Scilab Textbook Companion for Analog Electronics by U. A. Bakshi And A. P. Godse[1]

Created by
Prakhar Bangar
Electrical and Electronics
Electrical Engineering
Manipal University, Jaipur
College Teacher
No Teacher
Cross-Checked by
Mukul Kulkarni and Lavitha Pereira

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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 1

Feedback Amplifiers

Scilab code Exa 1.1 `transistor in the feedback amplifier`

```
1  //Example 1.1
2  clc
3  disp("Step 1: Identity topology")
4  disp("   The feedback voltage is applied across the
       resistance R_e1 and it is in series with input
       signal. Hence feedback is voltage series feedback
       .")
5  disp("")
6  disp("Step 2 and Step 3: Find input and output
       circuit.")
7  disp("   To find input circuit, set Vo = 0 (
       connecting C2 to ground), which gives parallel
       combination of Re with Rf at E1. To find output
       circuit, set Ii = 0 (opening the input node E1 at
        emitter of Q1), which gives series combination
       of Rf and Re1 across the output. The resultant
       circuit is shown in Fig.1.32")
8  disp("")
9  disp("Step 4: Find open loop voltage gain(A_v)")
10 format(5)
11 rl2=(4.7*10.1)/(4.7+10.1) // in k-ohm
```

```
12  disp ( rl2 ,"   R_L2 ( in  k-ohm )  =  R_c2  ||  ( R_e1+Rf )  =")
13  disp ("   A_i2  =  -hfe  =  -100")
14  disp ("   R_i2  =  hie  =  1100  ohm")
15  format (7)
16  av2 =(-100*3.21*10^3)/1100
17  disp ( av2 ,"   A_v2  =  A_i2*R_L2  /  R_i2  =")
18  disp ("   A_i1  =  -hfe  =  -100")
19  format (5)
20  rl1 =(22*220*22*1.100)/((220*22*1.100)+(22*22*1.100)
      +(22*220*1.100)+(22*220*22))   // in  ohm
21  disp ( rl1*10^3 ,"   R_L1 ( in  ohm )  =  R_c1  ||  R3  ||  R4  ||
      R_i2  =")
22  ri1 =1.1+(101*((0.1*10)/(0.1+10)))   // in  k-ohm
23  format (5)
24  disp ( ri1 ,"   R_i1 ( in  k-ohm )  =  hie  +  (1+hfe )*R_e1eff  =
                      where  Re1eff  =  ( R_e1  ||  Rf )")
25  av1 =(-100*995)/(11.099*10^3)
26  disp ( av1 ,"Therefore ,   A_v1  =  A_i1*RL1  /  Ri1  =")
27  disp ("The  overall  voltage  gain  without  feedback  is
      given  as ,")
28  av =-291.82*-8.96
29  format (7)
30  disp ( av ,"   Av  =  A_v1  *  A_v2  =")
31  disp ("The  overall  voltage  gain  taking  Rs  in  account
      is  given  as ,")
32  aV =(2614.7*11.099*10^3)/((11.099*10^3)+100)
33  format (8)
34  disp ( aV ,"   Av  =  Vo  /  Vs  =  Av*R_i1  /  R_i1+Rs  =")
35  disp ("")
36  disp ("Step  5:  Calculate  beta")
37  disp ("Looking  at  Fig .1.33.")
38  beta =100/(100+(10*10^3))
39  format (7)
40  disp ( beta ,"   beta  =  Vf  /  Vo  =")
41  d =1+(0.0099*2591.35)
42  format (6)
43  disp (d ,"   D  =  1  +  beta*Av  =")
44  avf =2591.35/26.65
```

```
45  disp ( avf , "   A_vf  =  Av/D  =")
46  rif =26.65*11.099    // in k-ohm
47  format (8)
48  disp ( rif , "   R_if ( in k-ohm )  =  R_i1  *  D  =")
49  riff =(295.788*220*22) /((220*22) +(295.788*22)
        +(295.788*220))    // in k-ohm
50  format (6)
51  disp ( riff , "   R ''_if ( in k-ohm )  =  R_if  ||  R1  ||  R2  =")
52  disp ("   R_of  =  Ro  /  D  =  infinity  /  D  =  infinity ")
53  disp ("Therefore ,   R ''_of  =  R ''_o  /  D              where
        R ''_o  =  R_L2")
54  roff =(3.21*10^3) /26.65    // in omh
55  format (7)
56  disp ( roff , "Therefore ,   R ''_of ( in ohm )  =  ")
```

Scilab code Exa 1.2 `closed loop gain with negative feedback`

```
1  //Example  1.2
2  clc
3  avf =600/(1+(600*0.01))
4  format (7)
5  disp ( avf , "A_vf  =  A  /  1+A*beta  =")
```

Scilab code Exa 1.3 `open and closed loop gain`

```
1  //Example  1.3
2  clc
3  disp ("Given:  beta  =  0.04 ,   Distortion  with  feedback
        =  3%,   Distortion  without  feedback  =  15%")
4  d =15/3
5  format (2)
6  disp (d , "Therefore ,   D  =")
7  disp ("where   D  =  1  +  A*beta  =  5")
```

```
 8  a=4/0.04
 9  format(4)
10  disp(a,"Therefore,   A =")
```

Scilab code Exa 1.4 `gain with feedback`

```
 1  //Example 1.4
 2  clc
 3  disp("(a) Gain with feedback")
 4  format(5)
 5  av=1000/(1+(0.05*1000))
 6  disp(av,"          AV_mid = Av_mid / 1+beta*Av_mid =")
 7  flf=50/(1+(0.05*1000))   // in Hz
 8  disp(flf,"(b)       f_Lf(in Hz) = f_L / 1+beta*Av_mid
        =")
 9  fhf=((50*10^3)*(1+(0.05*1000)))*10^-6   // in MHz
10  disp(fhf,"(c)       f_Hf(in MHz) = f_H * (1+beta*
        Av_mid) =")
```

Scilab code Exa 1.5 `input signal and second harmonic distortion with feedback`

```
 1  //Example 1.5
 2  clc
 3  disp("(a) beta:          -40 = 20*log[1+beta*A]")
 4  disp("Therefore,   1+beta*A = 100")
 5  b=99/1000
 6  format(6)
 7  disp(b,"Therefore,        beta =")
 8  disp("Gain of the amplifier with feedback is given
        as")
 9  avf=1000/100
10  disp(avf,"        A_Vf = A_V / 1+beta*A_V =")
```

```
11  disp(" (b) To maintain output power 10 W, we should
        maintain output voltage constant and to maintain
        output constant with feedback gain required Vs is
        ")
12  vsf =10*100*10^-3  // in V
13  disp(vsf,"          V_sf(in V) = Vs * 100 =")
14  disp(" (c) Second harmonic distortion is reduced by
        factor 1 + beta*A")
15  d2f=(0.1/100)*100 // in percentage
16  disp(d2f,"          D_2f(in percentage) = D_2 / 1+beta*A
        =")
```

Scilab code Exa 1.6 `beta and Af`

```
1  //Example 1.6
2  clc
3  disp(" (a) We know that")
4  disp("                dAf/Af = 0.1/1+beta*A * dA/A")
5  disp("Therefore,  1+beta*A = 37.5")
6  b=(36.5/2000)*100 // in percentage
7  format(6)
8  disp(b,"Therefore,  beta(in percentage) =")
9  af =2000/(1+(0.01825*2000))
10 disp(af,"(b)      Af = A / 1+beta*A =")
```

Scilab code Exa 1.7 `amount of feedback`

```
1  //Example 1.7
2  clc
3  disp("The voltage gain of the amplifier with
        feedback is given as,")
4  disp("A_vf = A / 1+A*beta   where   beta = 0.1 and A =
        100")
```

```
5  avf=100/(1+(100*0.1))
6  format(5)
7  disp(avf,"Therefore ,   A_vf =")
8  disp("The bandwidth of an amplifier with feedback is
        given by ,")
9  disp("B_wf = (1+A_mid*beta)f_H − f_L/(1+A_mid*beta)"
     )
10 disp("Assuming f_H >> f_L we have")
11 disp("B_w = f_H   and   B_wf = (1+A_mid*beta)B_w")
12 bwf=(1+(100*0.1))*300
13 disp(bwf,"Therefore ,   B_wf(in kHz) =")
14 disp("The gain bandwidth product before feedback can
        be given as")
15 gbp=100*300*10^3
16 format(7)
17 disp(gbp,"Gain bandwidth product = A_v*B_w =")
18 gbpf=9.09*3300*10^3
19 disp(gbpf,"Gain bandwidth product after feedback=
     A_vf*B_wf =")
20 disp("If bandwidth is to be limited to 800 kHz we
     have f_Hf = 800 kHz assuming f_Hf >> f_Lf")
21 disp("We know that")
22 disp("B_wf = (1+A_vmid*beta)*f_H")
23 b=((8/3)-1)/100
24 format(8)
25 disp(b,"Therefore ,   beta =")
```

Scilab code Exa 1.8 `A1 and A2`

```
1  //Example 1.8
2  clc
3  disp("For the above circuit voltage gain with
     feedback is given as")
4  disp(" A_f = A1[A2/1+A2*B2] / 1+A1[A2/1+A2B2]B1")
5  disp("(i)   deltaA_f = | A1[A2/1+A2*B2]/1+A1[A2/1+
```

13

```
   A2B2]B1 − |A1−deltaA_i|[A2/1+A2*B2]/1+|A1−
   deltaA_i|[A2/1+A2B2]B1 |")
6 disp("(ii)  deltaA_f = | A1[A2/1+A2*B2]/1+A1[A2/1+
   A2B2]B1 − A1[|A2−deltaA2|/1+|A2−deltaA2|*B2]/1+A1
   [|A2−deltaA2|/1+|A2−deltaA2|B2]B1 |")
```

Scilab code Exa 1.9 voltage gain and input and output impedance

```
1  //Example 1.9
2  clc
3  disp("The voltage gain with feedback can be given as
      ")
4  avf=4000/(1+(4000*0.05))
5  format(5)
6  disp(avf,"A_vf = A_v / 1+A_v*beta =")
7  disp("In a voltage series feedback input resistance
      with feedback is given as")
8  rif=2*(1+(0.05*4000))
9  disp(rif,"R_if(in k−ohm) = R_i(1+beta*A_v) =")
10 rof=(60*10^3)/(1+(0.05*4000))
11 format(6)
12 disp("In a voltage series feedback output resistance
       with feedback is given as")
13 disp(rof,"R_of(in ohm) = Ro / 1+beta*A_v =")
```

Scilab code Exa 1.10 amplifier without feedback

```
1  //Example 1.10
2  clc
3  disp("The voltage gain of amplifier can be given as"
      )
4  av=36/0.028
5  format(7)
```

```
6  disp(av,"A_v = Vo/V_in =")
7  disp("(i)   beta = 0.012")
8  disp("Therefore,  The gain of the amplifier with
      feedback is given as")
9  af=1285.7/(1+(1285.7*0.012))
10 format(6)
11 disp(af,"A_f = A_v / 1+A_v*beta =")
12 disp("The output voltage with feedback is given as")
13 vo=78.26*0.028
14 disp(vo,"Vo(in V) = A_f * V_in =")
15 vin=7*0.028
16 disp("(ii) If the output remains constant at 36V,
      then the distortion produced within the active
      devices of the amplifier is unchanged. However,
      since the distortion at the output is less than
      in part (i) by a factor of 7, it follows that the
       feedback now increased by 7 and hence, the
      voltage gain decreased by 7. Thus, the input
      signal required to produce the same output (as in
       part(i)) without feedback must be:")
17 disp(vin,"V_in(in V) =")
```

Scilab code Exa 1.11 gain of the amplifier with feedback

```
1  //Example 1.11
2  clc
3  disp("(i) The gain of the amplifier is given as")
4  disp("60 dB = 20 log(Vo/V_s)")
5  disp("Therefore,  A_v = Vo/V_s = 1000")
6  disp("beta = 1/20 = 0.05")
7  disp("Therefore,  The gain of amplifier with
      feedback is")
8  avf=1000/(1+(1000*0.05))
9  format(5)
10 disp(avf,"A_vf = A_v / 1+A_v*beta =")
```

```
11  disp(" ( i i ) The gain of the amplifier is directly
        proportional to the g_m. Therefore , the gain of
        the amplifier without feedback changes as same
        amount as g_m changes")
12  disp(" Therefore ,   A_v = A_v +- 0.5*A_v = 1000 +- 500
        ")
13  disp(" The gain of the amplifier with feedback is now
        given as")
14  avf1 =1500/(1+(1500*0.05))
15  avf2 =500/(1+(500*0.05))
16  format (6)
17  disp(avf1 ,avf2 ," A_vf = A_v / 1+A_v*beta =")
```

Scilab code Exa 1.12 `single stage RC coupled amplifier`

```
1  // Example 1.12
2  clc
3  disp(" A_v = 1000 and beta = 0.1")
4  fh =1+(0.1*1000)
5  format (4)
6  disp(fh ," ( i ) f_Hf/f_H = 1 + beta*A_v =")
7  fl =1/(1+(0.1*1000))
8  format (7)
9  disp(fl ," and   f_Lf/f_L = 1 / 1+beta*A_v =")
10 disp(" ( i i ) With f_L = 20 Hz and f_H = 50 kHz")
11 fll =20*0.0099
12 format (6)
13 disp(fll ," f_Lf ( in Hz) =")
14 fhh =(50*101)*10^-3
15 format (5)
16 disp(fhh ," f_Hf ( in MHz) =")
```

Scilab code Exa 1.13 `feedback ratio and input voltage`

```
1  //Example 1.13
2  clc
3  disp("The voltage gain of the amplifier is given as"
      )
4  av=50/0.2
5  format(4)
6  disp(av,"A_v = Vo/V_in =")
7  disp("We know that,")
8  b=((0.06/0.01)-1)/250
9  format(5)
10 disp(b,"B_2f = B_2 / 1+A_v*beta =")
11 disp("Therefore,  feedback ratio, beta =")
12 avf=250/(1+(250*0.02))
13 format(6)
14 disp(avf,"A_vf = A_v / 1+A_v*beta =")
15 vin=50/41.66
16 format(4)
17 disp("To produce output voltage of 50 V V_in must be
      ")
18 disp(vin,"V_in = 50/A_vf =")
```

Scilab code Exa 1.14 `Av and beta of amplifier`

```
1  //Example 1.14
2  clc
3  disp("Given A_vf = 120")
4  disp("A_v = Vo/V_s = Vo/60mV")
5  disp("and  A_vf = Vo/0.5")
6  vo=0.5*120
7  format(3)
8  disp(vo,"Therefore,  Vo(in V) =")
9  disp("with  Vo = 60 V we have,")
10 av=60/(60*10^-3)
11 format(5)
12 disp(av,"A_v =")
```

```
13  b=((1000/120)-1)/1000
14  format(8)
15  disp("We know that,")
16  disp("A_vf = A_v / 1+A_v*beta")
17  disp(b,"Therefore,  beta =")
```

Scilab code Exa 1.15 determine Avf

```
1  //Example 1.15
2  clc
3  disp("Step 1: Identify topology")
4  disp("  By shorting output(Vo = 0), feedback voltage
       V_f becomes zero, hence it is a voltage sampling
       . Since feedback is mixed in series with input
      the topology is voltage series feedback amplifier
      ")
5  disp("")
6  disp("Step 2 and Step 3: Find input and output
      circuit.")
7  disp("  To find input circuit, set Vo = 0. This
      places the parallel combination of resistors 3.3K
       and 3.3K at the first emitter. To find output
      circuit, set Ii = 0. This places resistors 3.3K
      and 3.3K in series across the output. The
      resultant circuit is shown in fig 1.48")
8  disp("")
9  disp("Step 4: Replace transistor with its h-
      parameter equivalent as shown in fig.1.49")
10  disp("")
11  disp("Step 5: Find open loop transfer gain.")
12  disp("A_v = A_v1*A_v2")
13  disp("    = V_i2/V_i1 * Vo/V_i2")
14  disp("    = Vo/V_i2 = -h_fe*R_L2 / R_i2")
15  rl2=3.3+3.3
16  format(4)
```

18

```
17  disp(rl2 ,"where   R_L2(in  k-ohm)  =")
18  disp("and   R_i2  =  h_ie  =  2  K")
19  voi=(-50*6.6)/2
20  disp(voi ,"Therefore ,   A_v2  =  Vo/V_i2  =")
21  disp("V_i2/V_i1  = -h_fe*R_L1  /  R_i1")
22  rl1=((51*2)/(53))
23  format(5)
24  disp(rl1 ,"where   R_L1(in  k-ohm)  =")
25  disp("and   R_i  =  [h_ie  +  (1+h_fe)(3.3K||3.3K)]")
26  ri=2+(51*1.65)
27  format(6)
28  disp(ri ,"Therefore ,   R_i1(in  k-ohm)  =  ")
29  vi21=(-50*1.92)/(86.15)
30  format(6)
31  disp(vi21 ,"Therefore ,   A_v1  =  V_i2/V_i1  =")
32  av=-165*-1.114
33  format(7)
34  disp(av ,"Therefore ,   A_v =")
35  disp("")
36  disp("Step  6:  Calculate  beta")
37  be=3.3/6.6
38  format(4)
39  disp(be ,"beta  =  V_f/Vo  =")
40  disp("We know  that ,   D  =  1  +  beta*A_v  =")
41  avf=183.86/92.93
42  format(6)
43  disp(avf ,"A_vf  =  A_v/D  =")
```

Scilab code Exa 1.16 `Avf and Rif`

```
1  //Example  1.16
2  clc
3  disp("Step  1:  Identify  topology")
4  disp("   By  shorting  output(Vo  =  0) ,  feedback  voltage
        V_f  becomes  zero.The  feedback  is  mixed  in  series
```

19

```
             feedback.")
 5  disp("")
 6  disp("Step 2 and Step 3: Find input and output
        circuit.")
 7  disp("  To find input circuit, set Vo = 0. This
        places the parallel combination of resistors 10K
        and 1K at the first emitter. To find output
        circuit, set Ii = 0. This places resistors 10K
        and 1K in series across the output. The resultant
         circuit is shown in fig 1.51.")
 8  disp("")
 9  disp("Step 4: Replace transistor with its h-
        parameter equivalent as shown in fig.1.52.")
10  disp("")
11  disp("Step 5: Find open loop transfer gain.")
12  disp("A_v = A_v1*A_v2")
13  disp("     = V_i2/V_i1 * Vo/V_i2")
14  disp("Vo/V_i2 = -h_fe*R_L2 / R_i2")
15  rl2=(5.1*11)/(16.1)
16  format(6)
17  disp(rl2,"where  R_L2(in k-ohm) =")
18  disp("and  R_i2 = h_ic = 1.1 K")
19  voi=(-50*3.484)/1.1
20  format(7)
21  disp(voi,"Therefore,  Vo/V_i2 =")
22  disp("V_i2/V_i1 = -h_fe*R_L1 / R_i1")
23  rl1=((1.1*1)/(2.1))*10^3
24  format(6)
25  disp(rl1,"where  R_L1(in ohm) =")  //answer in text
        book is wrong
26  disp("and  R_i = 82K || [h_ie + (1+h_fe)(1K||10K)]")
27  ri=((82*47.459)/(82+47.459))
28  format(3)
29  disp(ri,"Therefore,  R_i(in k-ohm) = ")
30  vi21=(-50*523.8)/(30*10^3)
31  format(6)
32  disp(vi21,"Therefore,  V_i2/V_i1 =")
33  av=-158.36*-0.888
```

```
34  format (7)
35  disp(av,"Therefore,   A_v =")
36  disp("")
37  disp("Step 6: Calculate beta")
38  be=1/10
39  format (4)
40  disp(be,"beta = V_f/Vo =")
41  disp("")
42  disp("Step 7: Calculate A_vf, R_if and R''_of")
43  d=1+(0.1*140.62)
44  format (7)
45  disp(d,"D = 1 + beta*A_v =")
46  avf=140.62/15.062
47  format (6)
48  disp(avf,"A_vf = A/D =")
49  rif=30*15.062
50  format (7)
51  disp(rif,"R_if(in k-ohm) = R_i*D =")
52  disp("R''_o = R_L2 = 3.484 k-ohm")
53  rof=(3.484*10^3)/15.062
54  disp(rof,"R''_of(in ohm) = R''_o/D =")
```

Scilab code Exa 1.17 D and Avf anf Rif and Rof

```
1  //Example 1.17
2  disp("Step 1: Identify topology")
3  disp("  By shorting output voltage (Vo = 0),
       feedback voltage Vf becomes zero and hence it is
       voltage sampling. The feedback voltage is applied
        in series with the input voltage hence the
       topology is voltage series feedback.")
4  disp("")
5  disp("Step 2 and Step 3: Find input and output
       circuit.")
6  disp("  To find input circuit, set Vo = 0. This
```

```
       places the parallel combination of resistor 10 K
       and 200 ohm at first source. To find output
       circuit, set Ii = 0. This places the resistor 10K
        and 200 ohm in series across the output. The
       resultant circuit is shown in fig 1.54.")
 7  disp("")
 8  disp("Step 4: Replace FET with its equivalent
       circuit as shown in fig.1.55.")
 9  disp("")
10  disp("Step 5: Find open loop transfer gain.")
11  disp("   Av = Vo / Vs = A_v1 * A_v2")
12  disp("   A_v2 = -u*R_L2 / R_L2+r_d")
13  rl2=(10.2*47)/(10.2+47)   // in k-ohm
14  format(5)
15  disp(rl2,"where   R_L2(in k-ohm) =")
16  av2=(-40*8.38)/18.38
17  format(7)
18  disp(av2,"   A_v2 =")
19  disp("   A_v1 = u*R_Deff / r_d+R_Deff+(1+u)*R_seff")
20  rdeff=(47*1000)/(47+1000)   // in k-ohm
21  format(6)
22  disp(rdeff,"   R_Deff(in k-ohm) = R_D || R_G2 =")
23  av1=(-40*44.98)/(10+44.89+(41*((0.2*10)/(10+0.2))))
24  disp(av1,"Therefore,   A_v1 =")
25  av=-28.59*-18.237
26  format(7)
27  disp(av,"Therefore,   Av = A_v1 * A_v2 =")
28  disp("")
29  disp("Step 6: Calculate beta")
30  beta=200/(10000)
31  format(5)
32  disp(beta,"   beta = Vf / Vo =")
33  disp("")
34  disp("step 7: Calculate D, A_vf, R_if, R''_of")
35  d=1+(0.02*521.39)
36  format(8)
37  disp(d,"   D = 1 + Av*beta =")
38  avf=521.39/11.4278
```

```
39  format (6)
40  disp(avf ,"   A_vf = Av / D =")
41  disp(" Ri = R_G = 1 M-ohm")
42  rif =11.4278
43  format (8)
44  disp(rif ,"   R_if(in M-ohm) = Ri * D =")
45  ro =10   // in k-ohm
46  format (3)
47  disp(ro ,"   R''o(in k-ohm) = rd =")
48  rof =(10*10^3)/11.4278   // in ohm
49  format (4)
50  disp(rof ,"   R''_of(in ohm) = R''o / D =")
51  rod =(10*8.38)/18.38
52  format (6)
53  disp(rod ,"R''_o(in k-ohm) =")
54  rofd =(4.559*10^3)/11.4278
55  format (4)
56  disp(rofd ,"Therefore ,   R''_of(in ohm) = R''_o/D =")
```

Scilab code Exa 1.18 voltage gain including feeback

```
1  //Example 1.18
2  clc
3  disp("Here, output voltage is sampled and fed in
       series with the input signal. Hence the topology
       is voltage series feedback.")
4  disp("   The open loop voltage gain for one stage is
       given as,")
5  disp("      Av = -gm*R_eq")
6  req =(8*40*1000)/((40*1000)+(8*1000)+(8*40))   // in k
       -ohm
7  format (5)
8  disp(req ,"   R_eq(in k-ohm) = r_d || R_d || (R_i1+R_2
       ) =")
9  av = -5*6.62
```

```
10  format (6)
11  disp(av ," Av =")
12  avm=-33.11^3
13  disp(avm ,"Av = Overall voltage gain = |A_vmid|^3 =")
        // answer in textbook is wrong
14  beta=50/(10^6)
15  format (7)
16  disp(beta ," beta = Vf / Vo = -R_1 / R_g = -R_1 /
        R_1+R_2 =")
17  d=1+((-5*10^-5)*-36306)
18  format (6)
19  disp(d ," D = 1 + |Av|* beta =")
20  avf=-36306/2.8153
21  disp(avf ," A_vf = Av / D =")
```

Scilab code Exa 1.19 Avf

```
1  //Example 1.19
2  clc
3  disp("Here, output terminals are B and ground, thus
        the forward gain is the gain of Q1 and it is ,")
4  disp(" A_v= -33.11")
5  disp("Here beta = V_f / V_B = V_f/V_o * V_o/V_C *
        V_C/V_B")
6  disp("where V_B and V_C are voltages at point B and
        C, respectively .")
7  disp("Therefore, beta_BN = V_f/V_o * A_v3 * A_v2
                because V_o/V_C = A_v3 and V_C/V_B = A_v2
        ")
8  bbn=(5*10^-5)*(33.11^2)
9  format (7)
10  disp(bbn ,"Therefore, beta= ")
11  avf=-33.11/2.815
12  format (6)
13  disp(avf ,"Therefore, |A_vf| = A_vf / 1+|A_f|* beta =
```

```
            ")
```

Scilab code Exa 1.20 `voltage gain with feedback`

```scilab
1 //Example 1.20
2 clc
3 disp("Step 1: Identify topology")
4 disp("   By shorting output(Vo = 0), feedback voltage
        does not become zero. By opening the output loop
         feedback becomes zero and hence it is current
        sampling. The feedback is applied in series with
        the input signal, hence topology used is current
        series feedback.")
5 disp("")
6 disp("Step 2 and Step 3: Find input and output
        circuit.")
7 disp("   To find input circuit, set Io = 0. This
        places Re in series with input. To find output
        circuit Ii = 0. This places Re in output side.
        The resultant circuit is shown in fig.1.58.")
8 disp("")
9 disp("Step 4: Replace transistor with its h-
        parameter equivalent as shown in fig 1.59.")
10 disp("")
11 disp("Step 5: Find open loop transfer gain.")
12 disp("   From quation(13) of section 1.12 we have")
13 disp("   A_vf = Io*R_L / Vs = G_Mf * R_L")
14 disp("        = -h_fe*R_L / R''s+h_ie+(1+h_fe)*Re")
15 disp("Here  R''s = Rs || R1 || R2")
16 disp("           = Rs || Rb          because R_b = R1
         || R2")
17 disp("Therefore,  Vo / Vs = Vo/Vi * Vi/Vs")
18 disp("where       Vi / Vs = Rb / Rs+Rb")
19 disp("Therefore,  Vo / Vs = (-h_fe*R_L / R''s+h_ie
        +(1+h_fe)*Re) * (Rb / Rs+Rb)")
```

```
20  disp("Dividing both numerator and denominator by Rs+
        Rb we get ,")
21  disp("   A_vf = Vo / Vs = [-h_fe*Rc*(Rb/Rb+Rs)] / R''
        s+h_ie+(1+h_fe)*Re     because RL = Rc")
22  disp("           = -h_fe*Rc*[1/1+(Rs/Rb)] / R''s+h_ie
        +(1+h_fe)*Re")
```

Scilab code Exa 1.21 `Rif and Aif and Avf`

```
1  //Example 1.21
2  clc
3  disp("Step 1: Identify topology")
4  disp("Making output voltage zero(Vo = 0); feedback
        does not become zero and hence it is not voltage
        sampling. By opening the output loop feedback
        becomes zero and hence it is a current sampling.
        As I_i = I_s-I_f, the feedback current appears in
         shunt with the input signl and hence the
        topology is current shunt feedback")
5  disp("")
6  disp("Step 2 and Step 3: Find input and output
        circuit")
7  disp("To find input circuit, set Vo = 0. This gives
        series combination of 20K and 1K across the input
         of the first transistor. To find output circuit,
         set V_i= 0. This gives parallel combination of
        20K and 1K at emitter of the second transistor.
        The resultant circuit is shown in fig 1.61")
8  disp("")
9  disp("Step 4: Find open circuit current gain")
10 disp("A_I = Io/I_s = -I_c2/I_s = -I_c2/I_b2 * I_b2/
        I_c1 * I_c1/I_b1 * I_b1/I_s")
11 disp("-I_c2/I_b2 = -h_fe = -100")
12 disp("I_b2/I_c1 = -R_c1 / R_i2+R_c1")
13 ri2=2+(101*(20/21))
```

```
14  format (6)
15  disp (ri2 ,"where  R_i2(in k−ohm) = h_ie + (1+h_fe)R_e
        =")
16  ibc =(-12)/(98.19+12)
17  format (6)
18  disp (ibc ,"Therefore ,  I_b2/I_c1 =")
19  disp ("I_c1/I_b1 = h_fe = 100")
20  ibs =(21/22)/(2+(21/22))
21  disp (ibs ,"I_b1/I_s =")
22  ai =100*0.109*0.323*100
23  format (4)
24  disp (ai ,"Therefore ,  A_I =")
25  disp ("")
26  disp ("Step 5: Calculate beta")
27  b=4/(24)
28  format (7)
29  disp (b ,"beta = I_f/Io = R_e2/R_e2+R'' =")
30  disp ("")
31  d=1+(0.1667*352)
32  format (6)
33  disp (d ,"Therefore ,  D = 1 + beta*A_I =")
34  aif =352/59.67
35  format (5)
36  disp (aif ,"A_if = A_I/D =")
37  ri =((1*21*2)/((21*2)+(1*2)+(21*1)))*10^3
38  format (4)
39  disp (ri ,"R_i(in ohm) =")
40  rif =646/59.67
41  format (6)
42  disp (rif ,"R_if(in ohm) = R_i/D =")
43  disp ("Ro = infinity")
44  disp ("Therefore ,  R_of = infinity    because h_oe =
        0")
45  disp ("R''_o = Ro || R_c2 = 4 k−ohm")
46  disp ("R''_of = R''_o = 4 k−ohm")
47  avf =(5.9*4)
48  disp (avf ,"A_vf = A_If*R_L/R_s =")
```

Scilab code Exa 1.22 `Avf and Rif and Rof`

```scilab
1  //Example 1.22
2  clc
3  disp("Step 1: Identify topology")
4  disp("Vo = 0, does not make feedback zero, but Io =
       0 makes feedback to become zero and hence it is
       current sampling. The feedback is fed in shunt
       with the input signal, hence topology is current
       shunt feedback")
5  disp("")
6  disp("Step 2 and Step 3: Find input and output
       circuit")
7  disp("To find input circuit, set Vo = 0. This gives
       series combination of R_e2 and 10K across the
       input. To find output circuit, set V1= 0. This
       gives parallel combination of R_e2 and 10K at E2.
       The resultant circuit is shown in fig 1.63")
8  disp("")
9  disp("Step 4: Replace transistor with its h-
       parameter equivalent as shown in fig 1.64")
10 disp("")
11 disp("Step 5 : Find open loop current gain")
12 disp("A_I = Io/I_s = -I_c/I_s = -I_o/I_b2 * I_b2/
       I_c1 * I_c1/I_b1 * I_b1/I_s")
13 disp("Io/I_b2 = -h_fe = -100")
14 disp("I_c2/I_b2 * I_b1/I_e1 = -h_ie*R_c1 / R_i2+R_c2
                because I_b2/I_c1 = R_c1/R_c1+R_i2")
15 ri2=1+(101*(10/11))
16 format(7)
17 disp(ri2,"where  R_i2(in k-ohm) = h_ie + (1+h_fe)(1K
       ||10K) =")
18 ibb=(-100*2.2)/(92.818+2.2)
19 format(6)
```

```
20  disp(ibb,"Therefore,  I_b1/I_s =")
21  ibs=(11/12)/(1+(11/12))
22  disp(ibs,"I_b1/I_s =")
23  ai=100*2.315*0.478
24  disp(ai,"A_I =")
25  disp("Step 6: Calculate beta")
26  b=1/(11)
27  format(5)
28  disp(b,"beta = R_e2/R_e2+R'' =")
29  disp("")
30  disp("Step 6: Calculate D,A_If, A_vf, R_if, R_of")
31  d=1+(0.09*110.7)
32  format(7)
33  disp(d,"D = 1 + beta*A_I =")  //answer in textbook
       is wrong
34  aif=110.7/11.063
35  format(3)
36  disp(aif,"A_if = A_I/D =")
37  ri=((1*11*1)/((11*1)+(1*1)+(11*1)))*10^3
38  format(4)
39  disp(ri,"R_i(in ohm) =")
40  rif=478/11.063
41  format(6)
42  disp(rif,"R_if(in ohm) = R_i/D =")
43  disp("Ro = infinity")
44  disp("Therefore,  R_of = Ro*D = infinity     because
       h_oe = 0")
45  disp("R''_o = 2.2 k-ohm")
46  disp("R''_of = R''_o = 2.2 k-ohm")
```

Scilab code Exa 1.23 `Rmf and Aof and Rif and Rof`

```
1  //Example 1.23
2  clc
3  disp("Step 1: Identify topology")
```

```
4  disp("Here output voltage is sampled and fed in
       shunt with the input siganl such that, I_s−I_f =
       I_i, hence topology is voltage shunt feedback")
5  disp("")
6  disp("Step 2 and Step 3: Find input and output
       circuit")
7  disp("To find input circuit, set Vo = 0. This places
        resistor R across the input. To find output
       circuit, set V_i = 0. This places resistor R
       across output. The resultant circuit is shown in
       fig 1.69")
8  disp("")
9  disp("Step 4: Replace transistor with its h−
       parameter equivalent circuits as shown in fig
       1.67")
10 disp("")
11 disp("Step 5 : Find open loop transresistance")
12 disp("R_M = Vo/I_s = R_c*Io/I_s = −R_c*I_c/I_s")
13 disp("     = R_c * −I_c/I_b * I_b/I_s")
14 icb=(-100*82)/94
15 format(6)
16 disp(icb,"−I_c/I_b = −h_fe*R / R+R_c =")
17 disp("I_b/I_s = Ro||R / R_s||(R+R_i1)")
18 ri1=1.1+(101*820*10^-3)
19 disp(ri1,"R_i1(in k−ohm) = h_ie + (1+h_fe)R_e =")
20 ibs=(82/83)/(83.92+(82/83))
21 format(7)
22 disp(ibs,"Therefore,  I_b/I_s =")
23 rm=-87.23*12*0.0116
24 format(7)
25 disp(rm,"Therefore,  R_M(in k−ohm) = Vo/I_s =")
26 disp("")
27 disp("Step 6: Calculate beta")
28 b=-1/(82*10^3)
29 format(10)
30 disp("beta = I_f/Io = V_i−Vo/Vo*R =")
31 disp(b,"       = −1/R =            because (Vo > V_i)"
       )
```

```
32  disp("")
33  disp("Step 7: Calculate D, R_Mf, A_vf, R_if, R''_of"
       )
34  d=1+(-1.22*-12.142*10^-2)
35  format(6)
36  disp(d,"D = 1 + beta*R_M =")
37  rmf=-12.142/1.148
38  format(6)
39  disp(rmf,"R_Mf(in k-ohm) = R_M/D =")
40  avf=-10.57
41  disp("A_vf = V0/V_s = Vo/I_s*R_s =")
42  disp(avf,"          = R_Mf/R_s =              because R_Mf =
       Vo/I_s")
43  ri=((1*82*83.92)/((82*83.92)+(1*83.92)+(82*1)))
44  disp(ri,"R_i(in k-ohm) = R_s || R_i1 || R =")
45  rif=(0.976*10^3)/1.148
46  format(4)
47  disp(rif,"R_if(in ohm) = R_i/D =")
48  disp("Ro = infinity")
49  disp("Therefore,  R_of = infinity/D = infinity
       because h_oe = 0")
50  ro=(12*82)/(94)
51  format(7)
52  disp(ro,"R''_o(in k-ohm) = R || R_c =")
53  rof=(10.468)/1.148
54  format(6)
55  disp(rof,"R''_of(in k-ohm) = R''_o/D =")
```

Scilab code Exa 1.24 `Avf and Rif and Rof`

```
1  //Example 1.24
2  clc
3  disp("Step 1: Identify topology")
4  disp("Here output voltage is sampled and fed in
       shunt with the input siganl such that, I_s-I_f =
```

```
          I_i , hence topology is voltage shunt feedback")
 5  disp("")
 6  disp("Step 2 and Step 3: Find input and output
        circuit")
 7  disp("To find input circuit , set Vo = 0. This places
         resistor R across the input. To find output
        circuit , set V_i = 0. This places resistor R
        across output. The resultant circuit is shown in
        fig 1.69. The circuit shows voltage source
        replaced by current source")
 8  disp("")
 9  disp("Step 4: Replace transistor with their h-
        parameter equivalent circuits as shown in fig
        1.70")
10  disp("")
11  disp("Step 5 : Find open loop transfer gain")
12  disp("R_M = Vo/I_s = R_c2*Io/I_s")
13  disp("      = R_c2 * Io/I_b2 * I_b2/I_e1 * I_e1/I_b1 *
        I_b1/I_s")
14  iob=(-100*2.2)/7.3
15  format(7)
16  disp(iob,"Io/I_b2 = -h_ie*R / R+R_c2 =")
17  iobe=(101*1.1)/3.1
18  format(6)
19  disp(iobe,"I_b2/I_e2 * I_e1/I_b1 = -h_ie*R / R+R_c2
        =")
20  disp("I_b1/I_s = R_s||R / (R_s||R)+R_i1")
21  ri1=2+(101*1.1)
22  disp(ri1,"where  R_i1(in k-ohm) = h_ie + (1+h_fe)R_e
        =")
23  ibs=(2.2/3.2)/((2.2/3.2)+(113.1))
24  format(8)
25  disp(ibs,"I_b1/I_s =")
26  rm=5.1*-30.137*35.84*6.04*10^-3
27  format(7)
28  disp(rm,"Therefore ,  R_M(in k-ohm) =")
29  disp("")
30  disp("Step 6: Calculate beta")
```

```
31  b=-1/(2.2*10^3)
32  format(10)
33  disp("beta = I_f/Io = V_i-Vo/Vo*R =")
34  disp(b,"       = -1/R =                  because (Vo > V_i)"
        )
35  disp("")
36  disp("Step 7: Calculate D, R_Mf, A_vf, R_if, R''_of"
        )
37  d=1+(4.545*33.539*10^-1)
38  format(7)
39  disp(d,"D = 1 + beta*R_M =")
40  rmf=-33.539/16.245
41  format(6)
42  disp(rmf,"R_Mf(in k-ohm) = R_M/D =")
43  avf=-2.065
44  disp(avf,"A_vf = V0/V_s = Vo/I_s*R_s =")
45  ri=((1*113.1*2.2)/((113.1*2.2)+(1*113.1)+(2.2*1)))
        *10^3
46  format(4)
47  disp(ri,"R_i(in ohm) = R_s || R_i1 || R =")   //
        answer in textbook wrong
48  rif=(683)/16.245
49  format(3)
50  disp(rif,"R_if(in ohm) = R_i/D =")
51  disp("Ro = infinity")
52  disp("Therefore,  R_of = infinity/D = infinity")
53  ro=(2.2*5.1)/(7.3)
54  format(6)
55  disp(ro,"R''_o(in k-ohm) = R || R_c2 =")
56  rof=(1.537*10^3)/16.245
57  disp(rof,"R''_of(in ohm) = R''_o/D =")
```

Scilab code Exa 1.25 `D and Rmf and Avf and Rif and Rof`

```
1  //Example 1.25
```

```
2  clc
3  disp("Step 1: Identify topology")
4  disp("By making Vo = 0, feedback current becomes
       zero. Hence it is a voltage sampling. The
       feedback is fed in shunt with the input signal
       and thus the topology is voltage shunt feedback")
5  disp("")
6  disp("Step 2 and Step 3: Find input and output
       circuit")
7  disp("To find input circuit, set Vo = 0. This places
        resistor R across the input. To find output
       circuit, set V_i = 0. This places resistor R
       across output. The resultant circuit is shown in
       fig 1.72")
8  disp("")
9  disp("Step 4: Replace FET with its equivalent
       circuit as shown in fig 1.73")
10 disp("")
11 disp("Step 5 : Find open loop transresistance")
12 disp("R_M = Vo/I_s = -g_m*V_gs*R_eff/I_s")
13 reff=(40*200*10)/((200*10)+(400)+(40*200))
14 format(5)
15 disp(reff,"where  R_eff(in k-ohm) = r_d || R || R_D
       =")
16 disp("and  V_gs = I_s*R_i = I_s * R_s||1M||R")
17 disp("            = I_s * 10K||1M||200K")
18 disp("            = 9.43*10^3  I_s")
19 rm=-2.5*9.43*7.69
20 format(7)
21 disp(rm,"R_M(in k-ohm) =")
22 disp("")
23 disp("Step 6: Calculate beta")
24 b=-1/(200*10^3)
25 format(7)
26 disp("beta = I_f/Io = V_i-Vo/Vo*R =")
27 disp(b,"       = -1/R =                because (Vo > V_i)"
       )
28 disp("")
```

```
29  disp("Step 7: Calculate D, R_Mf, A_vf, R_of, R''_of"
       )
30  d=1+(5*181.29*10^-3)
31  format(4)
32  disp(d,"D = 1 + beta*R_M =")
33  rmf=-181.29/1.9
34  format(7)
35  disp(rmf,"R_Mf(in k-ohm) = R_M/D =")
36  avf=-95.415/10
37  format(7)
38  disp(avf,"A_vf = V0/V_s = Vo/I_s*R_s = R_Mf/R_s =")
39  ri=(10*1000*200)/((1000*200)+(10*200)+(1000*10))
40  format(5)
41  disp(ri,"R_i(in k-ohm) = R_s || M || R =")
42  rif=(9.43)/1.9
43  format(6)
44  disp(rif,"R_if(in k-ohm) = R_i/D =")
45  ro=(40*200*10)/((200*10)+(400)+(40*200))
46  format(5)
47  disp(ro,"R''_o(in k-ohm) = r_eff = r_d || R || R_D =
       ")
48  rof=(7.69/1.9)
49  format(2)
50  disp(rof,"R''_of(in k-ohm) = R''_o/D =")
```

Scilab code Exa 1.26 `Aof and Rif and Rof`

```
1  //Example 1.26
2  clc
3  disp("Step 1: Identify topology")
4  disp("The feedback voltage is applied across the
       resistance R_e1 and it is in series with input
       signal. Hence feedback is voltage series feedback
       ")
5  disp("")
```

```
6  disp("Step 2 and Step 3: Find input and output
      circuit")
7  disp("To find input circuit, set Vo = 0, which gives
       parallel combination of R_e1 with R_f at E1 as
      shown in fig 1.75. To find output circuit, set
      I_i = 0 opening the input node E1 at emitter of
      Q1, which gives series combination of R_f and
      R_e1 across the output. The resultant circuit is
      shown in fig 1.75")
8  disp("")
9  disp("Step 4: Find open loop voltage gain (A_v)")
10 rl2=(2.2*52.5)/54.7
11 format(5)
12 disp(rl2,"R_L2(in k-ohm) = R_c2 || (R_f+R_e1) =")
13 disp("A_i2 = -h_fe = -50")
14 disp("R_i2 = h_ie = 1.2 k-ohm")
15 av2=(-50*2.11)/1.2
16 format(6)
17 disp(av2,"A_v2 = A_i2*R_L2 / R_i2 =")
18 rl1=(100*1.2)/101.2
19 disp(rl1,"R_L1(in k-ohm) = R_c1 || R_i2 =")
20 disp("A_i1 = -h_fe = -50")
21 ri2=1.2+(51*(51*1.5/52.5))
22 format(6)
23 disp(ri2,"R_i1(in k-ohm) = h_ie + (1+h_fe)R_e =")
24 av1=(-50*1.185)/75.51
25 disp(av1,"Therefore,  A_v1 = A_i1*R_L1 / R_i1 =")
26 disp("The overall gain without feedback is given as"
      )
27 av=-0.784*-87.91
28 disp(av,"A_v = A_v1*A_v2 =")
29 disp("")
30 disp("Step 5: Calculate beta")
31 b=1.5/52.5
32 format(7)
33 disp(b,"beta = V_f/Vo =")
34 disp("")
35 disp("Step 6: Calculate D,A_vf, R_if, R_of")
```

```
36  d=1+(0.0285*68.92)
37  format(6)
38  disp(d,"D = 1 + beta*A_v =")
39  avf=68.92/2.964
40  disp(avf,"A_vf = A_v/D =")
41  ri=(75.51*200.1485)/(200.1485+75.51)
42  disp(ri,"R_i(in k-ohm) = R || R_i1 =")
43  rif=54.82*2.964
44  format(7)
45  disp(rif,"R_if(in k-ohm) = R_i/D =")
46  disp("Ro = infinity    because h_oe = 0")
47  disp("R''_o = Ro || R_c2 || (R_f+R_e1) = Ro || R_L2
        = infinity || 2.11 K = 2.11 K")
48  rof=(2.11*10^3)/2.964
49  format(4)
50  disp(rof,"R''_of(in ohm) = R''_o/D =")
```

Scilab code Exa 1.27 `Aif and Avf and Rif and Rof and Ai`

```
1  //Example 1.27
2  clc
3  disp("Step 1: Identity topology")
4  disp("The feedback is given from emitter of Q2 to
        the base of Q2. If Io=0 then feedback current
        through 5K register is zero, hence it is current
        sampling. As feedback signal is mixed in shunt
        with input, the amplifier is current shunt
        feedback amplifier")
5  disp("")
6  disp("Step 2 and Step 3: Find input and output
        circuit")
7  disp("The input circuit of the amplifier without
        feedback is obatined by opening the output loop
        at the emitter of Q2(Io = 0). This places R''(5K)
         in series with R_s from base to emitter of Q1.
```

```
         The output circuit is found by shorting the input
          node, i.e. making V1=0. This places R''(5K) in
          parallel with R_e. The resultant equivalent
          circuit is shown in fig 1.78")
 8  disp("Step 4: Find open circuit transfer gain")
 9  disp("A_I = Io/I_s = -I_c/I_s = -I_c2/I_b2 * I_b2/
         I_c1 * I_c1/I_b1 * I_b1/I_s")
10  disp("We know that  -I_c2/I_b2 = A_i2 = -h_fe = -50
          and")
11  disp("-I_c/I_b1 = A_i1 = -h_fe = -50")
12  disp("Therefore,  I_c1/I_b1 = 50")
13  disp("Looking at fig 1.77 we can write")
14  disp("I_b2/I_c1 = -R_c1/R_c1+R_i2")
15  ri2=1.5+(51*(5*0.6/5.6))
16  format(6)
17  disp(ri2,"R_i2(in k-ohm) = h_ie + (1+h_fe)(R_e2||R
         '') =")
18  ibc=-2/30.82
19  format(7)
20  disp(ibc,"Therefore,  I_b2/I_c1 =")
21  disp("Looking at fig 1.78 we can write")
22  disp("I_b1/I_s = R/R+R_i1")
23  r=(5.6*10^3)/6.6
24  format(4)
25  disp(r,"where  R(in ohm) = R3 || (R''+R_e) =")
26  ri1=1.5+20.4
27  format(5)
28  disp(ri1,"and  R_i1(in k-ohm) = h_ie + (1+h_fe)R_e1
          =")
29  ib1=0.848/22.748
30  format(7)
31  disp(ib1,"Therefore,  I_b1/I_s =")
32  disp("Substituting the numerical values obtained in
          equations of A_I we get,")
33  ai=50*0.0649*50*0.0372
34  format(2)
35  disp(ai,"A_I =")
36  disp("")
```

```
37  disp("Step 5: Calculate beta")
38  b=0.6/5.6
39  format(6)
40  disp(b,"beta = I_f/Io = R_e2 / R_e2+R'' =")
41  disp("")
42  disp("Step 6: Calculate D,A_If, A_vI, R_sf, R_of")
43  d=1+(0.107*6)
44  format(6)
45  disp(d,"D = 1 + beta*A_I =")
46  aif=6/1.642
47  disp(aif,"A_if = A_I/D =")
48  avf=(3.654*12)/1
49  format(7)
50  disp(avf,"A_vf = Vo/V_s = -I_c2/I_s * R_c2/R_s =
        A_if*R_c2 / R_s =")
51  ri1=(848*21900)/(21900+848)
52  disp(ri1,"R_i1(in ohm) = R || R_i1 =")
53  rif=816.38/1.642
54  format(6)
55  disp(rif,"R_if(in ohm) = R_i/D =")
56  disp("Ro = infinity    because h_oe = 0")
57  disp("Therefore,  R_of = Ro*D = infinity")
58  disp("R''_o = Ro || R_c2 = infinity || 12 K = 12 K")
59  disp("R''_of = R''_o * 1+beta*A_i/1+beta*A1 = R''_o
        = R_c2 = 12K")
```

Scilab code Exa 1.28 `Avf and Rif and Rof`

```
1  //Example 1.28
2  clc
3  disp("Step 1: Identify topology")
4  disp("  The feedback voltage is applied across R_e1
        = 1.5 k-ohm, which is in series with input signal
        . Hence feedback is voltage series feedback")
5  disp("")
```

```
 6  disp("Step 2 and step 3: Find input and output
        circuit")
 7  disp("  To find input circuit , set Vo = 0 , which
        gives parallel combination of R_e1 with R_f at E1
         as shown in fig.1.80. To find ouput circuit , set
         I_i = 0 by opening the input node, E1 at emitter
         of Q1, which gives the series combination of R_f
         and R_e1 across the output. The resultant
        circuit is shown in fig.1.80")
 8  disp("")
 9  disp("Step 4: Find the open loop voltage gain (Av)")
10  rl2=(2.2*57.5)/(2.2+57.5)   // in k-ohm
11  format(6)
12  disp(rl2,"  R_L2(in k-ohm) = R_c2 || (Rf + R_e1) =")
13  disp("Since hoe*R_L2 = 10^-6*2.119 k-ohm = 0.002119
        is less than 0.1 we use approximate analysis.")
14  disp("  A_i2 = -h_fe = -200")
15  disp("  R_i2 = hie = 2 k-ohm")
16  av2=(-200*2.119)/2
17  disp(av2,"  A_v2 = A_i2*R_L2 / R_i2 =")
18  rl1=(120*2)/(122)   // in k-ohm
19  disp(rl1,"  R_L1(in k-ohm) = R_C1 || R_i2 =")
20  disp("Since hoe*R_L1 = 10^-6*1.967 = 0.001967 is
        less than 0.1 we use approximate analysis.")
21  disp("  A_i1 = -hfe = -200")
22  ri1=2+(201*((1.5*56)/(57.5)))   // in k-ohm
23  format(7)
24  disp(ri1,"  R_i1(in k-ohm) = hie + (1+hfe)*Re =")
25  av1=(-200*1.967)/295.63
26  format(5)
27  disp(av1,"Therefore ,  A_v1 = A_i1*R_L1 / R_i1 =")
28  disp("The overall gain without feedback is")
29  av=-1.33*-211.9
30  format(7)
31  disp(av,"  Av = A_v1 * A_v2 =")
32  disp("")
33  disp("Step 5: Calculate beta")
34  beta=1.5/57.5
```

```
35  format(6)
36  disp(beta," beta = Vf / Vo =")
37  disp("")
38  disp("Step 6: calculate D, A_vf, R_if, R_of")
39  d=1+(0.026*281.82)
40  disp(d," D = 1 + Av*beta =")
41  avf=281.82/8.327
42  disp(avf,"Therefore, A_vf = Av / D =")
43  ri=(295.63*150)/(295.63+150)   // in k-ohm
44  format(5)
45  disp(ri," Ri(in k-ohm) = R_i1 || R =")
46  rif=99.5*8.327   // in k-ohm
47  format(7)
48  disp(rif," R_if(in k-ohm) = Ri *D =")
49  disp(" Ro = 1/hoe = 1 M-ohm")
50  rof=((1*10^6)/8.327)*10^-3   // in k-ohm
51  format(4)
52  disp(rof," R_of(in k-ohm) = Ro / D =")
53  ro=(1000*2.119)/(2.119+1000)   // in k-ohm
54  format(7)
55  disp(ro," R''o(in k-ohm) = Ro || R_c2 || (Rf+R_e1)
       = Ro || R_L2 =")
56  rof=(2.1145*10^3)/8.327   // in ohm
57  format(4)
58  disp(rof," R''_of(in ohm) = R''o / D =")
```

Scilab code Exa 1.29 `Avf and Rif and Rof`

```
1  //Example 1.29
2  clc
3  disp("Fig 1.83 shows current shunt feedback
       amplifier open circuit transfer gain")
4  disp("A_I = -I_c2/I_s = -I_c2/I_b2 * I_b2/I_c1 *
       I_c1/I_b1 * I_b1/I_s")
5  disp("I_c2/I_b2 = A_i2 = -h_fe = -100")
```

```
 6  disp("−I_c1/I_b1 = 100")
 7  ri2=1+(101*(1/10.1))
 8  format(3)
 9  disp(ri2,"R_i2(in k−ohm) = h_ie + (1+h_fe)(R_e2||R
        '') =")
10  ibc=-2.2/14.2
11  format(6)
12  disp(ibc,"I_b2/I_c1 = −R_c1 / R_c1+(R_i2+R_b2) =")
13  disp("I_b1/I_s = R/R+h_ie")
14  r=(10.1*10^3)/11.1
15  disp(r,"R(in ohm) = R_s || (R''+R_e) =")
16  ibs=0.9099/1.9099
17  disp(ibs,"Therefore, I''_b/I_s =")
18  ai=100*0.155*100*0.476
19  disp(ai,"Therefore, A_I =")
20  disp("Calculate of beta:")
21  disp("I_f = −I_o*R_e2 / R_e2+R''")
22  disp("beta = I_f/Io = R_e2/R_e2+R'' = 100/100+10K")
23  d=1+(9.9*737.8*10^-3)
24  format(4)
25  disp(d,"D = 1 + beta*A_I =")
26  disp("A_if = A_I/D = 88.89")
27  avf=88.89*2.2
28  format(8)
29  disp(avf,"A_vf = Vo/V_s = −I_c2/I_s * R_c2/R_s =
        A_if*R_c2 / R_s =")
30  ri1=(909.9*1000)/1909.9
31  format(4)
32  disp(ri1,"R_i1(in ohm) = R || h_ie =")
33  rif=476/8.3
34  format(6)
35  disp(rif,"R_if(in ohm) = R_i/D =")
36  disp("R_of = R_c2 = 2.2 k−ohm")
```

Scilab code Exa 1.30 voltage gain and feedback voltage and output voltage

```
1  //Example  1.30
2  clc
3  disp(" (i) Voltage gain with feedback  A_f = A_v/D")
4  d=1+(0.02*100)
5  format(2)
6  disp(d,"Where,  D = 1 + beta*A_v =")
7  avf=100/3
8  format(6)
9  disp(avf,"Therefore,  A_vf =")
10 vf=0.02*33.33*40
11 disp(vf,"(ii) Feedback voltage  V_f(in mV) = beta*Vo
      = beta*A_vf*V_i =")
12 vo=33.33*40*10^-3
13 disp(vo,"(iii) Output voltage  Vo(in V) = A_vi*V_i =
      ")
```

Scilab code Exa 1.31 voltage gain and input and output impedance

```
1  //Example  1.31
2  disp("For beta = -0.01,  D = 1+beta*A_v = 11")
3  avf=-100/11
4  format(5)
5  disp(avf,"(i) Voltage gain  A_vf = A_v/D =")
6  rif=10*11
7  disp(rif,"(ii) Input impedance  R_if(in k-ohm) = R_i
      *D =")
8  rof=20/11
9  disp(rof,"(iii) Output impedance  R_of(in k-ohm) =
      Ro/D =")
10 disp("For beta = -0.01,  D = 1+beta*A_v = 51")
11 avf=-100/51
12 disp(avf,"(i) Voltage gain  A_vf = A_v/D =")
13 rif=10*51
14 disp(rif,"(ii) Input impedance  R_if(in k-ohm) = R_i
      *D =")
```

```
15  rof =20/51
16  format (6)
17  disp ( rof , " ( i i i )  Output  impedance   R_of ( in  k−ohm ) =
        Ro/D =" )
```

Scilab code Exa 1.32 `voltage`

```
1
2  //Example  1.32
3  clc
4  disp ( " Voltage  series  feedback  is  the  most  commonly
        used  feedback  arrangement  in  cascaded  amplifier .
        Voltage  series  feedback  increases  input
        resistance  and  decreases  output  resistance .
        Increase  in  input  resistance  reduces  the  loading
        effect  of  previous  stage  and  decreses  in  output
        resistance  reduces  the  loading  effect  of
        amplifier  itself  for  driving  the  next  stage . " )
```

Scilab code Exa 1.33 `feedback factor`

```
1  //Example  1.33
2  clc
3  disp ( " We  know  that , " )
4  disp ( " A_vf = A_v / 1+beta∗A_v" )
5  disp ( " Therefore ,  A_vf + beta∗A_v∗A_vf = A_v" )
6  b=20/2400
7  format (8)
8  disp (b , " Therefore ,  beta = A_v−A_vf / A_v∗A_vf =" )
```

Scilab code Exa 1.34 `gain with feedback and new bandwidth`

```
1  //Example  1.34
2  clc
3  disp("Given:  A_v  mid  =  40 ,  f_L  =  100  Hz ,  f_H  =  15
      kHz  and  beta  =  0.01")
4  avf =400/(1+(0.01*400))
5  format (3)
6  disp(avf ,"(i)  A_vf  =  A_v  mid  /  1+beta*A_v  mid  =")
7  flf =100/(1+(0.01*400))
8  disp(flf ,"(ii)  f_Lf  =  f_L  /  1+beta*A_v  mid  =")
9  fhf =(15)*(1+(0.01*400))   // in  kHz
10 disp(fhf ,"(iii)  f_Hf(in  kHz)  =  f_H  *  (1+beta*A_v  mid
      )  =")
11 bw =75 -0.02   // in  kHz
12 format (6)
13 disp(bw ,"(iv)  New  Bandwidth(in  kHz)  =  f_Hf  -  f_Lf  ="
      )
```

Chapter 2

Oscillators

Scilab code Exa 2.1 verify barkhausen criterion

```
1  //example 2.1
2  clc
3  disp("From the given information we can write,")
4  disp("    A = -16*10^6/j*omega    and    beta =
      10^3/[2*10^3+j*omega]^2")
5  disp("To verify the Barkhausen condition means to
      verify whether |A*beta| = 1 at a frequency for
      which A*beta = 0 degree. Let us express, A*beta
      in its rectangluar form.")
6  disp("  A*beta = -16*10^6*10^3 / j*omega*[2*10^3+j*
      omega]^2 = -16*10^9 / j*omega*[4*10^6+4*10^3*j*
      omega+(j*omega)^2]")
7  disp("            = -16*10^9 / j*omega*[4*10^6+4*10^3*j
      *omega-omega^2]        as j*2 = -1")
8  disp("            = -16*10^9 / 4*10^6*j*omega+4*10^3*j
      ^2*omega^2-j*omega^3]")
9  disp("            = -16*10^9 / j*omega*[4*10^6-omega
      ^2]-[omega^2*4*10^3]")
10 disp("Rationalising the denominator function we get,
      ")
11 disp("  A*beta = -16*10^9[-omega^2*4*10^3 - j*omega
```

46

```
   *[4*10^6−omega^2]] / [−[omega^2*4*10^3]−j*omega
   *[4*10^6−omega^2]]*[−omega^2*4*10^3 − j*omega
   *[4*10^6−omega^2]]")
12 disp(" Using (a−b)(a+b) = a^2 − b^2 in the
   denominator ,")
13 disp(" A*beta = 16*10^9[omega^2*4*10^3+j*omega
   *[4*10^6−omega^2]] / [−omega^2*4*10^3]^2 − [ j*
   omega*[4*10^6−omega^2]^2")
14 disp(" A*beta = 16*10^9[omega^2*4*10^3+j*omega
   *[4*10^6−omega^2]] / 16*10^6*omega^4 + omega
   ^2(4*10^6−omega^2)^2")
15 disp("Now to have A*beta = 0 degree , the imaginary
    part of A*beta must be zero. This is possible
   when ,")
16 disp("Therefore , omega*(4*10^6 − omega^2) = 0")
17 disp("Therefore , omega = 0 or 4*10^6 − omega^2 =
   0")
18 disp("Therefore , omega^2 = 4*10^6
   Neglecting zero value of frequency")
19 disp("Therefore , omega = 2*10^3 rad/sec")
20 disp("At this frequency |A*beta| can be obtained as ,
   ")
21 disp(" |A*beta| = 16*10^9[4*10^3*omega^2] /
   16*10^6*omega^4+omega^2[4*10^6−omega^2]^2
   at omega = 2*10^3")
22 ab=(2.56*10^20)/(2.56*10^20)
23 disp(ab," |A*beta| =")
24 disp("Therefore , At omega = 2*10^3 rad/sec , A*beta
   = 0 degree as imaginary part is zero while |A*
   beta| = 1. Thus Barkhausen Criterion is satisfied
   .")
25 disp("The frequency at which circuit will oscillate
   is the value of omega for which |A*beta| = 1 and
    A*beta = 0 degree at the same time")
26 disp("i.e. omega = 2*10^3 rad/sec")
27 disp("But omega = 2*pi*f")
28 f=(2*10^3)/(2*%pi)  // in Hz
29 format(9)
```

```
30 disp(f,"Therefore,  f(in Hz) = omega / 2 pi =")
```

Scilab code Exa 2.2 `C and hfe`

```
1  //Example 2.2
2  clc
3  disp("Refering to equation(1),")
4  ri=(25*57*1.8)/((57*1.8)+(25*1.8)+(25*57))  // in k-
       ohm
5  format(6)
6  disp(ri,"  R''_i(in k-ohm) = R1 || R2 || h_ie =")
7  disp("Now  R''_i + R3 = R")
8  r3=7.1-1.631  // in k-ohm
9  format(5)
10 disp(r3,"Therefore,  R3(in k-ohm) = R - R''_i =")
11 k=20/7.1
12 format(6)
13 disp(k,"  K = R_C / R =")
14 disp("Now  f = 1 / 2*pi*R*C*sqrt(6+4K)")
15 c=(1/(sqrt(6+(4*2.816))*2*%pi*7.1*10*10^6))*10^12
       // in pF
16 format(8)
17 disp(c,"Therefore,  C(in pF) =")
18 disp("  h_fe >= 4K + 23 + 29/K")
19 hfe=(4*2.816)+23+(29/2.816)
20 format(7)
21 disp(hfe,"  h_fe >=")
```

Scilab code Exa 2.3 `frequency of oscillations`

```
1  //Example 2.3
2  clc
```

```
3 disp ("The  given  values  are ,  R =  4.7  k−ohm  and  C =
      0.47  uF")
4 f=1/(2*%pi*sqrt(6)*(4.7*10^3)*(0.47*10^-6))   // in
      Hz
5 format(7)
6 disp(f,"   f(in  Hz)  =  1  /  2*pi*sqrt(6)*R*C =")
```

Scilab code Exa 2.4 `R and C`

```
1 //Example  2.4
2 clc
3 disp ("f  =  1  kHz")
4 disp ("Now   f  =  1  /  2*pi*sqrt(6)*R*C")
5 disp ("Choose   C =  0.1  uF")
6 r=1/(sqrt(6)*2*%pi*0.1*1*10^-3)   // in  ohm
7 format(8)
8 disp(r,"Therefore ,   R(in  ohm)  =  ")
9 disp ("Choose   R =  680  ohm     standard  value")
```

Scilab code Exa 2.5 `C and RD`

```
1 //Example  2.5
2 clc
3 disp ("Using  the  expression  for  the  frequency")
4 disp ("Now,   f  =  1  /  2*pi*R*C*sqrt(6)")
5 f=(1/(sqrt(6)*2*%pi*9.7*5*10^6))*10^9   // in  nF
6 format(5)
7 disp(f,"Therefore ,   C(in  nF)  =")
8 disp ("Now  using  the  equation(27)")
9 disp ("   |A|  =  g_m  *  R_L")
10 disp ("Therefore ,   |A|  >=  29")
11 disp ("Therefore ,   g_m  *  R_L >=  29")
12 rl=(29/(5000*10^-6))*10^-3   // in  k−ohm
```

```
13  format(4)
14  disp(rl,"Therefore, R_L(in k−ohm) >= 29 / g_m =")
15  disp("  R_L = R_D*r_d / R_D+r_d")
16  rd=(40)/4.8823
17  format(5)
18  disp(rd,"  Therefore, R_D(in k−ohm) = ")
19  disp("While for minimum value of R_L = 5.8 k−ohm")
20  disp("                              R_D = 6.78 k−ohm")
```

Scilab code Exa 2.6 `frequency of oscillator`

```
1   //exmaple 2.6
2   clc
3   disp("The circuit is Wien bridge oscillator using op
        −amp. The gain of the op−amp is")
4   a=1+3
5   disp(a,"A = 1 + R3/R4 =")
6   disp("So  A > 3")
7   disp("This satisfies the required oscillating
        condition. The feedback is given to non−inverting
         terminal ensuring the zero phase shift. Hence
        the circuit will work as the oscillator.")
8   f=1/(2*%pi*5.1*0.001)
9   format(8)
10  disp(f,"f(in kHz) = 1 / 2*pi*R*C =")
11  disp("This will be the frequency of oscillations")
```

Scilab code Exa 2.7 `min and max R2`

```
1   //Example 2.7
2   clc
3   disp("The frequency of the oscillator is given by,")
4   disp("  f = 1 / 2*pi*sqrt(R1*R2*C1*C2)")
```

```
5 disp("For     f = 10 kHz,")
6 r2=(1/(4*(%pi^2)*(100*10^6)*(10*10^3)*(0.001*10^-12)
     ))   // in k-ohm
7 format(6)
8 disp(r2,"Therefore,  R2(in k-ohm) =")
9 disp("For     f = 50 kHz,")
10 r2=(1/(4*(%pi^2)*(2500*10^6)*(10*10^3)
     *(0.001*10^-12)))   // in k-ohm
11 format(6)
12 disp(r2,"Therefore,  R2(in k-ohm) =")
13 disp("So minimum value of R2 is 1.013 k-ohm while
     the maximum value of R2 is 25.33 k-ohm")
```

Scilab code Exa 2.8 range over which capacitor is varied

```
1 //Example 2.8
2 clc
3 disp("The frequency is given by,")
4 disp("   f = 1 / 2*pi*sqrt(C*L_eq)")
5 leq=(2*10^-3)+(20*10^-6)
6 format(8)
7 disp(leq,"where  L_eq(in kHz) = L1 + L2 =")
8 disp("For  f = f_max = 2050 kHz")
9 format(5)
10 c=(1/(4*(%pi^2)*((2050*10^3)^2)*0.00202))*10^12   //
      in pF
11 disp(c,"Therefore,  C(in pF) =")
12 disp("For  f = f_min = 950 kHz")
13 c=(1/(4*(%pi^2)*((950*10^3)^2)*0.00202))*10^12   //
      in pF
14 format(6)
15 disp(c,"Therefore,  C(in pF) =")
16 disp("Hence C must be varied from 2.98 pF to 13.89
      pF, to get the required frequency variation.")
```

Scilab code Exa 2.9 Frequency of oscillations of a Hartley oscillator

```
1  //Example 2.9
2  clc
3  disp("The given values are ,")
4  disp("  L1 = 0.5 mH,  L2 = 1 mH,  C = 0.2 uF")
5  disp("Now  f = 1 / 2*pi*sqrt(C*L_eq)")
6  leq=0.5+1  // in mH
7  disp(leq,"and  L_eq(in mH) = L1 + L2 =")
8  f=(1/(2*%pi*sqrt(1.5*0.2*10^-9)))*10^-3  // in kHz
9  format(5)
10 disp(f,"Therefore ,  f(in kHz) =")
```

Scilab code Exa 2.10 range of C

```
1  //Example 2.10
2  clc
3  disp("L1 = 20 uH,  L2 = 2 mH")
4  leq=(20*10^-6)+(2*10^-3)
5  format(10)
6  disp(leq,"Therefore ,  L_eq(in H) = L1 + L2 =")
7  disp("For f = f_max = 2.5 MHz")
8  disp("f = 1 / 2*pi*sqrt(C*L_eq)")
9  c=(1/(((2*%pi*2.5*10^6)^2)*(2.002*10^-3)))*10^12
10 format(7)
11 disp(c,"Therefore ,  C(in pF) =")
12 disp("For f = f_min = 1 MHz")
13 c=(1/(((2*%pi*1*10^6)^2)*(2.002*10^-3)))*10^12
14 format(8)
15 disp(c,"Therefore ,  C(in pF) =")
16 disp("This C must be varied from 2.0244 pF to
       12.6525 pF")
```

Scilab code Exa 2.11 Frequency of oscillations of a transistorised Colpitts oscill

```
1 //Example 2.11
2 clc
3 disp("The equivalent capacitance is given by,")
4 ceq=(150*1.5*10^-21)/((150*10^-12)+(1.5*10^-9))  //
      in F
5 format(12)
6 disp(ceq,"  C_eq(in F) = C1*C2 / C1+C2 =")
7 disp("Now,   f = 1 / 2*pi*sqrt(L*C_eq)")
8 f=(1/(2*%pi*sqrt(50*136.363*10^-18)))*10^-6  // in
      MHz
9 format(6)
10 disp(f,"  f(in MHz) =")
```

Scilab code Exa 2.12 value of C

```
1 //Example 2.12
2 clc
3 disp("The given values are,")
4 disp("    L = 100 uH,    C1 = C2 = C    and    f = 500
      kHz")
5 disp("Now,     f = 1 / 2*pi*sqrt(L*C_eq)")
6 ceq=1/(4*(%pi^2)*(100*10^-6)*((500*10^3)^2))  // in
      F
7 format(11)
8 disp(ceq,"Therefore, C_eq(in F) =")
9 disp("but     C_eq = C1*C2 / C1+C2     and C1 = C2 = C
      ")
10 disp("Therefore,   C_eq = C / 2")
11 c=1.0132*2
```

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```
12  format(6)
13  disp(c,"Therefore ,   C(in  nF) =")
```

Scilab code Exa 2.13 value of inductor

```
1  //Example  2.13
2  clc
3  disp("Given ,  C1 = 100  pF,   C2 = 50  pF,   f = 10  MHz,
        L = ?")
4  ceq=(5000*10^-24)/(150*10^-12)
5  format(10)
6  disp(ceq,"C_eq(in  F) = C1*C2 / C1+C2 = ")
7  disp("f = 1 / 2*pi*sqrt(L*C_eq)")
8  l=(1/(4*(%pi^2)*(33.33*10^-12)*((10*10^6)^2)))*10^6
        // in  F
9  format(4)
10 disp(l,"Therefore ,  L(in  uH) =")
```

Scilab code Exa 2.14 range of tuning capacitor

```
1  //Example  2.14
2  clc
3  disp("For  a  tuned  collector  oscillator ,")
4  disp("f_r = 1 / 2*pi*sqrt(L*C)")
5  disp("where   L = 30  uH   and  f_r  to  be  varied  300  kHz
        to  1.5  MHz")
6  disp("For   f_r = 300  kHz")
7  c1=(1/(4*(%pi^2)*(30*10^-6)*((300*10^3)^2)))*10^9
        // in  nF
8  format(7)
9  disp(c1,"Therefore ,  C1(in  nF) =")
10 disp("For   f_r = 1.5  MHz")
```

```
11  c2 =(1/(4*(%pi^2)*(30*10^-6)*((1.5*10^6)^2)))*10^12
        // in pF
12  format (8)
13  disp(c2 ,"Therefore , C2(in pF) =")
14  disp("Hence C must be varied over 375.264 pF to
        9.3816 nF, to achieve frequency variations")
```

Scilab code Exa 2.15 series and parallel resonant frequency

```
1  //Example 2.15
2  clc
3  fs =(1/(2*%pi*sqrt(0.4*0.085*10^-12)))*10^-6   // in
       MHz
4  format (6)
5  disp(fs ,"(i)  f_s(in MHz) = 1 / 2*pi*sqrt(L*C) =")
6  ceq =0.085/1.085   // in pF
7  disp(ceq ,"(ii)  C_eq(in pF) = C*C_M / C+C_M =")
8  fp =(1/(2*%pi*sqrt(0.4*0.078*10^-12)))*10^-6   // in
       MHz  (the answer in textbook is wrong)
9  disp(fp ,"Therefore ,  f_p(in MHz) = 1 / 2*pi*sqrt(L*
       C_eq) =")
10 inc =((0.899-0.856)/0.856)*100   // in percentage
11 disp(inc ,"(iii)  %increase =")
12 q =(2*%pi*0.4*0.856*10^6)/(5*10^3)
13 format (8)
14 disp(q ,"(iv)  Q = omega_s*L / R = 2*pi*f_s*L / R =")
```

Scilab code Exa 2.16 series and parallel resonating frequency

```
1  //Example 2.16
2  clc
3  disp("    C_M = 2 pF")
4  fs =(1/(2*%pi*sqrt(2*0.01*10^-12)))*10^-6   // in MHz
```

```
5  format(6)
6  disp(fs,"Now   f_s(in MHz) = 1 / 2*pi*sqrt(L*C) =")
7  ceq=(2*0.01*10^-24)/(2.01*10^-12)   // in F
8  format(9)
9  disp(ceq,"   C_eq(in F) = C_M*C / C_M+C =")
10 fp=(1/(2*%pi*sqrt(2*9.95*10^-15)))*10^-6   // in MHz
11 format(6)
12 disp(fp,"   f_p = 1 / 2*pi*sqrt(L*C_eq) =")
13 disp("So f_s and f_p values are almost same.")
```

Scilab code Exa 2.17 frequency of oscillations and min value of hfe

```
1  //Example 2.17
2  clc
3  disp("R = 6 k-ohm,   C = 1500 pF,   R_C = 18 k-ohm")
4  k=18/6
5  disp(k,"Now     K = R_C / R =")
6  disp("Therefore,   f = 1 / 2*pi*R*C*sqrt(6+4K)")
7  f=(1/(2*%pi*(6*10^3)*(1500*10^-12)*sqrt(6+12)))
      *10^-3   // in kHZ
8  format(6)
9  disp(f,"   f(in kHz) =")
10 hfe=(4*3)+23+(29/3)
11 disp(hfe,"   (h_fe)min = 4K + 23 + 29/K =")
```

Scilab code Exa 2.18 R and hfe

```
1  //Example 2.18
2  clc
3  disp("Refering to equation(1) of section 4.5.3, the
      input impedance is given by,")
4  disp("R''_i = R1 || R2 || h_ie")
```

```
5  disp("Now  R1 = 25 k-ohm,   R2 = 47 k-ohm,   and   h_ie
       = 2 k-ohm")
6  format(7)
7  ri=(25*47*2)/((47*2)+(25*2)+(25*47))   // in k-ohm
8  disp(ri,"Therefore,  R''_i(in k-ohm) =")
9  disp("  K = R_C / R")
10 disp("Now  R_C = 10 k-ohm         ...given")
11 disp("Now  f = 1 / 2*pi*R*C*sqrt(6+4K)")
12 disp("Therefore,  R*sqrt(6+4K) = 31830.989")
13 disp("Now  K = R_C / R = 10*10^3 / R")
14 disp("Therefore,  R*sqrt(6+(40*10*10^3/R)) =
       31830.989")
15 disp("Therefore,  R^2*(6+(40*10*10^3/R)) =
       (31830.989)^2")
16 R=poly(0,'R')
17 p1=6*R^2+(40*10^3)*R-(31830.989)^2
18 t1=roots(p1)
19 ans1=t1(1)
20 format(6)
21 disp((-ans1)*10^-3,"Therefore,  R(in k-ohm)=
                  Neglecting negative value")
22 k=10/16.74
23 format(7)
24 disp(k,"Therefore,  K = R_C / R =")
25 disp("Therefore,  h_fe >= 4K + 23 + 29/K")
26 hfe=(4*0.5973)+23+(29/0.5973)
27 format(6)
28 disp(hfe,"  h_fe >=")
```

Scilab code Exa 2.19 change in frequency of oscillations

```
1  //Example 2.19
2  clc
3  ceq=((0.02*12*10^-24)/(12.02*10^-12))*10^12   // in
     pF
```

```scilab
 4  format(8)
 5  disp(ceq,"  C_eq(in pF) = C1*C2 / C1+C2 =")
 6  fs=(1/(2*%pi*sqrt(50*0.02*10^-15)))*10^-6   // in MHz
 7  format(7)
 8  disp(fs,"Therefore,  f_s(in MHz) = 1 / 2*pi*sqrt(L*
        C1) =")
 9  fp=(1/(2*%pi*sqrt(50*0.01996*10^-15)))*10^-6   // in
        MHz
10  format(7)
11  disp(fp,"Therefore,  f_p(in MHz) = 1 / 2*pi*sqrt(L*
        C_eq) =")
12  disp("Let C_s = 5 pF connected across the crystal")
13  c2=12+5
14  disp(c2,"Therefore,  C''2(in pF) = C2 + C_x =")
15  format(10)
16  ceq1=0.019976
17  disp(ceq1,"Therefore,  C''_eq(in pF) = C1*C''2 / C1+
        C''2 =")
18  fp1=5.03588
19  disp(fp1,"Therefore,  f''_p(in MHz) = 1 / 2*pi*sqrt(
        L*C_eq) =")
20  disp("New C_x = 6 pF is connected then,")
21  c21=12+6
22  disp(c21,"  C''''2(in pF) = C2 + C_x =")
23  ceq2=0.0199778
24  disp(ceq2,"Therefore,  C''''_eq(in pF) = C1*C''''2 /
        C1+C''''2 =")
25  fp2=5.035716
26  disp(fp2,"Therefore,  f''''_p(in MHz) = 1 / 2*pi*
        sqrt(L*C''''_eq) =")
27  c=(5.03588-5.035716)*10^6
28  disp(c,"Therefore,  Change(in Hz) = f''_p - f''''_p
        =")
```

Scilab code Exa 2.20 `C and hfe`

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```
1  //Example 2.20
2  clc
3  ri=(22*68*2)/((68*2)+(22*2)+(22*68))
4  format(7)
5  disp(ri,"R''_i(in k−ohm) = R1 || R2 || h_fe =")  //
      answer in textbook is wrong
6  disp("Now  R''_i + R3 = R")
7  r3=6.8-1.8243
8  disp(r3,"Therefore,  R3(in k−ohm) = R − R''_i =")
9  k=20/6.8
10 disp(k,"K = R_C / R =")
11 disp("Therefore,  f = 1 / 2*pi*RC*sqrt(6+4K)")
12 c=(1/(2*%pi*6.8*50*sqrt(6+(4*2.9411))*10^6))*10^12
13 format(8)
14 disp(c,"Therefore,  C(in pF) =")
15 hfe=(4*2.9411)+23+(29/2.9411)
16 disp(hfe,"And  h_fe >= 4 K + 23 + 29/K >=")
```

Scilab code Exa 2.21 `min and max value of R2`

```
1  //Example 2.21
2  clc
3  disp("The frequency of the oscillator is given by,")
4  disp("  f = 1 / 2*pi*sqrt(R1*R2*C1*C2)")
5  disp("For  f = 20 kHz,")
6  r2=(1/(4*(%pi^2)*((20*10^3)^2)*(10*10^3)
      *((0.001*10^-6)^2)))*10^-3
7  format(5)
8  disp(r2,"Therefore,  R2(in k−ohm) =")
9  disp("For  f = 70 kHz,")
10 r2=(1/(4*(%pi^2)*((70*10^3)^2)*(10*10^3)
      *((0.001*10^-6)^2)))*10^-3
11 format(6)
12 disp(r2,"Therefore,  R2(in k−ohm) =")
13 disp("So minimum value of R2 is 0.517 k−ohm while
```

the maximum value of R2 is 6.33 k–ohm")

Scilab code Exa 2.22 `gain of the transistor`

```
1  //Example 2.22
2  clc
3  disp("For a Hartley oscillator ,")
4  disp("   f = 1 / 2*pi*sqrt(L_eq*C)           where L_eq
       = L1 + L2 + 2M')
5  leq=(1/(4*(%pi^2)*((168*10^3)^2)*(50*10^-12)))*10^3
       // in mH
6  format(6)
7  disp(leq,"Therefore ,   L_eq(in mH) =")
8  l2=((17.95*10^-3)-(15*10^-3)-(5*10^-6))*10^3   // in
       mH
9  disp(l2,"Therefore ,   L2(in mH) =")
10 hfe=((15*10^-3)+(5*10^-6))/((2.945*10^-3)+(5*10^-6))
11 format(5)
12 disp(hfe,"Now     h_fe = L1+M / L2+M =")
```

Scilab code Exa 2.24 `percentage change in frequency`

```
1  //Example 2.24
2  clc
3  disp("(i)  Assume one perticular coupling direction
       for which ,")
4  disp("   L_eq = L1 + L2 + 2M = 0.25 mH")
5  format(8)
6  f=(1/(2*%pi*sqrt(0.25*100*10^-15)))*10^-6   // in MHz
7  disp(f,"Therefore ,   f(in MHz) = 1 / 2*pi*sqrt(L_eq*C
       ) =")
8  disp("Let the direction of coupling is reversed ,")
9  disp("   L_eq = L1 + L2 − 2M = 0.15 mH")
```

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```
10  fd=(1/(2*%pi*sqrt(0.15*100*10^-15)))*10^-6   // in
       MHz
11  format(7)
12  disp(fd,"Therefore,  f''(in MHz) = 1 / 2*pi*sqrt(
       L_eq*C) =")
13  pc=((1.2994-1.00658)/1.00658)*100   // in percentage
14  format(6)
15  disp(pc,"Therefore,  % change = f''-f/f * 100 =")
16  disp("(ii)  Let us assume direction of coupling such
        that,")
17  disp("   L_eq = L1 + L2 + 2M = 0.25 mH")
18  disp("    C_t = Trim capacitor = 100 pF")
19  disp("Therefore,  C_eq = C*C_t / C+C_t = 50 pF")
20  f1=(1/(2*%pi*sqrt(0.25*50*10^-15)))*10^-6   // in MHz
21  format(7)
22  disp(f1,"Therefore,  f = 1 / 2*pi*sqrt(L_eq*C_eq) ="
       )
23  disp("If now direction of coupling is reversed,")
24  disp("   L_eq = L1 + L2 - 2M = 0.15 mH")
25  f2=(1/(2*%pi*sqrt(0.15*50*10^-15)))*10^-6   // in MHz
26  format(8)
27  disp(f2,"Therefore,  f'' = 1 / 2*pi*sqrt(L_eq*C_eq)
       =")
28  pc1=((1.83776-1.4235)/1.4235)*100
29  format(7)
30  disp(pc1,"Therefore,  % change = f''-f/f * 100 =")
```

Scilab code Exa 2.25 design a RC phase shift oscillator

```
1  //Example 2.25
2  clc
3  disp("For RC phase shhift oscillator,")
4  disp("   h_fe = 4K + 23 + 29/K           ...given
       h_fe = 150")
5  disp("Therefore,   150 = 4K + 23 + 29/K")
```

```
6  disp("Therefore ,   4K^2 − 127K + 29 = 0")
7  K=poly(0,'K')
8  p1=4*K^2-127*K+29
9  t1=roots(p1)
10 format(6)
11 disp(t1,"Therefore , K =")
12 disp("   f = 1 / 2*pi*R*C*sqrt(6+4K)        ...given
       f = 5 kHz")
13 disp("Therefore ,Choose    C = 100 pF")
14 r=(1/(2*%pi*(1000*10^-12)*(5*10^3)*sqrt(6+(4*0.23))))
       )*10^-3   // in k−ohm
15 format(3)
16 disp(r,"Therefore ,   R(in k−ohm) =")
17 disp("   K = R_C / R   i.e.   R_C = KR = 2.7 k−ohm")
18 disp("Neglecting effect of biasing resistances
       assuming them to be large and selecting
       transistor with h_ie = 2 k−ohm")
19 disp("   R''_i = h_ie = 2 k−ohm")
20 disp("Therefore ,Last resistance in phase network")
21 r3=12-2
22 disp(r3,"   R3 = R − R''_i =")
23 disp("Using the back to back connected zener diodes
       of 9.3 V (Vz) each at the output of emitter
       follower and using this at the output of the
       oscillator , the output amplitude can be
       controlled to 10 V i.e. 20 V peak to peak. The
       zener diode 9.3V and forward biased diode of 0.7
       V gives total 10 V")
24 disp("The designed circuit is shown in fig.2.58")
```

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

Scilab code Exa 2.26 frequency of oscillations and feedback voltage and C1

```
1  //Example  2.26
2  clc
3  disp(" (1)  f  =  1  /  2* pi * sqrt (L*C_eq )")
4  ceq =(100*500)/600
5  format (7)
6  disp(ceq ," Where   C_eq (in  pF)  =  C1*C2  /  C1+C2  =")
7  f =(1/(2*%pi* sqrt (40*83.333*10^ -15)))*10^ -3
8  format (8)
9  disp(f," f (in  kHz)  =")
10 disp(" (2)  The  input  voltage  is  not  required  for  the
         oscillator . The  feedback  voltage , which  is  the
         part  of  the  output  voltage  is  enough  to  drive  the
          oscillator ")
11 disp(" V0  =  10  V")
12 disp(" For  Colpitts  oscillator ,  gain  =  C2  /  C1")
13 gain =500/100
14 disp(gain ," Therefore ,   Gain  =")
15 fv =10/5
16 disp(fv ," Therefore ,   Feedback  voltage (in  V)  =  V0  /
         Gain  =")
17 disp(" (3)  Minimum  gain  =  C2/C1  =  5")
18 disp(" h_fe (min)  =  C2/C1  =  5")
19 disp(" (4)  Gain  =  10  =  C2/C1")
20 c1 =500/10
21 disp(c1 ," Therefore ,   C1(in  pF)  =")
22 disp(" (5)  For  C1  =  50  pF   and   C2  =  500  pF")
23 ceq =(50*500)/550
24 format (8)
25 disp(ceq ," Where   C_eq (in  pF)  =  C1*C2  /  C1+C2  =")
26 f =(1/(2*%pi* sqrt (40*45.4545*10^ -15)))*10^ -3
27 disp(f," f (in  kHz)  =  1  /  2* pi * sqrt (L*C_eq )  =")
```

Scilab code Exa 2.27 `design colpitts oscillator`

```
1  //Example  2.27
```

```
2 clc
3 disp("The frequency required is, f = 1 MHz and for
     FET, u = 20")
4 disp("Now  u = C2/C1  for oscillations")
5 disp("Therefore,   20 = C2/C1")
6 disp("Therefore,   C2 = 20*C1      ....(1)")
7 disp("Let  C1 = 0.01 uF  hence  C2 = 0.2 uF")
8 ceq=((0.01*0.2)/(0.21))*10^3
9 format(7)
10 disp(ceq,"Therefore,  C_eq(in nF) = C1*C2 / C1+C2 ="
     )
11 disp("Now  f = 1 / 2*pi*sqrt(L*C_eq)")
12 l=(1/(((2*%pi*1*10^6)^2)*(9.5238*10^-9)))*10^6
13 format(5)
14 disp(l,"Therefore,  L(in uH) =")
15 disp("The baising resistances can be selected as,")
16 disp("R1 = 12 M-ohm  and  R2 = 8 M-ohm")
17 disp("These resistances must be large")
18 disp("The designed circuit is shown in the fig 2.59"
     )
```

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

Scilab code Exa 2.28 frequency of oscillations

```
1 //Example 2.28
2 clc
3 leq=500+5000+600
4 format(5)
5 disp(leq,"L_eq(in uH) = L1 + L2 + 2M =")
6 f=(1/(2*%pi*sqrt(150*6100*10^-18)))*10^-3
7 format(9)
8 disp(f,"f(in kHz) = 1 / 2*pi*sqrt(C*L_eq) =")
```

Scilab code Exa 2.29 `resonating frequencies`

```
1 //Example 2.29
2 clc
3 disp("L_s = 0.8 H,  C_s = 0.08 pF,  R_s = 5 k-ohm,
      C_M = 1 pF")
4 fs=(1/(2*%pi*sqrt(0.8*0.08*10^-12)))*10^-3
5 format(9)
6 disp(fs,"f_s(in kHz) = 1 / 2*pi*sqrt(C_s*L_s) =")
7 ceq=(0.08*10^-12)/1.08
8 format(11)
9 disp(ceq,"C_eq(in F) = C_M*C_s / C_M+C_s =")
10 fp=(1/(2*%pi*sqrt(0.8*7.4074*10^-14)))*10^-3
11 format(9)
12 disp(fp,"Therefore,  f_p(in kHz) = 1 / 2*pi*sqrt(C*
      L_eq) =")
```

Scilab code Exa 2.31 `determine percentage`

```
1 //Example 2.31
2 clc
3 disp("The series and parallel resonating frequencies
       are,")
4 disp("f_s = 1 / 2*pi*sqrt(C*L)  while  f_p = 1 / 2*
      pi*sqrt(L*C_eq)")
5 disp("f_p/f_s = 1/2*pi*sqrt(L*C_eq) * 2*pi*sqrt(LC)
      = sqrt(c/C_eq) but C_eq = C*C_M/C+C_M")
6 fp=sqrt(1+(0.04/2))
7 format(8)
8 disp(fp,"f_p/f_s = sqrt(C/(C*C_M/C+C_M)) = sqrt(C*(C
      +C_M)/C*C_M) = sqrt(1+(C/C_M)) =")
9 disp("f_p = 1.00995*f_s")
```

```
10  inc =0.00995*100
11  disp(inc,"Therefore,   %increase = (1.00995*f_s−f_s /
        f_s)*100 =")
```

Scilab code Exa 2.32 operating frequency and feedback fraction

```
1  //Example  2.32
2  clc
3  disp("C = 20 pF,   L2 = 1000 uH,   L1 = 100 uH,   M =
        20 uH")
4  leq=100+1000+40
5  format(5)
6  disp(leq,"Therefore,   L_eq(in uH) = L1 + L2 + 2M =")
7  f=(1/(2*%pi*sqrt(1140*20*10^-18)))*10^-6
8  format(6)
9  disp(f,"Therefore,   f(in MHz) = 1 / 2*pi*sqrt(L_eq*C
        ) =")
10  disp("The feedback fraction beta is given by,")
11  b=100/1100
12  format(7)
13  disp(b,"beta = V_f/V0 = X_L1 / X_L1+X_L2 = L1 / L1+
        L2 =")
14  disp("It is a Hartley oscillator")
```

Scilab code Exa 2.33 value of C and RD

```
1  //Example  2.33
2  clc
3  disp("Using the expression of the frequency,")
4  disp("f = 1 / 2*pi*RC*sqrt(6)")
5  c=(1/(2*%pi*10*sqrt(6)*10^6))*10^9
6  format(7)
7  disp(c,"Therefore,   C(in nF) =")
```

```
8  disp ( " For FET phase shift oscillator , " )
9  disp ( " | A | = g_m * R_L and | A | >= 29 " )
10  rl = ( 29 / 5000 ) *10^3
11  format (4)
12  disp ( rl , " Therefore , g_m * R_L >= 29 i.e. R_L ( in k−
       ohm ) >=" )
13  disp ( " With R_L = 5.8 k−ohm , " )
14  disp ( " R_L = R_D * r_d / R_D + r_d " )
15  rd = 40 / 5.8965
16  format (7)
17  disp ( rd , " Therefore , R_D ( in k−ohm ) =" )
```

Scilab code Exa 2.34 value of inductance

```
1  // Example 2.34
2  clc
3  disp ( " The name of the oscillator is Pierce
       oscillator " )
4  disp ( " C1 = 1000 pF , C2 = 100 pF , f_s = 1 MHz " )
5  ceq = ( 1000*100*10^-12 ) / 1100
6  format (11)
7  disp ( ceq , " C_eq ( in F ) = C1 * C2 / C1 + C2 =" )
8  disp ( " At resonance , X_L = X_Ceq i.e. 2 * pi * f * L = 1
       / 2 * pi * f * C_eq " )
9  l = ( 1 / ( ( ( 2 * %pi *10^6 )^2 ) * ( 90.909*10^-12 ) ) ) *10^6
10  format (4)
11  disp ( l , " Therefore , L ( in uH ) = 1 / ( 2 * pi * f ) ^2 * C_eq =" )
12  disp ( " The fig 2.61 ( a ) shows the electrical
       equivalent of the crystal " )
13  disp ( " At series resonance , " )
14  disp ( " X_L = X_C for crystal " )
15  disp ( " Therefore , C = 90.909 pF for crystal " )
16  disp ( " The mounting capacitance is about 1 to 2 pF " )
```

Scilab code Exa 2.36 design phase shift oscillator

```
1  //Example  2.36
2  clc
3  disp("f = 2 kHz")
4  disp("f = 1/ 2*pi*R*c*sqrt(6)                ...For
      phase shift oscillator")
5  disp("Choose  C = 1 nF")
6  r=(1/(2*%pi*2*sqrt(6)*10^-6))*10^-3
7  format(7)
8  disp(r,"Therefore,  r(in k-ohm) =")
9  disp("Select FET with g_m = 5000 us and r_d = 50 k-
      ohm")
10 disp("For phase shift oscillator, |A| >= 29 and |A|
      = g_m*R_L")
11 disp("Therefore,  g_m*R_L >= 29")
12 rl=(29/(5000*10^-6))*10^-3
13 disp(rl,"i.e.  R_L(in k-ohm) >= 29/g_m >=")
14 disp("Select  R_L = 6.8 k-ohm")
15 disp("But  R_L = R_D*r_d / R_D+r_d")
16 rd=7.87
17 disp(rd,"Therefore,  R_D(in k-ohm) =")
```

Chapter 3

Multivibrators and Blocking Oscillators

Scilab code Exa 3.1 stable state currents and voltages

```
1  //Example 3.1
2  clc
3  disp("The circuit is similar to the circuit shown in
       the fig 3.2. Assume that Q1 is OFF and Q2 is ON"
       )
4  disp("Case i : Junction voltages of ON transistor
       are neglected")
5  disp("i.e.  V_CE2 = 0 V and V_BE2 = 0 V")
6  disp("As emitter is grounded we can say,")
7  disp("  V_C2 = 0 V and V_B2 = 0")
8  disp("Now draw the equivalent circuit in a part from
       base of Q1 to the collector of Q2 as shown in
       fig. 3.4(a)")
9  vb1=-8*(10/60)
10 format(5)
11 disp(vb1,"Now  V_B1(in V) = - V_BB * (R1 / R1+R2) ="
       )
12 disp("As V_B1 < V_BE (cut-off) i.e. 0.7 V, it
       ensures that Q1 is OFF. To verify whether Q2 is
```

```
        ON or not , calculate I_C2")
13  i1=12/(2.2)
14  disp(i1,"I1(in mA) = V_CC/R_C = ")
15  i2=(8/60)
16  format(6)
17  disp(i2,"I2(in mA) = V_BB / R1+R2 = ")
18  ic=5.45-0.133
19  disp(ic,"Therefore,  I_C2(in mA) = I1 - I2 =")
20  ib=(5.316/30)*10^3
21  disp(ib,"Therefore,  (I_B2)min(in mA) = I_C2 / h_fe(
        min) =")
22  disp("Now to calculate actual I_B2 and verify that
        I_B2 > I_B2(min) let us draw part of circuit
        showing collector of Q1 to base of Q2")
23  disp("Now  I3 = current through R_C and R1, as I_C1
        = 0")
24  i3=12/12.2
25  format(7)
26  disp(i3,"Therefore,  I3(in mA) = V_CC / R_C+R1 =
                    ... as  V_B2 = 0 V")
27  i4=8/50
28  format(5)
29  disp(i4,"and  I4(in mA) = V_B2-V_BB / R2 =")
30  ib2=0.9836-0.16
31  format(7)
32  disp(ib2,"Therefore,  I_B2(in mA) = I3 - I4 =")
33  disp("As I_B2 > I_B2(min), the transistor Q2 is
        indeed in saturation")
34  vc1=12-(0.98396*2.2)
35  format(6)
36  disp(vc1,"Therefore,  V_C1(in V) = V_CC - I3*R_C =")
37  disp("Hence the stable state current and voltages
        are:")
38  disp("I_C1 = 0 A       I_C2 = 5.316 mA       I_B1 = 0
        A        I_B2 = 0.8236 mA")
39  disp("V_C1 = 9.836 V  V_C2 = 0 V            V_B1 =
        -1.33 V    V_B2 = 0 V")
40  disp("Output swing = V_C1 - V_C2")
```

```scilab
41  disp("Therefore,   V_W = 9.836 V")
42  disp("")
43  disp("Case ii : V_CE(sat) = 0.2 V   and   V_BE(sat) =
        0.7 V")
44  disp("For the transistor Q2, as emitter is grounded,
        from these voltages we can write,")
45  disp("   V_C2 = 0.2 V   and   V_B2 = 0.7 V")
46  disp("Referring to fig 3.4(a), we can write the
        equations to obtain the stable state currents and
        voltages")
47  disp("Now V_B1 will be due to V_BB and V_C2 hence
        using superposition principle, considering effect
        of each independently we can write,")
48  vb1=(-8*(10/60))+(0.2*(50/60))
49  format(5)
50  disp(vb1,"V_B1 = -V_BB(R1 + R1+R2)|V_C2=0 + V_C2(R2
        / R1+R2)|V_BB=0 =")
51  i1=11.8/2.2
52  disp(i1,"I1(in mA) = V_CC-V_C2 / R_C =")
53  i2=8.2/60
54  format(6)
55  disp(i2,"I2(in mA) = V_C2+V_BB / R1+R2 =")
56  ic2=5.36-0.136
57  disp(ic2,"Therefore,   I_C2(in mA) = I1 - I2 =")
58  ib2=5.223/30
59  disp(ib2,"Therefore,   I_B2(min)(in mA) = I_C2 / h_fe
        (min) =")
60  disp("To calculate I_B2, refer fig.3.4(b), with V_B2
        = 0.7 V")
61  i3=11.3/12.2
62  disp(i3,"Therefore,   I3(in mA) = V_CC-V_B1 / R_C+R1
        =")
63  i4=8.7/50
64  disp(i4,"and   I4(in mA) = V_B2-V_BB / R2 =")
65  ib2=0.926-0.174
66  disp(ib2,"Therefore,   I_B2(in mA) = I3 - I4 =")
67  vc1=12-(0.926*2.2)
68  format(7)
```

```
69  disp(vc1,"Therefore,   V_C1(in V) = V_CC − I3*R_C =")
70  disp("Hence the stable state current and voltages
        are:")
71  disp("I_C1 = 0 A          I_C2 = 5.223 mA        I_B1 =
        0 mA        I_B2 = 0.752 mA")
72  disp("V_C1 = 9.9628 V    V_C2 = 0.2 V          V_B1 =
        −1.16 V    V_B2 = 0.7 V")
73  vw=9.9628−0.2
74  disp(vw,"V_W(in V) = V_C1 − V_C2 =")
```

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

can be downloaded from the website wwww.scilab.in

Scilab code Exa 3.2 min value of hfe and stable state currents and voltages

```
1  //Example 3.2
2  clc
3  disp("Assume that the transistor Q1 is cut−off and
        the transistor Q2 is in saturation. Let us draw
        again the equivalent circuit from the base of Q1
        to the collector of Q2")
4  disp("This is shown in the fig. 3.8")
5  disp("Another equivalent circuit from collector of
        Q1 to base of Q2 is shown in the fig 3.9")
6  disp("To calculate the various voltages it is
        necessary to calculate the current I_C1, I_B2 as
        Q2 is ON. The current I_C1 = I_B1 = 0 as Q1 is
        OFF")
7  disp("Now it is not very easy to calculate these
        currents by writing the equations from the
        equivalent circuits shown in the fig 3.8 and 3.9.
         So to calculate let us obtain Thevenin''s
```

```scilab
        equivalent circuit once across collector and
        ground while another across base and ground for
        the same transistor Q2 assuming it as the load.")
 8  disp("To replace collector circuit of Q2 by Thevenin
        ''s equivalent, consider Q2 as open shown in the
        fig 3.10")
 9  disp("Referring to fig 3.10,")
10  voc=(12*40)/44
11  format(5)
12  disp(voc,"V_OC(in V) = I*(R1 + R2) = V_CC/(R1+R2+R_C
        ) * (R1+R2) =")
13  rth=160/44
14  format(6)
15  disp(rth,"and  R_TH(in k-ohm) = (R1+R2)||R_C =
                with V_CC-N short")
16  disp("To replace base circuit of Q2 by Thevenin''s
        equivalent, consider Q2 open and draw circuit as
        shown in the fig 3.11")
17  voc=(12*10)/44
18  format(5)
19  disp(voc,"V_OC(in V) = I*R2 = V_CC/(R1+R2+R_C) * R2
        =")
20  rth=340/44
21  format(6)
22  disp(rth,"and  R_TH(in k-ohm) = (R2)||(R1+R_C) =")
23  disp("Thus the equivalent circuit for Q1 ON, using
        Thevenin''s result calculated above, is as shown
        in the fig 3.12")
24  disp("For silicon transistor,")
25  disp("V_BE(sat) = 0.8 V and V_CE(sat) = 0.4 V")
26  disp("Applying KVL to base-emitter loop,")
27  disp("-7.727*I_B2 - V_BE2 - (I_C2 + I_B2)*0.5 + 2.73
        = 0")
28  disp("With V_BE2 = 0.8 V,  I_B2 + 0.06075*I_C2 =
        0.2345            ...(1)")
29  disp("Applying KVL to collector-emitter loop,")
30  disp("-3.636*I_C2 - V_CE2 - (I_C2 + I_B2)*0.5 + 10.9
        = 0")
```

```
31  disp("With  V_CE2  =  0.4  V,  4.14*I_C2  +  0.5*I_B2  =
        10.5                 ...(2)")
32  disp("Solving  equation(1)  and  (2)  simultaneously  we
        get,")
33  disp("I_C2  =  2.526  mA   and   I_B2  =  0.0847  mA")
34  hfe=2.526/0.0847
35  format(7)
36  disp(hfe,"Therefore,   h_fe(min)  =  I_C2  /  I_B2  =")
37  disp("The  various  voltages  can  be  obtained  now  by
        referring  fig  3.8  and  3.9")
38  disp("V_EN  =  (I_B2  +  I_C2)*R_E  =  1.305  V")
39  vcn2=0.4+1.305
40  format(6)
41  disp(vcn2,"V_CN2(in  V)  =  V_CE2  +  V_EN  =")
42  vbn2=0.8+1.305
43  disp(vbn2,"V_BN2(in  V)  =  V_BE2  +  V_EN  =")
44  vbn1=1.705*(10/40)
45  format(7)
46  disp(vbn1,"V_BN1(in  V)  =  V_CN2  *  (R2/R1+R2)  =")
47  vbe1=0.4262-1.305
48  disp(vbe1,"V_BE1(in  V)  =  V_BN1  −  V_EN  =")
49  disp("As  V_BE1  <  V_BE(sat)  which  is  about  0.8  V,  the
        transistor  Q1  is  indeed  OFF")
50  vcn1=(360/34)+((2.105*4)/34)
51  format(8)
52  disp(vcn1,"V_CN1(in  V)  =  V_CC*R1/(R_C+R1)  +  V_BN2*
        R_C/(R_C+R1)  =                 ...usinf  superposition
        principle")
53  disp("Thus  the  stable  state  voltages  and  currents
        are:")
54  disp("I_C1  =  0  mA           I_C2  =  2.526  mA        I_B1  =
        0  mA          I_B2  =  0.0847  mA")
55  disp("V_CN1  =  10.835  V    V_CN2  =  1.705  V        V_BN1
        =  0.4262  V    V_BN2  =  2.105  V")
56  disp("and   V_EN  =  +1.305  V")
57  disp("The  voltage  V_EN  provides  the  required  self
        bias")
```

Scilab code Exa 3.3 `component values of monostable multivibrator`

```scilab
1  //Example 3.3
2  clc
3  disp("Assume Q2 ON and Q1 in OFF condition")
4  disp("Therefore,  I_C2 = I_C(sat) = 6 mA")
5  disp("Now  I_C2 = V_CC-V_CE(sat)/R_C")
6  disp("For the silicon npn transistors,")
7  disp("V_CE(sat) = 0.3 V, V_BE(sat) = V_0 = 0.7 V")
8  disp("V_BE(cut-in) = V_T = 0.5 V")
9  rc=(5.7*10^3)/6
10 format(4)
11 disp(rc,"R_C(in ohm) =")
12 ib2s=6/20
13 disp(ib2s,"(I_B2)sat (in mA) = I_C(sat)/(h_fe)min ="
      )
14 disp("Therefore,  (I_B1)sat = 0.3 mA")
15 disp("Now  I_B2 = V_CC-V_BE(sat)/R")
16 r=5.3/0.3
17 format(6)
18 disp(r,"Therefore,  R(in k-ohm) =")
19 disp("In quasi-stable, Q1 is ON and Q2 is OFF")
20 disp("T = 0.69 RC")
21 c=120/(0.69*17.67)
22 format(5)
23 disp(c,"Therefore,  C(in nF) =")
24 disp("Consider the equivalent circuit in quasi-state
      (see fig 3.19)")
25 disp("As Q2 is OFF, V_C2 = V_CC")
26 disp("Therefore,  I3 = V_CC-V0/R1 = 5.3/R1")
27 disp("and  I4 = V0-V_BB/R2 = 2.2/R2")
28 disp("Assume I4 = (I_B1)sat = 0.3 mA")
29 r2=2.2/0.3
30 format(5)
```

```
31  disp(r2,"Therefore,   R2(in  k−ohm) =")
32  i3=0.3+0.3
33  disp(i3,"and   I3(in mA) = I4 + I_B1 =")
34  r1=5.3/0.6
35  format(6)
36  disp(r1,"Therefore,   R1(in  k−ohm) = ")
37  disp("The speed−up capacitor C1 can be chosen such
        that R1C1 = 1 usec hence")
38  c1=1000/8.833
39  format(7)
40  disp(c1,"C1(in pF) = ")
41  rb=(5.5/1100)*10^3
42  disp(rb,"Now  r''_B(in mA) = V_CC−V_CE(sat)−V0−V_Y /
        R_C+r''_bb =")
43  del=(150*5*10^-3)+0.2
44  disp(del,"Therefore,   delta(in V) = Overshoot = I''
        _B*r''_bb + V0 − V_Y =")
```

Scilab code Exa 3.4 `pulse width and period and frequency of output`

```
1  //Example 3.4
2  clc
3  disp("The components are ,")
4  disp("   C1 = C2 = C = 100 pF")
5  disp("R1 = R2 = 10 k−ohm")
6  t1=(0.69*10*100*10^-9)*10^6
7  format(5)
8  disp(t1,"Therefore,   T1(in usec) = T2 = 0.69*RC =")
9  p=2*0.69
10 disp(p,"Therefore,   Period(in usec) = T = T1+T2 =")
11 f=1/1.38
12 format(7)
13 disp(f,"Therefore,   f(in MHz) = 1/T =")
```

Scilab code Exa 3.5 various voltage levels and frequency of oscillations

```
1  //Example 3.5
2  clc
3  disp(" (a) For a silicon transistor ,")
4  disp("V_Y = 0.5 V,   V_BE2 = 0.6 V,   V0 = 0.7 V,
      V_CE( sat ) = 0.3 V")
5  disp("This is a practical circuit")
6  disp("Therefore ,   V_CC2 = V_CC = 30 V")
7  vbb=60/3
8  format (3)
9  disp(vbb,"V_BB(in V) = R2*V_CC / R1+R2 =")
10 vcc1=15+10
11 format (4)
12 disp(vcc1,"and   V_CC1(in V) = (R''''/R''+R'''')*V_CC
      + (R''/R''+R'''')*V_BB =")
13 disp("R_C1 = R''*R''''  / R''+R'''' = 550 ohm")
14 disp("Assume that Q1 saturates and Q2 is in active
      region .")
15 disp("I_C2 = V_CC1/R_e   and   R_e = R_e1 || R_e2 =
      1.65 k-ohm")
16 ic2=25/1.65
17 format (6)
18 disp(ic2,"Therefore ,   I_C2 (in mA) =")
19 ib2=15.15/30
20 disp(ib2,"I_B2 (in mA) =")
21 mul=0.505*0.55
22 disp(mul,"Therefore ,   I_B2*R_C1 (in V) =")
23 mull=15.15*0.22
24 disp(mull,"and   I_C2*R_C2 (in V) =")
25 disp("The highest level of V_EN1 is V1 given by ,")
26 v1=25-0.277-0.6-0.3+0.5
27 disp(v1,"V1(in V) = V_CC1 - I_B2*R_C1 - V_BE2 - V_CE
      ( sat ) + V_Y =")
```

```
28  disp("The  lowest  level  of  V_EN1  is ,")
29  ven1=20-0.7
30  disp(ven1,"V_EN1(t_-1)(in  V)  =  V_BB  -  V0 =")
31  vcn1=20-0.7+0.3
32  disp(vcn1,"V_CN1(t_-1)(in  V)  =  V_BB  -  V0 - V_CE(sat)
        =")
33  format(7)
34  vcn=25-0.277
35  disp(vcn,"V_CN1(t_+1)(in  V)  =  V_CC1  -  I_B2*R_C1 =")
36  disp("V_CN1  =  V_BN2")
37  ven2=19.6-0.5
38  disp(ven2,"V_EN(t_-1)(in  V)  =  V_BN2(t_-1)  -  V_Y =")
39  ven=25-0.277-0.6
40  disp(ven,"V_EN(t_+1)(in  V)  =  V_CC1  -  I_B2*R_C1  -
        V_BE2 =")
41  vd=24.123-19.1
42  disp(vd,"V_D(in  V)  =  V_EN2(t_+1)  -  V_EN2(t_-1) =")
43  disp("(b)  The  frequency  of  oscillations ,")
44  disp("f  =  1/T  =  1/T1+T2")
45  t1=((3.3*0.1*10^-3)*log(24.323/19.5))*10^6
46  format(6)
47  disp(t1,"T1(in  usec)  =  R_e1*C*ln(V1/V_BB-V_Y) =")
48  disp("and   T2  =  T1    as   R_e1  =  R_e2")
49  t=(2*72.93)*10^-3
50  format(7)
51  disp(t,"Therefore ,   T(in  ms)  =  2*T1 =")
52  f=1/0.1458
53  format(7)
54  disp(f,"Therefore ,   f(in  kHz)  =  1/T =")
```

Scilab code Exa 3.7 peak voltages and currents

```
1  //Example  3.7
2  clc
3  disp("(a)   T  =  t_p  +  t_f  +  t_a")
```

```
 4  tp=(5/470)*10^3
 5  format(8)
 6  disp(tp,"Now   t_p(in  usec) = nL/R =")
 7  tf=(50/(470*6*2))*10^3
 8  format(6)
 9  disp(tf,"t_f(in  usec) = (n/n+1)*L/R*V_CC/V_Y =")
10  ta=(1.57*sqrt(5*90*10^-15))*10^6
11  disp(ta,"t_a(in  usec) = 1.57*sqrt(LC) =")
12  t=10.6383+8.865+1.053
13  format(8)
14  disp(t,"T(in  usec) =")
15  f=(1/20.5564)*10^3
16  disp(f,"Therefore,   f(in  kHz) = 1/T =")
17  dc=10.6383/20.5564
18  format(7)
19  disp(dc,"Duty  cycle = t_p/T =")
20  disp("So duty  cycle  is  51.75% which  is  very  close  to
         50% giving  an  indication  that  Q ON  and  OFF  times
          are  equal  and  the  output  is  almost  symmetrical
        square  wave.")
21  disp("(b)   The  collector  voltage  varies  from  V_CC–V
        to  V_CC+V_Y")
22  v=10/2
23  disp(v,"Now   V(in  V) = V_CC  /  n+1 =")
24  disp("Therefore,   V_C  varies  from  10−5  i.e.  +5 V  to
         10+6 = 16  V")
25  disp("The  base  voltage  varies  from nV  to −nV_Y  i.e.
          +5 V  to −6  V")
26  disp("The  emitter  current  is  constant  given  by,")
27  ie=(5/470)*10^3
28  format(7)
29  disp(ie,"I_E(in  mA) = nV/R =")
30  ib=(10/(4*470))*10^3
31  disp("i_B = V_CC/(n+1)^2 * [n/R − t/L]")
32  format(5)
33  disp(ib,"So   i_B(max)(in  mA) = i_B|t=0 =")
34  ib=((10/4)*((1/470)-((10.63*10^-3)/5)))*10^6
35  format(6)
```

```
36  disp(ib,"i_B(t=t_p)(in  uA) =")
37  disp("i_C  =  V_CC/(n+1)^2  *  [n^2/R  +  t/L]")
38  ic=((10/4)*((1/470)+((10.63*10^-3)/5))))*10^3
39  format(7)
40  disp(ic,"i_C(t=t_p)(in  mA) =")
41  i0=(10/940)*10^3
42  disp(i0,"I_0  =  Peak  magnetizing  current  =  n*V_CC  /  (
        n+1)*R =")
43  disp("(c)   I''_m  which  is  the  magnetizing  current  at
          the  end  of  one  cycle  is  given  by")
44  im=(6*sqrt(90/5))
45  disp(im,"I''_m(in  mA) = V_Y*sqrt(C/L) =")  //answer
        in  textbook  is  wrong
```

Scilab code Exa 3.8 design a free running blocking oscillator

```
1  //Example  3.8
2  clc
3  disp("f  =  20  kHz   hence  T  =  1/f  =  50*10^-6  sec")
4  disp("Now   T  =  t_p+t_f+t_a  =  t_p+t_f          ...
        Neglecting  t_a")
5  disp("Therefore,   50*10^-6  =  t_p+t_f")
6  disp("Now   Duty  cycle  =  t_p/T  =  1/10")
7  disp("Therefore,   t_p  =  T/10  =  5*10^-6  sec")
8  tf=50-5
9  disp(tf,"Therefore,   t_f(in  usec) = ")
10  disp("i_E(max) = nV/R")
11  disp("Therefore,   nV/R  =  5*10^-3          ...(1)")
12  disp("t_p  =  nL/R")
13  disp("Therefore,   nL/R  =  5*10^-6          ...(2)")
14  disp("Dividing  equations  (1)  and  (2), V  =  1000  L
                ...(3)")
15  disp("And   V  =  V_CC  /  n+1  =  30  /  n+1      ...(4)")
16  disp("The  collector  voltage  pulse  extents  from  V_CC-
        V  to  V_CC+V_Y")
```

```
17  disp("Therefore,  Peak of the pulse = [V_CC+V_Y] − [
        V_CC−V] = V + V_Y")
18  disp("Therefore,  V + V_Y = 10     (Given)")
19  disp("and  t_f = (n/n+1)*L/R*V_CC/V_Y = 45*10^−6")
20  disp("Therefore,  nL/R*V_CC/(n+1)*1/V_Y = 45*10^−6")
21  disp("(5*10^−6)*V/V_Y = 45*10^−6")
22  disp("Using equation(5),  (5*10^−6)*(10−V_Y/V_Y) =
        45*10^−6")
23  disp("10 − V_Y = 9 V_Y")
24  disp("V_Y = 1 V")
25  disp("V = 10 − V_Y = 9 V")
26  disp("Using equation(4),  n = 2.3333")
27  disp("Using equation(3),  L = 9 mH")
28  disp("Using equation(2),  R = 4.2 k−ohm")
29  disp("The designed circuit can be shown as in the
        fig 3.73")
30  disp("Neglecting base current,")
31  disp("V_BE = V_CC*R2 / R1+R2")
32  disp("Therefore,  1 = 30*R2 / R1+R2")
33  disp("Therefore,  R1 = 29 R2")
34  disp("So let  R2 = 1 k−ohm")
35  r1=29
36  disp(r1,"R1(in k−ohm) =")
37  disp("This is required potential divider components"
        )
```

Scilab code Exa 3.10 `max I`

```
1  //example3.10
2  clc
3  disp("The circuit of self biased binary is shown in
        the fig. 3.80")
4  disp("Assume Q1 is OFF and Q2 is ON. As Q2 is in
        saturation,")
5  disp("V_CE(sat)=V_CE2=0.4V")
```

```
 6  disp("V_BE(sat)=V_BE2=0.8V")
 7  disp("a) Calculation for the stable state currents
        and voltages")
 8  disp("Draw equilvalent circuit from base of Q1 to
        collector of Q2.")
 9  disp("Another equivalent circuit from collector of
        Q1 to base of Q2 is shown in the fig.3.81")
10  disp("To calculate the various voltages, is
        necessary to calculate the currents I_c2, I_B2
        for ON transistor Q2. The currents I_C1=I_B1=0 mA
         as Q1 is OFF.")
11  disp("To obtain I_c2, I_B2 let us obtain. Thevenins
        equivalent once across collector and ground and
        other across base and ground, for ON transistor
        Q2.")
12  disp("Consider Thevenins equivalent across collector
         of Q2 and ground as shown in the fig. 3.83(a)
        while Thevenins equivalent across base of Q2 and
        ground as shown in the fig. 3.83(b).")
13  disp("Referring fig 3.83(a) we can write,")
14  i=(20*45)/49.7
15  format(7)
16  disp(i,"V_oc(in volts)=I(R1+R2)=(V_cc*(R1+R2))/(R1+
        R2+R_c)=")
17  r=(45*4.7)/(45+4.7)
18  format(6)
19  disp(r,"R_th(in k ohms) = (R1+R2)parallel to R_c
        with V_cc -N short  =")
20  disp("Referring fig 3.83(b),")
21  v=(20*15)/(30+15+4.7)
22  format(6)
23  disp(v,"V_OC(in V)=I*R2=(V_CC * R2)/(R1+R2+R_c)=")
24  t=(15*34.7)/(15+34.7)
25  format(7)
26  disp(t,"And,  R_th(in k ohm)=R2 parallel to(R1+R2)="
        )
27  disp("Applying KVL to base-emitter loop,")
28  disp("-I_B2(10.473)-0.8-0.39(I_B2+I_C2)+6.036=0")
```

```scilab
29  disp(" 0.863(I_B2)+0.39(I_C2)=5.236")
30  disp("I_B2+0.0359(I_C2)=0.482    Now multiply by
        0.39,")
31  disp(" 0.39(I_b2)+0.014(I_C2)=0.1879        ..(1)")
32  disp("Applying KVL to collector emitter loop,")
33  disp("(-I_C2)(4.255)-0.4-0.39(I_B2+I_C2)+18.108=0")
34  disp(" -0.39(I_B2)-4.645(I_c2)=-17.708       ..(2)")
35  disp("Adding equations (1) and (2) we get,")
36  disp(" -4.631(I_C2)=-17.5201")
37  c=(-17.5201)/(-4.631)
38  format(6)
39  disp(c,"I_C2(in mA)=")
40  b=(-17.708+((4.645)*(3.783)))/(-0.39)
41  disp(b,"and,        I_B2(in mA)=")
42  disp("From this, the various voltages can be
        obtained as,")
43  v=((0.346+3.783))*(0.390)
44  format(5)
45  disp(v,"V_EN(in V)=(I_B2+I_C2)*R_E =")
46  n=0.4+1.61
47  disp(n,"V_CN2(in V)=(V_CE2+V_EN)=")
48  b=0.8+1.61
49  disp(b,"V_BN2(in V)=(V_BE2+V_EN)=")
50  w=(2.01*15)/45
51  disp(w,"V_BN1(in V)=(V_CN2*R2)/(R1+R2)=")
52  v=0.67-1.61
53  format(5)
54  disp(v,"V_BE1(in V)=(V_BN1-V_EN)=0.61-1.61=")
55  disp("For cut-off, V_BE1 is 0V given, but actually
        it is still less i.e. -0.94 V. This ensures that
        Q1 is still OFF.")
56  a=(((20*30)/(4.7+30))+((2.41*4.7)/(4.7+30)))
57  format(7)
58  disp(a,"V_CN1(in V)=")
59  disp("b) To find (h_fe)_min")
60  disp("For the ON transistor Q2")
61  disp("I_C2=3.783mA,    I_B2=0.346mA")
62  h=3.783/0.346
```

```
63  format (3)
64  disp(h,"Therefore, (h_fe)_min = (I_C2)/(I_B2)=")
65  disp("Calculation of (I_CBO)_max")
66  disp("To calculate (I_CBO)_max consider the circuit
        shown in the fig 3.85")
67  disp("Obtain the Thevenins equivalent across
        terminal A and ground.The Thevenin voltage is V_A
        =V_B1=0.67 V")
68  disp("Looking into terminals A and ground,")
69  r=(34.7*15)/(34.7+15)
70  format (7)
71  disp(r,"R_th(in kohms)=(R_1+R_c)parallel to R2 =")
72  disp("Hence Thevenin equivalent is: To find
        I_CBO_max, ")
73  disp("V_BE(cut-off)=0V and V_EN =1.61 V ...
        Calculated earlier")
74  disp("As V_BE= 0, base must be also at same
        potential as emitter with respect to ground.")
75  disp("V_B1=V_EN=1.61 V    for(I_CBO)_max,")
76  o=(1.61-0.67)/(10.472*10^3)
77  format (11)
78  disp(o,"I_CBO_max(in A)=(V_B1-V_TH)/(R_TH)=")
79  disp("This is the maximum I_CBO")
```

Scilab code Exa 3.11 `find V`

```
1  //example3.11
2  clc
3  disp("For the npn silicon transistors,")
4  disp("V_CE(sat)=0.3 V   and   V_BE(sat)=0.7 V = V_rho"
        )
5  disp("While V_BE(cut-in)=0.5 V= V_gamma       ...
        Referring Table 3.1")
6  i=(12-0.3-0.7+0.5)/(2000+200)
7  format (6)
```

```
8  disp(i,"(I''_B)(in mA)=(V_CC-V_CE(sat)-V_rho-V_gamma
      )/(R_c+r''_bb)=")
9  disp("Hence the overshoot in base voltage of Q2 is:"
      )
10 d=(5.227*200*10^-3)+0.7-0.5
11 format(7)
12 disp(d,"delta(in V)=(I''_b*r''_bb)+(V_rho)-(V_gamma)
      =")
13 v=12-(5.227*2)
14 disp(v,"V_C1(in V)=(V_CC)-(I''_B*R_C)=")
15 disp("These are the values of various voltages just
      after the circuit returns back to stable state i.
      e at t=T.")
16 disp("The width of the output pulse")
17 t=(0.69*20*10^3)*(1000*10^-12)
18 format(11)
19 disp(t,"T(in sec)=(0.69*20*10^-3)*(1000*10^-12)=")
20 disp("The voltage waveforms at base of Q2, Q1 and
      collector of Q2, Q1 are shown in the fig 3.87 on
      previous page.")
21 disp("The overshoot in V_C1 is (delta'') and is same
       as (delta) ")
22 disp("Therefore, (delta'')=1.2454 V")
23 f=(-(14.7*20*10^3)/(40*10^3))+((12*20*10^3)
      /(40*10^3))
24 format(5)
25 disp(f,"V_F(in V)=((-V_BB*R1)/(R1+R2))+((V_CC*R2)/(
      R1+R2))= ")
26 disp("V_C2=V_CE(sat)=0.3 in stable state")
27 c=(((12*20000)/(40000))+((54.692*2000)/(22000)))
28 format(7)
29 disp(c,"V_C2(in V)[in quasi-stable state]=((V_CC*R1)
      /(R1+R2))+((V_delta*R_C)/(R1+R_C))= ")
```

Scilab code Exa 3.13 waveform at the base Q2 and and value of RC

```scilab
1  //Exmaple 3.13
2  clc
3  disp("Assume Q1 is normally OFF and Q2 is ON")
4  disp("The given waveform is at collector of Q1 i.e.
       V_C1")
5  disp("Therefore,  V_CE(sat) = 0.1 V  and  V_CC = 3 V
       ")
6  vc1=0.6-0.1
7  format(4)
8  disp(vc1,"The overshoot in V_C1(in V) = delta'' =")
9  disp("delta = delta'' = 0.5 V")
10 disp("For germanium, V_BE(sat) = V_0 = 0.3 V")
11 disp("V_BE(cut-in) = V_Y = 0.1 V")
12 disp("r''_bb = 200 ohm")
13 disp("Now  delta = I''_B*r''_bb + V0 + V_Y")
14 ib=(0.3/200)*10^3
15 disp(ib,"Therefore,  I''_B(in mA) =")
16 rc=(3-0.6)/(1.5)
17 disp("While  delta'' = V_CC - I_B''*R_C - V_CE(sat)"
       )
18 disp(rc,"Therefore,  R_C(in k-ohm) =")
19 disp("The waveform at base of Q2 is shown in fig
       3.91")
```

Scilab code Exa 3.14 find R

```scilab
1  //example3.14
2  clc
3  disp("The duty cycle is given as 60% i.e. 0.6")
4  disp("Therefore  duty cylcle = T2/(T1+T2)")
5  disp("Therefore  0.6=T2/(T1+T2)")
6  disp("Therefore  0.6(T1+T2)=T2")
7  disp("Therefore  T1=0.66*T2")
8  disp("f=1 kHz")
9  t=1/(10^3)
```

```
10  format(6)
11  disp(t,"T(in sec)=1/(1*10^3)=")
12  disp("Now, T=T1+T2")
13  disp("Therefore  T1+T2=1 msec")
14  disp("Therefore  0.66T2+T2=1 msec")
15  o=(10^-3)/1.66
16  format(7)
17  disp(o,"Therefore  T2(in sec)=")
18  t=1-0.6
19  disp(t,"T1(in msec)=")
20  disp("Consider the circuit diagram shown in the fig
       3.92")
21  disp("Assume Q2 ON and Q1 OFF")
22  disp("For ON transistor, assuming npn silicon
       transistor,")
23  disp("V_CE(sat)=V_C2=0.3V")
24  disp("V_BE(sat)=V_B2=0.7V")
25  disp("I_C(sat)=I_C2=2 mA")
26  disp("(h_fe)_min=30")
27  disp("I2=(V_CC-V_C2)/R_c")
28  disp("Neglecting thriugh C1,")
29  disp("I2=I_C2=2 mA")
30  disp("Therefore, (2*10^-3)=(10-0.3)/R_C")
31  r=9.7/(2*10^-3)
32  disp(r,"Therefore R_C(in ohms)= ")
33  h=(1.5*2)/30
34  disp(h,"Now   I_B2(in mA)=1.5*(I_B2)_min=1.5*(I_C2)
       /(h_fe)_min= ")
35  disp("Now, I_B2=(V_cc-V_B2)/R2")
36  r=9.3/(0.1*10^-3)
37  disp(r,"Therefore  R2(in ohms)=")
38  disp("Now assume C1=C2=C")
39  disp("Therefore T1=0.69(R1*C1) and T2=0.69(R2*C2)")
40  disp("Therefore T2=0.69(R2*C)")
41  c=(0.6*10^-3)/(0.69*93*10^3)
42  disp(c,"Therefore C(in F)= ")
43  disp("Therefore  T1=0.69*(R1*C)")
44  disp("Therefore  (0.4*10^-3)=(0.69*R1)*(9.35*10^-9)"
```

```
   )
45 r=(0.4*10^-3)/(0.69*9.35*10^-9)
46 disp(r,"Therefore   R1(in ohms)=")
```

Scilab code Exa 3.15 find Voltage

```
1  //example4.15
2  clc
3  disp("UTP=5 V, LTP=3 V, V_CC=12 V")
4  disp("V_i=V_B2=UTP=5 V when Q2 is ON.")
5  v=5-0.7
6  disp(v,"V_E(in V)=(V_i)-(V_BE1)=V_B2-V_BE2=5-0.7=")
7  disp("Let I_C2=I_E2=1 mA        ...In ON state")
8  r=4.3/(10^-3)
9  disp(r,"Therefore  R_E(in ohms)=V_E/I_E2=")
10 disp("Now, (I_C2)*(R_C2)=(V_CC)-(V_E)-(V_CE2)_sat
          ..Let (V_CE2)_sat =0.2V")
11 disp("(1*10^-3)*(R_C2)=12-4.3-0.2")
12 c=(12-4.3-0.2)/(10^-3)
13 disp(c,"Therefore R_C2(in ohms)= ")
14 i=(10^-3)/10
15 disp(i,"Now   I2(in A)=0.1(I_C2)=")
16 r=5/(10^-4)
17 disp(r,"Therefore   R2(in ohms)= ")
18 i=(10^-3)/100
19 disp(i,"I_B2(in A)=(I_C2)/(h_fe)_min =")
20 disp("Therefore   I2+I_B2=(V_CC-V_B2)/(R_C1-R1)")
21 disp("Therefore   R_C1+R1=(12-5)/((10^-4)+(10^-5))
      =63.6363*10^3   ..(1)")
22 disp("Now V_B2=B_B1=LTP=3 V  and  Q1 is ON.")
23 i=3/(50*10^3)
24 disp(i,"I1(in A)=(V_B2)/R2=")
25 c=(3-0.7)/(4.3*10^3)
26 format(10)
27 disp(c,"amd I_C1(in A)=I_E1=(V_B1-V_BE1)/R_E= ")
```

```scilab
28  disp("Therefore V_CC=(R_C1)*(I_C1+I1)+I1*(R1+R2)
        ..(2)")
29  disp("Using equation (1) in equation (2),")
30  disp("Therefore V_CC=(I_C1*R_C1)+I1*(R_C+R1)+I1*R2")
31  disp("12=(5.348*10^-4*R_C1)+(60*10^-6*63.6363*10^3)
        +(60*10^-4*50*10^3)")
32  r=(12-(60*63.6363*10^-3)-(60*50*10^-3))
        /(5.348*10^-4)
33  format(7)
34  disp(r,"Therefore R_c1(in ohm)=")
35  r=(63.6363*10^3)-(9.6892*10^3)
36  disp(r,"Therefore R1(iin ohms)=")
37  disp("Thus when Q2 is ON,")
38  v=12-(7.5)
39  disp(v,"V_o(in V)=V_CC-(I_C2(on))*R_C2=")
40  disp("And when Q2 is OFF,")
41  disp("V_o=V_CC=12 V")
42  disp("The designed circuit is shown ib the fig 3.93"
        )
```

Chapter 4

High Frequency Amplifiers

Scilab code Exa 4.1 `gm and rbe and Ce and omegaB`

```
1  //Example 4.1
2  clc
3  gm=(1/26)*10^3
4  format(6)
5  disp(gm,"(i) g_m(in mA/V) = I_C / V_T =")
6  rbe=200/(38.46)
7  format(5)
8  disp(rbe,"(ii) r_b''e(in k-ohm) = h_fe / g_m =")
9  cc=((38.46*10^-3)/(500*10^6))*10^12
10 format(6)
11 disp(cc,"(iii) (C_e + C_C)(in pF) = g_m / 2*pi*f_T =
        g_m / omega_T =")
12 cbe=76.92-3
13 disp(cbe,"Therefore,  C_b''e(in pF) = C_e =")
14 disp("(iv) We know that,")
15 disp("f_T = h_fe*f_beta")
16 disp("Therefore,  2*pi*f_T = h_fe*2*pi*f_beta")
17 disp("omega_T = h_fe*omega_beta")
18 ob=((500*10^6)/200)*10^-3
19 format(5)
20 disp(ob,"omega_beta(in rad/sec) = omega_T / h_fe =")
```

Scilab code Exa 4.2 `fT and hfe and Ai`

```
1  //Example  4.2
2  clc
3  ft=25*2
4  format(3)
5  disp(ft,"(i) f_T(in MHz) = | A_i |* f =")
6  hfe=50000/200
7  format(4)
8  disp(hfe,"(ii) h_fe(in kHz) = f_T / f_beta =")
9  disp("(iii) | A_i | = h_fe / sqrt(1+((f/f_beta)^2)) ="
      )
10 disp("At  f = 10 MHz")
11 ai=250/sqrt(1+(((10*10^6)/(200*10^3))^2))
12 format(2)
13 disp(ai," | A_i | =")
14 disp("At  f = 100 MHz")
15 ai=250/sqrt(1+(((100*10^6)/(200*10^3))^2))
16 format(4)
17 disp(ai," | A_i | =")
```

Scilab code Exa 4.10 `find gain`

```
1  //example4.10
2  clc
3  disp("a) The 3dB frequency for circuit gain and
      voltage gain is given as,")
4  disp("(f_H)=1/(2*pi*R_eq*C_eq)")
5  r=(200*1000)/(200+1000)
6  disp(r,"where R_eq(in ohm)=(R_s+r_bb'') parallel to r
      +b''e =")
```

```
7  c=(100*10^-12)+((1+50)*3*10^-12)
8  format(10)
9  disp(c,"and   C_eq(in  F)=(C_b''e)+(1+(g_m*R_L)*C_b''c
      )=  ")
10 f=1/((2*%pi*166.67*253*10^-12))
11 disp(f,"f_H(in  Hz)=  ")
12 disp("b)Voltage  gain  is  given  as,")
13 a=(-50*1)
14 disp(a,"A=(-g_m*R_L)=")
```

Scilab code Exa 4.12 `find resistance`

```
1  //example4.12
2  clc
3  disp("f_H=1/(2*pi*R_eq*C_eq)")
4  disp("and  f_H''=2(f_H)")
5  disp("1/(2*pi*R_eq*C_eq)  =  2/(2*pi*R_eq*C_eq)")
6  disp("R_eq''  =  R_eq/2")
7  disp("R_eq=(r_b''e)parallel  to  (r_bb''+R_s)")
8  disp("=  (r_b''e)=1000  ohm")
9  disp("Therefore   R_eq''  =500  ohm")
10 disp("Therefore   500=((r_b''e)*(r_bb''+R_s))/((r_b''
      e)+(r_bb''')+R_s)")
11 disp("  =  1000(100+R_s)/(1000+100+R_s)")
12 r=(4.5*10^5)/500
13 disp(r,"R_s(in  ohms)=  ")
```

Scilab code Exa 4.16 `mid frequency voltage gain and fb and fT`

```
1  //Example  4.16
2  clc
3  disp("Hybrid-pi  Equivalent  is  as  shown  in  fig.4.29")
4  disp("(i)  Mid  frequency  voltage  gain  :")
```

```
5  disp("V_o / V_s = -h_fe*R_L / R_s+h_ie")
6  hie=(100+1000)*10^-3
7  format(4)
8  disp(hie,"h_ie(in k-ohm) = r_bb'' + r_b''e =")
9  hfe=0.2*1000
10 disp(hfe,"h_fe = g_m * r_b''e =")
11 vo=-200/2
12 disp(vo,"Therefore,  V_o / V_s =")
13 fb=(1/(2*%pi*1000*(204*10^-12)))*10^-3
14 format(7)
15 disp(fb,"(ii) f_beta(in kHz) = 1 / 2*pi*r_b''e*(C_e+
       C_C) =")
16 format(4)
17 disp(fb,"f_beta(in kHz) = ")
18 ft=(200*780)*10^-3
19 disp(ft,"(iii) f_T(in kHz) = h_fe * f_beta =")
```

Scilab code Exa 4.17 source resistance and Rs and midband voltage gain

```
1  //Example 4.17
2  clc
3  disp("(i) We know that,")
4  disp("   f_H = 1 / 2*pi*R_eq*C_eq")
5  disp("where   R_eq = (R_s+r_bb'')*r_b''e / R_s+r_bb
       ''+r_b''e")
6  disp("and   C_eq = C_e + C_C*[1+g_m*R_L]")
7  rbe=100/100
8  format(2)
9  disp(rbe,"  r_b''e(in k-ohm) = h_fo / g_m = ")
10 disp("C_eq = C_e + C_C*[1+g_m*R_L] = C_e + C_C
       [1+100*10^-3*500]")
11 disp("     = C_e + 51 pF")
12 ce=((100*10^-3)/(2*%pi*(400*10^6)))*10^12
13 format(6)
14 disp(ce,"C_e(in pF) = g_m / 2*pi*f_T =")
```

```
15  ceq=39.79+51
16  disp(ceq,"Therefore,  C_eq(in pF) =")
17  req=1/(2*%pi*5*90.79*10^-6)
18  disp(req,"R_eq(in ohm) = 1 / 2*pi*f_H*C_eq =")
19  disp("Therefore, 350.6 = (R_s+100)*1000 / R_s+1100")
20  rs=(285.66*10^3)/649.4
21  format(7)
22  disp(rs,"Therefore,  R_s(in ohm) =")
23  disp("(ii) The mid-band voltage gain V_o/V_s is
        given as")
24  disp("  V_o/V_s = -h_fe*R_L / R_s+h_ie")
25  hie=(100+1000)*10^-3
26  format(4)
27  disp(hie,"where  h_ie(in K) = r_bb'' + r_b''e =")
28  vo=(-100*500)/(439.88+1100)
29  format(6)
30  disp(vo,"Therefore,  V_o/V_s =")
```

Scilab code Exa 4.20 `voltage gain`

```
1  //Example 4.20
2  clc
3  disp("Assume that the output time-constant is
        negligible as compared to the time consedtant.
        When this is the case")
4  disp("A_vs = V_o/V_s = -g_m*R''_L*G''_s / G''_s+g_b
        ''e+sC")
5  gs=6.66*10^-3
6  format(8)
7  disp(gs,"where  G''_s = 1 / (R_s||R_b)+r_bb'' =")
8  gbe=1/1000
9  format(6)
10  disp(gbe,"g_b''e = 1 / r_b''e =")
11  rl=(0.5/1.5)*10^3
12  format(7)
```

```
13  disp(rl,"R''_L(in ohm) = R_L || R_C =")
14  disp("  sC = admittance of C")
15  c=100+(3*(1+(50*333.33*10^-3)))
16  format(4)
17  disp(c,"where  C = C_e + C_C*(1+g_m*R''_L) =")
18  disp("At 10 kHz,")
19  sc=2*%pi*10*153*10^-9
20  format(8)
21  disp(sc,"sC = 2*pi*f*C =")
22  disp("Therefore, At 10kHz signal frequency")
23  avs=(-50*333.33*6.66*10^-6)/((6.66*10^-3)+(10^-3)
        +(9.613*10^-6))
24  format(6)
25  disp(avs,"A_vs = V_o / V_s =")
```

Chapter 5

Tuned Amplifier

Scilab code Exa 5.1 `Rs and Rp of inductor`

```
1 //Example  5.1
2 clc
3 rp=2*%pi*10^6*250*300*10^-9
4 format(7)
5 disp(rp,"R_p(in  k-ohm)  =  omega_0  *  L  *  Q =")
6 rs=(2*%pi*250)/300
7 format(6)
8 disp(rs,"R_s(in  ohm)  =  omega_0*L  /  Q =")
```

Scilab code Exa 5.2 `design single tuned amplifier`

```
1 //Example  5.2
2 clc
3 disp("From  equation  9  we  have")
4 disp("   BW =  1  /  2*pi*R*C")
5 rc=1/(2*%pi*10*10^3)
6 format(12)
7 disp(rc,"Therefore ,   R*C = 1  /  2*pi*BW =")
```

```
 8  disp("From equation 3 we have")
 9  disp("   R = r_i  ||  R_p  ||  r_b''e")
10  disp("where   r_i = 4 k-ohm")
11  rbe=100/0.04
12  disp(rbe,"r_b''e(in ohm) = h_fe / g_m =")
13  disp("R_p = Q_c * omega_0 * L = Q_c / omega_0*C")
14  disp("Therefore,   R = 4*10^3 || 2500 || Q_c/omega_0*
        C")
15  disp("C = 1 / 2*pi*10*10^3*R")
16  disp("Therefore,   C = 1 / 2*pi*10*10^3*[4*10^3 ||
        2500 || Q_c/2*pi*500*10^3*C]")
17  disp("The typical range for Q_c is 10 to 150.
        However, we have to assume Q such that value of
        C_p should be positive. Let us assume Q = 100")
18  disp("Therefore,   C = 1 / 2*pi*10*10^3*[1538.5 ||
        1/2*pi*5000*C]")
19  disp("                  = 1 / 2*pi*10*10^3*[1 /
        1/1538.5+2*pi*5000*C]")
20  disp("Solving for C we get")
21  disp("   C = 0.02 uF")
22  disp("We have")
23  disp("   C = C'' + C_b''e + (1+g_m*R_L)*C_b''e")
24  disp("Therefore,   C'' = C - [C_b''e + (1+g_m*R_L)*
        C_b''e]")
25  c=((0.02*10^-6)-[(1000*10^-12)+((1+(0.04*510))
        *100*10^-12)])*10^6
26  format(8)
27  disp(c,"Therefore,   C''(in uF) =")
28  disp("We have,")
29  disp("omega_0^2 = 1 / L*C")
30  l=(1/(((2*%pi*500*10^3)^2)*(0.02*10^-6)))*10^6
31  format(2)
32  disp(l,"Therefore,   L(in uH) = 1 / omega_0^2*C =")
33  disp("From equation 2 we have,")
34  rp=2*%pi*500*5*100*10^-3
35  format(5)
36  disp(rp,"R_p(in ohm) = omega*L*Q_c =")
37  r=(4000*1570*2500)/((1570*2500)+(4000*2500)
```

```
     +(4000*1570))
38  format(4)
39  disp(r,"Therefore,  R(in ohm) = r_i || R_p || r_b''e
        =")
40  disp("We have mid frequency gain as")
41  av=-0.04*777
42  disp(av,"A_v(max) = -g_m*R =")
```

Scilab code Exa 5.3 `bandwidth for four stages`

```
1  //Example 5.3
2  clc
3  disp("(i) We know that,")
4  bw=((20*10^3)*sqrt(((2)^(1/3))-1))*10^-3
5  format(7)
6  disp(bw,"BW_n(in kHz) = BW_1 * sqrt(2^1/n - 1) =")
7  bw1=((20*10^3)*sqrt(((2)^(1/4))-1))*10^-3
8  format(4)
9  disp(bw1,"(ii) BW_n(in kHz) = BW_1 * sqrt(2^1/n - 1)
        =")
```

Scilab code Exa 5.6 `find frequency`

```
1  //example5.6
2  clc
3  disp("a) We have,")
4  disp("A_vmid=(-g_m*R)= -15")
5  r=15/(5*10^-3)
6  disp(r,"Therefore R(in ohms)=(-15)/(-5*10^-3)= ")
7  disp("b) The Miller effect capacitance is given by "
        )
8  disp("C_d(in F)=C_gs+(1+g_m*R)*(C_g*d)")
9  c=(10^-12)+((1+15)*(3*10^-12))
```

```
10  format (8)
11  disp(c," = (1*10^-12)+(1+15)*(3*10^-12)=")
12  disp("c) The limit frequency of the uncompemsated
        amplifier is ")
13  f=1/(2*%pi*49*3*10^-9)
14  format (9)
15  disp(f,"f2(in Hz)=1/(2*pi*C_d*R)= ")
16  l=0.414*((3*10^3)^2)*(49*10^-12)
17  format (12)
18  disp(l,"d) L(in H)=q*C_d*R^2= ")
19  disp("e) Possible extension of frequency range")
20  e=1.72*1.08*10^6
21  disp(e,"f''2(in Hz)=1.72*f2= ")
```

Scilab code Exa 5.8 resonant frequency and impedance and voltage gain

```
1  //Example 5.8
2  clc
3  disp("(i) Resonant frequency:")
4  fr=(1/(2*%pi*sqrt(20*500*10^-18)))*10^-6
5  format (5)
6  disp(fr,"f_r(MHz) = 1 / 2*pi*sqrt(LC) =")
7  disp("(ii) We know that")
8  disp("Q_r = R_p / omega_r*L")
9  rp=30*2*%pi*1.59*20
10 format (5)
11 disp(rp,"Therefore, Impedance of tuned circuit R_p
       = Q_r * omega_r * L =")
12 disp("(iii) Voltage gain of stage A_v,")
13 av=(-50*((5994*1500)/(5994+1500)))/200
14 format (4)
15 disp(av,"A_v = A_I*R''_L / R''_i =")
```

Scilab code Exa 5.10 `find BW`

```
1  //example5.10
2  clc
3  disp("i) f_r=Resonant frequency")
4  f=1/((2*%pi)*sqrt(0.0004*2500*10^-12))
5  format(9)
6  disp(f,"= 1/(2*pi*sqrt(L*C))= ")
7  disp("ii) Tuned circuit dynamic resistance=R_p=L/CR"
      )
8  r=(80*10^6)/2500
9  disp(r,"= (400 microH)/(2500pF)*(5ohm)= ")
10 disp("iii) Gain at resonance=A_v=(-g_m*R_L)=(-g_m*
      R_p)")
11 a=-6*32
12 disp(a," = 6mA/V * 32kohm = ")
13 disp("iv) The signal bandwidth =BW=(f_r)/Q")
14 q=(2*%pi*0.159*400)/5
15 format(6)
16 disp(q,"Q=(omega_r*L)/R= ")
17 b=159000/79.92
18 format(7)
19 disp(b,"BW(in Hz)=(f_r)/Q= ")
```

Scilab code Exa 5.11 `resonant frequency and omega`

```
1  //Example 5.11
2  clc
3  disp("(i)  R_L = r_d || R_p")
4  disp("R_p = Tank circuit impedance at resonance = L
      / CR")
5  disp("f_r = 1 / 2*pi*sqrt(L*C)")
6  c=(1/(4*%pi^2*200*1.59^2*10^6))*10^12
7  format(3)
8  disp(c,"Therefore, C(in pF) = 1 / 4*pi^2*f_r^2*L ="
```

```
   )
9  disp("Q = omega_r*L / R = 2*pi*f_r*L / R")
10 r=(2*%pi*200*1.59)/50
11 disp(r,"Therefore,   R(in ohm) = 2*pi*f_r*L / Q =")
12 rf=((200*10^-6)/(50*40*10^-12))*10^-3
13 format(4)
14 disp(rf,"R_F(in k-ohm) = L / C*R =")
15 rl=(500*100)/600
16 format(6)
17 disp(rl,"R_L(in k-ohm) = r_d*R_p / r_d+R_p =")
18 av=5*83.33
19 format(7)
20 disp(av,"A_v = -g_m*R_L =           at resonance
      frequency omega_r")
21 disp("(ii) At   f = f_r+10 kHz = 1.6 MHz")
22 disp("|A_v / A_v(at resonance)| = 1 / sqrt(1+(f/f_r)
      ^2)")
23 ava=416.67/sqrt(1+((1.6/1.59)^2))
24 format(6)
25 disp(ava,"Therefore,   |A_v| = |A_v(at resonance| /
      sqrt(1+(f/f_r)^2) =")
```

Scilab code Exa 5.12 `resonant frequency and tank circuit impedance`

```
1  //Example 5.12
2  clc
3  fr=1/(2*%pi*sqrt(100*1000*10^-18))
4  format(8)
5  disp(fr,"(i) Resonant frequency f_r(in kHz) = 1 / 2*
      pi*sqrt(L*C) =")
6  disp("(ii) Tank circuit impedance at resonance can
      be given as")
7  rp=((100*10^6)/5000)*10^-3
8  disp(rp,"R_P(in k-ohm) = L / C*R =")
9  av=(-5*10^-3)*((500*20*10^3)/(520))
```

```
10  format (6)
11  disp (av ,” ( iii )   A_v = −g_m∗R_L = −g_m∗( r_d || R_P ) =”)
12  bw=(5/(2*%pi*100*10^-6))*10^-3
13  disp (” ( iv )   BW = f_r /Q”)
14  disp (”        BW = f_r ∗R / omega_r∗L     Therefore , Q =
          omega_r∗L / R”)
15  disp (bw ,”      BW( in kHz) = R / 2∗pi∗L =”)
```

Scilab code Exa 5.13 `tank circuit elements`

```
1  // Example 5.13
2  clc
3  disp (”BW = f_r / Q”)
4  q=10700/200
5  format (5)
6  disp (q ,” Therefore , Q = f_r / BW =”)
7  disp (”Q = omega_r∗L / R = 2∗pi∗f_r∗L / R”)
8  lr=53.5/(2*%pi*10.7*10^6)
9  format (9)
10  disp (lr ,” Therefore , L/R = Q / 2∗pi∗f_r =”)
11  disp (” |A_v| = g_m∗R_L = 30”)
12  rl=(30/5)
13  disp (rl ,” Therefore , R_L( in k−ohm) = ( r_d || R_p) =”
       )
14  disp (” Therefore , R_p = 6383 ohm”)
15  disp (”We know that”)
16  disp (”R_p = L/C∗R”)
17  c=((795*10^-9)/6383)*10^12
18  format (6)
19  disp (c ,” Therefore , C( in pF) =”)
20  disp (”We know that”)
21  l=(1/(4*%pi^2*((10.7*10^6)^2)*124.5*10^-12))*10^6
22  disp (” f_r = 1 / 2∗pi∗sqrt (L∗C)”)
23  format (6)
24  disp (l ,” Therefore , L( in uH) =”)
```

```
25  disp("We have")
26  disp("R_p = L / C*R")
27  r=(1.777*10^-6)/(6383*124.5*10^-12)
28  disp(r,"Therefore,   R(in ohm) = L / C*R_p =")
29  disp("Therefore, elements of tank circuit are:")
30  disp("L = 1.777 uH,   C = 124.5 pF   and   R = 2.236
        ohm")
```

Chapter 6

Power Amplifier Large Signal Amplifiers

Scilab code Exa 6.1 ICQ and VCEQ and PDC and Pac and efficency

```
1  //Example 6.1
2  clc
3  ibq=(20-0.7)/1.5
4  format(6)
5  disp(ibq,"(i) I_BQ(in mA) = V_CC-V_BE / R_B =")
6  icq=50*12.87
7  format(7)
8  disp(icq,"I_CQ(in mA) = beta * I_BQ =")
9  disp("(ii) V_CC = I_CQ*R_L + V_CEQ")
10 vceq=20-(643.5*16*10^-3)
11 format(5)
12 disp(vceq,"Therefore ,  V_CEQ(in V) = V_CC - I_CQ*R_L
       =")
13 format(6)
14 pdc=20*643.5*10^-3
15 disp(pdc,"(iii) P_DC(in W) = V_CC * I_CQ =")
16 disp("(iv) P_ac Peak current i_b = 9 mA")
17 ic=50*9
18 format(4)
```

```
19 disp(ic,"i_c(in mA) = beta * i_b =")
20 icm=450/sqrt(2)
21 format(8)
22 disp(icm,"Therefore, i_c(rms) = I_rms(in mA) = i_c(
       peak) / sqrt(2) =")
23 pac=318.19^2*16*10^-6
24 format(7)
25 disp(pac,"Therefore, P_ac(in W) = (I_rms)^2 * R_L =
       ")
26 n=(1.619*100)/12.87
27 disp(n,"(v) Efficiency eta(in percentage) = P_ac/
       P_DC * 100 =")
```

Scilab code Exa 6.2 `reflected load impedance`

```
1 //Example 6.2
2 clc
3 disp("R_L = 4 ohm, N1 = 200, N2 = 20")
4 n=20/200
5 format(4)
6 disp(n,"Therefore, n = N2 / N1 =")
7 rl=4/(0.1^2)
8 disp(rl,"Therefore, R''_L(in ohm) = R1 / n^2 =")
9 disp("As N2 < N1, the transformer is step down and
       hence R''_L > R_L, as the primary winding is high
       voltage winding.")
```

Scilab code Exa 6.3 `turns ratio`

```
1 //Example 6.3
2 clc
3 disp("R_L = 8 ohm, R''_L = 648 ohm")
4 disp("Now R''_L = R_L / n^2")
```

```
 5  n=8/648
 6  format (8)
 7  disp (n ,"Therefore ,   n^2 = R_L / R''_L =")
 8  disp ("Therefore ,   n = 0.1111 = Turn ratio")
 9  disp ("But ,   n = N2 / N1 = 0.1111")
10  disp ("Therefore ,   N1/N2 = 9")
11  disp ("Generally the turns ratio is specified as Ni/
        N2 : 1 i.e. for this transformer it is 9:1")
```

Scilab code Exa 6.4 find power dissipation

```
 1  // example6.4
 2  clc
 3  disp ("R_L=8ohm ,  I_CQ=140 mA,  V_CC=10V")
 4  disp ("P_ac=  0.48 W")
 5  disp ("The turns ratio are specified as N1/N2:1 i.e
         3:1")
 6  disp ("Therefore N1/N2=3")
 7  n=1/3
 8  disp (n ,"n=N2/N1=1/3=")
 9  r=8/(0.333)^2
10  disp (r ,"Therefore R''_L=R_L/n^2=")
11  disp ("1. As the transformer is ideal , whatever is
         the power delivered to the load , same is the power
          developed across primary .")
12  disp ("Therefore P_ac ( across primary )=0.48W")
13  disp ("2. Using equation (9) ,")
14  disp ("we get ,  P_ac=(V_1rms^2)/(R''_L )")
15  disp ("Therefore 0.48=(V_1rms^2)/72")
16  v=sqrt (34.56)
17  disp (v ,"Therefore V_1rms ( in V)=")
18  disp ("But rms value of the load voltage is V_2rms")
19  disp ("So (V1_rms)/(V2_rms )=N1/N2=3/1")
20  v=5.8787/3
21  disp (v ,"Therefore (V2_rms )( in V)=(V1_rms )/3=")
```

```
22 disp("This is the rms value of the load voltage.")
23 disp("3. The rms value of the primary voltage is (
      V1_rms) as calculated above.")
24 disp("Therefore (V1_rms)=5.8787 V")
25 disp("4. The power delivered to the load = (I_2rms
      ^2)*R_L        ..Refer equation 13.")
26 disp("0.48=(I_2rms^2)*8")
27 i=sqrt(0.06)
28 disp(i,"(I_2rms)[in A]=")
29 disp("This is the rms value of the load current as
      the resistance value used is R_L and not R''_L")
30 disp("5. The rms values of primary and secondary are
       related through the transformation ratio.")
31 disp("Therefore (I_1rms)/(I_2rms)=N2/N1=n=0.333")
32 i=0.2449*0.333
33 disp(i,"Thererfore (I_1rms)[in A]=0.2449*0.333= ")
34 disp("6. The dc power input is ,")
35 p=140*10^-2
36 disp(p,"P_DC(in W)=(V_CC)*(I_CQ)=")
37 n=(0.48*100)/1.4
38 disp(n,"7. %eta=(P_ac *100)/(P_dc)=")
39 d=1.4-0.48
40 disp(d,"P_d(in W)=")
41 disp("This is the power dissipation.")
```

Scilab code Exa 6.6 `second harmonic distortion`

```
1 //Example 6.6
2 clc
3 disp("R_L = 4 k-ohm,   (P_ac)_D = 0.85 W")
4 disp("The current without signal is I_CQ = 31 mA")
5 disp("The current with signal is I_CQ + B0 = 34 mA")
6 disp("The increase is due to harmonic content in the
      signal")
7 disp("Therefore,   B0 = 34 - 31 = 3 mA")
```

```
8  disp("But,   B2 = B0 = 3 mA")
9  disp("Now  (P_ac)_D = P_ac * [1+D2^2]      ...
       Assuming only second harmonic")
10 disp("Therefore,  (P_ac)_D = 1/2*B1^2*R_L * [1 + B2
       ^2/B1^2]")
11 disp("Therefore,  (P_ac)_D = 1/2*B1^2*R_L + 1/2*B2
       ^2*R_L")
12 disp("0.85 = 1/2*B1^2*(4*10^3) + 1/2*(9*10^-6)
       *(4*10^3)")
13 disp("Therefore,  B1 = 20.396 mA")
14 d2=300/20.396
15 format(7)
16 disp(d2,"Therefore,  D2(in percentage) = |B2|/|B1| *
       100 =")
```

Scilab code Exa 6.7 `class B amplifier`

```
1  //Example 6.7
2  clc
3  disp("The maximum power dissipation occurs when the
       value of V_m is")
4  disp("V_m = 2/pi * V_CC")
5  disp("Now  P_ac = V_m*I_m / 2")
6  disp("So at the time of maximum power dissipation,
       it is")
7  disp("P_ac = 2/pi * V_CC*I_m/2 = V_CC*I_m / pi")
8  disp("Now  P_DC = 2/pi * V_CC * I_m")
9  disp("Hence,  %eta = P_ac/P_DC * 100 = (V_CC*I_m/pi)
       /(2*V_CC*I_m/pi)*100 = 50%")
10 disp("Thus efficiency is just 50% when the power
       dissipation is maximum. While the maximum
       effiency of the class B operation is 78.5%")
```

Scilab code Exa 6.8 max power output and max power dissipation and max base and co

```
1  //Example 6.8
2  clc
3  disp("R_L = 12 ohm,  n = N2/N1 = 1/3 = 0.333,
       eta_trans = 78.5%")
4  rl=12/(0.333^2)
5  format(4)
6  disp(rl,"Therefore,  R''_L = R_L / n^2 =")
7  pac=(0.5*20^2)/108
8  format(7)
9  disp("(i) For P_max, V_m = V_CC")
10 disp(pac,"Threfore,  (P_ac)_max(in W) = 1/2 * V_CC
       ^2/R''_L =")
11 disp("But  eta_trans = 78.5%")
12 pl=0.785*1.8518
13 disp(pl,"Therefore,  P_L(in W) = eta_trans * (P_ac)
       _max =")
14 vm=(2*20)/%pi
15 format(8)
16 disp(vm,"(ii) Condition for (P_d)_max is V_m(in V) =
       2*V_CC/pi =")
17 pd=(2*20^2)/(108*%pi^2)
18 format(7)
19 disp(pd,"Therefore,  (P_d)_max(in W) = 2*V_CC^2 / pi
       ^2*R''_L =")
20 pdm=0.7505/2
21 disp(pdm,"Therefore,  (P_d)_max(in W) per transistor
       =")
22 disp("(iii) (P_ac)_max = V_rms * I_rms = V_m/sqrt(2)
       * I_m/sqrt(2) = V_m*I_m / 2  and  V_m = V_CC")
23 disp("Therefore,  1.8518 = 20*I_m / 2")
24 im=(2*1.8518)/20
25 disp(im,"Therefore,  I_m(in A) = (I_c)_max =")
26 ibm=(0.1851/25)*10^3
27 disp(ibm,"and  (i_b)_max(in mA) = (i_c))max / h_fe =
       ")
```

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Scilab code Exa 6.9 `find power developed`

```
1  //example6.9
2  clc
3  disp(" R_L=16 ohm, V_CC=25 V")
4  disp("Now 2N1=200, N2=50")
5  n=200/2
6  disp(n," Therefore N1=")
7  n=50/100
8  disp(n," Therefore n=N2/N1=")
9  r=16/(0.5^2)
10 disp(r," Therefore R''_L =(R_L)/(n^2)=")
11 disp("For maximum power output, V_m=V_CC")
12 p=(25^2)/(2*64)
13 disp(p,"i) (P_ac)_max [in W]=(V_CC^2)/(2*R_L)=")
14 disp(" ii) (P_dc)=(2*V_CC*I_m)/pi")
15 disp("Now (V_m)/(I_m)=(R''_L)")
16 disp("and V_m=V_CC")
17 i=25/64
18 disp(i," Therefore (I_m)=(V_CC)/(R''_L)=")
19 p=(2*25*0.3906)/(%pi)
20 disp(p," Therefore (P_DC)[in W]=")
21 n=(4.8848*100)/6.2169
22 disp(n," iii) %eta=(P_ac*100)/(P_DC)=")
23 p=(2*4.8828)/(%pi^2)
24 disp(p," iv) (P_d)_max[in W]=(2*(P_ac)_max)/(pi^2)=")
```

Scilab code Exa 6.12 `Pac and PD and efficiency`

```
1  //Example 6.12
2  clc
```

```
3  disp ("R_L = 8 ohm, V_CC = +−12 V hence dual supply
       version")
4  pac=0.5*(12^2/8)
5  format(2)
6  disp (pac," (1)   (P_ac)_max(in W) = 1/2 * V_CC^2/R_L =
       ")
7  disp (" (2)   P_DC = V_CC*I_DC   but I_DC = 2*I_m / pi")
8  disp ("             = V_CC * (2*I_m/pi)")
9  disp ("Now  R_L = V_m/I_m i.e. I_m = V_m/R_L and V_m
       = V_CC")
10 pdc=(12^2*2)/(8*%pi)
11 format(8)
12 disp (pdc,"Therefore,   P_DC(in W) = V_CC * 2 * V_CC/
       R_L * 1/pi =")
13 pdt=11.4591-9
14 disp (pdt,"Therefore,   Total P_D(in W) = P_DC − P_ac
       =")
15 pd=2.4591/2
16 format(7)
17 disp (pd,"Therefore,   P_D per transistor(in W) =")
18 n=900/11.4591
19 format(5)
20 disp (n," (3)   %eta(in percentage) = P_ac/P_DC * 100 =
       ")
```

Scilab code Exa 6.13 `find dc power developed`

```
1  //example6.13
2  clc
3  disp ("V_CC=10V ,R_L=5 ohm")
4  p=100/10
5  disp (p,"i) (P_ac)_max[in W]= (V_CC^2)/(2*R_L)=(10^2)
       /(2*5)=")
6  disp (" ii) To decide Power rating of transistors
       means to find (P_D)_max")
```

```
7  v=(2*10)/(%pi)
8  disp(v,"V_m(in V)=")
9  disp("Now, R_L=(V_m)/(I_m)")
10 i=6.3662/5
11 disp(i,"Therefore (I_m)[in A]=")
12 disp("Therefore (P_DC)=(V_CC)*(I_DC)=(V_CC)*(2*I_m)/
      pi    (I_DC)=(2*I_m)/pi")
13 p=(10*2*1.2732)/(%pi)
14 disp(p," =(10*2*1.2732)/(pi) =")
15 p=(6.3662*1.2732)/2
16 disp(p,"and  (P_ac)[in W]=(V_m*I_m)/2=")
17 p=8.1056-4.5027
18 disp(p,"(P_D)_max[in W]= (P_DC)-(P_ac)=")
19 p=4.0528/2
20 disp(p,"Therefore P_D rating fora each transistor =(
      P_D)_max/2=")
21 disp("iii) For (P_ac)_max, V_m=V_CC=10 V")
22 i=10/5
23 disp(i,"I_m(in A)=(V_m)/R_L=")
24 p=(10*2*2)/%pi
25 disp(p,"P_DC(in W)=")
```

Scilab code Exa 6.15 `power dissipated`

```
1  //Example 6.15
2  clc
3  disp("V_CC = 20 V,  R_L = 4 ohm")
4  vm=(2*20)/%pi
5  format(8)
6  disp(vm,"For (P_d)max,  V_m(in V) = 2/pi * V_CC = ")
7  disp("R_L = V_m / I_m")
8  im=12.7324/4
9  format(6)
10 disp(im,"Therefore,  I_m(in A) = V_m / R_L =")
11 idc=(2*3.183)/%pi
```

```
12  format(7)
13  disp(idc,"Therefore,   I_dc(in A) = 2*I_m / pi =")
14  pac=(0.5*12.7324^2)/4
15  format(8)
16  disp(pac,"Therefore,   P_ac(in W) = 1/2 * V_m^2/R_L =
        ")
17  pdc=20*2.0254
18  format(7)
19  disp(pdc,"and   P_dc(in W) = V_CC * I_DC =")
20  pdm=40.508-20.2542
21  format(8)
22  disp(pdm,"Therefore,   Total (P_d)max(in W) = P_dc -
        P_ac =")
23  pdma=20.2538/2
24  disp(pdma,"Therefore,   (P_d)max(in W) per transistor
        =")
```

Scilab code Exa 6.16 find turns ratio

```
1  //example6.16
2  clc
3  disp("For a given transistor,")
4  disp("Maximum collector current =I_cm =1A")
5  disp("Maximum power dissipation =P_d=10W")
6  disp("Maximum V_CEO =40V")
7  disp("For maximum output power,")
8  disp("I_cm=2*I_CQ")
9  i=1/2
10  disp(i,"I_CQ=1/2=")
11  disp("and V_CEO=2*V_CC")
12  v=40/2
13  disp(v,"V_CC(in V)=V_CEO/2=")
14  disp("and   V_cc=V_m=20V for (P_ac)_max")
15  disp("(P_ac)_max=(V_cc^2)/(2*R_L)")
16  disp("R''_L=(V_m)/I_m and I_m=I_CQ=0.5 A")
```

```
17  r =20/0.5
18  disp ( r ,"R' '_L ( in ohm)=")
19  p=(20^2)/80
20  disp (p ," ( P_ac )_max ( in W)=(20^2)/(2*40)=")
21  disp ("Now, R' '_L=R_L/n^2")
22  n=sqrt (0.0625)
23  disp (n ,"n=N2/N1=")
24  n=1/0.25
25  disp (n ," Therefore N1/N2=1/n=")
26  disp ("Hence the turns ratio of output transformer is
        4:1")
```

Scilab code Exa 6.19 find efficiency

```
1  //example6.19
2  clc
3  disp ("Using equation (2) from section 6.7 , we can
       determine I_BQ.")
4  i=(18-0.7)/(1.2*10^3)
5  format (10)
6  disp (i ,"I_BQ ( in A)=")
7  i=40*14.4167
8  format (7)
9  disp (i ,"Now  (I_CQ)[ in mA]=(beta*I_BQ)=")
10  v=18-(576.67*16*10^-3)
11  disp (v ,"And  (V_CEQ)[ in V]=(V_CC)-(I_CQ*R_L)=")
12  p=18*576.67
13  disp (p ,"So   P_dc ( in W)=(V_CC)*(I_CQ)=")
14  disp ("This is the input power.")
15  disp ("Now input a.c. voltage causes a base current
       of 5mA rms")
16  disp ("Therefore (I_b)_rms=5 mA")
17  i=40*5
18  disp (i ," Therefore i_c_rms ( in mA)=40*5=")
19  disp ("This is nothing but the output collector
```

```
                current , rms value I_rms")
20  disp("Therefore  I_rms  =  200mA")
21  disp("Using equation (13) from section 6.8 , we can
        write ,")
22  p=16*(200*10^-3)^2
23  disp(p,"P_ac(in W)=(I_rms^2)^R_L=")
24  disp("This is the power delivered to the load.")
25  disp("Hence the efficiency of the amplifier is ,")
26  n=(64000*10^-3)/10.38
27  disp(n,"%eta=(P_ac*100)/P_dc= ")
```

Scilab code Exa 6.20 base current and power delivered and efficiency

```
1  //Example 6.20
2  clc
3  disp("V_CC = 20 V,   R_L = 20 ohm, turns ratio 1.58:1
        ")
4  n=1/1.58
5  format(7)
6  disp(n,"  n = 1/1.58 = ")
7  rl=20/0.6329^2
8  disp(rl,"Therefore ,  R''_L(in ohm) = R_L / n^2 =")
9  disp("(i) For maximum possible peak to peak output
        voltage , the power output is also maximum
        possible. For this condition the slope of the a.c
        . load line can be expressed as")
10 disp("R''_L = V_m/I_m = V_CC/I_CQ")
11 icq=20/49.928
12 format(4)
13 disp(icq,"Therefore ,  I_CQ(in A) =")
14 ibq=0.4/40
15 format(5)
16 disp(ibq,"Therefore ,  I_BQ(in A) = I_CQ/beta =")
17 disp("This is the required value of the base current
        ")
```

```
18  disp(" ( i i )   P_ac = I_Irms^2 * R''_L")
19  disp("But for maximum power output condition ,")
20  irms =0.4/ sqrt (2)
21  format (8)
22  disp ( irms ,"I_Irms ( in A) = I_Im/sqrt (2) = I_CQ/sqrt
        (2) =")
23  pac =49.928*0.2828^2
24  format (2)
25  disp ( pac ,"Therefore ,   P_ac ( in W) =")
26  disp (" ( i i i )   %eta = P_ac/P_DC * 100")
27  pdc =20*0.4
28  disp ( pdc ,"Now   P_DC( in W) = V_CC * I_CQ =")
29  eta =400/8
30  format (3)
31  disp ( eta ,"%eta ( in percentage ) =")
```

Scilab code Exa 6.21 value of Vcc

```
1  // Example  6.21
2  clc
3  disp ("R_L = 8 ohm ,   P_ac (max) = 40 W")
4  disp (" 2*N1 = 160 ,   N2 = 40")
5  disp ("N1 = 80")
6  n =40/80
7  format (4)
8  disp (n ,"n = N2/N1 =")
9  rl =8/0.5^2
10 disp ( rl ,"Therefore ,   R''_L ( in ohm) = R_L / n^2 =")
11 disp ("Under maximum condition , V_CC = V_m")
12 disp ("Therefore ,   P_ac (max) = 1/2 * V_CC^2/R''_L")
13 vcc = sqrt (40*2*32)
14 format (6)
15 disp ( vcc ,"Therefore ,   V_CC( in V) =")
16 disp ("This is the required value of V_CC")
```

Scilab code Exa 6.22 input and output power and efficiency

```
1  //Example 6.22
2  clc
3  disp("For a common collector configuration the
       voltage gain is 1")
4  disp("Therefore, V_in(peak) = V_out(peak) = 20 V")
5  disp("i.e. V_m = 20 V")
6  disp("Now V_m/I_m = R_L")
7  im=20/16
8  format(5)
9  disp(im,"Therefore, I_m(in A) = V_m/R_L =")
10 disp("while V_CC = 25 V")
11 pdc=(2*25*1.25)/%pi
12 format(8)
13 disp(pdc,"Now P_DC(in W) = 2*V_CC*I_m / pi =")
14 pac=(20*1.25)/2
15 format(5)
16 disp(pac,"P_ac(in W) = V_m*I_m / 2 =")
17 eta=1250/19.8943
18 format(7)
19 disp(eta,"Therefore, %eta(in percentage) = P_ac*100
       / P_DC =")
```

Scilab code Exa 6.26 total harmonic distortion

```
1  //Example 6.26
2  clc
3  disp("(i) As single transistor is used, even
       harmonic components will not get eliminated")
4  d2=1000/120
5  d3=400/120
```

```
6  d4 =200/120
7  d5 =100/120
8  format (5)
9  disp (d2 ,"   D2( in  percentage ) = |B2|  /  |B1|  =")
10 disp (d3 ,"   D3( in  percentage ) = |B3|  /  |B1|  =")
11 format (6)
12 disp (d4 ,"   D4( in  percentage ) = |B4|  /  |B1|  =")
13 disp (d5 ,"   D5( in  percentage ) = |B5|  /  |B1|  =")
14 disp (" The  total  harmonic  distortion  is ,")
15 disp ("%D =  sqrt (D2^2 + D3^2 + D4^2 + D5^2) *  100")
16 d=sqrt ((0.0833^2)+(0.0333^2)+(0.01667^2)+(0.00833^2)
       )*100
17 format (7)
18 disp (d ," Therefore ,   %D( in  percentage ) =")
19 disp ("( ii ) When  identical  second  transistor  is  used ,
        then  all  even  harmonics  get  eliminated . So  only
      D3  and  D5  will  present ")
20 dp=sqrt ((0.033^2)+(0.00833^2))*100
21 disp (dp ," Therefore ,   %D( in  percentage ) = sqrt (D3^2 +
      D5^2)*100  =")
```

Scilab code Exa 6.27 `find min breakdown voltage`

```
1  // example6 .27
2  clc
3  disp (" From  the  fig  6.50  we  can  write ,")
4  disp ("V_CC=20V  and  R_L=12  ohm")
5  disp (" i )  The  maximum  ac  power  that  can  be  delivered
      to  the  load  is ,")
6  p=(20^2)/24
7  disp (p ,"( P_ac )_max [ in  W]=  ")
8  disp (" Let  new  power  delivered  to  load  be  (P_ac ) ''.")
9  disp (" The  corresponding  new  supply  voltage  be  (V''
      _cc )")
10 disp ("( P_ac ) '' [ in  W]=1.36( P_ac )_max      ..36%  more ")
```

```
11  p=1.36*16.67
12  disp(p,"= 1.36*16.67=")
13  disp("And (P_ac)''=(V''_cc^2)/R_L")
14  disp("Therefore 22.67=(V''_cc^2)/(2*12)")
15  v=sqrt(544.1088)
16  disp(v,"V''_cc(in V)=")
17  disp("Hence the percentage increase in supply
        voltage is ,")
18  p=(23.326-20)/0.2
19  disp(p,"= ((V''_cc-V_cc)*100)/V_cc= ")
20  disp("The mimimum breakdown voltage per transistor
        this condition is ,")
21  v=2*23.326
22  disp(v,"=2*V''_cc=2*23.326=")
```

Scilab code Exa 6.30 `find efficiency`

```
 1  //example6.30
 2  disp("The circuit used for providing proper biasing
        is self bias, for which the various currents can
        be shown in the fig 6.52")
 3  disp("Applying KVL to base emiter loop ,")
 4  disp("(-V_BE)-(I_E*R_E)+(I*R2)=0")
 5  disp("Theredfore (I*100)-(1+beta)*I_B*10=V_BE")
 6  disp("100I-210(I_B)=0.5      ..(1)")
 7  disp("Applying KVL through R1 and R2,")
 8  disp("(-R1(I+I_B))-(R2*I)+V_cc=0")
 9  disp("-1000(I+I_B)-100I=-V_cc")
10  disp("1100I+1000(I_B)=25      ..(2)")
11  disp("Multiplying equation (1) by 11 and subtracting
        from equation (2) we get ,")
12  disp("3310(I_B)=19.5")
13  i=19.5/3310
14  disp(i,"Therefore I_B(in A)=")
15  format(8)
```

```
16  disp("Thereofore  I_C=(beta*I_B)=117.82 mA=I_CQ")
17  disp("Now n=N2/N1=1/8")
18  r=5*(8^2)
19  disp("Therefore  (R''_L)=(R_L)/(n^2)=")
20  disp("i) For maximum power delivered to load ,")
21  disp("V_1m=V_CEQ")
22  disp("Apply KVL to collector−emitter loop ,")
23  disp("(−10I_C)−(V_CEQ)−(10*I_E)+V_CC=0")
24  v=25-(20*(117.82*10^-3))
25  format(7)
26  disp(v,"V_CEQ=V_cc−20*I_C          ...I_C=I_E")
27  p=(22.643^2)/640
28  disp(p,"(P_ac)_pri[in W]=(V_CEQ^2)/(2*R''_L)=")
29  p=0.9*0.8011
30  disp(p,"(P_ac)_max[in W]=0.9*0.8011=")
31  disp("This is maximum power delivered to the load .")
32  p=25*117.82*10^-3
33  format(7)
34  disp("ii) Now (P_DC)[in W]=V_CC*I_CQ=")
35  n=(0.721*100)/2.9455
36  format(6)
37  disp(n,"%eta=(P_ac*100)/(P_dc)=")
```

Scilab code Exa 6.32 `find R`

```
1  //example6.32
2  clc
3  disp("When no signal is applied , current drawn is")
4  disp("I_CQ =200mA from V_cc= 10V")
5  p=10*200*10^-3
6  disp("P_DC(in W)=V_CC*I_CQ=")
7  disp("For maximum power output ,")
8  disp("V_1m=V_cc=10V and I_1m=I_CQ=200mA")
9  p=2/2
10 disp(p,"P_ac(in W)=(V_1rms*I_1rms)=(V_1m*I_1m)
```

```
     /2=(10*200*10^−3)/2=")
11  disp("i) P_ac(max)=Maximum output power =1W")
12  n=100/2
13  disp(n,"ii) %eta=(P_ac*100)/(P_DC)=")
14  disp("P_d(max)=V_cc*I_CQ= 2W")
15  disp("The power dissipation rating of the transistor
        must be higher than 2W")
16  r=10/(200^10^-3)
17  disp(r,"Now  R''_L(in ohm)=(V_1m)/(I_1m)=")
18  n=1/5
19  disp(n,"Now R_L=2 ohm and n =N2/N1=1/5=")
20  r=2/(0.2^2)
21  disp(r,"R''_L(in ohm)=(R_L)/n^2=")
22  disp("As R''_L required matches with the R''_L of
        the circuit, impedance matching is perfect")
```

Scilab code Exa 6.33 `distortion factor`

```
1  //Example 6.33
2  clc
3  disp("B1 = 5*10^−2,  B2 = 10^−4,  B3 = 3*10^−6")
4  disp("These are the amplitudes of various frequency
        components")
5  d2=10^-4/(50*10^-2)
6  d3=(3*10^-6)/(50*10^-2)
7  d=sqrt((2*10^-4)^2+(6*10^-6)^2)*100
8  format(7)
9  disp(d2,"Therefore,  D2 = |B2|/|B1| =")
10  disp(d3,"Therefore,  D2 = |B3|/|B1| =")
11  format(5)
12  disp(d,"Therefore,  %D(in percentage) = sqrt(D2^2 +
        D3^2)*100 =")
```

Scilab code Exa 6.34 `power transfer`

```
1  //Example 6.34
2  clc
3  disp("V_CC = 12 V,  I_PP = 100 mA,  R_L = 5 ohm")
4  disp("Therefore,  I_m = I_PP/2 = 50 mA")
5  pac=((2500*10^-6)*5)/2
6  format(8)
7  disp(pac,"(i)  P_ac(in W) = I_m^2*R_L / 2 =")
8  disp("(ii)  P_ac(max) = 1/2 * V_CC^2/R_L")
9  disp("But  P_ac = V_m*I_m/2 and V_m = V_CC for
       maximum power")
10 rl=12^2/0.6
11 format(4)
12 disp(rl,"Therefore,  R''_L(in ohm) = ")
13 disp("But  R''_L = R_L/n^2  i.e. 240 = 5/n^2")
14 disp("Therefore,  n^2 = 0.02083  i.e. n = 0.1443 =
       N2/N1")
15 disp("Therefore,  N1/N2 = 6.928 : 1")
```

Scilab code Exa 6.35 `output and input power and collector efficiency and power dis`

```
1  //Example 6.35
2  clc
3  disp("I_CQ = 250 mA,  V_CEQ = 8 V")
4  disp("V_max = 15 V,  V_min = 1 V,  I_max = 450 mA,
       I_min = 40 mA")
5  ipp=450-40
6  disp(ipp,"Therefore,  I_pp(in mA) = I_max - I_min ="
       )
7  vpp=15-1
8  disp(vpp,"Therefore,  V_pp(in V) = V_max - V_min =")
9  vm=14/2
10 disp(vm,"Therefore,  V_m(in V) = V_pp/2 =")
11 im=410/2
```

```
12  disp(im,"Therefore,   I_m(in mA) = I_pp/2 =")
13  pac=(7*205*10^-3)/2
14  pdc=250*8*10^-3
15  n=71.75/2
16  pd=2-0.7175
17  format(7)
18  disp(pac,"(i)   P_ac(in W) = V_m*I_m/2 =
                         ...output power")
19  disp(pdc,"(ii)   P_DC(in W) = I_CQ*V_CEQ =
                      ...input power")
20  disp(n,"(iii)   %eta(in %) = P_ac/P_DC * 100 =
                 ...efficiency")
21  disp(pd,"(iv)   P_d(in W) = P_DC - P_ac =
                      ...power dissipation")
```