E -12;
 5  er  =  1;
 6  C  =  10E -9;  //  in  Farad
 7  V  =  1000;  //  in  Volts
 8  t  =  10E -6;  //  in  sec
 9
10  // calculation :
11  // energy  stored ,Wf
12  Wf  =  C*V*V/2
13  // average  power  developed
14  Pav  =  Wf/t
15
16  printf(" \n\n  Result  \n\n")
17  printf(" \n  the  energy  stored  is  %.2E  J",Wf)
18  printf(" \nthe  average  power  developed  is  %.0 f  W",Pav
       )
```

Scilab code Exa 40.13 Example 13

```
 1  // Problem  40.13:  A  capacitor  is  charged  with  5  mC.
       If  the  energy  stored  is  625  mJ,  determine  (a)  the
        voltage  across  the  plates  and  (b)  the
       capacitance  of  the  capacitor .
 2
 3  // initializing  the  variables :
 4  e0  =  8.85E -12;
 5  er  =  1;
 6  Q  =  5E -3;  //  in  Coulomb
 7  W  =  0.625;  //  in  Joules
 8
 9  // calculation :
10  // voltage  across  the  plates
```

```
11  V = 2*W/Q
12  // Capacitance C
13  C = Q/V
14
15  printf (" \n\n  Result  \n\n")
16  printf (" \n  voltage  across  the  plates  is  %.0 f  V",V)
17  printf (" \n  Capacitance  C  is  %.2E  F",C)
```

Scilab code Exa 40.14 Example 14

```
1  // Problem  40.14:  A  ceramic  capacitor  is  to  be
       constructed  to  have  a  capacitance  of  0.01    F  and
        to  have  a  steady  working  potential  of  2.5  kV
       maximum.  Allowing  a  safe  value  of  field  stress  of
        10  MV/m,  determine  (a)  the  required  thickness  of
        the  ceramic  dielectric ,  (b)  the  area  of  plate
       required  if  the  relative  permittivity  of  the
       ceramic  is  10,  and  (c)  the  maximum  energy  stored
       by  the  capacitor .
2
3  // initializing  the  variables :
4  e0 = 8.85E-12;
5  er = 10;
6  C = 0.01E-6; // in Farad
7  E = 10E6; // in V/m
8  V = 2500; // in Volts
9
10  // calculation :
11  // thickness  of  ceramic  dielectric ,
12  d = V/E
13  // cross−sectional  area  of  plate
14  A = C*d/(e0*er)
15  // Maximum  energy  stored ,
16  W = C*V*V/2
17
```

```
18  printf("\n\n Result \n\n")
19  printf("\n thickness of ceramic dielectric is %.2E m
        ",d)
20  printf("\n cross−sectional area of plate, is %.4f m2
        ",A)
21  printf("\n Maximum energy stored is %.4f J",W)
```

Scilab code Exa 40.15 Example 15

```
1  //Problem 40.15: A 400 pF capacitor is charged to a
       p.d. of 100 V. The dielectric has a cross−
       sectional area of 200 cm2 and a relative
       permittivity of 2.3. Calculate the energy stored
       per cubic metre of the dielectric.
2
3  //initializing the variables:
4  e0 = 8.85E-12;
5  er = 2.3;
6  A = 0.02; // in m2
7  C = 400E-12; // in Farad
8  V = 100; // in Volts
9
10 //calculation:
11 //energy stored per unit volume of dielectric,
12 W = ((C*V)^2)/(2*e0*er*A^2)
13
14 printf("\n\n Result \n\n")
15 printf("\n energy stored per unit volume of
       dielectric is %.4f J/m3",W)
```

Scilab code Exa 40.16 Example 16

```
1  //Problem 40.16: A coaxial cable has an inner core
       of radius 1.0 mm and an outer sheath of internal
       radius 4.0 mm. Determine the inductance of the
       cable per metre length. Assume that the relative
       permeability is unity.
2
3  //initializing the variables:
4  u0 = 4*%pi*1E-7;
5  ur = 1;
6  a = 0.001; // in m
7  b = 0.004; // in m
8
9  //calculation:
10 //inductance L
11 L = (u0*ur/(2*%pi))*(0.25 + log(b/a))
12
13 printf("\n\n Result \n\n")
14 printf("\n inductance L is %.2E H/m",L)
```

Scilab code Exa 40.17 Example 17

```
1  //Problem 40.17: A concentric cable has a core
       diameter of 10 mm. The inductance of the cable is
        4 x 10^-7 H/m. Ignoring inductance due to
       internal linkages, determine the diameter of the
       sheath. Assume that the relative permeability is
       1.
2
3  //initializing the variables:
4  u0 = 4*%pi*1E-7;
5  ur = 1;
6  da = 0.010; // in m
7  L = 4E-7; // in H/m
8
9  //calculation:
```

```
10  //diameter of the sheath
11  db = da*(%e^(L/(u0*ur/(2*%pi))))
12
13  printf("\n\n Result \n\n")
14  printf("\n diameter of the sheath is %.4f m",db)
```

Scilab code Exa 40.18 Example 18

```
1  //Problem 40.18: A coaxial cable 7.5 km long has a
       core 10 mm diameter and a sheath 25 mm diameter,
       the sheath having negligible thickness. Determine
        for the cable (a) the inductance, assuming
       nonmagnetic materials, and (b) the capacitance,
       assuming a dielectric of relative permittivity 3.
2
3  //initializing the variables:
4  u0 = 4*%pi*1E-7;
5  ur = 1;
6  e0 = 8.85E-12;
7  er = 3;
8  da = 0.010; // in m
9  db = 0.025; // in m
10  l = 7500; // in m
11
12  //calculation:
13  //inductance per metre length
14  L = (u0*ur/(2*%pi))*(0.25 + log(db/da))
15  //Since the cable is 7500 m long,
16  L7500 = L*7500
17  //capacitance C
18  C = 2*%pi*e0*er/(log(db/da))
19  ////Since the cable is 7500 m long,
20  C7500 = C*7500
21
22  printf("\n\n Result \n\n")
```

```
23  printf("\ninductance is %.5f H",L7500)
24  printf("\ncapCItance is %.2E F",C7500)
```

Scilab code Exa 40.19 Example 19

```
1  //Problem 40.19: A single-phase power line comprises
       two conductors each with a radius 8.0 mm and
       spaced 1.2 m apart in air. Determine the
       inductance of the line per metre length ignoring
       internal linkages. Assume the relative
       permeability ur = 1.
2
3  //initializing the variables:
4  u0 = 4*%pi*1E-7;
5  ur = 1;
6  e0 = 8.85E-12;
7  er = 3;
8  D = 1.2; // in m
9  a = 0.008; // in m
10
11  //calculation:
12  //inductance per metre length
13  L = (u0*ur/(%pi))*(log(D/a))
14
15  printf("\n\n Result \n\n")
16  printf("\ninductance is %.2E H/m",L)
```

Scilab code Exa 40.20 Example 20

```
1  //Problem 40.20: Determine (a) the loop inductance,
       and (b) the capacitance of a 1 km length of
       single-phase twin line having conductors of
       diameter 10 mm and spaced 800 mm apart in air.
```

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```
 2
 3  //initializing the variables:
 4  u0 = 4*%pi*1E-7;
 5  ur = 1;
 6  e0 = 8.85E-12;
 7  er = 1;
 8  l = 1000; // in m
 9  D = 0.8; // in m
10  a = 0.01/2; // in m
11
12  //calculation:
13  //inductance per metre length
14  L = (u0*ur/(%pi))*(0.25 + log(D/a))
15  //Since the cable is 1000 m long,
16  L1k = L*l
17  //capacitance C
18  C = %pi*e0*er/(log(D/a))
19  ////Since the cable is 1000 m long,
20  C1k = C*l
21
22  printf("\n\n Result \n\n")
23  printf("\ninductance is %.5f H",L1k)
24  printf("\ncapcitance is %.2E F",C1k)
```

Scilab code Exa 40.21 Example 21

```
 1  //Problem 40.21: The total loop inductance of an
       isolated twin power line is 2.185   H /m. The
       diameter of each conductor is 12 mm. Determine
       the distance between their centres.
 2
 3  //initializing the variables:
 4  L = 2.185E-6; // in H/m
 5  u0 = 4*%pi*1E-7;
 6  ur = 1;
```

```
7  a = 0.012/2; // in m
8
9  //calculation:
10 //distance D
11 D = a*%e^((L*%pi)/(u0*ur) - 0.25)
12
13 printf(”\n\n Result \n\n”)
14 printf(”\ndistance D is %.2f m”,D)
```

Scilab code Exa 40.22 Example 22

```
1  //Problem 40.22: Calculate the value of the energy
       stored when a current of 50 mA is flowing in a
       coil of inductance 200 mH. What value of current
       would double the energy stored?
2
3  //initializing the variables:
4  L = 0.2; // in H
5  I = 0.05; // in Amperes
6  u0 = 4*%pi*1E-7;
7  ur = 1;
8
9  //calculation:
10 //energy stored in inductor
11 W = L*I*I/2
12 //current I
13 I = (2*2*W/L)^0.5
14
15 printf(”\n\n Result \n\n”)
16 printf(”\nenergy stored in inductor is %.2E J”,W)
17 printf(”\ncurrent I is %.2E A”,I)
```

Scilab code Exa 40.23 Example 23

```
1  //Problem 40.23: The airgap of a moving coil
       instrument is 2.0 mm long and has a cross−
       sectional area of 500 mm2. If the flux density is
        50 mT, determine the total energy stored in the
       magnetic field of the airgap.
2
3  //initializing the variables:
4  B = 0.05; // in Tesla
5  A = 500E-6; // in m2
6  l = 0.002; // in m
7  u0 = 4*%pi*1E-7;
8
9  //calculation:
10 //energy stored
11 W = (B^2)/(2*u0)
12 //Volume of airgap
13 v = A*l
14 //energy stored in airgap
15 W = W*v
16
17 printf("\n\n Result \n\n")
18 printf("\nenergy stored in the airgap is %.2E J",W)
```

Scilab code Exa 40.24 Example 24

```
1  //Problem 40.24: Determine the strength of a uniform
        electric field if it is to have the same energy
       as that established by a magnetic field of flux
       density 0.8 T. Assume that the relative
       permeability of the magnetic field and the
       relative permittivity of the electric field are
       both unity.
2
3  //initializing the variables:
4  B = 0.8; // in Tesla
```

```
 5  A = 500E-6; // in m2
 6  l = 0.002; // in m
 7  u0 = 4*%pi*1E-7;
 8  ur = 1;
 9  e0 = 8.85E-12;
10  er = 1;
11
12  //calculation:
13  //energy stored in mag. field
14  W = (B^2)/(2*u0)
15  //electric field
16  E = (2*W/(e0*er))^0.5
17
18  printf("\n\n Result \n\n")
19  printf("\nelectric field strength is %.2E V/m",E)
```

Chapter 41

Attenuators

Scilab code Exa 41.01 Example 1

```
 1  //Problem 41.01: The ratio of output power to input
       power in a system is
 2  //(a)2 (b) 25 (c) 1000 and (d) 0.01
 3  //Determine the power ratio in each case (i) in
       decibels and (ii) in nepers.
 4
 5  //initializing the variables:
 6  //ratio of output power to input power
 7  rp1 = 2;
 8  rp2 = 25;
 9  rp3 = 1000;
10  rp4 = 0.01;
11
12  //calculation:
13  //power ratio in decibels
14  rpd1 = 10*log10(rp1)
15  rpd2 = 10*log10(rp2)
16  rpd3 = 10*log10(rp3)
17  rpd4 = 10*log10(rp4)
18  //power ratio in nepers
19  rpn1 = (log(rp1))/2
```

```
20  rpn2 = (log(rp2))/2
21  rpn3 = (log(rp3))/2
22  rpn4 = (log(rp4))/2
23
24  printf("\n\n Result \n\n")
25  printf("\n power ratio in decibels are (a)%.0f dB (b
        )%.0f dB (c) %.0f dB and (d) %.0f dB",rpd1,rpd2,
        rpd3,rpd4)
26  printf("\n power ratio in nepers are (a)%.3f Np (b)%
        .3f Np (c) %.3f Np and (d) %.3f Np",rpn1,rpn2,
        rpn3,rpn4)
```

Scilab code Exa 41.02 Example 2

```
1   //Problem 41.02: 5% of the power supplied to a cable
        appears at the output terminals. Determine the
        attenuation in decibels.
2
3   //initializing the variables:
4   rp = 0.05; // power ratio P2/P1
5
6   //calculation:
7   //power ratio in decibels
8   rpd = 10*log10(rp)
9
10  printf("\n\n Result \n\n")
11  printf("\nthe attenuation is %.0f dB",abs(rpd))
```

Scilab code Exa 41.03 Example 3

```
1   //Problem 41.03: An amplifier has a gain of 15 dB.
        If the input power is 12 mW, determine the output
        power.
```

```
 2
 3  //initializing the variables:
 4  gain = 1.5; // in dB
 5  Pi = 0.012; // in Watt
 6
 7  //calculation:
 8  //output power
 9  Po = Pi*10^gain
10
11  printf("\n\n Result \n\n")
12  printf("\noutput power is %.4f W",Po)
```

Scilab code Exa 41.04 Example 4

```
 1  //Problem 41.04: The current output of an attenuator
 2      is 50 mA. If the current ratio of the attenuator
 3      is 1.32 Np, determine (a) the current input and
 4      (b) the current ratio expressed in decibels.
 5      Assume that the input and load resistances of the
 6      attenuator are equal.
 2
 3  //initializing the variables:
 4  I2 = 0.05; // in Amperes
 5  rin = 1.32; // in Np
 6
 7  //calculation:
 8  //current input, I1
 9  I1 = I2*%e^(rin)
10  //current ratio in decibels
11  rid = 20*log10(I2/I1)
12
13  printf("\n\n Result \n\n")
14  printf("\ncurrent input, I1 is %.4f A",I1)
15  printf("\ncurrent ratio in decibels is %.2f dB",rid)
```

Scilab code Exa 41.05 Example 5

```
1 //Problem 41.05: Determine the characteristic
      impedance of each of the attenuator sections
      shown in Figure 41.9.
2
3 //initializing the variables:
4 R1a = 8; // in ohm
5 R2a = 21; // in ohm
6 R1b = 10; // in ohm
7 R2b = 15; // in ohm
8 R1c = 200; // in ohm
9 R2c = 56.25; // in ohm
10
11 //calculation:
12 //for a T-section attenuator the characteristic
      impedance
13 Roa = (R1a^2 + 2*R1a*R2a)^0.5
14 Rob = (R1b^2 + 2*R1b*R2b)^0.5
15 Roc = (R1c^2 + 2*R1c*R2c)^0.5
16
17 printf("\n\n Result \n\n")
18 printf("\nfor a T-sections attenuator the
      characteristic impedances are (a) %.0f ohm, (b) %
      .0f ohm and (c)%.0f ohm",Roa,Rob,Roc)
```

Scilab code Exa 41.06 Example 6

```
1 //Problem 41.06: A symmetrical pi-attenuator pad has
       a series arm of 500 ohm resistance and each
      shunt arm of 1 kohm resistance. Determine (a) the
```

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```
        c h a r a c t e r i s t i c  impedance , and ( b ) the
        attenuation ( in dB) produced by the pad .
2
3  // initializing the variables :
4  R1 = 500; // in ohm
5  R2 = 1000; // in ohm
6  I1 = 1; // in ampere ( lets say )
7
8  // calculation :
9  // for symmetrical pi−attenuator section
10  // characteristic impedance , R0
11  R0 = (R1*(R2^2)/(R1 + 2*R2))^0.5
12  // current Ix
13  Ix = (R2/(R2 + R1 + (R2*R0/(R2 + R0))))*I1
14  // current I2
15  I2 = (R2/(R2 + R0))*Ix
16  ri = I1/I2; // retio of currents
17  // attenuation
18  attn = 20*log10(ri)
19
20  printf(”\n\n Result \n\n”)
21  printf(”\n the characteristic impedance is %.0 f ohm”
       ,R0)
22  printf(”\n attenuation is %.2 f dB”,attn)
```

Scilab code Exa 41.07 Example 7

```
1  // Problem 41.07: For each of the attenuator networks
        shown in Figure 41.11 , determine ( a ) the input
       resistance when the output port is open−circuited
       , ( b ) the input resistance when the output port
       is short−circuited , and ( c ) the characteristic
       impedance .
2
3  // initializing the variables :
```

```
4  R1 = 15; // in ohm
5  R2 = 10; // in ohm
6  R3 = 5; // in ohm
7
8  //calculation:
9  //For the T−network shown in Figure 41.11(i):
10 Roct = R1 + R2
11 Rsct = R1 + R1*R2/(R1 + R2)
12 Rot = (Roct*Rsct)^0.5
13 //For the Pi−network shown in Figure 41.11(ii):
14 Rocpi = R3*(R1 + R3)/(R3 + R1 + R3)
15 Rscpi = R3*R1/(R3 + R1)
16 Ropi = (R1*(R3^2)/(R1 + 2*R3))^0.5
17
18 printf("\n\n Result \n\n")
19 printf("\n the input resistance when the output port
        is open−circuited is (a) %.0f ohm (b) %.0f ohm",
      Roct,Rocpi)
20 printf("\n the input resistance when the output port
        is short−circuited is (a) %.0f ohm (b) %.2f ohm"
      ,Rsct, Rscpi)
21 printf("\n the characteristic impedance is (a) %.1f
      ohm (b) %.2f ohm",Rot, Ropi)
```

Scilab code Exa 41.10 Example 10

```
1  //Problem 41.10: The attenuator shown in Figure
      41.15 feeds a matched load. Determine (a) the
      characteristic impedance R0, and (b) the
      insertion loss in decibels.
2
3  //initializing the variables:
4  R1 = 300; // in ohm
5  R2 = 450; // in ohm
6  I1 = 1; // in ampere (lets say)
```

```
 7
 8  // calculation :
 9  // the  characteristic  impedance  of  a  symmetric  T−pad
       attenuator  is  given  by
10  R0 = (R1^2 + 2*R1*R2)^0.5
11  //By  current  division
12  // current  I2
13  I2 = (R2/(R2 + R1+ R0))*I1
14  ri = I1/I2; // ratio  of  currents
15  // insertion  loss
16  il = 20*log10(ri)
17
18  printf (" \n\n  Result  \n\n")
19  printf (" \n  the  characteristic  impedance  is  %.0 f  ohm"
       ,R0)
20  printf (" \n  insertion  loss  is  %.2 f  dB",il)
```

Scilab code Exa 41.11 Example 11

```
 1  // Problem  41.11:  A  0    3  kohm  rheostat  is  connected
       across  the  output  of  a  signal  generator  of
       internal  resistance  500  ohm.  If  a  load  of  2  kohm
       is  connected  across  the  rheostat ,  determine  the
       insertion  loss  at  a  tapping  of  (a)  2  kohm,  (b)  1
       kohm .
 2
 3  // initializing  the  variables :
 4  r = 500; // in  ohm
 5  Rhm = 3000; // in  ohm
 6  RL = 2000; // in  ohm
 7  r1 = 2000; // in  ohm
 8  r2 = 1000; // in  ohm
 9  E = 1; // in  volts  (lets  say)
10
11  // calculation :
```

```
12 //Without the rheostat in the circuit the voltage
       across the 2 kohm load, VL
13 VL = (RL/(RL + r))*E
14 //voltage V2 with 2kohm tapping
15 V2 = ((RL*r1/(r1 + RL))/((RL*r1/(r1 + RL)) + Rhm -
       r1 + r))*E
16 rv1 = VL/V2; // ratio of currents
17 //insertion loss
18 il1 = 20*log10(rv1)
19 //voltage V1 with 1kohm tapping
20 V1 = ((RL*r2/(r2 + RL))/((RL*r2/(r2 + RL)) + Rhm -
       r2 + r))*E
21 rv2 = VL/V1; // ratio of currents
22 //insertion loss
23 il2 = 20*log10(rv2)
24
25 printf("\n\n Result \n\n")
26 printf("\n insertion loss for 2kohm tap is %.2f dB",
       il1)
27 printf("\n insertion loss for 1kohm tap is %.2f dB",
       il2)
```

Scilab code Exa 41.12 Example 12

```
1 //Problem 41.12: A symmetrical pi-attenuator pad has
       a series arm of resistance 1000 ohm and shunt
     arms each of 500ohm . Determine (a) its
     characteristic impedance, and (b) the insertion
     loss (in decibels) when feeding a matched load..
2
3 //initializing the variables:
4 R1 = 1000; // in ohm
5 R2 = 500; // in ohm
6 I1 = 1; // in amperes (lets say)
7
```

```
8  //calculation:
9  //characteristic  impedance  of  a  symmetrical
       attenuator
10 R0 = (R1*(R2^2)/(R1 + 2*R2))^0.5
11 //current Ix
12 Ix = (R2/(R2 + R1 + (R2*R0/(R2 + R0))))*I1
13 //current I2
14 I2 = (R2/(R2 + R0))*Ix
15 ri = I1/I2; // retio of currents
16 //insertion loss
17 il = 20*log10(ri)
18
19 printf("\n\n Result \n\n")
20 printf("\n characteristic impedance is %.0f ohm",R0)
21 printf("\n insertion loss is %.2f dB",il)
```

Scilab code Exa 41.13 Example 13

```
1  //Problem 41.13: An asymmetrical T-section
       attenuator is shown in Figure 41.24. Determine
       for the section (a) the image impedances, and (b)
        the iterative impedances.
2
3  //initializing the variables:
4  R1 = 100; // in ohm
5  R2 = 200; // in ohm
6  R3 = 300; // in ohm
7  I1 = 1; // in amperes (lets say)
8
9  //calculation:
10 //image impedance Roa
11 Roa = ((R1 + R2)*(R2 + (R1*R3/(R1 + R3))))^0.5
12 //image impedance Rob
13 Rob = ((R1 + R3)*(R3 + (R1*R2/(R1 + R2))))^0.5
14 //The iterative impedance at port 1
```

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```
15  Ri1 = (-1*R1 + (R1^2 - (-1*4*((R2*(R1 + R3)) + (R3*
        R1))))^0.5)/2
16  //The iterative impedance at port 2
17  Ri2 = (R1 + (R1^2 - (-1*4*((R3*(R1 + R2)) + (R2*R1))
        ))^0.5)/2
18
19  printf("\n\n Result \n\n")
20  printf("\n image impedance are %.1f ohm and %.0f ohm
        ",Roa,Rob)
21  printf("\n iterative impedances are %.1f ohm and %.1
        f ohm ",Ri1,Ri2)
```

Scilab code Exa 41.14 Example 14

```
1  //Problem 41.14: An asymmetrical pi-section
       attenuator is shown in Figure 41.28. Determine
       for the section (a) the image impedances, and (b)
        the iterative impedances.
2
3  //initializing the variables:
4  R1 = 1000; // in ohm
5  R2 = 2000; // in ohm
6  R3 = 3000; // in ohm
7  I1 = 1; // in amperes (lets say)
8
9  //calculation:
10  //image impedance Roa
11  Roa = (((R3 + R2)*R1/(R1 + R2 + R3))*(R1*R3/(R1 + R3
        )))^0.5
12  //image impedance Rob
13  Rob = (((R3 + R1)*R2/(R1 + R2 + R3))*(R2*R3/(R2 + R3
        )))^0.5
14  //The iterative impedance at port 1
15  Ri1 = (-1*R1 + ((R1^2) - (-1*4*2*R2*R1))^0.5)/(2*2)
16  //The iterative impedance at port 2
```

```
17  Ri2 = (R1 + ((-1*R1)^2 - (-1*4*2*R2*R1))^0.5)/(2*2)
18
19  printf("\n\n Result \n\n")
20  printf("\n image impedance are %.0f ohm and %.0f ohm
        ",Roa,Rob)
21  printf("\n iterative impedances are %.0f ohm and %.0
        f ohm ",Ri1,Ri2)
```

Scilab code Exa 41.15 Example 15

```
1  //Problem 41.15: A generator having an internal
       resistance of 500 ohm is connected to a 100 ohm
       load via an impedance-matching resistance pad as
       shown in Figure 41.33. Determine (a) the values
       of resistance R1 and R2, (b) the attenuation of
       the pad in decibels, and (c) its insertion loss.
2
3  //initializing the variables:
4  r = 500; // in ohm
5  RL = 100; // in ohm
6  E = 1; // in volts (lets say)
7
8  //calculation:
9  //res.
10 R1 = (r*(r - RL))^0.5
11 R2 = (r*RL^2/(r - RL))^0.5
12 //current I1
13 I1 = E/(r + R1 + R2*RL/(RL + R2))
14 //current I2
15 I2 = (R2/(R2 + RL))*I1
16 //input power
17 P1 = r*I1^2
18 //output power
19 P2 = RL*I2^2
20 //attenuation
```

```
21  attn = 10*log10 (P1/P2)
22  //Load current , IL
23  IL = E/(r + RL)
24  //voltage , VL
25  VL = IL*RL
26  //voltage , V1
27  V1 = E - I1*r
28  //voltage , V2
29  V2 = V1 - I1*R1
30  //insertion loss
31  il = 20*log10 (VL/V2)
32
33  printf ("\n\n Result \n\n")
34  printf ("\n R1 = %.1 f ohm and R2 = %.1 f ohm ",R1 ,R2)
35  printf ("\n attenuation is %.2 f dB ",attn)
36  printf ("\n In decibels , the insertion loss is %.2 f
        dB ",il)
```

Scilab code Exa 41.16 Example 16

```
1  //Problem 41.16: Five identical attenuator sections
       are connected in cascade. The overall attenuation
        is 70 dB and the voltage input to the first
       section is 20 mV. Determine (a) the attenuation
       of eac individual attenuation section , (b) the
       voltage output of the fina stage , and (c) the
       voltage output of the third stage .
2
3  //initializing the variables :
4  attn0 = 70; // in dB
5  n = 5; // numbers of identical atteneurs
6  V1 = 0.02; // in Volts
7
8  //calculation :
9  //attenuation of each section
```

```
10  attn = attn0/n
11  //output of the final stage
12  Vo = V1/(10^(attn0/20))
13  //voltage output of the third stage
14  V3 = V1/(10^(3*attn/20))
15
16  printf("\n\n Result \n\n")
17  printf("\n attenuation of each section = %.0f dB ",
        attn)
18  printf("\n output of the final stage is %.2E V ",Vo)
19  printf("\n voltage output of the third stage is %.2E
        V ",V3)
```

Chapter 42

Filter networks

Scilab code Exa 42.01 Example 1

```
1  //Problem 42.01: Determine the cut−off frequency and
       the nominal impedance of each of the low−pass
     filter sections shown in Figure 42.19.
2
3  //initializing the variables:
4  L1 = 2*100E-3; // in Henry
5  C1 = 0.2E-6; // in Fareads
6  L2 = 0.4; // in Henry
7  C2 = 2*200E-12; // in Fareads
8
9  //calculation:
10 //cut−off frequency
11 fc1 = 1/(%pi*(L1*C1)^0.5)
12 //nominal impedance
13 R01 = (L1/C1)^0.5
14 //cut−off frequency
15 fc2 = 1/(%pi*(L2*C2)^0.5)
16 //nominal impedance
17 R02 = (L2/C2)^0.5
18
19 printf("\n\n Result \n\n")
```

```
20  printf("\n cut−off frequency %.0f Hz and the nominal
        impedance is %.0f ohm ",fc1, R01)
21  printf("\n cut−off frequency %.0f Hz and the nominal
        impedance is %.0f ohm ",fc2, R02)
```

Scilab code Exa 42.02 Example 2

```
1  //Problem 42.02: A filter section is to have a
       characteristic impedance at zero frequency of 600
       ohm and a cut−off frequency at 5 MHz. Design (a)
       a low−pass T section filter, and (b) a low−pass
       pi section filter to meet these requirements.
2
3  //initializing the variables:
4  R0 = 600; // in ohm
5  fc = 5E6; // in Hz
6
7  //calculation:
8  //capacitance
9  C = 1/(%pi*R0*fc)
10 //inductance
11 L = R0/(%pi*fc)
12
13 printf("\n\n Result \n\n")
14 printf("\n A low−pass T section filter capcitance is
       %.2E farad and inductance is%.2E Henry",C, L/2)
15 printf("\n A low−pass pi section filter capcitance
       is %.2E farad and inductance is%.2E Henry",C/2, L
       )
```

Scilab code Exa 42.03 Example 3

```
1  //Problem 42.03: The nominal impedance of a low-pass
        pi section filter is 500 ohm and its cut-off
       frequency is at 100 kHz. Determine (a) the value
       of the characteristic impedance of the section at
        a frequency of 90 kHz, and (b) the value of the
       characteristic impedance of the equivalent low-
       pass T section filter.
2
3  //initializing the variables:
4  R0 = 500; // in ohm
5  fc = 100000; // in Hz
6  f = 90000; // in Hz
7
8  //calculation:
9  //characteristic impedance of the pi section
10 Zpi = R0/(1 - (f/fc)^2)^0.5
11 //characteristic impedance of the T section
12 Zt =  R0*(1 - (f/fc)^2)^0.5
13
14 printf("\n\n Result \n\n")
15 printf("\ncharacteristic impedance of the pi section
       is %.0f ohm",Zpi)
16 printf("\ncharacteristic impedance of the T section
       is %.0f ohm",Zt)
```

Scilab code Exa 42.04 Example 4

```
1  //Problem 42.04: A low-pass  section filter has a
       nominal impedanc of 600 ohm and a cut-off
       frequency of 2 MHz. Determine the frequency at
       which the characteristic impedance of the section
        is (a) 600 ohm (b) 1 kohm (c) 10kohm.
2
3  //initializing the variables:
4  R0 = 600; // in ohm
```

```
5  fc = 2E6; // in Hz
6  Z1 = 600; // in ohm
7  Z2 = 1000; // in ohm
8  Z3 = 10000; // in ohm
9
10 //calculation:
11 //frequency
12 f1 = fc*(1 - (R0/Z1)^2)^0.5
13 f2 = fc*(1 - (R0/Z2)^2)^0.5
14 f3 = fc*(1 - (R0/Z3)^2)^0.5
15
16 printf("\n\n Result \n\n")
17 printf("\nfrequency at which the characteristic
       impedance of the section is 600 ohm is %.0f Hz
       and 1000 Ohm is %.2E Hz and 10000 ohm is %.3E Hz
       ",f1,f2,f3)
```

Scilab code Exa 42.05 Example 5

```
1  //Problem 42.05: Determine for each of the high−pass
        filter sections shown in Figure 42.27 (i) the
       cut−off frequency, and (ii) the nominal impedance
        .
2
3  //initializing the variables:
4  L1 = 100E-3; // in Henry
5  C1 = 0.2E-6/2; // in Fareads
6  L2 = 200E-6/2; // in Henry
7  C2 = 4000E-12; // in Fareads
8
9  //calculation:
10 //cut−off frequency
11 fc1 = 1/(4*%pi*(L1*C1)^0.5)
12 //nominal impedance
13 R01 = (L1/C1)^0.5
```

```
14  //cut−off frequency
15  fc2 = 1/(4*%pi*(L2*C2)^0.5)
16  //nominal impedance
17  R02 = (L2/C2)^0.5
18
19  printf("\n\n Result \n\n")
20  printf("\n cut−off frequency %.0f Hz and the nominal
          impedance is %.0f ohm",fc1, R01)
21  printf("\n cut−off frequency %.0f Hz and the nominal
          impedance is %.0f ohm ",fc2, R02)
```

Scilab code Exa 42.07 Example 7

```
1  //Problem 42.07: A low−pass T section filter having
      a cut−off frequency of 15 kHz is connected in
      series with a high−pass T section filter having a
       cut−off frequency of 10 kHz. The terminating
      impedance of the filter is 600 ohm.(a) Determine
      the values of the components comprising the
      composite filter.
2
3  //initializing the variables:
4  R0 = 600; // in ohm
5  fc1 = 15000; // in Hz
6  fc2 = 10000; // in Hz
7
8  //calculation:
9  //capacitance
10 C1 = 1/(%pi*R0*fc1)
11 //inductance
12 L1 = R0/(%pi*fc1)
13 //capacitance
14 C2 = 1/(4*%pi*R0*fc2)
15 //inductance
16 L2 = R0/(4*%pi*fc2)
```

```
17
18  printf("\n\n Result \n\n")
19  printf("\n A low−pass T section filter capcitance is
        %.2E farad and inductance is%.2E Henry",C1, L1
        /2)
20  printf("\n A high−pass pi section filter capcitance
        is %.2E farad and inductance is%.2E Henry",2*C2,
        L2)
```

Scilab code Exa 42.08 Example 8

```
1  //Problem 42.08: A high−pass T section filter has a
       cut−off frequency of 500 Hz and a nominal
       impedance of 600 ohm. Determine the frequency at
       which the characteristic impedance of the section
        is (a) zero, (b) 300 ohm, (c) 590 ohm.
2
3  //initializing the variables:
4  R0 = 600; // in ohm
5  fc = 500; // in Hz
6  Z1 = 0; // in ohm
7  Z2 = 300; // in ohm
8  Z3 = 590; // in ohm
9
10 //calculation:
11 //frequency
12 f1 = fc
13 f2 = fc/(1 - (Z2/R0)^2)^0.5
14 f3 = fc/(1 - (Z3/R0)^2)^0.5
15
16 printf("\n\n Result \n\n")
17 printf("\nfrequency at which the characteristic
       impedance of the section is 0 ohm is %.0f Hz and
       300 Ohm is %.1f Hz and 590 ohm is %.0f Hz ",f1,f2
       ,f3)
```

Scilab code Exa 42.09 Example 9

```
1 //Problem 42.09: The propagation coefficients of two
       filter networks are given by (a) r = (1.25 + i0
      .52) (b) r = 1.794/_-39.4    Determine for each (i
      ) the attenuation coefficient , and (ii) the phase
       shift coefficient.
2
3 //initializing the variables:
4 r1 = 1.25 + %i*0.52; // propagation coefficients
5 rr = 1.794; // propagation coefficients
6 thetar = -39.4; // in ddegrees
7
8 //calculation:
9 //r
10 r2 = rr*cos(thetar*%pi/180) + %i*rr*sin(thetar*%pi
      /180)
11 //attenuation coefficient
12 a1 = real(r1)
13 a2 = real(r2)
14 //phase shift coefficient
15 b1 = imag(r1)
16 b2 = imag(r2)
17
18 printf("\n\n Result \n\n")
19 printf("\nattenuation coefficient are for (a) is %.2
      f N and for (b) is %.3f N ",a1,a2)
20 printf("\nphase shift coefficient are for (a) is %.2
      f rad and for (b) is %.3f rad ",b1,b2)
```

Scilab code Exa 42.10 Example 10

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```
1  //Problem 42.10: The current input to a filter
        section is 24/_10   mA and the current output is
        8/_-45   mA. Determine for the section (a) the
        attenuation coefficient, (b) the phase shift
        coefficient, and (c) the propagation coefficient.
        (d) If five such sections are cascaded determine
        the output current of the fifth stage and the
        overall propagation constant of the network.
2
3  //initializing the variables:
4  ri1 = 0.024; // in amperes
5  ri2 = 0.008; // in amperes
6  thetai1 = 10; // in ddegrees
7  thetai2 = -45; // in ddegrees
8
9  //calculation:
10 //currents
11 I1 = ri1*cos(thetai1*%pi/180) + %i*ri1*sin(thetai1*
        %pi/180)
12 I2 = ri2*cos(thetai2*%pi/180) + %i*ri2*sin(thetai2*
        %pi/180)
13 //ir
14 ir = I1/I2
15 irmag = ri1/ri2
16 thetai = thetai1-thetai2
17 //attenuation coefficient
18 a = log(irmag)
19 //phase shift coefficient
20 b = thetai*%pi/180
21 //propagation coefficient
22 r = a + %i*b
23 //output current of the fifth stage
24 I6 = I1/(ir^5)
25 x = ir^5
26 xmg = (real(x)^2 + imag(x)^2)^0.5
27 //overall attenuation coefficient
28 ad = log(xmg)
29 //overall phase shift coefficient
```

```
30  bd = atan(imag(x)/real(x)) + 2*%pi
31
32  printf("\n\n Result \n\n")
33  printf("\nattenuation coefficient is %.3f N ",a)
34  printf("\nphase shift coefficient is %.3f rad ",b)
35  printf("\npropagation coefficient is %.3f + (%.3f)i
        ",a,b)
36  printf("\nthe output current of the fifth stage is %
        .2E + (%.2E)i A and the overall propagation
        coefficient is %.2f + (%.2f)i",real(I6),imag(I6),
        ad,bd)
```

Scilab code Exa 42.11 Example 11

```
1  //Problem 42.11: For the low−pass T section filter
       shown in Figure 42.34 determine (a) the
       attenuation coefficient , (b) the phase shift
       coefficient and (c) the propagation coefficient r
       .
2
3  //initializing the variables:
4  XL = %i*5; // in ohms
5  Xc = -1*%i*10; // in ohms
6  RL = 12; // in ohms
7  I1 = 1; // in amperes (lets say)
8
9  //calculation:
10 //current I2
11 I2 = (Xc/(Xc + XL + RL))*I1
12 //current ratio
13 Ir = I1/I2
14 Irmg = (real(Ir)^2 + imag(Ir)^2)^0.5
15 //attenuation coefficient
16 a = log(Irmg)
17 //phase shift coefficient
```

```
18  b = atan(imag(Ir)/real(Ir))
19  //propagation coefficient
20  r = a + %i*b
21
22  printf("\n\n Result \n\n")
23  printf("\nattenuation coefficient is %.3f N ",a)
24  printf("\nphase shift coefficient is %.3f rad ",b)
25  printf("\npropagation coefficient is %.3f + (%.3f)i
        ",a,b)
```

Scilab code Exa 42.12 Example 12

```
1  //Problem 42.12: Determine for the filter section
       shown in Figure 42.40, (a) the time delay for the
        signal to pass through the filter, assuming the
       phase shift is small, and (b) the time delay for
       a signal to pass through the section at the cut−
       off frequency.
2
3  //initializing the variables:
4  L = 2*0.5; // in Henry
5  C = 2E-9; // in Farad
6
7  //calculation:
8  //time delay
9  t = (L*C)^0.5
10 //time delay at the cut−off frequency
11 tfc = t*%pi/2
12
13 printf("\n\n Result \n\n")
14 printf("\n time delay is %.2E sec ",t)
15 printf("\ntime delay at the cut−off frequency is %.2
       E sec",tfc)
```

Scilab code Exa 42.13 Example 13

```
1  //Problem 42.13: A filter network comprising n
       identical sections passes signals of all
       frequencies up to 500 kHz and provides a total
       delay of 9.55   s. If the nominal impedance of
       the circuit into which the filter is inserted is
       1 kohm, determine (a) the values of the elements
       in each section, and (b) the value of n.
2
3  //initializing the variables:
4  fc = 500000; // in Hz
5  t1 = 9.55E-6; // in secs
6  R0 = 1000; // in ohm
7
8  //calculation:
9  //for a low-pass filter section, capacitance
10 C = 1/(%pi*R0*fc)
11 //inductance
12 L = R0/(%pi*fc)
13 //time delay
14 t2 = (L*C)^0.5
15 //number of cascaded sections required
16 n = t1/t2
17
18 printf("\n\n Result \n\n")
19 printf("\n for low-pass T section inductance is %.2E
        H and capacitance is %.2E F",L/2,C)
20 printf("\n for low-pass pi section inductance is %.2
       E H and capacitance is %.2E F",L,C/2)
21 printf("\nnumber of cascaded sections required is %
       .0f",n)
```

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Scilab code Exa 42.14 Example 14

```scilab
1  //Problem 42.14: A filter network consists of 8
       sections in cascade having a nominal impedance of
        1 kohm. If the total delay time is 4  s ,
       determine the component values for each section
       if the filter is (a) a low-pass T network , and (b
       ) a high-pass pi network.
2
3  //initializing the variables:
4  n = 8; // sections in cascade
5  R0 = 1000; // in ohm
6  t1 = 4E-6; // in secs
7
8
9  //calculation:
10 //time delay
11 t2 = t1/n
12 //capacitance
13 C = t2/R0
14 //inductance
15 L = t2*R0
16
17 printf("\n\n Result \n\n")
18 printf("\n for low-pass T section inductance is %.2E
       H and capacitance is %.2E F",L/2,C)
19 printf("\n for high-pass pi section inductance is %
       .2E H and capacitance is %.2E F",2*L,C)
```

Chapter 43

Magnetically coupled circuits

Scilab code Exa 43.01 Example 1

```
1 //Problem 43.01: A and B are two coils in close
    proximity. A has 1200 turns and B has 1000 turns.
     When a current of 0.8 A flows in coil A a flux
    of 100 Wb links with coil A and 75% of this
    flux links coil B. Determine (a) the self
    inductance of coil A, and (b) the mutual
    inductance.
2
3 //initializing the variables:
4 Na = 1200;
5 Nb = 1000;
6 Ia = 0.8; // in amperes
7 Phia = 100E-6; // in Wb
8 xb = 0.75;
9
10 //calculation:
11 //self inductance of coil A
12 La = Na*Phia/Ia
13 //mutual inductance, M
14 Phib = xb*Phia
15 M = Nb*Phib/Ia
```

```
16
17  printf("\n\n Result \n\n")
18  printf("\n self inductance of coil A is %.2f H",La)
19  printf("\n mutual inductance , M is %.2E H",M)
```

Scilab code Exa 43.02 Example 2

```
1  //Problem 43.02: Two circuits have a mutual
       inductance of 600 mH. A current of 5 A in the
       primary is reversed in 200 ms. Determine the e.m.
       f. induced in the secondary , assuming the current
        changes at a uniform rate .
2
3  //initializing the variables :
4  M = 600E-3; // in Henry
5  Ia = 5; // in amperes
6  dt = 0.2; // in secs
7
8  //calculation :
9  //change of current
10 dIa = 2*Ia
11 dIadt = dIa/dt
12 //secondary induced e.m.f., E2
13 E2 = -1*M*dIadt
14
15 printf("\n\n Result \n\n")
16 printf("\n secondary induced e.m.f., E2 is %.0f V",
       E2)
```

Scilab code Exa 43.03 Example 3

```
1  //Problem 43.03: Two coils have self inductances of
       250 mH and 400 mH respectively. Determine the
       magnetic coupling coefficient of the pair of
       coils if their mutual inductance is 80 mH.
2
3  //initializing the variables:
4  La = 250E-3; // in Henry
5  Lb = 400E-3; // in Henry
6  M = 80E-3; // in Henry
7
8  //calculation:
9  //coupling coefficient,
10 k = M/(La*Lb)^0.5
11
12 printf("\n\n Result \n\n")
13 printf("\n coupling coefficient, is %.3f",k)
```

Scilab code Exa 43.04 Example 4

```
1  //Problem 43.04: Two coils, X and Y, having self
       inductances of 80 mH and 60 mH respectively, are
       magnetically coupled. Coil X has 200 turns and
       coil Y has 100 turns. When a current of 4A flows
       in coil X the change of flux in coil Y is 5 mWb.
       Determine (a) the mutual inductance between the
       coils, and (b) the coefficient of coupling.
2
3  //initializing the variables:
4  Lx = 80E-3; // in Henry
5  Ly = 60E-3; // in Henry
6  Nx = 200; // turns
7  Ny = 100; // turns
8  Ix = 4; // in Amperes
9  Phiy = 0.005; // in Wb
10
```

```
11  //calculation:
12  //mutual inductance, M
13  M = Ny*Phiy/(2*Ix)
14  //coupling coefficient,
15  k = M/(Lx*Ly)^0.5
16
17  printf("\n\n Result \n\n")
18  printf("\n mutual inductance, M is %.2E H",M)
19  printf("\n coupling coefficient, is %.3f",k)
```

Scilab code Exa 43.05 Example 5

```
1  //Problem 43.05: Two coils connected in series have
       self inductance of 40 mH and 10 mH respectively.
       The total inductance of the circuit is found to
       be 60 mH. Determine (a) the mutual inductance
       between the two coils, and (b) the coefficient of
       coupling.
2
3  //initializing the variables:
4  La = 40E-3; // in Henry
5  Lb = 10E-3; // in Henry
6  L = 60E-3; // in Henry
7
8  //calculation:
9  //mutual inductance, M
10  M = (L - La - Lb)/2
11  //coupling coefficient,
12  k = M/(La*Lb)^0.5
13
14  printf("\n\n Result \n\n")
15  printf("\n mutual inductance, M is %.2E H",M)
16  printf("\n coupling coefficient, is %.3f",k)
```

Scilab code Exa 43.06 Example 6

```
1  //Problem 43.06: Two mutually coupled coils X and Y
      are connected in series to a 240 V d.c. supply.
      Coil X has a resistance of 5 ohm and an
      inductance of 1 H. Coil Y has a resistance of 10
      ohm and an inductance of 5 H. At a certain
      instant after the circuit is connected, the
      current is 8 A and increasing at a rate of 15 A/s
      . Determine (a) the mutual inductance between the
       coils and (b) the coefficient of coupling.
2
3  //initializing the variables:
4  V = 240; // in Volts
5  Ra = 5; // in Ohm
6  La = 1; // in Henry
7  Rb = 10; // in Ohm
8  Lb = 5; // in Henry
9  I = 8; // in amperes
10 dIdt = 15; // in A/sec
11
12 //calculation:
13 //Kirchhoff s voltage law
14 L = (V - I*(Ra + Rb))/dIdt
15 //mutual inductance, M
16 M = (L - La - Lb)/2
17 //coupling coefficient,
18 k = M/(La*Lb)^0.5
19
20 printf("\n\n Result \n\n")
21 printf("\n mutual inductance, M is %.0f H",M)
22 printf("\n coupling coefficient, is %.3f",k)
```

Scilab code Exa 43.07 Example 7

```
1  //Problem 43.07: Two coils are connected in series
       and their effective inductance is found to be 15
       mH. When the connection to one coil is reversed,
       the effective inductance is found to be 10 mH. If
        the coefficient of coupling is 0.7, determine (a
       ) the self inductance of each coil, and (b) the
       mutual inductance.
2
3  //initializing the variables:
4  k = 0.7; // coefficient of coupling
5  L1 = 15E-3; // in Henry
6  L2 = 10E-3; // in Henry
7
8  //calculation:
9  //L1 = La + Lb + 2*k*(La*Lb)^0.5
10 //L2 = La + Lb - 2*k*(La*Lb)^0.5
11 //self inductance of coils
12 a = ((L1 - (L1  + L2)/2)/(2*k))^2
13 La1 =((L1  + L2)/2 + (((L1  + L2)/2)^2 - 4*a)^0.5)/2
14 La2 =((L1  + L2)/2 - (((L1  + L2)/2)^2 - 4*a)^0.5)/2
15 Lb1 = (L1 + L2)/2 - La1
16 Lb2 = (L1 + L2)/2 - La2
17 //mutual inductance, M
18 M = (L1 - L2)/4
19
20 printf("\n\n Result \n\n")
21 printf("\nself inductance of coils are %.2E H and %
       .2E H",La1, Lb1)
22 printf("\n mutual inductance, M is %.2E H",M)
```

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Scilab code Exa 43.08 Example 8

```
1  //Problem 43.08: For the circuit shown in Figure
       43.7, determine the p.d. E2 which appears across
       the open-circuited secondary winding, given that
       E1 D 8 sin 2500t volts.
2
3  //initializing the variables:
4  E1 = 8; // in Volts
5  thetae1 = 0; // in degrees
6  w = 2500; // in rad/sec
7  R = 15; // in ohm
8  L = 5E-3; // in Henry
9  M = 0.1E-3; // in Henry
10
11 //calculation:
12 //voltage
13 E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
       /180)
14 //Impedance of primary
15 Z1 = R + %i*w*L
16 //Primary current I1
17 I1 = E1/Z1
18 //E2
19 E2 = %i*w*M*I1
20
21 printf("\n\n Result \n\n")
22 printf("\nE2 is %.2f + (%.2f)i V",real(E2), imag(E2)
       )
```

Scilab code Exa 43.09 Example 9

```
1  //Problem 43.09: Two coils x and y, with negligible
       resistance, have self inductances of 20 mH and 80
        mH respectively, and the coefficient of coupling
```

```
          between them is 0.75. If a sinusoidal
          alternating p.d. of 5 V is applied to x,
          determine the magnitude of the open circuit e.m.f
          . induced in y.
 2
 3  //initializing the variables:
 4  Lx = 20E-3; // in Henry
 5  Ly = 80E-3; // in Henry
 6  k = 0.75; // coupling coeff.
 7  Ex = 5; // in Volts
 8
 9  //calculation:
10  //mutual inductance
11  M = k*(Lx*Ly)^0.5
12  //magnitude of the open circuit e.m.f. induced
13  Ey = M*Ex/Lx
14
15  printf("\n\n Result \n\n")
16  printf("\n mutual inductance is %.2f H",M)
17  printf("\n magnitude of the open circuit e.m.f.
          induced is %.2f V",Ey)
```

Scilab code Exa 43.10 Example 10

```
 1  //Problem 43.10: For the circuit shown in Figure
          43.9, determine the value of the secondary
          current I2 if E1 = 2/_0   volts and the frequency
          is 1000/pi Hz.
 2
 3  //initializing the variables:
 4  E1 = 2; // in Volts
 5  thetae1 = 0; // in degrees
 6  f = 1000/%pi; // in Hz
 7  R1 = 4; // in ohm
 8  R2 = 16; // in ohm
```

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```
 9  R3 = 16; // in ohm
10  R4 = 50; // in ohm
11  L = 10E-3; // in Henry
12  M = 2E-3; // in Henry
13
14  //calculation:
15  w = 2*%pi*f
16  //voltage
17  E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
        /180)
18  //R1e is the real part of Z1e
19  R1e = R1 + R2 + ((R3 + R4)*(M^2)*(w^2))/((R3 + R4)^2
        + (w*L)^2)
20  //X1e is the imaginary part of Z1e
21  X1e = w*L - (L*(M^2)*(w^3))/((R3 + R4)^2 + (w*L)^2)
22  Z1e = R1e + %i*X1e
23  Z2e = R3 + R4 + %i*w*L
24  //primary current, I1
25  I1 = E1/Z1e
26  //E2
27  E2 = %i*w*M*I1
28  //secondary current I2
29  I2 = E2/Z2e
30
31  printf("\n\n Result \n\n")
32  printf("\n secondary current I2 is %.2E +(%.2E)i A",
        real(I2), imag(I2))
```

Scilab code Exa 43.11 Example 11

```
1  //Problem 43.11: For the coupled circuit shown in
       Figure 43.10, calculate (a) the self impedance of
        the primary circuit, (b) the self impedance of
       the secondary circuit, (c) the impedance
       reflected into the primary circuit, (d) the
```

```
      effective  primary  impedance,  (e)  the  primary
      current,  and  (f)  the  secondary  current
 2
 3  //initializing  the  variables:
 4  E1 = 50;  // in  Volts
 5  thetae1 = 0;  // in  degrees
 6  w = 500;  // in  rad/sec
 7  R1 = 300;  // in  ohm
 8  L1 = 0.2;  // in  Henry
 9  L2 = 0.5;  // in  Henry
10  L3 = 0.3;  // in  Henry
11  R2 = 500;  // in  ohm
12  C = 5E-6;  // in  farad
13  M = 0.2;  // in  Henry
14
15  //calculation:
16  //voltage
17  E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
      /180)
18  // Self  impedance  of  primary  circuit
19  Z1 = R1 + %i*w*(L1 + L2)
20  //Self  impedance  of  secondary  circuit,
21  Z2 = R2 + %i*(w*L3 - 1/(w*C))
22  //reflected  impedance,  Zr
23  Zr = (w*M)^2/Z2
24  //Effective  primary  impedance,
25  Z1e = Z1 + Zr
26  //Primary  current  I1
27  I1 = E1/Z1e
28  //Secondary  current  I2
29  E2 = %i*w*M*I1
30  I2 = E2/Z2
31
32  printf("\n\n  Result  \n\n")
33  printf("\n  Self  impedance  of  primary  circuit,  Z1  is
       %.0f + (%.0f)i  ohm",real(Z1),  imag(Z1))
34  printf("\n  Self  impedance  of  secondary  circuit,  Z2
      is  %.0f + (%.0f)i  ohm",real(Z2),  imag(Z2))
```

```
35  printf("\n reflected impedance, Zr is %.0f +(%.0f)i
       ohm",real(Zr), imag(Zr))
36  printf("\n Effective primary impedance Z1(eff) is %
       .0f +(%.0f)i ohm",real(Z1e), imag(Z1e))
37  printf("\n primary current I1 is %.2f +(%.2f)i A",
       real(I1), imag(I1))
38  printf("\n secondary current I2 is %.2f +(%.2f)i A",
       real(I2), imag(I2))
```

Scilab code Exa 43.12 Example 12

```
1  //Problem 43.12: For the circuit shown in Figure
       43.12 each winding is tuned to resonate at the
       same frequency. Determine (a) the reso-nant
       frequency, (b) the value of capacitor C2 , (c)
       the effective primary impedance, (d) the primary
       current, (e) the voltage across capacitor C2 and
       (f) the coefficient of coupling.
2
3  //initializing the variables:
4  E1 = 20; // in Volts
5  thetae1 = 0; // in degrees
6  R1 = 15; // in ohm
7  C1 = 400E-12; // in farad
8  R2 = 30; // in ohm
9  L1 = 0.001; // in Henry
10 L2 = 0.0002; // in Henry
11 R3 = 50; // in ohm
12 M = 10E-6; // in Henry
13
14 //calculation:
15 //voltage
16 E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
       /180)
17 //the resonant frequency, fr
```

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```
18  fr = 1/(2*%pi*(L1*C1)^0.5)
19  w = 2*%pi*fr
20  //The secondary is also tuned to a resonant
        frequency
21  //capacitance ,C2
22  C2 = 1/(L2*(2*%pi*fr)^2)
23  //the effective primary impedance Z1eff
24  Z1e = R1 + R2 + ((w*M)^2)/R3
25  //Primary current I1
26  I1 = E1/Z1e
27  //Secondary current I2
28  E2 = %i*w*M*I1
29  I2 = E2/R3
30  //voltage across capacitor C2
31  Vc2 = I2*-1*%i/(w*C2)
32  //coefficient of coupling, k
33  k = M/(L1*L2)^0.5
34
35  printf("\n\n Result \n\n")
36  printf("\n the resonant frequency ,fr is %.0f Hz",fr)
37  printf("\n capacitance ,C2 is %.2E F",C2)
38  printf("\n Effective primary impedance Z1(eff) is %
        .0f +(%.0f)i ohm",real(Z1e), imag(Z1e))
39  printf("\n primary current I1 is %.2f +(%.2f)i A",
        real(I1), imag(I1))
40  printf("\n voltage across capacitor C2 is %.0f +(%.0
        f)i V",real(Vc2), imag(Vc2))
41  printf("\n coefficient of coupling, k  is %.4f",k)
```

Scilab code Exa 43.13 Example 13

```
1  //Problem 43.13:For the coupled circuit shown in
        Figure 43.16, determiine the values of currents
        I1 and I2.
2
```

```
 3  //initializing the variables :
 4  E1 = 250; // in Volts
 5  thetae1 = 0; // in degrees
 6  R1 = %i*50; // in ohm
 7  R2 = 10; // in ohm
 8  R3 = 10; // in ohm
 9  R4 = %i*50; // in ohm
10  R5 = 50; // in ohm
11  M = %i*10; // in ohm
12
13  //calculation :
14  //voltage
15  E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
        /180)
16  //Applying Kirchhoff s voltage law to the primary
        circuit gives
17  //(R1 + R2)*I1 − M*I2 = E1
18  //Applying Kirchhoff s voltage law to the
        secondary circuit gives
19  //−1*M*I1 + ( R3 + R4 + R5)*I2 = 0
20  //solving these two
21  I2 = E1/((R1 + R2)*(R3 + R4 + R5)/(M) + (-1*M))
22  I1 = I2*(R3 + R4 + R5)/(M)
23
24  printf("\n\n Result \n\n")
25  printf("\n primary current I1 is %.2f +(%.2f)i A",
        real(I1), imag(I1))
26  printf("\n secondary current I2 is %.2f +(%.2f)i A",
        real(I2), imag(I2))
```

Scilab code Exa 43.14 Example 14

```
1  //Problem 43.14:The circuit diagram of an air−cored
       transformer winding is shown in Figure 43.17. The
       coefficient of coupling between primary and
```

```
      secondary windings is 0.70. Determine for the
      circuit (a) the mutual inductance M, (b) the
      primary current I1 and (c) the secondary terminal
       p.d.
 2
 3  //initializing the variables:
 4  re = 40; // in Volts
 5  thetae1 = 0; // in degrees
 6  R1 = 5; // in ohm
 7  L1 = 0.001; // in Henry
 8  L2 = 0.006; // in Henry
 9  R2 = 40; // in ohm
10  rzl = 200; // in ohm
11  thetazl = -60; // in degrees
12  k = 0.70
13  f = 20000; // in Hz
14
15  //calculation:
16  w = 2*%pi*f
17  //voltage
18  E1 = re*cos(thetae1*%pi/180) + %i*re*sin(thetae1*%pi
      /180)
19  //impedance
20  ZL = rzl*cos(thetazl*%pi/180) + %i*rzl*sin(thetazl*
      %pi/180)
21  //mutual inductance, M
22  M = k*(L1*L2)^0.5
23  //Applying Kirchhoff s voltage law to the primary
       circuit gives
24  //(R1 + %i*w*L1)*I1 - %i*w*M*I2 = E1
25  //Applying Kirchhoff s voltage law to the
       secondary circuit gives
26  //-1*%i*w*M*I1 + ( R2 + ZL + %i*w*L2)*I2 = 0
27  //solving these two
28  I1 = E1/((R1 +%i*w*L1) - (%i*w*M)^2/(R2 + ZL + %i*w*
      L2))
29  //secondary terminal p.d.
30  pd = I2*ZL
```

499

```
31
32  printf("\n\n Result \n\n")
33  printf("\n mutual induction M is %.2E H",M)
34  printf("\n primary current I1 is %.2f +(%.2f)i A",
        real(I1), imag(I1))
35  printf("\n secondary terminal p.d. is %.2f +(%.2f)i
        V",real(pd), imag(pd))
```

Scilab code Exa 43.15 Example 15

```
1  //Problem 43.15:A mutual inductor is used to couple
       a 20 ohm resistive load to a 50/_0  V generator
        as shown in Figure 43.18. The generator has an
        internal resistance of 5 ohm and the mutual
        inductor parameters are R1 = 20 ohm , L1 = 0.2 H,
         R2 = 25 ohm , L2 = 0.4 H and M = 0.1 H. The
        supply frequency is 75/pi Hz. Determine (a) the
        generator current I1 and (b) the load current I2
        .
2
3  //initializing the variables:
4  E1 = 50; // in Volts
5  thetae1 = 0; // in degrees
6  r = 5; // in ohm
7  R1 = 20; // in ohm
8  L1 = 0.2; // in Henry
9  L2 = 0.4; // in Henry
10  R2 = 25; // in ohm
11  RL = 20; // in ohm
12  M = 0.1; // in Henry
13  f = 75/%pi; // in Hz
14
15  //calculation:
16  w = 2*%pi*f
17  //voltage
```

```
18  E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
      /180)
19  //Applying  Kirchhoff  s  voltage  law  to  the  primary
      circuit  gives
20  //(r + R1 + %i*w*L1)*I1 - %i*w*M*I2 = E1
21  //Applying  Kirchhoff  s  voltage  law  to  the
      secondary  circuit  gives
22  //-1*%i*w*M*I1 + ( R2 + RL + %i*w*L2)*I2 = 0
23  //solving  these  two
24  I2 = E1/((r + R1 + %i*w*L1)*(R2 + RL + %i*
      w*M) + (-1*%i*w*M))
25  I1 = I2*(R2 + RL + %i*w*L2)/(%i*w*M)
26
27  printf("\n\n Result \n\n")
28  printf("\n primary  current  I1  is  %.2f +(%.2f)i A",
      real(I1), imag(I1))
29  printf("\n load  current  I2  is  %.2f +(%.2f)i A",real(
      I2), imag(I2))
```

Scilab code Exa 43.16 Example 16

```
1  //Problem  43.16:The  mutual  inductor  of  problem  43.15
       is  connected  to  the  circuit  of  Figure  43.19.
      Determine  the  source  and  load  currents  for  (a)
      the  windings  as  shown  (i.e.  with  the  dots
      adjacent),  and  (b)  with  one  winding  reversed  (i.e
      . with  the  dots  at  opposite  ends).
2
3  //initializing  the  variables:
4  E1 = 50; // in  Volts
5  thetae1 = 0; // in  degrees
6  r = 5; // in  ohm
7  R1 = 20; // in  ohm
8  L1 = 0.2; // in  Henry
9  R = 8; // in  ohm
```

```
10  L = 0.1; // in Henry
11  L2 = 0.4; // in Henry
12  R2 = 25; // in ohm
13  RL = 20; // in ohm
14  M = 0.1; // in Henry
15  f = 75/%pi; // in Hz
16
17  //calculation:
18  w = 2*%pi*f
19  //voltage
20  E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
        /180)
21  //Applying Kirchhoff s voltage law to the primary
         circuit gives
22  //(r + R1 + %i*w*L1 + R + %i*w*L)*I1 - (%i*w*M + R +
         %i*w*L)*I2 = E1
23  //Applying Kirchhoff s voltage law to the
         secondary circuit gives
24  //-1*(%i*w*M + R + %i*w*L)*I1 + (R2 + RL + %i*w*L2 +
         R + %i*w*L)*I2 = 0
25  //solving these two
26  I2 = E1/((r + R1 + %i*w*L1 + R + %i*w*L)*(R2 + RL +
        %i*w*L2 + R + %i*w*L)/((%i*w*M + R + %i*w*L)) +
        (-1*(%i*w*M + R + %i*w*L)))
27  I1 = I2*(R2 + RL + %i*w*L2 + R + %i*w*L)/(%i*w*M + R
         + %i*w*L)
28  //reversing
29  //Applying Kirchhoff s voltage law to the primary
         circuit gives
30  //(r + R1 + %i*w*L1 + R + %i*w*L)*I1r - (-1*%i*w*M +
         R + %i*w*L)*I2r = E1
31  //Applying Kirchhoff s voltage law to the
         secondary circuit gives
32  //-1*(-1*%i*w*M + R + %i*w*L)*I1r + (R2 + RL + %i*w*
        L2 + R + %i*w*L)*I2r = 0
33  //solving these two
34  I2r = E1/((r + R1 + %i*w*L1 + R + %i*w*L)*(R2 + RL +
        %i*w*L2 + R + %i*w*L)/((-1*%i*w*M + R + %i*w*L))
```

```
         + (-1*(-1*%i*w*M + R + %i*w*L)))
35  I1r = I2r*(R2 + RL + %i*w*L2 + R + %i*w*L)/((-1*%i*w
     *M + R + %i*w*L))
36
37  printf("\n\n Result \n\n")
38  printf("\n primary current I1 is %.2f +(%.2f)i A",
     real(I1), imag(I1))
39  printf("\n load current I2 is %.2f +(%.2f)i A",real(
     I2), imag(I2))
40  printf("\n reversed primary current I1r is %.2f +(%
     .2f)i A",real(I1r), imag(I1r))
41  printf("\n reversed load current I2r is %.2f +(%.2f)
     i A",real(I2r), imag(I2r))
```

Chapter 44

Transmission lines

Scilab code Exa 44.01 Example 1

```
1  //Problem 44.01:A parallel−wire air−spaced
      transmission line operating at 1910 Hz has a
      phase shift of 0.05 rad/km. Determine (a) the
      wavelength on the line, and (b) the speed of
      transmission of a signal.
2
3  //initializing the variables:
4  f = 1910; // in Hz
5  b = 0.05; // in rad/km
6
7  //calculation:
8  w = 2*%pi*f
9  //wavelength
10 Y = 2*%pi/b
11 //speed of transmission
12 u = f*Y
13
14 printf(" \n\n Result \n\n")
15 printf(" \n wavelength Y is %.1f km",Y)
16 printf(" \n speed of transmission %.2E km/sec",u)
```

Scilab code Exa 44.02 Example 2

```
1 //Problem 44.02:A transmission line has an
      inductance of 4 mH/loop km and a capacitance of
      0.004   F /km. Determine , for a frequency of
      operation of 1 kHz, (a) the phase delay , (b) the
      wavelength on the line , and (c) the velocity of
      propagation (in metres per second) of the signal.
2
3 //initializing the variables:
4 L = 0.004; // in Henry/loop
5 C = 0.004E-6; // in F/loop
6 f = 1000; // in Hz
7
8 //calculation:
9 w = 2*%pi*f
10 //phase delay
11 b = w*(L*C)^0.5
12 //wavelength
13 Y = 2*%pi/b
14 //speed of transmission
15 u = f*Y
16
17 printf(”\n\n Result \n\n”)
18 printf(”\n phase delay is %.3f rad/km”,b)
19 printf(”\n wavelength Y is %.1f km”,Y)
20 printf(”\n speed of transmission %.2E km/sec”,u)
```

Scilab code Exa 44.03 Example 3

```
1 //Problem 44.03: When operating at a frequency of 2
      kHz, a cable has an attenuation of 0.25 Np/km and
```

a phase shift of 0.20 rad/km. If a 5 V rms
signal is applied at the sending end, determine
the voltage at a point 10 km down the line,
assuming that the termination is equal to the
characteristic impedance of the line.

```
2
3  // initializing the variables:
4  a = 0.25; // in Np/km
5  b = 0.20; // in rad/km
6  Vs = 5; // in Volts
7  n = 10; // in km
8  f = 2000; // in Hz
9
10 // calculation:
11 w = 2*%pi*f
12 // the voltage 10 km down the line
13 r = a + %i*b
14 VR = Vs*%e^(-1*n*r)
15
16 printf("\n\n Result \n\n")
17 printf("\n the voltage 10 km down the line is %.2 f
        +(%.2 f)i A",real(VR), imag(VR))
```

Scilab code Exa 44.04 Example 4

```
1  // Problem 44.04: A transmission line 5 km long has a
        characteristic impedance of 800/_−25   ohm. At a
        particular frequency, the attenuation
        coefficient of the line is 0.5 Np/km and the
        phase shift coefficient is 0.25 rad/km. Determine
        the magnitude and phase of the current at the
        receiving end, if the sending end voltage is 2.0/
        _0   V r.m.s.
2
3  // initializing the variables:
```

```
4  a = 0.5; // in Np/km
5  b = 0.25; // in rad/km
6  rvs = 2; // in Volts
7  thetavs = 0; // in degrees
8  rzo = 800; // in ohm
9  thetazo = -25; // in degrees
10 n = 5; // in km
11
12 // calculation:
13 // voltage
14 Vs = rvs*cos(thetavs*%pi/180) + %i*rvs*sin(thetavs*
      %pi/180)
15 // characteristic impedance
16 Zo = rzo*cos(thetazo*%pi/180) + %i*rzo*sin(thetazo*
      %pi/180)
17 // receiving end voltage
18 r = a + %i*b
19 VR = Vs*%e^(-1*n*r)
20 // Receiving end current,
21 IR = VR/Zo
22
23 printf("\n\n Result \n\n")
24 printf("\n Receiving end current, IR is %.2E +(%.2E)
      i A",real(IR), imag(IR))
```

Scilab code Exa 44.05 Example 5

```
1 // Problem 44.05: The voltages at the input and at
     the output of a transmission line properly
     terminated in its characteristic impedance are
     8.0 V and 2.0 V rms respectively. Determine the
     output voltage if the length of the line is
     doubled.
2
3 // initializing the variables:
```

```
4  Vs = 8; // in Volts
5  VR = 2; // in Volts
6  x = 2;
7
8  // calculation :
9  // receiving end voltage VR = Vs*e^(-nr)
10 //e^-nr = p
11 p = VR/Vs
12 // If the line is doubled in length , then
13 VR = Vs*(p)^2
14
15 printf("\n\n Result \n\n")
16 printf("\n Receiving end voltage If the line is
        doubled in length , VR is %.2f +(%.2f)i V",real(VR
        ), imag(VR))
```

Scilab code Exa 44.06 Example 6

```
1  //Problem 44.06: At a frequency of 1.5 kHz the open−
        circuit impedance of a length of transmission
        line is 800/_-50  ohm and the short−circuit
        impedance is 413/_-20  ohm. Determine the
        characteristic impedance of the line at this
        frequency.
2
3  // initializing the variables :
4  rzoc = 800; // in ohm
5  thetazoc = -50; // in degrees
6  rzsc = 413; // in ohm
7  thetazsc = -20; // in degrees
8  f = 1500; // in Hz
9
10 // calculation :
11 //open circuit impedance
12 Zoc = rzoc*cos(thetazoc*%pi/180) + %i*rzoc*sin(
```

```
     thetazoc*%pi/180)
13  //short circuit impedance
14  Zsc = rzsc*cos(thetazsc*%pi/180) + %i*rzsc*sin(
        thetazsc*%pi/180)
15  //characteristic impedance Zo
16  Zo = (Zoc*Zsc)^0.5
17
18  printf("\n\n Result \n\n")
19  printf("\n characteristic impedance Zo is %.0f +(%.0
        f)i ohm",real(Zo), imag(Zo))
```

Scilab code Exa 44.07 Example 7

```
1  //Problem 44.07: A transmission line has the
       following primary constants: resistance R = 15
       ohm/loop km, inductance L = 3.4 mH/loop km,
       conductance G = 3  S /km and capacitance C = 10
       nF/km. Determine the characteristic impedance of
       the line when the frequency is 2 kHz.
2
3  //initializing the variables:
4  R = 15; // in ohm/loop km
5  L = 0.0034; // in H/loop km
6  C = 10E-9; // in F/km
7  G = 3E-6; // in S/km
8  f = 2000; // in Hz
9
10  //calculation:
11  w = 2*%pi*f
12  //characteristic impedance Zo
13  Zo = ((R + %i*w*L)/(G + %i*w*C))^0.5
14
15  printf("\n\n Result \n\n")
16  printf("\n characteristic impedance Zo is %.1f +(%.1
        f)i ohm",real(Zo), imag(Zo))
```

Scilab code Exa 44.08 Example 8

```
1 //Problem 44.08: A transmission line having
     negligible losses has primary line constants of
     inductance L = 0.5 mH/loop km and capacitance C =
      0.12  F /km. Determine, at an operating
     frequency of 400 kHz, (a) the characteristic
     impedance, (b) the propagation coefficient, (c)
     the wavelength on the line, and (d) the velocity
     of propagation, in metres per second, of a signal
     .
2
3 //initializing the variables:
4 L = 0.0005; // in H/loop km
5 C = 0.12E-6; // in F/km
6 f = 400000; // in Hz
7
8 //calculation:
9 w = 2*%pi*f
10 //characteristic impedance Zo
11 Zo = (L/C)^0.5
12 //the propagation coefficient
13 r = %i*w*(L*C)^0.5
14 //the attenuation coefficient
15 a = real(r)
16 //the phaseshift coefficient
17 b = imag(r)
18 //wavelength
19 Y = 2*%pi/b
20 //velocity of propagation
21 u = f*Y
22
23 printf("\n\n Result \n\n")
24 printf("\n characteristic impedance Zo is %.1f +(%.1
```

```
     f ) i  ohm" ,real ( Zo ) ,  imag ( Zo ) )
25  printf ( " \n  propagation  coefficient  is  %.2 f  +(%.2 f ) i "
        ,a ,b )
26  printf ( " \n  wavelength  Y  is  %.3 f  km" ,Y )
27  printf ( " \n  speed  of  transmission  %.2E  km/ s e c " ,u )
```

Scilab code Exa 44.09 Example 9

```
1  //Problem  44.09:  At  a  frequency  of  1  kHz  the  primary
       constants  of  a  transmission  line  are  resistance
      R  =  25  ohm/ loop  km,  inductance  L  =  5  mH/ loop  km,
      capacitance  C  =  0.04    F /km  and  conductance  G  =
      80    S /km.  Determine  for  the  line  ( a )  the
      characteristic  impedance ,  ( b )  the  propagation
      coefficient  ,  ( c )  the  attenuation  coefficient  and
      ( d )  the  phase−shift  coefficient .
2
3  // initializing  the  variables :
4  R  =  25;  //  in  ohm/ loop  km
5  L  =  0.005;  //  in  H/ loop  km
6  C  =  0.04E−6;  //  in  F/km
7  G  =  80E−6;  //  in  S/km
8  f  =  1000;  //  in  Hz
9
10  // calculation :
11  w  =  2*%pi*f
12  // characteristic  impedance  Zo
13  Zo  =  ((R  +  %i*w*L)/(G  +  %i*w*C))^0.5
14  // the  propagation  coefficient
15  r  =((R  +  %i*w*L)*(G  +  %i*w*C))^0.5
16  // the  attenuation  coefficient
17  a  =  real ( r )
18  // the  phaseshift  coefficient
19  b  =  imag ( r )
20
```

```
21  printf("\n\n Result \n\n")
22  printf("\n characteristic impedance Zo is %.1f +(%.1
        f)i ohm",real(Zo), imag(Zo))
23  printf("\n propagation coefficient is %.4f +(%.4f)i"
        ,a,b)
24  printf("\n attenuation coefficient is %.4f Np/km",a)
25  printf("\n the phaseshift coefficient %.4f rad/km",b
        )
```

Scilab code Exa 44.10 Example 10

```
1  //Problem 44.10: An open wire line is 300 km long
        and is terminated in its characteristic impedance
        . At the sending end is a generator having an
        open-circuit e.m.f. of 10.0 V, an internal
        impedance of (400 + j0) ohmand a frequency of 1
        kHz. If the line primary constants are R = 8 ohm/
        loop km, L = 3 mH/loop km, C = 7500 pF/km and G =
         0.25   S /km, determine (a) the characteristic
        impedance, (b) the propagation coefficient, (c)
        the attenuation and phase-shift coefficients, (d)
         the sending-end current, (e) the receiving-end
        current, (f) the wavelength on the line, and (g)
        the speed of transmission of signal.
2
3  //initializing the variables:
4  R = 8; // in ohm/loop km
5  L = 0.003; // in H/loop km
6  C = 7500E-12; // in F/km
7  G = 0.25E-6; // in S/km
8  f = 1000; // in Hz
9  n = 300; // in km
10 Zg = 400 + %i*0; // in ohm
11 Vg = 10; // in Volts
12
```

```
13  //calculation:
14  w = 2*%pi*f
15  //characteristic impedance Zo
16  Zo = ((R + %i*w*L)/(G + %i*w*C))^0.5
17  //the propagation coefficient
18  r = ((R + %i*w*L)*(G + %i*w*C))^0.5
19  //the attenuation coefficient
20  a = real(r)
21  //the phaseshift coefficient
22  b = imag(r)
23  //the sending-end current,
24  Is = Vg/(Zg + Zo)
25  //the receiving-end current,
26  IR = Is*%e^(-1*n*r)
27  //wavelength
28  Y = 2*%pi/b
29  //velocity of propagation
30  u = f*Y
31
32  printf("\n\n Result \n\n")
33  printf("\n characteristic impedance Zo is %.1f +(%.1
        f)i ohm",real(Zo), imag(Zo))
34  printf("\n propagation coefficient is %.2f +(%.2f)i"
        ,a,b)
35  printf("\n attenuation coefficient is %.4f Np/km and
         the phaseshift coefficient %.4f rad/km",a,b)
36  printf("\n sending-end current Is is %.3E +(%.3E)i A
        ",real(Is), imag(Is))
37  printf("\n receiving-end current IR is %.3E +(%.3E)i
         A",real(IR), imag(IR))
38  printf("\n wavelength Y is %.3f km",Y)
39  printf("\n speed of transmission %.2E km/sec",u)
```

Scilab code Exa 44.11 Example 11

```
1  //Problem 44.11: An underground cable has the
       following primary constants: resistance R = 10
       ohm/loop km, inductance L = 1.5 mH/loop km,
       conductance G = 1.2   S /km and capacitance C =
       0.06   F /km. Determine by how much the inductance
        should be increased to satisfy the condition for
       minimum distortion.
2
3  //initializing the variables:
4  R = 10; // in ohm/loop km
5  L = 0.0015; // in H/loop km
6  C = 0.06E-6; // in F/km
7  G = 1.2E-6; // in S/km
8
9  //calculation:
10 //the condition for minimum distortion is given by
       LG = CR, from which,
11 Lm = C*R/G
12 dL = Lm - L
13
14 printf("\n\n Result \n\n")
15 printf("\n inductance should be increased by %.2E H/
       loop km for minimum distortion",dL)
```

Scilab code Exa 44.12 Example 12

```
1  //Problem 44.12: A cable has the following primary
       constants: resistance R = 80 ohm/loop km,
       conductance, G = 2   S /km, and capacitance C = 5
       nF/km. Determine, for minimum distortion at a
       frequency of 1.5 kHz (a) the value of inductance
       per loop kilometre required, (b) the propagation
       coefficient, (c) the velocity of propagation of
       signal, and (d) the wavelength on the line
2
```

```scilab
3  //initializing the variables:
4  R = 80; // in ohm/loop km
5  C = 5E-9; // in F/km
6  G = 2E-6; // in S/km
7  f = 1500; // in Hz
8
9  //calculation:
10 w = 2*%pi*f
11 //the condition for minimum distortion is given by
       LG = CR, from which, inductance
12 L = C*R/G
13 //attenuation coefficient,
14 a = (R*G)^0.5
15 //phase shift coefficient,
16 b = w*(L*C)^0.5
17 //propagation coefficient,
18 r = a + %i*b
19 //velocity of propagation,
20 u = 1/(L*C)^0.5
21 //wavelength
22 Y = u/f
23
24 printf("\n\n Result \n\n")
25 printf("\n inductance is %.2f H",L)
26 printf("\n propagation coefficient is %.4f +(%.4f)i"
       ,a,b)
27 printf("\n wavelength Y is %.2f km",Y)
28 printf("\n speed of transmission %.2E km/sec",u)
```

Scilab code Exa 44.13 Example 13

```scilab
1  //Problem 44.13: A cable which has a characteristic
       impedance of 75 ohm is terminated in a 250 ohm
       resistive load. Assuming that the cable has
       negligible losses and the voltage measured across
```

```
        the terminating load is 10 V, calculate the
        value of (a) the reflection coefficient for the
        line, (b) the incident current, (c) the incident
        voltage, (d) the reflected current, and (e) the
        reflected voltage.
2
3   //initializing the variables:
4   Zo = 75; // in ohm
5   ZR = 250; // in ohm
6   VR = 10; // in Volts
7
8   //calculation:
9   //reflection coefficient
10  p = (Zo - ZR)/(Zo + ZR)
11  //Current flowing in the terminating load
12  IR = VR/ZR
13  //incident current, Ii
14  Ii = IR/(1 + p)
15  //incident voltage, Vi
16  Vi = Ii*Zo
17  //reflected current, Ir
18  Ir = IR - Ii
19  //reflected voltage, Vr
20  Vr = -1*Ir*Zo
21
22  printf("\n\n Result \n\n")
23  printf("\n reflection coefficient is %.3f",p)
24  printf("\n incident current, Ii is %.4f A",Ii)
25  printf("\n incident voltage, Vi is %.2f V",Vi)
26  printf("\n reflected current, Ir is %.4f A",Ir)
27  printf("\n reflected voltage, Vr is %.2f V",Vr)
```

Scilab code Exa 44.14 Example 14

```
1   //Problem 44.14: A long transmission line has a
```

```
        characteristic impedance of 500 − j40  ohm and is
          terminated in an impedance of (a) 500 + j40 ohm
         and (b) 600 + j20 ohm. Determine the magnitude of
          the reflection coefficient in each case.
 2
 3  //initializing the variables:
 4  Zo = 500 - %i*40; // in ohm
 5  ZR1 = 500 + %i*40; // in ohm
 6  ZR2 = 600 + %i*20; // in ohm
 7
 8  //calculation:
 9  //reflection coefficient
10  p1 = (Zo - ZR1)/(Zo + ZR1)
11  p2 = (Zo - ZR2)/(Zo + ZR2)
12  p1mag = (real(p1)^2 + imag(p1)^2)^0.5
13  p2mag = (real(p2)^2 + imag(p2)^2)^0.5
14
15  printf("\n\n Result \n\n")
16  printf("\n reflection coefficient (a)%.3f and (b)%.3
        f",p1mag, p2mag)
```

Scilab code Exa 44.15 Example 15

```
 1  //Problem 44.15: A loss−free transmission line has a
        characteristic impedance of 500/ _0   and is
        connected to an aerial of impedance 320 + j240
        ohm. Determine (a) the magnitude of the ratio of
        the reflected to the incident voltage wave, and (
        b) the incident voltage if the reflected voltage
        is 20/ _35   V
 2
 3  //initializing the variables:
 4  rzo = 500; // in ohm
 5  thetazo = 0; // in degrees
 6  ZR = 320 + %i*240; // in ohm
```

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```
7  rvr = 20; // in volts
8  thetavr = 35; // in degrees
9
10 //calculation:
11 //voltage
12 VR = rvr*cos(thetavr*%pi/180) + %i*rvr*sin(thetavr*
      %pi/180)
13 //characteristic impedance
14 Zo = rzo*cos(thetazo*%pi/180) + %i*rzo*sin(thetazo*
      %pi/180)
15 //the ratio of the reflected to the incident voltage
16 //vr = VR/Vi
17 vr = (ZR - Zo)/(Zo + ZR)
18 vrmag = (real(vr)^2 + imag(vr)^2)^0.5
19 //incident voltage, Vi
20 Vi = VR/vr
21
22 printf("\n\n Result \n\n")
23 printf("\n the magnitude of the ratio Vr : Vi is %.3
      f",vrmag)
24 printf("\n incident voltage, Vi is %.2f +(%.2f)i V",
      real(Vi), imag(Vi))
```

Scilab code Exa 44.16 Example 16

```
1 //Problem 44.16: A transmission line has a
     characteristic impedance of 600/_0  and
     negligible loss. If the terminating impedance of
     the line is 400 + j250 ohm, determine (a) the
     reflection coefficient and (b) the standing-wave
     ratio.
2
3 //initializing the variables:
4 rzo = 600; // in ohm
5 thetazo = 0; // in degrees
```

```
6  ZR = 400 + %i*250; // in ohm
7
8  // calculation :
9  // characteristic impedance
10 Zo = rzo*cos(thetazo*%pi/180) + %i*rzo*sin(thetazo*
      %pi/180)
11 // reflection coefficient
12 p = (Zo - ZR)/(Zo + ZR)
13 pmag = (real(p)^2 + imag(p)^2)^0.5
14 // standing-wave ratio,
15 s = (1 + pmag)/(1 - pmag)
16
17 printf("\n\n Result \n\n")
18 printf("\n reflection coefficient, is %.4f +(%.4f)i
      V",real(p), imag(p))
19 printf("\n standing-wave ratio, s is %.3f",s)
```

Scilab code Exa 44.17 Example 17

```
1  //Problem 44.17: A low-loss transmission line has a
      mismatched load such that the reflection
      coefficient at the termination is 0.2/_-120  .
      The characteristic impedance of the line is 80
      ohm. Calculate (a) the standing-wave ratio, (b)
      the load impedance, and (c) the incident current
      flowing if the reflected current is 10 mA.
2
3  // initializing the variables :
4  rp = 0.2;
5  thetap = -120; // in degrees
6  Zo = 80; // in ohm
7  Ir = 0.01; // in Amperes
8
9  // calculation :
10 // reflection coefficient
```

```
11  p = rp*cos(thetap*%pi/180) + %i*rp*sin(thetap*%pi
        /180)
12  //standing−wave ratio ,
13  s = (1 + rp)/(1 - rp)
14  //load impedance ZR
15  ZR = Zo*(1 - p)/(1 + p)
16  //incident current
17  Ii = Ir*(s + 1)/(s - 1)
18
19  printf(”\n\n Result \n\n”)
20  printf(”\n standing−wave ratio , s is %.1 f”,s)
21  printf(”\n load impedance ZR is %.2 f +(%.2 f ) i ohm”,
        real(ZR), imag(ZR))
22  printf(”\n incident current is %.3 f A”,Ii)
```

Scilab code Exa 44.18 Example 18

```
1  //Problem 44.18: The standing−wave ratio on a
       mismatched line is calculated as 1.60. If the
       incident power arriving at the termination is 200
        mW, determine the value of the reflected power.
2
3  //initializing the variables :
4  s = 1.6;
5  Pi = 0.2; // in Watts
6
7  //calculation :
8  //reflected power , Pr
9  Pr = Pi*((s - 1)/(s + 1))^2
10
11  printf(”\n\n Result \n\n”)
12  printf(”\n reflected power , Pr is %.5 f W”,Pr)
```

Chapter 45

Transients and Laplace transforms

Scilab code Exa 45.01 Example 1

```
1  //Problem  45.01:  A  500  nF  capacitor  is  connected  in
      series  with  a  100  kohm  resistor  and  the  circuit
      is  connected  to  a  50  V,  d.c.  supply.  Calculate  (a
      )  the  initial  value  of  current  flowing ,  (b)  the
      value  of  current  150  ms  after  connection ,  (c)  the
       value  of  capacitor  voltage  80  ms  after
      connection ,  and  (d)  the  time  after  connection
      when  the  resistor  voltage  is  35  V.
2
3  //initializing  the  variables :
4  C = 500E-9;  //  in  Farad
5  R = 100000;  //  in  Ohm
6  V = 50;  //  in  VOlts
7  ti = 0.15;  //  in  sec
8  tc = 0.08;  //  in  sec
9  Vrt = 35;  //  in  Volts
10
11  //calculation :
12  //Initial  current ,
```

```
13  i0 = (V/R)
14  //when time t = 150ms current is
15  i150 = (V/R)*%e^(-1*ti/(R*C))
16  //capacitor voltage, Vc
17  Vc = V*(1 - %e^(-1*tc/(R*C)))
18  //time, t
19  tvr = -1*R*C*log(Vrt/V)
20
21  printf("\n\n Result \n\n")
22  printf("\n initial value of current flowing is %.2E
        A",i0)
23  printf("\n current flowing at t = 150ms is %.2E A",
        i150)
24  printf("\n  value of capacitor voltage at t = 80ms
        is %.2f V",Vc)
25  printf("\n  the time after connection when the
        resistor voltage is 35 V is %.4f sec",tvr)
```

Scilab code Exa 45.02 Example 2

```
1  //Problem 45.02: A d.c. voltage supply of 200 V is
       connected across a 5   F capacitor as shown in
       Figure 45.5. When the supply is suddenly cut by
       opening switch S, the capacitor is left isolated
       except for a parallel resistor of 2 Mohm.
       Calculate the p.d. across the capacitor after 20
       s.
2
3  //initializing the variables:
4  C = 5E-6; // in Farad
5  R = 2000000; // in Ohm
6  V = 200; // in VOlts
7  tc = 20; // in sec
8
9  //calculation:
```

```
10 // capacitor  voltage ,  Vc
11 Vc = V*(%e^(-1*tc/(R*C)))
12
13 printf (" \n\n  Result  \n\n")
14 printf (" \n   value  of  capacitor  voltage  at  t = 20s  is
       %.2 f  V" ,Vc )
```

Scilab code Exa 45.03 Example 3

```
1 // Problem  45.03:  A  coil  of  inductance  50 mH and
      resistance  5 ohm is  connected  to  a  110 V,  d . c .
      supply .  Determine  ( a )  the  final  value  of  current ,
       ( b )  the  value  of  current  after  4 ms,  ( c )  the
      value  of  the  voltage  across  the  resistor  after  6
      ms,  ( d )  the  value  of  the  voltage  across  the
      inductance  after  6 ms,  and  ( e )  the  time  when  the
      current  reaches  15 A.
2
3 // initializing  the  variables :
4 L = 0.05;  //  in  Henry
5 R = 5;  //  in  Ohm
6 V = 110;  //  in  VOlts
7 ti = 0.004;  //  in  sec
8 tvr = 0.006;  //  in  sec
9 tvl = 0.006;  //  in  sec
10 it = 15;  //  in  amperes
11
12 // calculation :
13 // steady  state  current  i
14 i = V/R
15 // when  time  t = 4ms  current  is
16 i4 = (V/R)*(1 - %e^(-1*ti*R/L))
17 // resistor  voltage ,  VR
18 VR6 = V*(1 - %e^(-1*tvr*R/L))
19 // inductor  voltage ,  VL
```

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```
20  VL6 = V*(%e^(-1*tvl*R/L))
21  //time , t
22  ti = (-1*L/R)*log(1 - it*R/V)
23
24  printf(" \n\n Result \n\n")
25  printf(" \n steady state current i is %.0f A",i)
26  printf(" \n when time t = 4ms current is is %.2f A",
         i4)
27  printf(" \n  value of resistor voltage at t = 6ms is
          %.2f V",VR6)
28  printf(" \n  value of inductor voltage at t = 6ms is
          %.2f V",VL6)
29  printf(" \n  the time after connection when the
          current is 15 A is %.5f sec",ti)
```

Scilab code Exa 45.04 Example 4

```
1  //Problem 45.04:  In the circuit shown in Figure
       45.8, a current of 5 A flows from the supply
       source. Switch S is then opened. Determine (a)
       the time for the current in the 2 H inductor to
       fall to 200 mA, and (b) the maximum voltage
       appearing across the resistor.
2
3  //initializing the variables:
4  i = 5; // in Amperes
5  L = 2 // in Henry
6  i1 = 0.2; // in Amperes
7  R = 10; // in Ohm
8
9  //calculation:
10 //time t
11 ti = (-1*L/R)*log(i1/i)
12 //voltage across the resistor is a maximum
13 VRm = i*R
```

```
14
15  printf("\n\n Result \n\n")
16  printf("\n  time t for the current in the 2 H
        inductor to fall to 200 mA is %.3f sec",ti)
17  printf("\n  max voltage across the resistor is %.0f
        V",VRm)
```

Scilab code Exa 45.05 Example 5

```
1  //Problem 45.05:  A series L   R   C circuit has
       inductance, L = 2 mH, resistance, R = 1 kohm and
       capacitance, C = 5   F. (a) Determine whether the
        circuit is over, critical or underdamped. (b) If
       C = 5 nF, determine the state of damping.
2
3  //initializing the variables:
4  L = 0.002 // in Henry
5  R = 1000; // in Ohm
6  C1 = 5E-6; // in farad
7  C2 = 5E-9; // in farad
8
9  //calculation:
10 a = (R/(2*L))^2
11 b = 1/(L*C1)
12 if (a>b) then
13     s1 = "overdamped";
14 elseif (a<b) then
15     s1 = "underdamped";
16 else
17     s1 = "critically damped";
18 end
19 c = 1/(L*C2)
20 if (a>c) then
21     s2 = "overdamped";
22 elseif (a<c) then
```

```
23      s2 = "underdamped";
24  else
25      s2 = "critically damped";
26  end
27
28  printf("\n\n Result \n\n")
29  printf("\n  circuit is %s",s1)
30  printf("\n  if C = 5 nF, circuit is %s",s2)
```

Scilab code Exa 45.06 Example 6

```
1  //Problem 45.06:  In the circuit of problem 45.05,
       what value of capacitance will give critical
       damping ?
2
3
4  //initializing the variables:
5  L = 0.002 // in Henry
6  R = 1000; // in Ohm
7
8  //calculation:
9  a = (R/(2*L))^2
10 //for critically damped
11 C = 4*L/R^2
12
13 printf("\n\n Result \n\n")
14 printf("\n  capacitance C is %.2E F",C)
```