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

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May 24, 2016

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

Book Description

Title: 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

```
//Problem 1.01: If a current of 5 A flows for 2
    minutes, find the quantity of electricity
    transferred.

//initializing the variables:
I = 5; // in Ampere
t = 120; // in sec

//calculation:
Q = I*t

printf("\n\nResult\n\n")
printf("\nQ: %.0f coulomb(C)\n",Q)
```

Scilab code Exa 1.02 Example 2

```
//Problem 1.02: A mass of 5000 g is accelerated at 2 m/s2 by a force. Determine the force needed.

//initializing the variables:
M = 5; // in Kg
a = 2; // in m/s2

//calculation:
F = M*a

printf("\n\nResult\n\n")
printf("\nForce: %.0f Newton(N)\n",F)
```

Scilab code Exa 1.03 Example 3

```
//Problem 1.03: Find the force acting vertically downwards on a mass of 200 g attached to a wire.

//initializing the variables:
M = 0.2; // in Kg
g = 9.81; // in m/s2

//calculation:
F = M*g

printf("\n\nResult\n\n")
printf("\nForce: %.3f Newton(N)\n",F)
```

Scilab code Exa 1.04 Example 4

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

```
machine is moved 20 m and what average power is
    utilized if the movement takes 25 s?

//initializing the variables:
F = 200; // in Newton
d = 20; // in m
t = 25; // in sec

//calculation:
W = F*d
P = W/t

printf("\n\nResult\n\n")
printf("\nPower: %.0f watt(W)\n",P)
```

Scilab code Exa 1.05 Example 5

```
//Problem 1.05: A mass of 1000 kg is raised through
    a height of 10m in 20s. What is (a) the work done
    and (b) the power developed?

//initializing the variables:
M = 1000; // in Kg
h = 10; // in m
t = 20; // in sec
g = 9.81 // in m/s2

//calculation:
W = M*g*h
P = W/t

printf("\n\nResult\n\n")
printf("\nWork Done: %.0f Joule(J)\n",W)
printf("\nPower: %.0f watt(W)\n",P)
```

Scilab code Exa 1.06 Example 6

```
//Problem 1.06: Find the conductance of a conductor
    of resistance (a) 10 ohm , (b) 5 kohm and (c) 100
     ohm.

//initializing the variables:
R1 = 10; // in ohm
R2 = 5000; // in ohm
R3 = 0.1; // in ohm
//calculation:
G1 = 1/R1
G2 = 1/R2
G3 = 1/R3

printf("\n\nResult\n\n")
printf("\nconductance(G1): %.1f seimen(S)n",G1)
printf("\nconductance(G2): %.4f seimen(S)n",G2)
printf("\nconductance(G3): %.0f seimen(S)n",G3)
```

Scilab code Exa 1.07 Example 7

```
//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?

//initializing the variables:
V = 5; // in Volts
I = 3; // in Ampere
t = 600; // in sec
//calculation:
P = V*I
```

```
E = P*t

printf("\n\nResult\n\n")
printf("\nEnergy(E): %.0f Joule(J)\n",E)
```

Scilab code Exa 1.08 Example 8

```
//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.

//initializing the variables:
E = 18E5; // in Joule
V = 250; // in Volts
t = 1800; // in sec

//calculation:
P = E/t
I = P/V

printf("\n\nResult\n\n")
printf("\nPower(P): %.0f Watt(W)",P)
printf("\nCurrent(I): %.0f Ampere(A)\n",I)
```

Chapter 2

An introduction to electric circuits

Scilab code Exa 2.01 Example 1

```
//Problem 2.01: What current must flow if 0.24
   coulombs is to be transferred in 15 ms?

//initializing the variables:
Q = 0.24; // in Coulomb
t = 0.015; // in sec

//calculation:
I = Q/t

printf("\n\nResult\n\n")
printf("\nCurrent(I): %.0f Ampere(A)\n",I)
```

Scilab code Exa 2.02 Example 2

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

```
    minutes, find the quantity of electricity
    transferred.

//initializing the variables:
I = 10; // in Ampere
t = 240; // in sec

//calculation:
Q = I*t

printf("\n\nResult\n\n")
printf("\nCharge(Q): %.0f Coulomb(C)\n",Q)
```

Scilab code Exa 2.03 Example 3

```
//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.

//initializing the variables:
I = 0.8; // in Ampere
V = 20; // in Volts

//calculation:
R = V/I

printf("\n\nResult\n\n")
printf("\nResistance(R): %.0f Ohms\n",R)
```

Scilab code Exa 2.04 Example 4

```
//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.

//initializing the variables:
I = 0.010; // in Ampere
R = 2000; // in ohms

//calculation:
V = I*R

printf("\n\nResult\n\n")
printf("\np.d.(V): %.0f Volts(V)\n",V)
```

Scilab code Exa 2.05 Example 5

```
//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?

//initializing the variables:
I = 0.050; // in Ampere
V = 12; // in Volts

//calculation:
R = V/I

printf("\n\nResult\n\n")
printf("\nResistance(R): %.0f Ohms\n",R)
```

Scilab code Exa 2.06 Example 6

```
//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?

//initializing the variables:
I = 0.005; // in Ampere
V1 = 100; // in Volts
V2 = 25; // in Volts

//calculation:
//resistance
R = V1/I
//Current when voltage is reduced to 25 V,
I = V2/R

printf("\n\nResult\n\n")
printf("\nResistance(R): %.0f Ohms",R)
printf("\n Current when voltage is reduced to 25 V
   is %.2E A",I)
```

Scilab code Exa 2.07 Example 7

```
//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?

//initializing the variables:
I1 = 0.050; // in Ampere
I2 = 200E-6; // in Ampere
V = 120; // in Volts

//calculation:
R1 = V/I1
```

```
R2 = V/I2

printf("\n\nResult\n\n")
printf("\nResistance(R1): %.0f Ohms",R1)
printf("\nResistance(R2): %.0f Ohms\n",R2)
```

Scilab code Exa 2.08 Example 8

```
//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.

//initializing the variables:
P = 100; // in Watt
V = 250; // in Volts

//calculation:
I = P/V
R = V/I

printf("\n\nResult\n\n")
printf("\nCurrent(I): %.1f Ampere(A)",I)
printf("\nResistance(R): %.0f Ohms\n",R)
```

Scilab code Exa 2.09 Example 9

```
//Problem 2.09: Calculate the power dissipated when a current of 4 mA flows through a resistance of 5 k

//initializing the variables:
I = 0.004; // in ampere
```

```
R = 5000; // in ohms

//calculation:
P = I*I*R

printf("\n\nResult\n\n")
printf("\nPower(P): %.2f Watt(W)\n",P)
```

Scilab code Exa 2.10 Example 10

```
//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.

//initializing the variables:
V = 240; // in Volts
R = 30; // in ohms

//calculation:
I = V/R
P = V*I

printf("\n\nResult\n\n")
printf("\nCurrent(I): %.0f Ampere(A)",I)
printf("\nPower(P): %.0f Watt(W)\n",P)
```

Scilab code Exa 2.11 Example 11

```
//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.

//initializing the variables:
I = 5; // in ampere
R = 100; // in ohms

//calculation:
V = I*R
P = I*R*I

printf("\n\nResult\n\n")
printf("\np.d(V): %.0f Volts(V)",V)
printf("\nPower(P): %.0f Watt(W)\n",P)
```

Scilab code Exa 2.12 Example 12

```
//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.

//initializing the variables:
I1 = 0.020; // in ampere
V1 = 20; // in Volts
I2 = 0.005; // in ampere
V2 = 16; // in Volts

//calculation:
R1 = V1/I1
R2 = V2/I2

printf("\n\nResult\n\n")
printf("\nResistance(R1): %.0f Ohms",R1)
printf("\nResistance(R2): %.0f Ohms\n",R2)
```

Scilab code Exa 2.13 Example 13

```
//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.

//initializing the variables:
V = 240; // in Volts
R = 960; // in ohms

//calculation:
I = V/R
P = I*V

printf("\n\nResult\n\n")
printf("\nCurrent(I): %.2f Ampere(A)",I)
printf("\nPower(P): %.0f Watt(W)\n",P)
```

Scilab code Exa 2.14 Example 14

```
//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.

//initializing the variables:
V = 12; // in Volts
R = 40; // in ohms
t = 120; // in sec

//calculation:
```

```
I = V/R
P = I*V
E = P*t

printf("\n\nResult\n\n")
printf("\nCurrent(I): %.1f Ampere(A)",I)
printf("\nPower(P): %.1f Watt(W)",P)
printf("\nEnergy(E): %.0f Joule(J)\n",E)
```

Scilab code Exa 2.15 Example 15

```
//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?

//initializing the variables:
V = 15; // in Volts
I = 2; // in ampere
t = 360; // in sec

//calculation:
E = V*I*t

printf("\n\nResult\n\n")
printf("\nEnergy(E): %.0f Joule(J)\n",E)
```

Scilab code Exa 2.16 Example 16

```
//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?
```

```
//initializing the variables:
V = 240; // in Volts
I = 13; // in ampere
t = 30; // in hours
p = 7; // in paise per kWh

//calculation:
P = V*I
E = P*t/1000 // in kWh
C = E*p

printf("\n\nResult\n\n")
printf("\nCost per week: %.1f Paise(p)\n",C)
```

Scilab code Exa 2.17 Example 17

```
//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.

//initializing the variables:
V = 250; // in Volts
E = 3.6E6; // energy in J
t = 2400; // in sec

//calculation:
P = E/t
I = P/V

printf("\n\nResult\n\n")
printf("\nPower(P): %.0f Watt(W)",P)
printf("\nCurrent(I): %.0f Ampere(A)\n",I)
```

Scilab code Exa 2.18 Example 18

```
//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.

//initializing the variables:
R = 20; // in ohms
I = 10; // in ampere
t = 6; // in hours
p = 7; // in paise per kWh

//calculation:
P = I*I*R
E = P*t/1000 // in kWh
C = E*p

printf("\n\nResult\n\n")
printf("\nPower(P): %.0f Watt(W)",P)
printf("\nCost per week: %.0f Paise(p)\n",C)
```

Scilab code Exa 2.19 Example 19

```
//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.

```

```
//initializing the variables:
P1 = 3; // in kW
P2 = 150; // in Watt
n1 = 2; // no. of P1 Equips
n2 = 6; // no. of P2 Equips
t1 = 20; // in hours each per week
t2 = 30; // in hours each per week
p = 7; // in paise per kWh

//calculation:
E1 = P1*t1*n1 // in kWh by two P1 eqips
E2 = P2*t2*n2/1000 // in kWh by six P2 eqips
Et = E1 + E2
C = Et * 7
printf("\n\nResult\n\n")
printf("\nCost per week: %.0f Paise(p)\n",C)
```

Chapter 3

Resistance variation

Scilab code Exa 3.01 Example 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.

//initializing the variables:
R = 600; // in ohms
L = 5; // in meter
L1 = 8; // in meter
R2 = 420; // in ohms

//calculation:
R1 = R*L1/L
L2 = R2*L/R

printf("\n\nResult\n\n")
printf("\n(a)Resistance %.0f Ohms",R1)
printf("\n(b)Length: %.1f meters(m)\n",L2)
```

Scilab code Exa 3.02 Example 2

```
//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.

//initializing the variables:
R = 300; // in ohms
A = 2; // in mm2
A1 = 5; // in mm2
R2 = 750; // in ohms

//calculation:
R1 = R*A/A1
A2 = R*A/R2

printf("\n\nResult\n\n")
printf("\n(a)Resistance %.0f Ohms",R1)
printf("\n(b)C.S.A: %.1f mm2\n",A2)
```

Scilab code Exa 3.03 Example 3

```
//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.

//initializing the variables:
```

```
R = 0.16; // in ohms
A = 3; // in mm2
L = 8; // in m
A1 = 1; // in mm2

//calculation:
L1 = L*3
R1 = R*A*L1/(A1*L)

printf("\n\nResult\n\n")
printf("\nResistance %.2f Ohms\n",R1)
```

Scilab code Exa 3.04 Example 4

```
//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.

//initializing the variables:
A = 100E-6; // in m2
L = 2000; // in m
p = 0.03E-6; // in ohm m

//calculation:
R = p*L/A

printf("\n\nResult\n\n")
printf("\nResistance %.1f Ohms\n",R)
```

Scilab code Exa 3.05 Example 5

```
//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.

//initializing the variables:
R = 0.25; // in ohms
L = 40; // in m
p = 0.02E-6; // in ohm m

//calculation:
A = p*L*1E6/R

printf("\n\nResult\n\n")
printf("\nC.S.A %.1f Ohms\n",A)
```

Scilab code Exa 3.06 Example 6

```
//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.

//initializing the variables:
R = 150; // in ohms
L = 1500; // in m
A = 0.17E-6; // in m2

//calculation:
p = R*A/L

printf("\n\nResult\n\n")
printf("\nresistivity %.3E Ohm m\n",p)
```

Scilab code Exa 3.07 Example 7

```
//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.

//initializing the variables:
d = 0.012; // in m
L = 1200; // in m
p = 1.7E-8; // in ohm m
pi = 3.14;

//calculation:
A = pi*d*d/4
R = p*L/A

printf("\n\nResult\n\n")
printf("\nresistance %.3f Ohm\n",R)
```

Scilab code Exa 3.08 Example 8

```
//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

//initializing the variables:
R0 = 100; // in ohms
T0 = 0; // in  C
T1 = 70; // in  C
a0 = 0.0043; // in per C
pi = 3.14;

//calculation:
```

```
R70 = R0*[1 + (a0*T1)]

printf("\n\nResult\n\n")
printf("\nresistance %.1f Ohm\n",R70)
```

Scilab code Exa 3.09 Example 9

```
//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

//initializing the variables:
R1 = 27; // in ohms
T0 = 0; // in  C
T1 = 35; // in  C
a0 = 0.0038; // in per C
pi = 3.14;

//calculation:
R0 = R1/[1 + (a0*T1)]

printf("\n\nResult\n\n")
printf("\nresistance %.2f Ohm\n",R0)
```

Scilab code Exa 3.10 Example 10

```
//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

```

```
//initializing the variables:
R0 = 1000; // in ohms
T0 = 0; // in  C
T1 = 80; // in  C
a0 = -0.0005; // in per C
pi = 3.14;

//calculation:
R80 = R0*[1 + (a0*T1)]

printf("\n\nResult\n\n")
printf("\nresistance %.0f Ohm\n",R80)
```

Scilab code Exa 3.11 Example 11

```
//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.

//initializing the variables:
R20 = 10; // in ohms
T0 = 20; // in  C
T1 = 100; // in  C
a20 = 0.004; // in per C
pi = 3.14;

//calculation:
R100 = R20*[1 + (a20)*(T1 - T0)]

printf("\n\nResult\n\n")
printf("\nresistance %.1f Ohm\n",R100)
```

Scilab code Exa 3.12 Example 12

```
//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.

//initializing the variables:
R18 = 200; // in ohms
R1 = 240; // in ohms
T0 = 18; // in  C
a18 = 0.0039; // in per C
pi = 3.14;

//calculation:
T1 = (((R1/R18)-1)/a18) + T0

printf("\n\nResult\n\n")
printf("\nTemperature %.2f  C \n",T1)
```

Scilab code Exa 3.13 Example 13

```
//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.
```

```
//initializing the variables:
R20 = 200; // in ohms
T0 = 20; // in  C
T1 = 90; // in  C
a0 = 0.004; // in per C
pi = 3.14;

//calculation:
R90 = R20*[1 + (a0*T1)]/[1 + (a0*T0)]

printf("\n\nResult\n\n")
printf("\nResistance %.0f ohms\n",R90)
```

Chapter 4

Chemical effects of electricity

Scilab code Exa 4.01 Example 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.

//initializing the variables:
R = 0.2; // in ohms
n = 8; // no. of cells
e = 2.2; // in volts

//calculation:
es = n*e
ep = e
Rs = n*R
Rp = R/n

printf("\n\nResult\n\n")
printf("\n(a)Resistance %.1f ohms",Rs)
printf("\n(a)e.m.f %.1f Volts(V)",es)
printf("\n(b)Resistance %.3f ohms",Rp)
```

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

Scilab code Exa 4.02 Example 2

```
//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

//initializing the variables:
r = 0.02; // in ohms
e = 2; // in volts
I1 = 5; // in Amperes
I2 = 50; // in Amperes

//calculation:
pd1 = e - (I1*r)
pd2 = e - (I2*r)

printf("\n\nResult\n\n")
printf("\n(a)p.d %.1f Volts(V)",pd1)
printf("\n(b)p.d %.1f Volts(V)\n",pd2)
```

Scilab code Exa 4.03 Example 3

```
//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.

//initializing the variables:
e1 = 25; // in volts
e2 = 24; // in volts
I2 = 10; // in Amperes
```

```

//calculation:
r = (e1 - e2)/I2

printf("\n\nResult\n\n")
printf("\n Resistance %.1f Ohms\n",r)
```

Scilab code Exa 4.04 Example 4

```
//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.

//initializing the variables:
r = 0.2; // in ohms
n = 10; // no. of cells
e = 1.5; // in volts
R = 58; // in ohms

//calculation:
es = n*e
rs = n*r
I = es/(rs + R)
pd = es - (I*rs)

printf("\n\nResult\n\n")
printf("\n (a)Current %.2f Amperes(A)",I)
printf("\n (b)p.d %.1f Volts(V)\n",pd)
```

Chapter 5

Series and parallel networks

Scilab code Exa 5.01 Example 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.

//initializing the variables:
V1 = 5; // in volts
V2 = 2; // in volts
V3 = 6; // in volts
I = 4; // in Amperes

//calculation:
Vt = V1 + V2 + V3
Rt = Vt/I
R1 = V1/I
R2 = V2/I
R3 = V3/I

printf("\n\nResult\n\n")
```

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

Scilab code Exa 5.02 Example 2

```
//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

//initializing the variables:
V1 = 10; // in volts
V2 = 4; // in volts
Vt = 25; // in volts
Rt = 100; // in ohms

//calculation:
V3 = Vt - V1 - V2
I = Vt/Rt
R2 = V2/I

printf("\n\nResult\n\n")
printf("\n (a)Voltage(V3) %.0f Volts(V)",V3)
printf("\n (b)current %.2f Amperes(A)",I)
printf("\n (c)Resistance(R2) %.0f Ohms",R2)
```

Scilab code Exa 5.03 Example 3

```
//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.

//initializing the variables:
Vt = 12; // in volts
R1 = 4; // in ohms
R2 = 9; // in ohms
R3 = 11; // in ohms

//calculation:
Rt = R1 + R2 + R3
I = Vt/Rt
V9 = I*R2
P11 = I*I*R3

printf("\n\nResult\n\n")
printf("\n (a)current %.1f Amperes(A)",I)
printf("\n (b)Voltage(V2) %.1f Volts(V)",V9)
printf("\n (c)Power %.2f Watt(W)",P11)
```

Scilab code Exa 5.04 Example 4

```
//Problem 5.04:Determine the value of voltage V
    shown in Figure 5.6.

//initializing the variables:
Vt = 50; // in volts
R1 = 4; // in ohms
R2 = 6; // in ohms

//calculation:
```

```
Rt = R1 + R2
I = Vt/Rt
V2 = I*R2

printf("\n\nResult\n\n")
printf("\n Voltage(V) %.0f Volts(V)\n",V2)
```

Scilab code Exa 5.05 Example 5

```
//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?

//initializing the variables:
Vt = 24; // in volts
R1 = 2; // in ohms
I = 3; // in Amperes
t = 50; // in hrs

//calculation:
V1 = I*R1
R2 = [Vt-(I*R1)]/I
E = Vt*I*t

printf("\n\nResult\n\n")
printf("\n (a)Voltage(V1) %.0f Volts(V)",V1)
printf("\n (b)Resistance(R2) %.0f Ohms",R2)
printf("\n (a)Energy(E) %.2E Wh",E)
```

Scilab code Exa 5.06 Example 6

```
//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

//initializing the variables:
R1 = 5; // in ohms
R3 = 20; // in ohms
I1 = 8; // in Amperes
It = 11; // in Amperes

//calculation:
Vt = I1*R1
I3 = Vt/R3
R2 = Vt/[It - I1 - I3]

printf("\n\nResult\n\n")
printf("\n (a)Ammeter Reading %.0f Amperes(A)",I3)
printf("\n (b)Resistance(R2) %.0f Ohms\n",R2)
```

Scilab code Exa 5.07 Example 7

```
//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.

//initializing the variables:
R1 = 3; // in ohms
R2 = 6; // in ohms
Vt = 12; // in volts

//calculation:
```

```
Rt = R1*R2/[R1 + R2]
I1 = [Vt/R1]

printf("\n\nResult\n\n")
printf("\n (a)Total Resistance %.0f Ohms",Rt)
printf("\n (b)Current(I1) %.0f Amperes(A)\n",I1)
```

Scilab code Exa 5.08 Example 8

```
//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.

//initializing the variables:
R1 = 10; // in ohms
R2 = 20; // in ohms
R3 = 60; // in ohms
I2 = 3; // in Amperes

//calculation:
Vt = I2*R2
I1 = Vt/R1
I3 = Vt/R3
I = I1 +I2 + I3

printf("\n\nResult\n\n")
printf("\n (a)Voltage(V) %.0f Volts(V)",Vt)
printf("\n (b)Total Current(I) %.0f Amperes(A)",I)
```

Scilab code Exa 5.10 Example 10

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

```
//initializing the variables:
R1 = 1; // in ohms
R2 = 2.2; // in ohms
R3 = 3; // in ohms
R4 = 6; // in ohms
R5 = 18; // in ohms
R6 = 4; // in ohms


//calculation:
R0 = 1/[(1/3) + (1/6) + (1/18)]
Rt = R1 + R2 + R0 + R6

printf("\n\nResult\n\n")
printf("\n Equivalent Resistance %.0f Ohms\n",Rt)
```

Scilab code Exa 5.11 Example 11

```
//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.

//initializing the variables:
R1 = 2.5; // in ohms
R2 = 6; // in ohms
R3 = 2; // in ohms
R4 = 4; // in ohms
Vt = 200; // in volts

//calculation:
R0 = 1/[(1/R2) + (1/R3)]
Rt = R1 + R0 + R4
It = Vt/Rt
```

```
I1 = It
I4 = It
I2 = R3*It/(R3+R2)
I3 = It - I2
V1 = I1*R1
V2 = I2*R2
V3 = I3*R3
V4 = I4*R4

printf("\n\nResult\n\n")
printf("\n (a)Total Current Supply %.0f Amperes(A)", It)
printf("\n (b)Current through resistors (R1, R2, R3, R4)%.0f, %.2f, %.2f, %.0f Amperes(A) respectively",I1, I2, I3, I4)
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

```
//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.

//initializing the variables:
R1 = 15; // in ohms
R2 = 10; // in ohms
R3 = 38; // in ohms
Vt = 250; // in volts
P = 2500; // in Watt

//calculation:
```

```
It = P/Vt
I2 = R1*It/(R1+R2)
I1 = It - I2
Re1 = 1/[(1/R1) + (1/R2)]
Rt = Vt/It
Re2 = Rt - Re1
Rx = 1/[(1/Re2) - (1/R3)]
I4 = R3*It/(R3+Rx)
I3 = It - I4

printf("\n\nResult\n\n")
printf("\n (a)Resistance (Rx) %.0f Ohms",Rx)
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

```
//Problem 5.13: For the arrangement shown in Figure
    5.22, find the current Ix

//initializing the variables:
R1 = 8; // in ohms
R2 = 2; // in ohms
R3 = 1.4; // in ohms
R4 = 9; // in ohms
R5 = 2; // in ohms
Vt = 17; // in volts

//calculation:
R01 = R1*R2/(R1 + R2)
R02 = R01 + R3
R03 = R4*R02/(R4 +R02)
Rt = R5 + R03
It = Vt/Rt
```

```
I1 = R4*It/(R4 + R02)
Ix = R2*I1/(R1 + R2)

printf("\n\nResult\n\n")
printf("\n Current(Ix) %.1f Amperes(A)\n",Ix)
```

Scilab code Exa 5.14 Example 14

```
//Problem 5.14: If three identical lamps are
    connected in parallel and the combined resistance
     is 150 ohms, find the resistance of one lamp.

//initializing the variables:
Rt = 150; // in ohms
n = 3; // no. of identical lamp

//calculation:
R = Rt*3 // (1/Rt)=(1/R)+(1/R)+(1/R)

printf("\n\nResult\n\n")
printf("\n Resistance %.0f Ohms\n",R)
```

Scilab code Exa 5.15 Example 15

```
//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.

//initializing the variables:
//series connection
n = 3; // no. of identical lamp
Vt = 150; // in volts
```

```

//calculation:
V = Vt/3 // Since each lamp is identical, then V volts across each.

printf("\n\nResult\n\n")
printf("\n Voltage across each resistor = %.0f Volts (V)",V)
```

Chapter 6

Capacitors and capacitance

Scilab code Exa 6.01 Example 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.

//initializing the variables:
C1 = 4E-6; // in Farad
C2 = 50E-12; // in Farad
Q1 = 5E-3; // in Coulomb
V2 = 2000; // in volts

//calculation:
V1 = Q1/C1
Q2 = C2*V2

printf("\n\nResult\n\n")
printf("\n (a)P.d %.0f Volts(V)",V1)
printf("\n (b)Charge(Q) %.2E Coulomb(C)",Q2)
```

Scilab code Exa 6.02 Example 2

```
//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.

//initializing the variables:
I = 4; // in amperes
C = 20E-6; // in Farad
t = 3E-3; // in sec

//calculation:
Q = I*t
V = Q/C

printf("\n\nResult\n\n")
printf("\n (a)P.d %.0f Volts(V)\n",V)
```

Scilab code Exa 6.03 Example 3

```
//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.

//initializing the variables:
I = 2E-3; // in amperes
C = 5E-6; // in Farad
V = 800; // in volts

//calculation:
Q = C*V
t = Q/I

printf("\n\nResult\n\n")
```

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

Scilab code Exa 6.04 Example 4

```
//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.

//initializing the variables:
Q = 0.2E-6; // in Coulomb
A = 800E-4; // in m2
d = 0.005; // in m
V = 250; // in Volts

//calculation:
D = Q/A
E = V/d

printf("\n\nResult\n\n")
printf("\n (a)Electric flux density D %.2E C/m2",D)
printf("\n (b)Electric field strength E %.2E V/m\n",
    E)
```

Scilab code Exa 6.05 Example 5

```
//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.
```

```

//initializing the variables:
D = 2E-6; // in  C/m2
e0 = 8.85E-12; // in F/m
er = 5;

//calculation:
E = D/(e0*er)

printf("\n\nResult\n\n")
printf("\n Electric field strength E %.2E V/m\n",E)
```

Scilab code Exa 6.06 Example 6

```
//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

//initializing the variables:
d = 0.8E-3; // in m
e0 = 8.85E-12; // in F/m
era = 1; // for air
erp = 2.3; // for polythene
V =200; // in Volts

//calculation:
E = V/d
//for air
Da = E*e0*era
//for polythene
Dp = E*e0*erp
printf("\n\nResult\n\n")
```

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

Scilab code Exa 6.07 Example 7

```
//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?

//initializing the variables:
A = 4E-4; // in m2
d = 0.1E-3; // in m
e0 = 8.85E-12; // in F/m
er = 100;
Q = 1.2E-6; // in coulomb

//calculation:
C = e0*er*A/d
V = Q/C

printf("\n\nResult\n\n")
printf("\n (a)Capacitance  %.2E F",C)
printf("\n (b)P.d.= %.0f Volts(V)\n",V)
```

Scilab code Exa 6.08 Example 8

```
//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

//initializing the variables:
A = 800E-4; // in m2
C = 4425E-12; // in Farads
e0 = 8.85E-12; // in F/m
er = 2.5;

//calculation:
d = e0*er*A/C

printf("\n\nResult\n\n")
printf("\n Thickness  %.2E m\n",d)
```

Scilab code Exa 6.09 Example 9

```
//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.

//initializing the variables:
n = 19; // no. of plates
L = 75E-3; // in m
B = 75E-3; // in m
d = 0.2E-3; // in m
e0 = 8.85E-12; // in F/m
er = 5;

//calculation:
```

```
A = L*B
C = e0*er*A*(n-1)/d

printf("\n\nResult\n\n")
printf("\n Capacitance %.2E F\n",C)
```

Scilab code Exa 6.10 Example 10

```
//Problem 6.10: Calculate the equivalent capacitance
    of two capacitors of 6  F and 4  F connected (
   a) in parallel and (b) in series

//initializing the variables:
C1 = 6E-6; // in Farads
C2 = 4E-6; // in Farads

//calculation:
// in Parallel
Cp = C1 +C2
// in Series
Cs = 1/[(1/C1) + (1/C2)]

printf("\n\nResult\n\n")
printf("\n (a)Capacitance in parallel %.2E F",Cp)
printf("\n (b)Capacitance in Series %.2E F\n",Cs)
```

Scilab code Exa 6.11 Example 11

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

//initializing the variables:
```

```
C1 = 30E-6; // in Farads
Cs = 12E-6; // in Farads

//calculation:
// in Series
C2 = 1/[(1/Cs) - (1/C1)]

printf("\n\nResult\n\n")
printf("\n (a)Capacitance in series %.2E F\n",C2)
```

Scilab code Exa 6.12 Example 12

```
//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.

//initializing the variables:
C1 = 1E-6; // in Farads
C2 = 3E-6; // in Farads
C3 = 5E-6; // in Farads
C4 = 6E-6; // in Farads
Vt = 100; // in Volts

//calculation:
// in Parallel
Cp = C1 + C2 + C3 + C4
Qt = Vt*Cp
Q1 = C1*Vt
Q2 = C2*Vt
Q3 = C3*Vt
Q4 = C4*Vt

printf("\n\nResult\n\n")
```

```
printf("\n (a)Equivalent Capacitance in Parallel %.2E F",Cp)
printf("\n (b)Total charge %.2E C",Qt)
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

```
//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.

//initializing the variables:
C1 = 3E-6; // in Farads
C2 = 6E-6; // in Farads
C3 = 12E-6; // in Farads
Vt = 350; // in Volts

//calculation:
// in series
Cs = 1/[(1/C1) + (1/C2) + (1/C3)]
Qt = Vt*Cs
V1 = Qt/C1
V2 = Qt/C2
V3 = Qt/C3

printf("\n\nResult\n\n")
printf("\n (a)Equivalent Capacitance in Series %.2E F",Cs)
printf("\n (b)Charge on each capacitors (C1, C2, C3) %.2E C",Qt)
printf("\n (b)P.d Across each capacitors (C1, C2, C3
```

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

Scilab code Exa 6.14 Example 14

```
//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)

//initializing the variables:
C = 0.2E-6; // in Farads
V = 1250; // in Volts
E  = 50E6; // in V/m
e0 = 8.85E-12; // in F/m
er = 6;

//calculation:
d = V/E
A = C*d/e0/er

printf("\n\nResult\n\n")
printf("\n (a)Thickness %.2E m",d)
printf("\n (b)Area of plate is %.2E m2 \n",A)
```

Scilab code Exa 6.15 Example 15

```
//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

//initializing the variables:
C = 3E-6; // in Farads
V = 400; // in Volts
t = 10E-6; // in secs

//calculation:
W = C*V*V/2
P = W/t

printf("\n\nResult\n\n")
printf("\n (a)Energy stored %.2f J",W)
printf("\n (b)Power developed %.2E W ",P)
```

Scilab code Exa 6.16 Example 16

```
//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.

//initializing the variables:
C = 12E-6; // in Farads
W = 4; // in Joules

//calculation:
V = (2*W/C)^0.5

printf("\n\nResult\n\n")
printf("\n P.d %.1f V\n",V)
```

Scilab code Exa 6.17 Example 17

```
//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.

//initializing the variables:
W = 1.2; // in Joules
Q = 10E-3; // in Coulomb

//calculation:
V = 2*W/Q
C = Q/V

printf("\n\nResult\n\n")
printf("\n (a)P.d %.0f V",V)
printf("\n (b)Capacitance %.2E F\n",C)
```

Chapter 7

Magnetic circuits

Scilab code Exa 7.01 Example 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.

//initializing the variables:
Phi = 150E-6; // in Wb
l = 200E-3; // in m
b = 100E-3; // in m

//calculation:
A = l*b
B = Phi/A

printf("\n\nResult\n\n")
printf("\n Flux density %.2E T\n",B)
```

Scilab code Exa 7.02 Example 2

```
//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.

//initializing the variables:
Phi = 353E-3; // in Wb
B = 1.8; // in tesla
Pi = 3.14;

//calculation:
A = Phi/B
r = (A/Pi)^0.5

printf("\n\nResult\n\n")
printf("\n radius of the pole face is %.2E m\n",r)
```

Scilab code Exa 7.03 Example 3

```
//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.

//initializing the variables:
H = 8000; // in A/m
d = 0.30; // in m
N = 750; // no. of turns
Pi = 3.14;

//calculation:
```

```
l = Pi*d
I = H*l/N

printf("\n\nResult\n\n")
printf("\n current I = %.2f Ampere(A)\n",I)
```

Scilab code Exa 7.04 Example 4

```
//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.

//initializing the variables:
B = 1.2; // in Tesla
H = 1250; // in A/m
Pi = 3.14;
u0 = 4*Pi*1E-7;

//calculation:
ur = B/(u0*H)

printf("\n\nResult\n\n")
printf("\n relative permeability of the steel = %.0f
    \n",ur)
```

Scilab code Exa 7.05 Example 5

```
//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.

//initializing the variables:
```

```
B = 0.25; // in Tesla
u0 = 4*%pi*1E-7;
l = 12E-3; // in m

//calculation:
H = B/u0
mmf = H*l

printf("\n\nResult\n\n")
printf("\n (a)Magnetic field strength H = %.0f A/m",
   H)
printf("\n (b)mmf = %.0f A\n",mmf)
```

Scilab code Exa 7.06 Example 6

```
//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.

//initializing the variables:
N = 300; // no. of turns
l = 0.40; // in m
A = 4E-4; // in m2
I = 5; // in Amperes
u0 = 4*%pi*1E-7;
ur = 1
//calculation:
H = N*I/l
B = u0*ur*H
Phi = B*A

```

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

Scilab code Exa 7.07 Example 7

```
//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.

//initializing the variables:
N = 2000; // no. of turns
d = 0.10; // in m
B = 0.4; // in Tesla
I = 0.25; // in Amperes
u0 = 4*%pi*1E-7;

//calculation:
l = %pi*d
H = N*I/l
ur = B/(u0*H)

printf("\n\nResult\n\n")
printf("\n (a)Magnetic field strength H = %.0f A/m",H)
printf("\n (b)relative permeability of the iron = %.0f ",ur)
```

Scilab code Exa 7.08 Example 8

```
//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.

//initializing the variables:
A = 10E-4; // in m2
l = 0.20; // in m
Phi = 0.3E-3; // in Wb
u0 = 4*%pi*1E-7;

//calculation:
B = Phi/A
// from the magnetisation curve, corresponding the
    value of B
H = 1000
mmf = H*l
printf("\n\nResult\n\n")
printf("\n (a)mmf = %.0f A\n",mmf)
```

Scilab code Exa 7.09 Example 9

```
//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.

//initializing the variables:
A = 18E-4; // in m2
l = 0.15; // in m
u0 = 4*%pi*1E-7;
```

```
ur = 4000;

//calculation:
S = l/(u0*ur*A)
u = u0*ur

printf("\n\nResult\n\n")
printf("\n (a)Reluctance S = %.0f /H",S)
printf("\n (b)Absolute permeability ,     = %.2E H/m\n
  ",u)
```

Scilab code Exa 7.10 Example 10

```
//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.

//initializing the variables:
A = 4E-4; // in m2
r = 0.05; // in m
I = 0.5; // in Amperes
Phi = 0.1E-3; // in Wb
u0 = 4*%pi*1E-7;
ur = 200;

//calculation:
l = 2*%pi*r
S = l/(u0*ur*A)
N = S*Phi/I

```

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

Scilab code Exa 7.11 Example 11

```
//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.

//initializing the variables:
A1 = 1E-4; // in m2
A2 = 0.5E-4; // in m2
l1 = 0.06; // in m
l2 = 0.02; // in m
N1 = 200; // no. of turns about 6 cm coil
I = 0.4; // in Amperes
u0 = 4*%pi*1E-7;
ur = 750;

//calculation:
//Reluctance
S1 = l1/(u0*ur*A1) // for 6 cm
S2 = l2/(u0*ur*A2) // for 2 cm
St = S1 + S2
Phi = N1*I/St
B2 = Phi/A2

printf("\n\nResult\n\n")
```

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

Scilab code Exa 7.12 Example 12

```
//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.

//initializing the variables:
A = 5E-4; // in m2
l = 0.4; // in m
r = 2E-3; // in m
u0 = 4*%pi*1E-7;
Phi = 0.7E-3; // in Wb

//calculation:
//For the silicon iron:
B = Phi/A
//From the B H curve for silicon iron,
  corresponding to value of B
Hs = 1650
mmfs = Hs*l
//For the air gap:
Ha = B/u0
mmfa = Ha*r
mmft = mmfs + mmfa

printf("\n\nResult\n\n")
printf("\n Total mmf to produce a flux of 0.7 mWb =
  %.0f A\n",mmft)
```

Scilab code Exa 7.13 Example 13

```
//Problem 7.13: Figure 7.4 shows a ring formed with two differentmaterials cast steel and mild steel. The dimensions are:
//                          mean length            cross-sectional area
//   Mild steel              400 mm                 500 mm2
//   Cast steel              300 mm                 312.5 mm2
//Find the total mmf required to cause a flux of 500 Wb in the magnetic circuit. Determine also the total circuit reluctance.

//initializing the variables:
A1 = 5E-4; // in m2
A2 = 3.125E-4; // in m2
l1 = 0.4; // in m
l2 = 0.3; // in m
u0 = 4*%pi*1E-7;
Phi = 0.5E-3; // in Wb

//calculation:
//For the mild steel:
B1 = Phi/A1
//From the B H curve for Mild steel, corresponding to value of B
Hm = 1400
mmfm = Hm*l1
//For the cast steel:
B2 = Phi/A2
//From the B H curve for cast steel steel, corresponding to value of B
```

```
Hc = 4800
mmfc = Hc*l2
mmft = mmfm + mmfc
//Reluctance
S = mmft/Phi

printf("\n\nResult\n\n")
printf("\n Total mmf to produce a flux of 0.5 mWb =
   %.0f A",mmft)
printf("\n Total circuit reluctance = %.2E /H",S)
```

Scilab code Exa 7.14 Example 14

```
//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.

//initializing the variables:
A = 2E-4; // in m2
l1 = 0.25; // in m
l2 = 0.001; // in m
u0 = 4*%pi*1E-7;
N = 5000; // no. of turns
B = 0.8; // in tesla
ua = 1; // for air

//calculation:
//for the core
//From the B H curve for Mild steel, corresponding
```

```
    to value of B = 0.8
H = 750
ur = B/(u0*H)
S1 = l1/(u0*ur*A)
//For the air gap:
S2 = l2/(u0*ua*A)
St = S1 + S2
//flux
Phi = B*A
//current
I = St*Phi/N

printf("\n\nResult\n\n")
printf("\n current = %.3f A",I)
```

Chapter 8

Electromagnetism

Scilab code Exa 8.02 Example 2

```
//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.

//initializing the variables:
B = 0.9; // in tesla
I = 20; // in Amperes
l = 0.30; // in m
alpha = 30; // in degree
u0 = 4*%pi*1E-7;

//calculation:
F1 = B*I*l
F2 = B*I*l*sin(alpha*%pi/180)

printf("\n\nResult\n\n")
```

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

Scilab code Exa 8.03 Example 3

```
//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.

//initializing the variables:
F = 1.92; // in newton
B = 1.2; // in tesla
l = 0.40; // in m
u0 = 4*%pi*1E-7;

//calculation:
I = F/(B*l)

printf("\n\nResult\n\n")
printf("\n (a)Current I = %.0f Amperes(A)",I)
```

Scilab code Exa 8.04 Example 4

```
//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.

//initializing the variables:
r = 0.06; // in m
I = 10; // in Amperes
l = 0.35; // in m
Phi = 0.5E-3; // in Wb
u0 = 4*%pi*1E-7;

//calculation:
A = %pi*r*r
B = Phi/A
F = B*I*l

printf("\n\nResult\n\n")
printf("\n (a)Force F = %.3f N\n",F)
```

Scilab code Exa 8.06 Example 6

```
//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.

//initializing the variables:
N1 = 1; // for a single-turn coil
N2 = 300; // no. of turns
b = 0.024; // in m
B = 0.8; // in Tesla
```

```
I = 0.05; // in Amperes
l = 0.030; // in m
u0 = 4*%pi*1E-7;

//calculation:
//For a single-turn coil,
F1 = N1*B*I*l
//for a coil wound with 300 turns.
F2 = N2*B*I*l

printf("\n\nResult\n\n")
printf("\n (a)For a single-turn coil, force on each coil side = %.4f N",F1)
printf("\n (b)For a 300-turn coil, force on each coil side = %.2f N",F2)
```

Scilab code Exa 8.07 Example 7

```
//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.

//initializing the variables:
Q = 1.6E-19; // in Coulomb
v = 3E7; // in m/s
B = 18.5E-6; // in Tesla
u0 = 4*%pi*1E-7;

//calculation:
F = Q*v*B

printf("\n\nResult\n\n")
printf("\n Force exerted on the electron in the
```

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

Chapter 9

Electromagnetic induction

Scilab code Exa 9.01 Example 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
   .

//initializing the variables:
l = 0.3; // in m
v = 4; // in m/s
B = 1.25; // in Tesla
R = 20; // in ohms
u0 = 4*%pi*1E-7;

//calculation:
E = B*l*v
I2 = E/R

printf("\n\nResult\n\n")
printf("\n (a)If the ends of the conductor are open
```

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

Scilab code Exa 9.02 Example 2

```
//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.

//initializing the variables:
l = 0.075; // in m
E = 9; // in Volts
B = 0.6; // in Tesla
R = 20; // in ohms
u0 = 4*%pi*1E-7;

//calculation:
v = E/(B*l)

printf("\n\nResult\n\n")
printf("\n velocity v = %.0f m/s\n",v)
```

Scilab code Exa 9.03 Example 3

```
//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.
```

```
//initializing the variables:
l = 0.02; // in m
b = 0.02; // in m
v = 15; // in m/s
R = 20; // in ohms
Phi = 5E-6; // in Wb
u0 = 4*%pi*1E-7;
a1 = 90; // in degrees
a2 = 60; // in degrees
a3 = 30; // in degrees

//calculation:
A = l*b
B = Phi/A
E90 = B*l*v*sin(a1*%pi/180)
E60 = B*l*v*sin(a2*%pi/180)
E30 = B*l*v*sin(a3*%pi/180)

printf("\n\nResult\n\n")
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

```
//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

//initializing the variables:
s = 36; // in m
v = 400; // in km/h
```

```
u0 = 4*%pi*1E-7;
B = 40E-6; // in Tesla

//calculation:
v0 = v*5/18
E = B*s*v0

printf("\n\nResult\n\n")
printf("\n Induced e.m.f. = %.2f V\n",E)
```

Scilab code Exa 9.06 Example 6

```
//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

//initializing the variables:
N = 200; // no. of turns
dt = 0.050; // change of time in sec
u0 = 4*%pi*1E-7;
dPhi = 0.025; // change of flux in Wb

//calculation:
E = -1*N*dPhi/dt

printf("\n\nResult\n\n")
printf("\n Induced e.m.f. = %.0f V\n",E)
```

Scilab code Exa 9.07 Example 7

```
//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.
```

```

//initializing the variables:
N = 150; // no. of turns
dt = 0.040; // change of time in sec
u0 = 4*%pi*1E-7;
dPhi = 800E-6; // change of flux in Wb

//calculation:
//Since the flux reverses, the flux changes from
    C400 Wb to 400 Wb, a total change of flux of
    800 Wb
E = -1*N*dPhi/dt

printf("\n\nResult\n\n")
printf("\n Induced e.m.f. = %.0f V\n",E)
```

Scilab code Exa 9.08 Example 8

```
//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

//initializing the variables:
L = 12; // in Henry
u0 = 4*%pi*1E-7;
dIdt = 4; // change of current with change in time
    in A/s

//calculation:
E = -1*L*dIdt

printf("\n\nResult\n\n")
printf("\n Induced e.m.f. = %.0f V\n",E)
```

Scilab code Exa 9.09 Example 9

```
//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.

//initializing the variables:
E = 1500; // in Volts
dt = 0.008; // Change of time in sec
dI = 4; // change of current in A/s

//calculation:
L = abs(E)*dt/dI

printf("\n\n Result \n\n")
printf("\n Inductance L = %.0f H\n",L)
```

Scilab code Exa 9.10 Example 10

```
//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?

//initializing the variables:
L = 8; // in Henry
I = 3; // in Amperes

//calculation:
W = L*I*I/2

printf("\n\n Result \n\n")
printf("\n Energy stored, W = %.0f J\n",W)
```

Scilab code Exa 9.11 Example 11

```
//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.

//initializing the variables:
I = 4; // in Amperes
N = 800; //turns
Phi = 0.005; // in Wb

//calculation:
L = N*Phi/I

printf("\n\n Result \n\n")
printf("\n Inductance L = %.0f H\n",L)
```

Scilab code Exa 9.12 Example 12

```
//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.

//initializing the variables:
I1 = 3; // in Amperes
I2 = 0; // in Amperes
dt = 0.150; // in secs
N = 1500; //turns
```

```
Phi = 0.025; // in Wb

//calculation:
L = N*Phi/I1
W = L*I1*I1/2
dI = I1 - I2
E = -1*L*dI/dt

printf("\n\n Result \n\n")
printf("\n (a)Inductance L = %.1f H",L)
printf("\n (b)energy stored W = %.2f J",W)
printf("\n (c)e.m.f. induced = %.0f V",E)
```

Scilab code Exa 9.13 Example 13

```
//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

//initializing the variables:
I1 = 2; // in Amperes
I2 = 0; // in Amperes
dt = 0.020; // in secs
N = 750; //turns
L = 3; // in Henry

//calculation:
Phi = L*I1/N
dI = I1 - I2
E = -1*L*dI/dt

printf("\n\n Result \n\n")
printf("\n (a)Flux = %.3f Wb",Phi)
printf("\n (b)e.m.f. induced = %.0f V",E)
```

Scilab code Exa 9.14 Example 14

```
//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.

//initializing the variables:
dI1dt = 200; // change of current with change in
    time in A/s
N = 2; // no. of coils
E2 = 1.5; // in Volts

//calculation:
M = abs(E2)/dI1dt

printf("\n\n Result \n\n")
printf("\n mutual inductance, M = %.4f H\n", M)
```

Scilab code Exa 9.15 Example 15

```
//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.

//initializing the variables:
M = 0.018; // in Henry
N = 2; // no. of coils
E2 = 0.72; // in Volts

```

```
//calculation:
dI1dt = abs(E2)/M

printf("\n\n Result \n\n")
printf("\n rate of change of current dI1/dt = %.0f A
   /s\n", dI1dt)
```

Scilab code Exa 9.16 Example 16

```
//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.

//initializing the variables:
M = 0.2; // in Henry
I1 = 10; // in Amperes
I2 = 4; // in Amperes
dt = 0.010; // in secs
N = 500; // turns

//calculation:
dI1dt = (I1 -I2)/dt
E2 = -1*dI1dt*M
dPhi = abs(E2)*dt/N

printf("\n\n Result \n\n")
printf("\n (a)Induced e.m.f. E2 = %.0f V", E2)
printf("\n (b)change of flux = %.4f Wb", dPhi)
```

Chapter 10

Electrical measuring instruments and measurements

Scilab code Exa 10.01 Example 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.

//initializing the variables:
Ia = 0.040; // in Amperes
I = 50; // in Amperes
ra = 25; // in ohms


//calculation:
Is = I - Ia
V = Ia*ra
Rs = V/Is

printf("\n\n Result \n\n")
```

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

Scilab code Exa 10.02 Example 2

```
//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.

//initializing the variables:
V = 100; // in volts
I = 0.008; // in Amperes
ra = 10; // in ohms


//calculation:
Rm = (V/I) - ra

printf("\n\n Result \n\n")
printf("\n value of the multiplier to be connected in series = %.3Eohms\n", Rm)
```

Scilab code Exa 10.03 Example 3

```
//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.

```

```
//initializing the variables:
fsd = 200; // in volts
R1 = 250; // in ohms
R2 = 2E6; // in ohms
sensitivity = 10000; // in ohms/V

//calculation:
Rv = sensitivity*fsd
Iv = V/Rv
Pv = V*Iv
I1 = V/R1
P1 = V*I1
I2 = V/R2
P2 = V*I2

printf("\n\n Result \n\n")
printf("\n (a)the power dissipated by the voltmeter
    = %.2E W", Pv)
printf("\n (b)the power dissipated by resistor 250
    ohm = %.0f W", P1)
printf("\n (c)the power dissipated by resistor 2
    Mohm = %.2E W", P2)
```

Scilab code Exa 10.04 Example 4

```
//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.

```

```
//initializing the variables:
V = 10; // in volts
fsd = 0.1; // in Amperes
ra = 50; // in ohms
R = 500; // in ohms

//calculation:
Ie = V/R
Ia = V/(R + ra)
Pa = Ia*Ia*ra
PR = Ia*Ia*R

printf("\n\n Result \n\n")
printf("\n (a)expected ammeter reading = %.2E A\",
    Ie)
printf("\n (b)Actual ammeter reading = %.2E A",Ia)
printf("\n (c)Power dissipated in the ammeter = %.2E
     W", Pa)
printf("\n (d)Power dissipated in the load resistor
    = %.2E W",PR)
```

Scilab code Exa 10.05 Example 5

```
//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.

//initializing the variables:
fsd = 100; // in volts
R1 = 40E3; // in ohms
R2 = 60E3; // in ohms
```

```
sensitivity = 1600; // in ohms/V

//calculation:
V1 = (R1/(R1 + R2))*fsd
Rv = fsd*sensitivity
Rep = R1*Rv/(R1 + Rv)
V1n = (Rep/(Rep + R2))*fsd

printf("\n\n Result \n\n")
printf("\n (a)the value of voltage V1 with the voltmeter6 not connected = %.0f V", V1)
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

```
//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.

//initializing the variables:
I = 20; // in amperes
R = 2; // in ohms
Rw = 0.01; // in ohms

//calculation:
PR = I*I*R
Rt = R + Rw
Pw = I*I*Rt

printf("\n\n Result \n\n")
printf("\n (a)the power dissipated in the load = %.0
```

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

Scilab code Exa 10.08 Example 8

```
//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.
//(In Figures 10.15 to 10.18 assume that the squares shown are 1 cm by 1 cm)

//initializing the variables:
tc = 100E-6; // in s/cm
Vc = 20; // in V/cm
w = 5.2; // in cm ( width of one complete cycle )
h = 3.6; // in cm ( peak-to-peak height of the display )

//calculation:
T = w*tc
f = 1/T
ptpv = h*Vc

printf("\n\n Result \n\n")
printf("\n (a)the periodic time, T = %.2E sec", T)
printf("\n (b)Frequency, f = %.0f Hz",f)
printf("\n (c)the peak-to-peak voltage = %.0f V", ptpv)
```

Scilab code Exa 10.09 Example 9

```
//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.
//(In Figures 10.15 to 10.18 assume that the squares shown are 1 cm by 1 cm)

//initializing the variables:
tc = 50E-3; // in s/cm
Vc = 0.2; // in V/cm
w = 3.5; // in cm ( width of one complete cycle )
h = 3.4; // in cm ( peak-to-peak height of the display )

//calculation:
T = w*tc
f = 1/T
ptpv = h*Vc

printf("\n\n Result \n\n")
printf("\n (a)the periodic time, T = %.2E sec ",T)
printf("\n (b)Frequency, f = %.2f Hz",f)
printf("\n (c)the peak-to-peak voltage = %.2f V",ptpv)
```

Scilab code Exa 10.10 Example 10

```
//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.
//(In Figures 10.15 to 10.18 assume that the squares shown are 1 cm by 1 cm)

//initializing the variables:
tc = 500E-6; // in s/cm
Vc = 5; // in V/cm
w = 4; // in cm ( width of one complete cycle )
h = 5; // in cm ( peak-to-peak height of the display )

//calculation:
T = w*tc
f = 1/T
ptpv = h*Vc
Amp = ptpv/2
Vrms = Amp/(2^0.5)

printf("\n\n Result \n\n")
printf("\n (a)Frequency, f = %.0f Hz",f)
printf("\n (b)the peak-to-peak voltage = %.0f V",ptpv)
printf("\n (c)Amplitude = %.1f V",Amp)
printf("\n (d)r.m.s voltage = %.2f V",Vrms)
```

Scilab code Exa 10.11 Example 11

```
//Problem 10.11: For the double-beam oscilloscope displays shown in Figure 10.18 determine (a) their frequency, (b) their r.m.s. values, (c) their phase difference. The time/cm switch is on 100 s/cm and the volts/cm switch on 2 V/cm.
```

```
//(In Figures 10.15 to 10.18 assume that the squares shown are 1 cm by 1 cm)

//initializing the variables:
tc = 100E-6; // in s/cm
Vc = 2; // in V/cm
w = 5; // in cm ( width of one complete cycle for both waveform )
h1 = 2; // in cm ( peak-to-peak height of the display )
h2 = 2.5; // in cm ( peak-to-peak height of the display )

//calculation:
T = w*tc
f = 1/T
ptpv1 = h1*Vc
Vrms1 = ptpv1/(2^0.5)
ptpv2 = h2*Vc
Vrms2 = ptpv2/(2^0.5)
phi = 0.5*360/w

printf("\n\n Result \n\n")
printf("\n (a)Frequency, f = %.0f Hz",f)
printf("\n (b1)r.m.s voltage of 1st waveform = %.2f V",Vrms1)
printf("\n (b2)r.m.s voltage of 2nd waveform = %.2f V",Vrms2)
printf("\n (c)Phase difference = %.0f  ",phi)
```

Scilab code Exa 10.12 Example 12

```
//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.
```

```

//initializing the variables:
rP1 = 3; // ratio of two powers
rP2 = 20; // ratio of two powers
rP3 = 400; // ratio of two powers
rP4 = 1/20; // ratio of two powers

//calculation:
X1 = 10*log10(3)
X2 = 10*log10(20)
X3 = 10*log10(400)
X4 = 10*log10(1/20)

printf("\n\n Result \n\n")
printf("\n (a)decibel power ratio for power ratio 3
    = %.2f dB ",X1)
printf("\n (b)decibel power ratio for power ratio 20
     = %.1f dB ",X2)
printf("\n (c)decibel power ratio for power ratio
    400 = %.1f dB ",X3)
printf("\n (d)decibel power ratio for power ratio
    1/20 = %.1f dB ",X4)
```

Scilab code Exa 10.13 Example 13

```
//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.

//initializing the variables:
I2 = 0.020; // in ampere
I1 = 0.005; // in ampere

//calculation:
```

```
X = 20*log10(I2/I1)

printf("\n\n Result \n\n")
printf("\n decibel current ratio = %.0f dB\n",X)
```

Scilab code Exa 10.14 Example 14

```
//Problem 10.14: 6% of the power supplied to a cable
    appears at the output terminals. Determine the
    power loss in decibels.

//initializing the variables:
rP = 0.06; // power ratios rP = P2/P1

//calculation:
X = 10*log10(rP)

printf("\n\n Result \n\n")
printf("\n decibel Power ratios = %.2f dB\n",X)
```

Scilab code Exa 10.15 Example 15

```
//Problem 10.15: An amplifier has a gain of 14 dB.
    Its input power is 8 mW. Find its output power.

//initializing the variables:
X = 14; // decibal power ratio in dB
P1 = 0.008; // in Watt

//calculation:
rP = 10^(X/10)
P2 = rP*P1

```

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

Scilab code Exa 10.16 Example 16

```
//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.

//initializing the variables:
X = 27; // Voltage gain in decibels
V2 = 4; // output voltage in Volts

//calculation:
V1 = V2/(10^(27/20))

printf("\n\n Result \n\n")
printf("\n input Voltage V1 = %.3f V\n",V1)
```

Scilab code Exa 10.17 Example 17

```
//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.

//initializing the variables:
```

```
R2 = 100; // in ohms
R3 = 400; // in ohms
R4 = 10; // in ohms

//calculation:
R1 = R2*R3/R4

printf("\n\n Result \n\n")
printf("\n unknown resistance , R1 = %.0f Ohms\n",R1)
```

Scilab code Exa 10.18 Example 18

```
//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

//initializing the variables:
E1 = 1.0186; // in Volts
l1 = 0.400; // in m
l2 = 0.650; // in m

//calculation:
E2 = (l2/l1)*E1

printf("\n\n Result \n\n")
printf("\n the e.m.f. of a dry cell = %.3f Volts\n",
   E2)
```

Scilab code Exa 10.19 Example 19

```
//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.

//initializing the variables:
I = 0.0025; // in Amperes
R = 5000; // in ohms
e1 = 0.4; // in %
e2 = 0.5; // in %

//calculation:
V = I*R
em = e1 + e2
Ve = em*V/100

printf("\n\n Result \n\n")
printf("\n voltage V = %.1fV(+-)%.2fV\n",V,Ve)
```

Scilab code Exa 10.20 Example 20

```
//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.

//initializing the variables:
I = 6.25; // in Amperes
Im = 10; // max in Amperes
```

```
V = 36.5; // in volts
Vm = 50; // max in volts
e = 2; // in %

//calculation:
R = V/I
Ve = e*Vm/100
Ve1 = Ve*100/V  // in  %
Ie = e*Im/100
Ie1 = Ie*100/I  // in %
em = Ve1 + Ie1
Re = em*R/100

printf("\n\n Result \n\n")
printf("\n Resistance R = %.2f ohms(+-)%.2f ohms\n",
   R,Re)
```

Scilab code Exa 10.21 Example 21

```
//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.

//initializing the variables:
R1 = 1000; // in ohms
R2 = 100; // in ohms
R3 = 432.5; // in ohms
e1 = 1; // in %
e2 = 0.5; // in %
e3 = 0.2; // in %

//calculation:
```

```
Rx = R2*R3/R1
em = e1 + e2 + e3
Re = em*Rx/100

printf("\n\n Result \n\n")
printf("\n Resistance R = %.2f ohms(+-)%.2f ohms\n",
   Rx,Re)
```

Chapter 13

DC circuit theory

Scilab code Exa 13.01 Example 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).

//initializing the variables:
Iab = 50; // in ampere
Ibc = 20; // in ampere
Iec = 15; // in ampere
Idf = 120; // in ampere
Ifg = 40; // in ampere
Iab = 50; // in ampere
I = 2; // in ampere
V1 = 4; // in volts
V2 = 3; // in volts
V3 = 6; // in volts
R1 = 1; // in ohms
R2 = 2; // in ohms
R3 = 2.5; // in ohms
R4 = 1.5; // in ohms

//calculation:
```

```
I1 = Iab - Ibc
I2 = Ibc + Iec
I3 = I1 - Idf
I4 = Iec - I3
I5 = Idf - Ifg
// Applying Kirchhoff s voltage law and moving clockwise around the loop of Figure 13.3(b) starting at point A:
E = I*R2 + I*R3 + I*R4 + I*R1 - V2 - V3 + V1

printf("\n\n Result \n\n")
printf("\n (a) unknown currents I1, I2, I3, I4, I5 are %.0fA, %.0fA, %.0fA, %.0fA, %.0fA respetively ",I1, I2, I3, I4, I5)
printf("\n (b) value of e.m.f. E = %.0f Volts",E)
```

Scilab code Exa 13.06 Example 6

```
//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.

//initializing the variables:
E1 = 8; // in volts
E2 = 3; // in volts
R1 = 3; // in ohms
R2 = 2; // in ohms
R3 = 18; // in ohms

//calculation:
//Removing source E2 gives the circuit of Figure 13.17(a).
//The current directions are labelled as shown in
```

```
    Figure 13.17(a), I1 flowing from the positive
    terminal of E1.
//From Figure 13.17(b), I1
r1 = 1/(1/R2 + 1/R3)
I1 = E1/(R1 + r1)
//From Figure 13.17(a), I2
I2 = (R3/(R3 + R2))*I1
I3 = (R2/(R3 + R2))*I1
//Removing source E1 gives the circuit of Figure
    13.18(a)
//The current directions are labelled as shown in
    Figures 13.18(a) and 13.18(b), I4 flowing from
    the positive terminal of E2
//From Figure 13.18(c), I4
r2 = 1/(1/R3 + 1/R1)
I4 = E2/(r2 + R2)
//From Figure 13.18(b), I5
I5 = (R3/(R1 + R3))*I4
I6 = (R1/(R1 + R3))*I4
//Resultant current in the R3 resistor
I18 = I3 - I6
//P.d. across the R3
V3 = I18*R3
//Resultant current in the E1
Ie1 = I1 + I5
//Resultant current in the E2
Ie2 = I2 + I4

printf("\n\n Result \n\n")
printf("\n Resultant current in the 18 ohm resistor
    is %.3f A",I18)
printf("\n P.d. across the 18 ohm resistor is %.3f V
    ",V3)
printf("\n Resultant current in the E1 is %.3f A",
    Ie1)
printf("\n Resultant current in the E2 is %.3f A",
    Ie2)
```

Scilab code Exa 13.07 Example 7

```
//Problem 13.07: Use Thevenin s theorem to find the current flowing in the 10 ohm resistor for the circuit shown in Figure 13.28(a).

//initializing the variables:
V = 10; // in volts
R1 = 2; // in ohms
R2 = 8; // in ohms
R3 = 5; // in ohms
R = 10; // in ohms

//calculation:
//The 10 ohm resistance branch is short-circuited as shown in Figure 13.28(b).
//Current I1
I1 = V/(R1 + R2)
//p.d. across AB, E
E = R2*I1
//the resistance  looking-in  at a break made between A and B is given by
r = R3 + (R1*R2)/(R2 + R1)
//The equivalent Thevenin s circuit is shown in Figure 13.28(d), the current in the 10 ohm resistance is given by:
I = E/(r + R)

printf("\n\n Result \n\n")
printf("\n the current in the 10 ohm resistance is given by %.3f A",I)
```

Scilab code Exa 13.08 Example 8

```
//Problem 13.08: For the network shown in Figure 13.29(a) determine the current in the 0.8 ohm resistor using Th evenin s theorem.

//initializing the variables:
V = 12; // in volts
R1 = 5; // in ohms
R2 = 1; // in ohms
R3 = 4; // in ohms
R = 0.8; // in ohms

//calculation:
//The 0.8 ohm resistance branch is short-circuited as shown in Figure 13.29(b).
//Current I1
I1 = V/(R1 + R2 + R3)
//p.d. across AB, E
E = R3*I1
//the resistance  looking-in  at a break made between A and B is given by
r = R3*(R1 + R2)/(R2 + R1 + R3)
//The equivalent Th evenin s circuit is shown in Figure 13.29(d), the current in the 0.8 ohm resistance is given by:
I = E/(r + R)

printf("\n\n Result \n\n")
printf("\n the current in the 0.8 ohm resistance is given by %.1f A",I)
```

Scilab code Exa 13.09 Example 9

```
//Problem 13.09: Use Th evenin 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.

//initializing the variables:
E1 = 4; // in volts
E2 = 2; // in volts
R1 = 2; // in ohms
R2 = 1; // in ohms
R3 = 4; // in ohms

//calculation:
//The 4 ohm resistance branch is short-circuited as
   shown in Figure 13.30(b).
//Current I1
I1 = (E1 - E2)/(R1 + R2)
//p.d. across AB, E
E = E1 - I1*R1
//the resistance  looking-in  at a break made
   between A and B is given by
r = R2*R1/(R2 + R1)
//The equivalent Th evenin s circuit is shown in
   Figure 13.30(d), the current in the 4ohm
   resistance is given by:
I = E/(r + R3)
//Power dissipated in R3
P3 = R3*I^2

printf("\n\n Result \n\n")
printf("\n the current in the 4 ohm resistance is
   given by %.3f A",I)
printf("\n power disipated in 4 ohm resistor is
   given by %.3f W",P3)
```

Scilab code Exa 13.10 Example 10

```
//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.

//initializing the variables:
V = 24; // in volts
R1 = 20; // in ohms
R2 = 5; // in ohms
R3 = 10; // in ohms
R4 = 5/3; // in ohms
R5 = 3; // in ohms

//calculation:
//The 3 ohm resistance branch is short-circuited as shown in Figure 13.31(b).
//P.d. across R3
V3 = (R3/(R3 + R2))*V
//p.d. across AB, E
E = V3
//the resistance  looking-in  at a break made between A and B is given by
r = R4 + R2*R3/(R2 + R3)
//The equivalent Th evenin s circuit is shown in Figure 13.31(e), the current in the 32 ohm resistance is given by:
I = E/(r + R5)

printf("\n\n Result \n\n")
printf("\n the current in the 3 ohm resistance is given by %.0f A",I)
```

Scilab code Exa 13.11 Example 11

```
//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.

//initializing the variables:
E = 54; // in volts
R1 = 2; // in ohms
R2 = 14; // in ohms
R3 = 3; // in ohms
R4 = 11; // in ohms
R5 = 32; // in ohms

//calculation:
//The 32ohm resistance branch is short-circuited as shown in Figure 13.32(b).
//The p.d. between A and C,
Vac = (R1/(R1 + R4))*E
//The p.d. between B and C,
Vbc = (R2/(R2 + R3))*E
//Hence the p.d. between A and B
Vab = Vbc - Vac
//the resistance  looking-in  at a break made between A and B is given by
r = R1*R4/(R1 + R4) + R2*R3/(R2 + R3)
//The equivalent Th evenin s circuit is shown in Figure 13.32(f), the current in the 32 ohm resistance is given by:
I = E/(r + R5)

printf("\n\n Result \n\n")
printf("\n the current in the 32 ohm resistance is given by %.0f A",I)
```

Scilab code Exa 13.12 Example 12

```
//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).

//initializing the variables:
V = 10; // in volts
R1 = 2; // in ohms
R2 = 8; // in ohms
R3 = 5; // in ohms
R4 = 10; // in ohms

//calculation:
//The 10ohm resistance branch is short−circuited as shown in Figure 13.34(b).
//Figure 13.34(c) is equivalent to Figure 13.34(b). Hence
Isc = V/R1
//the resistance  looking−in   at a break made between A and B is given by
r = R1*R2/(R1 + R2)
//From the Norton equivalent network shown in Figure 13.34(d) the current in the 10 ohm resistance is given by:
I = (r/(r + R3 + R4))*Isc

printf("\n\n Result \n\n")
printf("\n the current in the 10 ohm resistance is given by %.3f A",I)
```

Scilab code Exa 13.13 Example 13

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

```
   shown in Figure 13.35(a).

//initializing the variables:
V1 = 4; // in volts
V2 = 2; // in volts
R1 = 2; // in ohms
R2 = 1; // in ohms
R3 = 4; // in ohms

//calculation:
//The 4ohm resistance branch is short−circuited as
   shown in Figure 13.35(b).
//Figure 13.35(b)
Isc = V1/R1 + V2/R2
//the resistance  looking−in   at a break made
   between A and B is given by
r = R1*R2/(R1 + R2)
//From the Norton equivalent network shown in Figure
    13.35(c) the current in the 4ohm resistance is
   given by:
I = (r/(r + R3))*Isc

printf("\n\n Result \n\n")
printf("\n the current in the 4ohm resistance is
   given by %.3f A",I)
```

Scilab code Exa 13.14 Example 14

```
//Problem 13.14: Use Norton 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.

//initializing the variables:
V = 24; // in volts
```

```
R1 = 20; // in ohms
R2 = 5; // in ohms
R3 = 10; // in ohms
R4 = 5/3; // in ohms
R5 = 3; // in ohms

//calculation:
//The 3ohm resistance branch is short-circuited as
   shown in Figure 13.36(b).
//Figure 13.36(c) is equivalent to Figure 13.36(b).
Isc = V/R2
//the resistance  looking-in  at a break made
   between A and B is given by
r = R3*R2/(R3 + R2)
//From the Norton equivalent network shown in Figure
    13.36(f) the current in the 3ohm resistance is
   given by:
I = (r/(r + R4 + R5))*Isc

printf("\n\n Result \n\n")
printf("\n the current in the 3ohm resistance is
   given by %.0f A",I)
```

Scilab code Exa 13.15 Example 15

```
//Problem 13.15: Determine the current flowing in
   the 2ohm resistance in the network shown in
   Figure 13.37(a).

//initializing the variables:
I = 15; // in amperes
R1 = 6; // in ohms
R2 = 4; // in ohms
R3 = 8; // in ohms
R4 = 2; // in ohms
```

```
R5 = 7; // in ohms

//calculation:
//The 2ohm resistance branch is short-circuited as
   shown in Figure 13.37(b).
//Figure 13.37(c) is equivalent to Figure 13.37(b).
Isc = (R1/(R1 + R2))*I
//the resistance  looking-in   at a break made
   between A and B is given by
r = ((R1 + R2)*(R3 + R5)/(R1 + R2 + R3 + R5))
//From the Norton equivalent network shown in Figure
    13.37(e) the current in the 2ohm resistance is
   given by:
I = (r/(r + R4))*Isc

printf("\n\n Result \n\n")
printf("\n the current in the 2ohm resistance is
   given by %.2f A",I)
```

Scilab code Exa 13.18 Example 18

```
//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.

//initializing the variables:
E1 = 12; // in volts
E2 = 24; // in volts
R1 = 3; // in ohms
R2 = 2; // in ohms
R3 = 1.8; // in ohms

```

```
//calculation:
//For the branch containing the V1 source, converting to a Norton equivalent network gives
Isc1 = E1/R1
r1 = R1
//For the branch containing the V2 source, converting to a Norton equivalent network gives
Isc2 = E2/R2
r2 = R2
//Thus the network of Figure 13.46(a) converts to Figure 13.46(b).
//total short-circuit current
Isct = Isc1 + Isc2
//the resistance is
z = r1*r2/(r1 + r2)
//Both of the Norton equivalent networks shown in Figure 13.46(c) may be converted to Thevenin equivalent circuits. The open-circuit voltage across CD is
Vcd = Isct*z
//the current I flowing in a 1.8 ohm resistance connected between A and B is given by:
I = Vcd/(z + R3)

printf("\n\n Result \n\n")
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

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

```
the current flowing in the 200 ohm resistance.

//initializing the variables:
V1 = 10; // in volts
V2 = 6; // in volts
R1 = 2000; // in ohms
R2 = 3000; // in ohms
R3 = 600; // in ohms
R4 = 200; // in ohms
i = 0.001; // in amperes

//calculation:
//For the branch containing the V1 source,
    converting to a Norton equivalent network gives
Isc1 = V1/R1
r1 = R1
//For the branch containing the V2 source,
    converting to a Norton equivalent network gives
Isc2 = V2/R2
r2 = R2
//Thus the network of Figure 13.46(a) converts to
    Figure 13.46(b).
//total short-circuit current
Isct = Isc1 + Isc2
//the resistance is
z = r1*r2/(r1 + r2)
//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
Vcd = Isct*z
//The open-circuit voltage across EF is
Vef = i*R3
//the resistance looking-in at EF is
r3 = R3
//Thus Figure 13.46(c) converts to Figure 13.46(d).
    Combining the two Th evenin circuits gives
E = Vcd - Vef
```

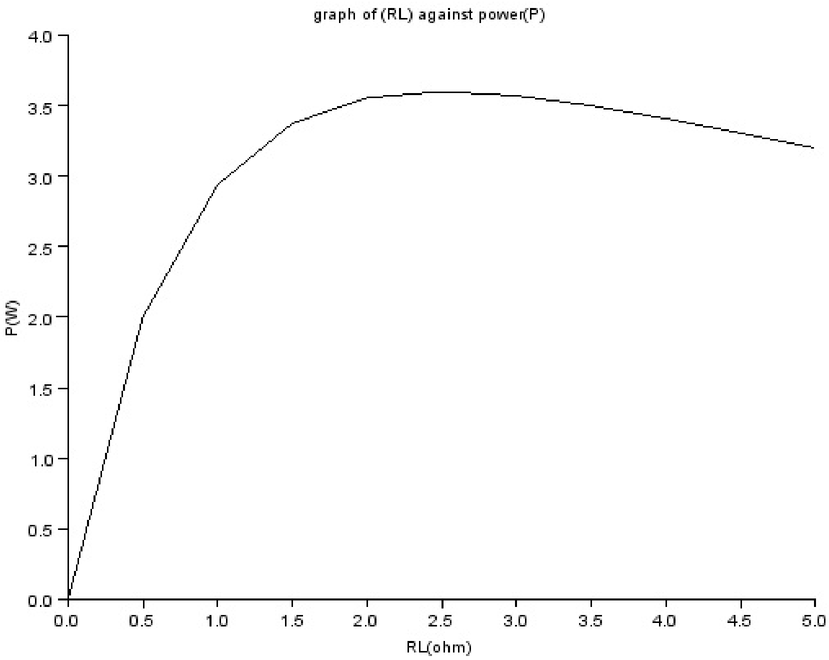

Figure 13.1: Example 20

```
r = z + r3
//the current I flowing in a 200 ohm resistance connected between A and B is given by:
I = E/(r + R4)

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
V = 6; // in volts
r = 2.5; // in ohms

//calculation:
RL=(0:0.5:5)';
function [y]=f(RL)
    y = RL*(V/(r + RL))^2;
endfunction
fplot2d(RL, f)
xtitle("graph of (RL) against power(P)", "RL(ohm)",
    "P(W)")
```

Scilab code Exa 13.21 Example 21

```
//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.

//initializing the variables:
V = 30; // in volts
r = 1.5; // in ohms

//calculation:
```

```
//current I = E/(r + RL)
//For maximum power, RL = r
RL = r
I = V/(r + RL)
//Power, P, dissipated in load RL, P
P = RL*I^2

printf("\n\n Result \n\n")
printf("\n (a) the value of the load resistor RL is %.1f ohm",RL)
printf("\n (b) maximum power dissipation = %.0f W",P)
```

Scilab code Exa 13.22 Example 22

```
//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.

//initializing the variables:
V = 15; // in volts
R1 = 3; // in ohms
R2 = 12; // in ohms

//calculation:
//Resistance RL is removed from the circuit as shown in Figure 13.51(b).
//The p.d. across AB is the same as the p.d. across the 12 ohm resistor.
E = (R2/(R1 + R2))*V
//Removing the source of e.m.f. gives the circuit of Figure 13.51(c),
//from which resistance, r
r = R1*R2/(R1 + R2)
```

```
//The equivalent Th evenin s circuit supplying
   terminals AB is shown in Figure 13.51(d), from
   which, current I = E/(r + RL)
//For maximum power, RL = r
RL = r
I = E/(r + RL)
//Power, P, dissipated in load RL, P
P = RL*I^2

printf("\n\n Result \n\n")
printf("\n (a) the value of the load resistor RL is
   %.1f ohm",RL)
printf("\n (b) maximum power dissipation = %.0f W",P
   )
```

Chapter 14

Alternating voltages and currents

Scilab code Exa 14.01 Example 1

```
//Problem 14.01: Determine the periodic time for
    frequencies of (a) 50 Hz and (b) 20 kHz

//initializing the variables:
f1 = 50; // in Hz
f2 = 20000; // in Hz

//calculation:
T1 = 1/f1
T2 = 1/f2

printf("\n\n Result \n\n")
printf("\n (a) Periodic time T = %.2f secs",T1)
printf("\n (b) Periodic time T = %.2E secs\n",T2)
```

Scilab code Exa 14.02 Example 2

```
//Problem 14.02: Determine the frequencies for periodic times of (a) 4 ms, (b) 4  s

//initializing the variables:
T1 = 0.004; // in secs
T2 = 4E-6; // in secs

//calculation:
f1 = 1/T1
f2 = 1/T2

printf("\n\n Result \n\n")
printf("\n (a) Frequency f = %.0f Hz",f1)
printf("\n (b) Frequency f = %.2E secs",f2)
```

Scilab code Exa 14.03 Example 3

```
//Problem 14.03: An alternating current completes 5 cycles in 8 ms. What is its frequency?

//initializing the variables:
T = (8E-3)/5; // in secs

//calculation:
f = 1/T

printf("\n\n Result \n\n")
printf("\n Frequency f = %.0f Hz\n",f)
```

Scilab code Exa 14.04 Example 4

```
//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

//initializing the variables:
Ta = 0.02; // Time for 1 complete cycle in secs
Vamax = 200; // in volts
Va1 = 25; // in volts
Va2 = 75; // in volts
Va3 = 125; // in volts
Va4 = 175; // in volts
Tb = 0.016; // Time for 1 complete cycle in secs
Ibmax = 10; // in Amperes

//calculation:
//for Triangular waveform (Figure 14.5(a))
fa = 1/Ta
Aaw = Ta*Vamax/4
Vaavg = Aaw*2/Ta
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
Ffa = Varms/Vaavg
Pfa = Vamax/Varms

//for Rectangular waveform (Figure 14.5(b))
fb = 1/Tb
Abw = Tb*Ibmax/2
Ibavg = Abw*2/Tb
Ibrms = 10
Ffb = Ibrms/Ibavg
Pfb = Ibmax/Ibrms

printf("\n\n Result \n\n")
printf("\n (a1)Frequency f = %.0f Hz",fa)
printf("\n (a2)average value over half a cycle = %.0
```

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

Scilab code Exa 14.06 Example 6

```
//Problem 14.06: Calculate the rms value of a
sinusoidal current of maximum value 20 A

//initializing the variables:
Imax = 20; // in Amperes

//calculation:
//for a sine wave
Irms = Imax/(2^0.5)

printf("\n\n Result \n\n")
printf("\n Rms value = %.2f A\n",Irms)
```

Scilab code Exa 14.07 Example 7

```
//Problem 14.07: Determine the peak and mean values
for a 240 V mains supply.

//initializing the variables:
Vrms = 240; // in Volts
```

```

//calculation:
//for a sine wave
Vmax = Vrms*(2^0.5)
Vmean = 0.637*Vmax

printf("\n\n Result \n\n")
printf("\n peak value = %.1f V",Vmax)
printf("\n mean value = %.1f V",Vmean)
```

Scilab code Exa 14.08 Example 8

```
//Problem 14.08: A supply voltage has a mean value
   of 150 V. Determine its maximum value and its rms
    value

//initializing the variables:
Vmean = 150; // in Volts

//calculation:
//for a sine wave
Vmax = Vmean/0.637
Vrms = 0.707*Vmax

printf("\n\n Result \n\n")
printf("\n peak value = %.1f V",Vmax)
printf("\n rms value = %.1f V",Vrms)
```

Scilab code Exa 14.09 Example 9

```
//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

//initializing the variables:
Vmax = 282.8; // in Volts
w = 314; // in rad/sec
t = 0.004; // in sec

//calculation:
//for a sine wave
Vrms = 0.707*Vmax
f = w/(2*%pi)
v = Vmax*sin(w*t)

printf("\n\n Result \n\n")
printf("\n (a)rms value = %.0f V",Vrms)
printf("\n (b)frequency f = %.0f Hz",f)
printf("\n (c)instantaneous value of voltage at 4 ms
    = %.1f V",v)
```

Scilab code Exa 14.10 Example 10

```
//Problem 14.10: An alternating voltage is given by
    v = 75sin(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

//initializing the variables:
Vmax = 75; // in Volts
w = 200*%pi; // in rad/sec
t = 0.004; // in sec
phi = 0.25; // in radians

```

```
//calculation:
//for a sine wave
Vptp = 2*Vmax
Vrms = 0.707*Vmax
f = w/(2*%pi)
T = 1/f
v = Vmax*sin(w*t)
phid = phi*180/%pi

printf("\n\n Result \n\n")
printf("\n (a) Amplitude, or peak value = %.0f V",
    Vmax)
printf("\n (b) Peak-to-peak value = %.0f V",Vptp)
printf("\n (c)rms value = %.0f V",Vrms)
printf("\n (d)periodic time, T = %.2f sec",T)
printf("\n (e)frequency f = %.0f Hz",f)
printf("\n (f)phase angle = %.2f ",phid)
```

Scilab code Exa 14.12 Example 12

```
//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 120sin 100pit (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

//initializing the variables:
Imax = 120; // in Amperes
w = 100*%pi; // in rad/sec
phi = 0.36; // in rad
t1 = 0; // in secs
```

```
t2 = 0.008; // in secs
i = 60; // in amperes

//calculation:
//for a sine wave
f = w/(2*%pi)
T = 1/f
phid = phi*180/%pi
i0 = Imax*sin((w*t1) + phi)
i8 = Imax*sin((w*t2)+phi)
ti = (asin(i/Imax) - phi)/w
tm1 = (asin(Imax/Imax) - phi)/w

printf("\n\n Result \n\n")
printf("\n (a)Peak value = %.0f A, Periodic time T = %.2f sec, Frequency, f = %.0f Hz Phase angle = %.1f ", Imax, T, f, phid)
printf("\n (b) When t = 0, i = %.1f A",i0)
printf("\n (c)When t = 8 ms = %.1f A", i8)
printf("\n (d)When i is 60 A, then time t = %.2E s",ti)
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

```
//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.

//initializing the variables:
L = 0.32; // in Henry
f1 = 50; // in Hz
f2 = 5000; // in Hz
Z = 124; // in ohms

//calculation:
XL = 2*%pi*f1*L
L = Z/(2*%pi*f2)

printf("\n\n Result \n\n")
printf("\n (a)Inductive reactance, XL = %.1f ohms ",
     XL)
printf("\n (b)Inductance L = %.2E H",L)
```

Scilab code Exa 15.02 Example 2

```
//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.

//initializing the variables:
L = 0.040; // in Henry
V1 = 240; // in volts
V2 = 100; // in volts
f1 = 50; // in Hz
f2 = 1000; // in Hz

//calculation:
XL1 = 2*%pi*f1*L
I1 = V1/XL1
XL2 = 2*%pi*f2*L
I2 = V2/XL2

printf("\n\n Result \n\n")
printf("\n (a)Inductive reactance, XL = %.2f ohms
   and current I = %.2f A", XL1, I1)
printf("\n (b)Inductive reactance, XL = %.1f ohms
   and current I = %.3f A", XL2, I2)
```

Scilab code Exa 15.03 Example 3

```
//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
```

```
//initializing the variables:
C = 10E-6; // in Farads
f1 = 50; // in Hz
f2 = 20000; // in Hz

//calculation:
Xc1 = 1/(2*%pi*f1*C)
Xc2 = 1/(2*%pi*f2*C)

printf("\n\n Result \n\n")
printf("\n (a)Capacitive reactance, Xc = %.1f ohms "
    , Xc1)
printf("\n (b)Capacitive reactance, Xc = %.3f ohms "
    , Xc2)
```

Scilab code Exa 15.04 Example 4

```
//Problem 15.04: A capacitor has a reactance of 40
    ohms when operated on a 50 Hz supply. Determine
    the value of its capacitance.

//initializing the variables:
Z = 40; // in ohms
f = 50; // in Hz

//calculation:
C = 1/(2*%pi*f1*Z)

printf("\n\n Result \n\n")
printf("\n Capacitance,C = %.2E F ", C)
```

Scilab code Exa 15.05 Example 5

```
//Problem 15.05: Calculate the current taken by a 23 F capacitor when connected to a 240 V, 50 Hz supply.

//initializing the variables:
C = 23E-6; // in Farads
f = 50; // in Hz
V = 240; // in volts

//calculation:
Xc = 1/(2*%pi*f1*C)
I = V/Xc

printf("\n\n Result \n\n")
printf("\n current I = %.2f A ",I)
```

Scilab code Exa 15.06 Example 6

```
//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.

//initializing the variables:
Vr = 12; // in volts
Vl = 5; // in volts

//calculation:
V = (Vr^2 + Vl^2)^0.5
phi = atan(Vl/Vr)
phid = phi*180/%pi

printf("\n\n Result \n\n")
printf("\n supply voltage V = %.0f V, phase angle
```

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

Scilab code Exa 15.07 Example 7

```
//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.

//initializing the variables:
V = 240; // in volts
R = 4; // in ohms
L = 0.00955; // in Henry
f = 50; // in Hz

//calculation:
XL = 2*%pi*f*L
Z = (R^2 + XL^2)^0.5
I = V/Z
phid = atan(XL/R)*180/%pi

printf("\n\n Result \n\n")
printf("\n (a)Inductive reactance, XL = %.0f ohms",XL)
printf("\n (b)Impedance, Z = %.0f ohms",Z)
printf("\n (c)Current, I = %.0f A",I)
printf("\n (d)phase angle between the supply voltage and current is %.2f ",phid)
```

Scilab code Exa 15.08 Example 8

```
//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.

//initializing the variables:
Vdc = 12; // in volts
Vac = 240; // in volts
Iac = 20; // in Amperes
Idc = 2; // in Amperes
f = 50; // in Hz

//calculation:
R = Vdc/Idc
Z = Vac/Iac
XL = (Z^2 - R^2)^0.5
L = XL/(2*%pi*f)

printf("\n\n Result \n\n")
printf("\n (a)Resistance, R = %.0f ohms",R)
printf("\n (b)Impedance, Z = %.0f ohms",Z)
printf("\n (c)Inductive reactance, XL = %.2f ohms",
   XL)
printf("\n (d)Inductance, L = %.4f H",L)
```

Scilab code Exa 15.09 Example 9

```
//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
```

```
//initializing the variables:
R = 200; // in ohms
L = 0.3183; // in henry
Vac = 240; // in volts
f = 50; // in Hz

//calculation:
XL = 2*%pi*f*L
Z = (R^2 + XL^2)^0.5
I = V/Z
VL = I*XL
VR = I*R
phid = atan(XL/R)*180/%pi

printf("\n\n Result \n\n")
printf("\n (a)Inductive reactance, XL = %.0f ohms",
    XL)
printf("\n (b)Impedance, Z = %.1f ohms",Z)
printf("\n (c)current, I = %.3f A",I)
printf("\n (d)p.d. across Inductor, VL = %.1f V and
    p.d. across resistance, VR = %.1f V",VL, VR)
printf("\n (e)circuit phase angle is %.2f ",phid)
```

Scilab code Exa 15.10 Example 10

```
//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.

```

```
//initializing the variables:
R = 100; // in ohms
L = 0.2; // in henry
Vmax = 200; // in volts
w = 500; // in rad/sec

//calculation:
Vrms = 0.707*Vmax
f = w/(2*%pi)
XL = 2*%pi*f*L
Z = (R^2 + XL^2)^0.5
I = Vrms/Z
VL = I*XL
VR = I*R
phid = atan(XL/R)*180/%pi

printf("\n\n Result \n\n")
printf("\n (a)Impedance, Z = %.1f ohms",Z)
printf("\n (b)current, I = %.0f A",I)
printf("\n (c)p.d. across resistance, VR = %.0f V",
    VR)
printf("\n (d)p.d. across Inductor, VL = %.0f V",VL)
printf("\n (e)circuit phase angle is %.0f ",phid)
```

Scilab code Exa 15.11 Example 11

```
//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.

//initializing the variables:
```

```
R = 30; // in ohms
L = 1.2273E-3; // in henry
f = 5000; // in Hz
VR = 6; // in volts

//calculation:
I =VR/R
XL = 2*%pi*f*L
Z = (R^2 + XL^2)^0.5
V = I*Z
VL = I*XL

printf("\n\n Result \n\n")
printf("\n (a)supply voltage = %.0f Volts",V)
printf("\n (b)p.d. across Inductor, VL = %.0f V",VL)
```

Scilab code Exa 15.12 Example 12

```
//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.

//initializing the variables:
R = 60; // in ohms
Rc = 20; // in ohms
L = 159.2E-3; // in henry
f = 50; // in Hz
V = 240; // in volts

//calculation:
```

```
XL = 2*%pi*f*L
Rt = R + Rc
Z = (Rt^2 + XL^2)^0.5
I = V/Z
phid = atan(XL/Rt)*180/%pi
VR = I*R
Zc = (Rc^2 + XL^2)^0.5
Vc = I*Zc
VL = I*XL
VRc = I*Rc

printf("\n\n Result \n\n")
printf("\n (a)Impedance, Z = %.2f ohms",Z)
printf("\n (b)current, I = %.3f A",I)
printf("\n (c)circuit phase angle is %.0f  ",phid)
printf("\n (d)p.d. across resistance, VR = %.1f V",VR)
printf("\n (e)p.d. across coil, Vc = %.0f V",Vc)
printf("\n (f1)p.d. across Inductor, VL = %.1f V",VL)
printf("\n (f2)p.d. across coil resistance, VRc = %.2f V",VRc)
```

Scilab code Exa 15.13 Example 13

```
//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.

//initializing the variables:
R = 25; // in ohms
C = 45E-6; // in Farads
f = 50; // in Hz
```

```
V = 240; // in volts

//calculation:
Xc = 1/(2*%pi*f*C)
Z = (R^2 + Xc^2)^0.5
I = V/Z
phid = atan(Xc/R)*180/%pi

printf("\n\n Result \n\n")
printf("\n (a)Impedance, Z = %.2f ohms",Z)
printf("\n (b)current, I = %.2f A",I)
printf("\n (c)phase angle between the supply voltage
    and current is %.2f ",phid)
```

Scilab code Exa 15.14 Example 14

```
//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.

//initializing the variables:
R = 40; // in ohms
f = 60; // in Hz
I = 3; //in amperes
Z = 50; // in ohms

//calculation:
Xc = (Z^2 - R^2)^0.5
C = 1/(2*%pi*f*Xc)
```

```
V = I*Z
phid = atan(Xc/R)*180/%pi
VR = I*R
Vc = I*Xc

printf("\n\n Result \n\n")
printf("\n (a)capacitance , C = %.2E F",C)
printf("\n (b)Voltage , V = %.0f Volts",V)
printf("\n (c)phase angle between the supply voltage and current is %.2 f ",phid)
printf("\n (d)p.d. across resistance , VR = %.0f V",VR)
printf("\n (e)p.d. across Capacitor , Vc = %.0f V",Vc)
```

Scilab code Exa 15.15 Example 15

```
//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.

//initializing the variables:
R = 5; // in ohms
C = 100E-6; // in Farads
L = 0.12; // in Henry
f = 50; // in Hz
V = 300; // in volts

//calculation:
XL = 2*%pi*f*L
Xc = 1/(2*%pi*f*C)
```

```
X = XL - Xc
//Since XL is greater than Xc, the circuit is inductive.
Z = (R^2 + (XL-Xc)^2)^0.5
I = V/Z
phid = atan((XL-Xc)/R)*180/%pi
Zcl = (R^2 + XL^2)^0.5
Vcl = I*Zcl
phidc = atan(XL/R)*180/%pi
Vc = I*Xc

printf("\n\n Result \n\n")
printf("\n (a)Current,I = %.2f A",I)
printf("\n (b)phase angle between the supply voltage and current is %.2f ",phid)
printf("\n (c)Voltage across the coil, Vcoil = %.0f Volts",Vcl)
printf("\n (d)p.d. across Capacitor, Vc = %.0f V",Vc)
```

Scilab code Exa 15.16 Example 16

```
//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.

//initializing the variables:
R1 = 8; // in ohms
C = 0.25E-6; // in Farads
L = 130E-6; // in Henry
```

```
Rc = 5; // in ohms
R2 = 10; // in ohms
f = 20000; // in Hz
V = 40; // in volts

//calculation:
XL = 2*%pi*f*L
Xc = 1/(2*%pi*f*C)
X = Xc - XL
R = R1 + R2 + Rc
//Since Xc is greater than XL, the circuit is
    capacitive.
Z = (R^2 + (Xc-XL)^2)^0.5
I = V/Z
phid = atan((Xc-XL)/R)*180/%pi
V1 = I*R1
V2 = I*((Rc^2 + XL^2)^0.5)
V3 = I*((R2^2 + Xc^2)^0.5)

printf("\n\n Result \n\n")
printf("\n (a)Current,I = %.3f A",I)
printf("\n (b)circuit phase angle is %.2f  ",phid)
printf("\n (c1)Voltage across the Resistance of 8
    ohms = %.2f Volts",V1)
printf("\n (c2)Voltage across the coil, Vcoil = %.2f
     Volts",V2)
printf("\n (c3)p.d. across Capacitor resistance
    circuit = %.2f Volts",V3)
```

Scilab code Exa 15.17 Example 17

```
//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.

//initializing the variables:
R1 = 4; // in ohms
C = 1.273E-6; // in Farads
L = 286E-6; // in Henry
R2 = 8; // in ohms
f = 5000; // in Hz
I = 5; // in amperes

//calculation:
XL = 2*%pi*f*L
phid1 = atan(XL/R)*180/%pi
V1 = I*((R1^2 + XL^2)^0.5)
Xc = 1/(2*%pi*f*C)
V2 = I*((R2^2 + Xc^2)^0.5)
phid2 = atan(Xc/R)*180/%pi
Z = ((R1+R2)^2 + (Xc-XL)^2)^0.5
V = I*Z
phid = atan((Xc-XL)/(R1+R2))*180/%pi

printf("\n\n Result \n\n")
printf("\n Voltage V1 = %.2f V and V2 = %.1f V",V1,
    V2)
printf("\n Voltage supply , V = %.0f V",V)
printf("\n circuit phase angle is %.2f ",phid)
```

Scilab code Exa 15.18 Example 18

```
//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.
```

```

//initializing the variables:
R = 10; // in ohms
C = 60E-6; // in Farads
L = 125E-3; // in Henry
V = 120; // in Volts

//calculation:
fr = 1/(2*%pi*(L*C)^0.5)
//At resonance, XL = Xc and impedance Z = R
I = V/R

printf("\n\n Result \n\n")
printf("\n (a)Resonance frequency,Fr = %.2f Hz",fr)
printf("\n (b)Current, I = %.0f",I)
```

Scilab code Exa 15.19 Example 19

```
//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.

//initializing the variables:
L = 0.05E-3; // in Henry
fr = 200000; // in Hz
V = 0.002; // in Volts
I = 0.1E-3; // in amperes

//calculation:
// L–C–R
//At resonance, XL = Xc and impedance Z = R
R = V/I
```

```
C = 1/(L*(2*%pi*fr)^2)

printf("\n\n Result \n\n")
printf("\n (a)Resistance , R = %.0f ohms",R)
printf("\n (b)Capacitance , C = %.2E F",C)
```

Scilab code Exa 15.20 Example 20

```
//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?

//initializing the variables:
L = 80E-3; // in Henry
C = 0.25E-6; // in Farads
R = 12.5; // in ohms
V = 100; // in Volts

//calculation:
fr = 1/(2*%pi*((L*C)^0.5))
//At resonance , XL = Xc and impedance Z = R
I = V/R
VL = I*(2*%pi*fr*L)
Vc = I/(2*%pi*fr*C)
Vm = VL/V

printf("\n\n Result \n\n")
printf("\n (a)the resonant frequency = %.1f Hz",fr)
printf("\n (b)Current , I = %.0f A",I)
printf("\n (b)Voltage magnification at resonance = %
```

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

Scilab code Exa 15.21 Example 21

```
//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.

//initializing the variables:
L = 60E-3; // in Henry
C = 30E-6; // in Farads
R = 2; // in ohms

//calculation:
Q = ((L/C)^0.5)/R

printf("\n\n Result \n\n")
printf("\n At resonance, Q-factor = %.2f",Q)
```

Scilab code Exa 15.22 Example 22

```
//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.

//initializing the variables:
L = 100E-3; // in Henry
```

```
C = 2E-6; // in Farads
R = 10; // in ohms
V = 50; // in Volts

//calculation:
fr = 1/(2*%pi*((L*C)^0.5))
//At resonance, XL = Xc and impedance Z = R
I = V/R
VL = I*(2*%pi*fr*L)
Vc = I/(2*%pi*fr*C)
Q = VL/V

printf("\n\n Result \n\n")
printf("\n (a)the resonant frequency = %.1f Hz",fr)
printf("\n (b)Current, I = %.0f A",I)
printf("\n (c)Voltage across coil at resonance is %
    .0fV and Voltage across capacitance at resonance
    is %.0fV",VL, Vc)
printf("\n (d)At resonance, Q-factor = %.2f",Q)
```

Scilab code Exa 15.23 Example 23

```
//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
    .

//initializing the variables:
L = 20E-3; // in Henry
R = 10; // in ohms
fr = 5000; // in Hz

//calculation:
```

```
Qr = (2*%pi*fr)*L/R
bw = fr/Qr

printf("\n\n Result \n\n")
printf("\n Bandwidth, (f2-f1) = %.1f Hz",bw)
```

Scilab code Exa 15.24 Example 24

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

t mA flows through a pure resistance of 5 kohm. Find
     the power dissipated in the resistor.

//initializing the variables:
R = 5000; // in ohms
Imax = 0.250; // in Amperes

//calculation:
Irms = 0.707*Imax
P = Irms*Irms*R

printf("\n\n Result \n\n")
printf("\n Power, P = %.1f Watts",P)
```

Scilab code Exa 15.25 Example 25

```
//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.

//initializing the variables:
R = 60; // in ohms
```

```
L = 75E-3; // in Henry
V = 110; // in Volts
f = 60; // in Hz

//calculation:
XL = 2*%pi*f*L
Z = (R^2 + XL^2)^0.5
I = V/Z
P = I*I*R

printf("\n\n Result \n\n")
printf("\n Power, P = %.0f Watts",P)
```

Scilab code Exa 15.26 Example 26

```
//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.

//initializing the variables:
VI = 300; // in VA
V = 150; // in Volts
f = 50; // in Hz

//calculation:
I = VI/V
XL = V/I
L = XL/(2*%pi*f)

printf("\n\n Result \n\n")
printf("\n Inductance = %.3f H",L)
```

Scilab code Exa 15.27 Example 27

```
//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.

//initializing the variables:
VI = 200000; // in VA
pf = 0.8; // power factor

//calculation:
P = VI*pf
Q = VI*sin(acos(pf))

printf("\n\n Result \n\n")
printf("\n rated power output is %.0fW and the
    corresponding reactive power is %.0f var",P,Q)
```

Scilab code Exa 15.28 Example 28

```
//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.

//initializing the variables:
V = 120; // in Volts
f = 50; // in Hz
P = 400; // in Watt
I = 8; // in Amperes

//calculation:
```

```
R = P/(I*I)
Z = V/I
XL = (Z^2 - R^2)^0.5
pf = P/(V*I)
phi = acos(pf)*180/%pi

printf("\n\n Result \n\n")
printf("\n (a)resistance = %.2f ohm ",R)
printf("\n (b)Impedance Z = %.0f Ohm ",Z)
printf("\n (c)reactance = %.2f ohm ",XL)
printf("\n (d)Power factor = %.4f",pf)
printf("\n (e)phase angle = %.2f  ",phi)
```

Scilab code Exa 15.29 Example 29

```
//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.

//initializing the variables:
V = 100; // in Volts
f = 60; // in Hz
P = 100; // in Watt
pf = 0.5; // power factor

//calculation:
I = P/(pf*V)
phi = acos(pf)*180/%pi
R = P/(I*I)
Z = V/I
Xc = (Z^2 - R^2)^0.5
C = 1/(2*%pi*f*Xc)
```

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

Chapter 16

Single phase parallel ac circuits

Scilab code Exa 16.01 Example 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.

//initializing the variables:
R = 20; // in Ohms
L = 2.387E-3; // in Henry
V = 60; // in Volts
f = 1000; // in Hz

//calculation:
IR = V/R
XL = 2*%pi*f*L
IL = V/XL
I = (IR^2 + IL^2)^0.5
phi = atan(IL/IR)
phid = phi*180/%pi
Z = V/I
```

```
P = V*I*cos(phi)

printf("\n\n Result \n\n")
printf("\n (a)Current through resistor is %.0f A and current through Inductor is %.0f A",IR, IL)
printf("\n (b)current , I = %.0f A ",I)
printf("\n (c)phase angle = %.2f  ",phid)
printf("\n (d)Impedance Z = %.0f Ohm ",Z)
printf("\n (e)Power consumed = %.0f Watt ",P)
```

Scilab code Exa 16.02 Example 2

```
//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.

//initializing the variables:
R = 80; // in Ohms
C = 30E-6; // in Farads
V = 240; // in Volts
f = 50; // in Hz

//calculation:
IR = V/R
Xc = 1/(2*%pi*f*C)
Ic = V/Xc
I = (IR^2 + Ic^2)^0.5
phi = atan(Ic/IR)
phid = phi*180/%pi
Z = V/I
P = V*I*cos(phi)
S = V*I
```

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

Scilab code Exa 16.03 Example 3

```
//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.

//initializing the variables:
pf = 0.6; // power factor
V = 120; // in Volts
f = 200; // in Hz
I = 2; // in Amperes

//calculation:
phi = acos(pf)
phid = phi*180/%pi
IR = I*cos(phi)
Ic = I*sin(phi)
R = V/IR
C = Ic/(2*%pi*f*V)

printf("\n\n Result \n\n")
printf("\n (a)Resistance R = %.0f Ohm ",R)
printf("\n (b)Capacitance ,C = %.2E F ",C)
```

Scilab code Exa 16.04 Example 4

```
//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.

//initializing the variables:
C = 25E-6; // in Farads
L = 120E-3; // in Henry
V = 100; // in Volts
f = 50; // in Hz

//calculation:
XL = 2*%pi*f*L
IL = V/XL
Xc = 1/(2*%pi*f*C)
Ic = V/Xc
//IL and Ic are anti-phase. Hence supply current,
I = IL - Ic
//the current lags the supply voltage V by 90
phi = %pi/2
phid = phi*180/%pi
Z = V/I
P = V*I*cos(phi)

printf("\n\n Result \n\n")
printf("\n (a)Current through Inductor is %.3f A and current through capacitor is %.3f A",IL, Ic)
printf("\n (b)current, I = %.3f A ",I)
printf("\n (c)phase angle = %.0f  ",phid)
printf("\n (d)Impedance Z = %.2f Ohm ",Z)
```

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

Scilab code Exa 16.05 Example 5

```
//Problem 16.05: Repeat Problem 16.04 for the condition when the frequency is changed to 150 Hz.

//initializing the variables:
C = 25E-6; // in Farads
L = 120E-3; // in Henry
V = 100; // in Volts
f = 150; // in Hz

//calculation:
XL = 2*%pi*f*L
IL = V/XL
Xc = 1/(2*%pi*f*C)
Ic = V/Xc
//IL and Ic are anti-phase. Hence supply current,
I = Ic - IL
//the current leads the supply voltage V by 90
phi = %pi/2
phid = phi*180/%pi
Z = V/I
P = V*I*cos(phi)

printf("\n\n Result \n\n")
printf("\n (a)Current through Inductor is %.3f A and current through capacitor is %.3f A",IL, Ic)
printf("\n (b)current, I = %.3f A ",I)
printf("\n (c)phase angle = %.0f  ",phid)
printf("\n (d)Impedance Z = %.2f Ohm ",Z)
printf("\n (e)Power consumed = %.0f Watt ",P)
```

Scilab code Exa 16.06 Example 6

```
//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.

//initializing the variables:
C = 30E-6; // in Farads
R = 40; // in Ohms
L = 159.2E-3; // in Henry
V = 240; // in Volts
f = 50; // in Hz

//calculation:
XL = 2*%pi*f*L
Z1 = (R^2 + XL^2)^0.5
ILR = V/Z1
phi1 = atan(XL/R)
phi1d = phi1*180/%pi
Xc = 1/(2*%pi*f*C)
Ic = V/Xc
phi2 = %pi/2
phi2d = phi2*180/%pi
Ih = ILR*cos(phi1) + Ic*cos(phi2)
Iv = -1*ILR*sin(phi1) + Ic*sin(phi2)
I = (Ih^2 + Iv^2)^0.5
phi = atan(abs(Iv)/Ih)
Z = V/I
```

```
P = V*I*cos(phi)
phid = phi*180/%pi
S = V*I
Q = V*I*sin(phi)

printf("\n\n Result \n\n")
printf("\n (a)Current through coil is %.3f A and
   lagged by phase angle is %.2f ",ILR,phi1d)
printf("\n (b)Current through capacitor is %.3f A
   and lead by phase angle is %.0f ",Ic,phi2d)
printf("\n (c)supply Current is %.3f A and lagged by
    phase angle is %.2f ",I,phid)
printf("\n (d)Impedance Z = %.2f Ohm ",Z)
printf("\n (e)Power consumed = %.0f Watt ",P)
printf("\n (f)apparent Power = %.1f VA ",S)
printf("\n (g)reactive Power = %.1f var ",Q)
```

Scilab code Exa 16.07 Example 7

```
//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.

//initializing the variables:
C = 0.02E-6; // in Farads
R = 3000; // in Ohms
L = 120E-3; // in Henry
V = 40; // in Volts
f = 5000; // in Hz
```

```

//calculation:
XL = 2*%pi*f*L
Z1 = (R^2 + XL^2)^0.5
ILR = V/Z1
phi1 = atan(XL/R)
phi1d = phi1*180/%pi
Xc = 1/(2*%pi*f*C)
Ic = V/Xc
phi2 = %pi/2
phi2d = phi2*180/%pi
Ih = ILR*cos(phi1) + Ic*cos(phi2)
Iv = -1*ILR*sin(phi1) + Ic*sin(phi2)
I = (Ih^2 + Iv^2)^0.5
phi = atan((Iv)/Ih)
phid = phi*180/%pi
Z = V/I
P = V*I*cos(phi)

printf("\n\n Result \n\n")
printf("\n (a)Current through coil is %.5f A and lagged by phase angle is %.2f ",ILR,phi1d)
printf("\n (b)Current through capacitor is %.5f A and lead by phase angle is %.0f ",Ic,phi2d)
printf("\n (c)supply Current is %.5f A and lagged by phase angle is %.2f ",I,phid)
printf("\n (d)Impedance Z = %.2f Ohm ",Z)
printf("\n (e)Power consumed = %.4f Watt ",P)
```

Scilab code Exa 16.08 Example 8

```
//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.

//initializing the variables:
C = 40E-6; // in Farads
R = 0; // in Ohms
L = 150E-3; // in Henry
V = 50; // in Volts

//calculation:
fr = ((1/(L*C) - R*R/(L*L))^0.5)/(2*%pi)
Xc = 1/(2*%pi*fr*C)
Icirc = V/Xc

printf("\n\n Result \n\n")
printf("\n (a)Parallel resonant frequency , fr = %.2f
     Hz ",fr)
printf("\n (b)Current circulating in L and C at
    resonance = %.3f A ",Icirc)
```

Scilab code Exa 16.09 Example 9

```
//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.

//initializing the variables:
C = 20E-6; // in Farads
R = 60; // in Ohms
L = 200E-3; // in Henry
V = 20; // in Volts
```

```
//calculation:
fr = ((1/(L*C) - R*R/(L*L))^0.5)/(2*%pi)
Rd = L/(R*C)
Ir = V/Rd
Q = 2*%pi*fr*L/R

printf("\n\n Result \n\n")
printf("\n (a)Parallel resonant frequency, fr = %.2f Hz ",fr)
printf("\n (b)the dynamic resistance,RD = %.1f ohm ",Rd)
printf("\n (c)Current at resonance = %.2f A ",Ir)
printf("\n (d)Q-factor = %.2f",Q)
```

Scilab code Exa 16.10 Example 10

```
//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.

//initializing the variables:
fr = 5000; // in ohm
R = 800; // in Ohms
L = 100E-3; // in Henry
V = 12; // in Volts

//calculation:
C = 1/(L*{(2*%pi*fr)^2 + R*R/(L*L)})
Rd = L/(R*C)
Ir = V/Rd
```

```
Q = 2*%pi*fr*L/R

printf("\n\n Result \n\n")
printf("\n (a)capacitance , C = %.3E F ",C)
printf("\n (b)the dynamic resistance ,RD = %.0f ohm "
    ,Rd)
printf("\n (c)Current at resonance = %.3E A ",Ir)
printf("\n (d)Q-factor = %.2f ",Q)
```

Scilab code Exa 16.11 Example 11

```
//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.

//initializing the variables:
f = 50; // in ohm
V = 240; // in Volts
pf = 0.6// power factor
Im = 50; // in amperes

//calculation:
phi = acos(pf)
phid = phi*180/%pi
Ic = Im*sin(phi)
I = Im*cos(phi)

printf("\n\n Result \n\n")
printf("\n (a)the capacitor current Ic must be %.0f
    A for the power factor to be unity. ",Ic)
printf("\n (b)Supply current I = %.0f A ",I)
```

Scilab code Exa 16.12 Example 12

```
//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.

//initializing the variables:
Pout = 4800; // in Watt
eff = 0.8;// effficiency
f = 50; // in ohm
V = 240; // in Volts
pf1 = 0.625// power factor
pf2 = 0.95// power factor

//calculation:
Pin = Pout/eff
Im = Pin/(V*pf1)
phi1 = acos(pf1)
phi1d = phi1*180/%pi
//When a capacitor C is connected in parallel with
   the motor a current Ic flows which leads V by 90
   .
phi2 = acos(pf2)
phi2d = phi2*180/%pi
Imh = Im*cos(phi1)
//Ih = I*cos(phi2)
```

```
Ih = Imh
I = Ih/cos(phi2)
Imv = Im*sin(phi1)
Iv = I*sin(phi2)
Ic = Imv - Iv
C = Ic/(2*%pi*f*V)
kvar = V*Ic/1000

printf("\n\n Result \n\n")
printf("\n (a)current taken by the motor, Im = %.0f
    A",Im)
printf("\n (b)supply current after p.f. correction,
    I = %.2f A ",I)
printf("\n (c)magnitude of the capacitor current Ic
    = %.0f A",Ic)
printf("\n (d)capacitance, C = %.0f   F ",(C/1E-6))
printf("\n (d)kvar rating of the capacitor = %.2f
    kvar ",kvar)
```

Scilab code Exa 16.13 Example 13

```
//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.

//initializing the variables:
```

```
S = 3000; // in VA
f = 50; // in ohm
V = 250; // in Volts
Iil = 10; // in Amperes
Ifl = 8; // in Amperes
pfil = 1// power factor
pffl = 0.7// power factor
pfm = 0.8// power factor
pf0 = 0.975// power factor

//calculation:
phiil = acos(pfil)
phiild = phiil*180/%pi
phifl = acos(pffl)
phifld = phifl*180/%pi
phim = acos(pfm)
phimd = phim*180/%pi
phi0 = acos(pf0)
phi0d = phi0*180/%pi
Im = S/V
Ih = Iil*cos(phiil) + Ifl*cos(phifl) + Im*cos(phim)
Iv = Iil*sin(phiil) - Ifl*sin(phifl) - Im*sin(phim)
Il = (Ih^2 + Iv^2)^0.5
phi = atan(abs(Iv)/Ih)
phid = phi*180/%pi
pf = cos(phi)
P = V*Il*pf
I = Il*cos(phi)/cos(phi0)
Ic = Il*sin(phi) - I*sin(phi0)
C = Ic/(2*%pi*f*V)

printf("\n\n Result \n\n")
printf("\n (a)total current , Il = %.2f A",Il)
printf("\n (b)Power factor = %.3f",pf)
printf("\n (c)Total power, P = %.3f Watt",P)
printf("\n (d)capacitance , C = %.2E F ",C)
```

Chapter 17

DC transients

Scilab code Exa 17.01 Example 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.

//initializing the variables:
C = 15E-6; // in Farads
R = 47000; // in ohms
V = 120; // in Volts

//calculation:
tou = R*C
```

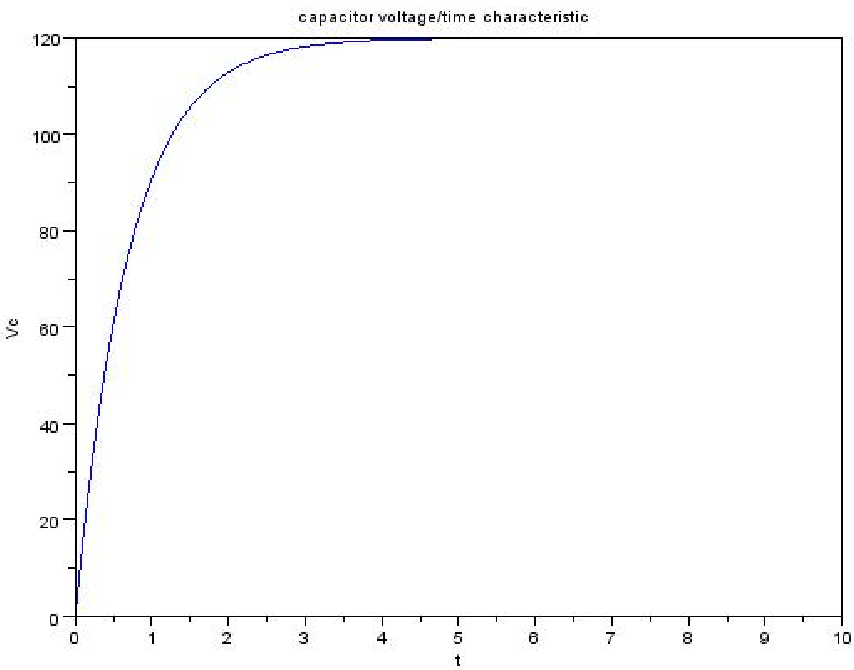

Figure 17.1: Example 1

```
t1 = tou
Vctou = V*(1-%e^(-1*t1/tou))
Vct = V/2
t = 0:0.1:10
Vc = V*(1-%e^(-1*t/tou));
plot(t,Vc)
xtitle("capacitor voltage/time characteristic", "t",
    "Vc")
t = -1*tou*log(1 - Vct/V)

printf("\ = \n\n Result \n\n")
printf("\n (a)the capacitor voltage at a time equal
    to one time constant = %.2f V",Vctou)
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

```
//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.

//initializing the variables:
C = 4E-6; // in Farads
```

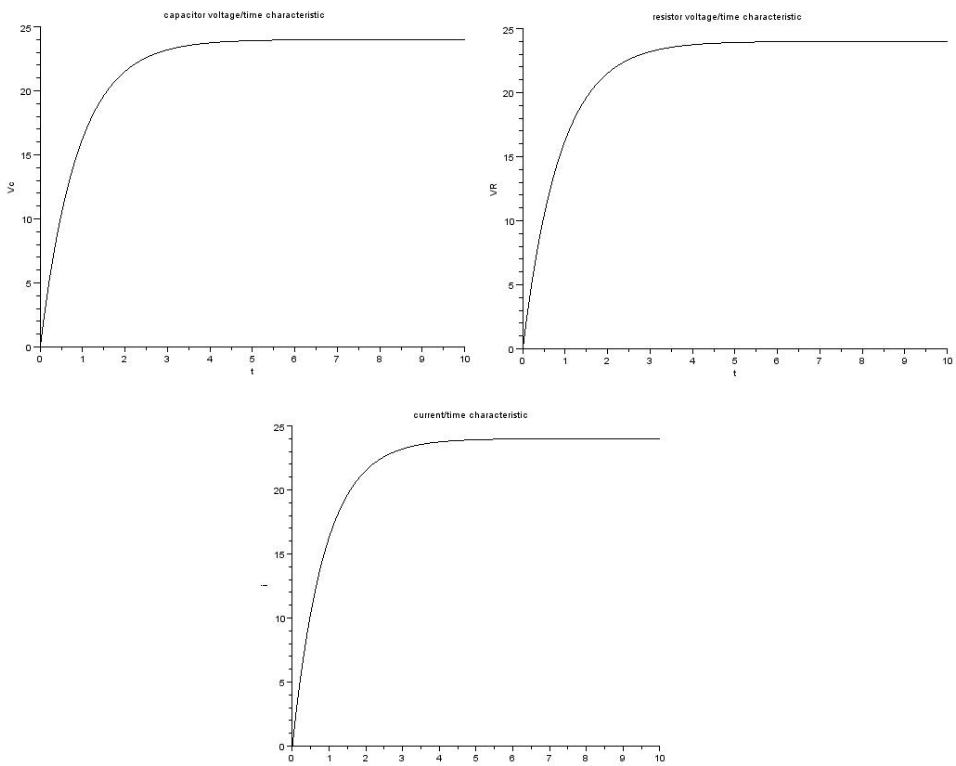

Figure 17.2: Example 2

```
R = 220000; // in ohms
V = 24; // in Volts
t1 = 1.5; // in secs

//calculation:
tou = R*C
t = 0:0.1:10
Vc = V*(1-%e^(-1*t/tou));
plot2d(t,Vc)
xtitle("capacitor voltage/time characteristic", "t",
    "Vc")
xset('window',1)
VR = V*(1-%e^(-1*t/tou));
plot2d(t,VR)
xtitle("resistor voltage/time characteristic", "t",
    "VR")
xset('window',2)
I = V/R
i = I*%e^(-1*t/tou)
plot2d(t,i)
xtitle("current/time characteristic", "t", "i")
Vct1 = V*%e^(-1*t1/tou)
VRt1 = V*%e^(-1*t1/tou)
it1 = I*%e^(-1*t1/tou)

printf("\ = \n\n Result \n\n")
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

```
//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

//initializing the variables:
C = 20E-6; // in Farads
R = 50000; // in ohms
V = 20; // in Volts
t1 = 1; // in secs
t2 = 2; // in secs
VRt = 15; // in Volts

//calculation:
tou = R*C
I = V/R
Vct1 = V*(1-%e^(-1*t2/tou))
t3 = -1*tou*log(VRt/V)
it1 = I*%e^(-1*t1/tou)

printf("\ = \n\n Result \n\n")
printf("\n (a)initial value of the current flowing is %.4f A",I)
printf("\n (b)time constant of the circuit %.0f Sec",tou)
printf("\n (c)the value of the current one second after connection, %.3f mA",(it1/1E-3))
printf("\n (d)the value of the capacitor voltage two seconds after connection %.1f V",Vct1)
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

```
//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

//initializing the variables:
C = 0.5E-6; // in Farads
V = 10; // in Volts
tou = 0.012; // in secs
t1 = 0.007; // in secs

//calculation:
R = tou/C
Vc = V*(1-%e^(-1*t1/tou))

printf("\ = \n\n Result \n\n")
printf("\n (a)value of the resistor is %.0f ohm",R)
printf("\n (b)capacitor voltage is %.2f V",Vc)
```

Scilab code Exa 17.05 Example 5

```
//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.

```

```
//initializing the variables:
R = 50000; // in ohms
V = 100; // in Volts
Vc1 = 20; // in Volts
tou = 0.8; // in secs
t1 = 0.5; // in secs
t2 = 1; // in secs

//calculation:
C = tou/R
t = -1*tou*log(Vc1/V)
I = V/R
it1 = I*%e^(-1*t1/tou)
Vc = V*%e^(-1*t2/tou)

printf("\n\n Result \n\n")
printf("\n (a)the value of the capacitor is %.2E F",C)
printf("\n (b)the time for the capacitor voltage to fall to 20 V is %.2f sec",t)
printf("\n (c)the current flowing when the capacitor has been discharging for 0.5 s is %.5f A",it1)
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

```
//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

```

```
//initializing the variables:
C = 0.1E-6; // in Farads
R = 4000; // in ohms
V = 200; // in Volts
Vc1 = 2; // in Volts

//calculation:
tou = R*C
I = V/R
t = -1*tou*log(Vc1/V)

printf("\n\n Result \n\n")
printf("\n (a) initial discharge current is %.2f A",
    I)
printf("\n (b)Time constant tou is %.4f sec",tou)
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

```
//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.

//initializing the variables:
L = 0.1; // in Henry
R = 20; // in ohms
```

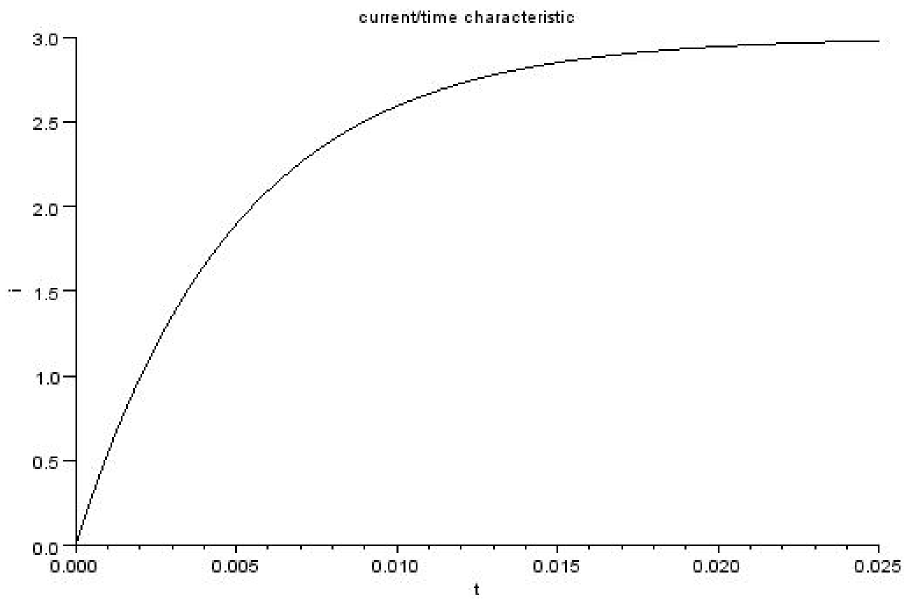

Figure 17.3: Example 7

```
V = 60; // in Volts
i2 = 1.5; // in Amperes

//calculation:
tou = L/R
t1 = 2*tou
t = 0:0.0001:0.025
I = V/R
i = I*(1 - %e^(-1*t/tou))
plot2d(t,i)
xtitle("current/time characteristic", "t", "i")
i1 = I*(1 - %e^(-1*t1/tou))
t2 = -1*tou*log(1 - i2/I)

printf("\ = \n\n Result \n\n")
printf("\n (a) the value of current flowing at a time equal to two time constants is %.3f A",i1)
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

```
//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.

//initializing the variables:
L = 0.04; // in Henry
R = 10; // in ohms
V = 120; // in Volts
```

```
i2 = 0.01*I; // in amperes

//calculation:
tou = L/R
t1 = tou
I = V/R
i1 = I*(1 - %e^(-1*t1/tou))
i2 = 0.01*I
t2 = -1*tou*log(i2/I)

printf("\ = \n\n Result \n\n")
printf("\n (a) the final value of current is %.0f A"
    ,I)
printf("\n (b)time constant of the circuit is %.3f
    sec",tou)
printf("\n (c) value of current after a time equal
    to the time constant is %.2f A",i1)
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

```
//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.

//initializing the variables:
L = 3; // in Henry
```

```
R = 15; // in ohms
V = 120; // in Volts
t1 = 0.1; // in secs
t3 = 0.3; // in secs

//calculation:
tou = L/R
I = V/R
i2 = 0.85*I
VL = V*%e^(-1*t1/tou)
t2 = -1*tou*log(1 - (i2/I))
i3 = I*(1 - %e^(-1*t3/tou))

printf("\ = \n\n Result \n\n")
printf("\n (a) steady state value of current is %.0f
     A",I)
printf("\n (b)time constant of the circuit is %.3f
    sec",tou)
printf("\n (c)value of the induced e.m.f. after 0.1
    s is %.2f V",VL)
printf("\n (d) time for the current to rise to 0.85
    times of its final values is %.3f sec",t2)
printf("\n (e)value of the current after 0.3 s is %
    .3f A",i3)
```

Scilab code Exa 17.10 Example 10

```
//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
```

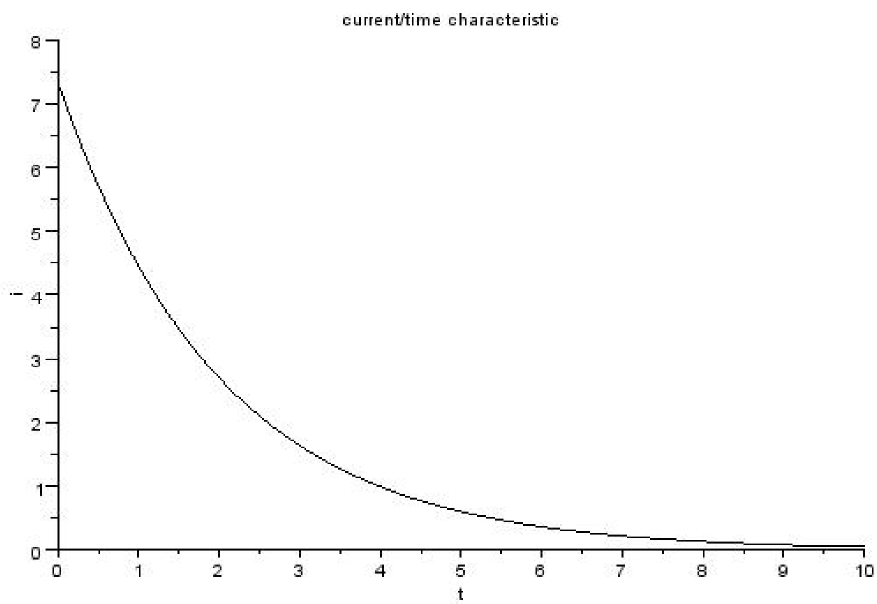

Figure 17.4: Example 10

```
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.

//initializing the variables:
R = 15; // in ohms
V = 110; // in Volts
tou = 2; // in secs
t1 = 3; // in secs
i2 =5; // in amperes

//calculation:
L = tou*R
t = 0:0.1:10
I = V/R
i = I*(%e^(-1*t/tou))
plot2d(t,i)
xtitle("current/time characteristic", "t", "i")
i1 = I*(%e^(-1*t1/tou))
t2 = -1*tou*log((i2/I))

printf("\ = \n\n Result \n\n")
printf("\n inductance is %.0f H",L)
printf("\n (a)the current flowing in the winding 3 s after being shorted-out is %.2f A",i1)
printf("\n (b)the time for the current to decay to 5 A is %.3f sec",t2)
```

Scilab code Exa 17.11 Example 11

```
//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.

//initializing the variables:
L = 6; // in Henry
r = 10; // in ohms
V = 120; // in Volts
tou = 0.3; // in secs
t1 = 1; // in secs

//calculation:
R = (L/tou) - r
Rt = R + r
I = V/Rt
i2 = 0.1*I
i1 = I*(%e^(-1*t1/tou))
t2 = -1*tou*log((i2/I))

printf("\ = \n\n Result \n\n")
printf("\n (a) resistance of the coil is %.0f ohm",R
   )
printf("\n (b) current flowing in the circuit one
   second after the shorting link has been placed is
    %.3f A",i1)
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

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

```
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.

//initializing the variables:
L = 0.2; // in Henry
R = 1000; // in ohms
V = 24; // in Volts

//calculation:
tou = L/R
t1 = 1*tou // in secs
t2 = 2*tou // in secs
t3 = 3*tou // in secs
I = V/R
i1 = I*(1 - %e^(-1*t1/tou))
VL = V*(%e^(-1*t2/tou))
VR = V*(1 - %e^(-1*t3/tou))

printf("\ = \n\n Result \n\n")
printf("\n time constant of the circuit is %.4f sec,
    and  the steady-state value of the current is %
   .3f A",tou, I)
printf("\n (a) urrent flowing in the circuit at a
   time equal to one time constant is %.5f A",i1)
printf("\n (b) voltage drop across the inductor at a
    time equal to two time constants is %.3f V",VL)
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

```
//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

//initializing the variables:
Vi2 = 2.45; // in Volts
Vi1 = 2.35; // in Volts
A0 = 120; // open−loop voltage gain

//calculation:
Vo = A0*(Vi2 - Vi1)

printf("\n\n Result \n\n")
printf("\n the output voltage is %.0f V",Vo)
```

Scilab code Exa 18.02 Example 2

```
//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.

//initializing the variables:
Vg = 150E3; // differential voltage gain
CMRR = 90; // in dB

//calculation:
CMG = Vg/(10^(CMRR/20))

printf("\n\n Result \n\n")
printf("\n common−mode gain is %.2f",CMG)
```

Scilab code Exa 18.03 Example 3

```
//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.

//initializing the variables:
Vg = 120; // differential voltage gain
Vi = 3; // in Volts
Vo = 0.024; // in Volts

//calculation:
CMG = Vo/Vi
CMRR = 20*log10(Vg/CMG)

printf("\n\n Result \n\n")
printf("\n common−mode gain is %.3f and CMRR is %.2f
    dB",CMG, CMRR)
```

Scilab code Exa 18.04 Example 4

```
//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

//initializing the variables:
Rf = 2000; // in ohms
Ri = 1000; // in ohms
Vi1 = 0.4; // in Volts
Vi2 = -1.2; // in Volts

//calculation:
Vo1 = -1*Rf*Vi1/Ri
Vo2 = -1*Rf*Vi2/Ri

printf("\n\n Result \n\n")
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

```
//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?

//initializing the variables:
```

```
Ii = 100E-9; // in Amperes
T = 20; // in  C
Rf = 1E6; // in ohms
Ri = 10000; // in ohms

//calculation:
A = -1*Rf/Ri
Vos = Ii*Ri*Rf/(Ri+Rf)

printf("\n\n Result \n\n")
printf("\n (a)the voltage gain is %.0f",A)
printf("\n (b)output offset voltage is %.5f V",Vos)
```

Scilab code Exa 18.06 Example 6

```
//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.

//initializing the variables:
Vg = 40; // in dB
bf = 5000; // in Hz
Ri = 10000; // in ohms

//calculation:
A = 10^(Vg/20)
Rf = A*Ri
f = A*bf

printf("\n\n Result \n\n")
printf("\n the voltage gain is %.0f, Rf = %.0f ohm and frequency = %.0f Hz",A, Rf, f)
```

Scilab code Exa 18.07 Example 7

```
//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

//initializing the variables:
Vi = -0.4; // in Volts
R1 = 4700; // in ohms
R2 = 10000; // in ohms

//calculation:
A = 1 + (R2/R1)
Vo = A*Vi

printf("\n\n Result \n\n")
printf("\n(a) the voltage gain is %.2f",A)
printf("\n(b) output voltageis %.2f V",Vo)
```

Scilab code Exa 18.08 Example 8

```
//Problem 18.08: For the summing op amp shown in Figure 18.11, determine the output voltage, Vo

//initializing the variables:
V1 = 0.5; // in Volts
V2 = 0.8; // in Volts
V3 = 1.2; // in Volts
R1 = 10000; // in ohms
R2 = 20000; // in ohms
R3 = 30000; // in ohms
```

```
Rf = 50000; // in ohms

//calculation:
Vo = -1*Rf*(V1/R1 + V2/R2 + V3/R3)

printf("\n\n Result \n\n")
printf("\n output voltageis %.1f V",Vo)
```

Scilab code Exa 18.10 Example 10

```
//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.

//initializing the variables:
Vs = -0.75; // in Volts
R = 200000; // in ohms
C = 2.5E-6; // in Farads
t = 0.1; // in secs

//calculation:
Vo = (-1/(C*R))*integrate('−0.75', 't', 0, 0.1)

printf("\n\n Result \n\n")
printf("\n output voltage is %.2f V",Vo)
```

Scilab code Exa 18.11 Example 11

```
//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:
//(a) V1 = 5 mV and V2 = 0
//(b) V1 = 0 and V2 = 5mV
//(c) V1 = 50 mV and V2 = 25mV
//(d) V1 = 25 mV and V2 = 50mV

//initializing the variables:
V1a = 0.005; // in Volts
V2a = 0; // in Volts
V1b = 0; // in Volts
V2b = 0.005; // in Volts
V1c = 0.05; // in Volts
V2c = 0.025; // in Volts
V1d = 0.025; // in Volts
V2d = 0.05; // in Volts
R1 = 10000; // in ohms
R2 = 10000; // in ohms
R3 = 100000; // in ohms
Rf = 100000; // in ohms

//calculation:
Vo1 = -1*Rf*V1a/R1
Vo2 = (R3/(R2+R3))*(1 + (Rf/R1))*V2b
Vo3 = -1*Rf*(V1c-V2c)/R1
Vo4 = (R3/(R2+R3))*(1 + (Rf/R1))*(V2d-V1d)

printf("\n\n Result \n\n")
printf("\n (a)output voltage is %.3f V",Vo1)
printf("\n (b)output voltage is %.3f V",Vo2)
printf("\n (c)output voltage is %.3f V",Vo3)
printf("\n (d)output voltage is %.3f V",Vo4)
```

Chapter 19

Three phase systems

Scilab code Exa 19.01 Example 1

```
//Problem 19.01: Three loads, each of resistance 30 ohm
, 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.

//initializing the variables:
Vl = 415; // in Volts
Rp = 30; // in ohms

//calculation:
Vp = Vl/(3^0.5)
Ip = Vp/Rp
Il = Ip

printf("\n\n Result \n\n")
printf("\n (a)the system phase voltage is %.1f V",Vp)
printf("\n (b)phase current is %.0f A",Ip)
printf("\n (c)line current is %.0f A",Il)
```

Scilab code Exa 19.02 Example 2

```
//Problem 19.02: A star-connected load consists of three identical coils each of resistance 30
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.

//initializing the variables:
R = 30; // in ohms
L = 0.1273; // in Henry
Ip = 5.08; // in Amperes
f = 50; // in Hz

//calculation:
XL = 2*%pi*f*L
Zp = (R*R + XL*XL)^0.5
Il = Ip
Vp = Ip*Zp
Vl = Vp*(3^0.5)

printf("\n\n Result \n\n")
printf("\n (a)line voltage is %.0f V",Vl)
```

Scilab code Exa 19.04 Example 4

```
//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.

```

```
//initializing the variables:
V = 415; // in Volts
PR = 24000; // in Watt
Py = 18000; // in Watt
Pb = 12000; // in Watt
VR = 240; // in Volts
Vy = 240; // in Volts
Vb = 240; // in Volts

//calculation:
//For a star-connected system VL = Vp*(3^0.5)
Vp = Vl/(3^0.5)
phir = 90*%pi/180
phiy = 330*%pi/180
phib = 210*%pi/180
// I = P/V  for a resistive load
IR = PR/VR
Iy = Py/Vy
Ib = Pb/Vb
Inh = IR*cos(phir) + Ib*cos(phib) + Iy*cos(phiy)
Inv = IR*sin(phir) + Ib*sin(phib) + Iy*sin(phiy)
In = (Inh^2 + Inv^2)^0.5

printf("\n\n Result \n\n")
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)
printf("\n (b)cuurnt in neutral line is %.1f A",In)
```

Scilab code Exa 19.05 Example 5

```
//Problem 19.05: Three identical coils each of
    resistance 30 ohm
 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.

//initializing the variables:
R = 30; // in ohms
L = 0.1273; // in Henry
VL = 440; // in Volts
f = 50; // in Hz

//calculation:
XL = 2*%pi*f*L
Zp = (R*R + XL*XL)^0.5
Vp = VL
//Phase current
Ip = Vp/Zp
//For a delta connection,
IL = Ip*(3^0.5)

printf("\n\n Result \n\n")
printf("\n (a)the phase current %.1f A",Ip)
printf("\n (b)line current %.2f A",IL)
```

Scilab code Exa 19.06 Example 6

```
//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.

//initializing the variables:
IL = 15; // in Amperes
VL = 415; // in Volts
f = 50; // in Hz

//calculation:
//For a delta connection
```

```
Ip = IL/(3^0.5)    //phase current
Vp = VL
//Capacitive reactance per phase
Xc = Vp/Ip
C = 1/(2*%pi*f*Xc)

printf("\n\n Result \n\n")
printf("\n capacitance is %.3E F",C)
```

Scilab code Exa 19.07 Example 7

```
//Problem 19.07: Three coils each having resistance
    3
ohm and inductive reactance 4 ohm
 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.

//initializing the variables:
R = 3; // in ohms
XL = 4; // in ohms
VL = 415; // in Volts

//calculation:
//For a star connection:
//IL = Ip
//VL = Vp*(3^0.5)
VLs = VL
Vps = VLs/(3^0.5)
//Impedance per phase,
Zp = (R*R + XL*XL)^0.5
Ips = Vps/Zp
ILs = Ips
//For a delta connection:
```

```
//VL = Vp
//IL = Ip*(3^0.5)
VLd = VL
Vpd = VLd
Ipd = Vpd/Zp
ILd = Ipd*(3^0.5)

printf("\n\n Result \n\n")
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)
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

```
//Problem 19.08: Three 12
ohms resistors are connected in star to a 415 V, 3-phase supply. Determine the total power dissipated by the resistors.

//initializing the variables:
Rp = 12; // in ohms
VL = 415; // in Volts

//calculation:
//Power dissipated , P = VL*IL*(3^0.5)*cos(phi)  or P = 3*Ip*Ip*Rp)
Vp = VL/(3^0.5)   // since the resistors are star-connected
```

```
//Phase current, Ip
Zp = Rp
Ip = Vp/Zp
//For a star connection
IL = Ip
// For a purely resistive load, the power factor cos(phi) = 1
pf = 1
P = VL*IL*(3^0.5)*pf

printf("\n\n Result \n\n")
printf("\n (a)total power dissipated by the resistors is %.0f W",P)
```

Scilab code Exa 19.09 Example 9

```
//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.

//initializing the variables:
P = 5000; // in Watts
IL = 8.6; // in amperes
VL = 400; // in Volts

//calculation:
//Power dissipated, P = VL*IL*(3^0.5)*cos(phi)  or P = 3*Ip*Ip*Rp)
pf = P/(VL*IL*(3^0.5))

printf("\n\n Result \n\n")
printf("\n power factor is %.3f",pf)
```

Scilab code Exa 19.10 Example 10

```
//Problem 19.10: Three identical coils, each of resistance 10 ohm
 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.

//initializing the variables:
R = 10; // in ohms
L = 0.042; // in Henry
VL = 415; // in Volts
f = 50; // in Hz

//calculation:
//For a star connection:
//IL = Ip
//VL = Vp*(3^0.5)
XL = 2*%pi*f*L
Zp = (R*R + XL*XL)^0.5
VLs = VL
Vps = VLs/(3^0.5)
//Impedance per phase,
Ips = Vps/Zp
ILs = Ips
//Power dissipated, P = VL*IL*(3^0.5)*cos(phi)  or P = 3*Ip*Ip*Rp)
pfs = R/Zp
Ps = VLs*ILs*(3^0.5)*pfs

//For a delta connection:
//VL = Vp
//IL = Ip*(3^0.5)
```

```
VLd = VL
Vpd = VLd
Ipd = Vpd/Zp
ILd = Ipd*(3^0.5)
//Power dissipated , P = VL*IL*(3^0.5)*cos(phi)  or
   P = 3*Ip*Ip*Rp)
pfd = R/Zp
Pd = VLd*ILd*(3^0.5)*pfd

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
Po = 12750; // in Watts
pf = 0.77; // power factor
eff = 0.85;
VL = 415; // in Volts

//calculation:
//eff = power_out/power_in
Pi = Po/eff
//Power P = VL*IL*(3^0.5)*cos(phi)  or  P = 3*Ip*Ip*
   Rp)
IL = Pi/(VL*(3^0.5)*pf) // line current

```

```
//For a delta connection:
//IL = Ip*(3^0.5)
Ip = IL/(3^0.5)

printf("\n\n Result \n\n")
printf("\n (a)power input is %.2E W",Pi)
printf("\n (b)line current is %.2f A",IL)
printf("\n (c)phase current is %.2f A",Ip)
```

Scilab code Exa 19.13 Example 13

```
//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
 and inductive reactance 40
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.

//initializing the variables:
R = 30; // in ohms
XL = 40; // in ohms
VL = 400; // in Volts

//calculation:
Zp = (R*R + XL*XL)^0.5
//a delta-connected load
Vp = VL
//Phase current
Ip = Vp/Zp
IL = Ip*(3^0.5)
//Alternator output power is equal to the power
    dissipated by the load.
//Power P = VL*IL*(3^0.5)*cos(phi)  or  P = 3*Ip*Ip*
```

```
Rp)
pf = R/Zp
P = VL*IL*(3^0.5)*pf
//Alternator output kVA,
S = VL*IL*(3^0.5)

printf("\n\n Result \n\n")
printf("\n (a)the current supplied by the alternator is %.2f A",IL)
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

```
//Problem 19.14: Each phase of a delta-connected load comprises a resistance of 30 ohm
 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.

//initializing the variables:
R = 30; // in ohms
C = 80E-6; // in Farads
f = 50; // in Hz
VL = 400; // in Volts

//calculation:
//Capacitive reactance
Xc = 1/(2*%pi*f*C)
Zp = (R*R + Xc*Xc)^0.5
pf = R/Zp
//a delta-connected load
```

```
Vp = VL
//Phase current
Ip = Vp/Zp
IL = Ip*(3^0.5)
//Power P = VL*IL*(3^0.5)*cos(phi)  or  P = 3*Ip*Ip*
   Rp)
P = VL*IL*(3^0.5)*pf
//Alternator output kVA,
S = VL*IL*(3^0.5)

printf("\n\n Result \n\n")
printf("\n (a)the phase current  is %.3f A",Ip)
printf("\n (b)the line current  is %.2f A",IL)
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

```
//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.

//initializing the variables:
Pi1 = 8000; // in Watts
Pi2 = 4000; // in Watts

//calculation:
//Total input power
Pi = Pi1 + Pi2
phi = atan((Pi1 - Pi2)*(3^0.5)/(Pi1 + Pi2))
//Power factor
pf = cos(phi)
```

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

Scilab code Exa 19.16 Example 16

```
//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.

//initializing the variables:
Pi = 12000; // in Watts
pf = 0.6; // power factor

//calculation:
//If the two wattmeters indicate Pi1 and Pi2 respectively
// Pit = Pi1 + Pi2
Pit = Pi
// Pid = Pi1 - Pi2
//power factor = 0.6 = cos(phi)
phi = acos(pf)
Pid = Pit*tan(phi)/(3^0.5)
//Hence wattmeter 1 reads
Pi1 = (Pid + Pit)/2
//wattmeter 2 reads
Pi2 = Pit - Pi1

printf("\n\n Result \n\n")
printf("\n reading in each wattameter are %.2E W and %.2E W",Pi1,Pi2)
```

Scilab code Exa 19.17 Example 17

```
//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.

//initializing the variables:
Pi1 = 10000; // in Watts
Pi2 = -3000; // in Watts

//calculation:
//Total input power
Pi = Pi1 + Pi2
phi = atan((Pi1 - Pi2)*(3^0.5)/(Pi1 + Pi2))
//Power factor
pf = cos(phi)

printf("\n\n Result \n\n")
printf("\n (a)power input is %.2E W",Pi)
printf("\n (b)power factor is %.3f",pf)
```

Scilab code Exa 19.18 Example 18

```
//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
```

```
wattmeters connected to measure the power by the two-wattmeter method.

//initializing the variables:
R = 8; // in ohms
XL = 8; // in ohms
VL = 415; // in Volts

//calculation:
//For a star connection:
//IL = Ip
//VL = Vp*(3^0.5)
VLs = VL
Vps = VLs/(3^0.5)
//Impedance per phase,
Zp = (R*R + XL*XL)^0.5
Ips = Vps/Zp
ILs = Ips
//Power dissipated, P = VL*IL*(3^0.5)*cos(phi)  or P = 3*Ip*Ip*Rp)
pf = R/Zp
Ps = VLs*ILs*(3^0.5)*pf
//If wattmeter readings are P1 and P2 then P1 + P2 = Pst
Pst = Ps
// Pid = Pi1 - Pi2
phi = acos(pf)
Psd = Pst*tan(phi)/(3^0.5)
//Hence wattmeter 1 reads
Ps1 = (Psd + Pst)/2
//wattmeter 2 reads
Ps2 = Pst - Ps1

//For a delta connection:
//VL = Vp
//IL = Ip*(3^0.5)
VLd = VL
Vpd = VLd
```

```
Ipd = Vpd/Zp
ILd = Ipd*(3^0.5)
//Power dissipated , P = VL*IL*(3^0.5)*cos(phi)  or
   P = 3*Ip*Ip*Rp)
Pd = VLd*ILd*(3^0.5)*pf
//If wattmeter readings are P1 and P2 then P1 + P2 =
    Pdt
Pdt = Pd
// Pid = Pi1 - Pi2
Pdd = Pdt*tan(phi)/(3^0.5)
//Hence wattmeter 1 reads
Pd1 = (Pdd + Pdt)/2
//wattmeter 2 reads
Pd2 = Pdt - Pd1

printf("\n\n Result \n\n")
printf("\n (a)When the coils are star-connected the
   wattmeter readings are %.3E W and %.3E W",Ps1,Ps2
   )
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

```
//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.

//initializing the variables:
N1 = 500; // primary turns
N2 = 3000; // secondary turns
V1 = 240; // in Volts

//calculation:
//For an ideal transformer, voltage ratio = turns ratio
V2 = V1*N2/N1

printf("\n\n Result \n\n")
printf("\n secondary voltage %.2E V",V2)
```

Scilab code Exa 20.02 Example 2

```
//Problem 20.02: An ideal transformer with a turns ratio of 2:7 is fed from a 240 V supply. Determine its output voltage.

//initializing the variables:
tr = 2/7;  // turns ratio
V1 = 240; // in Volts

//calculation:
//A turns ratio of 2:7 means that the transformer has 2 turns on the primary for every 7 turns on the secondary
V2 = V1/tr

printf("\n\n Result \n\n")
printf("\n output voltage %.0f V",V2)
```

Scilab code Exa 20.03 Example 3

```
//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.

//initializing the variables:
tr = 8/1;  // turns ratio
I1 = 3; // in Amperes
V1 = 240; // in Volts

//calculation:
//A turns ratio of 8:1 means that the transformer has 28 turns on the primary for every 1turns on the secondary
V2 = V1/tr
//secondary current
```

```
I2 = I1*tr

printf("\n\n Result \n\n")
printf("\n secondary voltage is %.0f V and secondary
    current is %.0f A",V2, I2)
```

Scilab code Exa 20.04 Example 4

```
//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.

//initializing the variables:
V1 = 240; // in Volts
V2 = 12; // in Volts
P = 150; // in Watts

//calculation:
I2 = P/V2
//A turns ratio = Vp/Vs
tr = V1/V2 // turn ratio
//  V1/V2 = I2/I1
//current taken from the supply
I1 = I2*V2/V1

printf("\n\n Result \n\n")
printf("\n turn ratio is %.0f and current taken from
    the supply is %.3f A",tr, I1)
```

Scilab code Exa 20.05 Example 5

```
//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.

//initializing the variables:
S = 5000; // in VA
tr = 10; // turn ratio
V1 = 2500; // in Volts

//calculation:
//A turns ratio of 8:1 means that the transformer
   has 28 turns on the primary for every 1turns on
   the secondary
V2 = V1/tr
//transformer rating in volt-amperes = Vs*Is
I2 = S/V2
//Minimum value of load resistance
RL = V2/I2
//  tr = I2/I1
I1 = I2/tr

printf("\n\n Result \n\n")
printf("\n (a)full-load secondary current is %.0f A"
   ,I2)
printf("\n (b)minimum load resistance is %.1f ohm",
   RL)
printf("\n (c) primary current is %.0f A",I1)
```

Scilab code Exa 20.06 Example 6

```
//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.

//initializing the variables:
V1 = 2400; // in Volts
V2 = 400; // in Volts
I0 = 0.5; // in Amperes
Pc = 400; // in Watts

//calculation:
//Core loss (i.e. iron loss) P = V1*I0*cos(phi0)
pf = Pc/(V1*I0)
phi0 = acos(pf)
//Magnetizing component
Im = I0*sin(phi0)
//Core loss component
Ic = I0*cos(phi0)

printf("\n\n Result \n\n")
printf("\n (a)magnetizing component is %.3f A and Core loss component is %.3f A",Im, Ic)
```

Scilab code Exa 20.07 Example 7

```
//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.

```

```
//initializing the variables:
V = 240; // in Volts
I0 = 0.8; // in Amperes
P = 72; // in Watts
f = 50; // in Hz

//calculation:
//Power absorbed = total core loss, P = V*I0*cos(
    phi0)
//Ic = I0*cos(phi0)
Ic = P/V
pf = Ic/I0
//From the right-angled triangle in Figure 20.2(b)
    and using
//Pythagoras theorem,
Im = (I0*I0 - Ic*Ic)^0.5

printf("\n\n Result \n\n")
printf("\n (a) Core loss component is %.2f A", Ic)
printf("\n (b) power factor is %.3f", pf)
printf("\n (c)magnetizing component is %.2f A",Im)
```

Scilab code Exa 20.08 Example 8

```
//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.

//initializing the variables:
S = 100000; // in VA
V1 = 4000; // in Volts
V2 = 200; // in Volts
N2 = 100; // sec turns
```

```
f = 50; // in Hz

//calculation:
//Transformer rating = V1*I1 = V2*I2
//primary current
I1 = S/V1
//secondary current
I2 = S/V2
//primary turns
N1 = N2*V1/V2
//maximum flux
//assuming E2 = V2
Phim = V2/(4.44*f*N2)

printf("\n\n Result \n\n")
printf("\n (a)primary current is %.0f A and
    secondary current is %.0f A", I1, I2)
printf("\n (b)number of primary turns is %.0f", N1)
printf("\n (c)maximum value of the flux is %.2E Wb",
    Phim)
```

Scilab code Exa 20.09 Example 9

```
//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.

//initializing the variables:
V1 = 250; // in Volts
A = 0.03; // in m2
N2 = 300; // sec turns
```

```
N1 = 25; // prim turns
f = 50; // in Hz

//calculation:
//e.m.f. E1 = 4.44*f*Phim*N1
//maximum flux density,
Phim = V1/(4.44*f*N1)
//Phim = Bm*A, where Bm = maximum core flux density and A = cross-sectional area of the core
//maximum core flux density
Bm = Phim/A
//voltage induced in the secondary winding,
V2 = V1*N2/N1

printf("\n\n Result \n\n")
printf("\n (a)maximum core flux density %.2f T", Bm)
printf("\n (b)voltage induced in the secondary winding is %.0f V", V2)
```

Scilab code Exa 20.10 Example 10

```
//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.

//initializing the variables:
V1 = 500; // in Volts
V2 = 100; // in Volts
Bm = 1.5; // in Tesla
A = 0.005; // in m2
f = 50; // in Hz

//calculation:
```

```
//Phim = Bm*A, where Bm = maximum core flux density
    and A = cross-sectional area of the core
//maximum core flux density
Phim = Bm*A
//e.m.f. E1 = 4.44*f*Phim*N1
//primary turns,
N1 = V1/(4.44*f*Phim)
//secondary turns,
N2 = V2*N1/V1

printf("\n\n Result \n\n")
printf("\n no. of primary and secondary turns are %
    .0f turns, and %.0f turns respectively", N1, N2)
```

Scilab code Exa 20.11 Example 11

```
//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.

//initializing the variables:
emfpt = 15; // in Volts
V1 = 4500; // in Volts
V2 = 225; // in Volts
Bm = 1.4; // in Tesla
f = 50; // in Hz

//calculation:
//E.m.f. per turn, V1/N1 = V2/N2 = emfpt
//primary turns,
N1 = V1/emfpt
//secondary turns,
```

```
N2 = V2/emfpt
//e.m.f. E1 = 4.44*f*Phim*N1
//maximum flux density,
Phim = V1/(4.44*f*N1)
//Phim = Bm*A, where Bm = maximum core flux density and A = cross-sectional area of the core
//cross-sectional area
A = Phim/Bm

printf("\n\n Result \n\n")
printf("\n (a)no. of primary and secondary turns are %.0f turns, and %.0f turns respectively", N1, N2)
printf("\n (b)cross-sectional area is %.2E m2", A)
```

Scilab code Exa 20.12 Example 12

```
//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.

//initializing the variables:
N1 = 2000; // prim turns
N2 = 800; // sec turns
I0 = 5; // in Amperes
pf0 = 0.20; // power factor
I2 = 100; // in Amperes
pf2 = 0.85; // power factor

//calculation:
```

```
//Let I01 be the component of the primary current
   which provides the restoring mmf. Then I01*N1 =
   I2*N2
I01 = I2*N2/N1
//If the power factor of the secondary is 0.85
phi2 = acos(pf2)
//If the power factor on no-load is 0.20,
phi0 = acos(pf0)
I1h = I0*cos(phi0) + I01*cos(phi2)
I1v = I0*sin(phi0) + I01*sin(phi2)
//Hence the magnitude of I1
I1 = (I1h*I1h + I1v*I1v)^0.5
pf1 = cos(atan(I1v/I1h))

printf("\n\n Result \n\n")
printf("\n Primary currnt is %.2f A, and Power
   factor is %.2f", I1, pf1)
```

Scilab code Exa 20.13 Example 13

```
//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.

//initializing the variables:
N1 = 600; // prim turns
N2 = 150; // sec turns
```

```
R1 = 0.25; // in ohms
R2 = 0.01; // in ohms
X1 = 1.0; // in ohms
X2 = 0.04; // in ohms

//calculation:
tr = N1/N2 // turn ratio
vr = tr // voltage ratio = turn raio, vr = V1/V2
//equivalent resistance Re
Re = R1 + R2*(vr^2)
//equivalent reactance, Xe
Xe = X1 + X2*(vr^2)
//equivalent impedance, Ze
Ze = (Re*Re + Xe*Xe)^0.5
//cos(phie) = Re/Ze
pfe = Re/Ze
phie = acos(pfe)
phied = phie*180/%pi // in  (deg)

printf("\n\n Result \n\n")
printf("\n (a)the equivalent resistance referred to
   the primary winding is %.2f ohm", Re)
printf("\n (b)the equivalent reactance referred to
   the primary winding is %.2f ohm", Xe)
printf("\n (c)the equivalent impedance referred to
   the primary winding is %.2f ohm", Ze)
printf("\n (d)phase angle is %.2f  ", phied)
```

Scilab code Exa 20.14 Example 14

```
//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.

```

```
//initializing the variables:
V1 = 200; // in Volts
V2 = 400; // in Volts
V2L = 387.6; // in Volts
S = 5000; // in VA

//calculation:
//regulation =(No-load secondary voltage - terminal
    voltage on load)*100/no-load secondary voltage
    in %
reg = (V2 - V2L)*100/V2

printf("\n\n Result \n\n")
printf("\n the regulation of the transformer is %.1f
    percent ", reg)
```

Scilab code Exa 20.15 Example 15

```
//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.

//initializing the variables:
VnL = 240; // in Volts
reg = 2.5; // in percent

//calculation:
//regulation =(No-load secondary voltage - terminal
    voltage on load)*100/no-load secondary voltage
    in %
VL = VnL - reg*VnL/100

printf("\n\n Result \n\n")
```

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

Scilab code Exa 20.16 Example 16

```
//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.

//initializing the variables:
S = 200000; // in VA
Pc = 1500; // in Watt
Pi = 1000; // in Watt
pf = 0.85; // power factor

//calculation:
//Efficiency = output power/input power = (input
    power losses)/input power
//Efficiency = 1 - losses/input power
//Full-load output power = V*I*pf
Po = S*pf
//Total losses
Pl = Pc + Pi
//Input power = output power + losses
PI = Po + Pl
//efficiency
eff = 1-(Pl/PI)

printf("\n\n Result \n\n")
printf("\n the transformer efficiency at full load
    is %.4f", eff)
```

Scilab code Exa 20.17 Example 17

```
//Problem 20.17: Determine the efficiency of the transformer in Problem 20.16 at half full-load and 0.85 power factor.

//initializing the variables:
S = 200000; // in VA
Pc = 1500; // in Watt
Pi = 1000; // in Watt
pf = 0.85; // power factor

//calculation:
//Efficiency = output power/input power = (input power losses)/input power
//Efficiency = 1 - losses/input power
//Half full-load power output = V*I*pf/2
Po = S*pf/2
//Copper loss (or I*I*R loss) is proportional to current squared
//Hence the copper loss at half full-load is
Pch = Pc/(2*2)
//Iron loss = 1000 W (constant)
//Total losses
Pl = Pch + Pi
//Input power at half full-load = output power at half full-load + losses
PI = Po + Pl
//efficiency
eff = (1-(Pl/PI))*100

printf("\n\n Result \n\n")
printf("\n the transformer efficiency at half full load is %.2f percent", eff)
```

Scilab code Exa 20.18 Example 18

```
//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.

//initializing the variables:
S = 400000; // in VA
R1 = 0.5; // in Ohm
R2 = 0.001; // in Ohm
V1 = 5000; // in Volts
V2 = 320; // in Volts
Pi = 2500; // in Watt
pf = 0.85; // power factor

//calculation:
//Rating = 400 kVA = V1*I1 = V2*I2
//Hence primary current
I1 = S/V1
//secondary current
I2 = S/V2
//Total copper loss = I1*I1*R1 + I2*I2*R2,
Pcf = I1*I1*R1 + I2*I2*R2
//On full load, total loss = copper loss + iron loss
Plf = Pcf + Pi
// full-load power output = V2*I2*pf
Pof = S*pf
//Input power at full-load = output power at full-load + losses
PIf = Pof + Plf
//Efficiency = output power/input power = (input power losses)/input power
//Efficiency = 1 - losses/input power
```

```
efff = (1-(Plf/PIf))*100

//Half full-load power output = V*I*pf/2
Poh = S*pf/2
//Copper loss (or I*I*R loss) is proportional to current squared
//Hence the copper loss at half full-load is
Pch = Pcf/(2*2)
//Iron loss = 2500 W (constant)
//Total losses
Plh = Pch + Pi
//Input power at half full-load = output power at half full-load + losses
PIh = Poh + Plh
//efficiency
effh = (1-(Plh/PIh))*100

printf("\n\n Result \n\n")
printf("\n (a)the transformer efficiency at full load is %.2f percent", efff)
printf("\n (b)the transformer efficiency at half full load is %.2f percent", effh)
```

Scilab code Exa 20.19 Example 19

```
//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.

//initializing the variables:
S = 500000; // in VA
Pcf = 4000; // in Watt
```

```
Pi = 2500; // in Watt
pf = 0.75; // power factor

//calculation:
//Let x be the fraction of full load kVA at which
    the efficiency is a maximum.
//The corresponding total copper loss = (4 kW)*(x^2)
//At maximum efficiency, copper loss = iron loss
    Hence
x = (Pi/Pcf)^0.5
//Hence the output kVA at maximum efficiency
So = x*S
//Total loss at maximum efficiency
Pl = 2*Pi
//Output power
Po = So*pf
//Input power = output power + losses
PI = Po + Pl
//Efficiency = output power/input power = (input
    power losses)/input power
//Efficiency = 1 - losses/input power
//Maximum efficiency
effm = (1 - Pl/PI)*100

printf("\n\n Result \n\n")
printf("\n the output kVA at maximum efficiency is %
    .2E VA", So)
printf("\n max. efficiency is %.2f pecent", effm)
```

Scilab code Exa 20.20 Example 20

```
//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.
```

```
//initializing the variables:
tr = 4; // turn ratio
RL = 100; // in Ohms

//calculation:
//the equivalent input resistance,
Ri = RL*(tr^2)

printf("\n\n Result \n\n")
printf("\n the equivalent input resistance is %.0f
    ohm", Ri)
```

Scilab code Exa 20.21 Example 21

```
//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.

//initializing the variables:
R1 = 112; // in Ohms
RL = 7; // in Ohms

//calculation:
//The equivalent input resistance, R1 of the
    transformer needs to be 112 ohm for maximum power
     transfer.
//R1 = RL*(tr^2)
// tr = N1/N2 turn ratio
tr = (R1/RL)^0.5

printf("\n\n Result \n\n")
printf("\n the optimum turns ratio is %.0f ", tr)
```

Scilab code Exa 20.22 Example 22

```
//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..

//initializing the variables:
tr = 5; // turn ratio
R1 = 150; // in Ohms

//calculation:
//The equivalent input resistance, R1 of the
   transformer needs to be 150 ohm for maximum power
    transfer.
//R1 = RL*(tr^2)
RL = R1/(tr^2)

printf("\n\n Result \n\n")
printf("\n the optimum value of load resistance is %
   .0f ohm", RL)
```

Scilab code Exa 20.23 Example 23

```
//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.
```

```
//initializing the variables:
V1 = 220; // in Volts
V2 = 1760; // in Volts
V = 220; // in Volts
RL = 1280; // in Ohms
R = 2; // in Ohms

//calculation:
//Turns ratio, tr = N1/N2 = V1/V2
tr = V1/V2
//Equivalent input resistance of the transformer,
//R1 = RL*(tr^2)
R1 = RL*(tr^2)
//Total input resistance
Rin = R + R1
// Primary current
I1 = V1/Rin
//For an ideal transformer V1/V2 = I2/I1,
I2 = I1*tr
//Power dissipated in load resistor RL
P = I2*I2*RL

printf("\n\n Result \n\n")
printf("\n (a) primary current flowing is %.0f A", I1)
printf("\n (b) power dissipated in the load resistor is %.0f W", P)
```

Scilab code Exa 20.24 Example 24

```
//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.

//initializing the variables:
tr = 25; // teurn ratio
V = 24; // in Volts
R1 = 15000; // in Ohms
Rin = 15000; // in ohms

//calculation:
//Turns ratio, tr = N1/N2 = V1/V2
//For maximum power transfer R1 needs to be equal to
     15 kohm
RL = R1/(tr^2)
//The total input resistance when the source is
    connected to the matching transformer is
Rt = Rin + R1
//Primary current,
I1 = V/Rt
//N1/N2 = I2/I1
I2 = I1*tr
//Power dissipated in load resistor RL
P = I2*I2*RL

printf("\n\n Result \n\n")
printf("\n (a) the load resistance is %.0f ohm", RL)
printf("\n (b) power dissipated in the load
    resistor is %.2E W", P)
```

Scilab code Exa 20.25 Example 25

```
//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.
```

```

//initializing the variables:
V1 = 320; // in Volts
V2 = 250; // in Volts
S = 20000; // in VA

//calculation:
//Rating = 20 kVA = V1*I1 = V2*I2
//Hence primary current, I1
I1 = S/V1
//secondary current, I2
I2 = S/V2
//Hence current in common part of the winding
I = I2 - I1

printf("\n\n Result \n\n")
printf("\n current in common part of the winding is
   %.1f A", I)
printf("\n primary current and secondary current are
    %.1f A and %.0f A respectively",I1, I2)
```

Scilab code Exa 20.26 Example 26

```
//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.

//initializing the variables:
V1a = 200; // in Volts
V2a = 150; // in Volts
V1b = 500; // in Volts
V2b = 100; // in Volts

```

```
//calculation:
//For a 200 V:150 V transformer, xa
xa = V2a/V1a
//volume of copper in auto transformer
vca = (1 - xa)*100 // of copper in a double-wound
    transformer
//the saving is
vsa = 100 - vca
//For a 500 V:100 V transformer, xb
xb = V2b/V1b
//volume of copper in auto transformer
vcb = (1 - xb)*100 // of copper in a double-wound
    transformer
//the saving is
vsb = 100 - vcb

printf("\n\n Result \n\n")
printf("\n (a)For a 200 V:150 V transformer, the
    saving is %.0f percent", vsa)
printf("\n (b)For a 500 V:100 V transformer, the
    saving is %.0f percent", vsb)
```

Scilab code Exa 20.27 Example 27

```
//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.

//initializing the variables:
N1 = 500; // prim turns
N2 = 50; // sec turns
VL = 2400; // in Volts

```

```
//calculation:
//For a star-connection, VL = Vp*(3^0.5)
VL1s = VL
//Primary phase voltage
Vp1s = VL1s/(3^0.5)
//For a delta-connection, VL = Vp
//N1/N2 = V1/V2, from which,
//secondary phase voltage, Vp2s
Vp2s = Vp1s*N2/N1
VL2d = Vp2s

//For a delta-connection, VL = Vp
VL1d = VL
//primary phase voltage Vp1d
Vp1d = VL1d
//Secondary phase voltage, Vp2d
Vp2d = Vp1d*N2/N1
//For a star-connection, VL = Vp*(3^0.5)
VL2s = Vp2d*(3^0.5)

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
N1 = 1; // prim turns
N2 = 60; // sec turns
I1 = 300; // in amperes
Ra = 0.15; // in ohms
R2 = 0.25; // in ohms

//calculation:
//Reading on the ammeter,
I2 = I1*(N1/N2)
//P.d. across the ammeter = I2*RA, where RA is the
   ammeter resistance
pd = I2*Ra
//Total resistance of secondary circuit
Rt = Ra + R2
//Induced e.m.f. in secondary
V2 = I2*Rt
//Total load on secondary
S = V2*I2

printf("\n\n Result \n\n")
printf("\n (a)the reading on the ammeter is %.0f A "
   ,I2)
printf("\n (b)potential difference across the
   ammeter is %.2f V ",pd)
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

```
//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.

//initializing the variables:
Z = 600; // no. of conductors
c = 2; // for a wave winding
p = 4; // no. of pairs
n = 625/60; // in rev/sec
Phi = 20E-3; // in Wb

//calculation:
//Generated e.m.f., E = 2*p*Phi*n*Z/c
E = 2*p*Phi*n*Z/c

printf("\n\n Result \n\n")
printf("\n the generated e.m.f is %.0f V ",E)
```

Scilab code Exa 21.02 Example 2

```
//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.

//initializing the variables:
Z = 50*16; // no. of conductors
p = 1; // let no. of pairs
c = 2*p; // for a lap winding
Phi = 30E-3; // in Wb
E = 240; // in Volts

//calculation:
//Generated e.m.f., E = 2*p*Phi*n*Z/c
//Rearranging gives, speed
n = E*c/(2*p*Phi*Z)

printf("\n\n Result \n\n")
printf("\n the speed at which the machine must be driven is %.0f rev/sec ",n)
```

Scilab code Exa 21.03 Example 3

```
//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.

//initializing the variables:
Z = 1200; // no. of conductors
p = 1; // let, no. of pairs
c = 2*p; // for a lap winding
```

```
Phi = 30E-3; // in Wb
n = 500/60; // in rev/sec

//calculation:
//Generated e.m.f., E = 2*p*Phi*n*Z/c
E = 2*p*Phi*n*Z/c

printf("\n\n Result \n\n")
printf("\n Generated e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.04 Example 4

```
//Problem 21.04: Determine the generated e.m.f. in problem 21.03 if the armature is wave-wound.

//initializing the variables:
Z = 1200; // no. of conductors
p = 4; // let , no. of pairs
c = 2; // for a wave winding
Phi = 30E-3; // in Wb
n = 500/60; // in rev/sec

//calculation:
//Generated e.m.f., E = 2*p*Phi*n*Z/c
E = 2*p*Phi*n*Z/c

printf("\n\n Result \n\n")
printf("\n Generated e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.06 Example 6

```
//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.

//initializing the variables:
n1 = 30; // in rev/sec
E1 = 200; // in Volts
n2 = 20; // in rev/sec
E2 = 250; // in Volts

//calculation:
//generated e.m.f., E proportional to phi*w and since w = 2*pi*n, then
// E proportional to phi*n
// E1/E2 = Phi1*n1/(Phi2*n2)
// let Phi2/Phi1 = Phi
Phi = E2*n1/(E1*n2)
Phi_inc = (Phi - 1)*100 ///in percent

printf("\n\n Result \n\n")
printf("\n percentage increase in the flux per pole is %.1f percent ",Phi_inc)
```

Scilab code Exa 21.07 Example 7

```
//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.

//initializing the variables:
Ra = 0.30; // in ohms
Ia = 30; // in Amperes
E = 200; // in Volts
```

```
//calculation:
//terminal voltage,
//V = E − Ia*Ra
V = E - Ia*Ra

printf("\n\n Result \n\n")
printf("\n terminal voltage of a generator is %.0f V
    ",V)
```

Scilab code Exa 21.08 Example 8

```
//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.

//initializing the variables:
RL = 60; // in ohms
Ia = 8; // in Amperes
Ra = 1; // in ohms

//calculation:
//terminal voltage,
//V = Ia*RL
V = Ia*RL
//Generated e.m.f., E
E = V + Ia*Ra

printf("\n\n Result \n\n")
printf("\n (a)terminal voltage is %.0f V ",V)
printf("\n (b)generated e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.09 Example 9

```
//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.

//initializing the variables:
E1 = 150; // in Volts
n1 = 20; // in rev/sec
Phi1 = 0.10; // in Wb
n2 = 25; // in rev/sec
Phi2 = 0.10; // in Wb
n3 = 20; // in rev/sec
Phi3 = 0.08; // in Wb
n4 = 24; // in rev/sec
Phi4 = 0.07; // in Wb

//calculation:
//generated e.m.f., E proportional to phi*w and since w = 2*pi*n, then
// E proportional to phi*n
// E1/E2 = Phi1*n1/(Phi2*n2)
E2 = E1*Phi2*n2/(Phi1*n1)
E3 = E1*Phi3*n3/(Phi1*n1)
E4 = E1*Phi4*n4/(Phi1*n1)

printf("\n\n Result \n\n")
printf("\n (a)the generated e.m.f is %.1f V ",E2)
printf("\n (b)generated e.m.f. is %.0f V ",E3)
printf("\n (c)generated e.m.f. is %.0f V ",E4)
```

Scilab code Exa 21.10 Example 10

```
//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.

//initializing the variables:
Ps = 20000; // in Watts
Vs = 200; // in Volts
Rs = 0.1; // in ohms
Rf = 50; // in ohms
Ra = 0.04; // in ohms

//calculation:
//Load current , I
Is = Ps/Vs
//Volt drop in the cables to the load
Vd = Is*Rs
//Hence terminal voltage ,
V = Vs + Vd
//Field current , If
If = V/Rf
//Armature current
Ia = If + Is
//Generated e.m.f. E
E = V + Ia*Ra

printf("\n\n Result \n\n")
printf("\n (a)terminal voltage is %.0f V ",V)
printf("\n (b)generated e.m.f. is %.2f V ",E)
```

Scilab code Exa 21.11 Example 11

```
//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.

//initializing the variables:
Is = 80; // in amperes
Vs = 200; // in Volts
Rf = 40; // in ohms
Rse = 0.02; // in ohms
Ra = 0.04; // in ohms

//calculation:
//Volt drop in series winding
Vse = Is*Rse
//P.d. across the field winding = p.d. across armature
V1 = Vs + Vse
//Field current, If
If = V1/Rf
//Armature current
Ia = If + Is
//Generated e.m.f. E
E = V1 + Ia*Ra

printf("\n\n Result \n\n")
printf("\n generated e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.12 Example 12

```
//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.

//initializing the variables:
Ps = 10000; // in Watt
Pl = 600; // in Watt
Ra = 0.75; // in ohms
Rf = 125; // in ohms
V = 250; // in Volts

//calculation:
//Output power Ps = V*I
//from which, load current I
I = Ps/V
//Field current, If
If = V/Rf
//Armature current
Ia = If + I
//Efficiency,
eff = Ps*100/((V*I) + (Ia*Ia*Ra) + (If*V) + (Pl)) //
    in Percent

printf("\n\n Result \n\n")
printf("\n Efficiency is %.2f percent ",eff)
```

Scilab code Exa 21.13 Example 13

```
//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
```

```
    current is 50 A.

//initializing the variables:
Ra = 0.2; // in ohms
V = 240; // in Volts
Ia = 50; // in Amperes

//calculation:
//For a motor, V = E + Ia*Ra
E = V - Ia*Ra

printf("\n\n Result \n\n")
printf("\n back e.m.f. is %.0f V ",E)
```

Scilab code Exa 21.14 Example 14

```
//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.

//initializing the variables:
Ra = 0.25; // in ohms
V = 300; // in Volts
Ig = 100; // in Amperes
Im = 80; // in Amperes

//calculation:
//As a generator, generated e.m.f.,
// E = V + Ia*Ra
Eg = V + Ig*Ra
//For a motor, generated e.m.f. (or back e.m.f.),
// E = V - Ia*Ra
E = V - Im*Ra
```

```

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

Scilab code Exa 21.15 Example 15

```
//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.

//initializing the variables:
p = 4;
c = 2; // for a wave winding
Phi = 25E-3; // Wb
Z = 900;
Ia = 30; // in Amperes

//calculation:
//torque T = p*Phi*Z*Ia/(pi*

c)
T = p*Phi*Z*Ia/(1*%pi*c)

printf("\n\n Result \n\n")
printf("\n the torque exerted is %.1f Nm ",T)
```

Scilab code Exa 21.16 Example 16

```
//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.

//initializing the variables:
V = 350; // in Volts
Ra = 0.5; // in ohms
n = 15; // in rev/sec
Ia = 60; // in Amperes

//calculation:
//Back e.m.f. E = V − Ia*Ra
E = V - Ia*Ra
//torque T = E*Ia/(2*
n*pi)
T = E*Ia/(2*n*%pi)

printf("\n\n Result \n\n")
printf("\n the torque exerted is %.1f Nm ",T)
```

Scilab code Exa 21.17 Example 17

```
//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

//initializing the variables:
p = 1; // let
c = 2*p; // for a lap winding
Phi = 20E-3; // Wb
```

```
Z = 500;
V = 250; // in Volts
Ra = 1; // in ohms
Ia = 40; // in Amperes

//calculation:
//Back e.m.f. E = V − Ia*Ra
E = V - Ia*Ra
//E.m.f. E = 2*p*Phi*n*Z/c
// rearrange,
n = E*c/(2*p*Phi*Z)
//torque T = E*Ia/(2*
n*pi)
T = E*Ia/(2*n*%pi)

printf("\n\n Result \n\n")
printf("\n (a)speed n is %.0f rev/sec ",n)
printf("\n (b)the torque exerted is %.2f Nm ",T)
```

Scilab code Exa 21.18 Example 18

```
//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
   .

//initializing the variables:
T1 = 25; // in Nm
T2 = 35; // in Nm
Ia1 = 16; // in Amperes
```

```
V = 100; // in Volts
x = 0.15;

//calculation:
//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.
//The torque at flux phi1 and armature current Ia1 is T1 = k*Phi1*Ia1.
//similarly T2 = k*Phi2*Ia2
Phi2 = (1 - x)*Phi1
Ia2 = T2*Ia1*Phi1/(Phi2*T1)

printf("\n\n Result \n\n")
printf("\n armature current at the new value of torque is %.2f A ",Ia2)
```

Scilab code Exa 21.19 Example 19

```
//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.

//initializing the variables:
T = 12; // in Nm
I = 15; // in Amperes
V = 100; // in Volts
n = 1500/60; // in rev/sec

//calculation:
//the efficiency of a generator = (output power/
```

```
    input power)*100 %
//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
//efficiency = V*I*100/(T*2*pi*

n) %
eff = V*I*100/(T*2*%pi*n) // in Percent
//The input power = output power + losses
// hence, T*2*%pi*n = V*I + losses
Pl = T*2*%pi*n - V*I

printf("\n\n Result \n\n")
printf("\n (a) efficiency is %.2f percent ",eff)
printf("\n (b) power loss is %.0f W ",Pl)
```

Scilab code Exa 21.20 Example 20

```
//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.

//initializing the variables:
Rf = 150; // in Ohms
Ra = 0.4; // in Ohms
I = 30; // in Amperes
V = 240; // in Volts

//calculation:
//Field current If
```

```
If = V/Rf
//Supply current I = Ia + If
//Hence armature current , Ia
Ia = I - If
//Back e.m.f. E = V − Ia∗Ra
E = V - (Ia*Ra)

printf("\n\n Result \n\n")
printf("\n (a)  current in the armature is %.1f A ",Ia)
printf("\n (b) Back e.m.f. E is %.2f V ",E)
```

Scilab code Exa 21.21 Example 21

```
//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.

//initializing the variables:
Ia1 = 30; // in Amperes
Ia2 = 45; // in Amperes
Ra = 0.4; // in ohm
n1 = 1350/60; // in Rev/sec
V = 200; // in Volts

//calculation:
//The relationship E proportional to (Phi∗n) applies to both generators and motors. For a motor,
//E = V − (Ia∗Ra)
E1 =  V - (Ia1*Ra)
E2 =  V - (Ia2*Ra)
```

```
//The relationship , E1/E2 = Phi1*n1/Phi2*n2,
   applies to both generators and motors. Since the
   flux is constant , Phi1 = Phi2
Phi2 = Phi1
n2 = E2*Phi1*n1/(Phi2*E1)

printf("\n\n Result \n\n")
printf("\n the speed of the motor is %.2f rev/sec ",
   n2)
```

Scilab code Exa 21.22 Example 22

```
//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.

//initializing the variables:
Ia1 = 30; // in Amperes
Ra = 0.4; // in ohm
n = 800/60; // in Rev/sec
V = 220; // in Volts
x= 0.1;

//calculation:
//For a d.c. shunt-wound motor , E = V - (Ia*Ra),
   Hence initial generated e.m.f.,
E1 =  V - (Ia1*Ra)
//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
E = E1*(1-x)
//Hence, the voltage drop due to the armature
    resistance is
Vd = V - E
//The instantaneous value of the current is
Ia = Vd/Ra
//T proportional to (Phi*Ia), since the torque is
    constant,
//Phi1*Ia1 = Phi2*Ia2, The flux 8 is reduced by 10%
    , hence
Phi2 = (1-x)*Phi1
Ia2 = Phi1*Ia1/Phi2

printf("\n\n Result \n\n")
printf("\n (a)instantaneous value of the current %.0
    f A ",Ia)
printf("\n (b)steady state value of armature current
    , %.2f A ",Ia2)
```

Scilab code Exa 21.23 Example 23

```
//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.

//initializing the variables:
Ia1 = 15; // in Amperes
Ia2 = 30; // in Amperes
```

```
Rf = 0.3; // in ohms
Ra = 0.2; // in ohm
n1 = 24; // in Rev/sec
V = 240; // in Volts
x= 2;

//calculation:
//generated e.m.f., E, at initial load, is given by
E1 =  V - Ia1*(Ra + Rf)
//When the current is increased to 30 A, the
    generated e.m.f. is given by:
E2 =  V - Ia2*(Ra + Rf)
//E proportional to (Phi*n)
//E1/E2 = Phi1*n1/Phi2*n2
Phi2 = x*Phi1
n2 = E2*Phi1*n1/(Phi2*E1)

printf("\n\n Result \n\n")
printf("\n (a)generated e.m.f., E is %.1f V ",E1)
printf("\n (b)speed of motor, n2, %.2f A ",n2)
```

Scilab code Exa 21.24 Example 24

```
//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.

//initializing the variables:
I = 80; // in Amperes
C = 1500; // in Watt
Rf = 40; // in ohms
Ra = 0.2; // in ohm
```

```
n = 1000/60; // in Rev/sec
V = 320; // in Volts

//calculation:
//Field current, If
If = V/Rf
//Armature current Ia
Ia = I - If
//Efficiency =((V*I - Ia*Ia*Ra - If*V - C)/(V*I))
    *100%
eff = ((V*I - (Ia*Ia*Ra) - (If*V) - C)/(V*I))*100 //
     in percent

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

Scilab code Exa 21.25 Example 25

```
//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.

//initializing the variables:
I = 40; // in Amperes
Rf = 0.05; // in ohms
Ra = 0.15; // in ohm
V = 250; // in Volts

//calculation:
//However for a series motor, If = 0 and the Ia*Ia*
    Ra loss needs to be I*I*(Ra + Rf)
//For maximum efficiency I*I*(Ra + Rf) = C
//Efficiency =((V*I -2*Ia*Ia*Ra)/(V*I))*100%
eff = ((V*I - (2*I*I*(Ra + Rf)))/(V*I))*100 // in
```

```
percent

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

Scilab code Exa 21.26 Example 26

```
//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.

//initializing the variables:
T = 15; // in Nm
n = 1200/60; // in rev/sec
eff = 0.8;
V = 200; // in Volts

//calculation:
//The efficiency of a motor = (output power/input power)*100 %
//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.
//Thus for a motor, efficiency =(T*2*pi*
n/(V*I))%
I = T*2*%pi*n/(V*eff)

printf("\n\n Result \n\n")
printf("\n current supplied, I is %.1f A",I)
```

Scilab code Exa 21.27 Example 27

```
//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.

//initializing the variables:
R = 2; // in ohm
n = 30; // in rev/sec
I = 10; // in A
C = 300; // in Watt
V = 400; // in Volts

//calculation:
//Efficiency =((V*I - I*I*R - C)/(V*I))*100%
eff = ((V*I - (I*I*R) - C)/(V*I))*100 // in percent

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

Scilab code Exa 21.28 Example 28

```
//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.

//initializing the variables:
Ia1 = 120; // in A
Ia2 = 60; // in A
Ra = 0.2; // in ohm
n1 = 10; // in rev/sec
R = 0.5; // in ohm
x = 0.8;
V = 500; // in Volts

//calculation:
//back e.m.f. at Ia1
E1 = V - Ia1*Ra
//at Ia2
E2 = V - Ia2*(Ra + R)
//E1/E2 = Phi1*n1/Phi2*n2
Phi2 = Phi1
n2 = Phi1*n1*E2/(Phi2*E1)
//Back e.m.f. when Ia2
E3 = V - Ia2*Ra
Phi3 = x*Phi1
n3 = Phi1*n1*E3/(Phi3*E1)

printf("\n\n Result \n\n")
printf("\n (a)speed n2 is %.2f rev/sec", n2)
printf("\n (b)speed n3 is %.2f rev/sec", n3)
```

Scilab code Exa 21.29 Example 29

```
//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.)

//initializing the variables:
Ia1 = 90; // in Amperes
Ra = 0.1; // in ohm
Rse = 0.05; // in ohm
Rd = 0.2; // in Ohm
n1 = 15; // in rev/sec
V = 300; // in Volts

//calculation:
//e.m.f. E1
E1 = V - Ia1*(Ra + Rse)
//With the Rd diverter in parallel with Rse
//equivalent resistance, Re
Re = Rd*Rse/(Rd+Rse)
//Torque, T proprtional to Ia*Phi and for full load
   torque, Ia1*Phi1 = Ia2*Phi2
//Since flux is proportional to field current Phi1
   proportional to Ta1 and Phi2 Proportional to I1
I1 =  (Ia1*Ia1*0.8)^0.5
//By current division, current I1
Ia2 = I1/(Rd/(Rd + Rse))
//Hence e.m.f. E2
E2 = V - Ia2*(Ra + Re)
//E1/E2 = Phi1*n1/Phi2*n2
n2 = E2*Ia1*n1/(I1*E1)

printf("\n\n Result \n\n")
printf("\n speed n2 is %.2f rev/sec", n2)
```

Scilab code Exa 21.30 Example 30

```
//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.

//initializing the variables:
Ia1 = 25; // in Amperes
Ra = 0.4; // in ohm
Rse = 0.2; // in ohm
n1 = 800/60; // in rev/sec
n2 = 600/60; // in rev/sec
V = 400; // in Volts

//calculation:
//e.m.f. E1
E1 = V - Ia1*(Ra + Rse)
//At n2, since the current is unchanged, the flux is
    unchanged.
//E1/E2 = n1/n2
E2 = E1*n2/n1
//and E2 = V - Ia1(Ra + Rse + R)
R = (V - E2)/Ia1 - Ra - Rse

printf("\n\n Result \n\n")
printf("\n Resistance is %.2f ohm", R)
```

Chapter 22

Three phase induction motors

Scilab code Exa 22.01 Example 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.

//initializing the variables:
f = 50; // in Hz
p = 2/2; // number of pairs of poles

//calculation:
//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.
ns = f/p
nsrpm = ns*60

printf("\n\n Result \n\n")
printf("\nsynchronous speed of the motor is %.0f rev
   /min", nsrpm)
```

Scilab code Exa 22.02 Example 2

```
//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.

//initializing the variables:
f = 60; // in Hz
ns = 900/60; // in rev/sec

//calculation:
//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.
p = f/ns
np = p*2

printf("\n\n Result \n\n")
printf("\nnumber of poles is %.0f", np)
```

Scilab code Exa 22.03 Example 3

```
//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.

//initializing the variables:
p = 2/2; // number of pairs of poles
ns = 6000/60; // in rev/sec

//calculation:
//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.
```

```
f = p*ns

printf("\n\n Result \n\n")
printf("\nfrequency is %.0f Hz",f)
```

Scilab code Exa 22.04 Example 4

```
//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.

//initializing the variables:
p = 4/2; // number of pairs of poles
f = 50; // in Hz
nr = 1455/60; // in rev/sec

//calculation:
//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.
ns = f/p
//The slip, s
s = ((ns - nr)/ns)*100 // in percent

printf("\n\n Result \n\n")
printf("\n(a) synchronous speed is %.0f rev/sec",ns)
printf("\n(b) slip is %.0f percent",s)
```

Scilab code Exa 22.05 Example 5

```
//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.

//initializing the variables:
p = 2/2; // number of pairs of poles
f = 60; // in Hz
s = 0.02; // slip

//calculation:
//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.
ns = f/p
//The the rotor runs at
nr = ns*(1 - s)
//frequency of the e.m.f. s induced in the rotor bars is
fr = ns - nr

printf("\n\n Result \n\n")
printf("\n(a) synchronous speed is %.0f rev/sec",ns)
printf("\n(b) rotor speed is %.1f rev/sec",nr)
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

```
//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.

```

```
//initializing the variables:
f = 50; // in Hz
nr = 1200/60; // in rev/min
s = 0.04; // slip

//calculation:
//the synchronous speed.
ns = nr/(1 - s)
nsrpm = ns*60
printf("\n\n Result \n\n")
printf("\n synchronous speed is %.0f rev/min",nsrpm)
```

Scilab code Exa 22.07 Example 7

```
//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.

//initializing the variables:
p = 8/2; // number of pairs of poles
f = 50; // in Hz
fr = 3; // in Hz

//calculation:
//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.
ns = f/p
//fr = s*f
s = (fr/f)
//the rotor speed.
nr = ns*(1 - s)
nrrpm = nr*60

```

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

Scilab code Exa 22.08 Example 8

```
//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.

//initializing the variables:
Psi = 32000; // in Watts
Psl = 1200; // in Watts
s = 0.05; // slip
Pfl = 750; // in Watts

//calculation:
//Input power to rotor = stator input power - stator losses
Pi =  Psi - Psl
//slip = rotor copper loss/rotor input
Pl = s*Pi
//Total mechanical power developed by the rotor = rotor input power - rotor losses
Pr = Pi - Pl
//Output power of motor = power developed by the rotor - friction and windage losses
Po = Pr - Pfl
//Efficiency of induction motor = (output power/input power)*100
```

```
eff = (Po/Psi)*100 // in percent

printf("\n\n Result \n\n")
printf("\n(a) rotor copper loss is %.0f Watt",Pl)
printf("\n(b) Total mechanical power developed by the rotor is %.0f W",Pr)
printf("\n(c) Output power of motor is %.0f Watt",Po)
printf("\n(d) efficiency of induction motor is %.2f percent",eff)
```

Scilab code Exa 22.09 Example 9

```
//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.

//initializing the variables:
Psi = 32000; // in Watts
Psl = 1200; // in Watts
Pfl = 750; // in Watts
x = 0.35;

//calculation:
nr = x*ns
//The slip , s
s = ((ns - nr)/ns)
//Input power to rotor = stator input power − stator losses
Pi = Psi - Psl
//slip = rotor copper loss/rotor input
Pl = s*Pi
```

```
//Total mechanical power developed by the rotor =
    rotor input power − rotor losses
Pr = Pi - Pl
//Output power of motor = power developed by the
    rotor − friction and windage losses
Po = Pr - Pfl
//Efficiency of induction motor = (output power/
    input power)*100
eff = (Po/Psi)*100 // in percent

printf("\n\n Result \n\n")
printf("\n(a) rotor copper loss is %.0f Watt",Pl)
printf("\n(b) efficiency of induction motor is %.2f
    percent",eff)
```

Scilab code Exa 22.10 Example 10

```
//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
    .

//initializing the variables:
V = 415; // in Volts
f = 50 ; // in Hz
nr = 24; // in rev/sec
p = 4/2; // no. of pole pairs
R2 = 0.35; // in Ohms
```

```
X2 = 3.5; // in Ohms
tr = 0.85; // turn ratio N2/N1
Pl = 770; // in Watt
m = 3; // no. of phases

//calculation:
//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.
ns = f/p
//The slip, s
s = ((ns - nr)/ns)*100 // in percent
//Phase voltage, E1 = V/(3^0.5)
E1 = V/(3^0.5)
//Full load torque
T = [m*(tr^2)/(2*%pi*ns)]*[(s/100)*E1*E1*R2/(R2*R2 + (X2*(s/100))^2)]
//Output power, including friction losses
Pm = 2*%pi*nr*T
//power output
Po = Pm - Pl
//Maximum torque occurs when R2 = Xr = 0.35 ohm
//Slip
sm = R2/X2
//maximum torque, Tm
Tm = [m*(tr^2)/(2*%pi*ns)]*[sm*E1*E1*R2/(R2*R2 + (X2*sm)^2)]
//speed at which maximum torque occurs
nrm = ns*(1 - sm)
nrmrpm = nrm*60
//At the start, i.e., at standstill, slip, s=1
ss = 1
//starting torque
Ts = [m*(tr^2)/(2*%pi*ns)]*[ss*E1*E1*R2/(R2*R2 + (X2*ss)^2)]

printf("\n\n Result \n\n")
printf("\n(a)Synchronous speed is %.0f rev/sec",ns)
```

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

Scilab code Exa 22.11 Example 11

```
//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.

//initializing the variables:
V = 415; // in Volts
f = 50 ; // in Hz
nr = 24; // in rev/sec
p = 4/2; // no. of pole pairs
R2 = 0.35; // in Ohms
X2 = 3.5; // in Ohms
tr = 0.85; // turn ratio N2/N1
m = 3; // no. of phases

//calculation:
//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.
ns = f/p
//The slip, s
s = ((ns - nr)/ns)*100 // in percent
//Phase voltage, E1 = V/(3^0.5)
E1 = V/(3^0.5)
//rotor current,
```

```
Ir = (s/100)*E1*tr/((R2^2 + (X2*(s/100))^2)^0.5)
//Rotor copper loss
Pcl = m*R2*(Ir^2)
//starting current,
ss =1
I2 = ss*tr*E1/((R2^2 + (X2*ss)^2)^0.5)

printf("\n\n Result \n\n")
printf("\n(a)rotor current is %.2f A",Ir)
printf("\n(b)Total copper loss is %.2f W",Pcl)
printf("\n(c)starting current is %.2f A",I2)
```

Scilab code Exa 22.12 Example 12

```
//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.

//initializing the variables:
V = 415; // in Volts
Psl = 650; // in Watt
pf = 0.87; // power factor

//calculation:
Pm = 11770; // watts from part (d), Problem 22.10
Pcl = 490.35; // watts, Rotor copper loss, from part (b), Problem 22.11
//Stator input power
P1 = Pm + Pcl + Psl
Po = 11000 // watts, Net power output, from part (d), Problem 22.10
```

```
//efficiency = (output/input) *100
eff = (Po/P1)*100 // in percent
//Power input , P1 = (3^0.5)*VL*IL*cos(phi)
// pf = cos(phi)
//supply current , IL
I = P1/((3^0.5)*V*pf)

printf("\n\n Result \n\n")
printf("\n(aStator input power is %.2E W",P1)
printf("\n(b)efficiency is %.2f percent",eff)
printf("\n(c)supply current is %.2f A",I)
```

Scilab code Exa 22.13 Example 13

```
//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.

//initializing the variables:
V = 415; // in Volts
f = 50 ; // in Hz
nr = 24; // in rev/sec
p = 4/2; // no. of pole pairs
R2 = 0.35; // in Ohms
X2 = 3.5; // in Ohms

//calculation:
//At the moment of starting , slip ,
s = 1
//Maximum torque occurs when rotor reactance equals rotor resistance
//for maximum torque
R2 = s*X2

```

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

Chapter 23

Revision of complex numbers

Scilab code Exa 23.01 Example 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.

//initializing the variables:
Z1 = 5 - 3*%i;
Z2 = 4 + 7*%i;
Z3 = 3.9 - 6.7*%i;

//calculation:
ZT = (Z1*Z2/(Z1 + Z2))+ Z3
y = imag(ZT)
x = real(ZT)

printf("\n\n Result \n\n")
printf("\n ZT is %.2f + (%.2f)i", x,y)
```

Scilab code Exa 23.02 Example 2

```
//Problem 23.02: Given Z1 = 3 + i4, Z2 = 2 − i5
   determine in cartesian form correct to three
   decimal places:
//(a)1/Z1, (b)1/Z2,  (c)1/Z1 + 1/Z2,  (d)1/(1/Z1 +
   1/Z2)

//initializing the variables:
Z1 = 3 + 4*%i;
Z2 = 2 - 5*%i;

//calculation:
za = 1/Z1
zb = 1/Z2
zc = za + zb
zd = 1/zc
zax = real(za)
zay = imag(za)
zbx = real(zb)
zby = imag(zb)
zcx = real(zc)
zcy = imag(zc)
zdx = real(zd)
zdy = imag(zd)

printf("\n\n Result \n\n")
printf("\n (a)1/Z1 is %.3f + (%.3f)i", zax,zay)
printf("\n (b)1/Z2 is %.3f + (%.3f)i", zbx,zby)
printf("\n (c)1/Z1 + 1/Z2 is %.3f + (%.3f)i", zcx,
   zcy)
printf("\n (d)1/(1/Z1 + 1/Z2) is %.3f + (%.3f)i",
   zdx,zdy)
```

Scilab code Exa 23.03 Example 3

```
//Problem 23.03: Solve the following complex equations:
//(a) 3(a + ib) = 9−i2
//(b) (2+i)(−2+i) = x+iy
//(c) (a−i(2b))+(b−i3a) = 5+i2

//initializing the variables:
Z1 = 9 - 2*%i;
Z2 = 2 + 1*%i;
Z3 = -2 + 1*%i;
Z4 = 5 + 2*%i;

//calculation:
za = Z1/3
zb = Z2*Z3
zca = (2*real(Z4) + imag(Z4))/-1
zcb = real(Z4) - zca
zaa = real(za)
zab = imag(za)
zbx = real(zb)
zby = imag(zb)

printf("\n\n Result \n\n")
printf("\n (a)a and b are %.0f and %.2f resp.", zaa, zab)
printf("\n (b)x and y are %.0f and %.0f resp.", zbx, zby)
printf("\n (c)a and b are %.0f and %.0f resp.", zca, zcb)
```

Scilab code Exa 23.05 Example 5

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

```

```
//initializing the variables:
r = 5; // magnitude
theta = -132; // in degree

//calculation:
x = r*sin(theta*%pi/180)
y = r*cos(theta*%pi/180)
z = x+%i*y

printf("\n\n Result \n\n")
printf("\n Z is %.3f + (%.3f)i", x,y)
```

Scilab code Exa 23.06 Example 6

```
//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)

//initializing the variables:
r1 = 4.7; // magnitude
theta1 = 35; // in degree
r2 = 7.3; // magnitude
theta2 = -48; // in degree

//calculation:
x1 = r1*cos(theta1*%pi/180)
y1 = r1*sin(theta1*%pi/180)
z1 = x1+%i*y1
x2 = r2*cos(theta2*%pi/180)
y2 = r2*sin(theta2*%pi/180)
z2 = x2+%i*y2
z3 = z1*z2/(z1 + z2)
x3 = real(z3)
y3 = imag(z3)
```

```
r3 = (x3^2 + y3^2)^0.5
theta3 = atan(y3/x3)*180/%pi

printf("\n\n Result \n\n")
printf("\n ZT is (%.2f/_%.2f  )", r3,theta3)
```

Scilab code Exa 23.07 Example 7

```
//Problem 23.07: Determine (-2 + i3)^5 in polar and
    in cartesian form.

//initializing the variables:
z = -2 + %i*3;

//calculation:
zc = z^5
x = real(zc)
y = imag(zc)
r = (x^2 + y^2)^0.5
theta = atan(y/x)*180/%pi
if ((x<0)&(y<0)) then
    theta = theta -180;
elseif ((x<0)&(y>0)) then
    theta = theta +180;
end

printf("\n\n Result \n\n")
printf("\n Z is %.0f + (%.0f)i", x,y)
printf("\n ZT is (%.1f/_%.2f  )", r,theta)
```

Scilab code Exa 23.08 Example 8

```
//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.

//initializing the variables:
z = 12 + %i*5;

//calculation:
x = real(z)
y = imag(z)
r = (x^2 + y^2)^0.5
theta1 = atan(y/x)*180/%pi
if ((x<0)&(y<0)) then
    theta1 = theta1 -180;
elseif ((x<0)&(y>0)) then
    theta1 = theta1 +180;
end
theta2 = theta1 + 360
rtheta1 = theta1/2
rtheta2 = theta2/2
if (rtheta2 > 180) then
    rtheta2 = rtheta2 -360;
elseif ((x<0)&(y>0)) then
    rtheta2 = rtheta2 +360;
end
rr = r^0.5
x1 = rr*cos(rtheta1*%pi/180)
y1 = rr*sin(rtheta1*%pi/180)
z1 = x1 + %i*y1
x2 = rr*cos(rtheta2*%pi/180)
y2 = rr*sin(rtheta2*%pi/180)
z2 = x2 + %i*y2

printf("\n\n Result \n\n")
printf("\n two roots are (%.2f + (%.2f)i) and (%.2f + (%.2f)i)", x1,y1,x2,y2)
printf("\n two roots are (%.1f/_%.2f  ) and (%.1f/_%
```

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

Chapter 24

Application of complex numbers to series ac circuits

Scilab code Exa 24.01 Example 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.

//initializing the variables:
z1 = 12 + %i*5;
z2 = -40*%i;
r3 = 30;
theta3 = 60;  // in degrees
r4 = 2.20E6;
theta4 = -30; // in degrees
f = 50; // in Hz

//calculation:
//for an R L series circuit, impedance
// Z = R + iXL
```

```
Ra = real(z1)
XLa = imag(z1)
La = XLa/(2*%pi*f)
//for a purely capacitive circuit, impedance Z = -iXc
Xcb = abs(imag(z2))
Cb = 1/(2*%pi*f*Xcb)
z3 = r3*cos(theta3*%pi/180) + %i*(r3*sin(theta3*%pi/180))
Rc = real(z3)
XLc = imag(z3)
Lc = XLc/(2*%pi*f)
z4 = r4*cos(theta4*%pi/180) + %i*(r4*sin(theta4*%pi/180))
Rd = real(z4)
Xcd = abs(imag(z4))
Cd = 1/(2*%pi*f*Xcd)

printf("\n\n Result \n\n")
printf("\n (a)an impedance (12 + i5)ohm represents a resistance of %.0f ohm in series with an inductance of %.2E", Ra,La)
printf("\n (b)an impedance -i40 ohm represents a pure capacitor of capacitance %.2E", Cb)
printf("\n (c)an impedance 30/_60  ohm represents a resistance of %.0f ohm in series with an inductance of %.2E", Rc,Lc)
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

```
//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.

//initializing the variables:
L = 0.1592 ; // in Henry
V = 250; // in Volts
f = 50; // in Hz
R = 0; // in ohms

//calculation:
//for an R L series circuit, impedance
// Z = R + iXL
XL = 2*%pi*f*L
Z = R + %i*XL
I = V/Z
x = real(I)
y = imag(I)
r = (x^2 + y^2)^0.5
if ((x==0)&(y<0)) then
    theta = -90
elseif ((x==0)&(y>0)) then
    theta = +90
else
    theta = atan(y/x)*180/%pi
end

printf("\n\n Result \n\n")
printf("\n current is (%.0f/_%.0f  ) A", r, theta)
```

Scilab code Exa 24.03 Example 3

```
//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.
```

```

//initializing the variables:
C = 3E-6 ; // in farad
f = 1000; // in Hz
ri = 2.83;
thetai = 90; // in degrees

//calculation:
//Capacitive reactance Xc
Xc = 1/(2*%pi*f*C)
// circuit impedance Z
Z = -1*%i*Xc
I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
    /180)
V = I*Z
x = real(V)
y = imag(V)

printf("\n\n Result \n\n")
printf("\n supply p.d. is %.0f + (%.0f) V", x,y)
```

Scilab code Exa 24.04 Example 4

```
//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.

//initializing the variables:
V = 240; // in Volts
f = 50; // in Hz
Z = 30 - %i*50;

```

```
//calculation:
//Since impedance Z = 30 − i50,
//resistance
R = real(Z)
//capacitive reactance
Xc = abs(imag(Z))
//capacitance
C = 1/(2*%pi*f*Xc)
//modulus of impedance
modZ = (R^2 + Xc^2)^0.5
I = V/Z
x = real(I)
y = imag(I)
r = (x^2 + y^2)^0.5
if ((x==0)&(y<0)) then
    theta = -90
elseif ((x==0)&(y>0)) then
    theta = +90
else
    theta = atan(y/x)*180/%pi
end

printf("\n\n Result \n\n")
printf("\n (a)resistance is %.0f ohm", R)
printf("\n (b)capacitance is %.2E Farad", C)
printf("\n (c)modulus of impedance is %.2f ohm", modZ)
printf("\n (d)current flowing and its phase angle is (%.2f/_%.2f ) A", r, theta)
```

Scilab code Exa 24.05 Example 5

```
//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
```

```
    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.

//initializing the variables:
V = 200; // in Volts
f = 50; // in Hz
R = 32; // in ohms
L = 0.15; // in Henry

//calculation:
//Inductive reactance XL
XL = 2*%pi*f*L
//impedance, Z
Z = R + %i*XL
//Current I
I = V/Z
xi = real(I)
yi = imag(I)
ri = (xi^2 + yi^2)^0.5
if ((xi==0)&(yi<0)) then
    thetai = -90
elseif ((xi==0)&(yi>0)) then
    thetai = +90
else
    thetai = atan(yi/xi)*180/%pi
end
//P.d. across the resistor
VR = I*R
xr = real(VR)
yr = imag(VR)
rr = (xr^2 + yr^2)^0.5
thetar = atan(yr/xr)*180/%pi
//P.d. across the coil, VL
VL = I*%i*XL
xl = real(VL)
yl = imag(VL)
```

```
rl = (xl^2 + yl^2)^0.5
thetal = atan(yl/xl)*180/%pi

printf("\n\n Result \n\n")
printf("\n (a)impedance is %.0f + (%.1f)i ohm", real(Z), imag(Z))
printf("\n (b)current flowing and its phase angle is (%.2f/_%.2f  ) A", ri, thetai)
printf("\n (c)P.d. across the resistor is (%.2f/_%.2f  ) V", rr,thetar)
printf("\n (d)P.d. across the coil, VL is (%.2f/_%.2f  ) V", rl, thetal)
```

Scilab code Exa 24.06 Example 6

```
//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.

//initializing the variables:
V = 120 + %i*200; // in Volts
f = 5E6; // in Hz
I = 7 + %i*16;  // in amperes

//calculation:
//impedance, Z
Z = V/I
R = real(Z)
X = imag(Z)
if ((R>0)&(X<0)) then
    printf("\n\n Result \n\n")
    C = -1/(2*%pi*f*X)
```

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

Scilab code Exa 24.07 Example 7

```
//Problem 24.07: For the circuit shown in Figure 24.11, determine the value of impedance Z2.

//initializing the variables:
rv = 70; // in volts
thetav = 30; // in degrees
ri = 3.5; // in amperes
thetai = -20; // in degrees
//z1 consist of two resistance
R1 = 4.36; // in ohms
R2 = -2.1*%i; // in ohms

//calculation:
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi/180)
//impedance, Z
Z = V/I
//Total impedance Z = z1 + z2
Z1 = R1 + R2
Z2 = Z - Z1
```

```
x = real(Z2)
y = imag(Z2)

printf("\n\n Result \n\n")
printf("\n impedance Z2 is %.2f + (%.2f) ohm\n",x,y)
```

Scilab code Exa 24.08 Example 8

```
//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.

//initializing the variables:
R = 90; // in ohms
XL = 150; // in ohms
ri = 1.35; // in amperes
thetai = 0; // in degrees

//calculation:
I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi/180)
//Circuit impedance Z
Z = R + %i*XL
//Supply voltage, V
V = I*Z
//Voltage across 90 ohm resistor
VR = real(V)
//Voltage across inductance, VL
VL = imag(V)
xv = real(V)
yv = imag(V)
```

```
rv = (xv^2 + yv^2)^0.5
thetav = atan(yv/xv)*180/%pi
phi = thetav - thetai

printf("\n\n Result \n\n")
printf("\n (a)Supply voltage, V is %.2f + (%.2f)i V",xv,yv)
printf("\n (b)Voltage across 90 ohm resistor, VR is %.2f V",VR)
printf("\n (c)Voltage across inductance, VL is %.2f V",VL)
printf("\n (d)Circuit phase angle is %.2f ",phi)
```

Scilab code Exa 24.09 Example 9

```
//Problem 24.09: A coil of resistance 25 ohm and inductance 20 mH has an alternating voltage given by v = 282.8sin(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.

//initializing the variables:
R = 25; // in ohms
L = 0.02; // in henry
Vm = 282.8; // in volts
w = 628.4; // in rad/sec
phiv = %pi/3; // phase angle

//calculation:
//rms voltage
Vrms = 0.707*Vm*cos(phiv) + %i*0.707*Vm*sin(phiv)
//frequency
f = w/(2*%pi)
```

```
//Inductive reactance XL
XL = 2*%pi*f*L
//Circuit impedance Z
Z = R + %i*XL
//Rms current
Irms = Vrms/Z
phii = atan(imag(Irms)/real(Irms))*180/%pi
phi = phiv*180/%pi - phii

printf("\n\n Result \n\n")
printf("\n (a)the rms value of voltage is %.2f + (%
    .2f)i V ",real(Vrms), imag(Vrms))
printf("\n (b)the circuit impedance is %.2f + (%.2f)
    i ohm ",R, XL)
printf("\n (c)the rms current flowing is %.2f + (%.2
    f)i A ",real(Irms), imag(Irms))
printf("\n (d)Circuit phase angle is %.2f  ",phi)
```

Scilab code Exa 24.10 Example 10

```
//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.

//initializing the variables:
R = 12; // in ohms
L = 0.10; // in henry
C = 120E-6; // in Farads
f = 50; // in Hz
V = 240; // in volts

//calculation:
//Inductive reactance, XL
```

```
XL = 2*%pi*f*L
//Capacitive reactance , Xc
Xc = 1/(2*%pi*f*C)
//Circuit impedance Z
Z = R + %i*(XL - Xc)
I = V/Z
phii = atan(imag(I)/real(I))*180/%pi
phiv = 0 // in degrees
phi = phiv - phii

printf("\n\n Result \n\n")
printf("\n the current flowing is %.2f + (%.2f)i A\n
    ",real(I), imag(I))
printf("and Circuit phase angle is %.2f \n",phi)
```

Scilab code Exa 24.11 Example 11

```
//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.

//initializing the variables:
C = 50E-6; // in Farads
f = 50; // in Hz
V = 225; // in volts
ri = 1.5; // in Amperes
thetai = -30; // in degrees

//calculation:
I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
    /180)
```

```
//Capacitive reactance, Xc
Xc = 1/(2*%pi*f*C)
//Circuit impedance Z
Z = V/I
R = real(Z)
XL = imag(Z) + Xc
//inductance L
L = XL/(2*%pi*f)
//Voltage across coil
Zcoil = R + %i*XL
Vcoil = I*Zcoil
//Voltage across capacitor,
Vc = -1*I*Xc*%i

printf("\n\n Result \n\n")
printf("\n (a)resistance is %.2f ohm and inductance
    is %.2f H ",R, L)
printf("\n (b)voltage across the coil is %.2f + (%.2
    f)i V ",real(Vcoil), imag(Vcoil))
printf("\n (c)voltage across the capacitor is %.2f +
     (%.2f)i V ",real(Vc), imag(Vc))
```

Scilab code Exa 24.12 Example 12

```
//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.

//initializing the variables:
C = 2.653E-6; // in Farads
R1 = 8; // in ohms
R2 = 5; // in ohms
L = 0.477E-3; // in Henry
```

```
f = 4000; // in Hz
ri = 6; // in Amperes
thetai = 0; // in degrees

//calculation:
I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi
   /180)
//Capacitive reactance, Xc
Xc = 1/(2*%pi*f*C)
//impedance Z1
Z1 = R1 - %i*Xc
//inductive reactance XL
XL = 2*%pi*f*L
//impedance Z2,
Z2 = R2 + %i*XL
//voltage V1
V1 = I*Z1
//voltage V2
V2 = I*Z2
//Supply voltage, V
V = V1 + V2
phiv = atan(imag(V)/real(V))*180/%pi
phi = phiv - thetai

printf("\n\n Result \n\n")
printf("\n supply voltage is %.2f + (%.2f)i V\n",
   real(V), imag(V))
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

```
//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.

//initializing the variables:
Z1 = 0 - %i*5; // in ohms
Z2 = 25 + %i*40; // in ohms
Z3 = 3 - %i*2; // in ohms
r4 = 50; // in ohms
theta4 = 40; // in degrees

//calculation:
//admittance Y
Y1 = 1/Z1
//conductance, G
G1 = real(Y1)
//Suspectance, Bc
Bc1 = abs(imag(Y1))
```

```
//admittance Y
Y2 = 1/Z2
//conductance, G
G2 = real(Y2)
//Suspectance, Bc
Bc2 = abs(imag(Y2))
//admittance Y
Y3 = 1/Z3
//conductance, G
G3 = real(Y3)
//Suspectance, Bc
Bc3 = abs(imag(Y3))
Z4 = r4*cos(theta4*%pi/180) + %i*r4*sin(theta4*%pi/180)
//admittance Y
Y4 = 1/Z4
//conductance, G
G4 = real(Y4)
//Suspectance, Bc
Bc4 = abs(imag(Y4))

printf("\n\n Result \n\n")
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)
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)
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)
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

```
//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

//initializing the variables:
Y2 = 0.001 - %i*0.002; // in S
Y3 = 0.05 + %i*0.08; // in S
r1 = 0.004; // in S
theta1 = 30; // in degrees

//calculation:
//impedance, Z
Z2 = 1/Y2
Z3 = 1/Y3
Y1 = r1*cos(theta1*%pi/180) + %i*r1*sin(theta1*%pi
   /180)
Z1 = 1/Y1

printf("\n\n Result \n\n")
printf("\n (a)Impedance,Z is (%.1f + (%.0f)i) ohm ",
   real(Z1), imag(Z1))
printf("\n (b)Impedance,Z is (%.0f + (%.0f)i) ohm ",
   real(Z2), imag(Z2))
printf("\n (c)Impedance,Z is (%.2f + (%.2f)i) ohm ",
   real(Z3), imag(Z3))
```

Scilab code Exa 25.03 Example 3

```
//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.

//initializing the variables:
Y = 0.040 - %i*0.025; // in S

//calculation:
//impedance, Z
Z = 1/Y
//conductance, G
G = real(Y)
//Suspectance, Bc
Bc = abs(imag(Y))
//parallrl
//resistance, R
Rp = 1/G
//capacitive reactance
Xcp = 1/Bc
//series
//resistance, R
Rs = real(Z)
//capacitive reactance
Xcs = abs(imag(Z))

printf("\n\n Result \n\n")
printf("\n (a)for parallel, resistance,R is %.0f ohm and capacitive reactance, Xc is %.0f ohm ",Rp,Xcp)
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

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

```

//initializing the variables:
R1 = 8; // in ohm
R = 5; // in ohm
R2 = 6; // ohm
rv = 50; // in volts
thetav = 0; // in degrees

//calculation:
//voltage,V
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//circuit impedance, ZT
ZT = R + (R1*%i*R2/(R1 + %i*R2))
//Current I
I = V/ZT
//current,I1
I1 = I*(%i*R2/(R1 + %i*R2))
//current, I2
I2 = I*(R1/(R1 + %i*R2))

printf("\n\n Result \n\n")
printf("\n current, I is (%.2f + (%.2f)i) A,current, I1 is (%.2f + (%.2f)i) A, current, I2 is (%.2f + (%.2f)i) A ",real(I), imag(I),real(I1), imag(I1), real(I2), imag(I2))
```

Scilab code Exa 25.05 Example 5

```
//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.

//initializing the variables:
```

```
R1 = 5; // in ohm
R2 = 3; // in ohm
R3 = 8; // ohm
Xc = 4; // in ohms
XL = 12; // in Ohms
V = 40; // in volts
f = 50; // in Hz

//calculation:
Z1 = R1 + %i*XL
Z2 = R2 - %i*Xc
Z3 = R3
//circuit admittance, YT = 1/ZT
YT = (1/Z1) + (1/Z2) + (1/Z3)
//Current I
I = V*YT
I1 = V/Z1
I2 = V/Z2
I3 = V/Z2
thetav = 0
thetai = atan(imag(I)/real(I))*180/%pi
phi = thetav - thetai
if (phi>0) then
    a = "lagging"
else
    a = "leading"
end

printf("\n\n Result \n\n")
printf("\n current, I is (%.2f + (%.2f)i) A,and its
   phase relative to the 40 V supply is %s by %.2f
   \n",real(I), imag(I),a,abs(phi))
```

Scilab code Exa 25.06 Example 6

```
//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.

//initializing the variables:
L = 0.07958; // in Henry
R = 18; // in ohm
C = 64.96E-6; // in Farad
rv = 250; // in volts
thetav = 0; // in degrees
f = 50; // in Hz

//calculation:
//Inductive reactance
XL = 2*%pi*f*L
//capacitive reactance
Xc = 1/(2*%pi*f*C)
//impedance of the coil,
Zcoil = R + %i*XL
//impedance presented by the capacitor,
Zc = -1*%i*Xc
//Total equivalent circuit impedance,
ZT = Zcoil*Zc/(Zcoil + Zc)
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//current, I
I = V/ZT
thetai = atan(imag(I)/real(I))*180/%pi
phi = thetav - thetai
if (phi>0) then
    a = "lagging"
else
```

```
    a = "leading"
end
//Current in the coil, ICOIL
Icoil = V/Zcoil
//Current in the capacitor, IC
Ic = V/Zc

printf("\n\n Result \n\n")
printf("\n (a)the circuit impedance is %.2f + (%.2f)i ohm ",real(ZT), imag(ZT))
printf("\n (b)supply current, I is %.2f + (%.2f)i A ",real(I), imag(I))
printf("\n (c)circuit phase relative is %s by %.2f ",a,abs(phi))
printf("\n (d)current in coil, Icoil is %.2f + (%.2f)i A ",real(Icoil), imag(Icoil))
printf("\n (e)current in capacitor, Ic is %.2f + (%.2f)i A ",real(Ic), imag(Ic))
```

Scilab code Exa 25.07 Example 7

```
//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.

//initializing the variables:
RL = %i*6; // in ohm
R2 = 8; // in ohm
Z3 = 10; // in ohm
rv = 50; // in volts
thetav = 30; // in degrees
ri = 31.4; // in amperes
thetai = 52.48; // in degrees
```

```
f = 5000; // in Hz

//calculation:
//impedance, Z2
Z2 = R2 + RL
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//current, I
I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi/180)
//Total circuit admittance,
YT = I/V
//admittance, Y3
Y3 = 1/Z3
//admittance, Y2
Y2 = 1/Z2
//admittance, Y1
Y1 = YT - Y2 - Y3
//impedance, Z1
Z1 = 1/Y1

printf("\n\n Result \n\n")
printf("\n (a)the impedance Z1 is %.2f + (%.2f)i ohm ",real(Z1), imag(Z1))

//resistance, R1
R1 = real(Z1)
X1 = imag(Z1)
if ((R1>0)&(X1<0)) then
    C1 = -1/(2*%pi*f*X1)
    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)
elseif ((R1>0)&(X1>0)) then
    L1 = 2*%pi*f*X1
    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)
end
```

Scilab code Exa 25.08 Example 8

```
//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.

//initializing the variables:
RL1 = %i*1.02; // in ohm
R1 = 1.65; // in ohm
RLa = %i*7; // in ohm
Ra = 5; // in ohm
Rcb = -1*%i*15; // in ohm
Rb = 4; // in ohm
rv = 91; // in volts
thetav = 0; // in degree

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
   /180)
//impedance, Z1
Z1 = R1 + RL1
//impedance, Za
Za = Ra + RLa
//impedance, Zb
Zb = Rb + Rcb
//impedance, Z, of the two branches connected in
   parallel
Z = Za*Zb/(Za + Zb)
```

```
//Total circuit impedance
ZT = Z1 + Z
//Supply current , I
I = V/ZT
thetai = atan(imag(I)/real(I))*180/%pi
phi = thetav - thetai
if (phi>0) then
    a = "lagging"
else
    a = "leading"
end
//Voltage V1
V1 = I*Z1
//Voltage V2
V2 = I*Z
//current Ia
Ia = V2/Za
//Current Ib
Ib = V2/Zb

printf("\n\n Result \n\n")
printf("\n (a)equivalent series circuit impedance is %.2f + (%.2f)i ohm ",real(ZT), imag(ZT))
printf("\n (b)supply current , I is %.2f + (%.2f)i A ",real(I), imag(I))
printf("\n (c)circuit phase relative is %s by %.2f ",a,abs(phi))
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))
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

```
//Problem 26.01: A coil of resistance 5 ohm and
   inductive reactance 12 ohm is connected across a
   supply voltage of 526/_30volts. Determine the
   active power in the circuit.

//initializing the variables:
RL = %i*12; // in ohm
R = 5; // in ohm
rv = 52; // in volts
thetav = 30; // in degree

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
   /180)
//impedance, Z
Z = R + RL
//current
I = V/Z
//Active power, P
Pa = real(V)*real(I) + imag(V)*imag(I)
```

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

Scilab code Exa 26.02 Example 2

```
//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.

//initializing the variables:
V = 120 + %i*200; // in volts
I = 15 + %i*8; // in amperes

//calculation:
//Active power, P
Pa = real(V)*real(I) + imag(V)*imag(I)
//Reactive power, Q
Q = imag(V)*real(I) - real(V)*imag(I)

printf("\n\n Result \n\n")
printf("\n (a) the active power in the circuit %.0f
    W",Pa)
printf("\n (b) the reactive power in the circuit %.0
    f var ",Q)
```

Scilab code Exa 26.03 Example 3

```
//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.

//initializing the variables:
Vm = 141.4; // in volts
w = 10000; // in rad/sec
phiv = %pi/9; // in radian
Pd = 1732; // in Watts
pf = 0.866; // power fctr

//calculation:
//the rms voltage,
Vrms = 0.707*Vm
//Power P = V*I*cos(phi)
//current magnitude, Irms
Irms = Pd/(Vrms*pf)
phid = acos(pf)
//current phase angle
phii = phiv + phid
phiid = phii*180/%pi // in degrees
//Voltage, V
V = Vrms*cos(phiv) + %i*Vrms*sin(phiv)
//current, I
I = Irms*cos(phii) + %i*Irms*sin(phii)
//Impedance, Z
Z = V/I
//resistance, R
R = real(Z)
//capacitive reactance, Xc
Xc = abs(imag(Z))
//capacitance, C
C = 1/ (w*Xc)

printf("\n\n Result \n\n")
printf("\n (a)the current flowing and Circuit phase
```

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

Scilab code Exa 26.04 Example 4

```
//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.

//initializing the variables:
rv = 100; // in volts
thetav = 0; // in degrees
R = 5; // in ohm
R1 = 3; // in ohms
RL = %i*4; // in ohm
Rc = -10*%i; // in ohms

//calculation:
//impedance, Z1
Z1 = R1 + RL
//impedance, Zc
Zc = Rc
//Circuit impedance, Z
Z = R + (Z1*Zc/(Z1 + Zc))
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
    /180)
I = V/Z
Imag = ((real(I))^2 + (imag(I))^2)^0.5
//Active power developed between points A and B
Pab = (Imag^2)*R
//Active power developed between points C and D
Pcd = (Imag^2)*real(Zc)
```

```
//Current, I1
I1 = I*Zc/(Zc + Z1)
I1mag = ((real(I1))^2 + (imag(I1))^2)^0.5
//active power developed between points E and F
Pef = (I1mag^2)*real(Z1)

printf("\n\n Result \n\n")
printf("\n (a)Active power developed between points
    A and B is %.2f W ",Pab)
printf("\n (b)Active power developed between points
    C and D is %.2f W ",Pcd)
printf("\n (c)Active power developed between points
    E and F is %.2f W ",Pef)
```

Scilab code Exa 26.05 Example 5

```
//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.

//initializing the variables:
Pa = 400; // in Watts
rv = 100; // in volts
thetav = 30; // in degrees
R = 4; // in ohm
pf = 0.766; // power factor

//calculation:
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
    /180)
//magnitude of apparent power,S = V*I
S = Pa/pf
```

```
phi = acos(pf)
theta = phi*180/%pi // in degrees
//Reactive power Q
Q = S*sin(phi)
//magnitude of current
Imag = S/rv
thetai = thetav - theta
I = Imag*cos(thetai*%pi/180) + %i*Imag*sin(thetai*%pi/180)
//Total circuit impedance ZT
ZT = V/I
//impedance Z
Z = ZT - R

printf("\n\n Result \n\n")
printf("\n (a)apparent power is %.2f VA ",S)
printf("\n (b)reactive power is %.2f var ",Q)
printf("\n (c)the current flowing and Circuit phase angle is %.2f/_%.0f  A ",Imag,thetai)
printf("\n (d)impedance, Z is %.2f + (%.2f)i ohm ",real(Z), imag(Z))
```

Scilab code Exa 26.06 Example 6

```
//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.

//initializing the variables:
S = 300000; // in VA
pf1 = 0.70; // in power factor
```

```
pf2 = 0.90; // in power factor

//calculation:
//active power, P
Pa = S*pf1
phi1 = acos(pf1)
phi1d = phi1*180/%pi
//Reactive power, Q
Q = S*sin(phi1)
phi2 = acos(pf2)
phi2d = phi2*180/%pi
//The capacitor rating needed to improve the power factor to 0.90
//the capacitor rating,
Pr = Q - (Pa*tan(phi2))

printf("\n\n Result \n\n")
printf("\n the rating (in kilovars) of the capacitors is %.1f kvar\n",(Pr/1E3))
```

Scilab code Exa 26.07 Example 7

```
//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.

//initializing the variables:
Z = 3 + %i*4; // in ohms
rv = 50; // in volts
```

```
thetav = 30; // in Degrees
f = 1500; // in Hz
pf1 = 0.966; // in power factor

//calculation:
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//Supply current, I
I = V/Z
Istr = real(I) - %i*imag(I)
//Apparent power, S
S = V*Istr
//active power, Pa
Pa = real(S)
//reactive power, Q
Q = abs(imag(S))
//apparent power, S
S = (real(S)^2 + imag(S)^2)^0.5
phi1 = acos(pf1)
phi1d = phi1*180/%pi
//rating of the capacitor
Pr = Q - Pa*tan(phi1)
//Current in capacitor, Ic
Ic = Pr/rv
//Capacitive reactance, Xc
Xc = rv/Ic
C = 1/(2*%pi*f*Xc)

printf("\n\n Result \n\n")
printf("\n (a)supply current, I is %.2f + (%.2f)i A ",real(I), imag(I))
printf("\n (b)active power is %.0f W, apparent power is %.0f W and reactive power is %.0f W ",Pa, S, Q)
printf("\n (c)the rating of the capacitors is %.1f var\n",Pr)
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

```
//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.

//initializing the variables:
R2 = 30000; // in ohms
R3 = 30000; // in ohms
R4 = 1000; // in ohms
C2 = 1e-9; // IN fARADS
C3 = 1e-9; // IN fARADS

//calculation:
//the bridge is balanced
R1 = R4/((R3/R2) + (C2/C3))
//frequency, f
f = 1/(2*%pi*((C2*C3*R2*R3)^0.5))

printf("\n\n Result \n\n")
printf("\n (a)Resistance R1 = %.0f ohm",R1)
```

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

Scilab code Exa 27.03 Example 3

```
//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.

//initializing the variables:
R3 = 600; // in ohms
R4 = 200; // in ohms
C2 = 0.2e-6; // IN fARADS
C3 = 4000e-12; // IN fARADS
f = 1500; //in Hz

//calculation:
//the bridge is balanced
//Resistance, Rx
Rx = R4*C3/C2
//Capacitance, Cx
Cx = C2*R3/R4
//Phase angle
phi = atan(1/(2*%pi*f*Cx*Rx))
phid = phi*180/%pi // in degrees
//Power factor of capacitor
Pc = cos(phi)
//Loss angle,
del = 90 - phid

printf("\n\n Result \n\n")
```

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

Chapter 28

Series resonance and Q factor

Scilab code Exa 28.01 Example 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.

//initializing the variables:
R = 10; // in ohms
C = 40e-6; // IN fARADS
L = 0.075; // IN Henry
V = 200; // in Volts

//calculation:
//Resonant frequency,
fr = 1/(2*%pi*((L*C)^0.5))
//Current at resonance, I
I = V/R

printf("\n\n Result \n\n")
printf("\n (a)Resonant frequency = %.1f Hz ",fr)
printf("\n (b)Current at resonance, I is %.0f A ",I)
```

Scilab code Exa 28.02 Example 2

```
//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.

//initializing the variables:
R = 8; // in ohms
L = 0.010; // IN Henry
f = 1000; // in Hz

//calculation:
//At resonance
//capacitance C
C = 1/(L*(2*%pi*f)^2)

printf("\n\n Result \n\n")
printf("\n capacitance, C is %.2E F\n",C)
```

Scilab code Exa 28.03 Example 3

```
//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.

//initializing the variables:
C1 = 1000e-12; // IN fARADS
C2 = 500e-12; // IN fARADS
fr1 = 92500; // in Hz
fr2 = 127800; // in Hz

//calculation:
//For a series R L C circuit the resonant
   frequency fr is given by:
//fr = 1/(2pi*(L*C)^2)
Cs = ((C1 - C2)/((fr2/fr1)^2 - 1)) - C2
L = 1/((C1 + Cs)*(2*%pi*fr1)^2)

printf("\n\n Result \n\n")
printf("\n (a)stray capacitance, Cs is %.2E F ",Cs)
printf("\n (b)inductance, L is %.2E H ",L)
```

Scilab code Exa 28.04 Example 4

```
//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.

//initializing the variables:
R = 10; // in ohms
C = 5e-6; // IN fARADS
```

```
rv = 20; //in volts
thetav = 0; // in degrees
f = 318.3; // in Hz

//calculation:
wr = 2*%pi*f
//The maximum voltage across the resistance occurs at resonance when the current is a maximum. At resonance,L = 1/c*wr^2
L = 1/(C*wr^2)
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//Current at resonance Ir
Ir = V/R
//p.d. across resistance, VR
VR = Ir*R
//inductive reactance, XL
XL = wr*L
//p.d. across inductance, VL
VL = Ir*(%i*XL)
//capacitive reactance, Xc
Xc = 1/(wr*C)
//p.d. across capacitor, Vc
Vc = Ir*(-1*%i*Xc)
//Q-factor at resonance, Qr
Qr = imag(VL)/V

printf("\n\n Result \n\n")
printf("\n (a)inductance, L is %.2E H ",L)
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))
printf("\n (c)Q-factor at resonance, Qr is %.0f  ",Qr)
```

Scilab code Exa 28.05 Example 5

```
//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.

//initializing the variables:
R = 80; // in ohms
C = 0.4e-6; // IN fARADS
L = 0.020; // IN Henry
Vm = 12; //in volts

//calculation:
//Resonant frequency,
fr = 1/(2*%pi*((L*C)^0.5))
wr = 2*%pi*fr
//Q = wr*L/R
Q = wr*L/R
Vc = Q*Vm
//the frequency f at which VC is a maximum value,
f = fr*(1 - (1/(2*Q*Q)))^0.5
//the maximum value of the p.d. across the capacitor is given by:
Vcm = Vc/(1 - (1/(2*Q))^2)^0.5

printf("\n\n Result \n\n")
printf("\n (a)The resonant frequency is %.1f Hz ",fr)
```

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

Scilab code Exa 28.06 Example 6

```
//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.

//initializing the variables:
QL = 60; // Q-factor
Qc = 390; // Q-factor

//calculation:
QT = QL*Qc/(QL + Qc)

printf("\n\n Result \n\n")
printf("\n the overall Q-factor is %.0f \n",QT)
```

Scilab code Exa 28.07 Example 7

```
//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
    .

```

```
//initializing the variables:
R = 5; // in ohms
L = 0.010; // IN Henry
fr = 10000; // in Hz

//calculation:
wr = 2*%pi*fr
//Q-factor at resonance is given by
Qr = wr*L/R
//Since Qr = fr/(f2 - f1),
bw = fr/Qr

printf("\n\n Result \n\n")
printf("\n bandwidth of the filter is %.1f Hz\n",bw)
```

Scilab code Exa 28.08 Example 8

```
//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.

//initializing the variables:
Zr = 50; // in ohms
fr = 1200; // in Hz
Qr = 30; // Q-factor

//calculation:
//At resonance the circuit impedance, Z
R = Zr
wr = 2*%pi*fr
```

```
//Q-factor at resonance is given by Qr = wr*L/R,
    then L is
L = Qr*R/wr
//At resonance r*L = 1/(wr*C)
//capacitance, C
C = 1/(L*wr*wr)
//bandwidth,.(f2     f1)
bw = fr/Qr
//upper half-power frequency, f2
f2 = (bw + ((bw^2) + 4*(fr^2))^0.5)/2
//lower half-power frequency, f1
f1 = f2 - bw
//At the half-power frequencies, current I
//I = 0.707*Ir
//Hence impedance
Z = (2^0.5)*R

printf("\n\n Result \n\n")
printf("\n (a)inductance, L is %.3f H ",L)
printf("\n (b)capacitance, C is %.2E F ",C)
printf("\n (c)bandwidth is %.0f Hz ",bw)
printf("\n (d)the upper half-power frequency, f2 is
    %.0f Hz and the lower half-power frequency, f1 is
    %.0f Hz ",f2,f1)
printf("\n (e)impedance at the half-power
    frequencies is %.2f ohm ",Z)
```

Scilab code Exa 28.09 Example 9

```
//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

//initializing the variables:
V = 0.2; // in Volts
I = 0.004; // in Amperes
fr = 3000; // in Hz
Qr = 100; // Q-factor

//calculation:
wr = 2*%pi*fr
//At resonance, impedance
Z = V/I
//At resonance the circuit impedance, Z
R = Z
//Q-factor at resonance is given by Qr = wr*L/R,
    then L is
L = Qr*R/wr
//At resonance r*L = 1/(wr*C)
//capacitance, C
C = 1/(L*wr*wr)
//Q-factor at resonance in a series circuit
    represents the voltage magnification Qr = Vc/V,
    then Vc is
Vc = Qr*V

printf("\n\n Result \n\n")
printf("\n (a)the circuit resistance is %.0f ohm ",R
    )
printf("\n (b)inductance, L is %.3f H ",L)
printf("\n (c)capacitance, C is %.2E F ",C)
printf("\n (d)the voltage across the capacitor is %
    .0f V ",Vc)
```

Scilab code Exa 28.10 Example 10

```
//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.

//initializing the variables:
R = 8.84; // in ohms
L = 0.3518; // IN Henry
C = 20e-6; // IN fARADS

//calculation:
//Resonant frequency,
fr = 1/(2*%pi*((L*C)^0.5))
wr = 2*%pi*fr
//Q-factor at resonance, Q = wr*L/R
Qr = wr*L/R
//bandwidth,.(f2   f1)
bw = fr/Qr
//the lower  3 dB frequency
f1 = fr - bw/2
//the upper  3 dB frequency
f2 = fr + bw/2

printf("\n\n Result \n\n")
printf("\n (a)Resonant frequency, fr is %.0f Hz",fr)
printf("\n (b)Q-factor at resonance is %.0f",Qr)
printf("\n (c)Bandwidth is %.0f Hz ",bw)
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

```
//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.

//initializing the variables:
R = 15; // in ohms
L = 0.008; // IN Henry
C = 0.3e-6; // IN fARADS
rv = 7.56; //in volts
thetav = 0; // in degrees
x = 0.03;

//calculation:
//Resonant frequency,
fr = 1/(2*%pi*((L*C)^0.5))
wr = 2*%pi*fr
//At resonance,
Zr = R
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//Current at resonance
Ir = V/Zr
//Q-factor at resonance, Q = wr*L/R
Qr = wr*L/R
//If the frequency is 3% above fr, then
del = x
I = Ir/(1 + (2*del*Qr*%i))
Z = V/I

```

```
printf("\n\n Result \n\n")
printf("\n (a)Current at resonance, Ir is %.2f A ",Ir)
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))
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

```
//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.

//initializing the variables:
R = 10; // in ohms
L = 0.005; // IN Henry
C = 0.25e-6; // IN fARADS
V = 50; //in volts

//calculation:
//Resonant frequency, for parallel
fr = ((1/(L*C) - ((R^2)/(L^2)))^0.5)/(2*%pi)
//dynamic resistance
Rd = L/(C*R)
//Current at resonance
Ir = V/Rd
```

```
wr = 2*%pi*fr
//Q-factor at resonance , Q = wr*L/R
Qr = wr*L/R

printf("\n\n Result \n\n")
printf("\n (a)Resonance frequency is %.0f Hz ",fr)
printf("\n (b)dynamic resistance %.0f ohm ",Rd)
printf("\n (c)Current at resonance , Ir is %.3f A ",
   Ir)
printf("\n (d)Q-factor at resonance is %.1f ",Qr)
```

Scilab code Exa 29.02 Example 2

```
//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.

//initializing the variables:
RL1 = 0; // in ohms
RL2 = 30; // in ohms
L = 0.100; // IN Henry
C = 40e-6; // IN fARADS
V = 50; //in volts

//calculation:
//for RL1
//Resonant frequency ,
wr1 = (1/(L*C))^0.5
fr1 = wr1/(2*%pi)
//for RL2
//Resonant frequency ,
wr2 = (1/(L*C) - ((RL2^2)/(L^2)))^0.5
fr2 = wr2/(2*%pi)

```

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

Scilab code Exa 29.03 Example 3

```
//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.

//initializing the variables:
R = 150; // in ohms
L = 0.120; // IN Henry
V = 20; //in volts
fr = 4000; // in Hz

//calculation:
//capacitance, C
C = 1/(L*[(2*%pi*fr)^2 + ((R^2)/(L^2))])
Rd = L/(C*R)
//Current at resonance
Ir = V/Rd
wr = 2*%pi*fr
//Q-factor at resonance, Q = wr*L/R
Qr = wr*L/R
//bandwidth,.(f2   f1)
```

```
bw = fr/Qr
//upper half-power frequency , f2
f2 = (bw + ((bw^2) + 4*(fr^2))^0.5)/2
//lower half-power frequency , f1
f1 = f2 - bw
//impedance at the   3 dB frequencies
Z = Rd/(2^0.5)

printf("\n\n Result \n\n")
printf("\n (a)the capacitance of the capacitor ,C is
    %.2E F",C)
printf("\n (b)dynamic resistance %.2E ohm ",Rd)
printf("\n (c)Current at resonance , Ir is %.3E A ",
    Ir)
printf("\n (d)Q-factor at resonance is %.2f ",Qr)
printf("\n (e)bandwidth is %.0f Hz ",bw)
printf("\n (f)the upper half-power frequency , f2 is
    %.0f Hz and the lower half-power frequency , f1 is
     %.0f Hz ",f2,f1)
printf("\n (g)impedance at the   3 dB frequencies
    is %.3E ohm",Z)
```

Scilab code Exa 29.04 Example 4

```
//Problem 29.03: A two-branch parallel network is
    shown in Figure 29.8. Determine the resonant
    frequency of the network.

//initializing the variables:
RL = 5; // in ohms
L = 0.002; // IN Henry
C = 25e-6; // IN fARADS
Rc = 3; // in ohms

//calculation:
```

```
//Resonant frequency, for parallel
fr = (1/(2*%pi*((L*C)^0.5)))*((RL^2 - (L/C))/(Rc^2 -
    (L/C)))^0.5

printf("\n\n Result \n\n")
printf("\n resonant frequency, fr is %.2f Hz",fr)
```

Scilab code Exa 29.05 Example 5

```
//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.

//initializing the variables:
RL = 3; // in ohms
fr = 1000; // in Hz
Xc = 10; // IN ohms
Rc = 4; // in ohms

//calculation:
XL1 = (((Rc^2 + Xc^2)/Xc) + ((((Rc^2 + Xc^2)/Xc)^2)
   - 4*(RL^2))^0.5)/2
XL2 = (((Rc^2 + Xc^2)/Xc) - ((((Rc^2 + Xc^2)/Xc)^2)
   - 4*(RL^2))^0.5)/2
wr = 2*%pi*fr
//inductance
L1 = XL1/wr
L2 = XL2/wr

printf("\n\n Result \n\n")
printf("\n inductance is either %.2E H or %.2E H",L1
   , L2)
```

Scilab code Exa 29.06 Example 6

```
//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.

//initializing the variables:
QL = 60; // Q-factor
Qc = 300; // Q-factor

//calculation:
QT = QL*Qc/(QL + Qc)

printf("\n\n Result \n\n")
printf("\n the overall Q-factor is %.0f \n",QT)
```

Scilab code Exa 29.07 Example 7

```
//Problem 29.07: In an LR 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.

//initializing the variables:
C = 10.61E-9; // in Farad
bw = 500; // in Hz
fr = 150000; // in Hz
x = 0.004
```

```
//calculation:
//Q-factor
Q = fr/bw
wr = 2*%pi*fr
//dynamic resistance, RD
Rd = L*Q/(C*wr*L)
del = x
Z = Rd/(1 + (2*del*Q*%i))
Zmag = (real(Z)^2 + imag(Z)^2)^0.5

printf("\n\n Result \n\n")
printf("\n (a)Q-factor %.2f",Q)
printf("\n (b)dynamic resistance %.2E ohm",Rd)
printf("\n (c)magnitude of the impedance %.2E ohm",
    Zmag)
```

Chapter 30

Introduction to network analysis

Scilab code Exa 30.01 Example 1

```
//Problem 30.01: Use Kirchhoff s laws to find the
    current flowing in each branch of the network
    shown in Figure 30.3.

//initializing the variables:
rv1 = 100; // in volts
rv2 = 50; // in volts
thetav1 = 0; // in degrees
thetav2 = 90; // in degrees
R1 = 25; // in ohm
R2 = 20; // in ohm
R3 = 10; // in ohm

//calculation:
//voltage
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
    %pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
    %pi/180)
```

```
//The branch currents and their directions are labelled as shown in Figure 30.4
//Two loops are chosen. loop ABEF, and loop BCDE
//using kirchoff rule in 3 loops
//two eqns obtained
//(R1 + R2)*I1 + R2*I2 = V1
//R2*I1 + (R2 + R3)*I2 = V2
I1 = (3*V1 - 2*V2)/(3*(R1 + R2) - 2*(R2))
I2 = (V2 - R2*I1)/(R2 + R3)
I = I1 + I2

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
V = 8; // in volts
R1 = 1; // in ohm
R2 = 2; // in ohm
R3 = 3; // in ohm
R4 = 4; // in ohm
R5 = 5; // in ohm
R6 = 6; // in ohm

//calculation:
//Currents and their directions are assigned as
```

```
shown in Figure 30.6.
//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
//using kirchoff rule in 3 loops
//three eqns obtained
//R5*I1 + (R6 + R4)*I2 - R4*I3 = V
//-1*R1*I1 + (R6 + R1)*I2 + R2*I3 = 0
// R3*I1 - (R3 + R4)*I2 + (R2 + R3 + R4)*I3 = 0
//using determinants
d1 = [V (R6 + R4) -1*R4; 0 (R6 + R1) R2; 0 (-1*(R3 + R4)) (R2 + R3 + R4)]
D1 = det(d1)
d2 = [R5 V -1*R4; -1*R1 0 R2; R3 0 (R2 + R3 + R4)]
D2 = det(d2)
d3 = [R5 (R6 + R4) V; -1*R1 (R6 + R1) 0; R3 (-1*(R3 + R4)) 0]
D3 = det(d3)
d = [R5 (R6 + R4) -1*R4; -1*R1 (R6 + R1) R2; R3 (-1*(R3 + R4)) (R2 + R3 + R4)]
D = det(d)
I1 = D1/D
I2 = D2/D
I3 = D3/D
//Current in the 2 ohm resistance
I = I1 - I2 + I3
//power dissipated in the 3 ohm resistance
P3 = R3*I^2

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

Scilab code Exa 30.03 Example 3

```
//Problem 30.03: For the a.c. network shown in Figure 30.7, determine the current flowing in each branch using Kirchhoff s laws.

//initializing the variables:
E1 = 5 + %i*0; // in volts
E2 = 2 + %i*4; // in volts
Z1 = 3 + %i*4; // in ohm
Z2 = 2 - %i*5; // in ohm
Z3 = 6 + %i*8; // in ohm

//calculation:
//Currents I1 and I2 with their directions are shown in Figure 30.8.
//Two loops are chosen with their directions both clockwise.loop ABEF and loop BCDE,
//using kirchoff rule in 3 loops
//two eqns obtained
//(Z1 + Z3)*I1 - Z3*I2 = E1
//-1*Z3*I1 + (Z2 + Z3)*I2 = E2
I1 = ((Z2 + Z3)*E1 + Z3*E2)/((Z2 + Z3)*(Z1 + Z3) - Z3*Z3)
I2 = -1*(E1 - (Z1 + Z3)*I1)/Z3
I3 = I1 - I2

printf("\n\n Result \n\n")
printf("\n current , I1 is %.2f + (%.2f)i A, current , I2 is %.2f + (%.2f)i A and current in Z3, I3 is %.3f + (%.3f)i A",real(I1), imag(I1),real(I2), imag(I2),real(I3), imag(I3))
```

Scilab code Exa 30.04 Example 4

```
//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.

//initializing the variables:
rv1 = 10; // in volts
rv2 = 12; // in volts
rv3 = 15; // in volts
thetav1 = 0; // in degrees
thetav2 = 0; // in degrees
thetav3 = 0; // in degrees
R1 = 4; // in ohm
R2 = -1*5*%i; // in ohm
R3 = 8; // in ohm
R4 = 4; // in ohm
R5 = %i*3; // in ohm

//calculation:
//voltages
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
    %pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
    %pi/180)
V3 = rv3*cos(thetav3*%pi/180) + %i*rv3*sin(thetav3*
    %pi/180)
//Currents I1, I2 and I3 with their directions are
    shown in Figure 30.10.
//Three loops are chosen. The choice of loop
    directions is arbitrary. loop ABGH, and loopBCFG
    and loop CDEF
Z4 = R4 + R5
```

```
//using kirchoff rule in 3 loops
//three eqns obtained
//R1*I1 + R2*I2 = V1 + V2
//-1*R3*I1 + (R3 + R2)*I2 + R3*I3 = V2 + V3
// -1*R3*I1 + R3*I2 + (R3 + Z4)*I3 = V3
//using determinants
d1 = [(V1 + V2) R2 0; (V2 + V3) (R3 + R2) R3; V3 R3 (R3 + Z4)]
D1 = det(d1)
d2 = [R1 (V1 + V2) 0; -1*R3 (V2 + V3) R3; -1*R3 V3 (R3 + Z4)]
D2 = det(d2)
d3 = [R1 R2 (V1 + V2); -1*R3 (R3 + R2) (V2 + V3); -1*R3 R3 V3]
D3 = det(d3)
d = [R1 R2 0; -1*R3 (R3 + R2) R3; -1*R3 R3 (R3 + Z4)]
D = det(d)
I1 = D1/D
I2 = D2/D
I3 = D3/D
I3mag = (real(I3)^2 + imag(I3)^2)^0.5

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
V1 = 4; // in volts
V2 = 5; // in volts
R1 = 3; // in ohm
R2 = 5; // in ohm
R3 = 4; // in ohm
R4 = 1; // in ohm
R5 = 6; // in ohm
R6 = 8; // in ohm

//calculation:
//The mesh currents I1, I2 and I3 are shown in
   Figure 31.2. Using Kirchhoff s voltage law in 3
    loops
```

```
//three eqns obtained
//(R1 + R2)*I1 - R2*I2 = V1
//-1*R2*I1 + (R2 + R3 + R4 + R5)*I2 - R4*I3 = 0
// -1*R4*I2 + (R4 + R6)*I3 = -1*V2
//using determinants
d1 = [V1 -1*R2 0; 0 (R2 + R3 + R4 + R5) -1*R4; -1*V2
    -1*R4 (R4 + R6)]
D1 = det(d1)
d2 = [(R1 + R2) V1 0; -1*R2 0 -1*R4; 0 -1*V2 (R4 +
   R6)]
D2 = det(d2)
d3 = [(R1 + R2) -1*R2 V1; -1*R2 (R2 + R3 + R4 + R5)
   0; 0 -1*R4 -1*V2]
D3 = det(d3)
d = [(R1 + R2) -1*R2 0; -1*R2 (R2 + R3 + R4 + R5)
   -1*R4; 0 -1*R4 (R4 + R6)]
D = det(d)
I1 = D1/D
I2 = D2/D
I3 = D3/D
IR2 = I1 - I2
IR4 = I2 - I3

printf("\n\n Result \n\n")
printf("\n (a)current in the 5 ohm resistance is %.2
   f A",IR2)
printf("\n (b)current in the 1 ohm resistance is %.2
   f A",IR4)
```

Scilab code Exa 31.02 Example 2

```
//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
```

```
active power delivered by the 100/_0  V voltage source.

//initializing the variables:
rv = 100; // in volts
thetav = 0; // in degrees
R1 = 5; // in ohm
R2 = -1*4*%i; // in ohm
R3 = 4; // in ohm
R4 = %i*3; // in ohm

//calculation:
//voltages
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//Currents I1, I2 with their directions are shown in Figure 31.03.
//Two loops are chosen. The choice of loop directions is arbitrary.
//using kirchoff rule in 2 loops
//two eqns obtained
//(R1 + R2)*I1 - R2*I2 = V
//-1*R2*I1 + (R3 + R2 + R4)*I2 = 0
//using determinants
d1 = [V -1*R2; 0 (R3 + R2 + R4)]
D1 = det(d1)
d2 = [(R1 + R2) V; -1*R2 0]
D2 = det(d2)
d = [(R1 + R2) -1*R2; -1*R2 (R3 + R2 + R4)]
D = det(d)
I1 = D1/D
I2 = D2/D
I1mag = (real(I1)^2 + imag(I1)^2)^0.5
//Current flowing in capacitor
Ic = I1 - I2
//Source power P
phi = atan(imag(I1)/real(I1))
P = V*I1mag*cos(phi)
```

```
Icmag = (real(Ic)^2 + imag(Ic)^2)^0.5

printf("\n\n Result \n\n")
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))
printf("\n (b)current in the capacitor is %.2f A",
   Icmag)
printf("\n (c)Source power P is %.2f W",P)
```

Scilab code Exa 31.03 Example 3

```
//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.

//initializing the variables:
rv1 = 415; // in volts
rv2 = 415; // in volts
thetav1 = 120; // in degrees
thetav2 = 0; // in degrees
R = 3 + %i*4; // in ohm

//calculation:
//voltages
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
   %pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
   %pi/180)
//Two mesh currents I1 and I2 are chosen as shown in
    Figure 31.4.
//Two loops are chosen. The choice of loop
   directions is arbitrary.
//using kirchoff rule in 2 loops
```

```
//two eqns obtained
//2*R*I1 - R*I2 = V1
//-1*R*I1 + 2*R*I2 = V2
//using determinants
d1 = [V1 -1*R; V2 2*R]
D1 = det(d1)
d2 = [2*R V1; -1*R V2]
D2 = det(d2)
d = [2*R -1*R; -1*R 2*R]
D = det(d)
I1 = D1/D
I2 = D2/D
I1mag = (real(I1)^2 + imag(I1)^2)^0.5
//line current IR
IR = I1
//line current IB
IB = -1*I2
//line current IY
IY = I2 - I1

printf("\n\n Result \n\n")
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

```
//Problem 31.04: For the network shown in Figure
   31.8, determine the voltage VAB, by using nodal
   analysis.

//initializing the variables:
ri = 20; // in amperes
thetai = 0; // in degrees
```

```
R1 = 10; // in ohm
R2 = %i*3; // in ohm
R3 = 4; // in ohm
R4 = 16; // in ohm

//calculation:
//current
I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi/180)
//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:
//IX + IY = I
V1 = I/((1/R4) +(1/(R2  +R3)))
IY = V1/(R2 + R3)
VAB = IY*R3

printf("\n\n Result \n\n")
printf("\n voltage VAB is %.2f + (%.2f)i V",real(VAB), imag(VAB))
```

Scilab code Exa 31.05 Example 5

```
//Problem 31.05: Determine the value of voltage VXY shown in the circuit of Figure 31.9.

//initializing the variables:
rv1 = 8; // in volts
rv2 = 8; // in volts
thetav1 = 0; // in degrees
thetav2 = 90; // in degrees
R1 = 5; // in ohm
```

```
R2 = %i*6; // in ohm
R3 = 4; // in ohm
R4 = 3; // in ohm

//calculation:
//voltages
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
   %pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
   %pi/180)
//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
VX = [(V1/(R1 + R3) + V2/(R2 + R4))/(1/(R1 + R3) +
   1/(R2 + R4))]
VXY = VX

printf("\n\n Result \n\n")
printf("\n voltage VXY is %.2f + (%.2f)i V",real(VXY
   ), imag(VXY))
```

Scilab code Exa 31.06 Example 6

```
//Problem 31.06: Use nodal analysis to determine the
    current flowing in each branch of the network
   shown in Figure 31.10.

//initializing the variables:
rv1 = 100; // in volts
rv2 = 50; // in volts
thetav1 = 0; // in degrees
thetav2 = 90; // in degrees
R1 = 25; // in ohm
R2 = 20; // in ohm
```

```
R3 = 10; // in ohm

//calculation:
//voltages
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
    %pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
    %pi/180)
//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.
//The equation at node 1 is I1 + I2 + I3 = 0
Vn1 = [(V1/R1 + V2/R3)/(1/R1 + 1/R2 + 1/R3)]
I1 = (Vn1 - V1)/R1
I2 = Vn1/R2
I3 = (Vn1 - V2)/R3

printf("\n\n Result \n\n")
printf("\n current, I1 is %.2f + (%.2f)i A, current,
     I2 is  %.2f + (%.2f)i A and current, I3 is %.2f
    + (%.2f)i A",real(I1), imag(I1),real(I2), imag(I2
    ),real(I3), imag(I3))
```

Scilab code Exa 31.07 Example 7

```
//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.

//initializing the variables:
rv1 = 25; // in volts
rv2 = 25; // in volts
```

```
thetav1 = 0; // in degrees
thetav2 = 90; // in degrees
R1 = 2; // in ohm
R2 = -1*%i*4; // in ohm
R3 = 5; // in ohm
R4 = %i*4; // in ohm
R5 = 2.5; // in ohm

//calculation:
//voltages
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*%pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*%pi/180)
//The equation at node 1
//Vn1*(1/R1 + 1/R2 + 1/R3) - Vn2/R3 = V1/R1
//The equation at node 2
//Vn1*(-1/R3) + Vn2*(1/R4 + 1/R5 + 1/R3) = V2/R5
//using determinants
d1 = [V1/R1 -1/R3; V2/R5 (1/R4 + 1/R5 + 1/R3)]
D1 = det(d1)
d2 = [(1/R1 + 1/R2 + 1/R3) V1/R1; -1/R3 V2/R5]
D2 = det(d2)
d = [(1/R1 + 1/R2 + 1/R3) -1/R3; -1/R3 (1/R4 + 1/R5 + 1/R3)]
D = det(d)
Vn1 = D1/D
Vn2 = D2/D
//current in the j4 ohm inductance is given by:
I4 = Vn2/R4
//current in the 5 ohm resistance is given by:
I3 = (Vn1 - Vn2)/R3
//active power dissipated in the 2.5 ohm resistor is given by
P5 = R5*((Vn2 - V2)/R5)^2
//magnitude of the active power dissipated
P5mag = (real(P5)^2 + imag(P5)^2)^0.5

```

```
printf("\n\n Result \n\n")
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))
printf("\n (b)the current in the j4 ohm inductance is %.2f + (%.2f)i A",real(I4), imag(I4))
printf("\n (c)the current in the 5 ohm resistance is %.2f + (%.2f)i A",real(I3), imag(I3))
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

```
//Problem 31.08: In the network shown in Figure 31.12 determine the voltage VXY using nodal analysis

//initializing the variables:
ri = 25; // in amperes
thetai = 0; // in degrees
R1 = 4; // in ohm
R2 = %i*3; // in ohm
R3 = 5; // in ohm
R4 = %i*10; // in ohm
R5 = %i*20; // in ohm

//calculation:
//current
I = ri*cos(thetai*%pi/180) + %i*ri*sin(thetai*%pi/180)
//Node 3 is taken as the reference node.
//At node 1,
//V1*(1/(R1 + R2) + 1/R3) - V2/R3 = I
//The equation at node 2
```

```
//V1*(-1/R3) + V2*(1/R4 + 1/R5 + 1/R3) = 0
//using determinants
d1 = [I -1/R3; 0 (1/R4 + 1/R5 + 1/R3)]
D1 = det(d1)
d2 = [(1/(R1 + R2) + 1/R3) I; -1/R3 0]
D2 = det(d2)
d = [(1/(R1 + R2) + 1/R3) -1/R3; -1/R3 (1/R4 + 1/R5
   + 1/R3)]
D = det(d)
V1 = D1/D
V2 = D2/D
//the voltage between point X and node 3 is
VX = V1*R2/(R1 + R2)
//Thus the voltage
VY = V2
VXY = VX - VY

printf("\n\n Result \n\n")
printf("\n voltage VXY is %.2f + (%.2f)i V",real(VXY
   ), imag(VXY))
```

Scilab code Exa 31.09 Example 9

```
//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.

//initializing the variables:
V = 8; // in volts
R1 = 1; // in ohm
R2 = 2; // in ohm
R3 = 3; // in ohm
R4 = 4; // in ohm
```

```
R5 = 5; // in ohm
R6 = 6; // in ohm

//calculation:
//In Figure 31.13, the reference node is shown at
    point A.
//At node 1,
//V1*(1/R1 + 1/R6 + 1/R5) - V2/R1 - V3/R5 = V/R5
//The equation at node 2
//V1*(-1/R1) + V2*(1/R2 + 1/R1 + 1/R3) - V3/R3 = 0
//At node 3
// - V1/R5 - V2/R3 + V3*(1/R4 + 1/R3 + 1/R5) = -1*V/
    R5
//using determinants
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)]
D1 = det(d1)
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)]
D2 = det(d2)
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]
D3 = det(d3)
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)]
D = det(d)
Vn1 = D1/D
Vn2 = D2/D
Vn3 = D3/D
//the current in the 2 ohm resistor
I2 = Vn2/R2
//power dissipated in the 3 ohm resistance
P3 = R3*((Vn2 - Vn3)/R3)^2

printf("\n\n Result \n\n")
printf("\n voltage at node 2 is %.2f V",Vn2)
printf("\n voltage at node 3 is %.2f V",Vn3)
```

```
printf("\n (a)current through 2 ohm resistor is %.2f A",I2)
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

```
//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

//initializing the variables:
rv1 = 100; // in volts
rv2 = 50; // in volts
thetav1 = 0; // in degrees
thetav2 = 90; // in degrees
r1 = 25; // in ohm
R = 20; // in ohm
r2 = 10; // in ohm

//calculation:
//voltage
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
    %pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
```

```
%pi/180)
//The circuit diagram is shown in Figure 32.7. Following the above procedure:
//The network is redrawn with the 50/_90 V source removed as shown in Figure 32.8
//Currents I1, I2 and I3 are labelled as shown in Figure 32.8.
I1 = V1/(r1 + r2*R/(R + r2))
I2 = (r2/(r2 + R))*I1
I3 = (R/(r2 + R))*I1
//The network is redrawn with the 100/_0 V source removed as shown in Figure 32.9
//Currents I4, I5 and I6 are labelled as shown in Figure 32.9.
I4 = V2/(r2 + r1*R/(r1 + R))
I5 = (r1/(r1 + R))*I4
I6 = (R/(r1 + R))*I4
//Figure 32.10 shows Figure 32.9 superimposed on Figure 32.8, giving the currents shown.
//Current in the 20 ohm load,
I20 = I2 + I5
//Current in the 100/_0 V source
IV1 = I1 - I6
//Current in the 50/_90 V source
IV2 = I4 - I3

printf("\n\n Result \n\n")
printf("\n (a)current in the 20 ohm load is %.3f + (%.3f)i A",real(I20), imag(I20))
printf("\n (b)Current in the 100/_0 V source is %.3f + (%.3f)i A",real(IV1), imag(IV1))
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

```
//Problem 32.02:Use the superposition theorem to
    determine the current in the 4 ohm resistor of
    the network shown in Figure 32.11.

//initializing the variables:
V1 = 12; // in volts
V2 = 20; // in volts
R1 = 5; // in ohm
R2 = 4; // in ohm
R3 = 2.5; // in ohm
R4 = 6; // in ohm
R5 = 2; // in ohm

//calculation:
//Removing the 20 V source gives the network shown
    in Figure 32.12.
//Currents I1 and I2 are shown labelled in Figure
    32.12
Re1 = (R4*R5/(R4 + R5)) + R3
Re2 = Re1*R2/(Re1  + R2) + R1
I1 = V1/Re2
I2 = (R2/(Re1 + R2))*I1
//Removing the 12 V source from the original network
     gives the network shown in Figure 32.14.
//Currents I3, I4 and I5 are shown labelled in
    Figure 32.14.
Re3 = (R1*R2/(R1 + R2)) + R3
Re4 = Re3*R4/(Re3 + R4) + R5
I3 = V2/Re4
I4 = (R4/(Re3 + R4))*I3
I5 = (R1/(R1 + R2))*I4
//Superimposing Figure 32.14 on Figure 32.12 shows
    that the current flowing in the 4 ohm resistor is
     given by
Ir4 = I5 - I2

printf("\n\n Result \n\n")
printf("\ncurrent in the 4 ohm resistor of the
```

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

Scilab code Exa 32.03 Example 3

```
//Problem 32.03: Use the superposition theorem to obtain the current flowing in the (4 + i3) ohm impedance of Figure 32.16.

//initializing the variables:
rv1 = 30; // in volts
rv2 = 30; // in volts
thetav1 = 45; // in degrees
thetav2 = -45; // in degrees
R1 = 4; // in ohm
R2 = 4; // in ohm
R3 = %i*3; // in ohm
R4 = -1*%i*10; // in ohm

//calculation:
//voltage
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*%pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*%pi/180)
//The network is redrawn with V2 removed, as shown in Figure 32.17.
//Current I1 and I2 are shown in Figure 32.17. From Figure 32.17,
Re1 = R4*(R2 + R3)/(R4 + R3 + R2)
Re2 = Re1 + R1
//current
I1 = V1/Re2
I2 = (R4/(R2 + R3 + R4))*I1
//The original network is redrawn with V1 removed, as shown in Figure 32.18
```

```
//Currents I3 and I4 are shown in Figure 32.18. From
    Figure 32.18,
Re3 = R1*(R2 + R3)/(R1 + R3 + R2)
Re4 = Re3 + R4
I3 = V2/Re4
I4 = (R1/(R2 + R3 + R1))*I3
//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
Ir4i3 = I2 - I4

printf("\n\n Result \n\n")
printf("\ncurrent in the (4 + i3) ohm impedance of
   the network is %.3f + (%.3f)i A",real(Ir4i3),
   imag(Ir4i3))
```

Scilab code Exa 32.04 Example 4

```
//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.

//initializing the variables:
E1 = 5 + %i*0; // in volts
E2 = 2 + %i*4; // in volts
Z1 = 3 + %i*4; // in ohm
Z2 = 2 - %i*5; // in ohm
Z3 = 6 + %i*8; // in ohm

//calculation:
//The original network is redrawn with E2 removed,
```

```
as shown in Figure 32.20.
//Currents I1, I2 and I3 are labelled as shown in Figure 32.20.
Ze1 = Z3*Z2/(Z3 + Z2)
Ze2 = Ze1 + Z1
//current
I1 = E1/Ze2
I2 = (Z2/(Z3 + Z2))*I1
I3 = (Z3/(Z3 + Z2))*I1
//The original network is redrawn with E1 removed, as shown in Figure 32.22
//Currents I4, I5 and I6 are shown labelled in Figure 32.22 with I4 flowing away from the positive terminal of the E2 source.
Ze3 = Z3*Z1/(Z3 + Z1)
Ze4 = Ze3 + Z2
I4 = E2/Ze4
I5 = (Z1/(Z3 + Z1))*I4
I6 = (Z3/(Z3 + Z1))*I4
//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
i1 = I1 + I6
i2 = I3 + I4
i3 = I2 - I5
//magnitude
i1mag = (real(i1)^2 + imag(i1)^2)^0.5
i2mag = (real(i2)^2 + imag(i2)^2)^0.5
E1mag = (real(E1)^2 + imag(E1)^2)^0.5
E2mag = (real(E2)^2 + imag(E2)^2)^0.5
//phase
phi1 = atan(imag(i1)/real(i1))
phi2 = atan(imag(i2)/real(i2))
//voltage across the(6 + i8) ohm impedance
V6i8 = i3*Z3
V6i8m = (real(V6i8)^2 + imag(V6i8)^2)^0.5
//power
```

```
P = (E1mag*i1mag*cos(phi1)) + (E2mag*i2mag*cos(phi2
    - atan(imag(E2)/real(E2))))

printf("\n\n Result \n\n")
printf("\n(b)current in the (6 + i8) ohm resistor of
    the network is %.3f V",V6i8m)
printf("\n(c)the total active power delivered to the
    network is %.3f W",P)
```

Scilab code Exa 32.05 Example 5

```
//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.

//initializing the variables:
rv1 = 50; // in volts
rv2 = 30; // in volts
thetav1 = 0; // in degrees
thetav2 = 90; // in degrees
R1 = 20; // in ohm
R2 = 5; // in ohm
R3 = -1*%i*3; // in ohm
R4 = 8; // in ohm
R5 = 8; // in ohm

//calculation:
//voltage
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
    %pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
```

```
%pi/180)
//The network is redrawn with the V2 source removed, as shown in Figure 32.26.
//Currents I1 to I5 are shown labelled in Figure 32.26.
//current
Re1 = R4*R5/(R5 + R4) + R3
Re2 = Re1*R2/(R2 + Re1)
I1 = V1/(Re2 + R1)
I2 = (Re1/(R2 + Re1))*I1
I3 = (R2/(Re1 + R2))*I1
I4 = (R4/(R4 + R5))*I3
I5 = I3 - I4
//The original network is redrawn with the V1 source removed, as shown in Figure 32.27.
//Currents I6 to I10 are shown labelled in Figure 32.27
Re3 = R1*R2/(R1 + R2)
Re4 = Re3 + R3
Re5 = Re4*R4/(Re4 + R4)
Re6 = Re5  + R5
I6 = V2/Re6
I7 = (Re4/(Re4 + R4))*I6
I8 = (R4/(Re4 + R4))*I6
I9 = (R1/(R1 + R2))*I8
I10 = (R2/(R1 + R2))*I8
//current flowing in the capacitor is given by
Ic = I3 - I8
//magnitude of the current in the capacitor
Icmag = (real(Ic)^2 + imag(Ic)^2)^0.5
//
i1 = I2 + I9
i1mag = (real(i1)^2 + imag(i1)^2)^0.5
//magnitude of the p.d. across the 5 ohm resistance is given by
Vr5m = i1mag*R2
//Active power dissipated in the 20 ohm resistance is given by
```

```
i2 = I1 - I10
i2mag = (real(i2)^2 + imag(i2)^2)^0.5
phii2 = atan(imag(i2)/real(i2))
Pr20 = R1*(i2mag)^2
//Active power developed by the V1
P1 = rv1*i2mag*cos(phii2)
//Active power developed by V2 source
i3 = I6 - I5
i3mag = (real(i3)^2 + imag(i3)^2)^0.5
phii3 = atan(imag(i3)/real(i3))
if ((imag(i3)>0) & (real(i3)<0)) then
    phii3 = phii3 + %pi
end
P2 = rv2*i3mag*cos(phii3 - (thetav2*%pi/180))
//Total power developed
P = P1 + P2

printf("\n\n Result \n\n")
printf("\n(a)the magnitude of the current flowing in
    the capacitor is %.2f A",Icmag)
printf("\n(b) the p.d. across the 5 ohm resistance
   is %.3f V",Vr5m)
printf("\n(c)the active power dissipated in the 20
   ohm resistance is %.0f W",Pr20)
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

```
//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.

//initializing the variables:
rv = 200; // in volts
thetav = 0; // in degrees
R1 = 5000; // in ohm
R2 = 20000; // in ohm
R3 = -1*%i*120000; // in ohm
R4 = 150000; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
    /180)
//Initially the (150-i120)kohm impedance is removed
    from the circuit as shown in Figure 33.13.
```

```
//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.
//From Figure 33.13,
//current, I1
I1 = V/(R1 + R2)
//The open-circuit e.m.f. E is equal to the p.d. across the 20 kohm resistor, i.e.
E = I1*R2
//Removing the V1 source gives the network shown in Figure 33.14.
//The impedance, z,  looking in  at the open-circuited terminals is given by
z = R1*R2/(R1 + R2)
//The Th evenin equivalent circuit is shown in Figure 33.15, where current iL is given by
ZL = R3 + R4
IL = E/(ZL + z)
ILmag = (real(IL)^2 + imag(IL)^2)^0.5
//current flowing in the capacitor
Ic = ILmag
//P.d. across the 150 kohm resistor,
Vr150 = ILmag*R4

printf("\n\n Result \n\n")
printf("\n(a)the current flowing in the capacitor is %.1E A",Ic)
printf("\n(b) the p.d. across the 150 ohm resistance is %.0f V",Vr150)
```

Scilab code Exa 33.02 Example 2

```
//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.

//initializing the variables:
V1 = 20; // in volts
V2 = 10; // in volts
R1 = 2; // in ohm
R2 = 1.5; // in ohm
L = 235E-6; // in Henry
R4 = 3; // in ohm
f = 2000; // in Hz

//calculation:
//The impedance through which current I is flowing
   is initially removed from the network, as shown
   in Figure 33.17.
//From Figure 33.17,
//current, I1
I1 = (V1 - V2)/(R1 + R4)
//the open circuit e.m.f. E
E = V1 - I1*R1
//When the sources of e.m.f. are removed from the
   circuit, the impedance, z,  looking in   at
   the break is given by
z = R1*R4/(R1 + R4)
//The Th evenin equivalent circuit is shown in
   Figure 33.18, where inductive reactance,
XL = 2*%pi*f*L
R3 = %i*XL
//Hence current
I = E/(R2 + R3 + z)

printf("\n\n Result \n\n")
printf("\n the current I is %.2f + (%.2f)i A",real(I
   ), imag(I))
```

Scilab code Exa 33.03 Example 3

```
//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

//initializing the variables:
rv = 50; // in volts
thetav = 0; // in degrees
R1 = -1*%i*400; // in ohm
R2 = 300; // in ohm
R3 = %i*144; // in ohm
R4 = 48; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//The R3 and R4 impedance is initially removed from the network as shown in Figure 33.20.
//From Figure 33.20,
//current, I
i = V/(R1 + R2)
//the open circuit e.m.f. E
E = i*R2
//When the V is removed from the circuit, the impedance, z, looking in at the break is given by
z = R1*R2/(R1 + R2)
//The Th evenin equivalent circuit is shown in Figure 33.21 connected to R# and R4,
//Hence current
I = E/(R4 + R3 + z)
Imag = (real(I)^2 + imag(I)^2)^0.5
```

```
//the power dissipated in the 48 ohm resistor
Pr48 = R4*Imag^2

printf("\n\n Result \n\n")
printf("\n the power dissipated in the 48 ohm
    resistor is %.2f W",Pr48)
```

Scilab code Exa 33.04 Example 4

```
//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.

//initializing the variables:
V = 100; // in volts
R1 = 5; // in ohm
R2 = 20; // in ohm
R3 = 46; // in ohm
R4 = 50; // in ohm
R5 = 15; // in ohm
R6 = 60; // in ohm
R7 = 16; // in ohm
R8 = 80; // in ohm

//calculation:
//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.
//From Figure 33.23,
E1 = (R2/(R1 + R2))*V
z1 = R1*R2/(R1 + R2)
//Thus the network of Figure 33.22 reduces to that
```

```
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
E2 = (R4/(R3 + R4 + z1))*E1
z2 = R4*(z1 + R3)/(R4 + z1 + R3)
//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
E3 = (R6/(R5 + R6 + z2))*E2
z3 = R6*(z2 + R5)/(R5 + z2 + R6)
//Thus the original network reduces to that of Figure 33.26 , from which the current in the 80 ohm resistor is given by
I = E3/(z3 + R7 + R8)

printf("\n\n Result \n\n")
printf("\n the current flowing in the 80 ohm resistor is %.2f A",I)
```

Scilab code Exa 33.05 Example 5

```
//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.

//initializing the variables:
rv = 24; // in volts
thetav = 0; // in degrees
R1 = -1*%i*3; // in ohm
R2 = 4; // in ohm
```

```
R3 = %i*3; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
    /180)
//Current I1 shown in Figure 33.27 is given by
I1 = V/(R1 + R2 + R3)
//The Th evenin equivalent voltage, i.e., the open−
    circuit voltage across terminals AB, is given by
E = I1*(R2 + R3)
//When the voltage source is removed, the impedance
    z  looking in  at AB is given by
z = (R2 + R3)*R1/(R1 + R2 + R3)
//Thus the Th evenin equivalent circuit is as shown
     in Figure 33.28.
//when (3.75 + i11) ohm impedance connected across
    terminals AB, the current I flowing in the
    impedance is given by
R = 3.75 + %i*11;  // in ohms
I = E/(R + z)
Imag = (real(I)^2 + imag(I)^2)^0.5
//the p.d. across the( 3.75 + i11)ohm impedance.
VR = I*R
VRmag = (real(VR)^2 + imag(VR)^2)^0.5

printf("\n\n Result \n\n")
printf("\n (a) the current I flowing in the (3.75 +
    i11) impedance is given by is %.0f A",Imag)
printf("\n (b) the magnitude of the p.d. across the
    impedance is %.1f V",VRmag)
```

Scilab code Exa 33.06 Example 6

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

```
determine the current flowing in the capacitor of
 the network shown in Figure 33.29.

//initializing the variables:
rv = 16.55; // in volts
thetav = -22.62; // in degrees
R1 = 4; // in ohm
R2 = %i*2; // in ohm
R3 = %i*6; // in ohm
R4 = 3; // in ohm
R5 = 5; // in ohm
R6 = -1*%i*8; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
   /180)
//The capacitor is removed from branch AB, as shown
   in Figure 33.30.
//Impedance, Z
Z1 = R3 + R4 + R5
Z = R1 + (Z1*R2/(R2 + Z1))
I1 = V/Z
I2 = (R2/(R2 +Z1))*I1
//The open-circuit voltage, E
E = I2*R5
//If the voltage source is removed from Figure
   33.30, the impedance, z,  looking in  at AB
   is given by
z = R5*((R1*R2/(R1 + R2)) + R3 + R4)/(R5 + ((R1*R2/(
   R1 + R2)) + R3 + R4))
//The Th evenin equivalent circuit is shown in
   Figure 33.31, where the current flowing in the
   capacitor, I, is given by
I = E/(z + R6)
Imag = (real(I)^2 + imag(I)^2)^0.5
phiid = (atan(imag(I)/real(I)))*180/%pi
printf("\n\n Result \n\n")
```

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

Scilab code Exa 33.07 Example 7

```
//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.

//initializing the variables:
rv1 = 5; // in volts
rv2 = 10; // in volts
thetav1 = 45; // in degrees
thetav2 = 0; // in degrees
R1 = 8; // in ohm
R2 = 5; // in ohm
R3 = %i*3; // in ohm
R4 = 4; // in ohm

//calculation:
//voltage
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*%pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*%pi/180)
//Current I1 shown in Figure 33.32 is given by
I1 = V2/(R2 + R3 + R4)
//Hence the voltage drop across the 5 ohm resistor is given by VX is in the direction shown in Figure 33.32,
Vx = I1*R2
//The open-circuit voltage E across PQ is the phasor sum of V1, Vx and V2, as shown in Figure 33.33.
```

```
E = V2 - V1 - Vx
//The impedance, z, looking in at terminals PQ with the voltage sources removed is given by
z = R1 + R2*(R3 + R4)/(R2 + R3 + R4)
//The Th evenin equivalent circuit is shown in Figure 33.34 with the 2 ohm resistance connected across terminals PQ.
//The current flowing in the 2 ohm resistance is given by
R = 2; // in ohms
I = E/(z + R)
Imag = (real(I)^2 + imag(I)^2)^0.5
//power P dissipated in the 2 ohm resistor is given by
Pr2 = R*Imag^2

printf("\n\n Result \n\n")
printf("\n power P dissipated in the 2 ohm resistor is %.4f W",Pr2)
```

Scilab code Exa 33.08 Example 8

```
//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.

//initializing the variables:
rv = 30; // in volts
thetav = 0; // in degrees
R1 = 15; // in ohm
R2 = 40; // in ohm
R3 = %i*20; // in ohm
R4 = 20; // in ohm
```

```
R5 = %i*5; // in ohm
R6 = 5; // in ohm
R7 = -1*%i*25; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//The R7 is initially removed from the network, as shown in Figure 33.36
Z1 = R1
Z2 = R2
Z3 = R3 + R4
Z4 = R5 + R6
//P.d. between A and C,
Vac = (Z1/(Z1 + Z4))*V
//P.d. between B and C,
Vbc = (Z2/(Z2 + Z3))*V
//Assuming that point A is at a higher potential than point B, then the p.d. between A and B is
Vab = Vac - Vbc
//the open-circuit voltage across AB is given by
E = Vab
//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
Va = V - Vac
//Between points C and B is a voltage drop of Vbc. Hence the voltage at point B
Vb = V - Vbc
//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
z = Z1*Z4/(Z1 + Z4) + Z2*Z3/(Z2 + Z3)
//The Th evenin equivalent circuit is shown in
```

```
   Figure 33.38, where current I is given by
I = E/(z + R7)
Imag = (real(I)^2 + imag(I)^2)^0.5

printf("\n\n Result \n\n")
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

```
//Problem 33.09: Use Norton s theorem to determine
    the value of current I in the circuit shown in
    Figure 33.47.

//initializing the variables:
V = 5; // in volts
R1 = 2; // in ohm
R2 = 3; // in ohm
R3 = -1*%i*3; // in ohm
R4 = 2.8; // in ohm

//calculation:
//The branch containing the R4 is short-circuited,
    as shown in Figure 33.48.
//The R2 in parallel with a short-circuit is the
    same as R2 in parallel with 0 ohm giving an
    equivalent impedance of
Z1 = R2*0/(R3 + 0)
//Hence the network reduces to that shown in Figure
    33.49, where
Isc = V/R1
//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
z = R1*R2/(R1 + R2)
```

```
//The Norton equivalent network is shown in Figure 33.51, where current I is given by
I = (z/(z + R4 + R3))*Isc

printf("\n\n Result \n\n")
printf("\n  the current flowing in the capacitor is %.2f + (%.2f)i A",real(I), imag(I))
```

Scilab code Exa 33.10 Example 10

```
//Problem 33.10: For the circuit shown in Figure 33.52 determine the current flowing in the inductive branch by using Norton s theorem.

//initializing the variables:
V1 = 20; // in volts
V2 = 10; // in volts
R1 = 2; // in ohm
R2 = 1.5; // in ohm
R3 = %i*2.95; // in ohm
R4 = 3; // in ohm

//calculation:
//The inductive branch is initially short-circuited, as shown in Figure 33.53.
//From Figure 33.53,
I1 = V1/R1
I2 = V2/R4
Isc = I1 + I2
//If the voltage sources are removed, the impedance, z,  looking in  at a break made in AB is given by
z = R1*R4/(R1 + R4)
//The Norton equivalent network is shown in Figure 33.54, where current I is given by
```

```
I = (z/(z + R2 + R3))*Isc

printf("\n\n Result \n\n")
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

```
//Problem 33.11: Use Norton s theorem to determine
    the magnitude of the p.d. across the 1 ohm
    resistance of the network shown in Figure 33.55.

//initializing the variables:
V = 10; // in volts
R1 = 4; // in ohm
R2 = 4; // in ohm
R3 = -1*%i*2; // in ohm
R4 = 1; // in ohm

//calculation:
//The branch containing the R4 is initially short-
    circuited , as shown in Figure 33.56.
//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
Isc = V/R1
//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
z = 1/(1/R1 + 1/R2 + 1/R3)
//The Norton equivalent network is shown in Figure
    33.59, from which current I is given by
I = (z/(z + R4))*Isc
Imag = (real(I)^2 + imag(I)^2)^0.5
```

```
Vr1 = Imag*R4

printf("\n\n Result \n\n")
printf("\n the magnitude of the p.d. across the 1
   ohm resistor is %.2f V", Vr1)
```

Scilab code Exa 33.12 Example 12

```
//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.

//initializing the variables:
rv = 20; // in volts
thetav = 0; // in degrees
R1 = 2; // in ohm
R2 = 4; // in ohm
R3 = %i*3; // in ohm
R4 = -1*%i*3; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
   /180)
//Terminals AB are initially short-circuited, as
   shown in Figure 33.61.
//The circuit impedance Z presented to the voltage
   source is given by
Z = R1 + R4*(R2 + R3)/(R2 + R3 + R4)
//Thus current I in Figure 33.61 is given by
I = V/Z
Isc = ((R2 + R3)/(R2 + R3 + R4))*I
//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
z = R4 + R1*(R2 + R3)/(R2 + R3 + R1)
//The Norton equivalent network is shown in Figure
   33.63.
R = 5; // in ohms
//Current IL
IL = (z/(z + R))*Isc
ILmag = (real(IL)^2 + imag(IL)^2)^0.5
//the power dissipated in the 5 ohm resistor is
Pr5 = R*ILmag^2

printf("\n\n Result \n\n")
printf("\n the power dissipated in the 5 ohm
   resistor is %.2f W", Pr5)
```

Scilab code Exa 33.13 Example 13

```
//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.

//initializing the variables:
rv1 = 5; // in volts
rv2 = 10; // in volts
thetav1 = 45; // in degrees
thetav2 = 0; // in degrees
R1 = 8; // in ohm
R2 = 5; // in ohm
R3 = %i*3; // in ohm
R4 = 4; // in ohm

```

```
//calculation:
//voltage
V1 = rv1*cos(thetav1*%pi/180) + %i*rv1*sin(thetav1*
    %pi/180)
V2 = rv2*cos(thetav2*%pi/180) + %i*rv2*sin(thetav2*
    %pi/180)
//Terminals PQ are initially short-circuited, as
    shown in Figure 33.65.
//Currents I1 and I2 are shown labelled.
    Kirchhoff s laws are used.
//For loop ABCD, and moving anticlockwise,
//I1*(R2 + R3 + R4) + I2*(R3 + R4) = V2
//For loop DPQC, and moving clockwise,
//R2*I1 - R1*I2 = V2 - V1
//Solving Equations by using determinants gives
d1 = [V2 (R3 + R4); (V2 - V1) -1*R1]
D1 = det(d1)
d2 = [(R2 + R3 + R4) V2; R2 (V2 - V1)]
D2 = det(d2)
d = [(R2 + R3 + R4) (R3 + R4); R2 -1*R1]
D = det(d)
I1 = D1/D
I2 = D2/D
//the short-circuit current Isc
Isc = I2
//The impedance, z, looking in at a break made
    between P and Q is given by
z = R1 + R2*(R3 + R4)/(R2 + R3 + R4)
//The Norton equivalent circuit is shown in Figure
    33.66, where current I is given by
R = 2; //in ohm
I = (z/(z + R))*Isc
Imag = (real(I)^2 + imag(I)^2)^0.5

printf("\n\n Result \n\n")
printf("\n the magnitude of the current flowing 5
    ohm resistor is %.2f A", Imag)
```

Scilab code Exa 33.15 Example 15

```
//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.

//initializing the variables:
E1 = 12; // in volts
E2 = 24; // in volts
Z1 = 3; // in ohm
Z2 = 2; // in ohm
R1 = %i*4; // in ohm
R2 = 1.8; // in ohm

//calculation:
Z3 = R1 + R2
//For the branch containing the E1 source,
    conversion to a Norton equivalent network gives
Isc1 = E1/Z1
//For the branch containing the E2 source,
    conversion to a Norton equivalent circuit gives
Isc2 = E2/Z2
//Thus Figure 33.73 shows a network equivalent to
    Figure 33.72. From Figure 33.73, the total short-
    circuit current
Isc = Isc1 + Isc2
//the total impedance is given by
z = Z1*Z2/(Z1 + Z2)
//Thus Figure 33.73 simplifies to Figure 33.74.
//The open-circuit voltage across AB of Figure
```

```
33.74, E
E = Isc*z
//the impedance  looking in  at AB,is z
//the Th evenin equivalent circuit is as shown in
    Figure 33.75.
R = 1.8 + %i*4; // in ohm
//when R impedance is connected to terminals AB of
    Figure 33.75, the current I flowing is given by
I = E/(z + R)
Imag = (real(I)^2 + imag(I)^2)^0.5

printf("\n\n Result \n\n")
printf("\n the magnitude of the current flowing (1.8
     + i4) ohm resistor is %.2f A", Imag)
```

Scilab code Exa 33.16 Example 16

```
//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.

//initializing the variables:
V1 = 5; // in volts
V2 = 10; // in volts
i = 0.001; // in Amperes
R1 = 1000; // in ohm
R2 = 4000; // in ohm
R3 = 2000; // in ohm
R4 = 200; // in ohm
R5 = -1*%i*4000; // in ohm

//calculation:
```

```
//For the branch containing the V1 source,
   conversion to a Norton equivalent network gives
Isc1 = V1/R1
z1 = R1
//For the branch containing the V2 source,
   conversion to a Norton equivalent circuit gives
Isc2 = V2/R2
z2 = R2
//Thus the circuit of Figure 33.76 converts to that
   of Figure 33.77.
//The above two Norton equivalent networks shown in
   Figure 33.77 may be combined, since the total
   short-circuit current is
Isc = Isc1 + Isc2
//the total impedance is given by
Z1 = z1*z2/(z1 + z2)
//Both of the Norton equivalent networks shown in
   Figure 33.78 may be converted to Thevenin
   equivalent circuits. Open-circuit voltage across
   CD is
Ecd = Isc*Z1
//the impedance  looking in  at CD is Z1
//Open-circuit voltage across EF
Eef = i*R3
//the impedance  looking in  Figure 33.79 at EF
Z2 = R3
//Thus Figure 33.78 converts to Figure 33.79.
//Combining the two Thevenin circuits gives e.m.f.
E = Ecd - Eef
//impedance z
z = Z1 + Z2
//the Thevenin equivalent circuit for terminals AB
    of Figure 33.76 is as shown in Figure 33.80.
Z3 = R4 + R5
//If an impedance Z3 is connected across terminals
   AB, then the current I flowing is given by
I = E/(z + Z3)
Imag = (real(I)^2 + imag(I)^2)^0.5
```

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

Scilab code Exa 33.17 Example 17

```
//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.

//initializing the variables:
V = 5; // in volts
i = 0.004; // in Amperes
R1 = 2000; // in ohm
R2 = %i*1000; // in ohm

//calculation:
//Converting the Th evenin circuit to a Norton network gives
Isc1 = V/R2
//Thus Figure 33.81 converts to that shown in Figure 33.82. The two Norton equivalent networks may be combined, giving
Isc = Isc1 + i
z = R1*R2/(R1 + R2)
//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,
E = Isc*z
//Thus the The venin equivalent circuit is as shown in Figure 33.84.
```

```
R = 600 - %i*800; // in ohms
//When a R impedance is connected across AB, the
   current I flowing is given by
I = E/(z + R)
Imag = (real(I)^2 + imag(I)^2)^0.5
//the power dissipated in the R resistor is
PR = R*Imag^2

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
rv = 40; // in volts
thetav = 0; // in degrees
ZA = %i*10; // in ohm
ZB = %i*15; // in ohm
ZC = %i*25; // in ohm
ZD = -1*%i*8; // in ohm
ZE = 10; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
```

```
//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.
Z1 = ZA*ZB/(ZA + ZB + ZC)
Z2 = ZC*ZB/(ZA + ZB + ZC)
Z3 = ZA*ZC/(ZA + ZB + ZC)
//The equivalent network is shown in Figure 34.10 and is further simplified in Figure 34.11
//(ZE + Z3) in parallel with (Z1 + ZD) gives an equivalent impedance of
z = (ZE + Z3)*(Z1 + ZD)/(Z1 + ZD + ZE + Z3)
//Hence the total circuit equivalent impedance across terminals AB is given by
Zab = z + Z2
//Supply current I
I = V/Zab
I1 = ((Z1 + ZD)/(Z1 + ZD + ZE + Z3))*I
I1mag = (real(I1)^2 + imag(I1)^2)^0.5
//Power P dissipated in the 10 ohm resistance of Figure 34.7 is given by
Pr10 = ZE*I1mag^2

printf("\n\n Result \n\n")
printf("\n (a)the equivalent circuit impedance across terminals AB is %.2f + (%.2f)i ohm",real(Zab), imag(Zab))
printf("\n (b)supply current I is %.2f + (%.2f)i A",real(I), imag(I))
printf("\n (c)power P dissipated in the 10 ohm resistor is %.2f W",Pr10)
```

Scilab code Exa 34.03 Example 3

```
//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.

//initializing the variables:
V = 52; // in volts
ZA = 8; // in ohm
ZB = 16; // in ohm
ZC = 40; // in ohm
ZD = 1; // in ohm
ZE = 4; // in ohm

//calculation:
//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
Z1 = ZA*ZB/(ZA + ZB + ZC)
Z2 = ZC*ZB/(ZA + ZB + ZC)
Z3 = ZA*ZC/(ZA + ZB + ZC)
//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
Zab = (Z1 + ZE)*(ZD + Z3)/(Z1 + ZE + ZD + Z3) + Z2
//Current supplied by the source, i.e., current I in Figure 34.15, is given by
I = V/Zab
//From Figure 34.15, current I1
```

```
I1 = ((ZD + Z3)/(Z1 + ZE + ZD + Z3))*I
//current I2
I2 = I - I1
//From Figure 34.14, p.d. across AC,
Vac = I1*ZE
//p.d. across AD
Vad = I2*ZD
//Hence p.d. between C and D is given
Vcd = Vac - Vad
//current in the 8 ohm resistance
Ir8 = Vcd/ZA

printf("\n\n Result \n\n")
printf("\n (a)the equivalent circuit impedance
    across terminals AB is %.2f  ohm",Zab)
printf("\n (b)the current supplied by the 52 V
    source is %.2f  A",I)
printf("\n (c)the current flowing in the 8 ohm
    resistance is %.2f A",Ir8)
```

Scilab code Exa 34.05 Example 5

```
//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.

//initializing the variables:
rv = 120; // in volts
thetav = 0; // in degrees
ZA = 25 - %i*5; // in ohm
ZB = 15 + %i*10; // in ohm
ZC = 20 - %i*30; // in ohm
ZD = 20 + %i*0; // in ohm
ZE = 0 + %i*10; // in ohm
```

```
ZF = 2.5 - %i*5; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
    /180)
//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),
Z1 = ZA*ZB/(ZA + ZB + ZC)
Z2 = ZC*ZB/(ZA + ZB + ZC)
Z3 = ZA*ZC/(ZA + ZB + ZC)
//The network is shown redrawn in Figure 34.22 and
    further simplified in Figure 34.23, from which,
Zab = ((Z3 + ZE)*(ZD + Z2)/(Z2 + ZE + ZD + Z3)) + (
    Z1 + ZF)
//Current I1
I1 = V/Zab
//current I2
I2 = ((ZE + Z3)/(Z2 + ZE + ZD + Z3))*I1
//current I3
I3 = I1 - I2
//The power P dissipated in the ZD impedance of
    Figure 34.20 is given by
Pzd = ZD*I2^2

printf("\n\n Result \n\n")
printf("\n (a)the current flowing in the (0+i10) ohm
     impedance is %.2f  A",I3)
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

```
//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
    .

//initializing the variables:
rv = 120; // in volts
thetav = 0; // in degrees
Z = 15 + %i*20; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
    /180)
//maximum power transfer occurs when R = mod(Z)
```

```
R = (real(Z)^2 + imag(Z)^2)^0.5
//the total circuit impedance
ZT = Z + R
//Current I flowing in the load is given by
I = V/ZT
Imag = (real(I)^2 + imag(I)^2)^0.5
//maximum power delivered
P = R*Imag^2

printf("\n\n Result \n\n")
printf("\n (a)maximum power transfer occurs when R is %.0f ohm",R)
printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.02 Example 2

```
//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.

//initializing the variables:
rv = 120; // in volts
thetav = 0; // in degrees
Z = 15 + %i*20; // in ohm

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//maximum power transfer occurs when X = -1*imag(Z) and R = real(Z)
z = real(Z) - %i*imag(Z)
//Total circuit impedance at maximum power transfer
```

```
condition,
ZT = Z + z
//Current I flowing in the load is given by
I = V/ZT
Imag = (real(I)^2 + imag(I)^2)^0.5
//maximum power delivered
P = real(Z)*I^2

printf("\n\n Result \n\n")
printf("\n (a)maximum power transfer occurs when Z is %.0f + (%.0f)i ohm",real(z), imag(z))
printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.03 Example 3

```
//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.

//initializing the variables:
rv = 200; // in volts
thetav = 0; // in degrees
R1 = 100; // in ohm
C = 1E-6; // in farad
f = 1000; // in Hz

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//Capacitive reactance, Xc
Xc = 1/(2*%pi*f*C)
//Hence source impedance,
```

```
z = R1*(%i*Xc)/(R1 + %i*Xc)
//maximum power transfer is achieved when R = mod(z)
R = (real(z)^2 + imag(z)^2)^0.5
//Total circuit impedance at maximum power transfer
    condition,
ZT = z + R
//Current I flowing in the load is given by
I = V/ZT
Imag = (real(I)^2 + imag(I)^2)^0.5
//maximum power transferred,
P = R*Imag^2

printf("\n\n Result \n\n")
printf("\n (a)maximum power transfer occurs when R
    is %.2f ohm",R)
printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.04 Example 4

```
//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.

//initializing the variables:
rv = 60; // in volts
thetav = 0; // in degrees
R1 = 4; // in ohm
XL = 10; // in ohm
Xc = 7; // in ohm
R2 = %i*XL; // in ohm
R3 = -1*%i*Xc; // in ohm

```

```
//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
    /180)
//maximum power transfer is achieved when
R = (R1^2 + (XL - Xc)^2)^0.5
//Hence source impedance,
ZT = R1 + R2 + R3 + R
//Current I flowing in the load is given by
I = V/ZT
Imag = (real(I)^2 + imag(I)^2)^0.5
//maximum power transferred,
P = R*Imag^2

printf("\n\n Result \n\n")
printf("\n (a)maximum power transfer occurs when R
    is %.2f ohm",R)
printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.05 Example 5

```
//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.

//initializing the variables:
V = 20; // in volts
R1 = 5; // in ohm
R2 = 15; // in ohm

//calculation:
//R is removed from the network as shown in Figure
    35.6
//P.d. across AB, E
```

```
E = (R2/(R1 + R2))*V
//Impedance  looking-in   at terminals AB with the source removed is given by
r = R1*R2/(R1 + R2)
//The equivalent Th evenin circuit supplying terminals AB is shown in Figure 35.7. From condition (2), for maximum power transfer
R = r
//Current I flowing in the load is given by
I = E/(R + r)
//maximum power transferred ,
P = R*I^2

printf("\n\n Result \n\n")
printf("\n (a)maximum power transfer occurs when R is %.2f ohm",R)
printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.06 Example 6

```
//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.

//initializing the variables:
rv = 100; // in volts
thetav = 30; // in degrees
R1 = 5; // in ohm
R2 = 5; // in ohm
R3 = %i*10; // in ohm

//calculation:
//voltage
```

```
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi/180)
//Resistance R and reactance X are removed from the network as shown in Figure 35.9
//P.d. across AB,
E = ((R2 + R3)/(R1 + R2 + R3))*V
//With the source removed the impedance, z, looking in at terminals AB is given by:
z = (R2 + R3)*R1/(R1 + R2 + R3)
//The equivalent Thevenin circuit is shown in Figure 35.10. From condition 3, maximum power transfer is achieved when X = -1*imag(z) and R = real(z)
X = -1*imag(z)
R = real(z)
Z = R + %i*X
//Current I flowing in the load is given by
I = E/(z + Z)
Imag = (real(I)^2 + imag(I)^2)^0.5
//maximum power transferred,
P = R*Imag^2

printf("\n\n Result \n\n")
printf("\n (a)maximum power transfer occurs when R is %.2f ohm and X is %.2f ohm",R, X)
printf("\n (b) maximum power delivered is %.0f W",P)
```

Scilab code Exa 35.07 Example 7

```
//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.

```

```
//initializing the variables:
Ro = 448; // in ohm
tr = 8; // turn ratio N1/N2

//calculation:
//The equivalent input resistance r of the
   transformer must be Ro for maximum power transfer
   .
r = Ro
RL = r*(1/tr)^2

printf("\n\n Result \n\n")
printf("\n the optimum value of load resistance is %
   .0f ohm",RL)
```

Scilab code Exa 35.08 Example 8

```
//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.

//initializing the variables:
Zo = 450 + %i*60; // in ohm
ZL = 40 + %i*19; // in ohm

//calculation:
//transformer turns ratio tr = (N1/N2)
Zomag = (real(Zo)^2 + imag(Zo)^2)^0.5
ZLmag = (real(ZL)^2 + imag(ZL)^2)^0.5
tr = (Zomag/ZLmag)^0.5

printf("\n\n Result \n\n")
printf("\n the transformer turns ratio is %.2f",tr)
```

Scilab code Exa 35.09 Example 9

```
//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.

//initializing the variables:
V1 = 240; // in volts
V2 = 1920; // in volts
R1 = 5; // in ohms
R2 = 1600; // in ohms

//calculation:
//The network is shown in Figure 35.12.
//turn ratio N1/N2 = V1/V2
tr = V1/V2
//Equivalent input resistance of the transformer,
RL = R2
r = RL*tr^2
//Total input resistance,
Rin = R1 + r
//primary current, I1
I1 = V1/Rin
//For an ideal transformer V1/V2 = I2/I1
I2 = I1*(V1/V2)
//Power dissipated in the load resistance
P = RL*I2^2

printf("\n\n Result \n\n")
printf("\n (a) primary current flowing is %.0f A",I1
    )
```

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

Scilab code Exa 35.10 Example 10

```
//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.

//initializing the variables:
rv = 30; // in volts
thetav = 0; // in degrees
r = 20000; // in ohms
tr = 20; // turn ratio

//calculation:
//voltage
V = rv*cos(thetav*%pi/180) + %i*rv*sin(thetav*%pi
   /180)
//The network diagram is shown in Figure 35.13.
//For maximum power transfer, r1 must be equal to
r1 = r
//load resistance RL
RL = r1/tr^2
//The total input resistance when the source is
   connected to the matching transformer is
RT = r + r1
//Primary current
I1 = V/RT
//N1/N2 = I2/I1
I2 = I1*tr
//Power dissipated in load resistance RL is given by
```

```
P = RL*I2^2

printf("\n\n Result \n\n")
printf("\n (a)the value of the load resistance is %
    .0f ohm",RL)
printf("\n (b) Power dissipated in the load
    resistance is %.2E W",P)
```

Chapter 36

Complex Waveforms

Scilab code Exa 36.03 Example 3

```
//Problem 36.03: Determine the rms value of the
   current waveform represented by i = 100sinwt + 20
   sin(3wt + pi/6) + 10sin(5wt + 2*pi/3) mA

//initializing the variables:
A1 = 0.100; // in amperes
A3 = 0.020; // in amperes
A5 = 0.010; // in amperes

//calculation:
//the rms value of current is given by
Irms = ((A1^2 + A3^2 + A5^2)/2)^0.5

printf("\n\n Result \n\n")
printf("\n the rms value of current is %.5f A",Irms)
```

Scilab code Exa 36.04 Example 4

```
//Problem 36.04: A complex voltage is represented by
// v = 10sinwt + 3sin(3wt) + 2sin(5wt) Volts
//Determine for the voltage, (a) the rms value, (b) the mean value and (c) the form factor.

//initializing the variables:
A1 = 10; // in volts
A3 = 3; // in volts
A5 = 2; // in volts

//calculation:
//the rms value of voltage is given by
Vrms = ((A1^2 + A3^2 + A5^2)/2)^0.5
//the mean value of voltage is given by
//x = wt
function [Y]=f(x)
    Y = (10*sin(x) + 3*sin(3*x) + 2*sin(5*x));
endfunction
Vav = (1/%pi)*(integrate('f', 'x', 0, %pi))
//form factor is given by
ff = Vrms/Vav

printf("\n\n Result \n\n")
printf("\n (a)the rms value of voltage is %.2f V", Vrms)
printf("\n (b)the mean value of voltage is %.2f V", Vav)
printf("\n (c)form factor is %.3f ",ff)
```

Scilab code Exa 36.06 Example 6

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

```
//initializing the variables:
A1 = 12; // in amperes
A3 = 5; // in amperes
A5 = 2; // in amperes
R = 20; // in ohms

//calculation:
//rms current
Irms = ((A1^2 + A3^2 + A5^2)/2)^0.5
//average power
P = R*Irms^2

printf("\n\n Result \n\n")
printf("\n average power %.0f W",P)
```

Scilab code Exa 36.07 Example 7

```
//Problem 36.07: A complex voltage v given by
// v = 60sinwt + 15sin(3wt + pi/4) + 10sin(5wt - pi
    /2) Volts
//is applied to a circuit and the resulting current
    i is given by
// i = 2sin(wt - pi/6) + 0.30sin(3wt - pi/12) + 0.1
    sin(5wt - 8pi/9) A
//Determine (a) the total active power supplied to
    the circuit, and (b) the overall power factor.

//initializing the variables:
Ia1 = 2; // in amperes
Ia3 = 0.3; // in amperes
Ia5 = 0.1; // in amperes
Va1 = 60; // in volts
Va3 = 15; // in volts
Va5 = 10; // in volts
```

```
Phii1 = -1*%pi/6; // in radians
Phii3 = -1*%pi/12; // in radians
Phii5 = -8*%pi/9; // in radians
Phiv1 = 0; // in radians
Phiv3 = %pi/4; // in radians
Phiv5 = -1*%pi/2; // in radians


//calculation:
//rms values;
I1 = Ia1/(2^0.5); // in amperes
I3 = Ia3/(2^0.5); // in amperes
I5 = Ia5/(2^0.5); // in amperes
V1 = Va1/(2^0.5); // in volts
V3 = Va3/(2^0.5); // in volts
V5 = Va5/(2^0.5); // in volts
//total power supplied,
P = V1*I1*cos(Phiv1 - Phii1) + V3*I3*cos(Phiv3 -
    Phii3) + V5*I5*cos(Phiv5 - Phii5)
//rms current
Irms = ((I1^2 + I3^2 + I5^2))^0.5
//rms voltage
Vrms = ((V1^2 + V3^2 + V5^2))^0.5
//overall power factor
pf = P/(Vrms*Irms)

printf("\n\n Result \n\n")
printf("\n(a)the total active power supplied to the
    circuit %.2f W",P)
printf("\n(b)overall power factor %.3f",pf)
```

Scilab code Exa 36.09 Example 9

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

```
//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.

//initializing the variables:
V1m = 240; // in volts
V3m = 40; // in volts
V5m = 30; // in volts
w1 = 314; // fundamental
R = 12; // in ohm
L = 0.00955; // in Henry

//calculation:
//fundamental or first harmonic
//inductive reactance,
XL1 = w1*L
//impedance at the fundamental frequency,
Z1 = R + %i*XL1
//Maximum current at fundamental frequency
I1m = V1m/Z1
I1mag = (real(I1m)^2 + imag(I1m)^2)^0.5
phii1 = atan(imag(I1m)/real(I1m))
//Third harmonic
XL3 = 3*XL1
//impedance at the third harmonic frequency,
Z3 = R + %i*XL3
//Maximum current at third harmonic frequency
I3m = V3m/Z3
I3mag = (real(I3m)^2 + imag(I3m)^2)^0.5
phii3 = atan(imag(I3m)/real(I3m))
//fifth harmonic
XL5 = 5*XL1
//impedance at the third harmonic frequency,
Z5 = R + %i*XL5
```

```
//Maximum current at third harmonic frequency
I5m = V5m/Z5
I5mag = (real(I5m)^2 + imag(I5m)^2)^0.5
phii5 = atan(imag(I5m)/real(I5m))
//rms voltage
Vrms = ((V1m^2 + V3m^2 + V5m^2)/2)^0.5
//rms current
Irms = ((I1mag^2 + I3mag^2 + I5mag^2)/2)^0.5
//power dissipated
P = R*Irms^2
//overall power factor
pf = P/(Vrms*Irms)

printf("\n\n Result \n\n")
printf("\n(b)the rms value of current is %.2f A",
    Irms)
printf("\n(c)the rms value of voltage is %.2f V",
    Vrms)
printf("\n(d)the total power dissipated %.0f W",P)
printf("\n(e)overall power factor %.3f",pf)
```

Scilab code Exa 36.10 Example 10

```
//Problem 36.10: An e.m.f. is represented by
// e = 50 + 200sinwt + 40sin(2wt − pi/2) + 5sin(4wt
    + pi/4) Volts
//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.

//initializing the variables:
Vom = 50; // in volts
```

```
V1m = 200; // in volts
V2m = 40; // in volts
V4m = 5; // in volts
f = 50; // in Hz
R = 50; // in ohm
C = 100E-6; // in farad
phiv1 = 0; // in rad
phiv2 = -1*%pi/2; // in rad
phiv4 = %pi/4; // in rad

//calculation:
//voltage
V1 = V1m*cos(phiv1) + %i*V1m*sin(phiv1)
V2 = V2m*cos(phiv2) + %i*V2m*sin(phiv2)
V4 = V4m*cos(phiv4) + %i*V4m*sin(phiv4)
//Inductance has no effect on a steady current. Hence the d.c. component of the current, i0, is given by
Iom = 0
//fundamental or first harmonic
w1 = 2*%pi*f
//inductive reactance,
Xc1 = 1/(w1*C)
//impedance at the fundamental frequency,
Z1 = R + %i*Xc1
//Maximum current at fundamental frequency
I1m = V1/Z1
I1mag = (real(I1m)^2 + imag(I1m)^2)^0.5
phii1 = atan(imag(I1m)/real(I1m))
//second harmonic
Xc2 = Xc1/2
//impedance at the third harmonic frequency,
Z2 = R + %i*Xc2
//Maximum current at third harmonic frequency
I2m = V2/Z2
I2mag = (real(I2m)^2 + imag(I2m)^2)^0.5
phii2 = atan(imag(I2m)/real(I2m))
//fourth harmonic
```

```
Xc4 = Xc1/4
//impedance at the third harmonic frequency ,
Z4 = R + %i*Xc4
//Maximum current at third harmonic frequency
I4m = V4/Z4
I4mag = (real(I4m)^2 + imag(I4m)^2)^0.5
phii4 = atan(imag(I4m)/real(I4m))
//rms current
Irms = (Iom^2 + (I1mag^2 + I2mag^2 + I4mag^2)/2)^0.5

printf("\n\n Result \n\n")
printf("\n(b)the rms value of current is %.2f A",
    Irms)
```

Scilab code Exa 36.11 Example 11

```
//Problem 36.11: A supply voltage v given by
// v = 25 + 100sinwt + 40sin(3wt + pi/6) + 20sin(5wt
     + pi/12) Volts
//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.

//initializing the variables:
Vom = 25; // in volts
V1m = 100; // in volts
V3m = 40; // in volts
V5m = 20; // in volts
w1 = 10000; // fundamental
R = 5; // in ohm
```

```
L = 500E-6; // in Henry
phiv1 = 0; // in rad
phiv3 = %pi/6; // in rad
phiv5 = %pi/12; // in rad

//calculation:
//voltage
V1 = V1m*cos(phiv1) + %i*V1m*sin(phiv1)
V3 = V3m*cos(phiv3) + %i*V3m*sin(phiv3)
V5 = V5m*cos(phiv5) + %i*V5m*sin(phiv5)
//Inductance has no effect on a steady current.
   Hence the d.c. component of the current, i0, is
   given by
Iom = Vom/R
//fundamental or first harmonic
//inductive reactance,
XL1 = w1*L
//impedance at the fundamental frequency,
Z1 = R + %i*XL1
//Maximum current at fundamental frequency
I1m = V1/Z1
I1mag = (real(I1m)^2 + imag(I1m)^2)^0.5
phii1 = atan(imag(I1m)/real(I1m))
//Third harmonic
XL3 = 3*XL1
//impedance at the third harmonic frequency,
Z3 = R + %i*XL3
//Maximum current at third harmonic frequency
I3m = V3/Z3
I3mag = (real(I3m)^2 + imag(I3m)^2)^0.5
phii3 = atan(imag(I3m)/real(I3m))
//fifth harmonic
XL5 = 5*XL1
//impedance at the third harmonic frequency,
Z5 = R + %i*XL5
//Maximum current at third harmonic frequency
I5m = V5/Z5
I5mag = (real(I5m)^2 + imag(I5m)^2)^0.5
```

```
phii5 = atan(imag(I5m)/real(I5m))
//rms current
Irms = (Iom^2 + (I1mag^2 + I3mag^2 + I5mag^2)/2)^0.5
//power dissipated
P = R*Irms^2

printf("\n\n Result \n\n")
printf("\n(b)the rms value of current is %.2f A", Irms)
printf("\n(c)the total power dissipated %.0f W",P)
```

Scilab code Exa 36.12 Example 12

```
//Problem 36.12: The voltage applied to a particular circuit comprising two components connected in series is given by
// v = 30 + 40sinwt + 25sin(2wt) + 15sin(4wt) Volts
//and the resulting current is given by
//  v = 0.743sin(wt + 1.19) + 0.78sin(2wt + 0.896) + 0.636sin(4wt + 0.559) A
//Determine (a) the average power supplied, (b) the type of components present, and (c) the values of the components.

//initializing the variables:
Vom = 30; // in volts
V1m = 40; // in volts
V2m = 25; // in volts
V4m = 15; // in volts
Iom = 0; // in amperes
I1m = 0.743; // in Amperes
I2m = 0.781; // in Amperes
I4m = 0.636; // in Amperes
phii1 = 1.190; // in rad
phii2 = 0.896; // in rad
```

```
phii4 = 0.559; // in rad
w = 1000; // in rad

//calculation:
//the average power P is given by
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)
//rms current
Irms = (Iom^2 + (I1m^2 + I2m^2 + I4m^2)/2)^0.5
//resistance R
R = P/(Irms^2)
//impedance
Z1 = V1m/I1m
//Xc1
Xc1 = (Z1^2 - R^2)^0.5
//capacitance
C = 1/(w*Xc1)

printf("\n\n Result \n\n")
printf("\n(a)the average power P is %.2f W",P)
printf("\n(c)the resistance R %.0f ohm and capacitance %.2E F",R,C)
```

Scilab code Exa 36.13 Example 13

```
//Problem 36.13: In the circuit shown in Figure 36.17 the supply voltage v is given by v = 300 sin314t + 120sin(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.

```

```
//initializing the variables:
V1m = 300; // in volts
V3m = 120; // in volts
phiv1 = 0; // in rad
phiv2 = 0.698; // in rad
w1 = 314; // in rad
C = 2.123E-6; // in farads
R1 = 560; // in ohms
R2 = 2000; // in Ohm

//calculation:
//voltage
V1 = V1m*cos(phiv1) + %i*V1m*sin(phiv1)
V3 = V3m*cos(phiv3) + %i*V3m*sin(phiv3)
//capacitive reactance,
Xc1 = 1/(w1*C)
//impedance at the fundamental frequency,
Z1 = R1 + %i*Xc1*R2/(R2 + %i*Xc1)
//Maximum current at fundamental frequency
I1m = V1/Z1
I1mag = (real(I1m)^2 + imag(I1m)^2)^0.5
phii1 = atan(imag(I1m)/real(I1m))
//Third harmonic
Xc3 = Xc1/3
//impedance at the third harmonic frequency,
Z3 = R1 + %i*Xc3*R2/(R2 + %i*Xc3)
//Maximum current at third harmonic frequency
I3m = V3/Z3
I3mag = (real(I3m)^2 + imag(I3m)^2)^0.5
phii3 = atan(imag(I3m)/real(I3m))
//Percentage harmonic content of the supply current is given by
percent = I3mag*100/I1mag
//total active power
P = (0.707*V1m)*(0.707*I1mag)*cos(phiv1 - phii1) + (0.707*V3m)*(0.707*I3m)*cos(phiv3 - phii3)

printf("\n\n Result \n\n")
```

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

Scilab code Exa 36.14 Example 14

```
//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.

//initializing the variables:
V1m = 400; // in volts
V3m = 10; // in volts
C = 0.2E-6; // in farads
R = 2; // in ohms
L = 0.5; // in Henry

//calculation:
//Resonance with the third harmonic means that
w = (1/(9*L*C))^0.5
//fundamental frequency, f
f = w/(2*%pi)
//At the fundamental frequency,
//impedance Z1
Z1 = R + %i*(w*L - 1/(w*C))
Z1mag = (real(Z1)^2 + imag(Z1)^2)^0.5
phiZ1 = atan(imag(Z1)/real(Z1))
//Maximum value of current at the fundamental
    frequency,
I1m = V1m/Z1mag
```

```
//At the third harmonic frequency,
Z3 = R + %i*(3*w*L - 1/(3*w*C))
Z3mag = (real(Z3)^2 + imag(Z3)^2)^0.5
phiZ3 = atan(imag(Z3)/real(Z3))
//Maximum value of current at the third harmonic
    frequency,
I3m = V3m/Z3

printf("\n\n Result \n\n")
printf("\n(a)fundamental frequency for resonance
    with the third harmonic is %.2f Hz",f)
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

```
//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.

//initializing the variables:
V1m = 800; // in volts
f = 50; // in Hz
x = 0.015;
C = 0.122E-6; // in farads
R = 5; // in ohms
```

```
L = 0.369; // in Henry

//calculation:
//voltage at nth harmonic
Vnm = x*V1m
w = 2*%pi*f
//For resonance at the nth harmonic nwL = 1/nwC
n = 1/(w*(L*C)^0.5)
//At resonance, impedance
Zn = R
//the maximum value of current at the nth harmonic
Inm = Vnm/Zn
//capacitive reactance, at nth harmonic
Xcn = 1/(n*w*C)
//the p.d. across the capacitor at the nth harmonic
Vcn = Inm*Xcn
//At the fundamental frequency, inductive reactance,
XL1 = w*L
//capacitive reactance
Xc1 = 1/(w*C)
//Impedance at the fundamental frequency,
Z1 = R + %i*(XL1 - Xc1)
Z1mag = (real(Z1)^2 + imag(Z1)^2)^0.5
phiZ1 = atan(imag(Z1)/real(Z1))
//Maximum value of current at the fundamental
    frequency,
I1m = V1m/Z1mag

printf("\n\n Result \n\n")
printf("\n(a)n = %.0f",n)
printf("\n(b)the maximum value of current at the nth
     harmonic %.2f A",Inm)
printf("\n(c)the p.d. across the capacitor at the
    nth harmonic is %.2f",Vcn)
printf("\n(d)the maximum value of the fundamental
    current. %.2f A",I1m)
```

Chapter 38

Magnetic materials

Scilab code Exa 38.01 Example 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.

//initializing the variables:
A = 12.5; // in cm2
x = 500; // horizontal axis 1 cm = 500 A/m
y = 0.2; // vertical axis 1 cm = 0.2 T
f = 50; // in Hz

//calculation:
//hysteresis loss per cycle
HL = A*x*y
//At 50 Hz frequency, hysteresis loss
HLf = HL*f

printf("\n\n Result \n\n")
```

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

Scilab code Exa 38.02 Example 2

```
//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

//initializing the variables:
n = 1.6; // the Steinmetz index
f1 = 50; // in Hz
f2 = 25; // in Hz
Bm1 = 1.5; // in Tesla
Bm2 = 1.1; // in Tesla
Ph1 = 62500; // in W/m3
v = 1;

//calculation:
//hysteresis loss Ph = kh*v*f*(Bm)^n
kh = Ph1/(v*f1*(Bm1)^n)
//When f = 25 Hz and Bm = 1.1 T,
Ph2 = kh*v*f2*(Bm2)^n

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
csa = 0.002; // in m2
l = 1; // in m
a = 400/0.01; // 10 mm = 400 A/m
b = 0.1/0.01; // 10 mm = 0.1 T
A = 0.01; // in m2
f = 80; // in Hz

//calculation:
//hysteresis loss per cycle
HL = A*a*b
//At a frequency of 80 Hz,
//hysteresis loss
HLf = HL*f
//Volume of ring
v = csa*l
//hysteresis loss
Ph = HLf*v

printf("\n\n Result \n\n")
printf("\n the hysteresis loss at a frequency of 80
    Hz is %.0f W",Ph)
```

Scilab code Exa 38.04 Example 4

```
//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.

//initializing the variables:
Phi1 = 0.01; // in Wb
Phi2 = 0.008; // in Wb
csa = 0.008; // in m2
v = 0.005; // in m3
f = 50; // in Hz
n = 1.7; // the Steinmetz constant
Ph1 = 100; // in Watt

//calculation:
//maximum flux density
Bm1 = Phi1/csa
//hysteresis loss Ph1 = kh*v*f*(Bm1)^n
kh = Ph1/(v*f*(Bm1)^n)
//When the maximum core flux is 8 mWb,
Bm2 = Phi2/csa
//hysteresis loss, Ph2
Ph2 = kh*v*f*(Bm2)^n

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
Pe1 = 10; // in W/m3
f1 = 50; // in Hz
f2 = 30; // in Hz

//calculation:
//When the eddy current loss is 10 W/m3, frequency f
    is 50 Hz.
//constant k
k = Pe1/(f1^2)
//When the frequency is 30 Hz, eddy current loss,
Pe2 = k*(f2^2)

printf("\n\n Result \n\n")
printf("\neddy current loss per cubic metre is %.1f
   W/m3",Pe2)
```

Scilab code Exa 38.06 Example 6

```
//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.
```

```

//initializing the variables:
Pe = 100; // in W/m3
f1 = 50; // in Hz
t1 = 0.0005; // in m
x = 1/3;
f2 = 250; // in Hz

//calculation:
//Pe = ke*(Bm1*f1*t1)^2
//Hence, at 50 Hz frequency
ke = Pe/(Bm1*f1*t1)^2
//At 250 Hz frequency
Bm2 = x*Bm1
t2 = ((Pe/ke)^0.5)/(Bm2*f2)

printf("\n\n Result \n\n")
printf("\nlamination thickness is %.2Em",t2)
```

Scilab code Exa 38.07 Example 7

```
//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

//initializing the variables:
Ph1 = 40; // in W
Pe1 = 20; // in W
f1 = 50; // in Hz
```

```
x = 1/2;
f2 = 60; // in Hz
t1 = 1;
//calculation:
//hysteresis loss Ph = kh*v*f*(Bm)^n = k1*f
//Thus when the hysteresis is 40 W and the frequency
    50 Hz,
k1 = Ph1/f1
//If the frequency is increased to 60 Hz,
Ph2 = k1*f2
//eddy current loss, Pe = ke*(Bm1*f1*t1)^2 = k2*f^2
//since the flux density and lamination thickness
   are constant.
//When the eddy current loss is 20 W the frequency
   is 50 Hz. Thus
k2 = Pe1/(f1^2)
//If the frequency is increased to 60 Hz,
Pe2 = k2*(f2^2)
//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
Phb2 = Ph1
//eddy current loss, Pe = ke*(Bm1*f1*t1)^2 = k2*t^3
k3 = Pe1/(t1^3)
t2 = 0.5*t1
Peb2 = k3*t2^3
//total core loss when the thickness of the
   laminations is halved is given by
TL = Phb2 + Peb2

printf("\n\n Result \n\n")
printf("\n(a)If the frequency is increased to 60 Hz,
   hysteresis loss is %.0f W and eddy current loss %
   .1f W",Ph2, Pe2)
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

```
//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.

//initializing the variables:
V1 = 500; // in Volts
V2 = 1000; // in Volts
Ph1 = 400; // in W
Pe1 = 150; // in W
f1 = 50; // in Hz
n = 1.6; // Steinmetz index
f2 = 100; // in Hz

//calculation:
//hysteresis loss Ph = k1*f*(E/f)^n
//At 500 V and 50 Hz
k1 = Ph1/(f1*(V1/f1)^1.6)
//At 1000 V and 100 Hz,
Ph2 = k1*f2*(V2/f2)^1.6
//eddy current loss, Pe = k2*E^2
//At 500 V,
k2 = Pe1/(V1^2)
//At 1000 V,
Pe2 = k2*(V2^2)
//the new total core loss
TL = Ph2 + Pe2

printf("\n\n Result \n\n")
printf("\n the new total core loss %.0f W",TL)
```

Scilab code Exa 38.10 Example 10

```
//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.

//initializing the variables:
TL1 = 400; // in Watt
TL2 = 498; // in Watt
x = 0.25;
y = 0.4;
f1 = 50; // in Hz
n = 1.7; // Steinmetz index
f2 = 60; // in Hz

//calculation:
//if volume v and the maximum flux density are constant
//hysteresis loss Ph = kh*v*f*(Bm)^n = k1*f
//(if the maximum flux density and the lamination thickness are constant)
//eddy current loss , Pe = ke*(Bm1*f1*t1)^2 = k2*f^2
//At 50 Hz frequency , TL1 = k1*f1 + k2*f1^2
//At 60 Hz frequency , TL2 = k1*f2 + k2*f2^2
//Solving equations gives the values of k1 and k2.
k2 = (5*TL2 - 6*TL1)/(5*(f2^2) - 6*(f1^2))
k1 = (TL1 - k2*f1^2)/f1
//hysteresis loss Ph = k1*f
```

```
Ph1 = k1*f1
//eddy current loss
Pe1 = k2*f1^2
//Since at 50 Hz the flux density is increased by 25
   %, the new hysteresis loss is
Ph2 = Ph1*(1 + x)^1.7
//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
Pe2 = Pe1*((1 + x)^2)*(1 + y)^3

printf("\n\n Result \n\n")
printf("\n (a)the hysteresis and eddy current losses
    at 50 Hz are %.0f W and %.0f W resp.",Ph1, Pe1)
printf("\n (b)the hysteresis and eddy current losses
    at 50 Hz after increement are %.1f W and %.1f W
   resp.",Ph2, Pe2)
```

Chapter 39

Dielectrics and dielectric loss

Scilab code Exa 39.01 Example 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.

//initializing the variables:
Rs = 1.5; // in ohms
Cs = 400E-12; // in Farads
f = 8E6; // in Hz

//calculation:
//for a series equivalent circuit,
//tan(del) = Rs*w*Cs
//loss angle,
del = atan(Rs*Cs*(2*%pi*f))
//power factor
pf = cos(del)
//the Q−factor
Q = 1/tan(del)
```

```
//dissipation factor,
D = 1/Q

printf("\n\n Result \n\n")
printf("\n (a)loss angle %.3f rad.",del)
printf("\n (b)power factor %.3f rad.",del)
printf("\n (c)Q-factor is %.2f ",Q)
printf("\n (d)dissipation factor %.3f rad.",D)
```

Scilab code Exa 39.02 Example 2

```
//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.

//initializing the variables:
del = 0.025; // in rad.
V = 5000; // in Volts
PL = 20; // power loss
f = 50; // in Hz

//calculation:
//power loss = w*C*V^2*tan(del)
Cp = PL/(2*%pi*f*V*V*tan(del))
//for a parallel equivalent circuit,
//tan(del) = 1/(Rp*w*Cp)
Rp = 1/(2*%pi*f*Cp*tan(del))

printf("\n\n Result \n\n")
printf("\n capacitance C %.2E F and parallel
    resistance %.2E ohm.",Cp, Rp)
```

Scilab code Exa 39.03 Example 3

```
//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.

//initializing the variables:
P = 500E-6; // in Watt
C = 2000E-12; // in Farads
V = 20; // in Volts
f = 10000; // in Hz

//calculation:
//power loss = w*C*V^2*tan(del)
//loss angle
del = atan(P/(2*%pi*f*V*V*C))
//for an equivalent series circuit,
//tan(del) = (Rs*w*Cs)
Cs = C
Rs = (tan(del))/(2*%pi*f*Cp)
//for an equivalent parallel circuit
//tan(del) = 1/(Rp*w*Cp)
Cp = C
Rp = 1/(2*%pi*f*Cp*tan(del))

printf("\n\n Result \n\n")
printf("\n (a)loss angle %.6f rad.",del)
printf("\n (b)series resistance %.2f ohm.",Rs)
printf("\n (c)parallel resistance %.2E ohm.",Rp)
```

Chapter 40

Field theory

Scilab code Exa 40.01 Example 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.

//initializing the variables:
e0 = 8.85E-12;
er = 2.8;
l = 1; // in m

//calculation:
//From Figure 40.9
m = 16; // number of parallel squares measured along
     each equipotential
n = 6; // the number of series squares measured
    along each line of force
C = e0*er*l*m/n

printf("\n\n Result \n\n")
printf("\n capacitance is %.3E Farad.",C)
```

Scilab code Exa 40.02 Example 2

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 3.4;
l = 100; // in m

//calculation:
//From Figure 40.10
m = 13; // number of parallel squares measured along
    each equipotential
n = 4; // the number of series squares measured
   along each line of force
C = e0*er*l*m/n

printf("\n\n Result \n\n")
printf("\n capacitance is %.3E Farad.",C)
```

Scilab code Exa 40.03 Example 3

```
//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.

```

```
//initializing the variables:
e0 = 8.85E-12;
er = 2.7;
ri = 0.0005; // in m
ro = 0.006; // in m

//calculation:
//capacitance C
C = 2*%pi*e0*er/(log(ro/ri))

printf("\n\n Result \n\n")
printf("\n capacitance is %.3E Farad.",C)
```

Scilab code Exa 40.04 Example 4

```
//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.

//initializing the variables:
C = 80E-12; // in Farads
e0 = 8.85E-12;
er = 3.5;
d0 = 0.008; // in m

//calculation:
//internal diameter
di = d0*(%e^(2*%pi*e0*er/C))

printf("\n\n Result \n\n")
printf("\n internal diameter is %.5f m.",di)
```

Scilab code Exa 40.05 Example 5

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 3.5;
di = 0.08; // in m
d0 = 0.032; // in m
r = 0.03; // in m
V = 40000; // in Volts

//calculation:
//capacitance C
C = 2*%pi*e0*er/(log(di/d0))
//dielectric stress at radius r,
E = V/(r*log(di/d0))
//maximum dielectric stress,
Emax = V/((d0/2)*(log((di/d0))))
//minimum dielectric stress,
Emin = V/((di/2)*(log((di/d0))))

printf("\n\n Result \n\n")
printf("\n capacitance is %.2E F/km",C*1E3)
printf("\n dielectric stress at radius r is %.2E V/m
   ",E)
printf("\n maximum dielectric stress, is %.2E V/m
```

```
minimum dielectric stress %.2E V/m",Emax, Emin)
```

Scilab code Exa 40.06 Example 6

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 3.5;
V = 60000; // in Volts
f = 50; // in Hz
Em = 10E6; // in V/m


//calculation:
//core radius, a
a = V/Em
//internal sheath radius,
b = a*%e^1
//capacitance
C = 2*%pi*e0*er/(log(b/a))
//Charging current
I = V*2*%pi*f*C
//charging current per kilometre
Ipkm = I*1000

printf("\n\n Result \n\n")
```

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

Scilab code Exa 40.07 Example 7

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 2.5;
di = 0.08; // in m
d0 = 0.025; // in m
r = 1000; // in m
V = 132000; // in Volts
f = 50; // in Hz
del = 3.5E-3; // rad.

//calculation:
//core radius, a
a = d0/2
//internal sheath radius,
b = di/2
//capacitance
C = 2*%pi*e0*er*1E3/(log(b/a))
//Charging current
```

```
I = V*2*%pi*f*C
//power loss
P = (2*%pi*f*C*tan(del))*V^2

printf("\n\n Result \n\n")
printf("\n (a)capacitance for a 1 km length is %.2E
   F",C)
printf("\n (b)the charging current %.2E A/km",I)
printf("\n (c)power loss %.0f W",P)
```

Scilab code Exa 40.08 Example 8

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 3.2;
di = 0.06; // in m
d0 = 0.020; // in m

//calculation:
//core radius , a
a = d0/2
//internal sheath radius ,
b = di/2
//capacitance
C = 2*%pi*e0*er/(log(b/a))

```

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

Scilab code Exa 40.09 Example 9

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 1;
D = 0.05; // in m
d = 0.005; // in m
l = 200; // in m

//calculation:
//capacitance
C = %pi*e0*er/(log(D/(d/2)))
//capacitance of a 200 m length
C200 = C*l

printf("\n\n Result \n\n")
printf("\n capacitance of a 200 m length is %.2E F",
   C200)
```

Scilab code Exa 40.10 Example 10

```
//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
```

```
    conductors at a frequency of 50 Hz is 15 kV.
    Determine, for a 1 km length of line, (a) the
    capacitance of the conductors, (b) the value of
    charge carried by each conductor, and (c) the
    charging current.

//initializing the variables:
e0 = 8.85E-12;
er = 1;
D = 1.2; // in m
r = 0.004; // in m
f = 50; // in Hz
V = 15000; // in Volts
l = 1000; // in m

//calculation:
//capacitance
C = %pi*e0*er/(log(D/r))
//capacitance of a 1 km length
Cpkm = C*l
//Charge Q
Q = Cpkm*V
//Charging current
I = V*2*%pi*f*Cpkm

printf("\n\n Result \n\n")
printf("\n capacitance per 1km length is %.2E F",
    Cpkm)
printf("\n Charge Q is %.2E C",Q)
printf("\n Charging current is %.3f A",I)
```

Scilab code Exa 40.11 Example 11

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

```
   The voltage between the lines is 10 kV at 50 Hz.
    If the line is air-insulated, determine (a) the
   maximum value required for the capacitance per
   metre length, and (b) the maximum diameter of
   each conductor if their distance between centres
   is 1.25 m.

//initializing the variables:
e0 = 8.85E-12;
er = 1;
I = 0.015; // in Amperes
d = 1.25; // in m
r = 800; // in m
f = 50; // in Hz
V = 10000; // in Volts

//calculation:
//capacitance
C = I/(2*%pi*f*V)
//required maximum value of capacitance
Cmax = C/r
//maximum diameter of each conductor
D = 2*d/(%e^(%pi*e0*er/Cmax))

printf("\n\n Result \n\n")
printf("\n required maximum value of capacitance is
   %.2E F/m",Cmax)
printf("\nthe maximum diameter of each conductor is
   %.4f m",D)
```

Scilab code Exa 40.12 Example 12

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 1;
C = 10E-9; // in Farad
V = 1000; // in Volts
t = 10E-6; // in sec

//calculation:
//energy stored,Wf
Wf = C*V*V/2
//average power developed
Pav = Wf/t

printf("\n\n Result \n\n")
printf("\n the energy stored is %.2E J",Wf)
printf("\nthe average power developed is %.0f W",Pav
)
```

Scilab code Exa 40.13 Example 13

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 1;
Q = 5E-3; // in Coulomb
W = 0.625; // in Joules

//calculation:
//voltage across the plates
```

```
V = 2*W/Q
//Capacitance C
C = Q/V

printf("\n\n Result \n\n")
printf("\n voltage across the plates is %.0f V",V)
printf("\n Capacitance C is %.2E F",C)
```

Scilab code Exa 40.14 Example 14

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 10;
C = 0.01E-6; // in Farad
E = 10E6; // in V/m
V = 2500; // in Volts

//calculation:
//thickness of ceramic dielectric ,
d = V/E
//cross-sectional area of plate
A = C*d/(e0*er)
//Maximum energy stored ,
W = C*V*V/2

```

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

Scilab code Exa 40.15 Example 15

```
//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.

//initializing the variables:
e0 = 8.85E-12;
er = 2.3;
A = 0.02; // in m2
C = 400E-12; // in Farad
V = 100; // in Volts

//calculation:
//energy stored per unit volume of dielectric,
W = ((C*V)^2)/(2*e0*er*A^2)

printf("\n\n Result \n\n")
printf("\n energy stored per unit volume of
  dielectric is %.4f J/m3",W)
```

Scilab code Exa 40.16 Example 16

```
//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.

//initializing the variables:
u0 = 4*%pi*1E-7;
ur = 1;
a = 0.001; // in m
b = 0.004; // in m

//calculation:
//inductance L
L = (u0*ur/(2*%pi))*(0.25 + log(b/a))

printf("\n\n Result \n\n")
printf("\n inductance L is %.2E H/m",L)
```

Scilab code Exa 40.17 Example 17

```
//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.

//initializing the variables:
u0 = 4*%pi*1E-7;
ur = 1;
da = 0.010; // in m
L = 4E-7; // in H/m

//calculation:
```

```
//diameter of the sheath
db = da*(%e^(L/(u0*ur/(2*%pi))))

printf("\n\n Result \n\n")
printf("\n diameter of the sheath is %.4f m",db)
```

Scilab code Exa 40.18 Example 18

```
//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.

//initializing the variables:
u0 = 4*%pi*1E-7;
ur = 1;
e0 = 8.85E-12;
er = 3;
da = 0.010; // in m
db = 0.025; // in m
l = 7500; // in m

//calculation:
//inductance per metre length
L = (u0*ur/(2*%pi))*(0.25 + log(db/da))
//Since the cable is 7500 m long,
L7500 = L*7500
//capacitance C
C = 2*%pi*e0*er/(log(db/da))
////Since the cable is 7500 m long,
C7500 = C*7500

printf("\n\n Result \n\n")
```

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

Scilab code Exa 40.19 Example 19

```
//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.

//initializing the variables:
u0 = 4*%pi*1E-7;
ur = 1;
e0 = 8.85E-12;
er = 3;
D = 1.2; // in m
a = 0.008; // in m

//calculation:
//inductance per metre length
L = (u0*ur/(%pi))*(log(D/a))

printf("\n\n Result \n\n")
printf("\ninductance is %.2E H/m",L)
```

Scilab code Exa 40.20 Example 20

```
//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.
```

```

//initializing the variables:
u0 = 4*%pi*1E-7;
ur = 1;
e0 = 8.85E-12;
er = 1;
l = 1000; // in m
D = 0.8; // in m
a = 0.01/2; // in m

//calculation:
//inductance per metre length
L = (u0*ur/(%pi))*(0.25 + log(D/a))
//Since the cable is 1000 m long,
L1k = L*l
//capacitance C
C = %pi*e0*er/(log(D/a))
////Since the cable is 1000 m long,
C1k = C*l

printf("\n\n Result \n\n")
printf("\ninductance is %.5f H",L1k)
printf("\ncapcitance is %.2E F",C1k)
```

Scilab code Exa 40.21 Example 21

```
//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.

//initializing the variables:
L = 2.185E-6; // in H/m
u0 = 4*%pi*1E-7;
ur = 1;
```

```
a = 0.012/2; // in m

//calculation:
//distance D
D = a*%e^((L*%pi)/(u0*ur) - 0.25)

printf("\n\n Result \n\n")
printf("\ndistance D is %.2f m",D)
```

Scilab code Exa 40.22 Example 22

```
//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?

//initializing the variables:
L = 0.2; // in H
I = 0.05; // in Amperes
u0 = 4*%pi*1E-7;
ur = 1;

//calculation:
//energy stored in inductor
W = L*I*I/2
//current I
I = (2*2*W/L)^0.5

printf("\n\n Result \n\n")
printf("\nenergy stored in inductor is %.2E J",W)
printf("\ncurrent I is %.2E A",I)
```

Scilab code Exa 40.23 Example 23

```
//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.

//initializing the variables:
B = 0.05; // in Tesla
A = 500E-6; // in m2
l = 0.002; // in m
u0 = 4*%pi*1E-7;

//calculation:
//energy stored
W = (B^2)/(2*u0)
//Volume of airgap
v = A*l
//energy stored in airgap
W = W*v

printf("\n\n Result \n\n")
printf("\nenergy stored in the airgap is %.2E J",W)
```

Scilab code Exa 40.24 Example 24

```
//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.

//initializing the variables:
B = 0.8; // in Tesla
```

```
A = 500E-6; // in m2
l = 0.002; // in m
u0 = 4*%pi*1E-7;
ur = 1;
e0 = 8.85E-12;
er = 1;

//calculation:
//energy stored in mag. field
W = (B^2)/(2*u0)
//electric field
E = (2*W/(e0*er))^0.5

printf("\n\n Result \n\n")
printf("\nelectric field strength is %.2E V/m",E)
```

Chapter 41

Attenuators

Scilab code Exa 41.01 Example 1

```
//Problem 41.01: The ratio of output power to input
    power in a system is
//(a)2 (b) 25 (c) 1000 and (d) 0.01
//Determine the power ratio in each case (i) in
    decibels and (ii) in nepers.

//initializing the variables:
//ratio of output power to input power
rp1 = 2;
rp2 = 25;
rp3 = 1000;
rp4 = 0.01;

//calculation:
//power ratio in decibels
rpd1 = 10*log10(rp1)
rpd2 = 10*log10(rp2)
rpd3 = 10*log10(rp3)
rpd4 = 10*log10(rp4)
//power ratio in nepers
rpn1 = (log(rp1))/2
```

```
rpn2 = (log(rp2))/2
rpn3 = (log(rp3))/2
rpn4 = (log(rp4))/2

printf("\n\n Result \n\n")
printf("\n power ratio in decibels are (a)%.0f dB (b
    )%.0f dB (c) %.0f dB and (d) %.0f dB",rpd1,rpd2,
    rpd3,rpd4)
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

```
//Problem 41.02: 5% of the power supplied to a cable
     appears at the output terminals. Determine the
    attenuation in decibels.

//initializing the variables:
rp = 0.05; // power ratio P2/P1

//calculation:
//power ratio in decibels
rpd = 10*log10(rp)

printf("\n\n Result \n\n")
printf("\nthe attenuation is %.0f dB",abs(rpd))
```

Scilab code Exa 41.03 Example 3

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

```

//initializing the variables:
gain = 1.5; // in dB
Pi = 0.012; // in Watt

//calculation:
//output power
Po = Pi*10^gain

printf("\n\n Result \n\n")
printf("\noutput power is %.4f W",Po)
```

Scilab code Exa 41.04 Example 4

```
//Problem 41.04: The current output of an attenuator is 50 mA. If the current ratio of the attenuator is 1.32 Np, determine (a) the current input and (b) the current ratio expressed in decibels. Assume that the input and load resistances of the attenuator are equal.

//initializing the variables:
I2 = 0.05; // in Amperes
rin = 1.32; // in Np

//calculation:
//current input, I1
I1 = I2*%e^(rin)
//current ratio in decibels
rid = 20*log10(I2/I1)

printf("\n\n Result \n\n")
printf("\ncurrent input, I1 is %.4f A",I1)
printf("\ncurrent ratio in decibels is %.2f dB",rid)
```

Scilab code Exa 41.05 Example 5

```
//Problem 41.05: Determine the characteristic
    impedance of each of the attenuator sections
    shown in Figure 41.9.

//initializing the variables:
R1a = 8; // in ohm
R2a = 21; // in ohm
R1b = 10; // in ohm
R2b = 15; // in ohm
R1c = 200; // in ohm
R2c = 56.25; // in ohm

//calculation:
//for a T-section attenuator the characteristic
    impedance
Roa = (R1a^2 + 2*R1a*R2a)^0.5
Rob = (R1b^2 + 2*R1b*R2b)^0.5
Roc = (R1c^2 + 2*R1c*R2c)^0.5

printf("\n\n Result \n\n")
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

```
//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
```

```
    characteristic impedance, and (b) the
    attenuation (in dB) produced by the pad.

//initializing the variables:
R1 = 500; // in ohm
R2 = 1000; // in ohm
I1 = 1; // in ampere (lets say)

//calculation:
// for symmetrical pi-attenuator section
//characteristic impedance, R0
R0 = (R1*(R2^2)/(R1 + 2*R2))^0.5
//current Ix
Ix = (R2/(R2 + R1 + (R2*R0/(R2 + R0))))*I1
//current I2
I2 = (R2/(R2 + R0))*Ix
ri = I1/I2; // retio of currents
//attenuation
attn = 20*log10(ri)

printf("\n\n Result \n\n")
printf("\n the characteristic impedance is %.0f ohm"
    ,R0)
printf("\n attenuation is %.2f dB",attn)
```

Scilab code Exa 41.07 Example 7

```
//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.

//initializing the variables:
```

```
R1 = 15; // in ohm
R2 = 10; // in ohm
R3 = 5; // in ohm

//calculation:
//For the T-network shown in Figure 41.11(i):
Roct = R1 + R2
Rsct = R1 + R1*R2/(R1 + R2)
Rot = (Roct*Rsct)^0.5
//For the Pi-network shown in Figure 41.11(ii):
Rocpi = R3*(R1 + R3)/(R3 + R1 + R3)
Rscpi = R3*R1/(R3 + R1)
Ropi = (R1*(R3^2)/(R1 + 2*R3))^0.5

printf("\n\n Result \n\n")
printf("\n the input resistance when the output port is open-circuited is (a) %.0f ohm (b) %.0f ohm",Roct,Rocpi)
printf("\n the input resistance when the output port is short-circuited is (a) %.0f ohm (b) %.2f ohm",Rsct, Rscpi)
printf("\n the characteristic impedance is (a) %.1f ohm (b) %.2f ohm",Rot, Ropi)
```

Scilab code Exa 41.10 Example 10

```
//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.

//initializing the variables:
R1 = 300; // in ohm
R2 = 450; // in ohm
I1 = 1; // in ampere (lets say)
```

```

//calculation:
//the characteristic impedance of a symmetric T-pad attenuator is given by
R0 = (R1^2 + 2*R1*R2)^0.5
//By current division
//current I2
I2 = (R2/(R2 + R1+ R0))*I1
ri = I1/I2; // ratio of currents
//insertion loss
il = 20*log10(ri)

printf("\n\n Result \n\n")
printf("\n the characteristic impedance is %.0f ohm",R0)
printf("\n insertion loss is %.2f dB",il)
```

Scilab code Exa 41.11 Example 11

```
//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.

//initializing the variables:
r = 500; // in ohm
Rhm = 3000; // in ohm
RL = 2000; // in ohm
r1 = 2000; // in ohm
r2 = 1000; // in ohm
E = 1; // in volts (lets say)

//calculation:
```

```
//Without the rheostat in the circuit the voltage
   across the 2 kohm load , VL
VL = (RL/(RL + r))*E
//voltage V2 with 2kohm tapping
V2 = ((RL*r1/(r1 + RL))/((RL*r1/(r1 + RL)) + Rhm -
   r1 + r))*E
rv1 = VL/V2; // ratio of currents
//insertion loss
il1 = 20*log10(rv1)
//voltage V1 with 1kohm tapping
V1 = ((RL*r2/(r2 + RL))/((RL*r2/(r2 + RL)) + Rhm -
   r2 + r))*E
rv2 = VL/V1; // ratio of currents
//insertion loss
il2 = 20*log10(rv2)

printf("\n\n Result \n\n")
printf("\n insertion loss for 2kohm tap is %.2f dB",
   il1)
printf("\n insertion loss for 1kohm tap is %.2f dB",
   il2)
```

Scilab code Exa 41.12 Example 12

```
//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..

//initializing the variables:
R1 = 1000; // in ohm
R2 = 500; // in ohm
I1 = 1; // in amperes (lets say)

```

```
//calculation:
//characteristic impedance of a symmetrical
   attenuator
R0 = (R1*(R2^2)/(R1 + 2*R2))^0.5
//current Ix
Ix = (R2/(R2 + R1 + (R2*R0/(R2 + R0))))*I1
//current I2
I2 = (R2/(R2 + R0))*Ix
ri = I1/I2; // retio of currents
//insertion loss
il = 20*log10(ri)

printf("\n\n Result \n\n")
printf("\n characteristic impedance is %.0f ohm",R0)
printf("\n insertion loss is %.2f dB",il)
```

Scilab code Exa 41.13 Example 13

```
//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.

//initializing the variables:
R1 = 100; // in ohm
R2 = 200; // in ohm
R3 = 300; // in ohm
I1 = 1; // in amperes (lets say)

//calculation:
//image impedance Roa
Roa = ((R1 + R2)*(R2 + (R1*R3/(R1 + R3))))^0.5
//image impedance Rob
Rob = ((R1 + R3)*(R3 + (R1*R2/(R1 + R2))))^0.5
//The iterative impedance at port 1
```

```
Ri1 = (-1*R1 + (R1^2 - (-1*4*((R2*(R1 + R3)) + (R3*R1))))^0.5)/2
//The iterative impedance at port 2
Ri2 = (R1 + (R1^2 - (-1*4*((R3*(R1 + R2)) + (R2*R1))))^0.5)/2

printf("\n\n Result \n\n")
printf("\n image impedance are %.1f ohm and %.0f ohm ",Roa,Rob)
printf("\n iterative impedances are %.1f ohm and %.1f ohm ",Ri1,Ri2)
```

Scilab code Exa 41.14 Example 14

```
//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.

//initializing the variables:
R1 = 1000; // in ohm
R2 = 2000; // in ohm
R3 = 3000; // in ohm
I1 = 1; // in amperes (lets say)

//calculation:
//image impedance Roa
Roa = (((R3 + R2)*R1/(R1 + R2 + R3))*(R1*R3/(R1 + R3)))^0.5
//image impedance Rob
Rob = (((R3 + R1)*R2/(R1 + R2 + R3))*(R2*R3/(R2 + R3)))^0.5
//The iterative impedance at port 1
Ri1 = (-1*R1 + ((R1^2) - (-1*4*2*R2*R1))^0.5)/(2*2)
//The iterative impedance at port 2
```

```
Ri2 = (R1 + ((-1*R1)^2 - (-1*4*2*R2*R1))^0.5)/(2*2)

printf("\n\n Result \n\n")
printf("\n image impedance are %.0f ohm and %.0f ohm
    ",Roa,Rob)
printf("\n iterative impedances are %.0f ohm and %.0
    f ohm ",Ri1,Ri2)
```

Scilab code Exa 41.15 Example 15

```
//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.

//initializing the variables:
r = 500; // in ohm
RL = 100; // in ohm
E = 1; // in volts (lets say)

//calculation:
//res.
R1 = (r*(r - RL))^0.5
R2 = (r*RL^2/(r - RL))^0.5
//current I1
I1 = E/(r + R1 + R2*RL/(RL + R2))
//current I2
I2 = (R2/(R2 + RL))*I1
//input power
P1 = r*I1^2
//output power
P2 = RL*I2^2
//attenuation
```

```
attn = 10*log10(P1/P2)
//Load current, IL
IL = E/(r + RL)
//voltage, VL
VL = IL*RL
//voltage, V1
V1 = E - I1*r
//voltage, V2
V2 = V1 - I1*R1
//insertion loss
il = 20*log10(VL/V2)

printf("\n\n Result \n\n")
printf("\n R1 = %.1f ohm and R2 = %.1f ohm ",R1,R2)
printf("\n attenuation is %.2f dB ",attn)
printf("\n In decibels, the insertion loss is %.2f dB ",il)
```

Scilab code Exa 41.16 Example 16

```
//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.

//initializing the variables:
attn0 = 70; // in dB
n = 5; // numbers of identical atteneurs
V1 = 0.02; // in Volts

//calculation:
//attenuation of each section
```

```
attn = attn0/n
//output of the final stage
Vo = V1/(10^(attn0/20))
//voltage output of the third stage
V3 = V1/(10^(3*attn/20))

printf("\n\n Result \n\n")
printf("\n attenuation of each section = %.0f dB ",
   attn)
printf("\n output of the final stage is %.2E V ",Vo)
printf("\n voltage output of the third stage is %.2E
    V ",V3)
```

Chapter 42

Filter networks

Scilab code Exa 42.01 Example 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.

//initializing the variables:
L1 = 2*100E-3; // in Henry
C1 = 0.2E-6; // in Fareads
L2 = 0.4; // in Henry
C2 = 2*200E-12; // in Fareads

//calculation:
//cut-off frequency
fc1 = 1/(%pi*(L1*C1)^0.5)
//nominal impedance
R01 = (L1/C1)^0.5
//cut-off frequency
fc2 = 1/(%pi*(L2*C2)^0.5)
//nominal impedance
R02 = (L2/C2)^0.5

printf("\n\n Result \n\n")
```

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

Scilab code Exa 42.02 Example 2

```
//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.

//initializing the variables:
R0 = 600; // in ohm
fc = 5E6; // in Hz

//calculation:
//capacitance
C = 1/(%pi*R0*fc)
//inductance
L = R0/(%pi*fc)

printf("\n\n Result \n\n")
printf("\n A low-pass T section filter capcitance is %.2E farad and inductance is%.2E Henry",C, L/2)
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

```
//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.

//initializing the variables:
R0 = 500; // in ohm
fc = 100000; // in Hz
f = 90000; // in Hz

//calculation:
//characteristic impedance of the pi section
Zpi = R0/(1 - (f/fc)^2)^0.5
//characteristic impedance of the T section
Zt =  R0*(1 - (f/fc)^2)^0.5

printf("\n\n Result \n\n")
printf("\ncharacteristic impedance of the pi section
    is %.0f ohm",Zpi)
printf("\ncharacteristic impedance of the T section
   is %.0f ohm",Zt)
```

Scilab code Exa 42.04 Example 4

```
//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.

//initializing the variables:
R0 = 600; // in ohm
```

```
fc = 2E6; // in Hz
Z1 = 600; // in ohm
Z2 = 1000; // in ohm
Z3 = 10000; // in ohm

//calculation:
//frequency
f1 = fc*(1 - (R0/Z1)^2)^0.5
f2 = fc*(1 - (R0/Z2)^2)^0.5
f3 = fc*(1 - (R0/Z3)^2)^0.5

printf("\n\n Result \n\n")
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

```
//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
    .

//initializing the variables:
L1 = 100E-3; // in Henry
C1 = 0.2E-6/2; // in Fareads
L2 = 200E-6/2; // in Henry
C2 = 4000E-12; // in Fareads

//calculation:
//cut-off frequency
fc1 = 1/(4*%pi*(L1*C1)^0.5)
//nominal impedance
R01 = (L1/C1)^0.5
```

```
//cut-off frequency
fc2 = 1/(4*%pi*(L2*C2)^0.5)
//nominal impedance
R02 = (L2/C2)^0.5

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

Scilab code Exa 42.07 Example 7

```
//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.

//initializing the variables:
R0 = 600; // in ohm
fc1 = 15000; // in Hz
fc2 = 10000; // in Hz

//calculation:
//capacitance
C1 = 1/(%pi*R0*fc1)
//inductance
L1 = R0/(%pi*fc1)
//capacitance
C2 = 1/(4*%pi*R0*fc2)
//inductance
L2 = R0/(4*%pi*fc2)
```

```

printf("\n\n Result \n\n")
printf("\n A low-pass T section filter capcitance is %.2E farad and inductance is%.2E Henry",C1, L1/2)
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

```
//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.

//initializing the variables:
R0 = 600; // in ohm
fc = 500; // in Hz
Z1 = 0; // in ohm
Z2 = 300; // in ohm
Z3 = 590; // in ohm

//calculation:
//frequency
f1 = fc
f2 = fc/(1 - (Z2/R0)^2)^0.5
f3 = fc/(1 - (Z3/R0)^2)^0.5

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
r1 = 1.25 + %i*0.52; // propagation coefficients
rr = 1.794; // propagation coefficients
thetar = -39.4; // in ddegrees

//calculation:
//r
r2 = rr*cos(thetar*%pi/180) + %i*rr*sin(thetar*%pi/180)
//attenuation coefficient
a1 = real(r1)
a2 = real(r2)
//phase shift coefficient
b1 = imag(r1)
b2 = imag(r2)

printf("\n\n Result \n\n")
printf("\nattenuation coefficient are for (a) is %.2f N and for (b) is %.3f N ",a1,a2)
printf("\nphase shift coefficient are for (a) is %.2f rad and for (b) is %.3f rad ",b1,b2)
```

Scilab code Exa 42.10 Example 10

```
//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.

//initializing the variables:
ri1 = 0.024; // in amperes
ri2 = 0.008; // in amperes
thetai1 = 10; // in ddegrees
thetai2 = -45; // in ddegrees

//calculation:
//currents
I1 = ri1*cos(thetai1*%pi/180) + %i*ri1*sin(thetai1*%pi/180)
I2 = ri2*cos(thetai2*%pi/180) + %i*ri2*sin(thetai2*%pi/180)
//ir
ir = I1/I2
irmag = ri1/ri2
thetai = thetai1-thetai2
//attenuation coefficient
a = log(irmag)
//phase shift coefficient
b = thetai*%pi/180
//propagation coefficient
r = a + %i*b
//output current of the fifth stage
I6 = I1/(ir^5)
x = ir^5
xmg = (real(x)^2 + imag(x)^2)^0.5
//overall attenuation coefficient
ad = log(xmg)
//overall phase shift coefficient
```

```
bd = atan(imag(x)/real(x)) + 2*%pi

printf("\n\n Result \n\n")
printf("\nattenuation coefficient is %.3f N ",a)
printf("\nphase shift coefficient is %.3f rad ",b)
printf("\npropagation coefficient is %.3f + (%.3f)i
    ",a,b)
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

```
//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
    .

//initializing the variables:
XL = %i*5; // in ohms
Xc = -1*%i*10; // in ohms
RL = 12; // in ohms
I1 = 1; // in amperes (lets say)

//calculation:
//current I2
I2 = (Xc/(Xc + XL + RL))*I1
//current ratio
Ir = I1/I2
Irmg = (real(Ir)^2 + imag(Ir)^2)^0.5
//attenuation coefficient
a = log(Irmg)
//phase shift coefficient
```

```
b = atan(imag(Ir)/real(Ir))
//propagation coefficient
r = a + %i*b

printf("\n\n Result \n\n")
printf("\nattenuation coefficient is %.3f N ",a)
printf("\nphase shift coefficient is %.3f rad ",b)
printf("\npropagation coefficient is %.3f + (%.3f)i ",a,b)
```

Scilab code Exa 42.12 Example 12

```
//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.

//initializing the variables:
L = 2*0.5; // in Henry
C = 2E-9; // in Farad

//calculation:
//time delay
t = (L*C)^0.5
//time delay at the cut-off frequency
tfc = t*%pi/2

printf("\n\n Result \n\n")
printf("\n time delay is %.2E sec ",t)
printf("\ntime delay at the cut-off frequency is %.2E sec",tfc)
```

Scilab code Exa 42.13 Example 13

```
//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.

//initializing the variables:
fc = 500000; // in Hz
t1 = 9.55E-6; // in secs
R0 = 1000; // in ohm

//calculation:
//for a low-pass filter section, capacitance
C = 1/(%pi*R0*fc)
//inductance
L = R0/(%pi*fc)
//time delay
t2 = (L*C)^0.5
//number of cascaded sections required
n = t1/t2

printf("\n\n Result \n\n")
printf("\n for low-pass T section inductance is %.2E H and capacitance is %.2E F",L/2,C)
printf("\n for low-pass pi section inductance is %.2E H and capacitance is %.2E F",L,C/2)
printf("\nnumber of cascaded sections required is %.0f",n)
```

Scilab code Exa 42.14 Example 14

```
//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.

//initializing the variables:
n = 8; // sections in cascade
R0 = 1000; // in ohm
t1 = 4E-6; // in secs


//calculation:
//time delay
t2 = t1/n
//capacitance
C = t2/R0
//inductance
L = t2*R0

printf("\n\n Result \n\n")
printf("\n for low-pass T section inductance is %.2E H and capacitance is %.2E F",L/2,C)
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

```
//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.

//initializing the variables:
Na = 1200;
Nb = 1000;
Ia = 0.8; // in amperes
Phia = 100E-6; // in Wb
xb = 0.75;

//calculation:
//self inductance of coil A
La = Na*Phia/Ia
//mutual inductance, M
Phib = xb*Phia
M = Nb*Phib/Ia
```

```
printf("\n\n Result \n\n")
printf("\n self inductance of coil A is %.2f H",La)
printf("\n mutual inductance, M is %.2E H",M)
```

Scilab code Exa 43.02 Example 2

```
//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.

//initializing the variables:
M = 600E-3; // in Henry
Ia = 5; // in amperes
dt = 0.2; // in secs

//calculation:
//change of current
dIa = 2*Ia
dIadt = dIa/dt
//secondary induced e.m.f., E2
E2 = -1*M*dIadt

printf("\n\n Result \n\n")
printf("\n secondary induced e.m.f., E2 is %.0f V",
   E2)
```

Scilab code Exa 43.03 Example 3

```
//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.

//initializing the variables:
La = 250E-3; // in Henry
Lb = 400E-3; // in Henry
M = 80E-3; // in Henry

//calculation:
//coupling coefficient,
k = M/(La*Lb)^0.5

printf("\n\n Result \n\n")
printf("\n coupling coefficient, is %.3f",k)
```

Scilab code Exa 43.04 Example 4

```
//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.

//initializing the variables:
Lx = 80E-3; // in Henry
Ly = 60E-3; // in Henry
Nx = 200; // turns
Ny = 100; // turns
Ix = 4; // in Amperes
Phiy = 0.005; // in Wb

```

```
//calculation:
//mutual inductance, M
M = Ny*Phiy/(2*Ix)
//coupling coefficient,
k = M/(Lx*Ly)^0.5

printf("\n\n Result \n\n")
printf("\n mutual inductance, M is %.2E H",M)
printf("\n coupling coefficient, is %.3f",k)
```

Scilab code Exa 43.05 Example 5

```
//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.

//initializing the variables:
La = 40E-3; // in Henry
Lb = 10E-3; // in Henry
L = 60E-3; // in Henry

//calculation:
//mutual inductance, M
M = (L - La - Lb)/2
//coupling coefficient,
k = M/(La*Lb)^0.5

printf("\n\n Result \n\n")
printf("\n mutual inductance, M is %.2E H",M)
printf("\n coupling coefficient, is %.3f",k)
```

Scilab code Exa 43.06 Example 6

```
//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.

//initializing the variables:
V = 240; // in Volts
Ra = 5; // in Ohm
La = 1; // in Henry
Rb = 10; // in Ohm
Lb = 5; // in Henry
I = 8; // in amperes
dIdt = 15; // in A/sec

//calculation:
//Kirchhoff s voltage law
L = (V - I*(Ra + Rb))/dIdt
//mutual inductance, M
M = (L - La - Lb)/2
//coupling coefficient,
k = M/(La*Lb)^0.5

printf("\n\n Result \n\n")
printf("\n mutual inductance, M is %.0f H",M)
printf("\n coupling coefficient, is %.3f",k)
```

Scilab code Exa 43.07 Example 7

```
//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.

//initializing the variables:
k = 0.7; // coefficient of coupling
L1 = 15E-3; // in Henry
L2 = 10E-3; // in Henry

//calculation:
//L1 = La + Lb + 2*k*(La*Lb)^0.5
//L2 = La + Lb - 2*k*(La*Lb)^0.5
//self inductance of coils
a = ((L1 - (L1  + L2)/2)/(2*k))^2
La1 =((L1  + L2)/2 + (((L1  + L2)/2)^2 - 4*a)^0.5)/2
La2 =((L1  + L2)/2 - (((L1  + L2)/2)^2 - 4*a)^0.5)/2
Lb1 = (L1 + L2)/2 - La1
Lb2 = (L1 + L2)/2 - La2
//mutual inductance, M
M = (L1 - L2)/4

printf("\n\n Result \n\n")
printf("\nself inductance of coils are %.2E H and %.2E H",La1, Lb1)
printf("\n mutual inductance, M is %.2E H",M)
```

Scilab code Exa 43.08 Example 8

```
//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.

//initializing the variables:
E1 = 8; // in Volts
thetae1 = 0; // in degrees
w = 2500; // in rad/sec
R = 15; // in ohm
L = 5E-3; // in Henry
M = 0.1E-3; // in Henry

//calculation:
//voltage
E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
    /180)
//Impedance of primary
Z1 = R + %i*w*L
//Primary current I1
I1 = E1/Z1
//E2
E2 = %i*w*M*I1

printf("\n\n Result \n\n")
printf("\nE2 is %.2f + (%.2f)i V",real(E2), imag(E2)
    )
```

Scilab code Exa 43.09 Example 9

```
//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.

//initializing the variables:
Lx = 20E-3; // in Henry
Ly = 80E-3; // in Henry
k = 0.75; // coupling coeff.
Ex = 5; // in Volts

//calculation:
//mutual inductance
M = k*(Lx*Ly)^0.5
//magnitude of the open circuit e.m.f. induced
Ey = M*Ex/Lx

printf("\n\n Result \n\n")
printf("\n mutual inductance is %.2f H",M)
printf("\n magnitude of the open circuit e.m.f. induced is %.2f V",Ey)
```

Scilab code Exa 43.10 Example 10

```
//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.

//initializing the variables:
E1 = 2; // in Volts
thetae1 = 0; // in degrees
f = 1000/%pi; // in Hz
R1 = 4; // in ohm
R2 = 16; // in ohm
```

```
R3 = 16; // in ohm
R4 = 50; // in ohm
L = 10E-3; // in Henry
M = 2E-3; // in Henry

//calculation:
w = 2*%pi*f
//voltage
E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
    /180)
//R1e is the real part of Z1e
R1e = R1 + R2 + ((R3 + R4)*(M^2)*(w^2))/((R3 + R4)^2
     + (w*L)^2)
//X1e is the imaginary part of Z1e
X1e = w*L - (L*(M^2)*(w^3))/((R3 + R4)^2 + (w*L)^2)
Z1e = R1e + %i*X1e
Z2e = R3 + R4 + %i*w*L
//primary current, I1
I1 = E1/Z1e
//E2
E2 = %i*w*M*I1
//secondary current I2
I2 = E2/Z2e

printf("\n\n Result \n\n")
printf("\n secondary current I2 is %.2E +(%.2E)i A",
    real(I2), imag(I2))
```

Scilab code Exa 43.11 Example 11

```
//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

//initializing the variables:
E1 = 50; // in Volts
thetae1 = 0; // in degrees
w = 500; // in rad/sec
R1 = 300; // in ohm
L1 = 0.2; // in Henry
L2 = 0.5; // in Henry
L3 = 0.3; // in Henry
R2 = 500; // in ohm
C = 5E-6; // in farad
M = 0.2; // in Henry

//calculation:
//voltage
E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi/180)
// Self impedance of primary circuit
Z1 = R1 + %i*w*(L1 + L2)
//Self impedance of secondary circuit,
Z2 = R2 + %i*(w*L3 - 1/(w*C))
//reflected impedance, Zr
Zr = (w*M)^2/Z2
//Effective primary impedance,
Z1e = Z1 + Zr
//Primary current I1
I1 = E1/Z1e
//Secondary current I2
E2 = %i*w*M*I1
I2 = E2/Z2

printf("\n\n Result \n\n")
printf("\n Self impedance of primary circuit, Z1 is %.0f + (%.0f)i ohm",real(Z1), imag(Z1))
printf("\n Self impedance of secondary circuit, Z2 is %.0f + (%.0f)i ohm",real(Z2), imag(Z2))
```

```
printf("\n reflected impedance, Zr is %.0f +(%.0f)i ohm",real(Zr), imag(Zr))
printf("\n Effective primary impedance Z1(eff) is %.0f +(%.0f)i ohm",real(Z1e), imag(Z1e))
printf("\n primary current I1 is %.2f +(%.2f)i A",real(I1), imag(I1))
printf("\n secondary current I2 is %.2f +(%.2f)i A",real(I2), imag(I2))
```

Scilab code Exa 43.12 Example 12

```
//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.

//initializing the variables:
E1 = 20; // in Volts
thetae1 = 0; // in degrees
R1 = 15; // in ohm
C1 = 400E-12; // in farad
R2 = 30; // in ohm
L1 = 0.001; // in Henry
L2 = 0.0002; // in Henry
R3 = 50; // in ohm
M = 10E-6; // in Henry

//calculation:
//voltage
E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi/180)
//the resonant frequency, fr
```

```
fr = 1/(2*%pi*(L1*C1)^0.5)
w = 2*%pi*fr
//The secondary is also tuned to a resonant frequency
//capacitance,C2
C2 = 1/(L2*(2*%pi*fr)^2)
//the effective primary impedance Z1eff
Z1e = R1 + R2 + ((w*M)^2)/R3
//Primary current I1
I1 = E1/Z1e
//Secondary current I2
E2 = %i*w*M*I1
I2 = E2/R3
//voltage across capacitor C2
Vc2 = I2*-1*%i/(w*C2)
//coefficient of coupling, k
k = M/(L1*L2)^0.5

printf("\n\n Result \n\n")
printf("\n the resonant frequency,fr is %.0f Hz",fr)
printf("\n capacitance,C2 is %.2E F",C2)
printf("\n Effective primary impedance Z1(eff) is %.0f +(%.0f)i ohm",real(Z1e), imag(Z1e))
printf("\n primary current I1 is %.2f +(%.2f)i A",real(I1), imag(I1))
printf("\n voltage across capacitor C2 is %.0f +(%.0f)i V",real(Vc2), imag(Vc2))
printf("\n coefficient of coupling, k  is %.4f",k)
```

Scilab code Exa 43.13 Example 13

```
//Problem 43.13:For the coupled circuit shown in Figure 43.16, determiine the values of currents I1 and I2.

```

```
//initializing the variables:
E1 = 250; // in Volts
thetae1 = 0; // in degrees
R1 = %i*50; // in ohm
R2 = 10; // in ohm
R3 = 10; // in ohm
R4 = %i*50; // in ohm
R5 = 50; // in ohm
M = %i*10; // in ohm

//calculation:
//voltage
E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi/180)
//Applying Kirchhoff s voltage law to the primary circuit gives
//(R1 + R2)*I1 - M*I2 = E1
//Applying Kirchhoff s voltage law to the secondary circuit gives
//-1*M*I1 + ( R3 + R4 + R5)*I2 = 0
//solving these two
I2 = E1/((R1 + R2)*(R3 + R4 + R5)/(M) + (-1*M))
I1 = I2*(R3 + R4 + R5)/(M)

printf("\n\n Result \n\n")
printf("\n primary current I1 is %.2f +(%.2f)i A", real(I1), imag(I1))
printf("\n secondary current I2 is %.2f +(%.2f)i A", real(I2), imag(I2))
```

Scilab code Exa 43.14 Example 14

```
//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.

//initializing the variables:
re = 40; // in Volts
thetae1 = 0; // in degrees
R1 = 5; // in ohm
L1 = 0.001; // in Henry
L2 = 0.006; // in Henry
R2 = 40; // in ohm
rzl = 200; // in ohm
thetazl = -60; // in degrees
k = 0.70
f = 20000; // in Hz

//calculation:
w = 2*%pi*f
//voltage
E1 = re*cos(thetae1*%pi/180) + %i*re*sin(thetae1*%pi
   /180)
//impedance
ZL = rzl*cos(thetazl*%pi/180) + %i*rzl*sin(thetazl*
   %pi/180)
//mutual inductance, M
M = k*(L1*L2)^0.5
//Applying Kirchhoff s voltage law to the primary
   circuit gives
//(R1 + %i*w*L1)*I1 - %i*w*M*I2 = E1
//Applying Kirchhoff s voltage law to the
   secondary circuit gives
//-1*%i*w*M*I1 + ( R2 + ZL + %i*w*L2)*I2 = 0
//solving these two
I1 = E1/((R1 +%i*w*L1) - (%i*w*M)^2/(R2 + ZL + %i*w*
   L2))
//secondary terminal p.d.
pd = I2*ZL
```

```
printf("\n\n Result \n\n")
printf("\n mutual induction M is %.2E H",M)
printf("\n primary current I1 is %.2f +(%.2f)i A", real(I1), imag(I1))
printf("\n secondary terminal p.d. is %.2f +(%.2f)i V",real(pd), imag(pd))
```

Scilab code Exa 43.15 Example 15

```
//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.

//initializing the variables:
E1 = 50; // in Volts
thetae1 = 0; // in degrees
r = 5; // in ohm
R1 = 20; // in ohm
L1 = 0.2; // in Henry
L2 = 0.4; // in Henry
R2 = 25; // in ohm
RL = 20; // in ohm
M = 0.1; // in Henry
f = 75/%pi; // in Hz

//calculation:
w = 2*%pi*f
//voltage
```

```
E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi
    /180)
//Applying Kirchhoff s voltage law to the primary
    circuit gives
//(r + R1 + %i*w*L1)*I1 - %i*w*M*I2 = E1
//Applying Kirchhoff s voltage law to the
    secondary circuit gives
//-1*%i*w*M*I1 + ( R2 + RL + %i*w*L2)*I2 = 0
//solving these two
I2 = E1/((r + R1 + %i*w*L1)*(R2 + RL + %i*w*L2)/(%i*
    w*M) + (-1*%i*w*M))
I1 = I2*(R2 + RL + %i*w*L2)/(%i*w*M)

printf("\n\n Result \n\n")
printf("\n primary current I1 is %.2f +(%.2f)i A",
    real(I1), imag(I1))
printf("\n load current I2 is %.2f +(%.2f)i A",real(
    I2), imag(I2))
```

Scilab code Exa 43.16 Example 16

```
//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).

//initializing the variables:
E1 = 50; // in Volts
thetae1 = 0; // in degrees
r = 5; // in ohm
R1 = 20; // in ohm
L1 = 0.2; // in Henry
R = 8; // in ohm
```

```
L = 0.1; // in Henry
L2 = 0.4; // in Henry
R2 = 25; // in ohm
RL = 20; // in ohm
M = 0.1; // in Henry
f = 75/%pi; // in Hz

//calculation:
w = 2*%pi*f
//voltage
E1 = E1*cos(thetae1*%pi/180) + %i*E1*sin(thetae1*%pi/180)
//Applying Kirchhoff s voltage law to the primary circuit gives
//(r + R1 + %i*w*L1 + R + %i*w*L)*I1 - (%i*w*M + R + %i*w*L)*I2 = E1
//Applying Kirchhoff s voltage law to the secondary circuit gives
//-1*(%i*w*M + R + %i*w*L)*I1 + (R2 + RL + %i*w*L2 + R + %i*w*L)*I2 = 0
//solving these two
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)))
I1 = I2*(R2 + RL + %i*w*L2 + R + %i*w*L)/(%i*w*M + R + %i*w*L)
//reversing
//Applying Kirchhoff s voltage law to the primary circuit gives
//(r + R1 + %i*w*L1 + R + %i*w*L)*I1r - (-1*%i*w*M + R + %i*w*L)*I2r = E1
//Applying Kirchhoff s voltage law to the secondary circuit gives
//-1*(-1*%i*w*M + R + %i*w*L)*I1r + (R2 + RL + %i*w*L2 + R + %i*w*L)*I2r = 0
//solving these two
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)))
I1r = I2r*(R2 + RL + %i*w*L2 + R + %i*w*L)/((-1*%i*w*M + R + %i*w*L))

printf("\n\n Result \n\n")
printf("\n primary current I1 is %.2f +(%.2f)i A", real(I1), imag(I1))
printf("\n load current I2 is %.2f +(%.2f)i A",real(I2), imag(I2))
printf("\n reversed primary current I1r is %.2f +(%.2f)i A",real(I1r), imag(I1r))
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

```
//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.

//initializing the variables:
f = 1910; // in Hz
b = 0.05; // in rad/km

//calculation:
w = 2*%pi*f
//wavelength
Y = 2*%pi/b
//speed of transmission
u = f*Y

printf("\n\n Result \n\n")
printf("\n wavelength Y is %.1f km",Y)
printf("\n speed of transmission %.2E km/sec",u)
```

Scilab code Exa 44.02 Example 2

```
//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.

//initializing the variables:
L = 0.004; // in Henry/loop
C = 0.004E-6; // in F/loop
f = 1000; // in Hz

//calculation:
w = 2*%pi*f
//phase delay
b = w*(L*C)^0.5
//wavelength
Y = 2*%pi/b
//speed of transmission
u = f*Y

printf("\n\n Result \n\n")
printf("\n phase delay is %.3f rad/km",b)
printf("\n wavelength Y is %.1f km",Y)
printf("\n speed of transmission %.2E km/sec",u)
```

Scilab code Exa 44.03 Example 3

```
//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.

//initializing the variables:
a = 0.25; // in Np/km
b = 0.20; // in rad/km
Vs = 5; // in Volts
n = 10; // in km
f = 2000; // in Hz

//calculation:
w = 2*%pi*f
//the voltage 10 km down the line
r = a + %i*b
VR = Vs*%e^(-1*n*r)

printf("\n\n Result \n\n")
printf("\n the voltage 10 km down the line is %.2f
    +(%.2f)i A",real(VR), imag(VR))
```

Scilab code Exa 44.04 Example 4

```
//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.

//initializing the variables:
```

```
a = 0.5; // in Np/km
b = 0.25; // in rad/km
rvs = 2; // in Volts
thetavs = 0; // in degrees
rzo = 800; // in ohm
thetazo = -25; // in degrees
n = 5; // in km

//calculation:
//voltage
Vs = rvs*cos(thetavs*%pi/180) + %i*rvs*sin(thetavs*
    %pi/180)
//characteristic impedance
Zo = rzo*cos(thetazo*%pi/180) + %i*rzo*sin(thetazo*
    %pi/180)
// receiving end voltage
r = a + %i*b
VR = Vs*%e^(-1*n*r)
//Receiving end current,
IR = VR/Zo

printf("\n\n Result \n\n")
printf("\n Receiving end current, IR is %.2E +(%.2E)
    i A",real(IR), imag(IR))
```

Scilab code Exa 44.05 Example 5

```
//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.

//initializing the variables:
```

```
Vs = 8; // in Volts
VR = 2; // in Volts
x = 2;

//calculation:
// receiving end voltage VR = Vs*e^(-nr)
//e^-nr = p
p = VR/Vs
//If the line is doubled in length, then
VR = Vs*(p)^2

printf("\n\n Result \n\n")
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

```
//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.

//initializing the variables:
rzoc = 800; // in ohm
thetazoc = -50; // in degrees
rzsc = 413; // in ohm
thetazsc = -20; // in degrees
f = 1500; // in Hz

//calculation:
//open circuit impedance
Zoc = rzoc*cos(thetazoc*%pi/180) + %i*rzoc*sin(
```

```
   thetazoc*%pi/180)
//short circuit impedance
Zsc = rzsc*cos(thetazsc*%pi/180) + %i*rzsc*sin(
   thetazsc*%pi/180)
//characteristic impedance Zo
Zo = (Zoc*Zsc)^0.5

printf("\n\n Result \n\n")
printf("\n characteristic impedance Zo is %.0f +(%.0
   f)i ohm",real(Zo), imag(Zo))
```

Scilab code Exa 44.07 Example 7

```
//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.

//initializing the variables:
R = 15; // in ohm/loop km
L = 0.0034; // in H/loop km
C = 10E-9; // in F/km
G = 3E-6; // in S/km
f = 2000; // in Hz

//calculation:
w = 2*%pi*f
//characteristic impedance Zo
Zo = ((R + %i*w*L)/(G + %i*w*C))^0.5

printf("\n\n Result \n\n")
printf("\n characteristic impedance Zo is %.1f +(%.1
   f)i ohm",real(Zo), imag(Zo))
```

Scilab code Exa 44.08 Example 8

```
//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.

//initializing the variables:
L = 0.0005; // in H/loop km
C = 0.12E-6; // in F/km
f = 400000; // in Hz

//calculation:
w = 2*%pi*f
//characteristic impedance Zo
Zo = (L/C)^0.5
//the propagation coefficient
r = %i*w*(L*C)^0.5
//the attenuation coefficient
a = real(r)
//the phaseshift coefficient
b = imag(r)
//wavelength
Y = 2*%pi/b
//velocity of propagation
u = f*Y

printf("\n\n Result \n\n")
printf("\n characteristic impedance Zo is %.1f +(%.1
```

```
    f)i ohm",real(Zo), imag(Zo))
printf("\n propagation coefficient is %.2f +(%.2f)i"
    ,a,b)
printf("\n wavelength Y is %.3f km",Y)
printf("\n speed of transmission %.2E km/sec",u)
```

Scilab code Exa 44.09 Example 9

```
//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.

//initializing the variables:
R = 25; // in ohm/loop km
L = 0.005; // in H/loop km
C = 0.04E-6; // in F/km
G = 80E-6; // in S/km
f = 1000; // in Hz

//calculation:
w = 2*%pi*f
//characteristic impedance Zo
Zo = ((R + %i*w*L)/(G + %i*w*C))^0.5
//the propagation coefficient
r =((R + %i*w*L)*(G + %i*w*C))^0.5
//the attenuation coefficient
a = real(r)
//the phaseshift coefficient
b = imag(r)

```

```
printf("\n\n Result \n\n")
printf("\n characteristic impedance Zo is %.1f +(%.1
    f)i ohm",real(Zo), imag(Zo))
printf("\n propagation coefficient is %.4f +(%.4f)i"
    ,a,b)
printf("\n attenuation coefficient is %.4f Np/km",a)
printf("\n the phaseshift coefficient %.4f rad/km",b
    )
```

Scilab code Exa 44.10 Example 10

```
//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.

//initializing the variables:
R = 8; // in ohm/loop km
L = 0.003; // in H/loop km
C = 7500E-12; // in F/km
G = 0.25E-6; // in S/km
f = 1000; // in Hz
n = 300; // in km
Zg = 400 + %i*0; // in ohm
Vg = 10; // in Volts

```

```
//calculation:
w = 2*%pi*f
//characteristic impedance Zo
Zo = ((R + %i*w*L)/(G + %i*w*C))^0.5
//the propagation coefficient
r = ((R + %i*w*L)*(G + %i*w*C))^0.5
//the attenuation coefficient
a = real(r)
//the phaseshift coefficient
b = imag(r)
//the sending-end current,
Is = Vg/(Zg + Zo)
//the receiving-end current,
IR = Is*%e^(-1*n*r)
//wavelength
Y = 2*%pi/b
//velocity of propagation
u = f*Y

printf("\n\n Result \n\n")
printf("\n characteristic impedance Zo is %.1f +(%.1f)i ohm",real(Zo), imag(Zo))
printf("\n propagation coefficient is %.2f +(%.2f)i",a,b)
printf("\n attenuation coefficient is %.4f Np/km and the phaseshift coefficient %.4f rad/km",a,b)
printf("\n sending-end current Is is %.3E +(%.3E)i A",real(Is), imag(Is))
printf("\n receiving-end current IR is %.3E +(%.3E)i A",real(IR), imag(IR))
printf("\n wavelength Y is %.3f km",Y)
printf("\n speed of transmission %.2E km/sec",u)
```

Scilab code Exa 44.11 Example 11

```
//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.

//initializing the variables:
R = 10; // in ohm/loop km
L = 0.0015; // in H/loop km
C = 0.06E-6; // in F/km
G = 1.2E-6; // in S/km

//calculation:
//the condition for minimum distortion is given by LG = CR, from which,
Lm = C*R/G
dL = Lm - L

printf("\n\n Result \n\n")
printf("\n inductance should be increased by %.2E H/loop km for minimum distortion",dL)
```

Scilab code Exa 44.12 Example 12

```
//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

```

```
//initializing the variables:
R = 80; // in ohm/loop km
C = 5E-9; // in F/km
G = 2E-6; // in S/km
f = 1500; // in Hz

//calculation:
w = 2*%pi*f
//the condition for minimum distortion is given by
    LG = CR, from which, inductance
L = C*R/G
//attenuation coefficient,
a = (R*G)^0.5
//phase shift coefficient,
b = w*(L*C)^0.5
//propagation coefficient,
r = a + %i*b
//velocity of propagation,
u = 1/(L*C)^0.5
//wavelength
Y = u/f

printf("\n\n Result \n\n")
printf("\n inductance is %.2f H",L)
printf("\n propagation coefficient is %.4f +(%.4f)i"
    ,a,b)
printf("\n wavelength Y is %.2f km",Y)
printf("\n speed of transmission %.2E km/sec",u)
```

Scilab code Exa 44.13 Example 13

```
//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.

//initializing the variables:
Zo = 75; // in ohm
ZR = 250; // in ohm
VR = 10; // in Volts

//calculation:
//reflection coefficient
p = (Zo - ZR)/(Zo + ZR)
//Current flowing in the terminating load
IR = VR/ZR
//incident current, Ii
Ii = IR/(1 + p)
//incident voltage, Vi
Vi = Ii*Zo
//reflected current, Ir
Ir = IR - Ii
//reflected voltage, Vr
Vr = -1*Ir*Zo

printf("\n\n Result \n\n")
printf("\n reflection coefficient is %.3f",p)
printf("\n incident current, Ii is %.4f A",Ii)
printf("\n incident voltage, Vi is %.2f V",Vi)
printf("\n reflected current, Ir is %.4f A",Ir)
printf("\n reflected voltage, Vr is %.2f V",Vr)
```

Scilab code Exa 44.14 Example 14

```
//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.

//initializing the variables:
Zo = 500 - %i*40; // in ohm
ZR1 = 500 + %i*40; // in ohm
ZR2 = 600 + %i*20; // in ohm

//calculation:
//reflection coefficient
p1 = (Zo - ZR1)/(Zo + ZR1)
p2 = (Zo - ZR2)/(Zo + ZR2)
p1mag = (real(p1)^2 + imag(p1)^2)^0.5
p2mag = (real(p2)^2 + imag(p2)^2)^0.5

printf("\n\n Result \n\n")
printf("\n reflection coefficient (a)%.3f and (b)%.3
   f",p1mag, p2mag)
```

Scilab code Exa 44.15 Example 15

```
//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

//initializing the variables:
rzo = 500; // in ohm
thetazo = 0; // in degrees
ZR = 320 + %i*240; // in ohm
```

```
rvr = 20; // in volts
thetavr = 35; // in degrees

//calculation:
//voltage
VR = rvr*cos(thetavr*%pi/180) + %i*rvr*sin(thetavr*%pi/180)
//characteristic impedance
Zo = rzo*cos(thetazo*%pi/180) + %i*rzo*sin(thetazo*%pi/180)
//the ratio of the reflected to the incident voltage
//vr = VR/Vi
vr = (ZR - Zo)/(Zo + ZR)
vrmag = (real(vr)^2 + imag(vr)^2)^0.5
//incident voltage, Vi
Vi = VR/vr

printf("\n\n Result \n\n")
printf("\n the magnitude of the ratio Vr : Vi is %.3f",vrmag)
printf("\n incident voltage, Vi is %.2f +(%.2f)i V",real(Vi), imag(Vi))
```

Scilab code Exa 44.16 Example 16

```
//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.

//initializing the variables:
rzo = 600; // in ohm
thetazo = 0; // in degrees
```

```
ZR = 400 + %i*250; // in ohm

//calculation:
//characteristic impedance
Zo = rzo*cos(thetazo*%pi/180) + %i*rzo*sin(thetazo*%pi/180)
//reflection coefficient
p = (Zo - ZR)/(Zo + ZR)
pmag = (real(p)^2 + imag(p)^2)^0.5
//standing-wave ratio,
s = (1 + pmag)/(1 - pmag)

printf("\n\n Result \n\n")
printf("\n reflection coefficient, is %.4f +(%.4f)i V",real(p), imag(p))
printf("\n standing-wave ratio, s is %.3f",s)
```

Scilab code Exa 44.17 Example 17

```
//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.

//initializing the variables:
rp = 0.2;
thetap = -120; // in degrees
Zo = 80; // in ohm
Ir = 0.01; // in Amperes

//calculation:
//reflection coefficient
```

```
p = rp*cos(thetap*%pi/180) + %i*rp*sin(thetap*%pi/180)
//standing-wave ratio,
s = (1 + rp)/(1 - rp)
//load impedance ZR
ZR = Zo*(1 - p)/(1 + p)
//incident current
Ii = Ir*(s + 1)/(s - 1)

printf("\n\n Result \n\n")
printf("\n standing-wave ratio, s is %.1f",s)
printf("\n load impedance ZR is %.2f +(%.2f)i ohm",real(ZR), imag(ZR))
printf("\n incident current is %.3f A",Ii)
```

Scilab code Exa 44.18 Example 18

```
//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.

//initializing the variables:
s = 1.6;
Pi = 0.2; // in Watts

//calculation:
//reflected power, Pr
Pr = Pi*((s - 1)/(s + 1))^2

printf("\n\n Result \n\n")
printf("\n reflected power, Pr is %.5f W",Pr)
```

Chapter 45

Transients and Laplace transforms

Scilab code Exa 45.01 Example 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.

//initializing the variables:
C = 500E-9; // in Farad
R = 100000; // in Ohm
V = 50; // in VOlts
ti = 0.15; // in sec
tc = 0.08; // in sec
Vrt = 35; // in Volts

//calculation:
//Initial current,
```

```
i0 = (V/R)
//when time t = 150ms current is
i150 = (V/R)*%e^(-1*ti/(R*C))
//capacitor voltage , Vc
Vc = V*(1 - %e^(-1*tc/(R*C)))
//time , t
tvr = -1*R*C*log(Vrt/V)

printf("\n\n Result \n\n")
printf("\n initial value of current flowing is %.2E A",i0)
printf("\n current flowing at t = 150ms is %.2E A",i150)
printf("\n value of capacitor voltage at t = 80ms is %.2f V",Vc)
printf("\n the time after connection when the resistor voltage is 35 V is %.4f sec",tvr)
```

Scilab code Exa 45.02 Example 2

```
//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.

//initializing the variables:
C = 5E-6; // in Farad
R = 2000000; // in Ohm
V = 200; // in VOlts
tc = 20; // in sec

//calculation:
```

```
//capacitor voltage, Vc
Vc = V*(%e^(-1*tc/(R*C)))

printf("\n\n Result \n\n")
printf("\n value of capacitor voltage at t = 20s is %.2f V",Vc)
```

Scilab code Exa 45.03 Example 3

```
//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.

//initializing the variables:
L = 0.05; // in Henry
R = 5; // in Ohm
V = 110; // in VOlts
ti = 0.004; // in sec
tvr = 0.006; // in sec
tvl = 0.006; // in sec
it = 15; // in amperes

//calculation:
//steady state current i
i = V/R
//when time t = 4ms current is
i4 = (V/R)*(1 - %e^(-1*ti*R/L))
//resistor voltage, VR
VR6 = V*(1 - %e^(-1*tvr*R/L))
//inductor voltage, VL
```

```
VL6 = V*(%e^(-1*tvl*R/L))
//time, t
ti = (-1*L/R)*log(1 - it*R/V)

printf("\n\n Result \n\n")
printf("\n steady state current i is %.0f A",i)
printf("\n when time t = 4ms current is is %.2f A",i4)
printf("\n  value of resistor voltage at t = 6ms is %.2f V",VR6)
printf("\n  value of inductor voltage at t = 6ms is %.2f V",VL6)
printf("\n  the time after connection when the current is 15 A is %.5f sec",ti)
```

Scilab code Exa 45.04 Example 4

```
//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.

//initializing the variables:
i = 5; // in Amperes
L = 2 // in Henry
i1 = 0.2; // in Amperes
R = 10; // in Ohm

//calculation:
//time t
ti = (-1*L/R)*log(i1/i)
//voltage across the resistor is a maximum
VRm = i*R
```

```
printf("\n\n Result \n\n")
printf("\n  time t for the current in the 2 H
    inductor to fall to 200 mA is %.3f sec",ti)
printf("\n  max voltage across the resistor is %.0f
    V",VRm)
```

Scilab code Exa 45.05 Example 5

```
//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.

//initializing the variables:
L = 0.002 // in Henry
R = 1000; // in Ohm
C1 = 5E-6; // in farad
C2 = 5E-9; // in farad

//calculation:
a = (R/(2*L))^2
b = 1/(L*C1)
if (a>b) then
    s1 = "overdamped";
elseif (a<b) then
    s1 = "underdamped";
else
    s1 = "critically damped";
end
c = 1/(L*C2)
if (a>c) then
    s2 = "overdamped";
elseif (a<c) then
```

```
    s2 = "underdamped";
else
    s2 = "critically damped";
end

printf("\n\n Result \n\n")
printf("\n  circuit is %s",s1)
printf("\n  if C = 5 nF, circuit is %s",s2)
```

Scilab code Exa 45.06 Example 6

```
//Problem 45.06: In the circuit of problem 45.05,
   what value of capacitance will give critical
   damping ?


//initializing the variables:
L = 0.002 // in Henry
R = 1000; // in Ohm

//calculation:
a = (R/(2*L))^2
//for critically damped
C = 4*L/R^2

printf("\n\n Result \n\n")
printf("\n  capacitance C is %.2E F",C)
```