

Scilab Textbook Companion for  
Solid State Devices and Circuits  
by V. Chaudhary and H. K. Maity<sup>1</sup>

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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.

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## Chapter 2

# Bipolar Junction Transistors

Scilab code Exa 2.1 Value of  $\alpha_{DC}$  and emitter current

```
1 // Exa 2.1
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_C = 15; // in mA
8 I_CbyI_E= 0.995;
9 I_E= I_C/I_CbyI_E; // in mA
10 I_B= 0.005*I_E; // in mA
11 I_CBO = 3; // in A
12 I_CBO = I_CBO * 10^-3; // in mA
13 alpha_dc= I_C/I_E;
14 disp(alpha_dc,"The value of Alpha_dc is");
15 // I_C = Alpha_dc*I_E + I_CBO;
16 I_E = (I_C-I_CBO)/alpha_dc; // in mA
17 disp(I_E,"The value of I_E in mA is");
```

---

Scilab code Exa 2.2 Value of  $I_C$  and  $I_E$

```

1 // Exa 2.2
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Alpha_dc = 0.99;
8 I_CB0 = 10; // in A
9 I_CB0 = I_CB0 * 10^-3; // in mA
10 I_E = 10; // in mA
11 // To calculate I_C :
12 I_C = (Alpha_dc*I_E) + I_CB0; // in mA
13 disp(I_C,"The value of I_C in mA is");
14 // To calculate I_B :
15 I_B = I_E-I_C; // in mA
16 I_B = I_B * 10^3; // in A
17 disp(I_B,"The value of I_B in A is");

```

---

### Scilab code Exa 2.3 Base current

```

1 // Exa 2.3
2 clc;
3 clear;
4 close;
5 format('v',4)
6 // Given data
7 Alpha_dc = 0.99;
8 I_C = 6; // in mA
9 I_CB0 = 15; // in A
10 I_CB0 = I_CB0 * 10^-3; // in mA
11 // I_C = Alpha_dc*I_E + I_CB0;
12 I_E = (I_C - I_CB0)/Alpha_dc; // in mA
13 I_B = I_E - I_C; // in mA
14 I_B = I_B * 10^3; // in A
15 disp(I_B,"The value of I_B in A is");

```

---

### Scilab code Exa 2.5 Emitter current

```
1 // Exa 2.5
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Alpha_dc = 0.98;
8 I_CBO = 12; // in A
9 I_CBO = I_CBO * 10^-6; // in A
10 I_B = 120; // in A
11 I_B = I_B * 10^-6; // in A
12 // Calculation of Beta_dc
13 Beta_dc = Alpha_dc/(1-Alpha_dc);
14 I_E = (1+Beta_dc)*I_B + (1+Beta_dc)*I_CBO; // in A
15 I_E = I_E * 10^3; // in mA
16 disp(I_E,"The value of I_E in mA is");
```

---

### Scilab code Exa 2.6 Region of operation

```
1 // Exa 2.6
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_BEsat = 0.8; // in V
8 V_BEact = 0.7; // in V
9 V_CEsat = 0.2; // in V
10 V_CC = 10; // in V
```

```

11 Beta = 100;
12 V = 5; // in V
13 R_B = 50* 10^3; // in ohm
14 R_E = 2* 10^3; // in ohm
15 R_C = 3* 10^3; // in ohm
16 //Applying KVL to input loop, V = R_B*I_B + V_BEact
    + I_C*R_E and I_C = Beta*I_B;
17 I_B = (V-V_BEact)/(R_B+R_E*Beta); // in A
18 // Applying KVL to collector circuit, V_CC= I_C*R_C+
    V_CEsat+I_E*R_E and I_E=I_C+I_B
19 I_C = (V_CC-V_CEsat-I_B*R_E)/(R_C+R_E); // in A
20 I_Bmin = I_C/Beta; // in A
21 if I_B < I_Bmin then
22     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), ")
23     disp("So the transistor is in the active region.
        ")
24 end

```

---

### Scilab code Exa 2.7 Value of IB IC and Vce

```

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

```

```

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

```

---

### Scilab code Exa 2.8 Value of V<sub>BB</sub>

```

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

```

```

17 I_Bmin= (V1+V2-V_CEsat)/(Beta*R_C+R_E*(1+Beta));//
    in A
18 I_Bmin= I_Bmin*10^3;// in mA
19 disp(I_Bmin,"The value of I_Bmin in mA is : ")
20 I_Bmin= I_Bmin*10^-3;// in A
21 I_E = (1+Beta)*I_Bmin;// in A
22 // Applying KVL to base emitter circuits , V_BB-
    I_Bmin*R_B-V_BEsat-(I_E*R_E)-V1=0
23 V_BB = (I_Bmin*R_B) + V_BEsat + (I_E*R_E) - V1;// in
    V
24 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

```

1 // Exa 2.9
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 bita = 200;
8 V_CEQ = 3;// in V
9 V_CC = 6;// in V
10 V_BB= -6;// in V
11 V_BE= 0.7;// in V
12 Vo = 0;// in V
13 R1= 90*10^3;// in ohm
14 R2= 90*10^3;// in ohm
15 // V_CC - I_CR_C - V_CEQ - I_ER_E-V_BB = 0 (i
    )
16 // Vo = V_CEQ + I_E*R_E - V_CC or
17 I_ER_E= Vo+V_CC-V_CEQ;// in V
18 // From eq(i)
19 I_CR_C= V_CC - I_ER_E - V_CEQ - V_BB;// in V

```

```

20 // Applying KVL to the input side of circuit
21 //V_CEQ-[(R1 || R2)*I_B]-V_BE-I_ER_E+V_CC=0 or
22 I_B= (V_CEQ-V_BE-I_ER_E+V_CC)/((R1*R2)/(R1+R2)); //
    in A
23 I_E= (1+bita)*I_B; //in A
24 R_E= I_ER_E/I_E; // in ohm
25 I_C= bita*I_B; // in A
26 R_C= I_CR_C/I_C; // in ohm
27 disp("Part (a) : ")
28 disp(R_E,"The value of R_E in ohm is : ")
29 disp(R_C,"The value of R_C in ohm is : ")
30 disp("Parb (b) :")
31 bita= 100;
32 I_E= (1+bita)*I_B; //in A
33 I_C= bita*I_B; // in A
34 Vo_new= V_CEQ+I_E*R_E-V_CC; // in V
35 Change_in_Vo= Vo_new-Vo; // in V
36 disp(Change_in_Vo,"The change in Vo in volts is : ")

```

---

### Scilab code Exa 2.10 Maximum value of bita

```

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

```

```

15 R_B = 50; // in k ohm
16 R_B = R_B * 10^3; // in ohm
17 I_Csat= poly(0, 'I_Cs ')
18 // Part (i) : To check the region of operation
19 // Applying KVL to collector circuit , we get : V_CC
    = (R_C*I_Cs) + V_CEsat + (I_E*R_E)          (i)
20 I_E = I_Csat; // in A (approximate)
21 // From eq(i)
22 I_Csat= (R_C*I_Csat) + V_CEsat + (I_E*R_E)-V_CC; //
    in A
23 I_Csat= roots(I_Csat); // in A
24 I_Bmin= I_Csat/bita; // in A
25 I_Bmin= I_Bmin*10^6; // in A
26 disp("Part (i)")
27 disp(I_Bmin, "The minimum value of I_B in A is : "
    )
28 I_B= poly(0, 'I_B ')
29 I_E= (1+bita)*I_B; // in A
30 // Applying KVL to input circuit , we get
31 // V_CC = I_B*R_B+V_BEsat+I_E*R_E or
32 I_B= I_B*R_B+V_BEsat+I_E*R_E-V_CC; // in A
33 I_B= roots(I_B); // in A
34 I_B= round(I_B*10^6); // in A
35 disp(I_B, "The value of I_B in A is : ")
36 if I_B>I_Bmin then
37     disp("As the value of I_B is greater than the
        value of I_B min")
38     disp("Hence the transistor is definitely in the
        saturation region")
39 end
40 I_E= (1+bita)*I_Bmin; // in A
41 V_C= V_CEsat+I_E*10^-6*R_E; // in V
42 disp(V_C, "Part (ii) : The value of V_C in volts is :
    ");
43 bita_min= I_Csat/(I_B*10^-6);
44 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

```
1 // Exa 2.11
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CEsat = 0.2; // in V
8 V_CC = 10; // in V
9 V_BEsat = 0.8; // in V
10 // Part (i) To obtain minimum value of R_C
11 R_B = 220; // in k ohm
12 R_B = R_B * 10^3; // in ohm
13 Beta = 100;
14 // Applying KVL to collector circuit , we get
15 //  $V_{CC} = V_{CEsat} + I_{Csat}R_C$  or (i)
16 I_CsatR_C= V_CC-V_CEsat; // in V
17 // Applying KVL to input loop
18 //  $V_{CC} = V_{BEsat} + I_B R_B$  or (ii)
19 I_B= (V_CC-V_BEsat)/R_B; // in A
20 // Just at saturation  $I_B = I_C / \text{Beta}$  or
21 I_C= Beta*I_B; // in A
22 R_Cmin= I_CsatR_C/I_C; // in ohm
23 R_Cmin= R_Cmin*10^-3; // in k ohm
24 disp(R_Cmin,"The minimum value of R_C to produce
    saturation of Si transistor in k is : ")
25
26 // Part (ii) To obtain maximum value of R_B
27 R_C = 1.2; // in k ohm
28 R_C = R_C * 10^3; // in ohm
29 I_Csat= I_CsatR_C/R_C; // in A
30 // Just at saturation
31 I_B= I_Csat/Beta; // in A
```

```

32 // Now on substituting the new value of I_B in eq (
    ii)
33 R_Bmax= (V_CC-V_BEsat)/I_B;// in ohm
34 R_Bmax= R_Bmax*10^-3;// in k ohm
35 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

```

1 // Exa 2.12
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CE = 2.5;// in V
8 Beta = 100;
9 R2 = 10 * 10^3;// in ohm
10 R4 = 300;// in ohm
11 V_CC = 5;// in V
12 I_C = 1 * 10^-3;// in A
13 V_BE= 0.6;// in V
14 // Applying KVL to collector circuit , we get
15 // V_CC = I_C*R3 + V_CE + I_E*R4 (i)
16 I_B = I_C/Beta;// in A
17 I_E = (I_C + I_B);// in A
18 // On substituting the value of I_B and I_E in eq (
    i), we get
19 R3= (V_CC-V_CE-I_E*R4)/I_C;// in ohm
20 V_B= I_E*R4+V_BE;// in V
21 // But also V_B= R2/(R1+R3)*V_CC, so
22 R1= R2*V_CC/V_B-R2;// in ohm
23 R1= R1*10^-3;// in k ohm
24 R3= R3*10^-3;// in k ohm
25 disp(R1,"The value of R1 in k is : ")

```

```
26 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

```
1 // Exa 2.13
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CEsat = 0.2; // in V
8 R_B = 100 * 10^3; // in ohm
9 R_C = 2 * 10^3; // in ohm
10 beta = 100;
11 R_E = 1 * 10^3; // in ohm
12 V_CC = 10; // in V
13 V_BEsat = 0.8; // in V
14 V_BEactive = 0.7; // in V
15 V_BE = 0.7; // in V
16 V_BEcutin = 0.5; // in V
17 // Applying KVL to output circuit , we get
18 //  $V_{CC} = R_C I_C + V_{CEsat} + R_E I_E$  (i)
19 I_Bmin = poly(0, 'I_Bm');
20 I_C = beta * I_Bmin; // in A
21 I_E = (1+beta) * I_Bmin; // in A
22 // From eq(i)
23 I_Bmin = (R_C * I_C + V_CEsat + R_E * I_E - V_CC) / R_E; // in A
24 I_Bmin = roots(I_Bmin); // in A
25 I_Bmin = I_Bmin * 10^6; // in A
26 // Applying KVL to input circuit , we get
27 //  $V_{CC} = R_B I_B + V_{BEsat} + R_E I_E$  (ii)
28 I_B = poly(0, 'I_B'); // in A
29 I_E = (1+beta) * I_B; // in A
30 // From eq(ii)
```

```

31 I_B= R_B*I_B + V_BEsat + R_E*I_E-V_CC;// in A
32 I_B= roots(I_B);// in A
33 I_B= I_B*10^6;// in A
34 if I_B>I_Bmin then
35     disp("As the value of I_B (" +string(I_B)+ " A )
           is greater than the value of I_Bmin (" +string
           (I_Bmin)+ " A)")
36     disp("Hence the transistor is in saturation
           region")
37 end
38
39 // Part (b) : To obtain the value of R_E
40 V_CE= 0.4;// in V (assumed)
41 // Rewrite eq(ii) as, V_CC = (R_C*I_C) + V_CE + (R_E
    *I_E) or
42 // 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 )
43 // Applying KVL to input circuit , V_CC= I_B*R_B+V_BE
    +(1+bita)*I_B*R_E      (iv)
44 // On substituting the I_B from eq (iii) in eq (iv)
45 R_E= [(V_CC-V_BE)*bita*R_C-(V_CC-V_CE)*R_B]/[(1+bita
    )*(V_BE-V_CE)];// in ohm
46 R_E= R_E*10^-3;// in k ohm
47 disp(R_E,"The value of R_E in k is : ")

```

---

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

```

1 // Exa 2.14          (Printed As Exa 2.13)
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Beta_dc = 100;

```

```

8 R_C = 0.5*10^3; // in ohm
9 V_BB = 0; // in V
10 V_BE= 0.7; // in V
11 R_B = 44 * 10^3; // in k ohm
12 R_E = 1 * 10^3; // in ohm
13 V_EE = -15; // in V
14 V_CC = 15; // in V
15 // Applying KVL to base circuit
16 // V_CC= R_B*I_B+V_BE+(1+Beta_dc)*R_E*I_B or
17 I_B= (V_CC-V_BE)/(R_B+(1+Beta_dc)*R_E); // in A
18 I_C= I_B*Beta_dc; // in A
19 I_E= (1+Beta_dc)*I_B; // in A
20 // Applying KVL to collector circuit
21 // V_CC = R_C*I_C + V_CE + R_E*I_E + V_EE or
22 V_CE= V_CC-V_EE-I_C*R_C-I_E*R_E; // in V
23 Vo2= I_E*R_E-V_CC; // in V
24 // But V_CE= V01-Vo2, so
25 Vo1= V_CE+Vo2; // in V
26 disp(Vo1,"The value of Vo1 in volts is : ")
27 disp(Vo2,"The value of Vo2 in volts is : ")
28 // Part (ii) New Value of R_C to make Vo1= 0 V
29 Vo1= 0;
30 // V_CC= I_C*R_C+Vo1-Vo2+I_E*R_E-V_EE or
31 R_C= (V_CC-V_EE-Vo1+Vo2-I_E*R_E)/(I_C); // in ohm
32 R_C= R_C*10^-3; // in k ohm
33 disp(R_C,"The value of R_C in k is : ")
34 // Part (iii) New value of R_E to get Vo2= 0;
35 Vo2= 0; // in V
36 // Formula Vo2= I_E*R_E-V_CC, so
37 R_E= (Vo2+V_CC)/I_E; // in ohm
38 R_E= R_E*10^-3; // in kohm
39 format('v',4)
40 disp(R_E,"The value of R_E in k is :")
41
42 // Note : The calculated value of R_C in the book is
    not correct

```

---

## Scilab code Exa 2.15 IC and IB

```
1 // Exa 2.15
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 bita = 50;
8 V_CC = 25; // in V
9 V_BB = 10; // in V
10 R_C = 15 * 10^3; // in ohm
11 R_B = 40 * 10^3; // in ohm
12 R_E = 5 * 10^3; // in ohm
13 V_BE = 0.7; // in V
14 I_B= poly(0, 'I_B');
15 I_E= (1+bita)*I_B; // in A
16 // Applying KVL to Base-Emitter loop ,
17 // V_BB = I_B*R_B + V_BE + I_E*R_E
18 I_B= I_B*R_B + V_BE + I_E*R_E - V_BB;
19 I_B= roots(I_B); // in A
20 I_E= (1+bita)*I_B; // in A
21 I_B= I_B*10^6; // in A
22 disp("Part (a) : On assuming that the transistor is
      in the active region")
23 disp(I_B,"The value of I_B in A is : ")
24 I_C= bita*I_B; // in A
25 I_C= I_C*10^-3; // in mA
26 disp(I_C,"The value of I_C in mA is");
27 I_E = (1+bita)*I_B; // in A
28 I_E = I_E * 10^-6; // in A
29 I_C= I_C*10^-3; // in A
30 I_B= I_B*10^-6; // in A
31
```

```

32 // Part (b): To verify that the transistor is not in
    the active region
33 // Applying KVL to collector circuit , we get  $V_{CC}=I_C R_C+V_{CE}+I_E R_E$  or
34  $V_{CE}= V_{CC}-I_C R_C-I_E R_E$ ; // in V
35 if  $V_{CE}<0$  then
36     disp(" Part (b)")
37     disp(" Since the value of  $V_{CE}$  (" + string( $V_{CE}$ ) +
        V) is negative ,")
38     disp(" hence the transistor is not in active
        region")
39 end
40
41 // Part (c)
42  $V_{BEsat}= 0.8$ ; // in V
43  $V_{CEsat}= 0.2$ ; // in V
44 // Applying KVL to base circuit ,  $V_{BB}= I_B R_B+V_{BEsat}+I_C R_E+I_B R_E$ , or
45 //  $I_B*(R_B+R_E)+I_C R_E= V_{BB}-V_{BEsat}$ 
    (i)
46 // Applying KVL to collector circuit ,  $V_{CC}= I_C R_C+V_{CEsat}+(I_C+I_B)*R_E$ , or
47 //  $I_B R_E+I_C*(R_C+R_E)= V_{CC}-V_{CEsat}$       (
    ii)
48 // Solving eq(i) and (ii) by matrix method
49  $A= [(R_B+R_E) R_E; R_E (R_C+R_E)]$ ;
50  $B= [V_{BB}-V_{BEsat} V_{CC}-V_{CEsat}]$ ;
51  $R= B*A^{-1}$ ;
52  $I_B= R(1)$ ; // in A
53  $I_B= I_B*10^6$ ; // in A
54  $I_C= R(2)$ ; // in A
55  $I_C= I_C*10^3$ ; // in mA
56 disp(" Part (c) : On assuming that the transistor is
    in saturation region")
57 disp( $I_B$ , "The value of  $I_B$  in A is : ")
58 disp( $I_C$ , "The value of  $I_C$  in mA is : ")
59  $I_{Bmin}= I_C/beta$ ; // in mA
60  $I_{Bmin}= I_{Bmin}*10^3$ ; // in A

```

```

61 if I_B>I_Bmin then
62     disp(" Part (d) :")
63     disp(" Since the value of I_B (" +string(I_B)+"
        A) is greater than the value of I_Bmin (" +
        string(I_Bmin)+" A)")
64     disp(" Hence the transistor is indeed in
        saturation region")
65 end
66
67 // Part (e) : R_E to bring the transistor out of
    saturation
68 Vcut= 0.5;//cut in voltage in V
69 I_B= poly(0, 'I_B ');// in A
70 I_C= beta*I_B;// in A
71 I_E= (1+beta)*I_B;// in A
72 // Applying KVL to input loop , V_BB= I_B*R_B+V_BE+(
    I_C+I_B)*R_E or
73 // I_B= (V_BB-V_BE)/(R_B+(1+beta)*R_E)
        (iii)
74 // I_C= beta*I_B = (V_BB-V_BE)/(R_B+(1+beta)*R_E)*
    beta (iv)
75 // V_B= V_BE+(1+beta)*I_B*R_E= V_BE+ (1+beta)*(V_BB-
    V_BE)/(R_B+(1+beta)*R_E)*R_E (v)
        (on substituting eq(iii))
76 // V_C= V_CC-I_C*R_C= V_CC-(V_BB-V_BE)/(R_B+(1+beta)
    *R_E)*beta*R_C (
    vi) (on substituting eq(iv))
77 // but V_B-V_C<= Vcut and substituting the value
    from eq (v) and (vi), we get
78 R_E= [beta*R_C*(V_BB-V_BE)-R_B*(Vcut+V_CC-V_BE)
    ]/[(1+beta)*(-V_BB+Vcut+V_CC)];// in ohm
79 R_E= R_E*10^-3;// in k ohm
80 disp(" Part (e) : The value of R_E >= " +string(R_E)+"
    k ")

```

---



Scilab code Exa 2.16 Region of transistor and output voltage

```
1 // Exa 2.16
2 clc;
3 clear;
4 close;
5 format('v',7)
6 // Given data
7 bita = 100;
8 V_CEsat = 0.2; // in V
9 V_BEsat = 0.8; // in V
10 R_C = 3; // in k ohm
11 R_C = R_C * 10^3; // in k ohm
12 V_CC = 10; // in V
13 R_B = 7; // in k ohm
14 R_B = R_B * 10^3; // in ohm
15 R_E = 500; // in ohm
16 V_BB = 3; // in V
17 V_BE= 0.7; // in V
18 // Part (a) :
19 // Applying KVL to input loop ,  $V_{BB} = I_B \cdot R_B + (I_B + I_C) \cdot R_E + V_{BEsat}$  or  $I_B \cdot (R_B + R_E) + I_C \cdot R_E = V_{BB} - V_{BEsat}$  (i)
20 // Applying KVL to output loop ,  $V_{CC} = I_C \cdot R_C + V_{CEsat} + (I_B + I_C) \cdot R_E$  or  $I_B \cdot R_E + I_C \cdot (R_C + R_E) = V_{CC} - V_{CEsat}$  (ii)
21 // Solving eq(i) and (ii) by matrix method
22 A= [(R_B+R_E) R_E; R_E (R_C+R_E)] ;
23 B= [V_BB-V_BEsat V_CC-V_CEsat];
24 R= B*A^-1;
25 I_B= R(1); // in A
26 I_C= R(2); // in A
27 I_Bmin= I_C/bita; // in A
28 I_B= I_B*10^3; // in mA
29 I_Bmin=I_Bmin*10^3; // in mA
30 if I_B>I_Bmin then
31     disp("As the value of I_B (" + string(I_B) + " mA)
           is greater than the value of I_Bmin (" + string
```

```

        (I_Bmin)+" mA")
32     disp("Hence the transistor is in saturation
        region")
33 end
34
35 // Pard (e) : R_E to bring the transistor out of
        saturation
36 Vcut =0.5;//cut in voltage in V
37 I_B= poly(0,'I_B');// in A
38 I_C= bita*I_B;// in A
39 I_E= (1+bita)*I_B;// in A
40 // Applying KVL to input loop , V_BB= I_B*R_B+V_BE+(
        I_C+I_B)*R_E or
41 // I_B= (V_BB-V_BE)/(R_B+(1+bita)*R_E)
        (iii)
42 // I_C= bita*I_B = (V_BB-V_BE)/(R_B+(1+bita)*R_E)*
        bita (iv)
43 // 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))
44 // 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))
45 // but V_C-V_B<= Vcut and substituting the value
        from eq (v) and (vi), we get
46 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
47 disp(R_E,"The value of R_E in ohm is : ")

```

---

### Scilab code Exa 2.17 Collector voltage and minimum value of hFE

```

1 // Exa 2.17
2 clc;
3 clear;

```

```

4 close;
5 format('v',6)
6 // Given data
7 V_CC = 9; // in V
8 R_C = 2; // in k ohm
9 R_C = R_C * 10^3; // in ohm
10 R_B = 50; // in k ohm
11 R_B = R_B * 10^3; // in ohm
12 Beta = 70;
13 R_E = 1; // in k ohm
14 R_E = R_E * 10^3; // in ohm
15 V_BEsat = 0.8; // in V
16 V_CEsat = 0.2; // in V
17 // Applying KVL to input loop, V_CC= I_B*R_B+V_BEsat
    +I_E*R_E or
18 I_B= (V_CC-V_BEsat)/(R_B+(1+Beta)*R_E); // in A
19 // Applying KVL to output loop, V_CC= I_C*R_C+
    V_CEsat+I_E*R_E or
20 I_C= (V_CC-V_CEsat-I_B*R_E)/(R_C+R_E); // in A
21 I_Bmin= I_C/Beta; // in A
22 I_B= I_B*10^6; // in A
23 I_Bmin= I_Bmin*10^6; // in A
24 if I_B>I_Bmin then
25     disp("Part (i) :")
26     disp("As the value of I_B (" + string(I_B) + " mA)
        is greater than the value of I_Bmin (" + string
        (I_Bmin) + " mA)")
27     disp("Hence the transistor is in saturation
        region")
28 end
29 disp("Part (ii) : ")
30 V_C= V_CC-I_C*R_C; // in V
31 disp(V_C,"The collector voltage in volts is : ")
32 h_FE= I_C/(I_B*10^-6);
33 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

```
1 // Exa 2.18
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CC= 12;// in V
8 beta_min= 30;
9 R1= 15;// in k ohm
10 R2= 100;// in k ohm
11 R_C= 2.2;// in kohm
12 V_BB= -12;// in V
13 V_BE= 0.7;// in V
14 // Part (i)
15 Vi= 12;// in V
16 V_BEsat= 0.8;// in V
17 V_CEsat= 0.2;// in V
18 // Applying KVL to B-E circuit , Vi= I1*R1+V_BEsat or
19 I1= (Vi-V_BEsat)/R1;// in mA
20 // Applying KVL to -12 V supply ,
21 I2= (V_BEsat-V_BB)/R2;// in mA
22 // Applying KVL to input loop ,
23 I_B= I1-I2;// in mA
24 // Applying KVL to output loop , V_CC= I_C*R_C+
    V_CEsat or
25 I_C= (V_CC-V_CEsat)/R_C;// in mA
26 I_Bmin= I_C/beta_min;// in mA
27 if I_B>I_Bmin then
28     disp(" Part (a) :")
29     disp("As the value of I_B (" +string(I_B)+ " mA)
        is greater than the value of I_Bmin (" +string
        (I_Bmin)+ " mA)")
```

```

30     disp("Hence the transistor is in saturation
          region")
31 end
32 Vo= V_CC-I_C*R_C;// in V
33 disp(Vo,"The output voltage in volts is : ")
34
35 // Part (b)
36 I2= (V_CC+V_BE)/R2;// in mA
37 // and I1= (V_CC-V_BE)/R1;// in mA           (i)
38 I_B= I_Bmin;// in mA
39 I1= I2+I_Bmin;// in mA
40 // Now from eq(i)
41 R1= (V_CC-V_BE)/I1;// in k ohm
42 disp("Part (b)")
43 disp(R1,"The value of R1 in k ohm is : ")
44
45 // Part (c)
46 I_C= 0;// in mA
47 Vo= V_CC-I_C*R_C;// in V
48 disp("Part (c) : Transistor is in cutoff")
49 disp(Vo,"The value of Vo in volts is : ")
50
51 // 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

```
1 // Exa 3.1
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CC = 15; // in V
8 R_C = 4; // in k ohm
9 R_C = R_C * 10^3; // in ohm
10 I_C = 0; // in A
11 V_CE = V_CC - (I_C*R_C); // in V
12 V_CE = 0; // in V
13 // V_CE = V_CC - I_C*R_C;
14 I_C = V_CC/R_C; // in A
15 I_C = I_C * 10^3; // in mA
16 plot([V_CC 0],[0 I_C])
17 xlabel("V_CE in volts")
18 ylabel("I_C in mA")
19 title("DC load line")
```

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

---

### Scilab code Exa 3.2 Q point

```
1 // Exa 3.2
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 R_C = 5; // in k ohm
8 V_CC = 10; // in V
9 I_C = 1; // in mA
10 V_CE = V_CC - (I_C*R_C); // in V
11 disp("Part (i) When Collector load = 5 kohm");
12 disp("Operating point is : "+string(V_CE)+" V, "+
    string(I_C)+" mA")
13 disp("The quiescent point 5V and 1mA");
14 R_C = 6; // in k ohm
15 V_CE = V_CC - (I_C*R_C); // in V
16 disp("Part (ii) When Collector load = 6 kohm");
17 disp("Operating point is : "+string(V_CE)+" V, "+
    string(I_C)+" mA")
```

---

### Scilab code Exa 3.3 Q point values

```
1 // Exa 3.3
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Beta = 100;
```

```

8 V_CC = 10; // in V
9 V_BE = 0.7; // in V
10 R_B = 150; // in k ohm
11 // V_CC - I_B*R_B - V_BE = 0;
12 I_B = (V_CC-V_BE)/R_B; // in mA
13 // I_C = Beta*I_B + (1+Beta)*I_CO;
14 I_C = Beta * I_B; // in A
15 // V_CC - I_C*R_C - V_CE = 0;
16 R_C = 1; // in k ohm
17 V_CE = V_CC - (I_C*R_C); // in V
18 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

```

1 // Exa 3.4
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CC = 12; // in V
8 R_C = 2.2; // in k ohm
9 R_C = R_C * 10^3; // in ohm
10 R_B = 240; //in k ohm
11 R_B = R_B * 10^3; // in ohm
12 V_BE = 0.7; // in V
13 // V_CC - I_B*R_B - V_BE = 0;
14 I_BQ = (V_CC-V_BE)/R_B; // in A
15 I_BQ = I_BQ * 10^6; // in A
16 disp(I_BQ,"The value of I_BQ in A is");
17 Beta = 50;
18 // I_CQ = Beta*I_BQ + (1+BEta)*I_CO;
19 I_CQ = Beta*I_BQ*10^-6; // in A
20 I_CQ = I_CQ * 10^3; // in mA

```



```

21 disp(I_CQ,"The value of I_CQ in mA is");
22 // V_CC - I_CQ*R_C - V_CEQ = 0;
23 V_CEQ = V_CC - I_CQ*10^-3*R_C;// in V
24 disp(V_CEQ,"The value of V_CEQ in V is");
25 V_B = V_BE;// in V
26 disp(V_B,"The value of V_B in V is");
27 V_C = V_CEQ;// in V
28 disp(V_C,"The value of V_C in V is");
29 // V_CE = V_CB + V_BE;
30 V_CB = V_CEQ - V_BE;// in V
31 V_BC = -V_CB;// in V
32 disp(V_BC,"The value of V_BC in V is");

```

---

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

```

1 // Exa 3.5
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CC = 12;// in V
8 R_B = 100;// in k ohm
9 R_C = 500*10^-3;// in k ohm
10 Beta_dc = 100;
11 V_BE= 0.7;// in V
12 // V_CC - I_BQ*R_B - V_BE = 0;
13 I_BQ = (V_CC - V_BE)/R_B;// in mA
14 I_CQ = Beta_dc*I_BQ;// in mA
15 // V_CC - I_CQ*R_C - V_CEQ = 0;
16 V_CEQ = V_CC - (I_CQ*R_C);// in V
17 disp("The Q point at 30 is : "+string(V_CEQ)+" V,
      "+string(I_CQ)+" mA")
18 Beta_dc = 120;

```

```

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

```

---

### Scilab code Exa 3.6 Stability factor

```

1 // Exa 3.36
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 R_B = 100; // in k ohm
8 R_B = R_B * 10^3; // in ohm
9 R_C = 1; // in k ohm
10 R_C = R_C * 10^3; // in ohm
11 V_BE = 0.3; // in V
12 // S = 1 + Beta and Beta = I_C/I_B;
13 V_CC = 12; // in V
14 V_CE = 6; // in V
15 I_C = (V_CC-V_CE)/R_C; // in A
16 I_C = I_C * 10^3; // in mA
17 I_B = (V_CC-V_BE)/R_B; // in A
18 I_B = I_B * 10^6; // in A
19 Beta = (I_C*10^-3)/(I_B*10^-6);
20 S = 1 + Beta;
21 disp(S,"The stability factor is");

```

---

### Scilab code Exa 3.7 Collector current VCE and stability factor

```
1 // Exa 3.7
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CC = 25; // in V
8 R_B = 180; // in k ohm
9 R_C = 820*10^-3; // in k ohm
10 R_E = 200*10^-3; // in k ohm
11 bita = 80;
12 V_BE = 0.7; // in V
13 // Applying KVL to B-E loop, V_CC-I_B*R_B-V_BE-I_E*
    R_E=0 or
14 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)
15 disp(I_C,"The collector current in mA is");
16 V_CE = V_CC - (I_C*R_C); // in V
17 disp(V_CE,"The collector to emmitter voltage in V is"
    );
18 S = (1 + bita)/(1 + ((bita*R_E)/(R_B+R_E)));
19 disp(S,"Current stability factor is");
20 Sdas = -bita/(R_B + R_E*(1+bita));
21 disp(Sdas,"The voltage stability factor is");
```

---

### Scilab code Exa 3.8 Q point value

```
1 // Exsa 3.8
2 clc;
3 clear;
```

```

4 close;
5 format('v',6)
6 // Given data
7 V_CC = 20; // in V
8 V_BE= 0.7; // in V
9 R_C = 4.7; //in k ohm
10 bita = 100;
11 R_B = 680; // in k ohm
12 I_C= poly(0,'I_C'); // in mA
13 I_B= I_C/bita; // in mA
14 // Applying KVL to C-B circuit ,  $V_{CC} - (I_C+I_B)*R_C$ 
     $- I_B*R_B - V_{BE} = 0$ ;
15 I_C= V_CC - (I_C+I_B)*R_C - I_B*R_B - V_BE;
16 I_C= roots(I_C); // in mA
17 I_B= I_C/bita; // in mA
18 V_CEQ = V_CC - (I_C+I_B)*R_C; // in V
19 disp("Q point : "+string(V_CEQ)+" volts , "+string(
    I_C)+" mA")

```

---

### Scilab code Exa 3.9 Collector to base bias circuit

```

1 // Exa 3.9
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CEQ = 5; // in V
8 I_CQ = 5; // in mA
9 V_CC = 12; // in V
10 bita = 120;
11 I_C = I_CQ; // in mA
12 V_BE = 0.7; // in V
13 I_B= I_C/bita; // in mA
14 //  $V_{CC} - (I_C+I_B)*R_C - V_{CE} = 0$  or

```

```

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

```

---

### Scilab code Exa 3.10 Stability factor

```

1 // Exa 3.10
2 clc;
3 clear;
4 close;
5 format('v',5);
6 // Given data
7 V_CC = 10; // in V
8 R_C = 1; // in k ohm
9 R_B = 100; //in k ohm
10 V_CE = 5; // in V
11 V_BE = 0.7; // in V
12 V_CB= V_CE-V_BE; // in V
13 I_B= V_CB/R_B; // in mA
14 // V_CC = (I_C+I_B)*R_C + V_CE = I_C*R_C + I_B*R_C +
    V_CE;
15 I_C = (V_CC-V_CE-(I_B*R_C))/R_C; // in mA
16 bita= I_C/I_B;
17 S = (1 + bita)/( 1 + bita*( R_C/(R_B+R_C) ) );
18 disp(S,"The value of stability factor is");
19 S_fixed_bias= 1+bita; // stability factor for fixed
    bias circuit
20 disp(S_fixed_bias,"For the fixed bias circuit , the
    value of stability factor would have been")
21 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

```
1 // Exa 3.11
2 clc;
3 clear;
4 close;
5 format('v',5)
6 //Given data
7 Beta = 100;
8 V_CC = 10; // V
9 R1 = 9.1; // in k ohm
10 R_C = 1; // in k ohm
11 R_E = 560*10^-3; // in k ohm
12 R2 = 4.7; // in k ohm
13 V_BE = 0.7; // in V
14 V_Th = (V_CC/(R1+R2))*R2; // in V
15 R_B = (R1*R2)/(R1+R2); // in k ohm
16 // V_Th - I_B*R_B - V_BE - I_E*R_E = 0 or
17 I_B = (V_Th-V_BE)/(R_B+((1+Beta)*R_E)); // in mA
18 // I_C = Beta*I_B + (1+Beta)*I_CO;
19 I_C = Beta*I_B; // in mA (neglecting I_CO as it is
    very small)
20 // V_CC - (I_C*R_C) - V_CE - I_E*R_E = 0;
21 V_CE = V_CC - (I_C*R_C) - (I_C*R_E); // in V
22 disp("Q Point : "+string(V_CE)+" volts , "+string(I_C
    )+" mA")
```

---

Scilab code Exa 3.12 Quiescent current and collector emitter voltage

```
1 // Exa 3.12
2 clc;
```

```

3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CC = 20; // in V
8 bita = 50;
9 R_C = 2; // in k ohm
10 R_E = 0.1; // in k ohm
11 R1 = 100; // in k ohm
12 R2 = 5; // in k ohm
13 R_Th = (R1*R2)/(R1+R2); // in k ohm
14 R_B = R_Th; // in k ohm
15 V_BE = 0.7; // in V
16 V_Th = (V_CC*R2)/(R1+R2); // in V
17 // Applying KVL to the base circuit, V_Th - I_B*R_B
    - V_BE - I_E*R_E = 0 or
18 I_B = (V_Th-V_BE)/(R_B + (R_E*(1+bita))); // in mA
    (on putting I_E= (1+bita)*I_B)
19 I_C = bita*I_B; // in mA
20 I_E = (1+bita)*I_B; // in mA
21 V_CE = V_CC - (I_C*R_C) - (I_E*R_E); // in V
22 disp("Q Point : "+string(V_CE)+" volts, "+string(I_C
    )+" mA")

```

---

### Scilab code Exa 3.13 Q point value

```

1 // Exa 3.13
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 bita= 44;
8 V_BE = 0.2; // in V
9 V_CC = -4.5; // in V

```

```

10 R1 = 2.7; // in k ohm
11 R_C = 1.5; // in k ohm
12 R2 = 27; // in k ohm
13 R_E = 0.27; // in k ohm
14 R_Th = (R1*R2)/(R1+R2); // in k ohm
15 R_B = R_Th; // in k ohm
16 V_Th = (V_CC*R_B)/R2; // in V
17 I_B= poly(0, 'I_B '); // in mA
18 I_C= beta*I_B; // in mA
19 I_E= -(I_C+I_B); // in mA
20 // Applying KVL to base circuit ,  $-V_{Th} - I_B R_B - V_{BE} + (I_E R_E) = 0$  (i)
21 I_B= (V_Th - I_B*R_B + V_BE + (I_E*R_E)); // in mA
22 I_B= roots(I_B); // in mA
23 I_C= beta*I_B; // in mA
24 I_E= -(I_C+I_B); // in mA
25 // Applying KVL to collector circuit ,  $-V_{CC} - I_C R_C - V_{CE} + I_E R_E = 0$  or
26 V_CE = V_CC - (I_C*R_C) + (I_E*R_E); // in V
27 disp("Part (a) : ")
28 disp("Q Point : "+string(V_CE)+" volts , "+string(I_C)+
    "+" mA")
29 // Calculation of R'Th or R'B (Thevenin's Resistance
    )
30 r_bb = 0.69; // in k ohm
31 R_deshB = ((R1*R2)/(R1+R2)) + r_bb; // in k ohm
32 // Calculation of Thevenin's voltage
33 I_B= (V_Th+V_BE)/(R_deshB+(1+beta)*R_E); // in mA
34 I_C= beta*I_B; // in mA
35 // Applying KVL to collector circuit ,  $-V_{CC} - (I_C R_C) - V_{CE} + I_E R_E = 0$  or
36 V_CE = V_CC - (I_C*R_C) + (I_E*R_E); // in V
37 disp("Part (b) : ")
38 disp("Q Point : "+string(V_CE)+" volts , "+string(I_C)+
    "+" mA")

```

---



### Scilab code Exa 3.14 DC bias voltage and current

```
1 // Exa 3.14
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 beta = 140;
8 V_BE = 0.7; // in V
9 V_CC = 22; // in V
10 R1 = 39; // in k ohm
11 R_C = 10; // in k ohm
12 R2 = 3.9; // in k ohm
13 R_E = 1.5; // in k ohm
14 // Calculation of Thevenin's Resistance
15 R_Th = (R1*R2)/(R1+R2); // in k ohm
16 // Calculation of Thevenin's Voltage
17 V_Th = (V_CC*R2)/(R1+R2); // in V
18 I_B = poly(0, 'I_B'); // in mA
19 I_E = (1+beta)*I_B; // in mA
20 // Applying KVL to input side, V_Th - I_B*R_Th -
    V_BE - I_E*R_E = 0 or
21 I_B = V_Th - I_B*R_Th - V_BE - I_E*R_E;
22 I_B = roots(I_B); // in mA
23 I_C = beta*I_B; // in mA
24 I_E = (1+beta)*I_B; // in mA
25 // Applying KVL to C-E circuit, V_CC - I_C*R_C -
    V_CE - I_E*R_E = 0 or
26 V_CE = V_CC - (I_C*R_C) - ((1+beta)*I_B*R_E); // in V
27 I_B = I_B*10^3; // in A
28 disp(I_B, "The value of I_B in A is");
29 disp(I_C, "The value of I_C in mA is");
30 disp(V_CE, "The value of V_CE in V is");
```

---

### Scilab code Exa 3.15 RE and stability factor

```
1 // Exa 3.15
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 V_CC =12; // in V
8 R_C = 4.3; // in k ohm
9 V_CE = 4; // in V
10 V_BE = 0.7; // in V
11 V_EE = 6; // in V
12 beta = 50;
13 // Applying KVL in base circuit ,  $-V_{BE} - I_{ER\_E} + V_{EE} = 0$  or
14  $I_{ER\_E} = V_{EE} - V_{BE}$ ; // in V
15 // Applying KVL in C-E circuit ,  $V_{CC} - I_C * R_C - V_{CE} - I_{ER\_E} + V_{EE} = 0$  or
16  $I_C = (V_{CC} - V_{CE} - I_{ER\_E} + V_{EE}) / R_C$ ; // in mA
17  $I_B = I_C / \beta$ ; // in mA
18  $I_E = I_C + I_B$ ; // in mA
19  $R_E = I_{ER\_E} / I_E$ ; // in k ohm
20 disp(R_E,"The value of R_E in k ohm is : ")
21 del_IC= beta*(1+beta)*R_E;
22 del_IC0= beta*(1+beta)*R_E;
23 S= del_IC/del_IC0;
24 disp(S,"The value of stability factor , S is : ")
25 S_desh= beta/((1+beta)*R_E);
26 disp(S_desh,"The value of stability factor , S'' is : ")
    ")
```

---

### Scilab code Exa 3.17 Junction temperature

```
1 // Exa 3.17 (Miss printed as example 3.14)
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 Tj = 150; // Junction temperature in degree C
8 P_Cmax = 125; // in mW
9 T = 25; // free-air temperature in degree C
10 T1 = 0; // in degree C
11 curve = (Tj-T)/(P_Cmax - T1); // in degreeC/mW
12 T_A = 25; // Ambient temperature in degree C
13 P_D = 75; // Collector junction dissipation in mW
14 theta = 1; // in degree C/mW
15 // Tj-T_A = theta*P_D;
16 Tj = T_A + (theta*P_D); // in degree C
17 disp(Tj,"The junction temperature in C is");
```

---

### Scilab code Exa 3.18 Thermal resistance and junction temperature

```
1 // Exa 3.18 (Miss printed as example
2 3.15)
3 clc;
4 clear;
5 close;
6 format('v',5)
7 // Given data
8 P_Cmax = 125; // in mW
9 P_D = P_Cmax; // in mW
10 T_A = 25; // in degree C
11 Tj = 150; // in degree C
12 // Tj-T_A = theta*P_D;
13 theta = (Tj-T_A)/P_D; // in degree C/mW
```

```

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

```

---

### Scilab code Exa 3.20 Biasing component for fixed bias

```

1 // Exa 3.20 (Miss printed as example
    3.17)
2 clc;
3 clear;
4 close;
5 format('v',7)
6 // Given data
7 V_E = 1; // in V
8 V_BE = 0.7; // in V
9 R_C = 1; // in k ohm
10 Beta = 180;
11 V_CC = 12; // in V
12 V_CEQ = 6; // in V
13 // Applying KVL into collector circuit , V_CC - I_C*
    R_C - V_CEQ = 0 or
14 I_C = (V_CC-V_CEQ)/R_C; // in mA
15 I_B = I_C/Beta; // in mA
16 // Applying KVL into base circuit , V_CC - I_B*R_B -
    V_BE = 0 or
17 R_B = (V_CC-V_BE)/I_B; // in k ohm
18 disp(R_B,"The value of R_B in k ohm is");
19 //Applying KVL to collector circuit , V_CC - I_C*R_C
    - V_CE - V_E = 0 or
20 I_C = (V_CC-V_CEQ-V_E)/R_C; // in mA
21 I_B = I_C/Beta; // in mA

```

```

22 I_E = I_C+I_B; // in mA
23 R_E = V_E/(I_E); // in k ohm
24 R_E= round(R_E*10^3); // in ohm
25 disp(R_E,"The value of R_E in ohm is");
26 I_R2 = 10*I_B; // in mA
27 V_BE= 0.6; // in V
28 //R2 =V_B/I_R2 = (V_E+V_BE)/I_R2;
29 R2 = (V_E+V_BE)/I_R2; // in k ohm
30 R2= R2*10^3; // in ohm
31 disp(R2,"The value of R2 in ohm is");
32 I_R1 = I_R2 + I_B; // in mA
33 //R1 = V_R1/I_R1 = (V_CC-V_B)/I_R1;
34 V_B = V_E+V_BE; // in V
35 R1 = (V_CC-V_B)/I_R1; // in k ohm
36 disp(R1,"The value of R1 in k ohm is");

```

---

### Scilab code Exa 3.21 Value of ICQ

```

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

```

```

16 I_C= beta*I_B; // in A
17 I_C= I_C*10^-3; // in mA
18 I_CQ= I_C; // in mA
19 disp(I_CQ,"The value of I_CQ at room temperature in
    mA is : ")
20 // Part (ii)
21 C= 2; // temperature coefficient in mV/ C
22 C= 2*10^-3; // in V/ C
23 T2= 20; // in C
24 T1= 0; // in C
25 I_CB02= I_CB0*2^((T2-T1)/10); // in A
26 V_BE2= V_BE-C*T2; // in V
27 // Now from eq(i), for the new value of I_B
28 I_B=(V_BB-V_BE2)/(R_B+(1+beta)*R_E); // in mA
29 I_B= I_B*10^3; // in A
30 I_C= beta*I_B+(1+beta)*I_CB02; // in A
31 I_C= I_C*10^-3; // in mA
32 I_CQ= I_C; // in mA
33 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

```

1 // Exa 3.22 (Miss printed as example
    3.19)
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 S = 10;
8 beta = 50;
9 h_fe = beta;
10 V_CC= 20; // in V
11 V_CE = 10; // in V

```

```

12 R_C = 2; // in k ohm
13 I_C = 4; // in mA
14 I_B = I_C/beta; // in mA
15 // Applying KVL to collector loop, V_CC - I_C*R_C -
    V_CE - I_E*R_E = 0 or
16 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)
17 R_E= round(R_E*10^3); // in ohm
18 disp(R_E,"The value of R_E in ohm is");
19 // Formula S = (1+beta)*( (1 + (R_B/R_E)))/( (1+beta)
    + (R_B/R_E) ) ) or
20 R_B= (1+beta)*(1-S)*R_E/(S-1-beta); // in ohm
21 // But R_B= R1 || R2= R1*R2/(R1+R2) => R2/(R1+R2)=
    R_B/R1 (i)
22 // Calculation of R1 and R2 :
23 V_BE= 0.2; // in V
24 // Applying KVL to input loop ,
25 V_R2= V_BE+(I_C+I_B)*10^-3*R_E; // in V
26 // But V_R2= R2*V_CC/(R1+R2) => R2/(R1+R2)= V_R2/
    V_CC (ii)
27 // On comparing eq (i) and (ii)
28 R1= R_B*V_CC/V_R2; // in ohm
29 R2= R1*V_R2/(V_CC-V_R2); // in ohm
30 R1= R1*10^-3; // in k ohm
31 R2= R2*10^-3; // in k ohm
32 disp(R1,"The value of R1 in k ohm is : ")
33 disp(R2,"The value of R2 in k ohm is : ")
34 // Effect of Reducing S or 3 :
35 S=3;
36 // Formula S = (1+beta)*( (1 + (R_B/R_E)))/( (1+beta)
    + (R_B/R_E) ) ) or
37 R_B= (1+beta)*(1-S)*R_E/(S-1-beta); // in ohm
38 R_B= R_B*10^-3; // in k ohm
39 disp(R_B,"When S<=3, the value of R_B in k ohm is :
    ")
40 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

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



```

20 Zi= Zi*10^-3;// in k ohm
21 disp(Zi,"The internal input impedance in k ohm is");
22 Zi= Zi*10^3;// in ohm
23 //Internal voltage gain , Av = Vce/Vbe or
24 Av = (A_I*R_L)/Zi;
25 disp(Av,"The internal voltage gain is");
26 Ri = floor(R_B*Zi/(R_B+Zi));// in ohm
27 Ri= Ri*10^-3;// in k ohm
28 disp(Ri,"The overall input impedance in k ohm is");
29 Ri= Ri*10^3;// in ohm
30 // V_S= I_i*R_S+v_be or
31 VS_by_vbe= Ri/(Ri+R_S);
32 Avs= Av*VS_by_vbe;
33 disp(Avs,"The overall voltage gain is : ")
34 // R_B*(I_i-I_b)= Zi*I_b or
35 I_bBYI_i= R_B/(R_B+Zi);
36 A_IS= A_I*I_bBYI_i;
37 disp(A_IS,"The overall current gain is : ")
38 Rdesh_S= R_B*R_S/(R_B+R_S);// in ohm
39 Rdesh_S= 3220
40 I_bByVce= -h_re/(h_ie+Rdesh_S);
41 Yo= h_oe-h_fe*h_re/(h_ie+Rdesh_S)*10^3;
42 Zo= 1/Yo;
43 disp(Zo,"The Output impedance in ohm is : ")

```

---

#### Scilab code Exa 4.2 Overall current gain

```

1 // Exa 4.2
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_CC = 15;// in V
8 R_L = 10;// in k ohm

```

```

 9 Rf = 200; // in k ohm
10 R_S = 5; // in k ohm
11 Rf2 = Rf; // in k ohm
12 h_fe = 50;
13 V_S= 10*10^-3; // in V
14 h_oe = 1/40; // in k ohm
15 R_L = (R_L*Rf2)/(R_L+Rf2); // in k ohm
16 Ai = -h_fe/(1+h_oe*R_L);
17 disp(Ai,"The internal current gain is");
18 //Zi = Vbe/Ib = h_ie +Ai*h_re*R_L;
19 h_ie = 1.1; // in k ohm
20 h_re = 2.5*10^-4;
21 Zi = h_ie +Ai*h_re*R_L; // in k ohm
22 disp(Zi,"The internal input impedance in k ohm is");
23 //A_V = Vce/Vbe = (Ai*R_L)/Zi;
24 A_V = (Ai*R_L)/Zi;
25 disp(A_V,"The internal voltage gain is");
26 Rf1= Rf/(1-A_V)
27 // Rf1 = Rf/(1-A_V); // in k ohm
28 //Ri = Vi/Ii = Vbe/Ii = (Rf1*Zi)/(Rf1+Zi);
29 Ri = (Rf1*Zi)/(Rf1+Zi); // in k ohm
30 disp(Ri,"The overall input impedance in k ohm is");
31 //A_VS = Vo/V_S or
32 A_VS = A_V*(Ri/(R_S+Ri));
33 disp(A_VS,"The overall voltage gain is");
34 //A_IS = I_L/Ii or
35 A_IS = (Rf2/(Rf2+R_L))*Ai*(Rf1/(Rf1+Zi));
36 disp(A_IS,"The overall current gain is");
37 Rdesh_S= Rf1*R_S/(Rf1+R_S); // in k ohm
38 Yo= h_oe-h_re*h_fe/(h_ie+Rdesh_S); // in mho
39 Zo= 1/Yo; // in ohm
40 disp(Zo,"The output impedance in ohm is : ")
41 Zdesh_o= Rf2*Zo/(Rf2+Zo); // in ohm
42 disp(Zdesh_o,"The overall output impedance in ohm is
: ");
43 Vo= V_S*abs(A_VS); // in V
44 Vo= Vo*10^3; // in mV
45 disp(Vo,"The magnitude of output voltage in mV is :

```

)

---

### Scilab code Exa 4.3 Output impedance

```
1 // Exa 4.3
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 h_ic = 2; // in k ohm
8 h_fc = -51;
9 h_oc = 25*10^-6; // in ohm
10 h_rc = 1;
11 V_CC = 20; // in V
12 R1 = 10; // in k ohm
13 R2 = 10; // in k ohm
14 R_S = 1; // in k ohm
15 R_E = 5; // in k ohm
16 R_B = 5; // in k ohm
17 R_L = 5; // in k ohm
18 // (i) Current Gain
19 Ai = (-h_fc)/(1+h_oc*R_E*10^3);
20 disp(Ai,"The current gain is");
21 // (ii) Input impedance
22 Zi = h_ic*10^3 + h_rc*Ai*R_E*10^3; // in ohm
23 Zi = Zi * 10^-3; // in k ohm
24 disp(Zi,"The input impedance in k ohm is");
25 // (iii) Voltage Gain
26 A_V = (Ai*R_L*10^3)/(Zi*10^3);
27 A_V = 1; // (approx)
28 disp(A_V,"The voltage gain is");
29 // (iv) Overall Input Impedance
30 Z_IS = (R_B*Zi)/(R_B+Zi); // in k ohm
31 disp(Z_IS,"The overall input impedance in k ohm is")
```

```

;
32 // (v) Overall voltage gain
33 A_VS = (A_V*Zi)/(Zi+R_S);
34 disp(A_VS,"The overall voltage gain is");
35 // (vi) Overall current gain
36 A_IS =Ai*(R_B/(R_B+Zi));
37 disp(A_IS,"The overall current gain is");
38 // (vii) Output impedance
39 RdasS = (R_S*R_B)/(R_S+R_B); // in k ohm
40 Yo = h_oc - ( h_fc*h_rc)/(h_ic*10^3+RdasS*10^3 ) ;
    // in mho
41 Zo = 1/Yo; // in ohm
42 disp(Zo,"The output impedance in ohm is");

```

---

#### Scilab code Exa 4.4 Overall current gain

```

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

```

```

20 // (ii) Input impedance
21 Zi = (h_ie*10^3) + (h_re*Ai*R_C*10^3); // in ohm
22 Zi = Zi * 10^-3; // in k ohm
23 disp(Zi,"The input impedance in k ohm is");
24 // (iii) Voltage gain
25 A_V = (Ai*R_C)/Zi;
26 disp(A_V,"The voltage gain is");
27 // (iv) Overall input impedance
28 R_B = (R1*R2)/(R1+R2); // in k ohm
29 Z_IS = (Zi*R_B)/(Zi+R_B); // in k ohm
30 disp(Z_IS,"The overall input impedance in k ohm is")
    ;
31 // (v) Overall voltage gain
32 A_VS = A_V * (Z_IS/(Z_IS+R_S));
33 disp(A_VS,"The overall voltage gain is");
34 // (vi) Overall current gain
35 A_IS = Ai*(R_B/(R_B+Zi));
36 disp(A_IS,"The overall current gain is");

```

---

#### Scilab code Exa 4.5 Power gain

```

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

```

```

15 // (i) Current Gain
16 Ai = -h_fe/(1 + (h_oe*R_L));
17 disp(Ai,"The current gain is");
18 // (ii) Input impedance
19 Zi = (h_ie*10^3) + (h_re*Ai*R_L); // in ohm
20 Zi= Zi*10^-3; // in k ohm
21 disp(Zi,"The input impedance in k ohm is");
22 Zi= Zi*10^3; // in ohm
23 // (iii) Voltage gain
24 A_V = Ai*R_L/Zi;
25 disp(A_V,"The voltage gain is");
26 // (iv) Power gain
27 A_P = Ai*A_V;
28 disp(A_P,"The power gain is");

```

---

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

```

1 // Exa 4.6
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 h_fe = 150;
8 Beta_dc = h_fe;
9 h_ie = 1*10^3; // in ohm
10 h_re = 0;
11 h_oe = 0;
12 V_CC = 18; // in V
13 V_BE= 0.7; // in V
14 R1 = 100*10^3; // in ohm
15 R2 = 50*10^3; // in ohm
16 R_C = 1*10^3; // in ohm
17 R_E = 0.5*10^3; // in ohm
18 V_Th = (V_CC/(R1+R2))*R2; // in V

```

```

19 R_Th =(R1*R2)/(R1+R2); // in ohm
20 // V_Th - I_B*R_Th - V_BE - (1+Beta)*-I_B*R_E = 0;
21 I_B = (V_Th-V_BE)/( R_Th + (1+Beta_dc)*R_E); // in A
22 //I_C = I_CQ = Beta*I_B;
23 I_C = Beta_dc*I_B; // in A
24 I_CQ = I_C; // in A
25 I_CQ= I_CQ*10^3; // in mA
26 disp(I_CQ,"The value of I_CQ in mA is");
27 I_E = (1+Beta_dc)*I_B; // in mA
28 // V_CC - I_C*R_C - V_CE - I_E*R_E = 0;
29 V_CE = V_CC - (I_C*R_C) - (I_E*R_E); // in V
30 disp(V_CE,"The value of V_CE in V is");
31 R_L =R_C; // in ohm
32 Ai = -h_fe/(1+(h_oe*R_L));
33 disp(Ai,"The current gain is ");
34 Zi = h_ie + h_re*Ai*R_L; // in ohm
35 Zi= Zi*10^-3; // in k ohm
36 disp(Zi,"The input impedance in k ohm is");
37 Zi= Zi*10^3; // in ohm
38 A_V = Ai*(R_L/Zi);
39 disp(A_V,"The voltage gain is");
40 R_B= (R1*R2)/(R1+R2); // in ohm
41 Z_IS =(Zi*R_B)/(Zi+R_B); // in ohm
42 Z_IS= Z_IS*10^-3; // in kohm
43 disp(Z_IS,"The overall input impedance in k ohm is")
    ;
44 Z_IS= Z_IS*10^3; // in ohm
45 A_VS =A_V*(Z_IS/Z_IS);
46 disp(A_VS,"The overall voltage gain is");
47 A_IS =Ai * (R_B/(R_B+Zi));
48 disp(A_IS,"The overall current gain is");

```

---

# Chapter 5

## BJT At High Frequency

Scilab code Exa 5.1 Parameter of hybrid phi model

```
1 // Exa 5.1
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_C = 2; // in mA
8 I_C = I_C * 10^-3; // in A
9 V_CEQ = 20; // in V
10 h_fe = 100;
11 I_BQ = 20; // in A
12 I_BQ = I_BQ * 10^-6; // in A
13 Beta = 100;
14 f_T = 50; // in MHz
15 f_T = f_T * 10^6; // in Hz
16 Cob = 3; // in pF
17 Cob = Cob * 10^-12; // in F
18 h_ie = 1400; // in ohm
19 T = 300; // in K
20 // (i) Transconductance
21 g_m = 11600*(I_C/T); // in S
```



```

22 g_m=g_m*10^6;// in S
23 disp(g_m,"The transconductance in S is");
24 // (ii) Input resistance
25 g_m=g_m*10^-6;// in S
26 r_be = h_fe/g_m; //in ohm
27 disp(r_be,"The input resistance in ohm is");
28 // (iii) Capacitance
29 Cbc = Cob ;// in F
30 Cbe = g_m/(2*%pi*f_T)-Cbc;// in F
31 Cbe= round(Cbe*10^12);// in pF
32 disp(Cbe,"The capacitance in pF is");
33 // (iv) Base Spreading Resistance
34 r_bb = round(h_ie - r_be);// in ohm
35 disp(r_bb,"The base spreading resistance in ohm is")
    ;

```

---

#### Scilab code Exa 5.2 Parameter of hybrid phi model

```

1 // Exa 5.2
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_C = 10;// in mA
8 I_C =I_C * 10^-3;// in A
9 V_CE = 10;// in V
10 V_T= 26*10^-3;// in V
11 h_ie = 500;// in ohm
12 h_oe = 4*10^-5;// in S
13 h_fe = 100;
14 g_be = 1/260;
15 h_re = 10^-4;
16 f_T = 50;// in MHz
17 f_T = f_T * 10^6;// in Hz

```

```

18 T = 300; // in K
19 Cob =3; // in pF
20 Cob = Cob * 10^-12; // in F
21 // (i) Transconductance
22 g_m = I_C/V_T; // in A/V
23 g_m= round(g_m*10^3); // in mA/V
24 disp(g_m,"The Transconductance in mA/V is");
25 // (ii) Input resistance
26 g_m= g_m*10^-3; // in A/V
27 r_be = round(h_fe/g_m); // in ohm
28 disp(r_be,"The input resistance in ohm is");
29 // (iii) Base spreading resistance
30 r_bb = h_ie - r_be; // in ohm
31 disp(r_bb,"The base spreading resistance in ohm is")
    ;
32 // (iv) The feedback conductance
33 format('e',8)
34 g_bc = h_re*g_be;
35 disp(g_bc,"The feedback conductance is");
36 // (v) The output conductance
37 g_ce = h_oe - (1+h_fe)*g_bc
38 disp(g_ce,"The output conductance is : ")
39 // (vi) Capacitance
40 format('v',6)
41 Cbe= g_m/(2*pi*f_T); // in F
42 Cbe= Cbe*10^12; // in pF
43 disp(Cbe,"The value of C_b''e in pF is : ")
44 Cc= Cob; // in F
45 Cc= Cc*10^12
46 disp(Cc,"The value of Cc in pF is : ")

```

---

### Scilab code Exa 5.3 Emitter diffusion capacitance

```

1 // Exa 5.3
2 clc;

```

```

3 clear;
4 close;
5 format('v',5)
6 // Given data
7 W = 10^-6; // in m
8 I_E = 2; // in mA
9 I_E = I_E * 10^-3; // in A
10 V_T = 26; // in mV
11 V_T = V_T * 10^-3; // in V
12 D_B = 47*10^-4;
13 //g_m = abs(I_C)/V_T = abs(I_E)/V_T;
14 // The emitter diffusion capacitance , Cbe = g_m*((W
    ^2)/(2*D_B));
15 Cbe = I_E/V_T*W^2/(2*D_B); // F
16 Cbe= Cbe*10^12; // in pF
17 disp(Cbe,"The emitter diffusion capacitance in pF is
    ");
18 Cbe= Cbe*10^-12; // in F
19 g_m = abs(I_E)/V_T;
20 // The transition frequency
21 f_T = g_m/(2*pi*Cbe); // in Hz
22 f_T = f_T * 10^-6; // in MHz
23 disp(f_T,"The transition frequency in MHz is");
24
25 // Note: The answer in the book is not accurate.

```

---

**Scilab code Exa 5.4** Beta cutoff frequency and gain bandwidth product

```

1 // Exa 5.4
2 clc;
3 clear;
4 close;
5 // Given data
6 I_CQ = 5; // in mA
7 I_CQ = I_CQ * 10^-3; // in A

```

```

8 V_VEQ = 10; // in V
9 h_ie = 600; // in ohm
10 h_fe = 100;
11 C_C = 3; // in pF
12 C_C = C_C * 10^-12; // in F
13 Ai = 10; // Ai(f)
14 f = 10; // in MHz
15 // Ai = h_fe / ( sqrt( 1 + ((f/f_Beta)^2) ) );
16 f_Beta = f / ( sqrt( ((h_fe/Ai)^2) - 1 ) ); // in MHz
17 disp(f_Beta, "The Beta cut off frequency in MHz is");
18 f_T = h_fe * f_Beta; // in MHz
19 disp(f_T, "The gain bandwidth product in MHz is");
20 g_m = 0.1923;
21 Ce = g_m / (2 * %pi * f_T * 10^6); // in F
22 disp(Ce, "The value of Ce in F is");
23 Cbe = Ce; // in F
24 disp(Cbe * 10^12, "The value of C_b''e in pF is : ");
25 r_be = h_fe / g_m; // in ohm
26 disp(r_be, "The value of r_b''e in ohm is");
27 r_bb = h_ie - r_be; // in ohm
28 disp(r_bb, "The value of r_bb'' in ohm is");

```

---

### Scilab code Exa 5.5 Base width of Si pnp transistor

```

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

```

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

---

### Scilab code Exa 5.6 Ce and fT

```
1 // Exa 5.6
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 D_B = 47; // in cm^2/sec
8 I_C = 2; // in mA
9 I_C = I_C * 10^-3; // in A
10 V_CEQ = 15; // in V
11 W = 1; // in m
12 W = W * 10^-4; // in cm
13 V_T = 0.026; // in V
14 g_m = I_C / (abs(V_T)); // in ohm
15 Ce = (g_m * (W^2)) / (2 * D_B); // in F
16 Ce = Ce * 10^12; // in pF
17 disp(Ce, "The value of Ce in pF is");
18 f_T = g_m / (2 * %pi * Ce * 10^-12); // in Hz
19 f_T = f_T * 10^-6; // in MHz
20 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

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

---

Scilab code Exa 6.2 Transfer curve

```

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

```

---

### Scilab code Exa 6.3 Value of ID

```

1 // Exa 6.3
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 I_Don = 10; // in mA
8 I_Don = I_Don * 10^-3; // in A
9 V_GS = -12; // in V
10 V_GSt = -3; // in V
11 //From I_Don = Kn*((V_GS-V_GSt)^2);
12 Kn = I_Don/((V_GS-V_GSt)^2); // in A/V
13 Kn = Kn * 10^3; // in mA/V
14 V_GS = -6; // in V
15 I_D = Kn*((V_GS-V_GSt)^2); // in mA
16 disp(I_D, "The drain current in mA is");

```

---

### Scilab code Exa 6.4 Minimum value of VDS

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

---

### Scilab code Exa 6.5 VGS and gm

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



```

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

```

---

### Scilab code Exa 6.6 Drain current

```

1 // Exa 6.6
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Vt = 2; // in V
8 unCox = 20; // in A/V^2
9 Kdasn = unCox; // in A/V^2
10 W = 100; // in m
11 L = 10; // in m
12 V_GS = 3; // in V
13 V_DS = 0.5; // in V
14 V_GS = 3; // in V
15 Vt = 2; // in V
16 del_V = V_GS - Vt; // in V
17 i_D = Kdasn*10^-6*(W/L)*( del_V*V_DS - 1/2*(V_DS^2)
    ); // in A
18 i_D = i_D * 10^6; // in A
19 disp("Part (a) For V_D= 0.5 V, NOMS is operating in
    Triode region.")
20 disp(i_D,"The drain current in A is");
21 V_DS = 1; // in V
22 i_D = (1/2)* Kdasn*10^-6*(W/L)*( del_V^2 ); // in A
23 i_D = i_D * 10^6; // in A
24 disp("Part (b) For V_D= 1 V, NOMS is operating in
    saturation region.")

```

```

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

```

---

### Scilab code Exa 6.7 Drain to source resistance

```

1 // Exa 6.7
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Vt = 2; // in V
8 i_D = 1; // in mA
9 i_D = i_D * 10^-3; // in A
10 V_GS = 3; // in V
11 // From  $i_D = 1/2 * K_{nw} \text{ByL} * (V_{GS} - V_t)^2$ 
12  $K_{nw} \text{ByL} = 2 * i_D / (V_{GS} - V_t)^2$ ;
13 V_GS = 4; // in V
14 V_DS = 5; // in V
15  $i_D = 1/2 * K_{nw} \text{ByL} * (V_{GS} - V_t)^2$ ; // in A
16  $i_D = i_D * 10^3$ ; // in mA
17 disp(i_D,"The value of i_D in mA is : ")
18 r_DS = 1/(KnwByL*(VGS-Vt)); // in ohm
19 disp(r_DS,"The value of drain to source resistance
      in ohm is : ")

```

---

### Scilab code Exa 6.8 Minimum V<sub>DS</sub> required

```
1 // Exa 6.8
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Vt = -2; // in V
8 KnwByL = 2*10^-3; // in A/V^2
9 V_GS = 1; // in V
10 V_DS = V_GS - Vt; // in V
11 disp(V_DS, "The minimum value of V_DS in V is");
12 i_D = 1/2*KnwByL*V_DS^2; // in A
13 i_D = i_D * 10^3; // in mA
14 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

```
1 // Exa 7.1
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_DSS = 8; // in mA
8 I_DSS = I_DSS * 10^-3; // in A
9 V_P = -8; // in V
10 V_DD = 16; // in V
11 R_D = 2; // in k ohm
12 R_D = R_D * 10^3; // in ohm
13 V_GG = 2; // in V
14 R_G = 1; // in Mohm
15 R_G = R_G * 10^6; // in ohm
16 I_G = 0;
17 // To calculate V_GS
18 V_GS = -V_GG; // in V
19 disp(V_GS,"The value of V_GS in V is");
20 // To calculate the drain current
21 I_DQ = I_DSS * ((1 - (V_GS/V_P))^2); // in A
```

```

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

```

---

### Scilab code Exa 7.2 VGSQ IDQ and VDS

```

1 // Exa 7.2
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_DSS = 10; // in mA
8 I_DSS = I_DSS * 10^-3; // in A
9 V_P = -4; // in V
10 V_DD= 20; // in V
11 R_S = 1; // in k ohm
12 R_S = R_S * 10^3; // in ohm
13 R_D = 2.7; // in k ohm
14 R_D = R_D * 10^3; // in ohm
15 I_DQ= poly(0,'I_DQ');
16 V_GS= -I_DQ*R_S; // in V
17 I_DQ= I_DQ-I_DSS*(1-V_GS/V_P)^2; // in A
18 I_DQ= roots(I_DQ); // in A
19 I_DQ= I_DQ(2); // in A
20 I_DQ= I_DQ*10^3; // in mA
21 disp(I_DQ,"The value of I_DQ in mA is : ")
22 I_DQ= I_DQ*10^-3; // in A
23 V_GSQ= -I_DQ*R_S; // in V
24 disp(V_GSQ,"The value of V_GSQ in volts is : ")
25 V_DS= V_DD-I_DQ*(R_D+R_S); // in V
26 disp(V_DS,"The value of V_DS in volts is : ")

```

---

Scilab code Exa 7.3 W by L ratio

```
1 // Exa 7.3
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Kn = 20*10^-3; // in A/V^2
8 Vt = -1; // in V
9 V_DD = 5; // in V
10 I_D = 100; // in mA
11 I_D = I_D*10^-3; // in A
12 V_GS = 0; // in V
13 // I_D = (1/2)*Kdasn*(W/L)*((V_GS-Vt)^2);
14 WbyL = (I_D*2)/(Kn*((V_GS-Vt)^2));
15 disp(WbyL,"The (W/L) ratio is");
16 V_DS = V_GS-Vt; // in V
17 V_Dmin = V_DS; // in V
18 R_Dmax = (V_DD-V_Dmin)/I_D; // in ohm
19 disp("The range of R_D is : 0 to "+string(R_Dmax)+"
      ");
20
21 //Note: The unit of R_Dmax in the book is wrong.
```

---

Scilab code Exa 7.5 IDQ and VDSQ

```
1 // Exa 7.5
2 clc;
3 clear;
4 close;
```

```

5 format('e',8)
6 // Given data
7 I_Don = 6; // in mA
8 I_Don = I_Don * 10^-3; // in A
9 V_GSon = 8; // in V
10 Vt = 3; // in V
11 V_DD = 12; // in V
12 R_D= 2*10^3; // in ohm
13 // (i) To obtain the value of K
14 K = I_Don/( (V_GSon-Vt)^2 ); // in A/V^2
15 disp(K,"The value of K in A/V^2 is");
16 format('v',7)
17 // To obtain the value of I_DQ
18 I_D= poly(0,'I_D');
19 V_GS= V_DD-I_D*R_D; // in V
20 I_D= I_D-K*(V_GS-Vt)^2; // in A
21 I_D= roots(I_D); // inA
22 I_D= I_D(2); // in A
23 I_D= I_D*10^3; // in mA
24 disp(I_D,"The value of I_D in mA is : ")
25 I_D= I_D*10^-3; // in A
26 // (iii) To obtain the value of V_DSQ
27 V_DSQ= V_DD-I_D*R_D; // in V
28 disp(V_DSQ,"The value of V_DSQ in volts is : ")

```

---

### Scilab code Exa 7.6 IDQ VGSQ and VDS

```

1 // Exa 7.6
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_DD = 40; // in V
8 Vt = 5; // in V

```

```

 9 R_D= 820; // in ohm
10 I_Don = 3; // in mA
11 I_Don = I_Don * 10^-3; // in A
12 V_GSon = 10; // in V
13 K = I_Don/( (V_GSon-Vt)^2 ); // in A/V^2
14 R2 = 18; // in Mohm
15 R2 = R2 * 10^6; // in ohm
16 R1 = 22; // in Mohm
17 R1 = R1 * 10^6; // in ohm
18 R_S = 3*10^3; // in ohm
19 I_D= poly(0, 'I_D');
20 V_G= R2/(R1+R2)*V_DD;
21 V_GS= V_G-I_D*R_D; // in V
22 I_D= I_D-K*(V_GS-Vt)^2; // in A
23 I_D= roots(I_D); // inA
24 I_D= I_D(2); // in A
25 I_D= I_D*10^3; // in mA
26 disp(I_D,"The value of I_D in mA is : ")
27 I_D= I_D*10^-3; // in A
28 V_GSQ= V_G-I_D*R_D; // in V
29 disp(V_GSQ,"The value of V_GSQ in volts is : ")
30 V_DSQ= V_DD-I_D*(R_D+R_S); // in V
31 disp(V_DSQ,"The value of V_DSQ in volts is : ")

```

---

### Scilab code Exa 7.7 Value of RS

```

1 // Exa 7.7
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 V_D = 12; // in V
8 V_GSQ = -2; // in V
9 V_DD = 16; // in V

```



```

10 R1 = 47; // in k ohm
11 R1 = R1 * 10^3; // in ohm
12 R2 = 91; // in k ohm
13 R2 = R2 * 10^3; // in ohm
14 V_G = (R1*V_DD)/(R1+R2); // in V
15 R_D = 1.8; // in k ohm
16 R_D = R_D * 10^3; // in ohm
17 I_D = (V_DD-V_D)/R_D; // in A
18 I_D = I_D * 10^3; // in mA
19 // V_GS = V_G - (I_D*R_S);
20 R_S = (V_G-V_GSQ)/(I_D*10^-3); // in ohm
21 R_S = R_S * 10^-3; // in k ohm
22 disp(R_S,"The value of R_S in k ohm is");

```

---

#### Scilab code Exa 7.8 VG and VSS

```

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

```

```

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

```

---

### Scilab code Exa 7.9 IDQ VGSQ VD VS VDS and VDG

```

1 // Exa 7.9
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_DSS = 8; // in mA
8 I_DSS = I_DSS * 10^-3; // in A
9 V_P = -4; // in V
10 V_DD = 16; // in V
11 R2 = 270; // in k ohm
12 R2 = R2 * 10^3; // in ohm
13 R1 = 2.1; // in Mohm
14 R1 = R1 * 10^6; // in ohm
15 R_S = 1.5; // in k ohm
16 R_S = R_S * 10^3; // in ohm
17 R_D = 2.4; // in k ohm
18 R_D = R_D * 10^3; // in ohm
19 V_G = (R2*V_DD)/(R1+R2); // in V
20 //V_GS = V_G - (I_D*R_S);
21 V_GS = V_G; // in V (at I_D=0 A)
22 I_D = V_G/R_S; // in A (at V_GS=0 V)
23 I_D = I_D * 10^3; // in mA
24 I_DQ = 2.4; // in mA
25 V_GSQ = -1.8; // in V
26 V_D = V_DD - (I_DQ*10^-3*R_D); // in V

```

```

27 V_S = I_DQ*10^-3*R_S; // in V
28 V_DS = V_DD - (I_DQ*10^-3*(R_S+R_D)); // in V
29 V_DG = V_D-V_G; // in V
30 disp(I_DQ,"The value of I_DQ in mA is");
31 disp(V_GSQ,"The value of V_GSQ in V is");
32 disp(V_D,"The value of V_D in V is");
33 disp(V_S,"The value of V_S in V is");
34 disp(V_DS,"The value of V_DS in V is");
35 disp(V_DG,"The value of V_DG in V is");

```

---

#### Scilab code Exa 7.10 Value of Vo

```

1 // Exa 7.10
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 I_DSS = 5.6; // in mA
8 I_DSS = I_DSS * 10^-3; // in A
9 V_P = 4; // in V
10 Vi = 0; // in V
11 V_CC = 12; // in V
12 R_D = 10; // in k ohm
13 R_D = R_D * 10^3; // in ohm
14 R_S = 10*10^3; // in ohm
15 I_D = poly(0, 'I_D');
16 V_GS = I_D*R_D - V_CC; // in V
17 I_D = I_D - I_DSS*(1 - V_GS/V_P)^2; // in A
18 I_D = roots(I_D); // in A
19 I_D = I_D(2); // in A
20 V_GS = I_D*R_D - V_CC; // in V
21 Vo = V_CC - I_D*R_S; // in V
22 I_D = I_D*10^3; // in mA
23 disp(I_D,"The value of I_D in mA is : ")

```

```

24 disp(Vo,"The value of Vo in volts is : ")
25
26 // 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

```

1 // Exa 7.11
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_DSS = 5.6; // in mA
8 I_DSS = I_DSS * 10^-3; // in A
9 V_P = -4; // in V
10 R_S = 10; // in k ohm
11 R_S = R_S * 10^3; // in ohm
12 R_D = 4.7; // in k ohm
13 R_D = R_D * 10^3; // in ohm
14 V_CC = 12; // in V
15 V_DD = 22; // in V
16 // (a) Calculation to find the value of Vo at Vi = 0
    V
17 Vi = 0; // in V
18 V_GS= poly(0, 'V_GS');
19 I_D= (V_CC-V_GS)/R_S; // in A
20 V_GS= I_D-I_DSS*(1-V_GS/V_P)^2; // in A
21 V_GS= roots(V_GS)
22 V_GS= V_GS(2); // in V
23 I_D= (V_CC-V_GS)/R_S; // in A
24 Vo= Vi-V_GS; // in V
25 disp(Vo,"For Vi=0 V, The value of Vo in volts is ; "
    )

```

```

26
27 // (a) Calculation to find the value of Vo at Vi =
    10 V
28 Vi = 10; // in V
29 V_GS= poly(0, 'V_GS');
30 I_D= (V_DD-V_GS)/R_S; // in A
31 V_GS= I_D-I_DSS*(1-V_GS/V_P)^2; // in A
32 V_GS= roots(V_GS)
33 V_GS= V_GS(2); // in V
34 I_D= (V_CC-V_GS)/R_S; // in A
35 Vo= Vi-V_GS; // in V
36 disp(Vo,"For Vi=10 V, The value of Vo in volts is ;
    ")
37
38 // (a) Calculation to find the value of Vi at Vo =
    10 V
39 Vo= 0; // in V
40 I_D= V_CC/R_S; // in A
41 V_GS= V_P*(1-sqrt(I_D/I_DSS)); // in V
42 Vi= V_GS+Vo; // in V
43 disp(Vi,"For Vo=0 V, The value of Vi in volts is ; "
    )

```

---

### Scilab code Exa 7.12 Quiescent value of IDS VDS and VGS

```

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

```

```

11 R_S = 1.2; // in k ohm
12 V_DD= 18; // in V
13 I_D= poly(0, 'I_D');
14 V_GS= I_D*R_S; // in V
15 I_D= I_D-I_DSS*(1-V_GS/V_P)^2;
16 I_D= roots(I_D);
17 I_D= I_D(2); // in mA
18 V_GS= I_D*R_S; // in V
19 V_DS= V_DD-I_D*(R_S+R_D); // in V
20 disp(I_D,"The value of I_D in mA is : ")
21 disp(V_GS,"The value of V_GS in volts is : ");
22 disp(V_DS,"The value of V_DS in volts is : ")

```

---

### Scilab code Exa 7.13 Value of rDS

```

1 // Exa 7.13
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Vt = -1; // in V
8 KnWbyL = 1*10^-3; // in A/V^2
9 V_DS = 0.1; // in V
10 V_GS = 0; // in V
11 I_D = ( (V_GS-Vt)*V_DS-1/2*KnWbyL ); // in mA
12 V = 9.9; // in V
13 R_D = V/I_D; // in k ohm
14 R_D= ceil(R_D); // in k ohm
15 disp(R_D,"The value of R_D in k ohm is : ")
16 V_DS = 0.1; // in V
17 r_DS = V_DS/(I_D*10^-3); // in ohm
18 r_DS= round(r_DS*10^-3); // in k ohm
19 disp(r_DS,"Effective resistance between source and
    drain in k ohm is");

```

---

**Scilab code Exa 7.14** Value of RS

```
1 // Exa 7.14
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_DD = 5; // in V
8 V_SS = -5; // in V
9 Vt = 2; // in V
10 I_D = 0.4; // in mA
11 I_D = I_D * 10^-3; // in A
12 miu_nCox=20*10^-6; // in A/V^2
13 W = 400; // in m
14 L = 10; // in m
15 V_GS= poly(0, 'V_GS');
16 V_GS=I_D-(1/2)*miu_nCox*(W/L)*((V_GS-Vt)^2);
17 V_GS= roots(V_GS)
18 V_GS= V_GS(1); // in V
19 V_S= -V_GS; // in V
20 R_S = (V_S-V_SS)/I_D; // in ohm
21 R_S = R_S * 10^-3; // in k ohm
22 disp(R_S,"The value of R_S in k ohm is");
23 V_D = 1; // in V
24 R_D = (V_DD-V_D)/I_D; // in ohm
25 R_D = R_D * 10^-3; // in k ohm
26 disp(R_D,"The value of R_D in k ohm is");
```

---

**Scilab code Exa 7.15** Designing of a circuit

```

1 // Exa 7.15
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_D= 0.4*10^-3; // in A
8 Vt = 2; // in V
9 miu_nCox = 20*10^-6; // in A/V^2
10 L = 10; // in m
11 W = 100; // in m
12 V_GS= poly(0, 'V_GS');
13 V_GS= I_D - (1/2)*miu_nCox*(W/L)*( (V_GS-Vt)^2 );
14 V_GS= roots(V_GS)
15 V_GS= V_GS(1); // in V
16 V_D = V_GS; // in V
17 disp(V_D,"The DC voltage in V is");
18 V_DD = 10; // in v
19 R = (V_DD - V_D)/I_D; // in ohm
20 R = R * 10^-3; // in k ohm
21 disp(R,"The value R in k ohm is");

```

---

#### Scilab code Exa 7.16 Designing of a circuit

```

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

```



```

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

```

---

### Scilab code Exa 7.17 Designing of a circuit

```

1 // Exa 7.17
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_D = 0.5; // in mA
8 V_D = 3; // in V
9 Vt = -1; // in v
10 KnWbyL = 1; // in mA/V^2
11 V_DD = 5; // in V
12 V_D = 3; // in v
13 V_GS= poly(0, 'V_GS');
14 V_GS= I_D -1/2*KnWbyL*(V_GS-Vt)^2; // in V
15 V_GS= roots(V_GS) // in V
16 V_GS= V_GS(1); // in V
17 R_G1 = 2; // in Mohm
18 R_G1 = R_G1 * 10^6; // in ohm
19 R_G2 = 3; // in Mohm
20 R_G2 = R_G2 * 10^6; // in ohm
21 V_GS = -2; // in V
22 R_D = V_D/I_D; // in k ohm
23 V_Dmax = V_D+abs(Vt); // in V
24 R_D = V_Dmax/I_D; // in k ohm
25 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

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

```

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

```

---

### Scilab code Exa 8.2 Zi Zo and Av

```

1 // Exa 8.2
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 I_DSS = 6; // in mA
8 I_DSS = I_DSS * 10^-3; // in A
9 V_P = -6; // in V
10 Y_DS = 40; // in S
11 R_D = 3.3; // in k ohm
12 R_D = R_D * 10^3; // in ohm
13 R_S = 1.1; // in k ohm
14 R_S = R_S * 10^3; // in ohm
15 R_G = 10; // in Mohm
16 R_G = R_G * 10^6; // in ohm
17 g_mo = (2*I_DSS)/(abs(V_P)); // in S
18 I_D = poly(0, 'I_D');
19 V_GS = -I_D*R_S; // in V
20 I_D = I_D - I_DSS*((1 - (V_GS/V_P))^2);
21 I_D = roots(I_D)
22 I_D = I_D(2); // in A
23 V_GSQ = -I_D*R_S; // in V
24 g_m = g_mo*(1 - (V_GSQ/V_P)); // in S
25 Zi = R_G; // in ohm
26 Zi = Zi*10^-6; // in M ohm

```

```

27 disp(Zi,"The value of Zi in M ohm is");
28 r_d = 40;// in k ohm assumed
29 r_d = r_d * 10^3;// in ohm
30 Zo = (r_d*R_D)/(r_d+R_D);// in ohm
31 Zo=R_D;// in ohm (as r_d > 10 *R_D)
32 Zo= Zo*10^-3;// in k ohm
33 disp(Zo,"The value of Zo in k ohm is");
34 Av = abs(-g_m*R_D);
35 disp(Av,"The value of Av is");

```

---

### Scilab code Exa 8.3 Zi Zo Av

```

1 // Exa 8.3
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_DD = 20;// inV
8 I_DSS = 8;// in mA
9 I_DSS = I_DSS * 10^-3;// in mA
10 V_P = -6;// in V
11 R_G = 1;// in Mohm
12 R_G = R_G * 10^6;// in ohm
13 R_S = 1;// in k ohm
14 R_S = R_S * 10^3;// in ohm
15 r_d = 50;// in k ohm
16 r_d = r_d * 10^3;// in ohm
17 V_GS = -2.6;// in V
18 I_D = 2.6;// in mA
19 I_D = I_D * 10^-3;// in A
20 g_mo = (2*I_DSS)/(abs(V_P));// in S
21 g_m = g_mo*(1 - (V_GS/V_P));// in S
22 Zi = R_G;// in ohm
23 Zi= Zi*10^-6;// in M ohm

```

```

24 disp(Zi,"The value of Zi in M ohm is");
25 Zo = R_S*1/g_m/(R_S+1/g_m);
26 disp(Zo,"The value of Zo is");
27 Av = g_m*R_S/(1 + (g_m*R_S));
28 disp(Av,"The value of Av is");

```

---

#### Scilab code Exa 8.4 gm Zi Zo And Av

```

1 // Exa 8.4
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_GSQ = -2.6; // in V
8 I_DQ = 3.8*10^-3; // in A
9 V_DD = 12; // in V
10 R_D = 1.5*10^3; // in ohm
11 R_S = 680; // in ohm
12 I_DSS = 12*10^-3; // in A
13 r_d = 20*10^3; // in ohm
14 V_P = -6; // in V
15 // (a) Transconductance
16 g_mo = (2*I_DSS)/(abs(V_P)); // in S
17 g_m = g_mo*(1-(V_GSQ/V_P)); // in mS
18 g_m= g_m*10^3; // in mS
19 disp(g_m,"The value of g_m in mS is");
20 // (b) Input impedance
21 g_m= g_m*10^-3; // in S
22 Zi=R_S*((r_d+R_D)/(1+g_m*r_d))/(R_S+((r_d+R_D)/(1+
    g_m*r_d)))
23 disp(Zi,"The value of Zi in ohm is");
24 // (c) Output impedance
25 Zo = (R_D*r_d)/(R_D+r_d); // in ohm
26 Zo= Zo*10^-3; // in k ohm

```

```

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

```

---

**Scilab code Exa 8.6** Input impedance output impedance and voltage gain

```

1 // Exa 8.6
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_DD = 10; // in V
8 R_D = 5.1; // in k ohm
9 R_D = R_D * 10^3; // in ohm
10 g_m = 2*10^-3; // in S
11 r_d = 50; // in k ohm
12 r_d = r_d * 10^3; // in ohm
13 Vi = 0; // in V
14 R_G = 1; // in Mohm
15 R_G = R_G * 10^6; // in ohm
16 // (i) Input impedance
17 Zi = R_G; // in ohm
18 Zi = Zi*10^-6; // in M ohm
19 disp(Zi,"The input impedance in Mohm is");
20 // (ii) Output impedance
21 Zo = (r_d*R_D)/(r_d+R_D); // in ohm
22 disp(Zo,"The output impedance in ohm is");
23 // (iii) Voltage gain
24 Av = -g_m*Zo;
25 disp(Av,"The voltage gain is");

```

---

### Scilab code Exa 8.7 gm rd Zi Zo and Av

```
1 // Exa 8.7
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 V_GSQ = -2; // in V
8 I_DSS = 8; // in mA
9 I_DSS = I_DSS * 10^-3; // in A
10 V_P = -8; // in V
11 YoS = 20; // in S
12 YoS = YoS * 10^-6; // in S
13 R_D = 5.1; // in k ohm
14 R_D = R_D * 10^3; // in ohm
15 R_G = 1; // in Mohm
16 R_G = R_G * 10^6; // in ohm
17 g_mo = (2*I_DSS)/(abs(V_P)); // in S
18 g_m = g_mo * (1 - (V_GSQ/V_P)); // in S
19 g_m = g_m * 10^3; // in mS
20 disp(g_m, "The value of g_m in mS is");
21 g_m = g_m * 10^-3; // in S
22 r_d = 1/YoS; // in ohm
23 r_d = r_d * 10^-3; // in k ohm
24 disp(r_d, "The value of r_d in k ohm is");
25 r_d = r_d * 10^3; // in ohm
26 Zi = R_G; // in ohm
27 Zi = Zi * 10^-6; // in M ohm
28 disp(Zi, "The value of Zi in M ohm is");
29 V_GS = 0; // in V
30 Zo = (r_d * R_D) / (r_d + R_D); // in ohm
31 disp(Zo, "The value of Zo in ohm is");
32 Av = -g_m * Zo;
```



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

---

**Scilab code Exa 8.8** Input impedance output impedance and voltage gain

```
1 // Exa 8.8
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 gm= 6000*10^-6; // in S
8 R1 = 2; // in M ohm
9 R1 = R1 * 10^6; // in ohm
10 R2 = 500; // in k ohm
11 R2 = R2 * 10^3; // in ohm
12 R_S= 4*10^3; // in ohm
13 R_L= 33*10^3; // in ohm
14 r_d= 50*10^3; // in ohm
15 Zi = (R1*R2)/(R1+R2); // in ohm
16 Zi= Zi*10^-3; // in k ohm
17 disp(Zi,"The input impedance in k ohm is");
18 Zo = (1/gm*R_S)/(1/gm+R_S); // in ohm
19 disp(Zo,"The output impedance in ohm is");
20 // Let Req= r_d || R_S || R_L; // in ohm
21 Req= r_d*R_S*R_L/(r_d*R_S+R_S*R_L+R_L*r_d); // in ohm
22 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)))
23 disp(Av,"The voltage gain is : ")
```

---

**Scilab code Exa 8.9** Input and output impedance and voltage gain

```
1 // Exa 8.9
2 clc;
```

```

3 clear;
4 close;
5 format('v',7)
6 // Given data
7 R1 = 3.3* 10^-3; // in ohm
8 R2 = 1.2* 10^6; // in ohm
9 R_D = 3.9* 10^3; // in ohm
10 R_S = 3.9* 10^3; // in ohm
11 R_L = 82* 10^3; // in ohm
12 g_m = 6000* 10^-6; // in S
13 r_d = 70* 10^3; // in ohm
14 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
15 disp(Zi,"The input impedance in ohm is");
16 Zo = (r_d*R_D)/(r_d+R_D); // in ohm
17 disp(Zo,"The output impedance in ohm is");
18 R = (R_D*R_L)/(R_D+R_L); // in ohm
19 Av = (R*(1+(g_m*r_d)))/( r_d+R );
20 disp(Av,"The voltage gain is");

```

---

# Chapter 9

## Frequency Response

Scilab code Exa 9.2 Overall voltage gain

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

```

22 omega_T= 2*%pi*f_r;// in radian
23 Rin= 38*10^3;// in ohm
24 R_S= 4*10^3;// in ohm
25 R_pie1= 80;//in ohm
26 Ve1ByVb1= 0.98;// in V/V
27 I_E1= V_E1/R_E1;// in A
28 I_E2= V_E2/R_E2;// in A
29 // We know, C_pie + C_miu= gm/omega_T or
30 C_Pie= gm/omega_T-C_miu;// in F
31 Vb1ByVs= Rin/(Rin+R_S);// in V/V
32 //Ve1ByVb1= R_E1*r_pie2/(R_E1*r_pie2)/(R_E1*r_pie2/(
    R_E1*r_pie2)+r_e1);
33 VeByVb1= R_E1*r_pie/(R_E1*r_pie)/(R_E1*r_pie/(R_E1*
    r_pie)+R_E1);// in V/V
34 // The gain of the common-emitter amplifier Q2
35 VoByVe1= -gm*R_C*R_L/(R_C+R_L);// in V/V
36 // The overall gain
37 VoByVs= Vb1ByVs*Ve1ByVb1*VoByVe1;// in V/V
38 RdeshS= R1*R2*R_S/(R1*R2+R2*R_S+R_S*R1);
39 RdeshE1= R_E1*r_pie/(R_E1+r_pie);// in k ohm
40 R_miu1= R_S*Rin/(R_S+Rin)*10^-3;// in k ohm
41 R_pi1= (r_pie*(RdeshS+RdeshE1)/(1+gm*RdeshE1))/r_pie
    +(RdeshS+RdeshE1)/(1+gm*RdeshE1);
42 R_T=round( RdeshE1*(r_pie+RdeshS)/(bita+1)/(RdeshE1
    +(r_pie+RdeshS)/(bita+1)));// in ohm
43 disp(VoByVs,"The overall voltage gain in V/V is : ")
44 disp(R_miu1,"The value of R_miu1 in ohm is : ")
45 disp(R_pie1,"The value of R_pie1 in ohm is : ")
46 disp(R_T,"The value of R_T in ohm is : ")

```

---

### Scilab code Exa 9.3 Value of k

```

1 // Exa 9.3
2 clc;
3 clear;

```

```

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

```

---

#### Scilab code Exa 9.4 Value of Cs and gm

```

1 // Exa 9.4
2 clc;
3 clear;
4 close;
5 // Given data
6 Rs = 1; // in k ohm
7 Rs = Rs * 10^3; // in ohm
8 omega_z = 10; // in rad/sec
9 omega_p = 100; // in rad/sec
10 //omega_z = 1/(Rs*Cs);
11 Cs = 1/(Rs*omega_z); // in F
12 disp(Cs*10^6,"The value of Cs in F is");
13 //omega_p = (g_m + (1/Rs))/Cs;
14 g_m = omega_p*Cs-1/Rs; // in A/V
15 g_m= g_m*10^3; // in mA/V
16 disp(g_m,"The value of g_m in mA/V is")
17
18 // 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

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

---

Scilab code Exa 10.2 Input impedance

```
1 // Exa 10.2
2 clc;
```

```

3 clear;
4 close;
5 format('v',6)
6 // Given data
7 A = 1000;
8 Zi = 1; // in k ohm
9 Zi = Zi * 10^3; // in ohm
10 Beta = 0.01;
11 Zdash_i = (1+A*Beta)*Zi; // in ohm
12 Zdash_i = Zdash_i * 10^-3; // in k ohm
13 disp(Zdash_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

```

1 // Exa 10.3
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 A = 60; // in dB
8 A = 10^(A/20);
9 Zo = 12000; // in ohm
10 Zdash_o = 600; // in ohm
11 // Zdash_o = Zo/(1+(A*Beta));
12 Beta = (((Zo/Zdash_o)-1)/A)*100; // in %
13 disp(Beta, "The feedback factor in % is");
14 Beta = Beta/100;
15 DAbyA = 0.1;
16 dAfbyAf = (1/(1 + (A*Beta)))*DAbyA*100; // in %
17 disp(dAfbyAf, "The percentage change in the overall
    gain in % is");

```

---

#### Scilab code Exa 10.4 Gain of a negative feedback amplifier

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

---

#### Scilab code Exa 10.5 Value of A and beta

```
1 // Exa 10.5
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Af = 100;
8 Vi = 0.6; // in V
9 Vdesh_o = Af*Vi; // in V
10 Vi = 50; // in mV
11 Vi = Vi * 10^-3; // in V
12 A = Vdesh_o/Vi;
13 disp(A,"The value of A is");
14 // Af = A/( 1 +(A*Beta) );
15 Beta = (((A/Af)-1)/A)*100; // in %
16 Beta= (A-Af)/(Af*A/100);
```



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

---

### Scilab code Exa 10.6 Voltage gain

```
1 // Exa 10.6
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 A = 1000;
8 Af = A - (0.40*1000);
9 //Af = A/( 1+(A*Beta) );
10 Beta = ((A/Af)-1)/A;
11 A_desh = 800;
12 A_desh_f= A_desh/( 1+(A_desh*Beta) );
13 disp(A_desh_f,"The voltage gain with feedback is");
14 // percentage reduction without feedback
15 P = ((A-A_desh)/A)*100; //in %
16 // percentage reduction with feedback
17 P1 = ((Af-A_desh_f)/Af)*100; // in %
18 disp(P1,"The percentage reduction with feedback in %
    is");
```

---

### Scilab code Exa 10.7 Small change in gain

```
1 // Exa 10.7
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
```

```

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

```

---

#### Scilab code Exa 10.8 New input voltage

```

1 // Exa 10.8
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 A = 100;
8 Beta = 1/25;
9 Af = A/(1 + (A*Beta));
10 disp(Af,"The gain with feedback is");
11 disp((A*Beta),"The feed back factor is");
12 Vi = 50; // in mV
13 Vo = Af*Vi*10^-3; // in V
14 disp(Vo,"The output voltage in V is");
15 V_feedback= (Beta*Vo); // feedback voltage in V
16 disp(V_feedback,"The feed back voltage in V is");
17 Vi = Vi*(1+(A*Beta)); // in mV
18 disp(Vi,"The new input voltage in mV is");

```

---

#### Scilab code Exa 10.9 Small change in gain

```

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

```

---

#### Scilab code Exa 10.10 New value of input voltage

```

1 // Exa 10.10
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 A = 200;
8 Beta = 5/100;
9 Af =A/(1 + (A*Beta));
10 disp(Af,"The gain of the amplifier with negative
    feedback is : ")
11 Dn = 10; // in %
12 Ddesh_n = Dn/(1+(A*Beta)); // in %
13 disp(Ddesh_n,"The distortion with negative feedback
    in % is : ");
14
15 // 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

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

---

#### Scilab code Exa 10.12 Upper and lower cutoff frequency

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

```

15 f_Hf = f_Hf * 10^-3; // in kHz
16 disp(f_Hf,"The upper cutoff frequency with negative
    feedback in kHz is");
17 f_Lf = f_L/(1+(Ao*Beta)); // in Hz
18 disp(f_Lf,"The lower cutoff frequency with negative
    feedback in Hz is");
19
20 // 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

```

1 // Exa 10.13
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 R1 = 20; // in k ohm
8 R1 = R1 * 10^3; // in ohm
9 R2 = 20; // in k ohm
10 R2 = R2 * 10^3; // in ohm
11 h_ie = 2; // in k ohm
12 h_ie = h_ie * 10^3; // in ohm
13 R_L = 1; // in k ohm
14 R_L = R_L * 10^3; // in ohm
15 R_E = 100; // in ohm
16 h_fe = 80;
17 A = (-h_fe*R_L)/h_ie;
18 disp(A,"The value of A is");
19 Beta = R_E/R_L;
20 disp(Beta,"The value of Beta is");
21 Rif = h_ie + (1+h_fe)*R_E; // in ohm
22 Rif = Rif * 10^-3; // in k ohm

```

```

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

```

---

#### Scilab code Exa 10.14 Feedback gain and new band width

```

1 // Exa 10.14
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 A = 200;
8 BW = 10; // in kHz
9 Beta = 10/100;
10 Af =A/(1+(A*Beta));
11 disp(Af,"The gain with negative feedback is");
12 BWf = BW*(1+(A*Beta)); // in kHz
13 disp(BWf,"The bandwidth with negative feedback in
    kHz is");

```

---

# Chapter 11

## Oscillators

Scilab code Exa 11.1 Oscillation frequency

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

---

Scilab code Exa 11.2 A RC phase shift oscillators

```
1 // Exa 11.2
```

```

2  clc;
3  clear;
4  close;
5  format('v',5)
6  // Given data
7  Av= 29;
8  I_Bmax = 0.5*10^-6; // in A
9  I1= 100*I_Bmax
10 Vo_sat = 0.9; // in V
11 V_CC = 9.0; // in V
12 V_EE= -9; // in V
13 V1= 9/Av; // in V
14 R1= V1/I1; // in ohm
15 R1= 5.6*10^3; // in ohm (standard value)
16 Rf= Av*R1; // in ohm
17 Rf= 180*10^3; // in ohm
18 R3= Rf; // in ohm
19 R=R1; // in ohm
20 C= 1/(2*%pi*R*sqrt(6)*1000); // in F
21 R= R*10^-3; // in k ohm
22 Rf= Rf*10^-3; // in k ohm
23 C= C*10^6; // in F
24 disp(R,"The value of R and R1 in k ohm is : ")
25 disp(Rf,"The value of Rf and R3 in k ohm is : ")
26 disp(C,"The value of C in F is : ")
27 disp(V_CC,"The value of V_CC in volts is : ")
28 disp(V_EE,"The value of V_EE in volts is : ")

```

---

### Scilab code Exa 11.3 Value of R and C

```

1  // Exa 11.3
2  clc;
3  clear;
4  close;
5  format('v',5)

```



```

6 // Given data
7 f = 5; // in kHz
8 f = f * 10^3; // in Hz
9 miu = 55;
10 r_d = 5.5; // in k ohm
11 r_d = r_d * 10^3; // in ohm
12 A= 29;
13 // abs(A) = g_m*R_L = (g_m*r_d*R_D)/(r_d+R_D) = (miu
    *R_D)/(r_d+R_D);
14 // miu*R_D = abs(A)*(r_d+R_D);
15 R_D = (abs(A)*r_d)/(miu-A); // in ohm
16 R_D= R_D*10^-3; // in k ohm
17 disp(R_D,"Minimum value of R_D in k ohm is");
18 R_D= R_D*10^3; // in ohm
19 Alpha = sqrt(6);
20 // Alpha = 1/(2*%pi*f*R_C);
21 RC = 1/(2*%pi*f*Alpha); // in sec
22 RC= round(RC*10^6); // in sec
23 disp(RC,"The value of RC in sec is");
24 RC= RC*10^-6; // in sec
25 R_L = (r_d*R_D)/(r_d+R_D); // in ohm
26 R = 30*10^3; // in ohm
27 C = RC/R; // in F
28 C = C * 10^12; // in pF
29 R= R*10^-3; // in k ohm
30 disp(R,"The value of R in k ohm is");
31 disp(C,"The value of C in pF is");

```

---

#### Scilab code Exa 11.4 BJT RC phase shift oscillator

```

1 // Exa 11.4
2 clc;
3 clear;
4 close;
5 format('v',5)

```

```

6 // Given data
7 f= 100*103; // in Hz
8 h_fe = 100;
9 h_ie = 1* 103; // in ohm
10 V_CE = 5; // in V
11 V_BE= 0.7; // in V
12 I_C = 1* 10-3; // in A
13 I_B= 0.01*10-3; // in A
14 V_CC = 20; // in V
15 R_E = 1* 103; // in ohm
16 I_E = I_C; // in A
17 R_C = (V_CC-V_CE-(I_E*R_E))/I_C; // in ohm
18 R = 10*103; // in k ohm
19 k = R_C/R;
20 h_fe=(23+29/k+4*k);
21 // Formula f= 1/(2*%pi*R*C*sqrt(6+4*k))
22 C= 1/(2*%pi*R*f*sqrt(6+4*k)); // in F
23 // R= R3+R1 || R2+h_ie = R3+h_ie (approx)
24 R3= R-h_ie; // in ohm
25 V_B= V_BE+I_E*R_E; // in V
26 R2= 10*103; // in ohm (assumed value)
27 I_R2= V_B/R2; // current in R2 in A
28 V_R1= V_CC-V_B; // drop across R1 in V
29 I_R1= I_R2+I_B; // in A
30 R1= V_R1/I_R1; // in ohm
31 R_E= R_E*10-3; // in k ohm
32 R_C= R_C*10-3; // in k ohm
33 R= R*10-3; // in k ohm
34 R1= R1*10-3; // in k ohm
35 R2= R2*10-3; // in k ohm
36 R3= R3*10-3; // in k ohm
37 C=C*1012; // in pF
38 disp(R_E,"The value of R_E in k ohm is");
39 disp(R_C,"The value of R_C in k ohm is");
40 disp(R,"The value of R in k ohm is");
41 disp("The value of h_fe >= "+string(h_fe));
42 disp(C,"The value of C in pF is : ")
43 disp(R3,"The value of R3 in k ohm is : ")

```

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

---

### Scilab code Exa 11.5 Transistor gain

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

---

### Scilab code Exa 11.7 Component values of wein bridge

```
1 // Exa 11.7
2 clc;
3 clear;
```

```

4 close;
5 format('v',6)
6 // Given data
7 f_max = 10; // in kHz
8 f_max = f_max * 10^3; // in Hz
9 R = 100*10^3; // in k ohm
10 C = 1/(2*pi*f_max*R); // in F
11 C= C*10^9; // in nF
12 disp(C,"For maximum frequency , the value of C in nF
    is");
13 f_min = 100; // in Hz
14 C = 1/(2*pi*f_min*R); // in F
15 C= C*10^9; // in nF
16 disp(C,"For minimum frequency , the value of C in nF
    is");

```

---

#### Scilab code Exa 11.8 Oscillation frequency

```

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

```

---

### Scilab code Exa 11.9 Q of the crystal

```
1 // Exa 11.9
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // Given data
7 L = 0.33;
8 Cs = 0.65; // in pF
9 Cs = Cs * 10^-12; // in F
10 C_M = 1; // in pF
11 C_M = C_M * 10^-12; // in F
12 R = 5.5; // in k ohm
13 R = R * 10^3; // in ohm
14 f_s = 1/(2*pi*sqrt(L*Cs)); // in Hz
15 f_s = f_s * 10^-6; // in MHz
16 disp(f_s, "The series resonant frequency in MHz is");
17 f_s = f_s * 10^6; // in Hz
18 Ceq = (Cs*C_M)/(Cs+C_M); // in F
19 f_P = 1/(2*pi*sqrt(L*Ceq)); // in Hz
20 f_P = f_P * 10^-6; // in MHz
21 disp(f_P, "The parallel resonant frequency in MHz is
    : ");
22 f_P = f_P * 10^6; // in Hz
23 P = ((f_P - f_s) / f_s) * 100; // in %
24 disp("The parallel resonant frequency exceeds series
    resonant frequency by "+string(P)+" % ");
25 Q = (sqrt(L/Cs))/R;
26 disp(Q, "The Q factor of the crystal is");
```

---

### Scilab code Exa 11.10 Parallel resonant frequency

```

1 // Exa 11.10
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 Cs = 0.04; // in pF
8 C_M = 2; // in pF
9 Per = (1/2)*(Cs/C_M)*100; // in %
10 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

```

1 // Exa 11.12
2 clc;
3 clear;
4 close;
5 format('v',6)
6 // Given data
7 C = 0.01; // in pF
8 C = C * 10^-12; // in F
9 L = 10; // in mH
10 L = L * 10^-3; // in H
11 f_o = 1/(2*pi*sqrt(L*C)); // in Hz
12 f_o = f_o * 10^-6; // in MHz
13 disp(f_o,"The oscillation frequency in MHz is");
14 R1 = 100; // in k ohm
15 R2 = 5; // in k ohm
16 A = 1 + (R1/R2);
17 // Beta = R/10;
18 // loopgain = A*Beta A*R/10 >=1
19 R= 10/A; // in k ohm
20 R=round(R*10^3); // in ohm
21 disp("The value of R is >= "+string(R)+" ohm")

```

