Scilab Textbook Companion for Electrical Engineering Fundamentals by V. Del Toro[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

The Fundamental laws of Electrical Engineering

Scilab code Exa 1.1 force between two like charges in free space

```
E0 = 1/(36*%pi*10^9); //permitivity in free space
k = 4*%pi*E0 ;
q1 = 1; // charge on the first particle in coulombs
q2 = 1; // charge on the second particle in coulombs
d = 1; // distance between the particles in meter
F = (q1*q2)/(k*d^2); //force between the two
   particles in newtons

disp(F, "force in free space between the two
   particles is in Newtons is:")
```

Chapter 2

The circuit elements

Scilab code Exa 2.1.a Determine the current flow and voltage drop across the resistor

```
V = 1; // voltage supply
R = 10; // resistance in ohms
I = V/R //current flowing through R
disp("a)")
disp(V,"voltage across the resistor (in volts)=")
disp(I,"current flowing through the resistor (in
    amps) =")
```

Scilab code Exa 2.1.b Determine the current flow and voltage drop across each resistor

```
V = 1; // voltage supply
R1 = 10; // first resistance in ohms
R2 = 5; //resistance of the second resistor
Vr1 = V * (R1/(R1 + R2)); //voltage across R1
Vr2 = V - Vr1; //voltage across R2
Ir = Vr1/R1; //current flowing through R
```

```

disp(Vr1,"voltage across the first resistor (in volts)=")
disp(Vr2,"voltage across the second resistor (in volts)=")
disp(Ir,"current flowing through the resistor (in amps) =")
```

Scilab code Exa 2.1.c Repeat parts A and B with the voltage source replaced by a current source of 1A

```
//c - a
R1 = 10; // first resistance in ohms
I = 1; // current source
V = I*R1; // voltage across R
disp("c - a)")
disp(V,"voltage across the resistor (in volts)=")
disp(I,"current flowing through the resistor (in amps) =")

//c - b
Vr1 = I*R1; // voltage across R1
Vr2 = I*R2; //voltage across R2
disp("c - b)")
disp(Vr,"voltage across the resistor (in volts)=")
disp(I,"current flowing through the resistor (in amps) =")
```

Scilab code Exa 2.2 From the given list of resistors choose a suitable resistor which can carry a current of 300mA

```
R = 100; // resistance in ohms
I = 0.3; // current in amps
```

```
P = I^2 * R; // power
//power specification of the resistors available in the stock
Pa = 5;
Pb = 7.5;
Pc = 10;

if Pa > P then
    disp(”we should select resistor a”)
end
if Pb > P then
    disp(”we should select resistor b”)
end
if Pc > P then
    disp(”we should select resistor c”)
end
```

Scilab code Exa 2.3 Find the resistance of the round copper conductor having the given specifications

```
L = 1; //length of the copper wire in meters
A = 1 * 10^-4; // cross sectional area of the wire in meter square
rho = 1.724 * 10^-8; // resistivity of copper in ohm meter
R = rho*L / A; // resistance of the wire in ohm

disp(R, ”resistance of the wire (in ohms)=”)
```

Scilab code Exa 2.4 Find the resistance of the round copper conductor having the given specifications

```
//1 inches = 0.0254meters
```

```
//1 foot = 0.3048 meters
d = 0.1*0.0254; // diameter of the wire in meters
L = 10*0.3048; //length of the wire in meters
rho = 1.724*10^-8; // resistivity of the wire in ohm-meter
A = %pi*(d/2)^2; // cross sectional area of the wire
R = rho*L/A; //resistance of the wire in ohm
disp(R,"resistance of the wire (in ohm)=")
```

Scilab code Exa 2.5 Find the time variation of the voltage drop appearing across the inductor terminals

```
L = 0.1; // inductance of the coil in henry
t1 = [0:0.001:0.1];
t2 = [0.101:0.001:0.3];
t3 = [0.301:0.001:0.6];
t4 = [0.601:0.001:0.7];
t5 = [0.701:0.001:0.9]
//current variation as a function of time
i1 = 100*t1;
i2 = (-50*t2) + 15;
i3 = -100*sin(%pi*(t3-0.3)/0.3);
i4 = (100*t4) - 60;
i5 = (-50*t5) + 45;

t = [t1,t2,t3,t4,t5];
i = [i1,i2,i3,i4,i5];
plot(t, i)

dt = 0.001;
di = diff(i);
V = L*di/dt; //voltage drop appearing across the inductor terminals
```

```
Tv = [0:0.001:0.899];
plot(Tv, V, "green")
```

Scilab code Exa 2.6 Find the time variation of the capacitor voltage

```
C = 0.01; // capacitance of the capacitor in Farads
t1 = [0:0.001:0.1];
t2 = [0.101:0.001:0.3];
t3 = [0.301:0.001:0.6];
t4 = [0.601:0.001:0.7];
t5 = [0.701:0.001:0.9]
//current variation as a function of time
i1 = 100*t1;
i2 = (-50*t2) + 15;
i3 = -100*sin(%pi*(t3-0.3)/0.3);
i4 = (100*t4) - 60;
i5 = (-50*t5) + 45;

t = [t1,t2,t3,t4,t5];
i = [i1,i2,i3,i4,i5];
plot(t, i)

// voltage across the capacitor as a function of time
V1 = (1/C)*integrate('100*t','t',0,t1);
V2 = (1/C)*integrate('(-50*t)+15','t',0.101,t2);
V3 = (1/C)*integrate('-100*sin(%pi*(t-0.3)/0.3)','t',0.301,t3);
V4 = (1/C)*integrate('(100*t) - 60','t',0.601,t4);
V5 = (1/C)*integrate('(-50*t) + 45','t',0.701,t5);
V = [V1, V2, V3, V4, V5];

plot(t, V, "green")
```

Scilab code Exa 2.7 Find A actual value of the voltage gain of the opamp circuit B ideal value of the voltage gain C percent error

```
//a
Ri = 1;
Rf = 39;
A = 10^5; //open loop gain of the op-amp
G = A/(1 + (A*Ri/(Ri+Rf))); //actual voltage gain of
    the circuit
disp("a")
disp(G,"actual voltage of the circuit =")

//b
G1 = 1 + (Rf/Ri); // voltage gain of the circuit
   with infinite open loop gain
disp("b")
disp(G1,"for ideal case the voltage gain =")

//c
er = ((G1 - G)/G)*100; //percent error
disp("c")
disp(er,"percent error of the ideal value compared
   to the actual value=")
```

Scilab code Exa 2.8 Design a non inverting opamp circuit of voltage gain 4

```
G = 4; // voltage gain of the circuit
r = G -1; // ratio of the resistances in the non-
   inverting op-amp circuit
disp(r,"Rf/Ri =")
```

```
//Result:
//A suitable choice for R1 is 10K, Hence Rf = 30K
```

Scilab code Exa 2.9 Find the input resistance of an inverting opamp circuit with voltage gain of 4

```
G = 4;
r = G; // ratio of the resistances in the inverting op-amp circuit
disp(r,"Rf/Ri")
//Result;
//A suitable choice for Rf=30K and R1=7.5K
//therefore input resistance R1 = 7.5K
```

This code can be downloaded from the website wwww.scilab.in

Chapter 3

Elementary network theory

Scilab code Exa 3.1 for the given circuit calculate the current flowing from the voltage source

```
V = 100; // volatage supply in volts
Rs = 40; //resistance in series in ohms
// parallel resistances in ohms
Rp1 = 33.33;
Rp2 = 50;
Rp3 = 20;
Rpinv = (1/Rp1)+(1/Rp2)+(1/Rp3); //reciprocal of
   equivalent resistance in  parallel
Req = Rs + (1/Rpinv) ;
I = V/Req; //current flowing from the voltage source
    in amps
disp(I,"current flowing from the voltage source(in
   amps) = ")
```

Scilab code Exa 3.2 Calculate the potential difference across terminals bc

```
V = 100; // volatage supply in volts
```

```
Rs = 40; //resistance in series in ohms
// parallel resistances in ohms
Rp1 = 33.33;
Rp2 = 50;
Rp3 = 20;
Rpinv = (1/Rp1)+(1/Rp2)+(1/Rp3); //reciprocal of
   equivalent resistance in  parallel
Rp = 1/Rpinv; // equivalent esistance in parallel
Vbc = V*(Rp/(Rs + Rp)); // potential difference
   across bc
disp(Vbc,"potential difference across bc = ")
```

Scilab code Exa 3.3 Determine the equivalent series circuit

```
// resistances in ohms
R1 = 25;
R2 = 300;
R3 = 80;
R4 = 30;
R5 = 60;

Rcd = R5*R4/(R5 + R4);
Rbd1 = Rcd + R3;
Rbd = Rbd1*R2/(Rbd1 + R2);
Req = Rbd + R1; // equivalent resistance
disp(Req, "equivalent resistance = ")
```

Scilab code Exa 3.4 Value of E for which power dissipation in R5 is 15W R5 is 15

```
// resistances in ohms
R1 = 25;
R2 = 300;
```

```
R3 = 80;
R4 = 30;
R5 = 60;

P5 = 15; //power dissipated in R5 (in watt)

I5 = sqrt(P5/R5); //current flowing through R5
V5 = R5*I5 ; //voltage across R5
Vcd = V5; //voltage across cd

I4 = Vcd/R4; //current flowing through R4
Icd = I5 + I4; //current flowing through cd

Vbd = (Icd*R3)+Vcd ; //voltage across bd
Ibd = (Vbd/R2)+Icd; //current through bd

V1 = R1*Ibd; //voltage across R1

E = V1 + Vbd;
disp(E,"E = ")

//Result : Value of E for which power dissipation in
    R is 15W = 200V
```

Scilab code Exa 3.8 Find current flowing through all the branches of the circuit

```
//mesh equations:
//60*I1 - 20*I2 = 20
//-20*I1 + 80*I2 = -65

R = [60 -20;-20 80];
E = [120;-65];
I = inv(R)*E;
I1 = I(1,:); //current flowing in first mesh
I2 = I(2,:); //current flowing in second mesh

Ibd = I1 - I2; //current flowing through branch bd
Iab = I1; //current flowing through branch ab
Icb = -I2; //current flowing through branch cb

disp(Ibd, "current flowing through branch bd = ")
disp(Iab,"current flowing through branch ab = ")
disp(Icb,"current flowing through branch cb = ")
```

downloaded from the website wwww.scilab.in

Scilab code Exa 3.12 Find A current flowing through Rl B valye of Rl for which the power transfer is maximum and the maximum power

```
//a
// circuit parameters
E1 = 120;
R1 = 40;
R2 = 20;
R3 = 60;

Voc = E1*R2/(R2 + R1); //open circuit voltage appearing at terminal 1
Ri = R3 + (R1*R2/(R1 + R2)); //equivalent resistance looking into the      network from terminal pair 01

function I = Il(Rl)
    I = Voc/(Ri + Rl) //current through Rl
endfunction

Il1 = Il(10); //Rl = 10 ohm
Il2 = Il(50); //Rl = 50 ohm
Il3 = Il(200); //Rl = 200 ohm

disp(”a”)
disp(Il1,”Il (Rl = 10ohm) = ”)
disp(Il2,”Il (Rl = 50ohm) = ”)
disp(Il3,”Il (Rl = 200ohm) = ”)

//b
//for maximum power Rl = Ri
Rl = Ri;
Plmax = (Voc/(2*Ri))^2 * Ri ; //maximum power to Rl
disp(”b”)
```

```
disp(Plmax,”maximum power to Rl(in Watt) = ”)
```

Scilab code Exa 3.13 Find the current flowing through R2 by using Nortons current source equivalent circuit

```
//circuit parameters
//voltage sources
E1 = 120;
E2 = 65;
//resistances
R1 = 40;
R2 = 11;
R3 = 60;

I = (E1/R1) + (E2/R3); //norton's current source
Req = R1*R3/(R1 + R3); //equivalent resistance

I2 = I*Req/(Req + R2); //current flowing through R2

disp(I2,”current flowing through R2 = ”)
```

Chapter 4

Circuit differential equations Forms and Solutions

Scilab code Exa 4.3 Determine the operational driving point impedances appearing at terminals ad and dg

```
//ad
Zab = complex(1,-0.5); //impedance appearing across
   terminals ab
Zbg = complex(1); //impedance appearing across
   terminals bg
Zbcd = complex(2+1,2); //impedance appearing across
   terminals bcd
Zad = Zab + (Zbg*Zbcd/(Zbg + Zbcd)); //impedance
   appearing across terminals ad
disp(Zad,"impedance appearing across terminals ad =
   ")

//dg
Zdg = Zbg + (Zab*Zbcd/(Zab+Zbcd)); //impedance
   appearing across termainals dg
disp(Zdg,"impedance appearing across terminals dg =
   ")
```

Chapter 5

Circuit dynamics and forced responses

This code can be downloaded from the website wwww.scilab.in

Scilab code Exa 5.2 Find the expression for the current flowing through the circuit and the total energy dissipated in the resistor

```
C = 10*10^-6 ; //capacitance(in farads)
R = 0.2*10^6; //resistance (in ohms)
Vi = 40; //initial voltage of the capacitor (in volts)
Wc = (1/2)*C*Vi^2; //energy stored in the capacitor
//current flowing in circuit as a function of time i(t) = 2*10^-4*exp(-t/2)
//power dissipated in the resistor = R*i^2
Wr = integrate('R*4*10^-8*exp(-t)','t',0,100)
```

```
disp(Wc,"energy stored in the capacitor(in Joules) =
    ")
disp(Wr,"energy dissipated in the resistor(in Joules
   ) = ")
```

Chapter 6

The laplace transform method of finding circuit solutions

Scilab code Exa 6.1 Find the laplace transform of the given pulse

```
function F = laplace(s, T1, T2)
    //pulse:
    // f = u(t - T1) - u(t - T2)
    F = integrate('exp(-s*t)','t',T1,T2); //laplace
       transform of the pulse
endfunction
```

Chapter 7

Sinusoidal steady state response of circuits

Scilab code Exa 7.1 Find the average value of the given periodic function

```
Vm = 2; // assumption
//average value of the function
//v(t) = Vm*alpha/(%pi/3) for 0 <= alpha <= %pi/3
//      = Vm    for  %pi/3 <= alpha <= %pi/2
Vav = (2/%pi)*integrate('Vm*alpha*(3/%pi)','alpha'
    ,0,%pi/3) + (2/%pi)*integrate('Vm*alpha/alpha','
    alpha',%pi/3,%pi/2);
disp(Vav)
```

Scilab code Exa 7.2 Determine the power factor and average power delivered to the circuit

```
theta = %pi/6; //phase difference between current
    and voltage
pf = cos(theta); //power factor
disp(pf,"power factor = ")
```

```

Vm = 170; //peak voltage
Im = 14.14; //peak current

Pav = Vm*Im*pf/2; //average power delivered to the circuit
disp(Pav,"average power delivered to the circuit = ")
```

Scilab code Exa 7.3 Find the expression for the sum of i1 and i2

```
// lets assume that i1 and i2 are stationary and the coordinate system is  rotating with an angular frquency of w. And i1 lies on the x-axis (i.e. making an angle of 0 degree with the x-axis)
theta = %pi/3; //phase difference between i1 and i2;
I1 = 10*sqrt(2); // peak value of i1
I2 = 20*sqrt(2); // peak value of i2
I = sqrt(I1^2 + I2^2 + 2*I1*I2*cos(theta)); //peak value of the resultant current

phi = atan(I2*sin(theta)/(I1 + I2*cos(theta)));//phase difference between the resultant and i1(in radians)
disp(I,"peak value of the resultant current = ")
disp(phi,"phase difference between the resultant and i1 = ")
// result : i = I sin(wt + phi)
```

Scilab code Exa 7.4 Find the effective value of the resultant current

```
I1 = 10; //peak value of i1
I2 = 20; //peak value of i2
```

```
theta = %pi/3; //phase difference between i1 and i2
// complex representation of the two currents
i1 = complex(10);
i2 = complex(20*cos(%pi/3),20*sin(%pi/3));

i = i1 + i2 ; //resultant current
I = sqrt (real(i)^2 + imag(i)^2); //calculating the peak value of the resultant current by using its real and imaginary parts
phi = atan(imag(i)/real(i)); //calculatig the phase of the resultant current by using its real and imaginary parts
disp(i,"resultant current = ")
disp(I,"peak value of the resultant current = ")
disp(phi,"phase of the resultant current = ")
//result : i = Isin(wt + phi)
```

Scilab code Exa 7.5 Find the time expression for the resultant current

```
I1 = 3; //peak value of i1
I2 = 5; //peak value of i2
I3 = 6; //peak value of i3
theta1 = %pi/6; //phase difference between i2 and i1
theta2 = -2*%pi/3; //phase difference between i3 and i1
// complex representation of the currents
i1 = complex(3);
i2 = complex(5*cos(%pi/6),5*sin(%pi/6));
i3 = complex(6*cos(-2*%pi/3),6*sin(-2*%pi/3));

i = i1 + i2 + i3; //resultant current
I = sqrt (real(i)^2 + imag(i)^2); //calculating the peak value of the resultant current by using its real and imaginary parts
phi = atan(imag(i)/real(i)); //calculatig the phase
```

```
   of the resultant current by using its real and
   imaginary parts
disp(I,"peak value of the resultant current = ")
disp(phi,"phase of the resultant current = ")
//result : i = Isin(wt + phi)
```

Scilab code Exa 7.6 Find the value of the given expression

```
//find V*Z1/Z2
V = complex(45*sqrt(3), -45);
Z1 = complex(2.5*sqrt(2), 2.5*sqrt(2));
Z2 = complex(7.5, 7.5*sqrt(3));
// we have to find V*Z1/Z2
Z = V*Z1/Z2;
disp(Z,"V*Z1/Z2 = ")
```

Scilab code Exa 7.7 Find A value of steady state current and the relative phase angle C magnitude and phase of voltage drops appearing across each element D average power E power factor

```
//a
f = 60; //frequency of the volatge source
V = complex(141);//voltage supply V = 141sin(wt)
R = 3; //resistance of the circuit
L = 0.0106; // inductance of the circuit
Z = complex(R,2*%pi*f*L);//impedance of the circuit
  = R + jwL
i = V/Z; //current
I = sqrt (real(i)^2 + imag(i)^2); //calculating the
   peak value of the current by using its real and
   imaginary parts
```

```
phi = atan(imag(i)/real(i)); //calculatig the phase of the resultant current by using its real and imaginary parts
disp("a")
disp(I,"effective value of the steady state current = ")
disp(phi,"relative phase angle = ")

//b
// expression for the instantaneous current can be written as
//i = I sin(wt + phi)

//c
R = complex(3);
 vr = V*R/Z; // voltage across the resistor
Vr = sqrt (real(vr)^2 + imag(vr)^2); //peak value of the voltage across the resistor
phi1 = atan(imag(vr)/real(vr)); //phase of the voltage across the resistor

vl = V - vr; //voltage across the inductor
Vl = sqrt (real(vl)^2 + imag(vl)^2); //peak value of the voltage across the inductor
phi2 = atan(imag(vl)/real(vl)); //phase of the voltage across the inductor
disp("c")
disp(Vr,"effective value of the voltage drop across the resistor = ")
disp(phi1,"phase of the voltage drop across the resistor = ")
disp(Vl,"effective value of the voltage drop across the inductor = ")
disp(phi2,"phase of the voltage drop across the inductor = ")

//d
Pav = V*I*cos(phi); //average power dissipated by
```

```
   the circuit
disp("d")
disp(Pav,"average power dissipated by the circuit =
   ")

//e
pf = cos(phi); //power factor
disp("e")
disp(pf,"power factor = ")
```

Scilab code Exa 7.8 Find the equivalent impedance appearing between points a and c

```
//impedances in the circuit
Z1 = complex(10,10);
Z2 = complex(15,20);
Z3 = complex(3,-4);
Z4 = complex(8,6);

Ybc = (1/Z2)+(1/Z3)+(1/Z4); //admittance of the
   parallel combination
Zbc = (1/Ybc); //impedance of the parallel
   combination

Z = Z1 + Zbc; // equivalent impedance of the circuit

disp(Z,"equivalent impedance of the circuit = ")
```

Scilab code Exa 7.9 Find the current which flows through branch Z3

```
V1 = complex(10);
V2 = complex(10*cos(-%pi/3),10*sin(-%pi/3));
Z1 = complex(1,1);
```

```
Z2 = complex(1,-1);
Z3 = complex(1,2);

//by mesh analysis we get the following equations:
//I1*Z11 - I2*Z12 = V1
//-I1*Z21 + I2*Z22 = -V2; where I1 and I2 are the
   currrents flowing in the first and second meshes
   respectively
Z11 = Z1 + Z1;
Z12 = Z1 + Z2;
Z21 = Z12;
Z22 = Z2 + Z2;

// the mesh equations can be represented in the
   matrix form as I*Z = V
Z = [Z11, -Z12; -Z21, Z22]; //impedance matrix
V = [V1; -V2]; //voltage matrix
I = inv(Z)*V; //current matrix = [I1;I2]

I1 = I(1,:); // I1 = first row of I matrix
I2 = I(2,:); // I1 = second row of I matrix

Ibr = I1 - I2; //current flowing through Z3

disp(Ibr,"current flowing through Z3 = ")
```

Scilab code Exa 7.10 Find the current in the Z3 branchby using the Nodal method

```
V1 = complex(10);
V2 = complex(10*cos(-%pi/3),10*sin(-%pi/3));
Z1 = complex(1,1);
Z2 = complex(1,-1);
Z3 = complex(1,2);
//By appling the nodal analysis we get the following
```

```
   equation:
//Va((1/Z1)+(1/Z2)+(1/Z3)) = (V1/Z1) + (V2/Z2)

Y = (1/Z1)+(1/Z2)+(1/Z3);
Va = (1/Y)*((V1/Z1) + (V2/Z2)); //voltage of node a

Ibr = Va/Z3; //current flowing through Z3

disp(Ibr,"current flowing through Z3 = ")
```

Scilab code Exa 7.11 Find the current flowing through Z3 by using Thevinins theoram

```
V1 = complex(10);
V2 = complex(10*cos(-%pi/3),10*sin(-%pi/3));
Z1 = complex(1,1);
Z2 = complex(1,-1);
Z3 = complex(1,2);

Zth = Z3 + (Z1*Z2/(Z1+Z2)); // thevinin resistance

I = (V1 - V2)/(Z1 + Z2); // current flowing through
   the circuit when R3 is not connected
Vth = V1 - I*Z1; //thevinin voltage

Ibr = Vth/Zth; //current flowing through Z3

disp(Ibr,"current flowing through Z3 = ")
```

Chapter 9

Semiconductor electronic devices

Scilab code Exa 9.2 Find the values of self bais source resistance and drain load resistance at Q point

```
// Quiescent point
Idq = 0.0034; // drain current
Vdq = 15; // drain voltage
Vgq = 1; // gate voltage

Vdd = 24; //drain supply voltage

Rs = Vgq/Idq;
disp(Rs,"The value of self bais source resistance is
   (in ohm): ")

Rd = (Vdd - Vdq)/Idq ;
disp(Rd,"The value of drain load resistance is(in
   ohm): ")
```

Scilab code Exa 9.3 Find A midband frequency current gain of the first stage B bandwidth of the first stage amplifier

```
//a
//transistor parameters
 R2 = 0.625;
 hie = 1.67;
 Rb = 4.16;
 Rl = 2.4;
 Roe = 150;

 Cc = 25 * 10^-6;
 rBB = 0.29;
 rBE = 1.375;
 Cd = 6900 * 10^-12;
 Ct = 40 * 10^-12;
 gm = 0.032;

  Req = (Rl*Roe)/(Rl + Roe);
  hfe = 44;
  a = 1 + (R2/Req);
  b = 1 + (hie/Rb);
  Aim = -hfe/(a*b); // mid band frequency gain
  disp("a")
  disp(Aim,"The mid band frequency gain of the first
      stage of the circuit is: ")

  //b
  Tl = 2*%pi*(Req + R2)*Cc*(10^3);
  Fl = 1/Tl;

  Rp = (Req*R2)/(Req + R2);
  C = Cd + Ct*(1 + gm*Rp*10^3);
  d = Rb + hie ;
  e = rBE * (Rb + rBB)* 10^3 * C ;
  Fh = d/(2*%pi*e);

  BW = Fh - Fl;
```

```
disp("b")
disp(BW, "The bandwidth of the first stage amplifier in Hz is :")
```

Chapter 11

Binary logic Theory and Implimentation

Scilab code Exa 11.1 Determine th decimal equivalents of the binary numbers A 101 B 11011

```
//a
N2 = '101'; //binary ordered sequence
N = bin2dec(N2); //decimal equivalent of N2
disp("a")
disp(N, "decimal equivalent of 101 = ")

//b
N2 = '11011'; //binary ordered sequence
N = bin2dec(N2); //decimal equivalent of N2
disp("b")
disp(N, "decimal equivalent of 11011 = ")
```

Scilab code Exa 11.2 Determine the decimal equivalent of A octal number 432 B hexadecimal number C4F

```
//a
N8 = '432'; //octal number
N = oct2dec(N8); //decimal representation of N8
disp("a")
disp(N,"decimal equivalent of 432 = ")

//b
N16 = 'C4F'; //hexadecimal number
N = hex2dec(N16); //decimal representation of N16
disp("b")
disp(N,"decimal equivalent of C4F = ")
```

Scilab code Exa 11.3 Find the binary and octal equivalents of 247

```
N = 247;
N2 = dec2bin(N); //binary equivalent of N
N8 = dec2oct(N); //octal equivalent of N
disp(N2, "binary equivalent of 247 = ")
disp(N8, "octal equivalent of 247 = ")
```

Chapter 12

Simplifying logical functions

Chapter 15

Magnetic circuit computations

Scilab code Exa 15.1 Find A magneto motive force B current C relative permiability and reluctance of each material

```
//a
phi = 6*10^-4; //given magnetic flux (in Wb)
A = 0.001; // cross sectional area (in meter square)
B = phi/A ; //
Ha = 10; //magnetic field intensity of material a needed to establish  the given magnetic flux
Hb = 77; // magnetic field intensity of material b
Hc = 270; // magnetic field intensity of material c
La = 0.3; //arc length of material a (in meters)
Lb = 0.2; //arc length of material b (in meters)
Lc = 0.1; //arc length of material c (in meters)

F = Ha*La + Hb*Lb + Hc*Lc; //magnetomotive force
disp("a")
disp(F, "magnetomotive force needed to establish a flux of 6*10^-4(in At) = ")

//b
N = 100; //no. of turns
I = F/N; //current in amps
```

```
disp("b")
disp(I,"current that must be made to flow through the coil(in amps) = ")

//c
MU0 = 4*%pi*10^-7;
MUa = B/Ha; //permeability of material a
MUb = B/Hb; //permeability of material b
MUc = B/Hc; //permeability of material c

MUra = MUa/MU0; //relative permeability of material a
MUrb = MUb/MU0; //relative permeability of material b
MUrc = MUc/MU0; //relative permeability of material c

Ra = Ha*La/phi; //reluctance of material a
Rb = Hb*Lb/phi; //reluctance of material b
Rc = Hc*Lc/phi; //reluctance of material c

disp("c")
disp(MUra,"relative permeability of material a = ")
disp(MUrb,"relative permeability of material b = ")
disp(MUrc,"relative permeability of material c = ")
disp(Ra,"reluctance of material a = ")
disp(Rb,"reluctance of material b = ")
disp(Rc,"reluctance of material c = ")
```

Scilab code Exa 15.3 Find the mmf produced by the coil

```
mu0 = 4*%pi*10^-7;
A = 0.0025; //cross sectional area of the coil
//dimensions of the coil (in meters)
Lg = 0.002; //air gap length (in meters)
```

```
Lbd = 0.025;
Lde = 0.1;
Lef = 0.025;
Lfk = 0.2;
Lbc = 0.175;
Lcab = 0.5;

Lbghc = 2*(Lbd + Lde + Lef + (Lfk/2)) - Lg;//length of the ferromagnetic material involved here

phig = 4*10^-4; //air gap flux (in Wb)
Bg = phig/A ; //air gap flux density (in tesla)
Hg = Bg/mu0 ; //feild intensity of the air gap
mmfg = Hg*Lg ; //mmf produced in the air gap (in At)

Bbc = 1.38 ; //flux density corresponding to cast steel

Hbghc = 125; //field intensity corresponding to flux density of 0.16T in the steel
mmfbghc = Hbghc*Lbghc ; // mmf corresponding to bghc

mmfbc = mmfg + mmfbghc ; //mmf across path bc
Hbc = mmfbc/Lbc;
phibc = Bbc*A ; //flux produced in bc

phicab = phig + phibc; //total fiux existing in leg cab
Bcab = phicab/0.00375; //flux density
Hcab = 690;
mmfcab = Hcab*Lcab; //mmf in leg cab

mmf = mmfbc + mmfcab ; //mmf produced by the coil

disp(mmf,"mmf produced by the coil(in At) = ")
```

Scilab code Exa 15.5 B Find the magnetic force exerted on the plunger

```
//b
mu0 = 4*%pi*10^-7 ;
//plunger magnet dimensions (in meters)
x = 0.025;
h = 0.05;
a = 0.025;
g = 0.00125;

mmf = 1414; //(in At)

F = %pi*a*mu0*(mmf^2)*(h^2)*(1/(x + h)^2)/g; //magnitude of the force
disp(F, "magnitude of the force (in Newtons) = ")
```

Chapter 16

Transformers

Scilab code Exa 16.1 Find A equivalent resistance and reactance referred to both the sides B voltage drops across these in Volts and in per cent of the rated winding voltage C Repeat B for the low voltage side D equivalent leakage impedances referred to both the sides

```
//a
V1 = 1100; //higher voltage
V2 = 220; //lower voltage
a = V1/V2; //turns ratio
r1 = 0.1; //high voltage winding resistance(in ohms)
x1 = 0.3; //high voltage leakage reactance(in ohms)
r2 = 0.004; //low voltage winding resistance(in ohms)
x2 = 0.012; //low voltage leakage reactance(in ohms)

Re1 = r1 + (a^2)*r2 ; //equivalent winding resistance referred to the     primary side
Xe1 = x1 + (a^2)*x2 ; //equivalent leakage reactance referred to the      primary side
Re2 = (r1/a^2) + r2 ; //equivalent winding resistance referred to the     secondary side
Xe2 = (x1/a^2) + x2 ; //equivalent leakage reactance referred to the     secondary side
```

```

disp("a")
disp(Re1,"equivalent winding resistance referred to the primary side")
disp(Xe1,"equivalent leakage reactance referred to the primary side")
disp(Re2,"equivalent winding resistance referred to the secondary side")
disp(Xe2,"equivalent leakage reactance referred to the secondary side")

//b
P = 100; //power (in kVA)
I21 = P*1000/V1; //primary winding current rating
Vre1 = I21*Re1; //equivalent resistance drop (in volts)
VperR1 = Vre1*100/V1 ; // % equivalent resistance drop

Vxe1 = I21*Xe1; //equivalent reactance drop (in volts)
VperX1 = Vxe1*100/V1; // % equivalent reactance drop

disp("b")
disp(Vre1,"equivalent resistance drop expressed in terms of primary quantities(in volts) = ")
disp(VperR1,"% equivalent resistance drop expressed in terms of primary  quantities = ")
disp(Vxe1,"equivalent reactance drop expressed in terms of primary quantities(in volts) =")
disp(VperX1,"% equivalent reactance drop expressed in terms of primary  quantities = ")

//c
I2 = a*I21; // secondary winding current rating
Vre2 = I2*Re2; //equivalent resistance drop (in volts)
VperR2 = Vre2*100/V2 ; // % equivalent resistance
```

```
drop

Vxe2 = I2*Xe2; //equivalent reactance drop (in volts)
VperX2 = Vxe2*100/V2; // % equivalent reactance drop

disp("c")
disp(Vre2,"equivalent resistance drop expressed in terms of secondary quantities(in volts) = ")
disp(VperR2,"% equivalent resistance drop expressed in terms of secondary  quantities = ")
disp(Vxe2,"equivalent reactance drop expressed in terms of secondary quantities(in volts) =")
disp(VperX2,"% equivalent reactance drop expressed in terms of secondary  quantities = ")

//d
Ze1 = complex(Re1,Xe1); //equivalent leakage impedance referred to the  primary
Ze2 = Ze1/a ; //equivalent leakage impedance referred to the  secondary

disp("d")
disp(Ze1,"equivalent leakage impedance referred to the  primary = ")
disp(Ze2,"equivalent leakage impedance referred to the  secondary = ")
```

Scilab code Exa 16.2 Compute the 6 parameters of the equivalent circuit referred to the high and low sides

```
Pl = 396; //wattmeter reading on open circuit test
Vl = 120; //voltmeter reading on open circuit test
Il = 9.65; //ammeter reading o open circuit test
a = 2400/120; //turns ratio
```

```

theata = acos(Pl/(Vl*Il)); //phase difference between voltage and current
Irl = Il*cos(theata); //resistive part of Im
Ixl = Il*sin(theata); //reactive part of Im

rl = Vl/Irl; //low voltage winding resistance
rh = (a^2)*rl; //rl on the high side
xl = Vl/Ixl; //magnetizing reactance referred to the lower side
xh = (a^2)*xl; //corresponding high side value

Ph = 810; //wattmeter reading on short circuit test
Vh = 92; //voltmeter reading on short circuit test
Ih = 20.8; //ammeter reading on short circuit test

Zeh = Vh/Ih; //equivalent impeadance referred to the higher side
Zel = Zeh/(a^2); //equivalent impedance referred to the lower side
Reh = Ph/(Ih^2); //equivalent resistance referred to the higher side
Rel = Reh/(a^2); //equivalent resistance referred to the lower side
Xeh = sqrt((Zeh^2) - (Reh^2)); //equivalent reactance referred to the  higher side
Xel = Xeh/(a^2); //equivalent reactance referred to the lower side

disp(Zeh,"equivalent impeadance referred to the higher side  = ")
disp(Zel,"equivalent impedance referred to the lower side = ")
disp(Reh,"equivalent resistance referred to the higher side = ")
disp(Rel,"equivalent resistance referred to the lower side = ")
disp(Xeh,"equivalent reactance referred to the
```

```
   higher side = ")
disp(Xel," equivalent reactance referred to the lower
    side = ")
```

Scilab code Exa 16.3 For the transformer compute A efficiency B voltage regulation

```
//a
P = 50; //power rating (in kVA)
Ph = 810; //wattmeter reading on short circuit test
Pl = 396; //wattmeter reading on open circuit test
Ih = 20.8; //ammeter reading on short circuit test
pf = 0.8; //power factor = 0.8 lagging

losses = (Ph + Pl)/1000; //losses in kW
outputP = P*pf; //output power
inputP = outputP + losses ; //input power

efficiency = outputP/inputP ;
disp("a")
disp(efficiency," efficiency = ")

//b
Xeh = 4; //equivalent reactance referred to the
   higher side
Reh = 1.87; //equivalent resistance referred to the
   higher side
Zeh = complex(Reh, Xeh); //equivalent impedance
   referred to the higher  side
ih = complex(Ih*pf, -Ih*sqrt(1 - (pf^2)));
V1 = 2400 + Zeh*ih ; //primary voltage

voltageRegulation = (real(V1)-2400)*100/2400;//
   percent voltage regulation
disp("b")
```

```
disp(voltageRegulation,"percent voltage regulaton =
   ")
```

Chapter 18

The three phase Induction motor

Scilab code Exa 18.1 Find A input line current and power factor B developed electromagnetic torque C horse power output D efficiency

```
//a
V1 = 440/sqrt(3);
s = 0.025; //slip
r1 = 0.1;
r2 = 0.12;
x1 = 0.35;
x2 = 0.4;

z = complex(r1 + r2/s, x1 + x2);
i2 = V1/z; //input line current
I2 = sqrt(real(i2)^2 + imag(i2)^2); //magnitude of input line current
disp("a")
disp(i2,"input line current = ")

i1 = complex(18*cos(-1.484), 18*sin(-1.484)); //magnetizing current
I1 = sqrt(real(i1)^2 + imag(i1)^2); //magnitude of
```

```
magnetizing current
i = i1 + i2; //total current drawn from the voltage source
I = sqrt(real(i)^2 + imag(i)^2); //magnitude of total current
theta = atan(imag(i)/real(i)); //phase difference between current and voltage
pf = cos(theta); //power factor
disp(pf,"power factor = ")
if theta >= 0 then
    disp("leading")
else disp("lagging")
end

//b
f = 60; //hertz
ns = 1800;
ws = 2*%pi*ns/f; //stator angular velocity
Pg = 3*I2^2*r2/s; //power
T = Pg/ws; //developed electromagnetic torque
disp("b")
disp(T,"developed electromagneic torque (in Newton-meter) = ")

//c
Prot = 950; //rotational losses (in watts)
Po = Pg*(1 - s) - Prot ; //output power
HPo = Po/746; //output horse power
disp("c")
disp(HPo,"output horse power = ")

//d
Pc = 1200; //core losses (in W)
SCL = 3*I^2*r1; //stator copper loss
RCL = 3*I2^2*r2; //rotar copper loss
loss = Pc + SCL + RCL + Prot; //total losses
Pi = real(3*V1*i); //input power
efficiency = 1 - (loss/Pi);
```

```
disp(efficiency,"efficiency = ")
```

Chapter 19

Computations of Synchronous Motor Performance

Scilab code Exa 19.1 Find A induced excitation voltage per phase B line current C power factor

```
//a
efficiency = 0.9;
Pi = 200*746/efficiency; //input power
x = 11; //reactance of the motor
V1 = 2300/sqrt(3); //voltage rating
delta = 15*%pi/180; //power angle
Ef = Pi*x/(3*V1*sin(delta)); //the induced
    excitation voltage per phase
disp("a")
disp(Ef,"the induced excitation voltage per phase =
    ")

//b
z = complex(0,x); //impedance of the motor
ef = complex(Ef*cos(-delta),Ef*sin(-delta));

Ia = (V1 - ef)/z ; //armature current
disp("b")
```

```
disp(Ia,”armatur current = ”)

//c
theata = atan(imag(Ia)/real(Ia)); //phase difference between Ia and V1
pf = cos(theata); //power factor

disp(”c”)
disp(pf,”power factor = ”)

if sin(theata)> 0  then
    disp(”leading”)
else
    disp(”lagging”)
end
```

Chapter 20

DC machines

Scilab code Exa 20.2 Caculate A electromagnetic torque B flux per pole C rotational losses D efficiency E shaft laod

```
//a
Vt = 230; //(in volts)
Ia = 73; //armature current (in amps)
If = 1.6; //feild current (in amps)
Ra = 0.188; //armature circuit resistance(in ohms)
n = 1150; //rated speed of the rotor(in rpm)
Po = 20*746; //output power (in watts)

Ea = Vt - (Ia*Ra); //armature voltage
wm = 2*%pi*n/60; //rated speed of the rotor (in rad/
    sec)
T = Ea*Ia/wm ; //electromagnetic torque

disp("a")
disp(T,"electromagnetic torque = ")

//b
a = 4; //no. of parallel armature paths
p = 4; //no. of poles
z = 882; //no. of armature conductors
```

```
flux = Ea*60*a/(p*z*n); //flux per pole (in Wb)

disp("b")
disp(flux,"flux per pole = ")

//c
Prot = (Ea*Ia) - Po; //rotational loss (in watt)
disp("c")
disp(Prot,"rotational losses = ")

//d
losses = Prot + (Ia^2 * Ra) + (Vt * If) ;
Pi = (Ea*Ia) + (Ia^2 * Ra) + (Vt * If); //input
   power
efficiency = 1 - (losses/Pi);

disp("d")
disp(efficiency,"efficiency = ")
```

Scilab code Exa 20.3 Determine the new operating speed

```
// final flux = 0.8*initial flux
Ia1 = 73; //initial armature current (in amps)
Vt = 230; //(in volts)
Ra = 0.188; //armature circuit resistance
n1 = 1150; //initial rotor speed (in rpm)
Ea1 = 216.3; //initial armature voltage

Ia2 = (1/0.8)*Ia1 ; //final armature current
Ea2 = Vt - (Ia2*Ra); //final armature voltage

n2 = (Ea2/Ea1)*(1/0.8)*n1; //final rotor speed

disp(n2,"final rotor speed(in rpm) = ")
```

Scilab code Exa 20.4 find A motor speed B required pulse frequency C repeat part A and B for the given ON time to cycle time ratio

```
//a
rop = 0.4; //ratio of ON time T0 to cycle time Tp
Vb =550; //rated terminal voltage of the dc motor
Ia = 30; //current drawn by the motor (in amps)
Ra = 1; //armature circuit resistance (in ohms)
ts = 5.94; //torque and speed parameter of the motor
    (in N-m/A)

Vm = rop*Vb; //average value of the armature
   terminal voltage
Ea = Vm - (Ia*Ra); //induced armature voltage

wm = Ea/ts; //motor speed (in rad/s)
disp("a")
disp(wm,"motor speed (in rad/s) = ")

//b
deltaI = 5; //change of armature current during the
   ON period
La = 0.1; //armature winding inductance (in H)
To = La*deltaI/(Vb - Ea); //ON time
Tp = To/rop; //cycle time

f = 1/Tp ; //required pulses per second
disp("b")
disp(f,"required pulses per second = ")

//c
rop = 0.7; //new ratio of ON time T0 to cycle time
   Tp
Vm = rop*Vb; //average value of the armature
```

```
terminal voltage
Ea = Vm - (Ia*Ra); //induced armature voltage

wm = Ea/ts; //motor speed (in rad/s)
disp("c")
disp(wm,"motor speed with To/Tp equal to 0.7 (in rad/s) = ")

To = La*deltaI/(Vb - Ea); //ON time
Tp = To/rop; //cycle time

f = 1/Tp ; //required pulses per second
disp(f,"required pulses per second with To/Tp equal to 0.7 = ")
```

Chapter 23

Principles of Automatic Control

Scilab code Exa 23.1 Determine the new transfer gain and feedback factor

```
deltaGi = 420 - 380; //variation in the without feedback gain
Gi = 400; //without feedback gain
T = 400; //transfer function of the closed loop system
// (variation in T)/T = (change in G)/G * (1/ 1+H*G) = 0.02
//1 + H*G  = R
R = (deltaGi/Gi)/0.02;

G = T*R; //new direct transmission gain with feedback
H = (G/T - 1)/G; //feedback factor

disp(G,"new direct transmission gain with feedback = ")
disp(H,"feedback factors = ")
```

Chapter 24

Dynamic behaviour of Control systems

Scilab code Exa 24.2 find A dynamic response of the system B position lag error C change in amplifier gain D damping ratio and maximum percent overshoot E output gain factor for maximum overshoot equal to 25percent

```
//a
//parameter values
Kp = 0.5; //V/rad
Ka = 100; //V/V
Km = 2*10^-4 ; //lb-ft/V
F = 1.5*10^-4; //lb-ft/rad/s
J = 10^-5 //slug-ft^2

K = Kp*Ka*Km ; //loop propotional gain
dr = F/(2*sqrt(K*J)); //damping ratio
wn = sqrt(K/J);
ts = 5/(dr*wn);
wd = wn*sqrt(1 - dr^2); //frequency at which damped
    oscillations occur
disp("a")
disp(wd, "damped oscillations occur at a frequency =
    ")
```

```
disp(dr,”damping ratio = ”)

//b
Tl = 10^-3; //load disturbance (lb-ft)
e = Tl/K; //position lag error
disp(”b”)
disp(e,”position lag error (in rad) = ”)

//c
KaNew = (e/0.025)*Ka; //new loop gain
disp(”c”)
disp(KaNew,”new loop gain for which the position lag error is equal to  0.025rad = ”)

//d
drNew = F/(2*sqrt(Kp*KaNew*Km*J)); //new damping ratio
disp(”d”)
disp(drNew,”new damping ratio = ”)

//e
//for a maximum overshoot of 25% , (F + Qo)/2*sqrt(K*J) = 0.4
Qo = (0.4*2*sqrt(Kp*KaNew*Km*J)) - F ;
Ko = Qo/(KaNew*K) ; //output gain factor
disp(”e”)
disp(Ko,”output gain factor = ”)
```