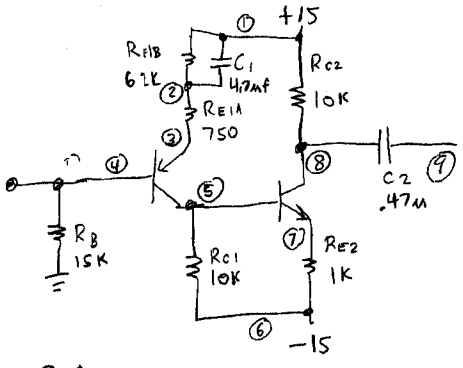
Topology: 2 common emitter stages, direct coupled (1)

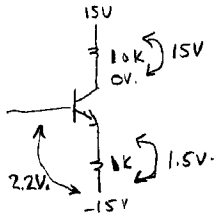


Stage 2:

Choose $R_{C2} = 10K$

$R_{E2} = 1K$ for gain ≈ 10

Choose $V_{Ca2} = 0$ so $V_{RC2} = 15$, $I = 1.5$ ma

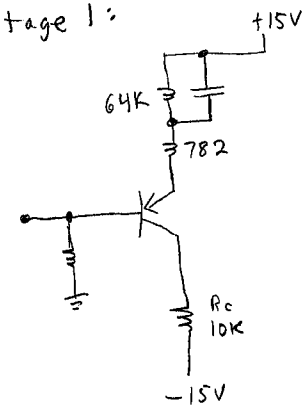


$\frac{r_\pi}{\beta} = \frac{.026}{.0015} = 17.3\ \Omega$

Actual gain $= \frac{10000}{1017} = 9.83$

Z_{in} to stage 2 $= \beta R_E = (50)(1K)$
$= 50K$

Stage 1:



(2)

$V_{RC} = 2.2$ from stage 2

Choose $V_B = 0$

Then $V_E = .7$

Choose $R_C = 10K$

Make -- R_E will be $< 1K$

$Z_{in} \approx \beta R_E \approx 50K$ or less.

Making it lower will make Z_{in} lower, bias more critical.

$I_c = \frac{2.2}{10K} = .22$ ma

$R_E = \frac{14.3}{.22ma} = 65K$

$\frac{r_\pi}{\beta} = \frac{.026}{.00022} = 118\ \Omega$

Effective collector load = 10K max
8.3K min (β=50
9.0K typ (β=10

Need gain: 112.2 max total
89.1 min

Design for 100.

R_E effective $= \frac{9K}{10} = 900\ \Omega$

$R_{E1A} = 900 - 118 = 782\ \Omega$ → use 750Ω
(r_π)

$R_{E1B} = 65K - 782 \approx 64K$ → use 62K

$Z_{in_{min}}$ = (900)(50) = 45K

↑ to amp

Z_{in} required > 10K

Choose R_B = 15K ($R_B \| 45K > 10K$)

Check: Z_{in} = 15K || 45K = 11.25K

Check base current:

$I_B = \frac{.22ma}{50} = 4.4\mu A$

Voltage drop in R_B = (4.4μA)(15K) = .066 V.

Ignore it.

Capacitors:

With no load, C_2 doesn't matter, only C_1 matters.

With 10K load -- Allow 1.5 dB at 100 Hz

Estimate 3dB at 50 Hz (each stage)

$\omega = 2\pi f = 314$

$C_2 = \frac{1}{2\pi f R_L} = \frac{1}{(314)(10k)} = 3.18\ e\text{-}7 = .32\mu f \rightarrow$ use .47μf

$C_1 = \frac{1}{2\pi f R} = \frac{1}{(314)(900)} = 3.53\ \mu f \rightarrow$ use 4.7μf

(900 ↑)

FET — analysis.

Finding g_m ... Call this "V_{GST}"

$I_D = K(V_{GS} - V_{TH})^2 = K V_{GST}^2$

$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{\partial I_D}{\partial V_{GST}} \frac{\partial V_{GST}}{\partial V_{GS}} = (2K V_{GST})(1) = 2K V_{GST}$

But $I_D = K V_{GST}^2 = (\sqrt{K} V_{GST})^2$

$g_m = 2K V_{GST} = 2\sqrt{K}\sqrt{K} V_{GST} = 2\sqrt{K}\sqrt{I_{DQ}} = 2\sqrt{K I_{DQ}}$

Exercises: p. 266 7, 8, 9

```
list
Vcc  1  0  DC   15.
Vee  6  0  DC  -15.
Vin  4  0  GENERATOR
Rb  4  0  15.K
Re1b  1  2  62.K
Re1a  2  3  750.
Rc1  5  6  10.K
Rc2  1  8  10.K
Re2  7  6  1.K
C1  1  2  4.7u
C2  8  9  470.n
Q1  5  4  3  3  p  area= 1.
Q2  8  5  7  7  n  area= 1.
.model  n  npn  (  kf= 0.  af= 1.  bf= 50.  br= 1.  is= 100.E-18  nf= 1.  nr= 1.  i
sc= 0.  c4= 0.  nc= 2.  ise= 0.  c2= 0.  ne= 1.5  rb= 0.  rbm= 0.  re= 0.  rc= 0.
cjc= 0.  cje= 0.  cjs= 0.  fc= 0.5  mjc= 0.33  mje= 0.33  mjs= 0.  vjc= 0.75  vje=
0.75  vjs= 0.75  xcjc= 1.  itf= 0.  ptf= 0.  tf= 0.  tr= 0.  xtf= 0.  xtb= 0.  xti=
 3.  eg= 1.11)
*+()
.model  p  pnp  (  kf= 0.  af= 1.  bf= 50.  br= 1.  is= 100.E-18  nf= 1.  nr= 1.  i
sc= 0.  c4= 0.  nc= 2.  ise= 0.  c2= 0.  ne= 1.5  rb= 0.  rbm= 0.  re= 0.  rc= 0.
cjc= 0.  cje= 0.  cjs= 0.  fc= 0.5  mjc= 0.33  mje= 0.33  mjs= 0.  vjc= 0.75  vje=
0.75  vjs= 0.75  xcjc= 1.  itf= 0.  ptf= 0.  tf= 0.  tr= 0.  xtf= 0.  xtb= 0.  xti=
 3.  eg= 1.11)
*+()
pr op v nodes
op
#           v(1)        v(2)        v(3)        v(4)        v(5)        v(6)        v(7)
      v(8)        v(9)
 300.15     15.         0.90588     0.73538     44.573p    -13.009     -15.        -13.78
8     3.1148      0.
pr op vbe q*
op
#           vbe(Q1)     vbe(Q2)
 300.15    -0.73538     0.77868
pr op ic q*
op
#           ic(Q1)      ic(Q2)
 300.15    -222.87u     0.0011885
pr ac vdb 4 8
ac 1k
#Freq        vdb(4)      vdb(8)
 1.K        -7.7592n     39.212
ac 100
#Freq        vdb(4)      vdb(8)
 100.       -7.497n      38.582
del n p
b
.model p pnp bf=100
.model n npn bf=100

op
#           ic(Q1)      ic(Q2)
 300.15    -225.07u     0.0013236
ac1k
#Freq        vdb(4)      vdb(8)
 1.K        -6.7847n     40.121
del n p
b
.model n npn bf=200
.model p pnp bf=200

op
#           ic(Q1)      ic(Q2)
 300.15    -226.19u     0.0014018
ac
#Freq        vdb(4)      vdb(8)
 1.K        -6.2901n     40.606
del n p
b
.model p pnp bf=100 is=1e-15
.model n npn bf=100 is=1e-15

op
#           ic(Q1)      ic(Q2)
 300.15    -226.01u     0.0013847
pr op v nodes
op
#           v(1)        v(2)        v(3)        v(4)        v(5)        v(6)        v(7)
      v(8)        v(9)
 300.15     15.         0.84739     0.67619     22.601p    -12.878     -15.        -13.60
1     1.1531      0.
ac
#Freq        vdb(4)      vdb(8)
 1.K        -6.7852n     40.132
cdl n p
del n p
b
.model n npn bf=100 is=10e-15
.model p pnp bf=100 is=10e-15

op
#           v(1)        v(2)        v(3)        v(4)        v(5)        v(6)        v(7)
      v(8)        v(9)
 300.15     15.         0.78865     0.61674     22.694p    -12.875     -15.        -13.54
      0.54212     0.
ac
#Freq        vdb(4)      vdb(8)
 1.K        -6.7857n     40.143
>
```