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

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Feedback Amplifiers

Scilab code Exa 1.1 transistor in the feedback amplifier

```
//Example 1.1
clc
disp("Step 1: Identity topology")
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
    .")
disp("")
disp("Step 2 and Step 3: Find input and output
    circuit.")
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")
disp("")
disp("Step 4: Find open loop voltage gain(A_v)")
format(5)
rl2=(4.7*10.1)/(4.7+10.1) // in k-ohm
```

```
disp(rl2,"  R_L2(in k-ohm) = R_c2 || (R_e1+Rf) =")
disp("  A_i2 = -hfe = -100")
disp("  R_i2 = hie = 1100 ohm")
format(7)
av2=(-100*3.21*10^3)/1100
disp(av2,"  A_v2 = A_i2*R_L2 / R_i2 =")
disp("  A_i1 = -hfe = -100")
format(5)
rl1=(22*220*22*1.100)/((220*22*1.100)+(22*22*1.100)+(22*220*1.100)+(22*220*22))  // in ohm
disp(rl1*10^3,"  R_L1(in ohm) = R_c1 || R3 || R4 || R_i2 =")
ri1=1.1+(101*((0.1*10)/(0.1+10)))  // in k-ohm
format(5)
disp(ri1,"  R_i1(in k-ohm) = hie + (1+hfe)*R_e1eff =                 where Re1eff = (R_e1 || Rf)")
av1=(-100*995)/(11.099*10^3)
disp(av1,"Therefore,  A_v1 = A_i1*RL1 / Ri1 =")
disp("The overall voltage gain without feedback is given as,")
av=-291.82*-8.96
format(7)
disp(av,"  Av = A_v1 * A_v2 =")
disp("The overall voltage gain taking Rs in account is given as,")
aV=(2614.7*11.099*10^3)/((11.099*10^3)+100)
format(8)
disp(aV,"  Av = Vo / Vs = Av*R_i1 / R_i1+Rs =")
disp("")
disp("Step 5: Calculate beta")
disp("Looking at Fig.1.33.")
beta=100/(100+(10*10^3))
format(7)
disp(beta,"  beta = Vf / Vo =")
d=1+(0.0099*2591.35)
format(6)
disp(d,"  D = 1 + beta*Av =")
avf=2591.35/26.65
```

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

Scilab code Exa 1.2 closed loop gain with negative feedback

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

Scilab code Exa 1.3 open and closed loop gain

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

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

Scilab code Exa 1.4 gain with feedback

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

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

```
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
    ")
vsf=10*100*10^-3  // in V
disp(vsf,"         V_sf(in V) = Vs * 100 =")
disp("(c) Second harmonic distortion is reduced by
    factor 1 + beta*A")
d2f=(0.1/100)*100 // in percentage
disp(d2f,"        D_2f(in percentage) = D_2 / 1+beta*A
     =")
```

Scilab code Exa 1.6 beta and Af

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

Scilab code Exa 1.7 amount of feedback

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

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

Scilab code Exa 1.8 A1 and A2

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

```
A2B2]B1 - |A1-deltaA_i|[A2/1+A2*B2]/1+|A1-deltaA_i|[A2/1+A2B2]B1 |")
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

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

Scilab code Exa 1.10 amplifier without feedback

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

```
disp(av,"A_v = Vo/V_in =")
disp("(i)  beta = 0.012")
disp("Therefore,  The gain of the amplifier with
    feedback is given as")
af=1285.7/(1+(1285.7*0.012))
format(6)
disp(af,"A_f = A_v / 1+A_v*beta =")
disp("The output voltage with feedback is given as")
vo=78.26*0.028
disp(vo,"Vo(in V) = A_f * V_in =")
vin=7*0.028
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:")
disp(vin,"V_in(in V) =")
```

Scilab code Exa 1.11 gain with feedback

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

```
disp("(ii) 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")
disp("Therefore,  A_v = A_v +- 0.5*A_v = 1000 +- 500 ")
disp("The gain of the amplifier with feedback is now given as")
avf1=1500/(1+(1500*0.05))
avf2=500/(1+(500*0.05))
format(6)
disp(avf1,avf2,"A_vf = A_v / 1+A_v*beta =")
```

Scilab code Exa 1.12 single stage RC coupled amplifier

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

Scilab code Exa 1.13 feedback ratio and input voltage

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

Scilab code Exa 1.14 Av and beta of amplifier

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

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

Scilab code Exa 1.15 determine Avf

```
//Example 1.15
clc
disp("Step 1: Identify topology")
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
   ")
disp("")
disp("Step 2 and Step 3: Find input and output
   circuit.")
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")
disp("")
disp("Step 4: Replace transistor with its h-
   parameter equivalent as shown in fig.1.49")
disp("")
disp("Step 5: Find open loop transfer gain.")
disp("A_v = A_v1*A_v2")
disp("     = V_i2/V_i1 * Vo/V_i2")
disp("     = Vo/V_i2 = -h_fe*R_L2 / R_i2")
rl2=3.3+3.3
format(4)
```

```
disp(rl2,"where  R_L2(in k-ohm) =")
disp("and  R_i2 = h_ie = 2 K")
voi=(-50*6.6)/2
disp(voi,"Therefore,  A_v2 = Vo/V_i2 =")
disp("V_i2/V_i1 = -h_fe*R_L1 / R_i1")
rl1=((51*2)/(53))
format(5)
disp(rl1,"where  R_L1(in k-ohm) =")
disp("and  R_i = [h_ie + (1+h_fe)(3.3K||3.3K)]")
ri=2+(51*1.65)
format(6)
disp(ri,"Therefore,  R_i1(in k-ohm) = ")
vi21=(-50*1.92)/(86.15)
format(6)
disp(vi21,"Therefore,  A_v1 = V_i2/V_i1 =")
av=-165*-1.114
format(7)
disp(av,"Therefore,  A_v =")
disp("")
disp("Step 6: Calculate beta")
be=3.3/6.6
format(4)
disp(be,"beta = V_f/Vo =")
disp("We know that,  D = 1 + beta*A_v =")
avf=183.86/92.93
format(6)
disp(avf,"A_vf = A_v/D =")
```

Scilab code Exa 1.16 Avf and Rif

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

```
feedback.")
disp("")
disp("Step 2 and Step 3: Find input and output circuit.")
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.")
disp("")
disp("Step 4: Replace transistor with its h-parameter equivalent as shown in fig.1.52.")
disp("")
disp("Step 5: Find open loop transfer gain.")
disp("A_v = A_v1*A_v2")
disp("     = V_i2/V_i1 * Vo/V_i2")
disp("Vo/V_i2 = -h_fe*R_L2 / R_i2")
rl2=(5.1*11)/(16.1)
format(6)
disp(rl2,"where  R_L2(in k-ohm) =")
disp("and  R_i2 = h_ic = 1.1 K")
voi=(-50*3.484)/1.1
format(7)
disp(voi,"Therefore,  Vo/V_i2 =")
disp("V_i2/V_i1 = -h_fe*R_L1 / R_i1")
rl1=((1.1*1)/(2.1))*10^3
format(6)
disp(rl1,"where  R_L1(in ohm) =")  //answer in text book is wrong
disp("and  R_i = 82K || [h_ie + (1+h_fe)(1K||10K)]")
ri=((82*47.459)/(82+47.459))
format(3)
disp(ri,"Therefore,  R_i(in k-ohm) = ")
vi21=(-50*523.8)/(30*10^3)
format(6)
disp(vi21,"Therefore,  V_i2/V_i1 =")
av=-158.36*-0.888
```

```
format(7)
disp(av,"Therefore,  A_v =")
disp("")
disp("Step 6: Calculate beta")
be=1/10
format(4)
disp(be,"beta = V_f/Vo =")
disp("")
disp("Step 7: Calculate A_vf, R_if and R''_of")
d=1+(0.1*140.62)
format(7)
disp(d,"D = 1 + beta*A_v =")
avf=140.62/15.062
format(6)
disp(avf,"A_vf = A/D =")
rif=30*15.062
format(7)
disp(rif,"R_if(in k-ohm) = R_i*D =")
disp("R''_o = R_L2 = 3.484 k-ohm")
rof=(3.484*10^3)/15.062
disp(rof,"R''_of(in ohm) = R''_o/D =")
```

Scilab code Exa 1.17 D and Avf anf Rif and Rof

```
//Example 1.17
disp("Step 1: Identify topology")
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.")
disp("")
disp("Step 2 and Step 3: Find input and output
   circuit.")
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.")
disp("")
disp("Step 4: Replace FET with its equivalent
   circuit as shown in fig.1.55.")
disp("")
disp("Step 5: Find open loop transfer gain.")
disp("   Av = Vo / Vs = A_v1 * A_v2")
disp("   A_v2 = -u*R_L2 / R_L2+r_d")
rl2=(10.2*47)/(10.2+47)   // in k-ohm
format(5)
disp(rl2,"where  R_L2(in k-ohm) =")
av2=(-40*8.38)/18.38
format(7)
disp(av2,"   A_v2 =")
disp("   A_v1 = u*R_Deff / r_d+R_Deff+(1+u)*R_seff")
rdeff=(47*1000)/(47+1000)   // in k-ohm
format(6)
disp(rdeff,"   R_Deff(in k-ohm) = R_D || R_G2 =")
av1=(-40*44.98)/(10+44.89+(41*((0.2*10)/(10+0.2))))
disp(av1,"Therefore,   A_v1 =")
av=-28.59*-18.237
format(7)
disp(av,"Therefore,   Av = A_v1 * A_v2 =")
disp("")
disp("Step 6: Calculate beta")
beta=200/(10000)
format(5)
disp(beta,"   beta = Vf / Vo =")
disp("")
disp("step 7: Calculate D, A_vf, R_if, R''_of")
d=1+(0.02*521.39)
format(8)
disp(d,"   D = 1 + Av*beta =")
avf=521.39/11.4278
```

```
format(6)
disp(avf,"   A_vf = Av / D =")
disp("Ri = R_G = 1 M-ohm")
rif=11.4278
format(8)
disp(rif,"   R_if(in M-ohm) = Ri * D =")
ro=10   // in k-ohm
format(3)
disp(ro,"   R''o(in k-ohm) = rd =")
rof=(10*10^3)/11.4278   // in ohm
format(4)
disp(rof,"   R''_of(in ohm) = R''o / D =")
rod=(10*8.38)/18.38
format(6)
disp(rod,"R''_o(in k-ohm) =")
rofd=(4.559*10^3)/11.4278
format(4)
disp(rofd,"Therefore,  R''_of(in ohm) = R''_o/D =")
```

Scilab code Exa 1.18 voltage gain including feeback

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

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

Scilab code Exa 1.19 Avf

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

```
")
```

Scilab code Exa 1.20 voltage gain with feedback

```
//Example 1.20
clc
disp("Step 1: Identify topology")
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.")
disp("")
disp("Step 2 and Step 3: Find input and output circuit.")
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.")
disp("")
disp("Step 4: Replace transistor with its h-parameter equivalent as shown in fig 1.59.")
disp("")
disp("Step 5: Find open loop transfer gain.")
disp("  From quation(13) of section 1.12 we have")
disp("  A_vf = Io*R_L / Vs = G_Mf * R_L")
disp("       = -h_fe*R_L / R''s+h_ie+(1+h_fe)*Re")
disp("Here  R''s = Rs || R1 || R2")
disp("           = Rs || Rb          because R_b = R1 || R2")
disp("Therefore,  Vo / Vs = Vo/Vi * Vi/Vs")
disp("where       Vi / Vs = Rb / Rs+Rb")
disp("Therefore,  Vo / Vs = (-h_fe*R_L / R''s+h_ie+(1+h_fe)*Re) * (Rb / Rs+Rb)")
```

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

```
//Example 1.21
clc
disp("Step 1: Identify topology")
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")
disp("")
disp("Step 2 and Step 3: Find input and output
   circuit")
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")
disp("")
disp("Step 4: Find open circuit current gain")
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")
disp("-I_c2/I_b2 = -h_fe = -100")
disp("I_b2/I_c1 = -R_c1 / R_i2+R_c1")
ri2=2+(101*(20/21))
```

```
format(6)
disp(ri2,"where  R_i2(in k-ohm) = h_ie + (1+h_fe)R_e =")
ibc=(-12)/(98.19+12)
format(6)
disp(ibc,"Therefore,  I_b2/I_c1 =")
disp("I_c1/I_b1 = h_fe = 100")
ibs=(21/22)/(2+(21/22))
disp(ibs,"I_b1/I_s =")
ai=100*0.109*0.323*100
format(4)
disp(ai,"Therefore,  A_I =")
disp("")
disp("Step 5: Calculate beta")
b=4/(24)
format(7)
disp(b,"beta = I_f/Io = R_e2/R_e2+R'' =")
disp("")
d=1+(0.1667*352)
format(6)
disp(d,"Therefore,  D = 1 + beta*A_I =")
aif=352/59.67
format(5)
disp(aif,"A_if = A_I/D =")
ri=((1*21*2)/((21*2)+(1*2)+(21*1)))*10^3
format(4)
disp(ri,"R_i(in ohm) =")
rif=646/59.67
format(6)
disp(rif,"R_if(in ohm) = R_i/D =")
disp("Ro = infinity")
disp("Therefore,  R_of = infinity    because h_oe = 0")
disp("R''_o = Ro || R_c2 = 4 k-ohm")
disp("R''_of = R''_o = 4 k-ohm")
avf=(5.9*4)
disp(avf,"A_vf = A_If*R_L/R_s =")
```

Scilab code Exa 1.22 Avf and Rif and Rof

```
//Example 1.22
clc
disp("Step 1: Identify topology")
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")
disp("")
disp("Step 2 and Step 3: Find input and output
    circuit")
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")
disp("")
disp("Step 4: Replace transistor with its h-
    parameter equivalent as shown in fig 1.64")
disp("")
disp("Step 5 : Find open loop current gain")
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")
disp("Io/I_b2 = -h_fe = -100")
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")
ri2=1+(101*(10/11))
format(7)
disp(ri2,"where  R_i2(in k-ohm) = h_ie + (1+h_fe)(1K
    ||10K) =")
ibb=(-100*2.2)/(92.818+2.2)
format(6)
```

```
disp(ibb,"Therefore,  I_b1/I_s =")
ibs=(11/12)/(1+(11/12))
disp(ibs,"I_b1/I_s =")
ai=100*2.315*0.478
disp(ai,"A_I =")
disp("Step 6: Calculate beta")
b=1/(11)
format(5)
disp(b,"beta = R_e2/R_e2+R'' =")
disp("")
disp("Step 6: Calculate D,A_If, A_vf, R_if, R_of")
d=1+(0.09*110.7)
format(7)
disp(d,"D = 1 + beta*A_I =")  //answer in textbook
    is wrong
aif=110.7/11.063
format(3)
disp(aif,"A_if = A_I/D =")
ri=((1*11*1)/((11*1)+(1*1)+(11*1)))*10^3
format(4)
disp(ri,"R_i(in ohm) =")
rif=478/11.063
format(6)
disp(rif,"R_if(in ohm) = R_i/D =")
disp("Ro = infinity")
disp("Therefore,  R_of = Ro*D = infinity      because
    h_oe = 0")
disp("R''_o = 2.2 k-ohm")
disp("R''_of = R''_o = 2.2 k-ohm")
```

Scilab code Exa 1.23 Rmf and Aof and Rif and Rof

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

```
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")
disp("")
disp("Step 2 and Step 3: Find input and output circuit")
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")
disp("")
disp("Step 4: Replace transistor with its h-parameter equivalent circuits as shown in fig 1.67")
disp("")
disp("Step 5 : Find open loop transresistance")
disp("R_M = Vo/I_s = R_c*Io/I_s = -R_c*I_c/I_s")
disp("     = R_c * -I_c/I_b * I_b/I_s")
icb=(-100*82)/94
format(6)
disp(icb,"-I_c/I_b = -h_fe*R / R+R_c =")
disp("I_b/I_s = Ro||R / R_s||(R+R_i1)")
ri1=1.1+(101*820*10^-3)
disp(ri1,"R_i1(in k-ohm) = h_ie + (1+h_fe)R_e =")
ibs=(82/83)/(83.92+(82/83))
format(7)
disp(ibs,"Therefore,  I_b/I_s =")
rm=-87.23*12*0.0116
format(7)
disp(rm,"Therefore,  R_M(in k-ohm) = Vo/I_s =")
disp("")
disp("Step 6: Calculate beta")
b=-1/(82*10^3)
format(10)
disp("beta = I_f/Io = V_i-Vo/Vo*R =")
disp(b,"     = -1/R =                because (Vo > V_i)"
)
```

```
disp("")
disp("Step 7: Calculate D, R_Mf, A_vf, R_if, R''_of")
d=1+(-1.22*-12.142*10^-2)
format(6)
disp(d,"D = 1 + beta*R_M =")
rmf=-12.142/1.148
format(6)
disp(rmf,"R_Mf(in k-ohm) = R_M/D =")
avf=-10.57
disp("A_vf = V0/V_s = Vo/I_s*R_s =")
disp(avf,"      = R_Mf/R_s =          because R_Mf = Vo/I_s")
ri=((1*82*83.92)/((82*83.92)+(1*83.92)+(82*1)))
disp(ri,"R_i(in k-ohm) = R_s || R_i1 || R =")
rif=(0.976*10^3)/1.148
format(4)
disp(rif,"R_if(in ohm) = R_i/D =")
disp("Ro = infinity")
disp("Therefore, R_of = infinity/D = infinity because h_oe = 0")
ro=(12*82)/(94)
format(7)
disp(ro,"R''_o(in k-ohm) = R || R_c =")
rof=(10.468)/1.148
format(6)
disp(rof,"R''_of(in k-ohm) = R''_o/D =")
```

Scilab code Exa 1.24 Avf and Rif and Rof

```
//Example 1.24
clc
disp("Step 1: Identify topology")
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")
disp("")
disp("Step 2 and Step 3: Find input and output circuit")
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")
disp("")
disp("Step 4: Replace transistor with their h-parameter equivalent circuits as shown in fig 1.70")
disp("")
disp("Step 5 : Find open loop transfer gain")
disp("R_M = Vo/I_s = R_c2*Io/I_s")
disp("     = R_c2 * Io/I_b2 * I_b2/I_e1 * I_e1/I_b1 * I_b1/I_s")
iob=(-100*2.2)/7.3
format(7)
disp(iob,"Io/I_b2 = -h_ie*R / R+R_c2 =")
iobe=(101*1.1)/3.1
format(6)
disp(iobe,"I_b2/I_e2 * I_e1/I_b1 = -h_ie*R / R+R_c2 =")
disp("I_b1/I_s = R_s||R / (R_s||R)+R_i1")
ri1=2+(101*1.1)
disp(ri1,"where  R_i1(in k-ohm) = h_ie + (1+h_fe)R_e =")
ibs=(2.2/3.2)/((2.2/3.2)+(113.1))
format(8)
disp(ibs,"I_b1/I_s =")
rm=5.1*-30.137*35.84*6.04*10^-3
format(7)
disp(rm,"Therefore ,  R_M(in k-ohm) =")
disp("")
disp("Step 6: Calculate beta")
```

```
b=-1/(2.2*10^3)
format(10)
disp("beta = I_f/Io = V_i-Vo/Vo*R =")
disp(b,"      = -1/R =              because (Vo > V_i)")
disp("")
disp("Step 7: Calculate D, R_Mf, A_vf, R_if, R''_of")
d=1+(4.545*33.539*10^-1)
format(7)
disp(d,"D = 1 + beta*R_M =")
rmf=-33.539/16.245
format(6)
disp(rmf,"R_Mf(in k-ohm) = R_M/D =")
avf=-2.065
disp(avf,"A_vf = V0/V_s = Vo/I_s*R_s =")
ri=((1*113.1*2.2)/((113.1*2.2)+(1*113.1)+(2.2*1)))*10^3
format(4)
disp(ri,"R_i(in ohm) = R_s || R_i1 || R =")  // answer in textbook wrong
rif=(683)/16.245
format(3)
disp(rif,"R_if(in ohm) = R_i/D =")
disp("Ro = infinity")
disp("Therefore,  R_of = infinity/D = infinity")
ro=(2.2*5.1)/(7.3)
format(6)
disp(ro,"R''_o(in k-ohm) = R || R_c2 =")
rof=(1.537*10^3)/16.245
disp(rof,"R''_of(in ohm) = R''_o/D =")
```

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

```
//Example 1.25
```

```
clc
disp("Step 1: Identify topology")
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")
disp("")
disp("Step 2 and Step 3: Find input and output
   circuit")
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")
disp("")
disp("Step 4: Replace FET with its equivalent
   circuit as shown in fig 1.73")
disp("")
disp("Step 5 : Find open loop transresistance")
disp("R_M = Vo/I_s = -g_m*V_gs*R_eff/I_s")
reff=(40*200*10)/((200*10)+(400)+(40*200))
format(5)
disp(reff,"where  R_eff(in k-ohm) = r_d || R || R_D
   =")
disp("and  V_gs = I_s*R_i = I_s * R_s||1M||R")
disp("            = I_s * 10K||1M||200K")
disp("            = 9.43*10^3 I_s")
rm=-2.5*9.43*7.69
format(7)
disp(rm,"R_M(in k-ohm) =")
disp("")
disp("Step 6: Calculate beta")
b=-1/(200*10^3)
format(7)
disp("beta = I_f/Io = V_i-Vo/Vo*R =")
disp(b,"      = -1/R =              because (Vo > V_i)"
   )
disp("")
```

```
disp("Step 7: Calculate D, R_Mf, A_vf, R_of, R''_of")
d=1+(5*181.29*10^-3)
format(4)
disp(d,"D = 1 + beta*R_M =")
rmf=-181.29/1.9
format(7)
disp(rmf,"R_Mf(in k-ohm) = R_M/D =")
avf=-95.415/10
format(7)
disp(avf,"A_vf = V0/V_s = Vo/I_s*R_s = R_Mf/R_s =")
ri=(10*1000*200)/((1000*200)+(10*200)+(1000*10))
format(5)
disp(ri,"R_i(in k-ohm) = R_s || M || R =")
rif=(9.43)/1.9
format(6)
disp(rif,"R_if(in k-ohm) = R_i/D =")
ro=(40*200*10)/((200*10)+(400)+(40*200))
format(5)
disp(ro,"R''_o(in k-ohm) = r_eff = r_d || R || R_D =")
rof=(7.69/1.9)
format(2)
disp(rof,"R''_of(in k-ohm) = R''_o/D =")
```

Scilab code Exa 1.26 Aof and Rif and Rof

```
//Example 1.26
clc
disp("Step 1: Identify topology")
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")
disp("")
```

```
disp("Step 2 and Step 3: Find input and output circuit")
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")
disp("")
disp("Step 4: Find open loop voltage gain (A_v)")
rl2=(2.2*52.5)/54.7
format(5)
disp(rl2,"R_L2(in k-ohm) = R_c2 || (R_f+R_e1) =")
disp("A_i2 = -h_fe = -50")
disp("R_i2 = h_ie = 1.2 k-ohm")
av2=(-50*2.11)/1.2
format(6)
disp(av2,"A_v2 = A_i2*R_L2 / R_i2 =")
rl1=(100*1.2)/101.2
disp(rl1,"R_L1(in k-ohm) = R_c1 || R_i2 =")
disp("A_i1 = -h_fe = -50")
ri2=1.2+(51*(51*1.5/52.5))
format(6)
disp(ri2,"R_i1(in k-ohm) = h_ie + (1+h_fe)R_e =")
av1=(-50*1.185)/75.51
disp(av1,"Therefore,  A_v1 = A_i1*R_L1 / R_i1 =")
disp("The overall gain without feedback is given as"
)
av=-0.784*-87.91
disp(av,"A_v = A_v1*A_v2 =")
disp("")
disp("Step 5: Calculate beta")
b=1.5/52.5
format(7)
disp(b,"beta = V_f/Vo =")
disp("")
disp("Step 6: Calculate D,A_vf, R_if, R_of")
```

```
d=1+(0.0285*68.92)
format(6)
disp(d,"D = 1 + beta*A_v =")
avf=68.92/2.964
disp(avf,"A_vf = A_v/D =")
ri=(75.51*200.1485)/(200.1485+75.51)
disp(ri,"R_i(in k-ohm) = R || R_i1 =")
rif=54.82*2.964
format(7)
disp(rif,"R_if(in k-ohm) = R_i/D =")
disp("Ro = infinity    because h_oe = 0")
disp("R''_o = Ro || R_c2 || (R_f+R_e1) = Ro || R_L2
    = infinity || 2.11 K = 2.11 K")
rof=(2.11*10^3)/2.964
format(4)
disp(rof,"R''_of(in ohm) = R''_o/D =")
```

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

```
//Example 1.27
clc
disp("Step 1: Identity topology")
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")
disp("")
disp("Step 2 and Step 3: Find input and output
    circuit")
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")
disp("Step 4: Find open circuit transfer gain")
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")
disp("We know that  -I_c2/I_b2 = A_i2 = -h_fe = -50 and")
disp("-I_c/I_b1 = A_i1 = -h_fe = -50")
disp("Therefore,  I_c1/I_b1 = 50")
disp("Looking at fig 1.77 we can write")
disp("I_b2/I_c1 = -R_c1/R_c1+R_i2")
ri2=1.5+(51*(5*0.6/5.6))
format(6)
disp(ri2,"R_i2(in k-ohm) = h_ie + (1+h_fe)(R_e2||R'') =")
ibc=-2/30.82
format(7)
disp(ibc,"Therefore,  I_b2/I_c1 =")
disp("Looking at fig 1.78 we can write")
disp("I_b1/I_s = R/R+R_i1")
r=(5.6*10^3)/6.6
format(4)
disp(r,"where  R(in ohm) = R3 || (R''+R_e) =")
ri1=1.5+20.4
format(5)
disp(ri1,"and  R_i1(in k-ohm) = h_ie + (1+h_fe)R_e1 =")
ib1=0.848/22.748
format(7)
disp(ib1,"Therefore,  I_b1/I_s =")
disp("Substituting the numerical values obtained in equations of A_I we get,")
ai=50*0.0649*50*0.0372
format(2)
disp(ai,"A_I =")
disp("")
```

```
disp("Step 5: Calculate beta")
b=0.6/5.6
format(6)
disp(b,"beta = I_f/Io = R_e2 / R_e2+R'' =")
disp("")
disp("Step 6: Calculate D,A_If, A_vI, R_sf, R_of")
d=1+(0.107*6)
format(6)
disp(d,"D = 1 + beta*A_I =")
aif=6/1.642
disp(aif,"A_if = A_I/D =")
avf=(3.654*12)/1
format(7)
disp(avf,"A_vf = Vo/V_s = -I_c2/I_s * R_c2/R_s =
    A_if*R_c2 / R_s =")
ri1=(848*21900)/(21900+848)
disp(ri1,"R_i1(in ohm) = R || R_i1 =")
rif=816.38/1.642
format(6)
disp(rif,"R_if(in ohm) = R_i/D =")
disp("Ro = infinity    because h_oe = 0")
disp("Therefore,  R_of = Ro*D = infinity")
disp("R''_o = Ro || R_c2 = infinity || 12 K = 12 K")
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

```
//Example 1.28
clc
disp("Step 1: Identify topology")
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")
disp("")
```

```
disp("Step 2 and step 3: Find input and output
    circuit")
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")
disp("")
disp("Step 4: Find the open loop voltage gain (Av)")
rl2=(2.2*57.5)/(2.2+57.5)  // in k-ohm
format(6)
disp(rl2,"  R_L2(in k-ohm) = R_c2 || (Rf + R_e1) =")
disp("Since hoe*R_L2 = 10^-6*2.119 k-ohm = 0.002119
    is less than 0.1 we use approximate analysis.")
disp("   A_i2 = -h_fe = -200")
disp("   R_i2 = hie = 2 k-ohm")
av2=(-200*2.119)/2
disp(av2,"  A_v2 = A_i2*R_L2 / R_i2 =")
rl1=(120*2)/(122)  // in k-ohm
disp(rl1,"  R_L1(in k-ohm) = R_C1 || R_i2 =")
disp("Since hoe*R_L1 = 10^-6*1.967 = 0.001967 is
    less than 0.1 we use approximate analysis.")
disp("   A_i1 = -hfe = -200")
ri1=2+(201*((1.5*56)/(57.5)))  // in k-ohm
format(7)
disp(ri1,"  R_i1(in k-ohm) = hie + (1+hfe)*Re =")
av1=(-200*1.967)/295.63
format(5)
disp(av1,"Therefore,  A_v1 = A_i1*R_L1 / R_i1 =")
disp("The overall gain without feedback is")
av=-1.33*-211.9
format(7)
disp(av,"  Av = A_v1 * A_v2 =")
disp("")
disp("Step 5: Calculate beta")
beta=1.5/57.5
```

```
format(6)
disp(beta,"   beta = Vf / Vo =")
disp("")
disp("Step 6: calculate D, A_vf, R_if, R_of")
d=1+(0.026*281.82)
disp(d,"   D = 1 + Av*beta =")
avf=281.82/8.327
disp(avf,"Therefore,   A_vf = Av / D =")
ri=(295.63*150)/(295.63+150)   // in k-ohm
format(5)
disp(ri,"   Ri(in k-ohm) = R_i1 || R =")
rif=99.5*8.327   // in k-ohm
format(7)
disp(rif,"   R_if(in k-ohm) = Ri *D =")
disp("   Ro = 1/hoe = 1 M-ohm")
rof=((1*10^6)/8.327)*10^-3   // in k-ohm
format(4)
disp(rof,"   R_of(in k-ohm) = Ro / D =")
ro=(1000*2.119)/(2.119+1000)   // in k-ohm
format(7)
disp(ro,"   R''o(in k-ohm) = Ro || R_c2 || (Rf+R_e1)
    = Ro || R_L2 =")
rof=(2.1145*10^3)/8.327   // in ohm
format(4)
disp(rof,"   R''_of(in ohm) = R''o / D =")
```

Scilab code Exa 1.29 Avf and Rif and Rof

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

```
disp("-I_c1/I_b1 = 100")
ri2=1+(101*(1/10.1))
format(3)
disp(ri2,"R_i2(in k-ohm) = h_ie + (1+h_fe)(R_e2||R
    '') =")
ibc=-2.2/14.2
format(6)
disp(ibc,"I_b2/I_c1 = -R_c1 / R_c1+(R_i2+R_b2) =")
disp("I_b1/I_s = R/R+h_ie")
r=(10.1*10^3)/11.1
disp(r,"R(in ohm) = R_s || (R''+R_e) =")
ibs=0.9099/1.9099
disp(ibs,"Therefore,  I''_b/I_s =")
ai=100*0.155*100*0.476
disp(ai,"Therefore,  A_I =")
disp("Calculate of beta:")
disp("I_f = -I_o*R_e2 / R_e2+R''")
disp("beta = I_f/Io = R_e2/R_e2+R'' = 100/100+10K")
d=1+(9.9*737.8*10^-3)
format(4)
disp(d,"D = 1 + beta*A_I =")
disp("A_if = A_I/D = 88.89")
avf=88.89*2.2
format(8)
disp(avf,"A_vf = Vo/V_s = -I_c2/I_s * R_c2/R_s =
    A_if*R_c2 / R_s =")
ri1=(909.9*1000)/1909.9
format(4)
disp(ri1,"R_i1(in ohm) = R || h_ie =")
rif=476/8.3
format(6)
disp(rif,"R_if(in ohm) = R_i/D =")
disp("R_of = R_c2 = 2.2 k-ohm")
```

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

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

Scilab code Exa 1.31 voltage gain and input and output impedance

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

```
rif=10*51
disp(rif,"(ii) Input impedance  R_if(in k-ohm) = R_i*D =")
rof=20/51
format(6)
disp(rof,"(iii) Output impedance  R_of(in k-ohm) = Ro/D =")
```

Scilab code Exa 1.32 voltage

```

//Example 1.32
clc
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

```
//Example 1.33
clc
disp("We know that,")
disp("A_vf = A_v / 1+beta*A_v")
disp("Therefore,  A_vf + beta*A_v*A_vf = A_v")
b=20/2400
format(8)
disp(b,"Therefore,  beta = A_v-A_vf / A_v*A_vf =")
```

Scilab code Exa 1.34 gain with feedback and new bandwidth

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

Chapter 2

Oscillators

Scilab code Exa 2.1 verify barkhausen criterion

```
//example 2.1
clc
disp("From the given information we can write,")
disp("     A = -16*10^6/j*omega   and   beta = 10^3/[2*10^3+j*omega]^2")
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.")
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]")
disp("            = -16*10^9 / j*omega*[4*10^6+4*10^3*j*omega-omega^2]        as j*2 = -1")
disp("            = -16*10^9 / 4*10^6*j*omega+4*10^3*j^2*omega^2-j*omega^3]")
disp("            = -16*10^9 / j*omega*[4*10^6-omega^2]-[omega^2*4*10^3]")
disp("Rationalising the denominator function we get,")
disp("   A*beta = -16*10^9[-omega^2*4*10^3 - j*omega
```

```
    *[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]]")
disp("Using (a-b)(a+b) = a^2 - b^2 in the
    denominator,")
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")
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")
disp("Now to have A*beta = 0 degree, the imaginary
    part of A*beta must be zero. This is possible
    when,")
disp("Therefore,  omega*(4*10^6 - omega^2) = 0")
disp("Therefore,  omega = 0  or  4*10^6 - omega^2 =
    0")
disp("Therefore,  omega^2 = 4*10^6
    Neglecting zero value of frequency")
disp("Therefore,  omega = 2*10^3 rad/sec")
disp("At this frequency |A*beta| can be obtained as,
    ")
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")
ab=(2.56*10^20)/(2.56*10^20)
disp(ab,"   |A*beta| =")
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
    .")
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")
disp("i.e.       omega = 2*10^3  rad/sec")
disp("But        omega = 2*pi*f")
f=(2*10^3)/(2*%pi)  // in Hz
format(9)
```

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

Scilab code Exa 2.2 C and hfe

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

Scilab code Exa 2.3 frequency of oscillations

```
//Example 2.3
clc
```

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

Scilab code Exa 2.4 R and C

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

Scilab code Exa 2.5 C and RD

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

```
format(4)
disp(rl,"Therefore,  R_L(in k-ohm) >= 29 / g_m =")
disp("  R_L = R_D*r_d / R_D+r_d")
rd=(40)/4.8823
format(5)
disp(rd,"  Therefore,  R_D(in k-ohm) = ")
disp("While for minimum value of R_L = 5.8 k-ohm")
disp("                          R_D = 6.78 k-ohm")
```

Scilab code Exa 2.6 frequency of oscillator

```
//exmaple 2.6
clc
disp("The circuit is Wien bridge oscillator using op-amp. The gain of the op-amp is")
a=1+3
disp(a,"A = 1 + R3/R4 =")
disp("So  A > 3")
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.")
f=1/(2*%pi*5.1*0.001)
format(8)
disp(f,"f(in kHz) = 1 / 2*pi*R*C =")
disp("This will be the frequency of oscillations")
```

Scilab code Exa 2.7 min and max R2

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

```
disp("For     f = 10 kHz,")
r2=(1/(4*(%pi^2)*(100*10^6)*(10*10^3)*(0.001*10^-12)))  // in k-ohm
format(6)
disp(r2,"Therefore,  R2(in k-ohm) =")
disp("For     f = 50 kHz,")
r2=(1/(4*(%pi^2)*(2500*10^6)*(10*10^3)*(0.001*10^-12)))  // in k-ohm
format(6)
disp(r2,"Therefore,  R2(in k-ohm) =")
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

```
//Example 2.8
clc
disp("The frequency is given by,")
disp("   f = 1 / 2*pi*sqrt(C*L_eq)")
leq=(2*10^-3)+(20*10^-6)
format(8)
disp(leq,"where  L_eq(in kHz) = L1 + L2 =")
disp("For   f = f_max = 2050 kHz")
format(5)
c=(1/(4*(%pi^2)*((2050*10^3)^2)*0.00202))*10^12  // in pF
disp(c,"Therefore,  C(in pF) =")
disp("For   f = f_min = 950 kHz")
c=(1/(4*(%pi^2)*((950*10^3)^2)*0.00202))*10^12  // in pF
format(6)
disp(c,"Therefore,  C(in pF) =")
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

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

Scilab code Exa 2.10 range of C

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

Scilab code Exa 2.11 frequency of oscillations

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

Scilab code Exa 2.12 value of C

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

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

Scilab code Exa 2.13 value of inductor

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

Scilab code Exa 2.14 range of tuning capacitor

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

```
c2=(1/(4*(%pi^2)*(30*10^-6)*((1.5*10^6)^2)))*10^12
    // in pF
format(8)
disp(c2,"Therefore, C2(in pF) =")
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

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

Scilab code Exa 2.16 series and parallel resonating frequency

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

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

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

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

Scilab code Exa 2.18 R and hfe

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

```
disp("Now  R1 = 25 k-ohm,  R2 = 47 k-ohm,  and  h_ie = 2 k-ohm")
format(7)
ri=(25*47*2)/((47*2)+(25*2)+(25*47))  // in k-ohm
disp(ri,"Therefore,  R''_i(in k-ohm) =")
disp("  K = R_C / R")
disp("Now  R_C = 10 k-ohm          ...given")
disp("Now  f = 1 / 2*pi*R*C*sqrt(6+4K)")
disp("Therefore,  R*sqrt(6+4K) = 31830.989")
disp("Now  K = R_C / R = 10*10^3 / R")
disp("Therefore,  R*sqrt(6+(40*10*10^3/R)) = 31830.989")
disp("Therefore,  R^2*(6+(40*10*10^3/R)) = (31830.989)^2")
R=poly(0,'R')
p1=6*R^2+(40*10^3)*R-(31830.989)^2
t1=roots(p1)
ans1=t1(1)
format(6)
disp((-ans1)*10^-3,"Therefore,  R(in k-ohm)=           Neglecting negative value")
k=10/16.74
format(7)
disp(k,"Therefore,  K = R_C / R =")
disp("Therefore,  h_fe >= 4K + 23 + 29/K")
hfe=(4*0.5973)+23+(29/0.5973)
format(6)
disp(hfe,"  h_fe >=")
```

Scilab code Exa 2.19 change in frequency of oscillations

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

```
format(8)
disp(ceq,"  C_eq(in pF) = C1*C2 / C1+C2 =")
fs=(1/(2*%pi*sqrt(50*0.02*10^-15)))*10^-6  // in MHz
format(7)
disp(fs,"Therefore,  f_s(in MHz) = 1 / 2*pi*sqrt(L*C1) =")
fp=(1/(2*%pi*sqrt(50*0.01996*10^-15)))*10^-6  // in MHz
format(7)
disp(fp,"Therefore,  f_p(in MHz) = 1 / 2*pi*sqrt(L*C_eq) =")
disp("Let C_s = 5 pF connected across the crystal")
c2=12+5
disp(c2,"Therefore,  C''2(in pF) = C2 + C_x =")
format(10)
ceq1=0.019976
disp(ceq1,"Therefore,  C''_eq(in pF) = C1*C''2 / C1+C''2 =")
fp1=5.03588
disp(fp1,"Therefore,  f''_p(in MHz) = 1 / 2*pi*sqrt(L*C_eq) =")
disp("New C_x = 6 pF is connected then,")
c21=12+6
disp(c21,"  C''''2(in pF) = C2 + C_x =")
ceq2=0.0199778
disp(ceq2,"Therefore,  C''''_eq(in pF) = C1*C''''2 / C1+C''''2 =")
fp2=5.035716
disp(fp2,"Therefore,  f''''_p(in MHz) = 1 / 2*pi*sqrt(L*C''''_eq) =")
c=(5.03588-5.035716)*10^6
disp(c,"Therefore,  Change(in Hz) = f''_p - f''''_p =")
```

Scilab code Exa 2.20 C and hfe

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

Scilab code Exa 2.21 min and max value of R2

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

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

Scilab code Exa 2.24 percentage change in frequency

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

```
fd=(1/(2*%pi*sqrt(0.15*100*10^-15)))*10^-6  // in MHz
format(7)
disp(fd,"Therefore,  f''(in MHz) = 1 / 2*pi*sqrt(L_eq*C) =")
pc=((1.2994-1.00658)/1.00658)*100  // in percentage
format(6)
disp(pc,"Therefore,  % change = f''-f/f * 100 =")
disp("(ii)  Let us assume direction of coupling such that,")
disp("   L_eq = L1 + L2 + 2M = 0.25 mH")
disp("    C_t = Trim capacitor = 100 pF")
disp("Therefore,  C_eq = C*C_t / C+C_t = 50 pF")
f1=(1/(2*%pi*sqrt(0.25*50*10^-15)))*10^-6  // in MHz
format(7)
disp(f1,"Therefore,  f = 1 / 2*pi*sqrt(L_eq*C_eq) =")
disp("If now direction of coupling is reversed,")
disp("   L_eq = L1 + L2 - 2M = 0.15 mH")
f2=(1/(2*%pi*sqrt(0.15*50*10^-15)))*10^-6  // in MHz
format(8)
disp(f2,"Therefore,  f'' = 1 / 2*pi*sqrt(L_eq*C_eq) =")
pc1=((1.83776-1.4235)/1.4235)*100
format(7)
disp(pc1,"Therefore,  % change = f''-f/f * 100 =")
```

Scilab code Exa 2.25 design a RC phase shift oscillator

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

```
disp("Therefore,  4K^2 - 127K + 29 = 0")
K=poly(0,'K')
p1=4*K^2-127*K+29
t1=roots(p1)
format(6)
disp(t1,"Therefore, K =")
disp("  f = 1 / 2*pi*R*C*sqrt(6+4K)          ...given
   f = 5 kHz")
disp("Therefore,Choose    C = 100 pF")
r=(1/(2*%pi*(1000*10^-12)*(5*10^3)*sqrt(6+(4*0.23)))
   )*10^-3  // in k-ohm
format(3)
disp(r,"Therefore,  R(in k-ohm) =")
disp("  K = R_C / R  i.e.  R_C = KR = 2.7 k-ohm")
disp("Neglecting effect of biasing resistances
   assuming them to be large and selecting
   transistor with h_ie = 2 k-ohm")
disp("  R''_i = h_ie = 2 k-ohm")
disp("Therefore,Last resistance in phase network")
r3=12-2
disp(r3,"  R3 = R - R''_i =")
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")
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

```
//Example 2.26
clc
disp("(1) f = 1 / 2*pi*sqrt(L*C_eq)")
ceq=(100*500)/600
format(7)
disp(ceq,"Where  C_eq(in pF) = C1*C2 / C1+C2 =")
f=(1/(2*%pi*sqrt(40*83.333*10^-15)))*10^-3
format(8)
disp(f,"f(in kHz) =")
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")
disp("V0 = 10 V")
disp("For Colpitts oscillator, gain = C2 / C1")
gain=500/100
disp(gain,"Therefore,  Gain =")
fv=10/5
disp(fv,"Therefore,  Feedback voltage(in V) = V0 / Gain =")
disp("(3) Minimum gain = C2/C1 = 5")
disp("h_fe(min) = C2/C1 = 5")
disp("(4) Gain = 10 = C2/C1")
c1=500/10
disp(c1,"Therefore,  C1(in pF) =")
disp("(5) For C1 = 50 pF  and  C2 = 500 pF")
ceq=(50*500)/550
format(8)
disp(ceq,"Where  C_eq(in pF) = C1*C2 / C1+C2 =")
f=(1/(2*%pi*sqrt(40*45.4545*10^-15)))*10^-3
disp(f,"f(in kHz) = 1 / 2*pi*sqrt(L*C_eq) =")
```

Scilab code Exa 2.27 design colpitts oscillator

```
//Example 2.27
```

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

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

Scilab code Exa 2.29 resonating frequencies

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

Scilab code Exa 2.31 determine percentage

```
//Example 2.31
clc
disp("The series and parallel resonating frequencies are,")
disp("f_s = 1 / 2*pi*sqrt(C*L) while f_p = 1 / 2*pi*sqrt(L*C_eq)")
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")
fp=sqrt(1+(0.04/2))
format(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)) =")
disp("f_p = 1.00995*f_s")
```

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

Scilab code Exa 2.32 operating frequency and feedback fraction

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

Scilab code Exa 2.33 value of C and RD

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

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

Scilab code Exa 2.34 value of inductance

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

Scilab code Exa 2.36 design phase shift oscillator

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

Chapter 3

Multivibrators and Blocking Oscillators

Scilab code Exa 3.1 stable state currents and voltages

```
//Example 3.1
clc
disp("The circuit is similar to the circuit shown in
    the fig 3.2. Assume that Q1 is OFF and Q2 is ON"
   )
disp("Case i : Junction voltages of ON transistor
   are neglected")
disp("i.e.  V_CE2 = 0 V and V_BE2 = 0 V")
disp("As emitter is grounded we can say,")
disp("  V_C2 = 0 V and V_B2 = 0")
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)")
vb1=-8*(10/60)
format(5)
disp(vb1,"Now  V_B1(in V) = - V_BB * (R1 / R1+R2) ="
   )
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")
i1=12/(2.2)
disp(i1,"I1(in mA) = V_CC/R_C = ")
i2=(8/60)
format(6)
disp(i2,"I2(in mA) = V_BB / R1+R2 = ")
ic=5.45-0.133
disp(ic,"Therefore,  I_C2(in mA) = I1 - I2 =")
ib=(5.316/30)*10^3
disp(ib,"Therefore,  (I_B2)min(in mA) = I_C2 / h_fe(
    min) =")
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")
disp("Now  I3 = current through R_C and R1, as I_C1
   = 0")
i3=12/12.2
format(7)
disp(i3,"Therefore,  I3(in mA) = V_CC / R_C+R1 =
                    ...as  V_B2 = 0 V")
i4=8/50
format(5)
disp(i4,"and  I4(in mA) = V_B2-V_BB / R2 =")
ib2=0.9836-0.16
format(7)
disp(ib2,"Therefore,  I_B2(in mA) = I3 - I4 =")
disp("As I_B2 > I_B2(min), the transistor Q2 is
    indeed in saturation")
vc1=12-(0.98396*2.2)
format(6)
disp(vc1,"Therefore,  V_C1(in V) = V_CC - I3*R_C =")
disp("Hence the stable state current and voltages
    are:")
disp("I_C1 = 0 A       I_C2 = 5.316 mA       I_B1 = 0
   A         I_B2 = 0.8236 mA")
disp("V_C1 = 9.836 V  V_C2 = 0 V            V_B1 =
    -1.33 V    V_B2 = 0 V")
disp("Output swing = V_C1 - V_C2")
```

```
disp("Therefore,  V_W = 9.836 V")
disp("")
disp("Case ii : V_CE(sat) = 0.2 V  and  V_BE(sat) = 0.7 V")
disp("For the transistor Q2, as emitter is grounded, from these voltages we can write,")
disp("  V_C2 = 0.2 V  and  V_B2 = 0.7 V")
disp("Referring to fig 3.4(a), we can write the equations to obtain the stable state currents and voltages")
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,")
vb1=(-8*(10/60))+(0.2*(50/60))
format(5)
disp(vb1,"V_B1 = -V_BB(R1 + R1+R2)|V_C2=0 + V_C2(R2 / R1+R2)|V_BB=0 =")
i1=11.8/2.2
disp(i1,"I1(in mA) = V_CC-V_C2 / R_C =")
i2=8.2/60
format(6)
disp(i2,"I2(in mA) = V_C2+V_BB / R1+R2 =")
ic2=5.36-0.136
disp(ic2,"Therefore,  I_C2(in mA) = I1 - I2 =")
ib2=5.223/30
disp(ib2,"Therefore,  I_B2(min)(in mA) = I_C2 / h_fe(min) =")
disp("To calculate I_B2, refer fig.3.4(b), with V_B2 = 0.7 V")
i3=11.3/12.2
disp(i3,"Therefore,  I3(in mA) = V_CC-V_B1 / R_C+R1 =")
i4=8.7/50
disp(i4,"and  I4(in mA) = V_B2-V_BB / R2 =")
ib2=0.926-0.174
disp(ib2,"Therefore,  I_B2(in mA) = I3 - I4 =")
vc1=12-(0.926*2.2)
format(7)
```

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

```
//Example 3.2
clc
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")
disp("This is shown in the fig. 3.8")
disp("Another equivalent circuit from collector of
    Q1 to base of Q2 is shown in the fig 3.9")
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")
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 equivalent circuit once across collector and ground while another across base and ground for the same transistor Q2 assuming it as the load.")
disp("To replace collector circuit of Q2 by Thevenin''s equivalent, consider Q2 as open shown in the fig 3.10")
disp("Referring to fig 3.10,")
voc=(12*40)/44
format(5)
disp(voc,"V_OC(in V) = I*(R1 + R2) = V_CC/(R1+R2+R_C) * (R1+R2) =")
rth=160/44
format(6)
disp(rth,"and  R_TH(in k-ohm) = (R1+R2)||R_C =          with V_CC-N short")
disp("To replace base circuit of Q2 by Thevenin''s equivalent, consider Q2 open and draw circuit as shown in the fig 3.11")
voc=(12*10)/44
format(5)
disp(voc,"V_OC(in V) = I*R2 = V_CC/(R1+R2+R_C) * R2 =")
rth=340/44
format(6)
disp(rth,"and  R_TH(in k-ohm) = (R2)||(R1+R_C) =")
disp("Thus the equivalent circuit for Q1 ON, using Thevenin''s result calculated above, is as shown in the fig 3.12")
disp("For silicon transistor,")
disp("V_BE(sat) = 0.8 V and V_CE(sat) = 0.4 V")
disp("Applying KVL to base-emitter loop,")
disp("-7.727*I_B2 - V_BE2 - (I_C2 + I_B2)*0.5 + 2.73 = 0")
disp("With V_BE2 = 0.8 V,  I_B2 + 0.06075*I_C2 = 0.2345            ...(1)")
disp("Applying KVL to collector-emitter loop,")
disp("-3.636*I_C2 - V_CE2 - (I_C2 + I_B2)*0.5 + 10.9
```

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

Scilab code Exa 3.3 component values of monostable multivibrator

```
//Example 3.3
clc
disp("Assume Q2 ON and Q1 in OFF condition")
disp("Therefore,  I_C2 = I_C(sat) = 6 mA")
disp("Now  I_C2 = V_CC-V_CE(sat)/R_C")
disp("For the silicon npn transistors,")
disp("V_CE(sat) = 0.3 V, V_BE(sat) = V_0 = 0.7 V")
disp("V_BE(cut-in) = V_T = 0.5 V")
rc=(5.7*10^3)/6
format(4)
disp(rc,"R_C(in ohm) =")
ib2s=6/20
disp(ib2s,"(I_B2)sat (in mA) = I_C(sat)/(h_fe)min =")
disp("Therefore,  (I_B1)sat = 0.3 mA")
disp("Now  I_B2 = V_CC-V_BE(sat)/R")
r=5.3/0.3
format(6)
disp(r,"Therefore,  R(in k-ohm) =")
disp("In quasi-stable, Q1 is ON and Q2 is OFF")
disp("T = 0.69 RC")
c=120/(0.69*17.67)
format(5)
disp(c,"Therefore,  C(in nF) =")
disp("Consider the equivalent circuit in quasi-state (see fig 3.19)")
disp("As Q2 is OFF, V_C2 = V_CC")
disp("Therefore,  I3 = V_CC-V0/R1 = 5.3/R1")
disp("and  I4 = V0-V_BB/R2 = 2.2/R2")
disp("Assume I4 = (I_B1)sat = 0.3 mA")
r2=2.2/0.3
format(5)
```

```
disp(r2,"Therefore,  R2(in k-ohm) =")
i3=0.3+0.3
disp(i3,"and  I3(in mA) = I4 + I_B1 =")
r1=5.3/0.6
format(6)
disp(r1,"Therefore,  R1(in k-ohm) = ")
disp("The speed-up capacitor C1 can be chosen such that R1C1 = 1 usec hence")
c1=1000/8.833
format(7)
disp(c1,"C1(in pF) = ")
rb=(5.5/1100)*10^3
disp(rb,"Now  r''_B(in mA) = V_CC-V_CE(sat)-V0-V_Y / R_C+r''_bb =")
del=(150*5*10^-3)+0.2
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

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

Scilab code Exa 3.5 various voltage levels and frequency of oscillations

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

```
disp("The lowest level of V_EN1 is,")
ven1=20-0.7
disp(ven1,"V_EN1(t_-1)(in V) = V_BB - V0 =")
vcn1=20-0.7+0.3
disp(vcn1,"V_CN1(t_-1)(in V) = V_BB - V0 - V_CE(sat) =")
format(7)
vcn=25-0.277
disp(vcn,"V_CN1(t_+1)(in V) = V_CC1 - I_B2*R_C1 =")
disp("V_CN1 = V_BN2")
ven2=19.6-0.5
disp(ven2,"V_EN(t_-1)(in V) = V_BN2(t_-1) - V_Y =")
ven=25-0.277-0.6
disp(ven,"V_EN(t_+1)(in V) = V_CC1 - I_B2*R_C1 - V_BE2 =")
vd=24.123-19.1
disp(vd,"V_D(in V) = V_EN2(t_+1) - V_EN2(t_-1) =")
disp("(b) The frequency of oscillations,")
disp("f = 1/T = 1/T1+T2")
t1=((3.3*0.1*10^-3)*log(24.323/19.5))*10^6
format(6)
disp(t1,"T1(in usec) = R_e1*C*ln(V1/V_BB-V_Y) =")
disp("and T2 = T1 as R_e1 = R_e2")
t=(2*72.93)*10^-3
format(7)
disp(t,"Therefore, T(in ms) = 2*T1 =")
f=1/0.1458
format(7)
disp(f,"Therefore, f(in kHz) = 1/T =")
```

Scilab code Exa 3.7 peak voltages and currents

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

```
tp=(5/470)*10^3
format(8)
disp(tp,"Now  t_p(in  usec) = nL/R =")
tf=(50/(470*6*2))*10^3
format(6)
disp(tf,"t_f(in usec) = (n/n+1)*L/R*V_CC/V_Y =")
ta=(1.57*sqrt(5*90*10^-15))*10^6
disp(ta,"t_a(in usec) = 1.57*sqrt(LC) =")
t=10.6383+8.865+1.053
format(8)
disp(t,"T(in usec) =")
f=(1/20.5564)*10^3
disp(f,"Therefore,  f(in kHz) = 1/T =")
dc=10.6383/20.5564
format(7)
disp(dc,"Duty cycle = t_p/T =")
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.")
disp("(b)  The collector voltage varies from V_CC-V to V_CC+V_Y")
v=10/2
disp(v,"Now  V(in V) = V_CC / n+1 =")
disp("Therefore,  V_C varies from 10-5 i.e. +5 V to 10+6 = 16 V")
disp("The base voltage varies from nV to -nV_Y i.e. +5 V to -6 V")
disp("The emitter current is constant given by,")
ie=(5/470)*10^3
format(7)
disp(ie,"I_E(in mA) = nV/R =")
ib=(10/(4*470))*10^3
disp("i_B = V_CC/(n+1)^2 * [n/R - t/L]")
format(5)
disp(ib,"So  i_B(max)(in mA) = i_B|t=0 =")
ib=((10/4)*((1/470)-((10.63*10^-3)/5)))*10^6
format(6)
```

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

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

```
disp("Therefore, Peak of the pulse = [V_CC+V_Y] - [V_CC-V] = V + V_Y")
disp("Therefore, V + V_Y = 10    (Given)")
disp("and  t_f = (n/n+1)*L/R*V_CC/V_Y = 45*10^-6")
disp("Therefore, nL/R*V_CC/(n+1)*1/V_Y = 45*10^-6")
disp("(5*10^-6)*V/V_Y = 45*10^-6")
disp("Using equation(5), (5*10^-6)*(10-V_Y/V_Y) = 45*10^-6")
disp("10 - V_Y = 9 V_Y")
disp("V_Y = 1 V")
disp("V = 10 - V_Y = 9 V")
disp("Using equation(4), n = 2.3333")
disp("Using equation(3), L = 9 mH")
disp("Using equation(2), R = 4.2 k-ohm")
disp("The designed circuit can be shown as in the fig 3.73")
disp("Neglecting base current,")
disp("V_BE = V_CC*R2 / R1+R2")
disp("Therefore, 1 = 30*R2 / R1+R2")
disp("Therefore, R1 = 29 R2")
disp("So let  R2 = 1 k-ohm")
r1=29
disp(r1,"R1(in k-ohm) =")
disp("This is required potential divider components")
```

Scilab code Exa 3.10 max I

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

```
disp("V_BE(sat)=V_BE2=0.8V")
disp("a) Calculation for the stable state currents
   and voltages")
disp("Draw equilvalent circuit from base of Q1 to
   collector of Q2.")
disp("Another equivalent circuit from collector of
   Q1 to base of Q2 is shown in the fig.3.81")
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.")
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.")
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).")
disp("Referring fig 3.83(a) we can write,")
i=(20*45)/49.7
format(7)
disp(i,"V_oc(in volts)=I(R1+R2)=(V_cc*(R1+R2))/(R1+
   R2+R_c)=")
r=(45*4.7)/(45+4.7)
format(6)
disp(r,"R_th(in k ohms) = (R1+R2)parallel to R_c
   with V_cc -N short  =")
disp("Referring fig 3.83(b),")
v=(20*15)/(30+15+4.7)
format(6)
disp(v,"V_OC(in V)=I*R2=(V_CC * R2)/(R1+R2+R_c)=")
t=(15*34.7)/(15+34.7)
format(7)
disp(t,"And,  R_th(in k ohm)=R2 parallel to(R1+R2)="
   )
disp("Applying KVL to base-emitter loop,")
disp("-I_B2(10.473)-0.8-0.39(I_B2+I_C2)+6.036=0")
```

```
disp("0.863(I_B2)+0.39(I_C2)=5.236")
disp("I_B2+0.0359(I_C2)=0.482    Now multiply by
   0.39,")
disp("0.39(I_b2)+0.014(I_C2)=0.1879       ..(1)")
disp("Applying KVL to collector emitter loop,")
disp("(-I_C2)(4.255)-0.4-0.39(I_B2+I_C2)+18.108=0")
disp("-0.39(I_B2)-4.645(I_c2)=-17.708      ..(2)")
disp("Adding equations (1) and (2) we get,")
disp("-4.631(I_C2)=-17.5201")
c=(-17.5201)/(-4.631)
format(6)
disp(c,"I_C2(in mA)=")
b=(-17.708+((4.645)*(3.783)))/(-0.39)
disp(b,"and,        I_B2(in mA)=")
disp("From this, the various voltages can be
   obtained as,")
v=((0.346+3.783))*(0.390)
format(5)
disp(v,"V_EN(in V)=(I_B2+I_C2)*R_E =")
n=0.4+1.61
disp(n,"V_CN2(in V)=(V_CE2+V_EN)=")
b=0.8+1.61
disp(b,"V_BN2(in V)=(V_BE2+V_EN)=")
w=(2.01*15)/45
disp(w,"V_BN1(in V)=(V_CN2*R2)/(R1+R2)=")
v=0.67-1.61
format(5)
disp(v,"V_BE1(in V)=(V_BN1-V_EN)=0.61-1.61=")
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.")
a=(((20*30)/(4.7+30))+((2.41*4.7)/(4.7+30)))
format(7)
disp(a,"V_CN1(in V)=")
disp("b) To find (h_fe)_min")
disp("For the ON transistor Q2")
disp("I_C2=3.783mA,    I_B2=0.346mA")
h=3.783/0.346
```

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

Scilab code Exa 3.11 find V

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

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

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

Scilab code Exa 3.14 find R

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

```
format(6)
disp(t,"T(in sec)=1/(1*10^3)=")
disp("Now, T=T1+T2")
disp("Therefore  T1+T2=1 msec")
disp("Therefore  0.66T2+T2=1 msec")
o=(10^-3)/1.66
format(7)
disp(o,"Therefore  T2(in sec)=")
t=1-0.6
disp(t,"T1(in msec)=")
disp("Consider the circuit diagram shown in the fig
    3.92")
disp("Assume Q2 ON and Q1 OFF")
disp("For ON transistor, assuming npn silicon
    transistor,")
disp("V_CE(sat)=V_C2=0.3V")
disp("V_BE(sat)=V_B2=0.7V")
disp("I_C(sat)=I_C2=2 mA")
disp("(h_fe)_min=30")
disp("I2=(V_CC-V_C2)/R_c")
disp("Neglecting thriugh C1,")
disp("I2=I_C2=2 mA")
disp("Therefore, (2*10^-3)=(10-0.3)/R_C")
r=9.7/(2*10^-3)
disp(r,"Therefore R_C(in ohms)= ")
h=(1.5*2)/30
disp(h,"Now   I_B2(in mA)=1.5*(I_B2)_min=1.5*(I_C2)
    /(h_fe)_min= ")
disp("Now, I_B2=(V_cc-V_B2)/R2")
r=9.3/(0.1*10^-3)
disp(r,"Therefore  R2(in ohms)=")
disp("Now assume C1=C2=C")
disp("Therefore T1=0.69(R1*C1) and T2=0.69(R2*C2)")
disp("Therefore T2=0.69(R2*C)")
c=(0.6*10^-3)/(0.69*93*10^3)
disp(c,"Therefore C(in F)= ")
disp("Therefore  T1=0.69*(R1*C)")
disp("Therefore  (0.4*10^-3)=(0.69*R1)*(9.35*10^-9)"
```

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

Scilab code Exa 3.15 find Voltage

```
//example4.15
clc
disp("UTP=5 V, LTP=3 V, V_CC=12 V")
disp("V_i=V_B2=UTP=5 V when Q2 is ON.")
v=5-0.7
disp(v,"V_E(in V)=(V_i)-(V_BE1)=V_B2-V_BE2=5-0.7=")
disp("Let I_C2=I_E2=1 mA          ... In ON state")
r=4.3/(10^-3)
disp(r,"Therefore  R_E(in ohms)=V_E/I_E2=")
disp("Now, (I_C2)*(R_C2)=(V_CC)-(V_E)-(V_CE2)_sat
     ..Let (V_CE2)_sat =0.2V")
disp("(1*10^-3)*(R_C2)=12-4.3-0.2")
c=(12-4.3-0.2)/(10^-3)
disp(c,"Therefore R_C2(in ohms)= ")
i=(10^-3)/10
disp(i,"Now  I2(in A)=0.1(I_C2)=")
r=5/(10^-4)
disp(r,"Therefore  R2(in ohms)= ")
i=(10^-3)/100
disp(i,"I_B2(in A)=(I_C2)/(h_fe)_min =")
disp("Therefore  I2+I_B2=(V_CC-V_B2)/(R_C1-R1)")
disp("Therefore  R_C1+R1=(12-5)/((10^-4)+(10^-5))
   =63.6363*10^3  ..(1)")
disp("Now V_B2=B_B1=LTP=3 V  and  Q1 is ON.")
i=3/(50*10^3)
disp(i,"I1(in A)=(V_B2)/R2=")
c=(3-0.7)/(4.3*10^3)
format(10)
disp(c,"amd I_C1(in A)=I_E1=(V_B1-V_BE1)/R_E= ")
```

```
disp(" Therefore V_CC=(R_C1)*(I_C1+I1)+I1*(R1+R2)
    ..(2)")
disp(" Using equation (1) in equation (2),")
disp(" Therefore V_CC=(I_C1*R_C1)+I1*(R_C+R1)+I1*R2")
disp(" 12=(5.348*10^-4*R_C1)+(60*10^-6*63.6363*10^3)
    +(60*10^-4*50*10^3)")
r=(12-(60*63.6363*10^-3)-(60*50*10^-3))
    /(5.348*10^-4)
format(7)
disp(r," Therefore R_c1(in ohm)=")
r=(63.6363*10^3)-(9.6892*10^3)
disp(r," Therefore R1(iin ohms)=")
disp(" Thus when Q2 is ON,")
v=12-(7.5)
disp(v," V_o(in V)=V_CC-(I_C2(on))*R_C2=")
disp(" And when Q2 is OFF,")
disp(" V_o=V_CC=12 V")
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

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

Scilab code Exa 4.2 fT and hfe and Ai

```
//Example 4.2
clc
ft=25*2
format(3)
disp(ft,"(i) f_T(in MHz) = |A_i|*f =")
hfe=50000/200
format(4)
disp(hfe,"(ii) h_fe(in kHz) = f_T / f_beta =")
disp("(iii) |A_i| = h_fe / sqrt(1+((f/f_beta)^2)) =")
disp("At f = 10 MHz")
ai=250/sqrt(1+(((10*10^6)/(200*10^3))^2))
format(2)
disp(ai,"|A_i| =")
disp("At f = 100 MHz")
ai=250/sqrt(1+(((100*10^6)/(200*10^3))^2))
format(4)
disp(ai,"|A_i| =")
```

Scilab code Exa 4.10 find gain

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

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

Scilab code Exa 4.12 find resistance

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

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

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

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

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

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

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

Scilab code Exa 4.20 voltage gain

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

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

Chapter 5

Tuned Amplifier

Scilab code Exa 5.1 Rs and Rp of inductor

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

Scilab code Exa 5.2 design single tuned amplifier

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

```
disp("From equation 3 we have")
disp("  R = r_i || R_p || r_b''e")
disp("where  r_i = 4 k-ohm")
rbe=100/0.04
disp(rbe,"r_b''e(in ohm) = h_fe / g_m =")
disp("R_p = Q_c * omega_0 * L = Q_c / omega_0*C")
disp("Therefore,  R = 4*10^3 || 2500 || Q_c/omega_0*
   C")
disp("C = 1 / 2*pi*10*10^3*R")
disp("Therefore,  C = 1 / 2*pi*10*10^3*[4*10^3 ||
   2500 || Q_c/2*pi*500*10^3*C]")
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")
disp("Therefore,  C = 1 / 2*pi*10*10^3*[1538.5 ||
   1/2*pi*5000*C]")
disp("                    = 1 / 2*pi*10*10^3*[1 /
   1/1538.5+2*pi*5000*C]")
disp("Solving for C we get")
disp("  C = 0.02 uF")
disp("We have")
disp("  C = C'' + C_b''e + (1+g_m*R_L)*C_b''e")
disp("Therefore,  C'' = C - [C_b''e + (1+g_m*R_L)*
   C_b''e]")
c=((0.02*10^-6)-[(1000*10^-12)+((1+(0.04*510))
   *100*10^-12)])*10^6
format(8)
disp(c,"Therefore,  C''(in uF) =")
disp("We have,")
disp("omega_0^2 = 1 / L*C")
l=(1/(((2*%pi*500*10^3)^2)*(0.02*10^-6)))*10^6
format(2)
disp(l,"Therefore,  L(in uH) = 1 / omega_0^2*C =")
disp("From equation 2 we have,")
rp=2*%pi*500*5*100*10^-3
format(5)
disp(rp,"R_p(in ohm) = omega*L*Q_c =")
r=(4000*1570*2500)/((1570*2500)+(4000*2500)
```

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

Scilab code Exa 5.3 bandwidth for four stages

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

Scilab code Exa 5.6 find frequency

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

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

Scilab code Exa 5.8 resonant frequency and impedance and voltage gain

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

Scilab code Exa 5.10 find BW

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

Scilab code Exa 5.11 resonant frequency and omega

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

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

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

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

Scilab code Exa 5.13 tank circuit elements

```
//Example 5.13
clc
disp("BW = f_r / Q")
q=10700/200
format(5)
disp(q,"Therefore,  Q = f_r / BW =")
disp("Q = omega_r*L / R = 2*pi*f_r*L / R")
lr=53.5/(2*%pi*10.7*10^6)
format(9)
disp(lr,"Therefore,  L/R = Q / 2*pi*f_r =")
disp("|A_v| = g_m*R_L = 30")
rl=(30/5)
disp(rl,"Therefore,  R_L(in k-ohm) = (r_d || R_p) ="
  )
disp("Therefore,  R_p = 6383 ohm")
disp("We know that")
disp("R_p = L/C*R")
c=((795*10^-9)/6383)*10^12
format(6)
disp(c,"Therefore,  C(in pF) =")
disp("We know that")
l=(1/(4*%pi^2*((10.7*10^6)^2)*124.5*10^-12))*10^6
disp("f_r = 1 / 2*pi*sqrt(L*C)")
format(6)
disp(l,"Therefore,  L(in uH) =")
```

```
disp("We have")
disp("R_p = L / C*R")
r=(1.777*10^-6)/(6383*124.5*10^-12)
disp(r,"Therefore, R(in ohm) = L / C*R_p =")
disp("Therefore, elements of tank circuit are:")
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

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

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

Scilab code Exa 6.2 reflected load impedance

```
//Example 6.2
clc
disp("R_L = 4 ohm, N1 = 200, N2 = 20")
n=20/200
format(4)
disp(n,"Therefore, n = N2 / N1 =")
rl=4/(0.1^2)
disp(rl,"Therefore, R''_L(in ohm) = R1 / n^2 =")
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

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

```
n=8/648
format(8)
disp(n,"Therefore,  n^2 = R_L / R''_L =")
disp("Therefore,  n = 0.1111 = Turn ratio")
disp("But,  n = N2 / N1 = 0.1111")
disp("Therefore,  N1/N2 = 9")
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

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

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

Scilab code Exa 6.6 second harmonic distortion

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

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

Scilab code Exa 6.7 class B amplifier

```
//Example 6.7
clc
disp("The maximum power dissipation occurs when the
   value of V_m is")
disp("V_m = 2/pi * V_CC")
disp("Now  P_ac = V_m*I_m / 2")
disp("So at the time of maximum power dissipation,
   it is")
disp("P_ac = 2/pi * V_CC*I_m/2 = V_CC*I_m / pi")
disp("Now  P_DC = 2/pi * V_CC * I_m")
disp("Hence,  %eta = P_ac/P_DC * 100 = (V_CC*I_m/pi)
   /(2*V_CC*I_m/pi)*100 = 50%")
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 collector current

```
//Example 6.8
clc
disp("R_L = 12 ohm,  n = N2/N1 = 1/3 = 0.333, eta_trans = 78.5%")
rl=12/(0.333^2)
format(4)
disp(rl,"Therefore,  R''_L = R_L / n^2 =")
pac=(0.5*20^2)/108
format(7)
disp("(i) For P_max, V_m = V_CC")
disp(pac,"Threfore,  (P_ac)_max(in W) = 1/2 * V_CC^2/R''_L =")
disp("But  eta_trans = 78.5%")
pl=0.785*1.8518
disp(pl,"Therefore,  P_L(in W) = eta_trans * (P_ac)_max =")
vm=(2*20)/%pi
format(8)
disp(vm,"(ii) Condition for (P_d)_max is V_m(in V) = 2*V_CC/pi =")
pd=(2*20^2)/(108*%pi^2)
format(7)
disp(pd,"Therefore,  (P_d)_max(in W) = 2*V_CC^2 / pi^2*R''_L =")
pdm=0.7505/2
disp(pdm,"Therefore,  (P_d)_max(in W) per transistor =")
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")
disp("Therefore,  1.8518 = 20*I_m / 2")
im=(2*1.8518)/20
disp(im,"Therefore,  I_m(in A) = (I_c)_max =")
ibm=(0.1851/25)*10^3
disp(ibm,"and  (i_b)_max(in mA) = (i_c))max / h_fe =")
```

Scilab code Exa 6.9 find power developed

```
//example6.9
clc
disp("R_L=16 ohm, V_CC=25 V")
disp("Now 2N1=200, N2=50")
n=200/2
disp(n,"Therefore N1=")
n=50/100
disp(n,"Therefore n=N2/N1=")
r=16/(0.5^2)
disp(r,"Therefore R''_L =(R_L)/(n^2)=")
disp("For maximum power output, V_m=V_CC")
p=(25^2)/(2*64)
disp(p,"i) (P_ac)_max [in W]=(V_CC^2)/(2*R_L)=")
disp("ii) (P_dc)=(2*V_CC*I_m)/pi")
disp("Now (V_m)/(I_m)=(R''_L)")
disp("and V_m=V_CC")
i=25/64
disp(i,"Therefore (I_m)=(V_CC)/(R''_L)=")
p=(2*25*0.3906)/(%pi)
disp(p,"Therefore (P_DC)[in W]=")
n=(4.8848*100)/6.2169
disp(n,"iii) %eta=(P_ac*100)/(P_DC)=")
p=(2*4.8828)/(%pi^2)
disp(p,"iv) (P_d)_max[in W]=(2*(P_ac)_max)/(pi^2)=")
```

Scilab code Exa 6.12 Pac and PD and efficiency

```
//Example 6.12
clc
```

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

Scilab code Exa 6.13 find dc power developed

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

```
v=(2*10)/(%pi)
disp(v,"V_m(in V)=")
disp("Now, R_L=(V_m)/(I_m)")
i=6.3662/5
disp(i,"Therefore (I_m)[in A]=")
disp("Therefore (P_DC)=(V_CC)*(I_DC)=(V_CC)*(2*I_m)/pi     (I_DC)=(2*I_m)/pi")
p=(10*2*1.2732)/(%pi)
disp(p,"  =(10*2*1.2732)/(pi) =")
p=(6.3662*1.2732)/2
disp(p,"and  (P_ac)[in W]=(V_m*I_m)/2=")
p=8.1056-4.5027
disp(p,"(P_D)_max[in W]= (P_DC)-(P_ac)=")
p=4.0528/2
disp(p,"Therefore P_D rating fora each transistor =(P_D)_max/2=")
disp("iii) For (P_ac)_max, V_m=V_CC=10 V")
i=10/5
disp(i,"I_m(in A)=(V_m)/R_L=")
p=(10*2*2)/%pi
disp(p,"P_DC(in W)=")
```

Scilab code Exa 6.15 power dissipated

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

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

Scilab code Exa 6.16 find turns ratio

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

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

Scilab code Exa 6.19 find efficiency

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

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

Scilab code Exa 6.20 base current and power delivered and efficiency

```
//Example 6.20
clc
disp("V_CC = 20 V,  R_L = 20 ohm, turns ratio 1.58:1")
n=1/1.58
format(7)
disp(n,"  n = 1/1.58 = ")
rl=20/0.6329^2
disp(rl,"Therefore,  R''_L(in ohm) = R_L / n^2 =")
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")
disp("R''_L = V_m/I_m = V_CC/I_CQ")
icq=20/49.928
format(4)
disp(icq,"Therefore,  I_CQ(in A) =")
ibq=0.4/40
format(5)
disp(ibq,"Therefore,  I_BQ(in A) = I_CQ/beta =")
disp("This is the required value of the base current")
```

```
disp("(ii)  P_ac = I_Irms^2 * R''_L")
disp("But for maximum power output condition,")
irms=0.4/sqrt(2)
format(8)
disp(irms,"I_Irms(in A) = I_Im/sqrt(2) = I_CQ/sqrt
   (2) =")
pac=49.928*0.2828^2
format(2)
disp(pac,"Therefore,  P_ac(in W) =")
disp("(iii)  %eta = P_ac/P_DC * 100")
pdc=20*0.4
disp(pdc,"Now  P_DC(in W) = V_CC * I_CQ =")
eta=400/8
format(3)
disp(eta,"%eta(in percentage) =")
```

Scilab code Exa 6.21 value of Vcc

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

Scilab code Exa 6.22 input and output power and efficiency

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

Scilab code Exa 6.26 total harmonic distortion

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

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

Scilab code Exa 6.27 find min breakdown voltage

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

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

Scilab code Exa 6.30 find efficiency

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

```
disp("Thereofore I_C=(beta*I_B)=117.82 mA=I_CQ")
disp("Now n=N2/N1=1/8")
r=5*(8^2)
disp("Therefore (R''_L)=(R_L)/(n^2)=")
disp("i) For maximum power delivered to load,")
disp("V_1m=V_CEQ")
disp("Apply KVL to collector-emitter loop,")
disp("(-10I_C)-(V_CEQ)-(10*I_E)+V_CC=0")
v=25-(20*(117.82*10^-3))
format(7)
disp(v,"V_CEQ=V_cc-20*I_C       ...I_C=I_E")
p=(22.643^2)/640
disp(p,"(P_ac)_pri[in W]=(V_CEQ^2)/(2*R''_L)=")
p=0.9*0.8011
disp(p,"(P_ac)_max[in W]=0.9*0.8011=")
disp("This is maximum power delivered to the load.")
p=25*117.82*10^-3
format(7)
disp("ii) Now (P_DC)[in W]=V_CC*I_CQ=")
n=(0.721*100)/2.9455
format(6)
disp(n,"%eta=(P_ac*100)/(P_dc)=")
```

Scilab code Exa 6.32 find R

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

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

Scilab code Exa 6.33 distortion factor

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

Scilab code Exa 6.34 power transfer

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

Scilab code Exa 6.35 output and input power and collector efficiency and power dissipated

```
//Example 6.35
clc
disp("I_CQ = 250 mA,  V_CEQ = 8 V")
disp("V_max = 15 V,  V_min = 1 V,  I_max = 450 mA,  I_min = 40 mA")
ipp=450-40
disp(ipp,"Therefore,  I_pp(in mA) = I_max - I_min =")
vpp=15-1
disp(vpp,"Therefore,  V_pp(in V) = V_max - V_min =")
vm=14/2
disp(vm,"Therefore,  V_m(in V) = V_pp/2 =")
```

```
im=410/2
disp(im,"Therefore,   I_m(in mA) = I_pp/2 =")
pac=(7*205*10^-3)/2
pdc=250*8*10^-3
n=71.75/2
pd=2-0.7175
format(7)
disp(pac,"(i)   P_ac(in W) = V_m*I_m/2 =
                        ...output power")
disp(pdc,"(ii)   P_DC(in W) = I_CQ*V_CEQ =
                     ...input power")
disp(n,"(iii)   %eta(in %) = P_ac/P_DC * 100 =
                 ...efficiency")
disp(pd,"(iv)   P_d(in W) = P_DC - P_ac =
                       ...power dissipation")
```