Scilab Textbook Companion for Solid State Devices and Circuits by V. Chaudhary and H. K. Maity[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 2

Bipolar Junction Transistors

Scilab code Exa 2.1 Value of alphaDC and emitter current

```
// Exa 2.1
clc;
clear;
close;
format('v',6)
// Given data
I_C = 15;// in mA
I_CbyI_E= 0.995;
I_E= I_C/I_CbyI_E;// in mA
I_B= 0.005*I_E;// in mA
I_CBO = 3;// in  A
I_CBO = I_CBO * 10^-3;// in mA
alpha_dc= I_C/I_E;
disp(alpha_dc,"The value of Alpha_dc is");
// I_C = Alpha_dc*I_E + I_CBO;
I_E = (I_C-I_CBO)/alpha_dc;// in mA
disp(I_E,"The value of I_E in mA is");
```

Scilab code Exa 2.2 Value of IC and IE

```
// Exa 2.2
clc;
clear;
close;
format('v',6)
// Given data
Alpha_dc = 0.99;
I_CBO = 10;// in   A
I_CBO = I_CBO * 10^-3;// in mA
I_E = 10;// in mA
// To calculate I_C :
I_C = (Alpha_dc*I_E) + I_CBO;// in mA
disp(I_C,"The value of I_C in mA is");
// To calculate I_B :
I_B = I_E-I_C;// in mA
I_B = I_B * 10^3;// in   A
disp(I_B,"The value of I_B in   A is");
```

Scilab code Exa 2.3 Base current

```
// Exa 2.3
clc;
clear;
close;
format('v',4)
// Given data
Alpha_dc = 0.99;
I_C = 6;// in mA
I_CBO = 15;// in   A
I_CBO = I_CBO * 10^-3;// in mA
// I_C = Alpha_dc*I_E + I_CBO;
I_E = (I_C - I_CBO)/Alpha_dc;// in mA
I_B = I_E - I_C;// in mA
I_B = I_B * 10^3;// in   A
disp(I_B,"The value of I_B in   A is");
```

Scilab code Exa 2.5 Emitter current

```
// Exa 2.5
clc;
clear;
close;
format('v',6)
// Given data
Alpha_dc = 0.98;
I_CBO = 12;// in  A
I_CBO = I_CBO * 10^-6;// in A
I_B = 120;// in  A
I_B = I_B * 10^-6;// in A
// Calculation of Beta_dc
Beta_dc = Alpha_dc/(1-Alpha_dc);
I_E = (1+Beta_dc)*I_B + (1+Beta_dc)*I_CBO;// in A
I_E = I_E * 10^3;// in mA
disp(I_E,"The value of I_E in mA is");
```

Scilab code Exa 2.6 Region of operation

```
// Exa 2.6
clc;
clear;
close;
format('v',6)
// Given data
V_BEsat = 0.8;// in V
V_BEact = 0.7;// in V
V_CEsat = 0.2;// in V
V_CC = 10;// in V
```

```
Beta = 100;
V = 5;// in V
R_B = 50* 10^3;// in ohm
R_E = 2* 10^3;// in ohm
R_C = 3* 10^3;// in ohm
//Applying KVL to input loop,  V = R_B*I_B + V_BEact + I_C*R_E and I_C = Beta*I_B;
I_B = (V-V_BEact)/(R_B+R_E*Beta);// in A
// Applying KVL to collector circuit, V_CC= I_C*R_C+V_CEsat+I_E*R_E and I_E=I_C+I_B
I_C = (V_CC-V_CEsat-I_B*R_E)/(R_C+R_E);// in A
I_Bmin = I_C/Beta;// in A
if I_B < I_Bmin then
    disp("Since the value of I_B ( "+string(I_B*10^6)+ "  A ) is less than the value of I_Bmin ( "+string(I_Bmin*10^6)+"  A ), ")
    disp("So the transistor is in the active region.")
end
```

Scilab code Exa 2.7 Value of IB IC and Vce

```
// Exa 2.7
clc;
clear;
close;
format('v',6)
// Given data
Beta = 100;
V_BEsat = 0.8;// in V
V_BEact = 0.7;// in V
V_CC = 10;// in V
V = 5;// in V
R_B = 50* 10^3;// in ohm
R_E = 2* 10^3;// in ohm
```

```
R_C = 3* 10^3;// in ohm
// As the transistor is in active region , so V = R1*I_B + V_BEact + (1+Beta)*I_B*R2;
I_B = (V-V_BEact)/(R_B+(1+Beta)*R_E);// in A
I_B = round(I_B * 10^6);// in  A
disp(I_B,"The value of I_B in  A is");
I_C = Beta*I_B*10^-6;// in A
I_C = I_C * 10^3;// in mA
disp(I_C,"The value of I_C in mA is");
// Applying KVL to collector circuit , V_CC = (I_C*R3) + V_CEact + (I_C+I_B)*R2;
V_CEact = V_CC - (I_B*10^-6*R_E) - (I_C*10^-3*(R_E+R_C));// in V
disp(V_CEact,"The value of V_CE in V is");
```

Scilab code Exa 2.8 Value of VBB

```
// Exa 2.8
clc;
clear;
close;
format('v',6)
// Given data
V_CEsat = 0.2;// in V
V_BEsat = 0.8;// in V
Beta = 100;
R_C = 0.5* 10^3;// in ohm
R_E = 1* 10^3;// in ohm
R_B = 44* 10^3;// in ohm
V1 = 15;// in V
V2 = 15;// in V
//Applying KVL to collector circuit , V1+V2 - I_Csat*R_C - V_CEsat - I_E*R_E = 0;
//but I_Csat = beta*I_Bmin and I_E = (1+Beta)*I_Bmin , So
```

```
I_Bmin= (V1+V2-V_CEsat)/(Beta*R_C+R_E*(1+Beta));// in A
I_Bmin= I_Bmin*10^3;// in mA
disp(I_Bmin,"The value of I_Bmin in mA is : ")
I_Bmin= I_Bmin*10^-3;// in A
I_E = (1+Beta)*I_Bmin;// in A
// Applying KVL to base emitter circuits , V_BB-I_Bmin*R_B-V_BEsat-(I_E*R_E)-V1=0
V_BB = (I_Bmin*R_B) + V_BEsat + (I_E*R_E) - V1;// in V
disp(V_BB,"The value of V_BB which just barely saturate the transistor in V is");
```

Scilab code Exa 2.9 RC and RE

```
// Exa 2.9
clc;
clear;
close;
format('v',6)
// Given data
bita = 200;
V_CEQ = 3;// in V
V_CC = 6;// in V
V_BB= -6;// in V
V_BE= 0.7;// in V
Vo = 0;// in V
R1= 90*10^3;// in ohm
R2= 90*10^3;// in ohm
// V_CC - I_CR_C - V_CEQ - I_ER_E-V_BB = 0          (i)
// Vo = V_CEQ + I_E*R_E - V_CC or
I_ER_E= Vo+V_CC-V_CEQ;// in V
// From eq(i)
I_CR_C= V_CC - I_ER_E - V_CEQ - V_BB;// in V
```

```
// Applying KVL to the input side of circuit
//V_CEQ-[(R1 || R2)*I_B]-V_BE-I_ER_E+V_CC=0 or
I_B= (V_CEQ-V_BE-I_ER_E+V_CC)/((R1*R2)/(R1+R2));//
    in A
I_E= (1+bita)*I_B;//in A
R_E= I_ER_E/I_E;// in ohm
I_C= bita*I_B;// in A
R_C= I_CR_C/I_C;// in ohm
disp("Part (a) : ")
disp(R_E,"The value of R_E in ohm is : ")
disp(R_C,"The value of R_C in ohm is : ")
disp("Parb (b) :")
bita= 100;
I_E= (1+bita)*I_B;//in A
I_C= bita*I_B;// in A
Vo_new= V_CEQ+I_E*R_E-V_CC;// in V
Change_in_Vo= Vo_new-Vo;// in V
disp(Change_in_Vo,"The change in Vo in volts is : ")
```

Scilab code Exa 2.10 Maximum value of bita

```
// Exa 2.10
clc;
clear;
close;
format('v',6)
// Given data
bita = 75;
V_CC = 9;// in V
V_CEsat = 0.2;// in V
V_BEsat = 0.8;// in V
R_C = 2;// in k ohm
R_C = R_C * 10^3;// in ohm
R_E = 1;// in k ohm
R_E = R_E * 10^3;// in ohm
```

```
R_B = 50;// in k ohm
R_B = R_B * 10^3;// in ohm
I_Csat= poly(0,'I_Cs')
// Part (i) : To check the region of operation
// Applying KVL to collector circuit , we get : V_CC = (R_C*I_Cs) + V_CEsat + (I_E*R_E)        (i)
 I_E = I_Csat;// in A (approximate)
 // From eq(i)
I_Csat= (R_C*I_Csat) + V_CEsat + (I_E*R_E)-V_CC;// in A
I_Csat= roots(I_Csat);// in A
I_Bmin= I_Csat/bita;// in A
I_Bmin= I_Bmin*10^6;// in  A
disp("Part (i)")
disp(I_Bmin,"The minimum value of  I_B in  A is : ")
I_B= poly(0,'I_B')
I_E= (1+bita)*I_B;// in A
// Applying KVL to input circuit , we get
// V_CC = I_B*R_B+V_BEsat+I_E*R_E or
I_B= I_B*R_B+V_BEsat+I_E*R_E-V_CC;// in A
I_B= roots(I_B);// in A
I_B= round(I_B*10^6);// in  A
disp(I_B,"The value of I_B in  A is : ")
if I_B>I_Bmin then
    disp("As the value of I_B is greater than the value of I_B min")
    disp("Hence the trasistor is definitely in the saturation region")
end
I_E= (1+bita)*I_Bmin;// in  A
V_C= V_CEsat+I_E*10^-6*R_E;// in V
disp(V_C,"Part (ii) : The value of V_C in volts is : ");
bita_min= I_Csat/(I_B*10^-6);
disp(bita_min,"Part (iii) : The minimum value of bita that will change the state of transistor is : ")
```

Scilab code Exa 2.11 Minimum value of RC required

```
// Exa 2.11
clc;
clear;
close;
format('v',6)
// Given data
V_CEsat = 0.2;// in V
V_CC = 10;// in V
V_BEsat = 0.8;// in V
// Part (i) To obtain minimum value of R_C
R_B = 220;// in k ohm
R_B = R_B * 10^3;// in ohm
Beta = 100;
// Applying KVL to collector circuit , we get
// V_CC = V_CEsat + I_Esat*R_C   or                    (i)
I_CsatR_C= V_CC-V_CEsat;// in V
// Applying KVL to input loop
// V_CC= V_BEsat+I_B*R_B   or                          (ii)
I_B= (V_CC-V_BEsat)/R_B;// in A
// Just at saturation I_B= I_C/Beta or
I_C= Beta*I_B;// in A
R_Cmin= I_CsatR_C/I_C;// in ohm
R_Cmin= R_Cmin*10^-3;// in k ohm
disp(R_Cmin,"The minimum value of R_C to produce
   saturation of Si transistor in k  is : ")

// Part (ii) To obtain maximum value of R_B
R_C = 1.2;// in k ohm
R_C = R_C * 10^3;// in ohm
I_Csat= I_CsatR_C/R_C;// in A
// Just at saturation
I_B= I_Csat/Beta;// in A
```

```
// Now on substituting the new value of I_B in eq (ii)
R_Bmax= (V_CC-V_BEsat)/I_B;// in ohm
R_Bmax= R_Bmax*10^-3;// in k ohm
disp(R_Bmax,"The largest value of R_B that will saturate the transistor in k  is : ")
```

Scilab code Exa 2.12 Value R1 and R3

```
// Exa 2.12
clc;
clear;
close;
format('v',6)
// Given data
V_CE = 2.5;// in V
Beta = 100;
R2 = 10 * 10^3;// in ohm
R4 = 300;// in ohm
V_CC = 5;// in V
I_C = 1 * 10^-3;// in A
V_BE= 0.6;// in V
// Applying KVL to collector circuit , we get
// V_CC = I_C*R3 + V_CE + I_E*R4                    (i)
 I_B = I_C/Beta;// in A
 I_E = (I_C + I_B);// in A
 // On substituting the value of I_B and I_E in eq (i), we get
 R3= (V_CC-V_CE-I_E*R4)/I_C;// in ohm
V_B= I_E*R4+V_BE;// in V
// But also V_B= R2/(R1+R3)*V_CC, so
R1= R2*V_CC/V_B-R2;// in ohm
R1= R1*10^-3;// in k ohm
R3= R3*10^-3;// in k ohm
disp(R1,"The value of R1 in k  is : ")
```

```
disp(R3,"The value of R3 in k  is : ")
```

Scilab code Exa 2.13 Value of RE for which transistor just comes out of saturation

```
// Exa 2.13
clc;
clear;
close;
format('v',6)
// Given data
V_CEsat = 0.2;// in V
R_B = 100 * 10^3;// in ohm
R_C = 2 * 10^3;// in ohm
bita = 100;
R_E = 1 * 10^3;// in ohm
V_CC = 10;//in V
V_BEsat = 0.8;// in V
V_BEactive = 0.7;// in V
V_BE= 0.7;// in V
V_BEcutin = 0.5;// in V
// Applying KVL to output circuit , we get
// V_CC = R_C*I_C + V_CEsat + R_E*I_E        (i)
I_Bmin= poly(0,'I_Bm');
I_C= bita*I_Bmin;// in A
I_E= (1+bita)*I_Bmin;// in A
// From eq(i)
I_Bmin= R_C*I_C + V_CEsat + R_E*I_E-V_CC;// in A
I_Bmin= roots(I_Bmin);// in A
I_Bmin= I_Bmin*10^6;// in  A
// Applying KVL to input circuit , we get
// V_CC = R_B*I_B + V_BEsat + R_E*I_E        (ii)
I_B= poly(0,'I_B');// in A
I_E= (1+bita)*I_B;// in A
// From eq(ii)
```

```
I_B= R_B*I_B + V_BEsat + R_E*I_E-V_CC;// in A
I_B= roots(I_B);// in A
I_B= I_B*10^6;// in  A
if I_B>I_Bmin then
    disp("As the value of I_B ("+string(I_B)+"  A ) is greater than the value of I_Bmin ("+string(I_Bmin)+"  A )")
    disp("Hence the transistor is in saturation region")
end

// Part (b) : To obtain the value of R_E
V_CE= 0.4;// in V (assumed)
// Rewrite eq(ii) as, V_CC = (R_C*I_C) + V_CE + (R_E*I_E) or
// I_B= (V_CC-V_CE)/(bita*R_C+(1+bita)*R_E)   (iii)     (as I_C= bita*I_B and I_E= (1+bita)*I_B )
// Applying KVL to input circuit, V_CC= I_B*R_B+V_BE+(1+bita)*I_B*R_E      (iv)
// On substituting the I_B from eq (iii) in eq (iv)
R_E= [(V_CC-V_BE)*bita*R_C-(V_CC-V_CE)*R_B]/[(1+bita)*(V_BE-V_CE)];// in ohm
R_E= R_E*10^-3;// in k ohm
disp(R_E,"The value of R_E in k  is : ")
```

Scilab code Exa 2.14 Vo1 and Vo2 and new value of RC

```
// Exa 2.14        (Printed As Exa 2.13)
clc;
clear;
close;
format('v',6)
// Given data
Beta_dc = 100;
```

```
R_C = 0.5*10^3;// in ohm
V_BB = 0;// in V
V_BE= 0.7;// in V
R_B = 44 * 10^3;// in k ohm
R_E = 1 * 10^3;// in ohm
V_EE = -15;// in V
V_CC = 15;// in V
// Applying KVL to base circuit
// V_CC= R_B*I_B+V_BE+(1+Beta_dc)*R_E*I_B or
I_B= (V_CC-V_BE)/(R_B+(1+Beta_dc)*R_E);// in A
I_C= I_B*Beta_dc;// in A
I_E= (1+Beta_dc)*I_B;// in A
// Applying KVL to collector circuit
// V_CC = R_C*I_C + V_CE + R_E*I_E + V_EE or
V_CE= V_CC-V_EE-I_C*R_C-I_E*R_E;// in V
Vo2= I_E*R_E-V_CC;// in V
// But V_CE= V01-Vo2, so
Vo1= V_CE+Vo2;// in V
disp(Vo1,"The value of Vo1 in volts is : ")
disp(Vo2,"The value of Vo2 in volts is : ")
// Part (ii) New Value of R_C to make Vo1= 0 V
Vo1= 0;
// V_CC= I_C*R_C+Vo1-Vo2+I_E*R_E-V_EE or
R_C= (V_CC-V_EE-Vo1+Vo2-I_E*R_E)/(I_C);// in ohm
R_C= R_C*10^-3;// in k ohm
disp(R_C,"The value of R_C in k  is : ")
// Part (iii) New value of R_E to get Vo2= 0;
Vo2= 0;// in V
// Formula Vo2= I_E*R_E-V_CC, so
R_E= (Vo2+V_CC)/I_E;// in ohm
R_E= R_E*10^-3;// in kohm
format('v',4)
disp(R_E,"The value of R_E in k  is :")

// Note : The calculated value of R_C in the book is
    not correct
```

Scilab code Exa 2.15 IC and IB

```
// Exa 2.15
clc;
clear;
close;
format('v',6)
// Given data
bita = 50;
V_CC = 25;// in V
V_BB = 10;// in V
R_C = 15 * 10^3;// in ohm
R_B = 40 * 10^3;// in ohm
R_E = 5 * 10^3;// in ohm
V_BE = 0.7;// in V
I_B= poly(0,'I_B');
I_E= (1+bita)*I_B;// in A
// Applying KVL to Base-Emitter loop,
// V_BB = I_B*R_B + V_BE + I_E*R_E
I_B=  I_B*R_B + V_BE + I_E*R_E-V_BB;
I_B= roots(I_B);// in A
I_E= (1+bita)*I_B;// in A
I_B= I_B*10^6;// in  A
disp("Part (a) : On assuming that the transistor is
    in the active region")
disp(I_B,"The value of I_B in  A is : ")
I_C= bita*I_B;// in  A
I_C= I_C*10^-3;// in mA
disp(I_C,"The value of I_C in mA is");
I_E = (1+bita)*I_B;// in  A
I_E = I_E * 10^-6;// in A
I_C= I_C*10^-3;// in A
I_B= I_B*10^-6;// in A
```

```
// Part (b): To verify that the transistor is not in the active region
// Applying KVL to collector circuit, we get V_CC= I_C*R_C+V_CE+I_E*R_E or
V_CE= V_CC-I_C*R_C-I_E*R_E;// in V
if V_CE<0 then
    disp("Part (b)")
    disp("Since the value of V_CE ("+string(V_CE)+" V) is negative,")
    disp("hence the transistor is not in active region")
end

// Part (c)
V_BEsat= 0.8;// in V
V_CEsat= 0.2;// in V
// Applying KVL to base circuit, V_BB= I_B*R_B+V_BEsat+I_C*R_E+I_B*R_E, or
// I_B*(R_B+R_E)+I_C*R_E= V_BB-V_BEsat            (i)
// Applying KVL to collector circuit, V_CC= I_C*R_C+V_CEsat+(I_C+I_B)*R_E, or
// I_B*R_E+I_C*(R_C+R_E)= V_CC-V_CEsat            (ii)
// Solving eq(i) and (ii) by matrix method
A= [(R_B+R_E) R_E;R_E (R_C+R_E)];
B= [V_BB-V_BEsat V_CC-V_CEsat];
R= B*A^-1;
I_B= R(1);// in A
I_B= I_B*10^6;// in  A
I_C= R(2);// in A
I_C= I_C*10^3;// in mA
disp("Part (c) : On assuming that the transistor is in saturation region")
disp(I_B,"The value of I_B in  A is : ")
disp(I_C,"The value of I_C  in mA is : ")
I_Bmin= I_C/bita;// in mA
I_Bmin= I_Bmin*10^3;// in  A
```

```
if I_B>I_Bmin then
    disp("Part (d) :")
    disp("Since the value of I_B ("+string(I_B)+" A ) is greater than the value of I_Bmin ("+string(I_Bmin)+"  A )")
    disp("Hence the transistor is indeed in saturation region")
end

// Pard (e) : R_E to bring the transistor out of saturation
Vcut= 0.5;//cut in voltage in V
I_B= poly(0,'I_B');// in A
I_C= bita*I_B;// in A
I_E= (1+bita)*I_B;// in A
// Applying KVL to input loop, V_BB= I_B*R_B+V_BE+(I_C+I_B)*R_E or
// I_B= (V_BB-V_BE)/(R_B+(1+bita)*R_E)                    (iii)
// I_C= bita*I_B =  (V_BB-V_BE)/(R_B+(1+bita)*R_E)*bita      (iv)
// V_B= V_BE+(1+bita)*I_B*R_E= V_BE+ (1+bita)*(V_BB-V_BE)/(R_B+(1+bita)*R_E)*R_E          (v)            (on substituting eq(iii))
// V_C= V_CC-I_C*R_C= V_CC-(V_BB-V_BE)/(R_B+(1+bita)*R_E)*bita*R_C                          (vi)              (on substituting eq(iv))
// but V_B-V_C<= Vcut and substituting the value from eq (v) and (vi), we get
R_E= [bita*R_C*(V_BB-V_BE)-R_B*(Vcut+V_CC-V_BE)]/[(1+bita)*(-V_BB+Vcut+V_CC)];// in ohm
R_E= R_E*10^-3;// in k ohm
disp("Part (e) : The value of R_E >= "+string(R_E)+" k ")
```

Scilab code Exa 2.16 Region of transistor and output voltage

```
// Exa 2.16
clc;
clear;
close;
format('v',7)
// Given data
bita = 100;
V_CEsat = 0.2;// in V
V_BEsat = 0.8;// in V
R_C = 3;// in k ohm
R_C = R_C * 10^3;// in k ohm
V_CC = 10;// in V
R_B = 7;// in k ohm
R_B = R_B * 10^3;// in ohm
R_E = 500;// in ohm
V_BB = 3;// in V
V_BE= 0.7;// in V
// Part (a) :
// Applying KVL to input loop, V_BB = I_B*R_B+(I_B+I_C)*R_E+V_BEsat or I_B*(R_B+R_E)+I_C*R_E= V_BB-V_BEsat          (i)
// Applying KVL to output loop, V_CC=I_C*R_C+V_CEsat+(I_B+I_C)*R_E or I_B*R_E+I_C*(R_C+R_E)= V_CC-V_CEsat          (ii)
// Solving eq(i) and (ii)by matrix method
A= [(R_B+R_E) R_E;R_E (R_C+R_E)] ;
B= [V_BB-V_BEsat V_CC-V_CEsat];
R= B*A^-1;
I_B= R(1);// in A
I_C= R(2);// in A
I_Bmin= I_C/bita;// in A
I_B= I_B*10^3;// in mA
I_Bmin=I_Bmin*10^3;// in mA
if I_B>I_Bmin then
    disp("As the value of I_B ("+string(I_B)+" mA) is greater than the value of I_Bmin ("+string
```

```
(I_Bmin)+" mA)")
    disp("Hence the transistor is in saturation region")
end

// Pard (e) : R_E to bring the transistor out of saturation
Vcut =0.5;//cut in voltage in V
I_B= poly(0,'I_B');// in A
I_C= bita*I_B;// in A
I_E= (1+bita)*I_B;// in A
// Applying KVL to input loop, V_BB= I_B*R_B+V_BE+(I_C+I_B)*R_E or
// I_B= (V_BB-V_BE)/(R_B+(1+bita)*R_E)                    (iii)
// I_C= bita*I_B =  (V_BB-V_BE)/(R_B+(1+bita)*R_E)*bita    (iv)
// V_C= -V_CC+I_C*R_C= -V_CC+(V_BB-V_BE)/(R_B+(1+bita)*R_E)*bita*R_C                        (v)                  (on substituting eq(iv))
// V_B= V_BE-(1+bita)*I_B*R_E= V_BE- (1+bita)*(V_BB-V_BE)/(R_B+(1+bita)*R_E)*R_E        (vi)                  (on substituting eq(iii))
// but V_C-V_B<= Vcut and substituting the value from eq (v) and (vi), we get
R_E= [(V_BB-V_BE)*bita*R_C-(Vcut+V_CC+V_BE)*R_B]/[(1+bita)*(Vcut+V_CC-V_BB+2*V_BE)];// in ohm
disp(R_E,"The value of R_E in ohm is : ")
```

Scilab code Exa 2.17 Collector voltage and minimum value of hFE

```
// Exa 2.17
clc;
clear;
```

```
close;
format('v',6)
// Given data
V_CC = 9;// in V
R_C = 2;// in k ohm
R_C =R_C * 10^3;// in ohm
R_B = 50;// in k ohm
R_B = R_B * 10^3;//in ohm
Beta = 70;
R_E = 1;// in k ohm
R_E = R_E * 10^3;// in ohm
V_BEsat = 0.8;// in V
V_CEsat = 0.2;// in V
// Applying KVL to input loop, V_CC= I_B*R_B+V_BEsat
   +I_E*R_E or
I_B= (V_CC-V_BEsat)/(R_B+(1+Beta)*R_E);// in A
// Applying KVL to output loop, V_CC= I_C*R_C+
   V_CEsat+I_E*R_E or
I_C= (V_CC-V_CEsat-I_B*R_E)/(R_C+R_E);// in A
I_Bmin= I_C/Beta;// in A
I_B= I_B*10^6;// in  A
I_Bmin= I_Bmin*10^6;// in  A
if I_B>I_Bmin then
    disp("Part (i) :")
    disp("As the value of I_B ("+string(I_B)+" mA)
       is greater than the value of I_Bmin ("+string
       (I_Bmin)+" mA)")
    disp("Hence the transistor is in saturation
       region")
end
disp("Part (ii) : ")
V_C= V_CC-I_C*R_C;// in V
disp(V_C,"The collector voltage in volts is : ")
h_FE= I_C/(I_B*10^-6);
disp(h_FE,"The minimum value of h_FE that will
   change the state of the transistor is : ")
```

Scilab code Exa 2.18 Output voltage and minimum value of R1

```
// Exa 2.18
clc;
clear;
close;
format('v',6)
// Given data
V_CC= 12;// in V
bita_min= 30;
R1= 15;// in k ohm
R2= 100;// in k ohm
R_C= 2.2;// in kohm
V_BB= -12;// in V
V_BE= 0.7;// in V
// Part (i)
Vi= 12;// in V
V_BEsat= 0.8;// in V
V_CEsat= 0.2;// in V
// Applying KVL to B-E circuit, Vi= I1*R1+V_BEsat or
I1= (Vi-V_BEsat)/R1;// in mA
// Applying KVL to -12 V supply,
I2= (V_BEsat-V_BB)/R2;// in mA
// Applying KVL to input loop,
I_B= I1-I2;// in mA
// Applying KVL to output loop, V_CC= I_C*R_C+V_CEsat or
I_C= (V_CC-V_CEsat)/R_C;// in mA
I_Bmin= I_C/bita_min;// in mA
if I_B>I_Bmin then
    disp("Part (a) :")
    disp("As the value of I_B ("+string(I_B)+" mA) is greater than the value of I_Bmin ("+string(I_Bmin)+" mA)")
```

```
    disp("Hence the transistor is in saturation region")
end
Vo= V_CC-I_C*R_C;// in V
disp(Vo,"The output voltage in volts is : ")

// Part (b)
I2= (V_CC+V_BE)/R2;// in mA
// and I1= (V_CC-V_BE)/R1;// in mA          (i)
I_B= I_Bmin;// in mA
I1= I2+I_Bmin;// in mA
// Now from eq(i)
R1= (V_CC-V_BE)/I1;// in k ohm
disp("Part (b)")
disp(R1,"The value of R1 in k ohm is : ")

// Part (c)
I_C= 0;// in mA
Vo= V_CC-I_C*R_C;// in V
disp("Part (c) : Transistor is in cutoff")
disp(Vo,"The value of Vo in volts is : ")

// Note: There is some difference between coding output and answer of the book. This is why because in the book the calculate value of I_C is 5.36 mA/ 30 = 0.178 mA while accurate value is 0.179 mA
```

Chapter 3

Transistor Biasing And Thermal Stabilization

Scilab code Exa 3.1 DC load line

```
// Exa 3.1
clc;
clear;
close;
format('v',6)
// Given data
V_CC = 15;// in V
R_C = 4;// in k ohm
R_C =R_C * 10^3;// in ohm
I_C = 0;// in A
V_CE = V_CC - (I_C*R_C);// in V
V_CE = 0;// in V
// V_CE = V_CC - I_C*R_C;
I_C = V_CC/R_C;// in A
I_C = I_C * 10^3;// in mA
plot([V_CC 0],[0 I_C])
xlabel("V_CE in volts")
ylabel("I_C in mA")
title("DC load line")
```

```
disp("DC load line shown in figure")
```

Scilab code Exa 3.2 Q point

```
// Exa 3.2
clc;
clear;
close;
format('v',6)
// Given data
R_C = 5;// in k ohm
V_CC = 10;// in V
I_C = 1;// in mA
V_CE = V_CC - (I_C*R_C);// in V
disp("Part (i) When Collector load = 5 kohm");
disp("Operating point is : "+string(V_CE)+" V, "+
   string(I_C)+" mA")
disp("The quiescent point 5V and 1mA");
R_C = 6;// in k ohm
V_CE = V_CC - (I_C*R_C);// in V
disp("Part (ii) When Collector load = 6 kohm");
disp("Operating point is : "+string(V_CE)+" V, "+
   string(I_C)+" mA")
```

Scilab code Exa 3.3 Q point values

```
// Exa 3.3
clc;
clear;
close;
format('v',6)
// Given data
Beta = 100;
```

```
V_CC = 10;// in V
V_BE = 0.7;// in V
R_B = 150;// in k ohm
// V_CC - I_B*R_B - V_BE = 0;
I_B = (V_CC-V_BE)/R_B;// in mA
// I_C = Beta*I_B + (1+Beta)*I_CO;
I_C = Beta * I_B;// in A
// V_CC - I_C*R_C - V_CE = 0;
R_C = 1;// in k ohm
V_CE = V_CC - (I_C*R_C);// in V
disp("The operating point is : "+string(V_CE)+" V, "
   +string(I_C)+" mA")
```

Scilab code Exa 3.4 IBQ ICQ VCEQ VB VC and VBC

```
// Exa 3.4
clc;
clear;
close;
format('v',6)
// Given data
V_CC = 12;// in V
R_C = 2.2;// in k ohm
R_C = R_C * 10^3;// in ohm
R_B = 240;//in k ohm
R_B = R_B * 10^3;// in ohm
V_BE = 0.7;// in V
// V_CC - I_B*R_B - V_BE = 0;
I_BQ = (V_CC-V_BE)/R_B;// in A
I_BQ = I_BQ * 10^6;// in  A
disp(I_BQ,"The value of I_BQ in  A is");
Beta = 50;
// I_CQ = Beta*I_BQ + (1+BEta)*I_CO;
I_CQ = Beta*I_BQ*10^-6;// in A
I_CQ = I_CQ * 10^3;// in mA
```

```
disp(I_CQ,"The value of I_CQ in mA is");
// V_CC - I_CQ*R_C - V_CEQ = 0;
V_CEQ = V_CC - I_CQ*10^-3*R_C;// in V
disp(V_CEQ,"The value of V_CEQ in V is");
V_B = V_BE;// in V
disp(V_B,"The value of V_B in V is");
V_C = V_CEQ;// in V
disp(V_C,"The value of V_C in V is");
// V_CE = V_CB + V_BE;
V_CB = V_CEQ - V_BE;// in V
V_BC = -V_CB;// in V
disp(V_BC,"The value of V_BC in V is");
```

Scilab code Exa 3.5 Percent change the Q point value over temparature range

```
// Exa 3.5
clc;
clear;
close;
format('v',6)
// Given data
V_CC = 12;// in V
R_B = 100;// in k ohm
R_C = 500*10^-3;// in k ohm
Beta_dc = 100;
V_BE= 0.7;// in V
// V_CC - I_BQ*R_B - V_BE = 0;
I_BQ = (V_CC - V_BE)/R_B;// in mA
I_CQ = Beta_dc*I_BQ;// in mA
// V_CC - I_CQ*R_C - V_CEQ = 0;
V_CEQ = V_CC - (I_CQ*R_C);// in V
disp("The Q point at 30   is : "+string(V_CEQ)+" V, "+string(I_CQ)+" mA")
Beta_dc = 120;
```

```
I_CQ1 = Beta_dc*I_BQ;// in mA
V_CEQ1 = V_CC - (I_CQ1*R_C);// in V
disp("The Q point at 80  is : "+string(V_CEQ1)+" V, "+string(I_CQ1)+" mA")
PerI_CQ = ((I_CQ1-I_CQ)/I_CQ)*100;// in %
disp("The percentage change in I_CQ is : "+string(PerI_CQ )+" % (increase)");
PerV_CEQ = ((V_CEQ1-V_CEQ)/V_CEQ)*100;// in %
disp("The percentage change in V_CEQ is : "+string(abs(PerV_CEQ))+" % (decrease)");
```

Scilab code Exa 3.6 Stability factor

```
// Exa 3.36
clc;
clear;
close;
format('v',5)
// Given data
R_B = 100;// in k ohm
R_B = R_B * 10^3;// in ohm
R_C = 1;// in k ohm
R_C = R_C * 10^3;// in ohm
V_BE = 0.3;// in V
// S = 1 + Beta and Beta = I_C/I_B;
V_CC = 12;// in V
V_CE = 6;// in V
I_C = (V_CC-V_CE)/R_C;// in A
I_C = I_C * 10^3;// in mA
I_B = (V_CC-V_BE)/R_B;// in A
I_B = I_B * 10^6;// in  A
Beta = (I_C*10^-3)/(I_B*10^-6);
S = 1 + Beta;
disp(S,"The stability factor is");
```

Scilab code Exa 3.7 Collector current VCE and stability factor

```
// Exa 3.7
clc;
clear;
close;
format('v',6)
// Given data
V_CC = 25;// in V
R_B = 180;// in k ohm
R_C = 820*10^-3;// in k ohm
R_E = 200*10^-3;// in k ohm
bita = 80;
V_BE = 0.7;// in V
// Applying KVL to B-E loop, V_CC-I_B*R_B-V_BE-I_E*R_E=0 or
I_C= (V_CC-V_BE)/((R_B+R_E)/bita-R_E);// in A   (on putting I_B= I_C/bita and I_E= I_B+I_E)
disp(I_C,"The collector current in mA is");
V_CE = V_CC - (I_C*R_C);// in V
disp(V_CE,"The collector to emmiter voltage in V is");
S = (1 + bita)/( 1 + ( (bita*R_E)/(R_B+R_E) ) );
disp(S,"Current stability factor is");
Sdas = -bita/( R_B + R_E*(1+bita) );
disp(Sdas,"The voltage stability factor is");
```

Scilab code Exa 3.8 Q point value

```
// Exsa 3.8
clc;
clear;
```

```
close;
format('v',6)
// Given data
V_CC = 20;// in V
V_BE= 0.7;// in V
R_C = 4.7;//in k ohm
bita = 100;
R_B = 680;// in k ohm
I_C= poly(0,'I_C');// in mA
I_B= I_C/bita;// in  mA
// Applying KVL to C-B circuit , V_CC - (I_C+I_B)*R_C
    - I_B*R_B - V_BE = 0;
I_C= V_CC - (I_C+I_B)*R_C - I_B*R_B - V_BE;
I_C= roots(I_C);// in mA
I_B= I_C/bita;// in  mA
V_CEQ = V_CC - (I_C+I_B)*R_C;// in V
disp("Q point : "+string(V_CEQ)+" volts , "+string(
   I_C)+" mA")
```

Scilab code Exa 3.9 Collector to base bias circuit

```
// Exa 3.9
clc;
clear;
close;
format('v',6)
// Given data
V_CEQ = 5;// in V
I_CQ = 5;// in mA
V_CC = 12;// in V
bita = 120;
I_C = I_CQ;// in mA
V_BE = 0.7;// in V
I_B= I_C/bita;// in mA
// V_CC - (I_C+I_B)*R_C - V_CE = 0 or
```

```
R_C= (V_CC-V_CEQ)/(I_C+I_B);// in k ohm
// Applying KVL to base circuit , V_CC - (I_C+I_B)*
    R_C - I_B*R_B - V_BE = 0 or
R_B= (V_CEQ-V_BE)/I_B;// in k ohm
disp(R_C,"The value of R_C in k ohm is");
disp(R_B,"The value of R_B in k ohm is");
```

Scilab code Exa 3.10 Stability factor

```
// Exa 3.10
clc;
clear;
close;
format('v',5);
// Given data
V_CC = 10;// in V
R_C = 1;// in k ohm
R_B = 100;//in k ohm
V_CE = 5;// in V
V_BE = 0.7;// in V
V_CB= V_CE-V_BE;// in V
I_B= V_CB/R_B;// in mA
// V_CC = (I_C+I_B)*R_C + V_CE = I_C*R_C + I_B*R_C +
     V_CE;
I_C =  (V_CC-V_CE-(I_B*R_C))/R_C;// in mA
bita= I_C/I_B;
S = (1 + bita)/( 1 + bita*( R_C/(R_B+R_C) ) );
disp(S,"The value of stability factor is");
S_fixed_bias= 1+bita;// stability factor for fixed
    bias circuit
disp(S_fixed_bias,"For the fixed bias circuit , the
    value of stability factor would have been")
disp("Thus collector to base circuit has a low value
     of S and hence provides better Q point stability
    ")
```

Scilab code Exa 3.11 Q point value

```
// Exa 3.11
clc;
clear;
close;
format('v',5)
//Given data
Beta = 100;
V_CC = 10;// V
R1 = 9.1;// in k ohm
R_C = 1;// in k ohm
R_E = 560*10^-3;// in  k ohm
R2 = 4.7;// in k ohm
V_BE = 0.7;// in V
V_Th = (V_CC/(R1+R2))*R2;// in V
R_B = (R1*R2)/(R1+R2);// in k ohm
// V_Th - I_B*R_B - V_BE - I_E*R_E = 0 or
I_B = (V_Th-V_BE)/(R_B+((1+Beta)*R_E));// in mA
// I_C = Beta*I_B + (1+Beta)*I_CO;
I_C = Beta*I_B;// in mA (neglecting I_CO as it is
    very small)
// V_CC - (I_C*R_C) - V_CE - I_E*R_E = 0;
V_CE = V_CC - (I_C*R_C) - (I_C*R_E);// in V
disp("Q Point : "+string(V_CE)+" volts, "+string(I_C
    )+" mA")
```

Scilab code Exa 3.12 Quiescent current and collector emitter voltage

```
// Exa 3.12
clc;
```

```
clear;
close;
format('v',6)
// Given data
V_CC = 20;// in V
bita = 50;
R_C = 2;// in k ohm
R_E = 0.1;// in k ohm
R1 = 100;// in k ohm
R2 = 5;// in k ohm
R_Th = (R1*R2)/(R1+R2);// in k ohm
R_B = R_Th;// in k ohm
V_BE = 0.7;// in V
V_Th = (V_CC*R2)/(R1+R2);// in V
// Applying KVL to the base circuit, V_Th - I_B*R_B - V_BE - I_E*R_E = 0 or
I_B = (V_Th-V_BE)/(R_B + (R_E*(1+bita)));// in mA (on putting I_E= (1+bita)*I_B)
I_C = bita*I_B;// in mA
I_E = (1+bita)*I_B;// in mA
V_CE = V_CC - (I_C*R_C) - (I_E*R_E);// in V
disp("Q Point : "+string(V_CE)+" volts, "+string(I_C)+" mA")
```

Scilab code Exa 3.13 Q point value

```
// Exa 3.13
clc;
clear;
close;
format('v',5)
// Given data
bita= 44;
V_BE = 0.2;// in V
V_CC = -4.5;// in V
```

```
R1 = 2.7;// in k ohm
R_C = 1.5;// in k ohm
R2 = 27;// in k ohm
R_E = 0.27;// in k ohm
R_Th = (R1*R2)/(R1+R2);// in k ohm
R_B = R_Th;// in k ohm
V_Th = (V_CC*R_B)/R2;// in V
I_B= poly(0,'I_B');// in mA
I_C= bita*I_B;// in mA
I_E= -(I_C+I_B);// in mA
// Applying KVL to base circuit, -V_Th - I_B*R_B - V_BE + (I_E*R_E) = 0      (i)
I_B= (V_Th - I_B*R_B + V_BE + (I_E*R_E));// in mA
I_B= roots(I_B);// in mA
I_C= bita*I_B;// in mA
I_E= -(I_C+I_B);// in mA
// Applying KVL to collector circuit, -V_CC - I_C*R_C - V_CE + I_E*R_E = 0 or
V_CE = V_CC - (I_C*R_C) + (I_E*R_E);// in V
disp("Part (a) : ")
disp("Q Point : "+string(V_CE)+" volts, "+string(I_C)+" mA")
// Calculation of R'Th or R'B (Thevenin's Resistance)
r_bb = 0.69;// in k ohm
R_deshB = ((R1*R2)/(R1+R2)) + r_bb;// in k ohm
// Calculation of Thevenin's voltage
I_B= (V_Th+V_BE)/(R_deshB+(1+bita)*R_E);// in mA
I_C= bita*I_B;// in mA
// Applying KVL to collector circuit, -V_CC - (I_C*R_C) - V_CE + I_E*R_E = 0 or
V_CE = V_CC - (I_C*R_C) + (I_E*R_E);// in V
disp("Part (b) : ")
disp("Q Point : "+string(V_CE)+" volts, "+string(I_C)+" mA")
```

Scilab code Exa 3.14 DC bias voltage and current

```
// Exa 3.14
clc;
clear;
close;
format('v',5)
// Given data
bita = 140;
V_BE = 0.7;// in V
V_CC = 22;// in V
R1 = 39;// in k ohm
R_C = 10;// in k ohm
R2 = 3.9;// in k ohm
R_E = 1.5;// in k ohm
// Calculation of Thevenin's Resistance
R_Th = (R1*R2)/(R1+R2);// in k ohm
// Calculation of Thevenin's Voltage
V_Th = (V_CC*R2)/(R1+R2);// in V
I_B= poly(0,'I_B');// in mA
I_E= (1+bita)*I_B;// in mA
// Applying KVL to input side, V_Th - I_B*R_Th -
    V_BE - I_E*R_E=0 or
I_B= V_Th - I_B*R_Th - V_BE - I_E*R_E;
I_B= roots(I_B);// in mA
I_C = bita*I_B;// in mA
I_E= (1+bita)*I_B;// in mA
// Applying KVL to C-E circuit, V_CC - I_C*R_C -
    V_CE - I_E*R_E = 0 or
V_CE = V_CC - (I_C*R_C) - ((1+bita)*I_B*R_E);// in V
I_B= I_B*10^3;// in  A
disp(I_B,"The value of I_B in  A is");
disp(I_C,"The value of I_C in mA is");
disp(V_CE,"The value of V_CE in V is");
```

Scilab code Exa 3.15 RE and stability factor

```
// Exa 3.15
clc;
clear;
close;
format('v',5)
// Given data
V_CC =12;// in V
R_C = 4.3;// in k ohm
V_CE = 4;// in V
V_BE = 0.7;// in V
V_EE = 6;// in V
bita = 50;
// Applying KVL in base circuit, -V_BE - I_ER_E +
   V_EE = 0 or
I_ER_E = V_EE - V_BE;// in V
// Applying KVL in C-E circuit, V_CC-I_C*R_C-V_CE-
   I_ER_E+V_EE=0 or
I_C = (V_CC - V_CE - I_ER_E + V_EE)/R_C;// in mA
I_B = I_C/bita;// in mA
I_E = I_C+I_B;// in mA
R_E= I_ER_E/I_E;// in k ohm
disp(R_E,"The value of R_E in k ohm is : ")
del_IC= bita*(1+bita)*R_E;
del_ICO= bita*(1+bita)*R_E;
S= del_IC/del_ICO;
disp(S,"The value of stability factor, S is : ")
S_desh= bita/((1+bita)*R_E);
disp(S_desh,"The value of stability factor, S'' is :
   ")
```

Scilab code Exa 3.17 Junction temperature

```
// Exa 3.17             (Miss printed as example 3.14)
clc;
clear;
close;
format('v',5)
// Given data
Tj = 150;//Junction temperature in degree C
P_Cmax = 125;// in mW
T = 25;// free-air temperature in degree C
T1 = 0;// in degree C
curve = (Tj-T)/(P_Cmax - T1);// in degreeC/mW
T_A = 25;// Ambient temperature in degree C
P_D = 75;// Collector junction dissipation in mW
theta = 1;// in degree C/mW
// Tj-T_A = theta*P_D;
Tj = T_A + (theta*P_D);// in degree C
disp(Tj,"The junction temperature in  C is");
```

Scilab code Exa 3.18 Thermal resistance and junction temperature

```
// Exa 3.18             (Miss printed as example
   3.15)
clc;
clear;
close;
format('v',5)
// Given data
P_Cmax = 125;// in mW
P_D = P_Cmax;// in mW
T_A = 25;// in degree C
Tj = 150;// in degree C
// Tj-T_A = theta*P_D;
theta = (Tj-T_A)/P_D;// in degree C/mW
```

```
disp(theta,"The thermal resistance for a transistor in  C/mW is");
// For theta= 1  C/mW
P_D = 75;// in mW
// Tj-T_A = theta*P_D;
Tj = (theta*P_D) + T_A;// in degree C
disp(Tj,"The junction temperature in  C is");
```

Scilab code Exa 3.20 Biasing component for fixed bias

```
// Exa 3.20                    (Miss printed as example 3.17)
clc;
clear;
close;
format('v',7)
// Given data
V_E = 1;// in V
V_BE = 0.7;// in V
R_C = 1;// in k ohm
Beta = 180;
V_CC = 12;// in V
V_CEQ = 6;// in V
// Applying KVL into collector circuit, V_CC - I_C*R_C - V_CEQ = 0 or
I_C = (V_CC-V_CEQ)/R_C;// in mA
I_B = I_C/Beta;// in mA
// Applying KVL into base circuit, V_CC - I_B*R_B - V_BE = 0 or
R_B = (V_CC-V_BE)/I_B;// in k ohm
disp(R_B,"The value of R_B in k ohm is");
//Applying KVL to collector circuit, V_CC - I_C*R_C - V_CE - V_E = 0 or
I_C = (V_CC-V_CEQ-V_E)/R_C;// in mA
I_B = I_C/Beta;// in mA
```

```
I_E = I_C+I_B;// in mA
R_E = V_E/(I_E);// in k ohm
R_E= round(R_E*10^3);// in ohm
disp(R_E,"The value of R_E in ohm is");
I_R2 = 10*I_B;// in mA
V_BE= 0.6;// in V
//R2 =V_B/I_R2 = (V_E+V_BE)/I_R2;
R2 = (V_E+V_BE)/I_R2;// in k ohm
R2= R2*10^3;// in ohm
disp(R2,"The value of R2 in ohm is");
I_R1 = I_R2 + I_B;// in mA
//R1 = V_R1/I_R1 = (V_CC-V_B)/I_R1;
V_B = V_E+V_BE;// in V
R1 = (V_CC-V_B)/I_R1;// in k ohm
disp(R1,"The value of R1 in k ohm is");
```

Scilab code Exa 3.21 Value of ICQ

```
// Exa 3.21                    (Miss printed as example
   3.18)
clc;
clear;
close;
format('v',5)
// Given data
V_BB= 6;// in V
I_CBO =0.5;// in   A
V_BE = 0.7;// in V
R_B= 50;// in k ohm
R_E= 1;// in k ohm
bita = 75;
// V_BB - I_B*R_B - V_BE - I_E*R_E = 0 or
I_B=(V_BB-V_BE)/(R_B+(1+bita)*R_E);// in mA       (on
   putting I_E= (1+bita)*I_B)              (i)
I_B= round(I_B*10^3);// in   A
```

```
I_C= bita*I_B;// in  A
I_C= I_C*10^-3;// in mA
I_CQ= I_C;// in mA
disp(I_CQ,"The value of I_CQ at room temperature in mA is : ")
// Part (ii)
C= 2;// temperature coefficient in mV/ C
C= 2*10^-3;// in V/ C
T2= 20;// in  C
T1= 0;// in  C
I_CBO2= I_CBO*2^((T2-T1)/10);// in  A
V_BE2= V_BE-C*T2;// in V
// Now from eq(i), for the new value of I_B
I_B=(V_BB-V_BE2)/(R_B+(1+bita)*R_E);// in mA
I_B= I_B*10^3;// in  A
I_C= bita*I_B+(1+bita)*I_CBO2;// in  A
I_C= I_C*10^-3;// in mA
I_CQ= I_C;// in mA
disp(I_CQ,"The value of I_CQ when temperature increases by 20  C in mA is : ")
```

Scilab code Exa 3.22 Value of R1 R2 and RE

```
// Exa 3.22                    (Miss printed as example 3.19)
clc;
clear;
close;
format('v',6)
// Given data
S = 10;
bita = 50;
h_fe = bita;
V_CC= 20;// in V
V_CE = 10;// in V
```

```
R_C = 2;// in k ohm
I_C = 4;// in mA
I_B =I_C/bita;// in mA
// Applying KVL to collector loop, V_CC -I_C*R_C - V_CE - I_E*R_E = 0 or
R_E = (V_CC -I_C*R_C - V_CE)/(I_C+I_B);// in k ohm (on putting I_E= I_C+I_B)
R_E= round(R_E*10^3);// in ohm
disp(R_E,"The value of R_E in ohm is");
// Formula S = (1+bita)*( (1 + (R_B/R_E))/( (1+bita) + (R_B/R_E) ) ) or
R_B= (1+bita)*(1-S)*R_E/(S-1-bita);// in ohm
// But R_B= R1 || R2= R1*R2/(R1+R2) => R2/(R1+R2)= R_B/R1            (i)
// Calculation of R1 and R2 :
V_BE= 0.2;// in V
// Applying KVL to input loop,
V_R2= V_BE+(I_C+I_B)*10^-3*R_E;// in V
// But V_R2= R2*V_CC/(R1+R2) => R2/(R1+R2)= V_R2/V_CC            (ii)
// On comparing eq (i) and (ii)
R1= R_B*V_CC/V_R2;// in ohm
R2= R1*V_R2/(V_CC-V_R2);// in ohm
R1= R1*10^-3;// in k ohm
R2= R2*10^-3;// in k ohm
disp(R1,"The value of R1 in k ohm is : ")
disp(R2,"The value of R2 in k ohm is : ")
// Effect of Reducing S or 3 :
S=3;
// Formula S = (1+bita)*( (1 + (R_B/R_E))/( (1+bita) + (R_B/R_E) ) ) or
R_B= (1+bita)*(1-S)*R_E/(S-1-bita);// in ohm
R_B= R_B*10^-3;// in k ohm
disp(R_B,"When S<=3, the value of R_B in k ohm is : ")
disp("Thus S is reduced below 3 at the cost of reduction of it''s input impedance")
```

Chapter 4

The Transistor At Low Frequency

Scilab code Exa 4.1 Overall current gain

```
// Exa 4.1
clc;
clear;
close;
format('v',6)
// Given data
R1 = 100*10^3;// in ohm
R2 = 10*10^3;// in ohm
h_fe = 50;
h_oe = 1/40;// in ohm
R_L = 5*10^3;// in ohm
R_S= 5*10^3;// in ohm
h_ie = 1.1*10^3;// in ohm
h_re = 2.5*10^-4;
R_B = (R1*R2/(R1+R2));// in ohm
A_I = (-h_fe)/(1 + h_oe*R_L);
disp(A_I,"The internal current gain is");
//Internal input impedance, Zi = Vbe/Ib or
Zi = (h_ie + h_re*A_I*R_L);// in ohm
```

```
Zi= Zi*10^-3;// in k ohm
disp(Zi,"The internal input impedance in k ohm is");
Zi= Zi*10^3;// in ohm
//Internal voltage gain , Av = Vce/Vbe or
Av = (A_I*R_L)/Zi;
disp(Av,"The internal voltage gain is");
Ri = floor(R_B*Zi/(R_B+Zi));// in ohm
Ri= Ri*10^-3;// in k ohm
disp(Ri,"The overall input impedance in k ohm is");
Ri= Ri*10^3;// in ohm
// V_S= I_i*R_S+v_be or
VS_by_vbe= Ri/(Ri+R_S);
Avs= Av*VS_by_vbe;
disp(Avs,"The overall voltage gain is : ")
// R_B*(I_i-I_b)= Zi*I_b or
I_bBYI_i= R_B/(R_B+Zi);
A_IS= A_I*I_bBYI_i;
disp(A_IS,"The overall current gain is : ")
Rdesh_S= R_B*R_S/(R_B+R_S);// in ohm
Rdesh_S= 3220
I_bByVce= -h_re/(h_ie+Rdesh_S);
Yo= h_oe-h_fe*h_re/(h_ie+Rdesh_S)*10^3;
Zo= 1/Yo;
disp(Zo,"The Output impedance in ohm is : ")
```

Scilab code Exa 4.2 Overall current gain

```
// Exa 4.2
clc;
clear;
close;
format('v',6)
// Given data
V_CC = 15;// in V
R_L = 10;// in k ohm
```

```
Rf = 200;// in k ohm
R_S = 5;// in k ohm
Rf2 = Rf;// in k ohm
h_fe = 50;
V_S= 10*10^-3;// in V
h_oe = 1/40;// in k ohm
R_L = (R_L*Rf2)/(R_L+Rf2);// in k ohm
Ai = -h_fe/(1+h_oe*R_L);
disp(Ai,"The internal current gain is");
//Zi = Vbe/Ib = h_ie +Ai*h_re*R_L;
h_ie = 1.1;// in k ohm
h_re = 2.5*10^-4;
Zi = h_ie +Ai*h_re*R_L;// in k ohm
disp(Zi,"The internal input impedance in k ohm is");
//A_V = Vce/Vbe = (Ai*R_L)/Zi;
A_V = (Ai*R_L)/Zi;
disp(A_V,"The internal voltage gain is");
Rf1= Rf/(1-A_V)
// Rf1 = Rf/(1-A_V);// in k ohm
//Ri = Vi/Ii = Vbe/Ii = (Rf1*Zi)/(Rf1+Zi);
Ri = (Rf1*Zi)/(Rf1+Zi);// in k ohm
disp(Ri,"The overall input impedance in k ohm is");
//A_VS = Vo/V_S or
A_VS = A_V*(Ri/(R_S+Ri));
disp(A_VS,"The overall voltage gain is");
//A_IS = I_L/Ii or
A_IS = (Rf2/(Rf2+R_L))*Ai*(Rf1/(Rf1+Zi));
disp(A_IS,"The overall current gain is");
Rdesh_S= Rf1*R_S/(Rf1+R_S);// in k ohm
Yo= h_oe-h_re*h_fe/(h_ie+Rdesh_S);// in mho
Zo= 1/Yo;// in ohm
disp(Zo,"The output impedance in ohm is : ")
Zdesh_o= Rf2*Zo/(Rf2+Zo);// in ohm
disp(Zdesh_o,"The overall output impedance in ohm is
    : ");
Vo= V_S*abs(A_VS);// in V
Vo= Vo*10^3;// in mV
disp(Vo,"The magnitude of output voltage in mV is :
```

```
")
```

Scilab code Exa 4.3 Output impedance

```
// Exa 4.3
clc;
clear;
close;
format('v',6)
// Given data
h_ic = 2;// in k ohm
h_fc = -51;
h_oc = 25*10^-6;// in ohm
h_rc= 1;
V_CC = 20;// in V
R1 = 10;// in k ohm
R2 = 10;// in k ohm
R_S = 1;// in k ohm
R_E = 5;// in k ohm
R_B= 5;// in k ohm
R_L= 5;// in k ohm
// (i) Current Gain
Ai = (-h_fc)/(1+h_oc*R_E*10^3);
disp(Ai,"The current gain is");
// (ii) Input impedance
Zi = h_ic*10^3 + h_rc*Ai*R_E*10^3;// in ohm
Zi = Zi * 10^-3;// in k ohm
disp(Zi,"The input impedance in k ohm is");
// (iii) Voltage Gain
A_V = (Ai*R_L*10^3)/(Zi*10^3);
A_V = 1;// (approx)
disp(A_V,"The voltage gain is");
// (iv) Overall Input Impedance
Z_IS = (R_B*Zi)/(R_B+Zi);// in k ohm
disp(Z_IS,"The overall input impedance in k ohm is")
```

```
;
// (v) Overall voltage gain
A_VS = (A_V*Zi)/(Zi+R_S);
disp(A_VS,"The overall voltage gain is");
// (vi) Overall current gain
A_IS =Ai*(R_B/(R_B+Zi));
disp(A_IS,"The overall current gain is");
// (vii) Output impedance
RdasS = (R_S*R_B)/(R_S+R_B);// in k ohm
Yo = h_oc - ( (h_fc*h_rc)/(h_ic*10^3+RdasS*10^3) );
    // in mho
Zo = 1/Yo;// in ohm
disp(Zo,"The output impedance in ohm is");
```

Scilab code Exa 4.4 Overall current gain

```
// Exa 4.4
clc;
clear;
close;
format('v',6)
// Given data
h_ie = 1.1;// in k ohm
h_re = 2.5*10^-4;
h_fe = 50;
h_oe = 25*10^-6;// in A
V_CC = 15;// in V
R1 = 20;// in k ohm
R_C = 2;// in k ohm
R2 = 10;// in k ohm
R_S = 1;// in k ohm
R_E = 1;// in k ohm
// (i) Current Gain
Ai = -h_fe/(1 + h_oe*R_C*10^3);
disp(Ai,"The current gain is");
```

```
// (ii) Input impedance
Zi = (h_ie*10^3) + (h_re*Ai*R_C*10^3);//in ohm
Zi = Zi * 10^-3;// in k ohm
disp(Zi,"The input impedance in k ohm is");
// (iii) Voltage gain
A_V = (Ai*R_C)/Zi;
disp(A_V,"The voltage gain is");
// (iv) Overall input impedance
R_B = (R1*R2)/(R1+R2);// in k ohm
Z_IS = (Zi*R_B)/(Zi+R_B);// in k ohm
disp(Z_IS,"The overall input impedance in k ohm is")
    ;
// (v) Overall voltage gain
A_VS = A_V * (Z_IS/(Z_IS+R_S));
disp(A_VS,"The overall voltage gain is");
// (vi) Overall current gain
A_IS =Ai*(R_B/(R_B+Zi));
disp(A_IS,"The overall current gain is");
```

Scilab code Exa 4.5 Power gain

```
// Exa 4.5
clc;
clear;
close;
format('v',7)
// Given data
h_ie = 1.1;// in k ohm
h_oe = 25;// in A/V
h_oe = h_oe * 10^-6;// in A/V
h_fe = 50;
h_re = 2.5*10^-4;
R_L = 1.6;// in ohm
R_S = 1;// in k ohm
V_CC = 15;// in V
```

```
// (i) Current Gain
Ai = -h_fe/(1 + (h_oe*R_L));
disp(Ai,"The current gain is");
// (ii) Input impedance
Zi = (h_ie*10^3) + (h_re*Ai*R_L);// in ohm
Zi= Zi*10^-3;// in k ohm
disp(Zi,"The input impedance in k ohm is");
Zi= Zi*10^3;// in ohm
// (iii) Voltage gain
A_V = Ai*R_L/Zi;
disp(A_V,"The voltage gain is");
// (iv) Power gain
A_P = Ai*A_V;
disp(A_P,"The power gain is");
```

Scilab code Exa 4.6 ICQ VCEQ Ai Zi Av ZIS AVS AIS

```
// Exa 4.6
clc;
clear;
close;
format('v',6)
// Given data
h_fe = 150;
Beta_dc = h_fe;
h_ie = 1*10^3;// in ohm
h_re = 0;
h_oe = 0;
V_CC = 18;// in V
V_BE= 0.7;// in V
R1 = 100*10^3;// in ohm
R2 = 50*10^3;// in ohm
R_C = 1*10^3;// in ohm
R_E = 0.5*10^3;// in ohm
V_Th = (V_CC/(R1+R2))*R2;// in V
```

```
R_Th =(R1*R2)/(R1+R2);// in ohm
// V_Th - I_B*R_Th - V_BE - (1+Beta)*-I_B*R_E = 0;
I_B = (V_Th-V_BE)/( R_Th + (1+Beta_dc)*R_E);// in A
//I_C = I_CQ = Beta*I_B;
I_C = Beta_dc*I_B;// in A
I_CQ = I_C;// in A
I_CQ= I_CQ*10^3;// in mA
disp(I_CQ,"The value of I_CQ in mA is");
I_E = (1+Beta_dc)*I_B;// in mA
// V_CC - I_C*R_C - V_CE - I_E*R_E = 0;
V_CE = V_CC - (I_C*R_C) - (I_E*R_E);// in V
disp(V_CE,"The value of V_CE in V is");
R_L =R_C;// in ohm
Ai = -h_fe/(1+(h_oe*R_L));
disp(Ai,"The current gain is ");
Zi = h_ie + h_re*Ai*R_L;// in ohm
Zi= Zi*10^-3;// in k ohm
disp(Zi,"The input impedance in k ohm is");
Zi= Zi*10^3;// in ohm
A_V = Ai*(R_L/Zi);
disp(A_V,"The voltage gain is");
R_B= (R1*R2)/(R1+R2);// in ohm
Z_IS =(Zi*R_B)/(Zi+R_B);// in ohm
Z_IS= Z_IS*10^-3;// in kohm
disp(Z_IS,"The overall input impedance in k ohm is");
Z_IS= Z_IS*10^3;// in ohm
A_VS =A_V*(Z_IS/Z_IS);
disp(A_VS,"The overall voltage gain is");
A_IS =Ai * (R_B/(R_B+Zi));
disp(A_IS,"The overall current gain is");
```

Chapter 5

BJT At High Frequency

Scilab code Exa 5.1 Parameter of hybrid phi model

```
// Exa 5.1
clc;
clear;
close;
format('v',6)
// Given data
I_C = 2;// in mA
I_C =I_C * 10^-3;// in A
V_CEQ = 20;// in V
h_fe = 100;
I_BQ = 20;// in  A
I_BQ = I_BQ * 10^-6;// in A
Beta = 100;
f_T = 50;// in MHz
f_T = f_T * 10^6;// in Hz
Cob = 3;// in pF
Cob = Cob * 10^-12;// in F
h_ie = 1400;// in ohm
T = 300;// in K
// (i) Transconductance
g_m = 11600*(I_C/T);// in S
```

```
g_m=g_m*10^6;// in   S
disp(g_m,"The transconductance in   S is");
// (ii) Input resistance
g_m=g_m*10^-6;// in S
r_be = h_fe/g_m; //in ohm
disp(r_be,"The input resistance in ohm is");
// (iii) Capacitance
Cbc = Cob ;// in F
Cbe = g_m/(2*%pi*f_T)-Cbc;// in F
Cbe= round(Cbe*10^12);// in pF
disp(Cbe,"The capacitance in pF is");
// (iv) Base Spreading Resistance
r_bb = round(h_ie - r_be);// in ohm
disp(r_bb,"The base spreading resistance in ohm is")
    ;
```

Scilab code Exa 5.2 Parameter of hybrid phi model

```
// Exa 5.2
clc;
clear;
close;
format('v',6)
// Given data
I_C = 10;// in mA
I_C =I_C * 10^-3;// in A
V_CE = 10;// in V
V_T= 26*10^-3;// in V
h_ie = 500;// in ohm
h_oe = 4*10^-5;// in S
h_fe  = 100;
g_be = 1/260;
h_re = 10^-4;
f_T = 50;// in MHz
f_T = f_T * 10^6;// in Hz
```

```
T = 300;// in K
Cob =3;// in pF
Cob = Cob * 10^-12;// in F
// (i) Transconductance
g_m = I_C/V_T;// in A/V
g_m= round(g_m*10^3);// in mA/V
disp(g_m,"The Transconductance in mA/V is");
// (ii) Input resistance
g_m= g_m*10^-3;// in A/V
r_be = round(h_fe/g_m);// in ohm
disp(r_be,"The input resistance in ohm is");
// (iii) Base spreading resistance
r_bb = h_ie - r_be;// in ohm
disp(r_bb,"The base spreading resistance in ohm is")
    ;
// (iv) The feedback conductance
format('e',8)
g_bc = h_re*g_be;
disp(g_bc,"The feedback conductance is");
// (v) The output conductance
g_ce = h_oe - (1+h_fe)*g_bc
disp(g_ce,"The output conductance is : ")
// (vi) Capacitance
format('v',6)
Cbe= g_m/(2*%pi*f_T);// in F
Cbe= Cbe*10^12;// in pF
disp(Cbe,"The value of C_b''e in pF is : ")
Cc= Cob;// in F
Cc= Cc*10^12
disp(Cc,"The value of Cc in pF is : ")
```

Scilab code Exa 5.3 Emitter diffusion capacitance

```
// Exa 5.3
clc;
```

```
clear;
close;
format('v',5)
// Given data
W = 10^-6;// in m
I_E =2;// in mA
I_E = I_E * 10^-3;// in A
V_T = 26;// in mV
V_T = V_T * 10^-3;// in V
D_B = 47*10^-4;
//g_m = abs(I_C)/V_T = abs(I_E)/V_T;
// The emitter diffusion capacitance, Cbe = g_m*((W
   ^2)/(2*D_B));
Cbe = I_E/V_T*W^2/(2*D_B);// F
Cbe= Cbe*10^12;// in pF
disp(Cbe,"The emitter diffusion capacitance in pF is
   ");
Cbe= Cbe*10^-12;// in F
g_m = abs(I_E)/V_T;
// The transition frequency
f_T = g_m/(2*%pi*Cbe);// in Hz
f_T = f_T * 10^-6;// in MHz
disp(f_T,"The transition frequency in MHz is");

// Note: The answer in the book is not accurate.
```

Scilab code Exa 5.4 Bita cutoff frequency and gain bandwidth product

```
// Exa 5.4
clc;
clear;
close;
// Given data
I_CQ = 5;// in mA
I_CQ = I_CQ * 10^-3;// in A
```

```
V_VEQ = 10;// in V
h_ie = 600;// in ohm
h_fe = 100;
C_C = 3;// in pF
C_C = C_C * 10^-12;// in F
Ai = 10;// Ai(f)
f = 10;// in MHz
// Ai = h_fe/( sqrt( 1 + ((f/f_Beta)^2) ) );
f_Beta = f/(sqrt( ((h_fe/Ai)^2) - 1 ));// in MHz
disp(f_Beta,"The Beta cut off frequency in MHz is");
f_T = h_fe*f_Beta;// in MHz
disp(f_T,"The gain bandwidth product in MHz is");
g_m = 0.1923;
Ce = g_m/(2*%pi*f_T*10^6);// in F
disp(Ce,"The value of Ce in F is");
Cbe= Ce;// in F
disp(Cbe*10^12,"The value of C_b''e in pF is : ")
r_be = h_fe/g_m;// in ohm
disp(r_be,"The value of r_b''e in ohm is");
r_bb = h_ie - r_be;// in ohm
disp(r_bb,"The value of r_bb'' in ohm is");
```

Scilab code Exa 5.5 Base width of Si pnp transistor

```
// Exa 5.5
clc;
clear;
close;
// Given data
f_T = 400;// in MHz
D_Beta = 13;// in cm^2/sec
//Ce = (g_m*(W^2))/(2*D_B), so
//f_T = (g_m/(2*%pi))*( (2*D_B)/(g_m*(W^2)) ) = D_B
    /(%pi*(W^2));
W = sqrt( D_Beta/(%pi*f_T*10^6) );// in cm
```

```
W = W * 10^4;// in  m
disp(W,"The base width of silicon transistor in  m is");
```

Scilab code Exa 5.6 Ce and fT

```
// Exa 5.6
clc;
clear;
close;
format('v',5)
// Given data
D_B = 47;// in cm^2/sec
I_C = 2;// in mA
I_C = I_C * 10^-3;// in A
V_CEQ = 15;// in V
W = 1;// in  m
W = W * 10^-4;// in cm
V_T = 0.026;// in V
g_m =I_C/(abs(V_T));// in ohm
Ce = (g_m*(W^2))/(2*D_B);// in F
Ce = Ce * 10^12;// in pF
disp(Ce,"The value of Ce in pF is");
f_T = g_m/(2*%pi*Ce*10^-12);// in Hz
f_T = f_T * 10^-6;// in MHz
disp(f_T,"The value of f_T in MHz is");
```

Chapter 6

The Field Effect Transistor And MOSFET

Scilab code Exa 6.1 Transfer curve

```
// Exa 6.1
clc;
clear;
close;
// Given data
I_DSS = 10;// in mA
V_P = -4;// in V
V_GS= V_P:0.1:0
I_D = I_DSS * ((1 - (V_GS/V_P))^2);// in A
plot(V_GS,I_D);
xlabel("V_GS in volts");
ylabel("I_D in mA")
title("Transfer curve")
disp("The transfer curve shown in the figure.")
```

Scilab code Exa 6.2 Transfer curve

```
// Exa 6.2
clc;
clear;
close;
// Given data
I_DSS = 4;// in mA
V_P = 3;// in V
V_GS= 0:0.1:V_P
I_D = I_DSS * ((1 - (V_GS/V_P))^2);// in A
plot(V_GS,I_D);
xlabel("V_GS in volts");
ylabel("I_D in mA")
title("Transfer curve")
disp("The transfer curve shown in the figure.")
```

Scilab code Exa 6.3 Value of ID

```
// Exa 6.3
clc;
clear;
close;
format('v',5)
// Given data
I_Don = 10;// in mA
I_Don = I_Don * 10^-3;// in A
V_GS = -12;// in V
V_GSt = -3;// in V
//From I_Don = Kn*((V_GS-V_GSt)^2);
Kn = I_Don/((V_GS-V_GSt)^2);// in A/V
Kn= Kn* 10^3;// in mA/V
V_GS = -6;// in V
I_D = Kn*((V_GS-V_GSt)^2);// in mA
disp(I_D,"The drain current in mA is");
```

Scilab code Exa 6.4 Minimum value of VDS

```
// Exa 6.4
clc;
clear;
close;
format('v',6)
// Given data
I_DSS = 8;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P =-5;// in V
V_GS = -2;// in V
V_DSmin = V_GS - V_P;// in V
disp(V_DSmin,"The minimum value of V_DS in V is");
I_DS = I_DSS*((1 - (V_GS/V_P))^2);// in A
I_DS = I_DS * 10^3;// in mA
disp(I_DS,"The drain current in mA is");
```

Scilab code Exa 6.5 VGS and gm

```
// Exa 6.5
clc;
clear;
close;
format('v',6)
// Given data
I_DSS = 1.65;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -2;// in V
I_D = 0.8;// in mA
I_D = I_D * 10^-3;// in A
V_DD = 24;// in V
```

```
V_GS = V_P * (1 - sqrt( I_D/I_DSS ));// in V
disp(V_GS,"The value of V_GS in V is");
g_mo = -2 * (I_DSS*10^3/V_P);// in ms
g_m = g_mo * (1 - V_GS/V_P);// in ms
disp(g_m,"The value of g_m in ms is");
```

Scilab code Exa 6.6 Drain current

```
// Exa 6.6
clc;
clear;
close;
format('v',6)
// Given data
Vt = 2;// in V
unCox = 20;// in  A /V^2
Kdasn = unCox;// in  A /V^2
W = 100;// in  m
L = 10;// in  m
V_GS = 3;// in V
V_DS = 0.5;// in V
V_GS = 3;// in V
Vt = 2;// in V
del_V = V_GS-Vt;// in V
i_D = Kdasn*10^-6*(W/L)*( del_V*V_DS - 1/2*(V_DS^2)
   );// in A
i_D = i_D * 10^6;// in  A
disp("Part (a) For V_D= 0.5 V, NOMS is operating in
   Triode region.")
disp(i_D,"The drain current in  A is");
V_DS = 1;// in V
i_D = (1/2)* Kdasn*10^-6*(W/L)*( del_V^2 );// in A
i_D = i_D * 10^6;// in  A
disp("Part (b) For V_D= 1 V, NOMS is operating in
   saturation region.")
```

```
disp(i_D,"The drain current in  A is");
V_DS = 5;// in V
i_D = (1/2)* Kdasn*10^-6*(W/L)*( del_V^2 );// in A
i_D = i_D * 10^6;// in  A
disp("Part (c) For V_D= 5 V, NOMS is operating in
   saturation region.")
disp(i_D,"The drain current in  A is");
```

Scilab code Exa 6.7 Drain to source resistance

```
// Exa 6.7
clc;
clear;
close;
format('v',6)
// Given data
Vt = 2;// in V
i_D = 1;// in mA
i_D = i_D * 10^-3;// in A
V_GS = 3;// in V
// From i_D= 1/2*KnwByL*(V_GS-Vt)^2
KnwByL= 2*i_D/(V_GS-Vt)^2;
V_GS= 4;// in V
V_DS= 5;// in V
i_D= 1/2*KnwByL*(V_GS-Vt)^2;// in A
i_D= i_D*10^3;// in mA
disp(i_D,"The value of i_D in mA is : ")
r_DS= 1/(KnwByL*(V_GS-Vt));// in ohm
disp(r_DS,"The value of drain to source resistance
   in ohm is : ")
```

Scilab code Exa 6.8 Minimum VDS required

```
// Exa 6.8
clc;
clear;
close;
format('v',6)
// Given data
Vt = -2;// in V
KnwByL = 2*10^-3;// in A/V^2
V_GS = 1;// in V
V_DS = V_GS-Vt;// in V
disp(V_DS,"The minimum value of V_DS in V is");
i_D = 1/2*KnwByL*V_DS^2;// in A
i_D = i_D * 10^3;// in mA
disp(i_D,"The value of i_D in mA is");
```

Chapter 7

FET Biasing

Scilab code Exa 7.1 Different values of VGSQ IDQ and VDS

```
// Exa 7.1
clc;
clear;
close;
format('v',6)
// Given data
I_DSS = 8;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -8;// in V
V_DD = 16;// in V
R_D = 2;// in k ohm
R_D = R_D * 10^3;// in ohm
V_GG = 2;// in V
R_G = 1;// in Mohm
R_G = R_G * 10^6;// in ohm
I_G = 0;
// To calculate V_GS
V_GS = -V_GG;// in V
disp(V_GS,"The value of V_GS in V is");
// To calculate the drain current
I_DQ =I_DSS*((1 - (V_GS/V_P))^2);// in A
```

```
I_DQ = I_DQ * 10^3;// in mA
disp(I_DQ,"The value of I_DQ in mA is");
// To calculate V_DS
// V_DD = I_D*R_D + V_DS;
V_DS = V_DD - (I_DQ*10^-3*R_D);// in V
disp(V_DS,"The value of V_DS in V is");
```

Scilab code Exa 7.2 VGSQ IDQ and VDS

```
// Exa 7.2
clc;
clear;
close;
format('v',6)
// Given data
I_DSS = 10;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -4;// in V
V_DD= 20;// in V
R_S = 1;// in k ohm
R_S = R_S * 10^3;// in ohm
R_D = 2.7;// in k ohm
R_D = R_D * 10^3;// in ohm
I_DQ= poly(0,'I_DQ');
V_GS= -I_DQ*R_S;// in V
I_DQ= I_DQ-I_DSS*(1-V_GS/V_P)^2;// in A
I_DQ= roots(I_DQ);// in A
I_DQ= I_DQ(2);// in A
I_DQ= I_DQ*10^3;// in mA
disp(I_DQ,"The value of I_DQ in mA is : ")
I_DQ= I_DQ*10^-3;// in A
V_GSQ= -I_DQ*R_S;// in V
disp(V_GSQ,"The value of V_GSQ in volts is : ")
V_DS= V_DD-I_DQ*(R_D+R_S);// in V
disp(V_DS,"The value of V_DS in volts is : ")
```

Scilab code Exa 7.3 W by L ratio

```
// Exa 7.3
clc;
clear;
close;
format('v',6)
// Given data
Kn = 20*10^-3;// in A/V^2
Vt = -1;// in V
V_DD = 5;// in V
I_D = 100;// in mA
I_D= I_D*10^-3;// in A
V_GS = 0;// in V
// I_D = (1/2)*Kdasn*(W/L)*((V_GS-Vt)^2);
WbyL = (I_D*2)/(Kn*((V_GS-Vt)^2));
disp(WbyL,"The (W/L) ratio is");
V_DS = V_GS-Vt;// in V
V_Dmin = V_DS;// in V
R_Dmax = (V_DD-V_Dmin)/I_D;// in ohm
disp("The range of R_D is : 0 to "+string(R_Dmax)+"
    ");

//Note: The unit of R_Dmax in the book is wrong.
```

Scilab code Exa 7.5 IDQ and VDSQ

```
// Exa 7.5
clc;
clear;
close;
```

```
format('e',8)
// Given data
I_Don = 6;// in mA
I_Don = I_Don * 10^-3;// in A
V_GSon = 8;// in V
Vt = 3;// in V
V_DD = 12;// in V
R_D= 2*10^3;// in ohm
// (i) To obtain the value of K
K = I_Don/( (V_GSon-Vt)^2 );// in A/V^2
disp(K,"The value of K in A/V^2 is");
format('v',7)
// To obtain the value of I_DQ
I_D= poly(0,'I_D');
V_GS= V_DD-I_D*R_D;// in V
I_D= I_D-K*(V_GS-Vt)^2;// in A
I_D= roots(I_D);// inA
I_D= I_D(2);// in A
I_D= I_D*10^3;// in mA
disp(I_D,"The value of I_D in mA is : ")
I_D= I_D*10^-3;// in A
// (iii) To obtain the value of V_DSQ
V_DSQ= V_DD-I_D*R_D;// in V
disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 7.6 IDQ VGSQ and VDS

```
// Exa 7.6
clc;
clear;
close;
format('v',6)
// Given data
V_DD = 40;// in V
Vt = 5;// in V
```

```
R_D= 820;// in ohm
I_Don = 3;// in mA
I_Don = I_Don * 10^-3;// in A
V_GSon = 10;// in V
K = I_Don/( (V_GSon-Vt)^2 );// in A/V^2
R2 = 18;// in Mohm
R2 = R2 * 10^6;// in ohm
R1 = 22;// in Mohm
R1 = R1 * 10^6;// in ohm
R_S = 3*10^3;// in ohm
I_D= poly(0,'I_D');
V_G= R2/(R1+R2)*V_DD;
V_GS= V_G-I_D*R_D;// in V
I_D= I_D-K*(V_GS-Vt)^2;// in A
I_D= roots(I_D);// inA
I_D= I_D(2);// in A
I_D= I_D*10^3;// in mA
disp(I_D,"The value of I_D in mA is : ")
I_D= I_D*10^-3;// in A
V_GSQ= V_G-I_D*R_D;// in V
disp(V_GSQ,"The value of V_GSQ in volts is : ")
V_DSQ= V_DD-I_D*(R_D+R_S);// in V
disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 7.7 Value of RS

```
// Exa 7.7
clc;
clear;
close;
format('v',5)
// Given data
V_D = 12;// in V
V_GSQ = -2;// in V
V_DD = 16;// in V
```

```
R1 = 47;// in k ohm
R1 = R1 * 10^3;// in ohm
R2 = 91;// in k ohm
R2 = R2 * 10^3;// in ohm
V_G = (R1*V_DD)/(R1+R2);// in V
R_D = 1.8;// in k ohm
R_D = R_D * 10^3;// in ohm
I_D = (V_DD-V_D)/R_D;// in A
I_D = I_D * 10^3;// in mA
// V_GS = V_G - (I_D*R_S);
R_S = (V_G-V_GSQ)/(I_D*10^-3);// in ohm
R_S = R_S * 10^-3;// in k ohm
disp(R_S,"The value of R_S in k ohm is");
```

Scilab code Exa 7.8 VG and VSS

```
// Exa 7.8
clc;
clear;
close;
format('v',5)
// Given data
I_D = 12*10^-3;// in A
V_DS = 6;// in V
V_P = 3;// in V
R_SS= 1*10^3;// in ohm
I_DSS = 20*10^-3;// in A
V_GS= poly(0,'V_GS');
V_GS= I_D-I_DSS*(1-V_GS/V_P)^2;
V_GS= roots(V_GS);// in V
V_GS= V_GS(1);// in V
disp(V_GS,"The value of V_GS in volts is : ")
// Applying KVL on it's input section , V_G= V_GS+I_D
   *R_SS+V_SS or
// I_D*RSS+V_SS= V_G-V_GS    (i)
```

```
// V_DS+I_D*R_SS+V_SS= 0        (ii)
// From eq (i) and (ii)
V_G= V_GS-V_DS;// in V
disp(V_G,"The value of V_G in volts is : ")
V_SS= V_G-V_GS-I_D*R_SS;// in V
disp(V_SS,"The value of V_SS in V is : ")
```

Scilab code Exa 7.9 IDQ VGSQ VD VS VDS and VDG

```
// Exa 7.9
clc;
clear;
close;
format('v',6)
// Given data
I_DSS = 8;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -4;// in V
V_DD = 16;// in V
R2 = 270;// in k ohm
R2 = R2 * 10^3;// in ohm
R1 = 2.1;// in Mohm
R1 = R1 * 10^6;// in ohm
R_S = 1.5;// in k ohm
R_S = R_S * 10^3;// in ohm
R_D = 2.4;// in k ohm
R_D = R_D * 10^3;// in ohm
V_G = (R2*V_DD)/(R1+R2);// in V
//V_GS = V_G - (I_D*R_S);
V_GS = V_G;// in V (at I_D=0 A)
I_D = V_G/R_S;// in A (at V_GS=0 V)
I_D = I_D * 10^3;// in mA
I_DQ = 2.4;// in mA
V_GSQ = -1.8;// in V
V_D = V_DD - (I_DQ*10^-3*R_D);// in V
```

```
V_S = I_DQ*10^-3*R_S;// in V
V_DS = V_DD - (I_DQ*10^-3*(R_S+R_D));// in V
V_DG = V_D-V_G;// in V
disp(I_DQ,"The value of I_DQ in mA is");
disp(V_GSQ,"The value of V_GSQ in V is");
disp(V_D,"The value of V_D in V is");
disp(V_S,"The value of V_S in V is");
disp(V_DS,"The value of V_DS in V is");
disp(V_DG,"The value of V_DG in V is");
```

Scilab code Exa 7.10 Value of Vo

```
// Exa 7.10
clc;
clear;
close;
format('v',5)
// Given data
I_DSS = 5.6;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = 4;// in V
Vi = 0;// in V
V_CC = 12;// in V
R_D = 10;// in  k ohm
R_D = R_D * 10^3;// in ohm
R_S= 10*10^3;// in ohm
I_D= poly(0,'I_D');
V_GS= I_D*R_D-V_CC;// in V
I_D= I_D-I_DSS*(1-V_GS/V_P)^2;// in A
I_D= roots(I_D);// in A
I_D= I_D(2);// in A
V_GS= I_D*R_D-V_CC;// in V
Vo= V_CC-I_D*R_S;// in V
I_D= I_D*10^3;// in mA
disp(I_D,"The value of I_D in mA is : ")
```

```
disp(Vo,"The value of Vo in volts is : ")

// Note: In the book, there is calculation error to
   find the value of I_D this is why the value of Vo
    is also wrong.
```

Scilab code Exa 7.11 Value of Vo

```
// Exa 7.11
clc;
clear;
close;
format('v',6)
// Given data
I_DSS = 5.6;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -4;// in V
R_S = 10;// in k ohm
R_S = R_S * 10^3;// in ohm
R_D = 4.7;// in k ohm
R_D = R_D * 10^3;// in ohm
V_CC = 12;// in V
V_DD = 22;// in V
// (a) Calculation to find the value of Vo at Vi = 0
    V
Vi = 0;// in V
V_GS= poly(0,'V_GS');
I_D= (V_CC-V_GS)/R_S;// in A
V_GS= I_D-I_DSS*(1-V_GS/V_P)^2;// in A
V_GS= roots(V_GS)
V_GS= V_GS(2);// in V
I_D= (V_CC-V_GS)/R_S;// in A
Vo= Vi-V_GS;// in V
disp(Vo,"For Vi=0 V, The value of Vo in volts is ; "
   )
```

```
// (a) Calculation to find the value of Vo at Vi =
    10 V
Vi = 10;// in V
V_GS= poly(0,'V_GS');
I_D= (V_DD-V_GS)/R_S;// in A
V_GS= I_D-I_DSS*(1-V_GS/V_P)^2;// in A
V_GS= roots(V_GS)
V_GS= V_GS(2);// in V
I_D= (V_CC-V_GS)/R_S;// in A
Vo= Vi-V_GS;// in V
disp(Vo,"For Vi=10 V, The value of Vo in volts is ;
    ")

// (a) Calculation to find the value of Vi at Vo =
    10 V
Vo= 0;// in V
I_D= V_CC/R_S;// in A
V_GS= V_P*(1-sqrt(I_D/I_DSS));// in V
Vi= V_GS+Vo;// in V
disp(Vi,"For Vo=0 V, The value of Vi in volts is ; "
    )
```

Scilab code Exa 7.12 Quuiescent value of IDS VDS and VGS

```
// Exa 7.12
clc;
clear;
close;
format('v',6)
// Given data
I_DSS = 12;// in mA
V_P = 5;// in V
R_D = 3.3;// in k ohm
R_G = 1.5*10^3;// in k ohm
```

```
R_S = 1.2;// in k ohm
V_DD= 18;// in V
I_D= poly(0,'I_D');
V_GS= I_D*R_S;// in V
I_D= I_D-I_DSS*(1-V_GS/V_P)^2;
I_D= roots(I_D);
I_D= I_D(2);// in mA
V_GS= I_D*R_S;// in V
V_DS= V_DD-I_D*(R_S+R_D);// in V
disp(I_D,"The value of I_D in mA is : ")
disp(V_GS,"The value of V_GS in volts is : ");
disp(V_DS,"The value of V_DS in volts is : ")
```

Scilab code Exa 7.13 Value of rDS

```
// Exa 7.13
clc;
clear;
close;
format('v',6)
// Given data
Vt = -1;// in V
KnWbyL = 1*10^-3;// in A/V^2
V_DS = 0.1;// in V
V_GS = 0;// in V
I_D = ( (V_GS-Vt)*V_DS-1/2*KnWbyL );// in mA
V = 9.9;// in V
R_D = V/I_D;// in k ohm
R_D= ceil(R_D);// in k ohm
disp(R_D,"The value of R_D in k ohm is : ")
V_DS = 0.1;// in V
r_DS = V_DS/(I_D*10^-3);// in ohm
r_DS= round(r_DS*10^-3);// in k ohm
disp(r_DS,"Effective resistance between source and
   drain in k ohm is");
```

Scilab code Exa 7.14 Value of RS

```
// Exa 7.14
clc;
clear;
close;
format('v',6)
// Given data
V_DD = 5;// in V
V_SS = -5;// in V
Vt = 2;// in V
I_D = 0.4;// in mA
I_D = I_D * 10^-3;// in A
miu_nCox=20*10^-6;// in A/V^2
W = 400;// in  m
L = 10;// in  m
V_GS= poly(0,'V_GS');
V_GS=I_D-(1/2)*miu_nCox*(W/L)*( (V_GS-Vt)^2 );
V_GS= roots(V_GS)
V_GS= V_GS(1);// in V
V_S= -V_GS;// in V
R_S = (V_S-V_SS)/I_D;// in ohm
R_S = R_S * 10^-3;// in k ohm
disp(R_S,"The value of R_S in k ohm is");
V_D = 1;// in V
R_D = (V_DD-V_D)/I_D;// in ohm
R_D = R_D * 10^-3;// in k ohm
disp(R_D,"The value of R_D in k ohm is");
```

Scilab code Exa 7.15 Designing of a circuit

```
// Exa 7.15
clc;
clear;
close;
format('v',6)
// Given data
I_D= 0.4*10^-3;// in A
Vt = 2;// in V
miu_nCox = 20*10^-6;// in A/V^2
L = 10;// in  m
W = 100;// in  m
V_GS= poly(0,'V_GS');
V_GS= I_D - (1/2)*miu_nCox*(W/L)*( (V_GS-Vt)^2 );
V_GS= roots(V_GS)
V_GS= V_GS(1);// in V
V_D = V_GS;// in V
disp(V_D,"The DC voltage in V is");
V_DD = 10;// in v
R = (V_DD - V_D)/I_D;// in ohm
R = R * 10^-3;// in k ohm
disp(R,"The value R in k ohm is");
```

Scilab code Exa 7.16 Designing of a circuit

```
// Exa 7.16
clc;
clear;
close;
format('v',6)
// Given data
Vt =  1;// in V
KnWbyL= 10*10^-3;// in A/V^2
V_DD = 5;// in V
V_D = 0.1;// in V
I_D = Vt*( (V_DD-Vt)*V_D - 1/2*KnWbyL );// in mA
```

```
R_D = (V_DD-V_D)/(I_D*10^-3);// in ohm
R_D= R_D*10^-3;// in k ohm
disp(R_D,"The value of R_D in k ohm is : ")
V_DS = 0.1;// in V
r_DS =round(V_DS/(I_D*10^-3));// in ohm
disp(r_DS,"Effective resistance between drain and
    the source in ohm is");
```

Scilab code Exa 7.17 Designing of a circuit

```
// Exa 7.17
clc;
clear;
close;
format('v',6)
// Given data
I_D = 0.5;// in mA
V_D = 3;// in V
Vt = -1;// in v
KnWbyL = 1;// in mA/V^2
V_DD = 5;// in V
V_D = 3;// in v
V_GS= poly(0,'V_GS');
V_GS= I_D -1/2*KnWbyL*(V_GS-Vt)^2;// in V
V_GS= roots(V_GS)// in V
V_GS= V_GS(1);// in V
R_G1 = 2;// in Mohm
R_G1 = R_G1 * 10^6;// in ohm
R_G2 = 3;// in Mohm
R_G2 = R_G2 * 10^6;// in ohm
V_GS = -2;// in V
R_D = V_D/I_D;// in k ohm
V_Dmax = V_D+abs(Vt);// in V
R_D = V_Dmax/I_D;// in k ohm
disp(R_D,"The largest value of R_D in k ohm is");
```

Chapter 8

Field Effect Transistor Amplifiers

Scilab code Exa 8.1 Input impedance

```
// Exa 8.1
clc;
clear;
close;
format('v',6)
// Given data
V_P = -4;// in V
r_d = 40*10^3;// in ohm
I_DSS = 10*10^-3;// in A
V_GG = 1;// in V
R_D = 1.8*10^3;// in ohm
R_G = 1*10^6;// in ohm
g_mo = 2*I_DSS/(abs(V_P));// in S
V_GSQ = -1.5;// in V
g_m = g_mo*(1-(V_GSQ/V_P));// in S
Zi = R_G;// in ohm
Zi= Zi*10^-6;// in M ohm
disp(Zi,"The input impedance in M ohm is");
Zo = (r_d*R_D)/(r_d+R_D);// in ohm
```

```
Zo = R_D;// in ohm (as r_d >10*R_D)
Zo= Zo*10^-3;// in k ohm
disp(Zo,"The output impedance in k ohm is");
//Av = Vo/Vi = -g_m*R_D;
Av = -g_m*R_D;
disp(Av,"The voltage gain is");
```

Scilab code Exa 8.2 Zi Zo and Av

```
// Exa 8.2
clc;
clear;
close;
format('v',6)
// Given data
I_DSS = 6;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -6;// in V
Y_DS = 40;// in  S
R_D = 3.3;// in k ohm
R_D = R_D * 10^3;// in ohm
R_S = 1.1;// in k ohm
R_S = R_S * 10^3;// in ohm
R_G = 10;// in Mohm
R_G =R_G * 10^6;// in ohm
g_mo = (2*I_DSS)/(abs(V_P));// in S
I_D= poly(0,'I_D');
V_GS = -I_D*R_S;// in V
I_D=  I_D - I_DSS*((1 - (V_GS/V_P))^2);
I_D= roots(I_D)
I_D= I_D(2);// in A
V_GSQ = -I_D*R_S;// in V
g_m = g_mo*( 1-(V_GSQ/V_P) );// in S
Zi = R_G;// in ohm
Zi= Zi*10^-6;// in M ohm
```

```
disp(Zi,"The value of Zi in M ohm is");
r_d = 40;// in k ohm assumed
r_d = r_d * 10^3;// in ohm
Zo = (r_d*R_D)/(r_d+R_D);// in ohm
Zo=R_D;// in ohm (as r_d > 10 *R_D)
Zo= Zo*10^-3;// in k ohm
disp(Zo,"The value of Zo in k ohm is");
Av = abs(-g_m*R_D);
disp(Av,"The value of Av is");
```

Scilab code Exa 8.3 Zi Zo Av

```
// Exa 8.3
clc;
clear;
close;
format('v',6)
// Given data
V_DD = 20;// inV
I_DSS = 8;// in mA
I_DSS = I_DSS * 10^-3;// in mA
V_P = -6;// in V
R_G = 1;// in Mohm
R_G = R_G * 10^6;// in ohm
R_S = 1;// in k ohm
R_S = R_S * 10^3;// in ohm
r_d = 50;// in k ohm
r_d = r_d * 10^3;// in ohm
V_GS = -2.6;// in V
I_D = 2.6;// in mA
I_D = I_D * 10^-3;// in A
g_mo = (2*I_DSS)/(abs(V_P));// in S
g_m = g_mo*(1 - (V_GS/V_P));// in S
Zi = R_G;// in ohm
Zi= Zi*10^-6;// in M ohm
```

```
disp(Zi,"The value of Zi in M ohm is");
Zo = R_S*1/g_m/(R_S+1/g_m);
disp(Zo,"The value of Zo is");
Av = g_m*R_S/(1 + (g_m*R_S));
disp(Av,"The value of Av is");
```

Scilab code Exa 8.4 gm Zi Zo And Av

```
// Exa 8.4
clc;
clear;
close;
format('v',6)
// Given data
V_GSQ = -2.6;// in V
I_DQ = 3.8*10^-3;// in A
V_DD = 12;// in V
R_D = 1.5*10^3;// in ohm
R_S = 680;// in ohm
I_DSS = 12*10^-3;// in A
r_d = 20*10^3;// in ohm
V_P = -6;// in V
// (a) Transconductance
g_mo = (2*I_DSS)/(abs(V_P));// in S
g_m = g_mo*(1-(V_GSQ/V_P));// in mS
g_m= g_m*10^3;// in mS
disp(g_m,"The value of g_m in mS is");
// (b) Input impedance
g_m= g_m*10^-3;// in S
Zi=R_S*((r_d+R_D)/(1+g_m*r_d))/(R_S+((r_d+R_D)/(1+
    g_m*r_d)))
disp(Zi,"The value of Zi in ohm is");
// (c) Output impedance
Zo = (R_D*r_d)/(R_D+r_d);// in ohm
Zo= Zo*10^-3;// in k ohm
```

```
disp(Zo,"The value of Zo in k ohm is");
// Voltage gain
//Av = Vo/Vi = (R_D*(1 + (g_m*10^-3*r_d)))/(R_D+r_d)
    ;
Av = (R_D*(1 + (g_m*r_d)))/(R_D+r_d);
disp(Av,"The value of Av is");
```

Scilab code Exa 8.6 Input impedance output impedance and voltage gain

```
// Exa 8.6
clc;
clear;
close;
format('v',6)
// Given data
V_DD = 10;// in V
R_D = 5.1;// in  k ohm
R_D = R_D * 10^3;// in ohm
g_m = 2*10^-3;// in S
r_d = 50;// in k ohm
r_d = r_d * 10^3;// in ohm
Vi = 0;// in V
R_G = 1;// in Mohm
R_G = R_G * 10^6;// in ohm
// (i) Input impedance
Zi = R_G;// in ohm
Zi= Zi*10^-6;// in M ohm
disp(Zi,"The input impedance in Mohm is");
// (ii) Output impedance
Zo = (r_d*R_D)/(r_d+R_D);// in ohm
disp(Zo,"The output impedance in ohm is");
// (iii) Voltage gain
Av = -g_m*Zo;
disp(Av,"The voltage gain is");
```

Scilab code Exa 8.7 gm rd Zi Zo and Av

```
// Exa 8.7
clc;
clear;
close;
format('v',6)
// Given data
V_GSQ = -2;// in V
I_DSS = 8;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -8;// in V
YoS = 20;// in   S
YoS = YoS * 10^-6;// in S
R_D = 5.1;// in k ohm
R_D = R_D * 10^3;// in ohm
R_G = 1;// in Mohm
R_G = R_G * 10^6;// in ohm
g_mo = (2*I_DSS)/(abs(V_P));// in S
g_m = g_mo * (1 - (V_GSQ/V_P));// in S
g_m= g_m*10^3;// in mS
disp(g_m,"The value of g_m in mS is");
g_m= g_m*10^-3;// in S
r_d = 1/YoS;// in ohm
r_d= r_d*10^-3;// in k ohm
disp(r_d,"The value of r_d in k ohm is");
r_d= r_d*10^3;// in ohm
Zi = R_G;// in ohm
Zi= Zi*10^-6;// in M ohm
disp(Zi,"The value of Zi in M ohm is");
V_GS = 0;// in V
Zo = (r_d*R_D)/(r_d+R_D);// in ohm
disp(Zo,"The value of Zo in ohm is");
Av = -g_m*Zo;
```

```
disp(Av,"The value of Av is");
```

Scilab code Exa 8.8 Input impedance output impedance and voltage gain

```
// Exa 8.8
clc;
clear;
close;
format('v',6)
// Given data
gm= 6000*10^-6;// in S
R1 = 2;// in M ohm
R1 = R1 * 10^6;// in ohm
R2 = 500;// in k ohm
R2 = R2 * 10^3;// in ohm
R_S= 4*10^3;// in ohm
R_L= 33*10^3;// in ohm
r_d= 50*10^3;// in ohm
Zi = (R1*R2)/(R1+R2);// in ohm
Zi= Zi*10^-3;// in k ohm
disp(Zi,"The input impedance in k ohm is");
Zo = (1/gm*R_S)/(1/gm+R_S);// in ohm
disp(Zo,"The output impedance in ohm is");
// Let Req= r_d || R_S || R_L;// in ohm
Req= r_d*R_S*R_L/(r_d*R_S+R_S*R_L+R_L*r_d);// in ohm
Av=gm*(r_d*R_S*R_L/(r_d*R_S+R_S*R_L+r_d*R_L))/(1+gm
   *(r_d*R_S*R_L/(r_d*R_S+R_S*R_L+r_d*R_L)))
disp(Av,"The voltage gain is : ")
```

Scilab code Exa 8.9 Input and output impedance and voltage gain

```
// Exa 8.9
clc;
```

```
clear;
close;
format('v',7)
// Given data
R1 = 3.3* 10^-3;// in ohm
R2 = 1.2* 10^6;// in ohm
R_D = 3.9* 10^3;// in ohm
R_S = 3.9* 10^3;// in ohm
R_L = 82* 10^3;// in ohm
g_m = 6000* 10^-6;// in S
r_d = 70* 10^3;// in ohm
Zi = (R_S*( (r_d+R_D)/(1+(g_m*r_d)) ))/(R_S+( (r_d+
    R_D)/(1+(g_m*r_d)) ));// in ohm
disp(Zi,"The input impedance in ohm is");
Zo = (r_d*R_D)/(r_d+R_D);// in ohm
disp(Zo,"The output impedance in ohm is");
R = (R_D*R_L)/(R_D+R_L);// in ohm
Av = (R*(1+(g_m*r_d)))/( r_d+R );
disp(Av,"The voltage gain is");
```

Chapter 9

Frequency Response

Scilab code Exa 9.2 Overall voltage gain

```
// Exa 9.2
clc;
clear;
close;
format('v',5)
// Given data
bita= 100;
V_B1= 5;// in V
V_E1= 4.3;// in V
R_E1= 4.3*10^3;// in ohm
V_E2= 3.6;// in V
R_E2= 3.6*10^3;// in ohm
R_C=4*10^3;// in ohm
R_L= 4*10^3;// in ohm
R1= 100*10^3;// in ohm
R2= 100*10^3;// in ohm
gm= 40*10^-3;// in A/V
re= 25;// in W
r_pie= 2.5*10^3;// in W
f_r= 400*10^6;// in Hz
C_miu= 2*10^-12;// in F
```

```
omega_T= 2*%pi*f_r;// in radian
Rin= 38*10^3;// in ohm
R_S= 4*10^3;// in ohm
R_pie1= 80;//in ohm
Ve1ByVb1= 0.98;// in V/V
I_E1= V_E1/R_E1;// in A
I_E2= V_E2/R_E2;// in A
// We know, C_pie + C_miu= gm/ometa_T or
C_Pie= gm/omega_T-C_miu;// in F
Vb1ByVs= Rin/(Rin+R_S);// in V/V
//Ve1ByVb1= R_E1*r_pie2/(R_E1*r_pie2)/(R_E1*r_pie2/(R_E1*r_pie2)+r_e1);
VeByVb1= R_E1*r_pie/(R_E1*r_pie)/(R_E1*r_pie/(R_E1*r_pie)+R_E1);// in V/V
// The gain of the common-emitter amplifier Q2
VoByVe1= -gm*R_C*R_L/(R_C+R_L);// in V/V
// The overall gain
VoByVs= Vb1ByVs*Ve1ByVb1*VoByVe1;// in V/V
RdeshS= R1*R2*R_S/(R1*R2+R2*R_S+R_S*R1);
RdeshE1= R_E1*r_pie/(R_E1+r_pie);// in k ohm
R_miu1= R_S*Rin/(R_S+Rin)*10^-3;// in k ohm
R_pi1= (r_pie*(RdeshS+RdeshE1)/(1+gm*RdeshE1))/r_pie+(RdeshS+RdeshE1)/(1+gm*RdeshE1);
R_T=round( RdeshE1*(r_pie+RdeshS)/(bita+1)/(RdeshE1+(r_pie+RdeshS)/(bita+1)));// in ohm
disp(VoByVs,"The overall voltage gain in V/V is : ")
disp(R_miu1,"The value of R_miu1 in ohm is : ")
disp(R_pie1,"The value of R_pie1 in ohm is : ")
disp(R_T,"The value of R_T in ohm is : ")
```

Scilab code Exa 9.3 Value of k

```
// Exa 9.3
clc;
clear;
```

```
close;
format('v',5)
// Given data
wH= '0.9*wp1';
wp2='wp1*k';
//wH= 1/sqrt(1/wp1^1+1/(k*wp1)^2)
k= sqrt(0.9^2/(1-0.9^2));
disp(k,"The value of k is : ")
```

Scilab code Exa 9.4 Value of Cs and gm

```
// Exa 9.4
clc;
clear;
close;
// Given data
Rs = 1;// in k ohm
Rs = Rs * 10^3;// in ohm
omega_z = 10;// in rad/sec
omega_p = 100;// in rad/sec
//omega_z = 1/(Rs*Cs);
Cs = 1/(Rs*omega_z);// in F
disp(Cs*10^6,"The value of Cs in  F is");
//omega_p = (g_m + (1/Rs))/Cs;
g_m = omega_p*Cs-1/Rs;// in A/V
g_m= g_m*10^3;// in mA/V
disp(g_m,"The value of g_m in mA/V is")

// Note: The unit of g_m in the book is wrong. It
   will be in mA/V not in nA/V.
```

Chapter 10

Feedback Amplifiers

Scilab code Exa 10.1 Change in overall gain of the feedback amplifier

```
// Exa 10.1
clc;
clear;
close;
format('v',6)
// Given data
A = 60;// in dB
A= 10^(A/20)
Beta = 0.005;
dAbyA = -12/100;
// On putting the value of A, bita and dA/A
dAfbyAf = (1/(1+A*Beta))*(dAbyA);
disp(dAfbyAf,"The change in overall gain is");
```

Scilab code Exa 10.2 Input impedance

```
// Exa 10.2
clc;
```

```
clear;
close;
format('v',6)
// Given data
A = 1000;
Zi = 1;// in k ohm
Zi = Zi * 10^3;// in ohm
Beta = 0.01;
Zdesh_i = (1+A*Beta)*Zi;// in ohm
Zdesh_i =Zdesh_i *10^-3;// in k ohm
disp(Zdesh_i,"The input impedance of the feedback
    amplifier in k ohm is");
```

Scilab code Exa 10.3 Feedback factor and percentage change in overall gain

```
// Exa 10.3
clc;
clear;
close;
format('v',6)
// Given data
A = 60;// in dB
A= 10^(A/20);
Zo = 12000;// in ohm
Zdesh_o = 600;// in ohm
//Zdesh_o = Zo/(1+(A*Beta));
Beta = (((Zo/Zdesh_o)-1)/A)*100;// in %
disp(Beta,"The feedback factor in % is");
Beta = Beta/100;
DAbyA = 0.1;
dAfbyAf = (1/(1 + (A*Beta)))*DAbyA*100;// in %
disp(dAfbyAf,"The percentage change in the overall
    gain in % is");
```

Scilab code Exa 10.4 Gain of a negative feedback amplifier

```
// Exa 10.4
clc;
clear;
close;
format('v',5)
// Given data
A = 100;
Beta = 1/10;
Af = A/(1 + (A*Beta));
disp(Af,"The gain of negative feedback amplifier is"
    );
```

Scilab code Exa 10.5 Value of A and bita

```
// Exa 10.5
clc;
clear;
close;
format('v',6)
// Given data
Af = 100;
Vi = 0.6;// in V
Vdesh_o = Af*Vi;// in V
Vi = 50;// in mV
Vi = Vi * 10^-3;// in V
A = Vdesh_o/Vi;
disp(A,"The value of A is");
// Af = A/( 1 +(A*Beta) );
Beta = (((A/Af)-1)/A)*100;// in %
Beta= (A-Af)/(Af*A/100);
```

```
Beta= Beta*100;// in %
disp(Beta,"The value of Beta in % is");
```

Scilab code Exa 10.6 Voltage gain

```
// Exa 10.6
clc;
clear;
close;
format('v',6)
// Given data
A = 1000;
Af = A - (0.40*1000);
//Af = A/( 1+(A*Beta) );
Beta = ((A/Af)-1)/A;
A_desh = 800;
A_desh_f= A_desh/( 1+(A_desh*Beta) );
disp(A_desh_f,"The voltage gain with feedback is");
// percentage reduction without feedback
P = ((A-A_desh)/A)*100;//in %
// percentage reduction with feedback
P1 = ((Af-A_desh_f)/Af)*100;// in %
disp(P1,"The percentage reduction with feedback in %
    is");
```

Scilab code Exa 10.7 Small change in gain

```
// Exa 10.7
clc;
clear;
close;
format('v',6)
// Given data
```

```
dAbyA = 10/100;
A = 200;
Beta = 0.25;
// Af = A/(1+(A*Beta))          (i)
// differentiating w.r.to A we get, dAf = dA/((1+(
    Beta*A))^2)    (ii)
// From eq(i) and (ii)
dAfbyAf =  1/(1+A*Beta)*dAbyA
disp(dAfbyAf,"The small change in gain is");
```

Scilab code Exa 10.8 New input voltage

```
// Exa 10.8
clc;
clear;
close;
format('v',6)
// Given data
A = 100;
Beta = 1/25;
Af = A/(1 + (A*Beta));
disp(Af,"The gain with feedback is");
disp((A*Beta),"The feed back factor is");
Vi = 50;// in mV
Vo =Af*Vi*10^-3;// in V
disp(Vo,"The output voltage in V is");
V_feedback= (Beta*Vo);// feedback voltage in V
disp(V_feedback,"The feed back voltage in V is");
Vi = Vi*(1+(A*Beta));// in mV
disp(Vi,"The new input voltage in mV is");
```

Scilab code Exa 10.9 Small change in gain

```
// Exa 10.9
clc;
clear;
close;
format('v',6)
// Given data
Beta = 0.25;
A = 100;
dA= 10;// in %
// Af = A/(1+(A*Beta))           (i)
//dAf = dA/((1+(Beta*A))^2) (ii)
// From eq (i) and (ii)
dAbyA = dA/A;
disp(dAbyA,"The small change in gain is");
```

Scilab code Exa 10.10 New value of input voltage

```
// Exa 10.10
clc;
clear;
close;
format('v',6)
// Given data
A = 200;
Beta = 5/100;
Af =A/(1 + (A*Beta));
disp(Af,"The gain of the amplifier with negative
   feedback is : ")
Dn = 10;// in %
Ddesh_n = Dn/(1+(A*Beta));// in %
disp(Ddesh_n,"The distortion with negative feedback
   in % is : ");

// Note: In the book, the calculation to find the
   gain of the amplifier with negative feedback i.e
```

```
Af is wrong.
```

Scilab code Exa 10.11 Percentage of feedback

```
// Exa 10.11
clc;
clear;
close;
format('e',8)
// Given data
Af = 10;
A = 50;
// Af =A/(1 + (A*Beta) );
Beta = ((A/Af)-1)/A*100;// in %
dAfByAf = 1/( 1+100/4 )*Af/100;
disp(dAfByAf,"The percentage of feedback is");
```

Scilab code Exa 10.12 Upper and lower cutoff frequency

```
// Exa 10.12
clc;
clear;
close;
format('v',5)
// Given data
Ao = 100;
f_L = 20;// in Hz
f_H = 40;// in kHz
f_H = f_H*10^3;// in Hz
Beta = 0.1;
Af = Ao/(1 + (Beta*Ao));
disp(Af,"The overall gain at mid frequency is");
f_Hf = f_H*(1+(Ao*Beta));// in Hz
```

```
f_Hf = f_Hf * 10^-3;// in kHz
disp(f_Hf,"The upper cutoff frequency with negative feedback in kHz is");
f_Lf = f_L/(1+(Ao*Beta));// in Hz
disp(f_Lf,"The lower cutoff frequency with negative feedback in Hz is");

// Note: The calculated value of lower cutoff frequency with negative feedback i.e f_Lf is wrong. So the answer in the book is wrong.
```

Scilab code Exa 10.13 Value of A B Rif Af and loop gain

```
// Exa 10.13
clc;
clear;
close;
format('v',6)
// Given data
R1 = 20;// in k ohm
R1 = R1 * 10^3;// in ohm
R2 = 20;// in k ohm
R2 = R2 * 10^3;// in ohm
h_ie = 2;// in k ohm
h_ie = h_ie * 10^3;// in ohm
R_L = 1;// in k ohm
R_L = R_L * 10^3;// in ohm
R_E = 100;// in ohm
h_fe = 80;
A = (-h_fe*R_L)/h_ie;
disp(A,"The value of A is");
Beta = R_E/R_L;
disp(Beta,"The value of Beta is");
Rif = h_ie + (1+h_fe)*R_E;// in ohm
Rif = Rif * 10^-3;// in k ohm
```

```
disp(Rif,"The value of R_if in k ohm is");
Af = (-h_fe*R_L)/(Rif*10^3);
disp(Af,"The value of Af is");
AB = A*Beta;
AB= real(20*log10(AB));// in d
disp(AB,"The value of loopgain in d   is");
```

Scilab code Exa 10.14 Feedback gain and new band width

```
// Exa 10.14
clc;
clear;
close;
format('v',5)
// Given data
A = 200;
BW = 10;// in kHz
Beta = 10/100;
Af =A/(1+(A*Beta));
disp(Af,"The gain with negative feedback is");
BWf = BW*(1+(A*Beta));// in kHz
disp(BWf,"The bandwidth with negative feedback in
   kHz is");
```

Chapter 11

Oscillators

Scilab code Exa 11.1 Oscillation frequency

```
// Exa 11.1
clc;
clear;
close;
format('v',6)
// Given data
w=poly(0,'w');
// For sustained oscillation ,
w= 4*w*10^6-w^3;
w= roots(w);
w= w(1);// in rad/sec
f= round(w/(2*%pi));// in Hz
disp(f,"The frequency of oscillation in Hz is : ")
disp("Hence the system will oscillate")
```

Scilab code Exa 11.2 A RC phase shift oscillators

```
// Exa 11.2
```

```
clc;
clear;
close;
format('v',5)
// Given data
Av= 29;
I_Bmax = 0.5*10^-6;// in A
I1= 100*I_Bmax
Vo_sat = 0.9;// in V
V_CC = 9.0;// in V
V_EE= -9;// in V
V1= 9/Av;// in V
R1= V1/I1;// in ohm
R1= 5.6*10^3;// in ohm (standard value)
Rf= Av*R1;// in ohm
Rf= 180*10^3;// in ohm
R3= Rf;// in ohm
R=R1;// in ohm
C= 1/(2*%pi*R*sqrt(6)*1000);// in F
R= R*10^-3;// in k ohm
Rf= Rf*10^-3;// in k ohm
C= C*10^6;// in  F
disp(R,"The value of R and R1 in k ohm is : ")
disp(Rf,"The value of Rf and R3 in k ohm is : ")
disp(C,"The value of C in  F is : ")
disp(V_CC,"The value of V_CC in volts is : ")
disp(V_EE,"The value of V_EE in volts is : ")
```

Scilab code Exa 11.3 Value of R and C

```
// Exa 11.3
clc;
clear;
close;
format('v',5)
```

```
// Given data
f = 5;// in kHz
f = f * 10^3;// in Hz
miu = 55;
r_d = 5.5;// in k ohm
r_d = r_d * 10^3;// in ohm
A= 29;
// abs(A) = g_m*R_L = (g_m*r_d*R_D)/(r_d+R_D) = (miu
    *R_D)/(r_d+R_D);
// miu*R_D = abs(A)*(r_d+R_D);
R_D = (abs(A)*r_d)/(miu-A);// in ohm
R_D= R_D*10^-3;// in k ohm
disp(R_D,"Minimum value of R_D in  k ohm is");
R_D= R_D*10^3;// in ohm
Alpha = sqrt(6);
// Alpha = 1/(2*%pi*f*R_C);
RC = 1/(2*%pi*f*Alpha);// in sec
RC= round(RC*10^6);// in  sec
disp(RC,"The value of RC in  sec is");
RC= RC*10^-6;// in sec
R_L = (r_d*R_D)/(r_d+R_D);// in ohm
R = 30*10^3;// in ohm
C = RC/R;// in F
C = C * 10^12;// in pF
R= R*10^-3;// in k ohm
disp(R,"The value of R in k ohm is");
disp(C,"The value of C in pF is");
```

Scilab code Exa 11.4 BJT RC phase shift oscillator

```
// Exa 11.4
clc;
clear;
close;
format('v',5)
```

```
// Given data
f= 100*10^3;// in Hz
h_fe = 100;
h_ie = 1* 10^3;// in ohm
V_CE = 5;// in V
V_BE= 0.7;// in V
I_C = 1* 10^-3;// in A
I_B= 0.01*10^-3;// in A
V_CC = 20;// in V
R_E = 1* 10^3;// in ohm
I_E = I_C;// in A
R_C = (V_CC-V_CE-(I_E*R_E))/I_C;// in ohm
R = 10*10^3;// in k ohm
k = R_C/R;
h_fe=(23+29/k+4*k);
// Formula f= 1/(2*%pi*R*C*sqrt(6+4*k))
C= 1/(2*%pi*R*f*sqrt(6+4*k));// in F
// R= R3+R1 || R2+h_ie = R3+h_ie (approx)
R3= R-h_ie;// in ohm
V_B= V_BE+I_E*R_E;// in V
R2= 10*10^3;// in ohm (assumed value)
I_R2= V_B/R2;// current in R2 in A
V_R1= V_CC-V_B;// drop across R1 in V
I_R1= I_R2+I_B;// in A
R1= V_R1/I_R1;// in ohm
R_E= R_E*10^-3;// in k ohm
R_C= R_C*10^-3;// in k ohm
R= R*10^-3;// in k ohm
R1= R1*10^-3;// in k ohm
R2= R2*10^-3;// in k ohm
R3= R3*10^-3;// in k ohm
C=C*10^12;// in pF
disp(R_E,"The value of R_E in k ohm is");
disp(R_C,"The value of R_C in k ohm is");
disp(R,"The value of R in k ohm is");
disp("The value of h_fe >= "+string(h_fe));
disp(C,"The value of C in pF is : ")
disp(R3,"The value of R3 in k ohm is : ")
```

```
disp(R2,"The value of R2 in k ohm is : ")
disp(R1,"The value of R1 in k ohm is : ")
```

Scilab code Exa 11.5 Transistor gain

```
// Exa 11.5
clc;
clear;
close;
format('v',6)
// Given data
f = 5;// in kHz
f = f * 10^3;// in Hz
R1 = 14;// in k ohm
R2 = 75;// in k ohm
R_C = 18;// in k ohm
R = 6;// in k ohm
h_ie = 2;// in k ohm
k = R_C/R;// in k ohm
// f = 1/( 2*%pi*RC*sqrt(6+(4*k)) );
C = 1/( 2*%pi*R*10^3*f*sqrt(6+(4*k)) );// in F
C = C * 10^9;// in nF
disp(C,"The value of capacitor in nF is");
h_fe= 23+(29/k)+(4*k);
disp("The value of h_fe >= "+string(h_fe))
disp("Thus the transistor used mush have a minimum
    current gain of 45")
```

Scilab code Exa 11.7 Component values of wein bridge

```
// Exa 11.7
clc;
clear;
```

```
close;
format('v',6)
// Given data
f_max = 10;// in kHz
f_max = f_max * 10^3;// in Hz
R = 100*10^3;// in k ohm
C = 1/(2*%pi*f_max*R);// in F
C= C*10^9;// in nF
disp(C,"For maximum frequency, the value of C in nF
    is");
f_min = 100;// in Hz
C = 1/(2*%pi*f_min*R);// in F
C= C*10^9;// in nF
disp(C,"For minimum frequency, the value of C in nF
    is");
```

Scilab code Exa 11.8 Oscillation frequency

```
// Exa 11.8
clc;
clear;
close;
format('v',4)
// Given data
R4 = 220;// in k ohm
R4 = R4 * 10^3;// in ohm
R3 = R4;// in ohm
R = R4;// in ohm
C1 = 250* 10^-12;// in F
C2 = C1;// in F
C = C1;// in F
f = 1/(2*%pi*R*C);// in Hz
f= f*10^-3;// in k Hz
disp(f,"The frequency of oscillation in kHz is");
```

Scilab code Exa 11.9 Q of the crystal

```
// Exa 11.9
clc;
clear;
close;
format('v',5)
// Given data
L = 0.33;
Cs = 0.65;// in pF
Cs = Cs * 10^-12;// in F
C_M = 1;// in pF
C_M = C_M * 10^-12;// in F
R = 5.5;// in k ohm
R = R * 10^3;// in ohm
f_s = 1/(2*%pi*sqrt( L*Cs ));// in Hz
f_s= f_s*10^-6;// in MHz
disp(f_s,"The series resonant frequency in MHz is");
f_s= f_s*10^6;// in Hz
Ceq = (Cs*C_M)/(Cs+C_M);// in F
f_P = 1/(2*%pi*sqrt( L*Ceq ));// in Hz
f_P= f_P*10^-6;// in MHz
disp(f_P,"The parallel resonant frequency in MHz is : ")
f_P= f_P*10^6;// in Hz
P = ((f_P-f_s)/f_s)*100;// in %
disp("The parallel resonant frequency exceds series resonant frequency by "+string(P)+" % ");
Q = (sqrt(L/Cs))/R;
disp(Q,"The Q factor of the crystal is");
```

Scilab code Exa 11.10 Parallel resonant frequency

```
// Exa 11.10
clc;
clear;
close;
format('v',6)
// Given data
Cs = 0.04;// in pF
C_M = 2;// in pF
Per = (1/2)*(Cs/C_M)*100;// in %
disp("Parallel resonant frequency is greater than
    series resonant frequency by "+string(Per)+" %")
```

Scilab code Exa 11.12 Frequency of oscillation and minimum value of R

```
// Exa 11.12
clc;
clear;
close;
format('v',6)
// Given data
C = 0.01;// in pF
C = C * 10^-12;// in F
L = 10;// in mH
L = L * 10^-3;// in H
f_o = 1/(2*%pi*sqrt(L*C));// in Hz
f_o = f_o * 10^-6;// in MHz
disp(f_o,"The oscillation frequency in MHz is");
R1 = 100;// in k ohm
R2 = 5;// in k ohm
A = 1 + (R1/R2);
// Beta = R/10;
// loopgain = A*Beta A*R/10 >=1
R= 10/A;// in k ohm
R=round(R*10^3);// in ohm
disp("The value of R is >= "+string(R)+" ohm")
```