problems.pdf: 65, 66, 71a, 75, 68

65: $I_b = \frac{20-.6}{1M} = 19.4\ \mu A$

$I_c = \beta I_b = 2.91\ mA \Rightarrow r_e = \frac{25}{I_c} = 8.6\Omega$

$V_{out} = 20 - \underbrace{3.3}_{R_c} \cdot I_c = 10.4V$

$A_v = \frac{-R_c}{r_e} = \frac{-3300}{8.6} = -384$

$Z_{in} = 1M \| (\beta+1) r_e = (\beta+1) r_e = (151)(8.6) = 1.3\ k\Omega$

$C_{in} = \frac{10}{\omega Z_{in}} = \frac{10}{2\pi \cdot 60 \cdot 1300} = 20\ \mu F$

$C_{out} = \frac{1}{\omega R_C} = \frac{1}{2\pi\ 60\ 3300} = .8\ \mu F$

66: $V_B = \frac{R_{B2}}{R_{B1}+R_{B2}} V_{cc} = \frac{2}{10} 20 = 4V \rightarrow V_E = 3.4V \rightarrow I_c = \frac{3.4V}{330\Omega} = 10.3\ mA$

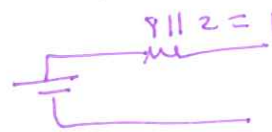
$V_C = V_{cc} - R_c I_c = 20 - 1k(10.3\ mA) = 9.7V$

if $\beta < \infty$ then $V_B \downarrow \Rightarrow V_E \downarrow \Rightarrow I_c \downarrow \Rightarrow V_c \uparrow$

10 if $V_c = 10.7V \Rightarrow I_c = \frac{9.3V}{1K} = 9.3\ mA \Rightarrow V_E = 330 \cdot I_c = 3.07V$

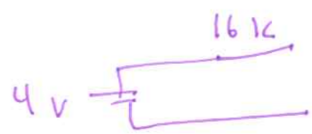
$V_B = 3.67V$ (ie droop $= .33V$) $\leftarrow R_{TH} \cdot I_B \Rightarrow I_B = \frac{.33V}{1.6K} = .206\ mA$

8k+2k:



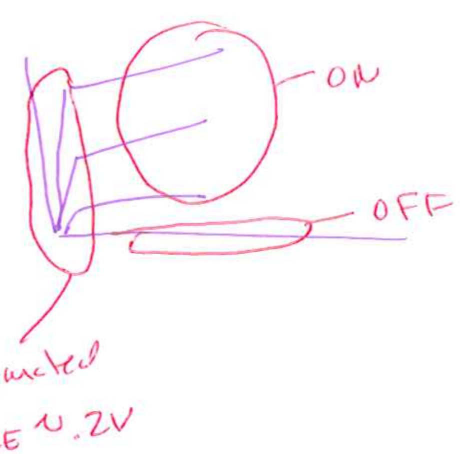
$\beta = \frac{9.3\ mA}{.206\ mA} = 45$

80k + 20k:



$I_B = .0206\ mA$ $\beta = 450$

71a



75) $V_{cc} = 20V$ $V_B = 2V$ $I_B = 20\mu A$ $\beta R_E = 70K$ $I_C = 2mA$

(A) $R_{B1} \| R_{B2} = 7K$ → $\frac{V_B}{V_{cc}} = \frac{2}{20} = \frac{R_{B1}\|R_{B2}}{R_{B1}} = \frac{7K}{R_{B1}} \Rightarrow R_{B1} = 70K$

R_{B2}: $\frac{1}{R_{B2}} = \frac{1}{R_{B1}\|R_{B2}} - \frac{1}{R_{B1}} = \frac{1}{7} - \frac{1}{70} \Rightarrow R_{B2} = 7.77K$

droop $= (R_{B1}\|R_{B2}) I_B = (7K)(20\mu A) = .14V$

so $V_{out} = 2 - .14 = 1.86V \Rightarrow V_E = 1.26$

$\frac{\Delta V_E}{V_E} = \frac{.14}{1.4} = 10\%$

$40\mu A \rightarrow .28V \rightarrow \frac{.28}{1.4} = 20\%$

(B) $R_{B2} = \frac{2V}{9 \times 20\mu A} = 11.1\ K\Omega$ } $R_{B1}\|R_{B2} = 9.89K$

$R_{B1} = \frac{18V}{10 \times 20\mu A} = 90\ K\Omega$

"droop" up

$V_{out} = \frac{11.1}{101.1} 20 = 2.196$ ← $\frac{\Delta V_E}{V_E} = \frac{.2}{1.4} = 14\%$

droop $= (9.89k)(40\mu A) = .396$

1.800 ← drop below : 14%

Note: (B) gives higher input impedance but also more sensitive to β changes. However the changes are balanced i.e. with (A) V_B is always smaller than "design" whereas with (B) if β↑ V_B above design, β↓ V_B below design } in some sense this gives more room for error.

68) $A_v = -10 = -\frac{R_c}{R_e} \Rightarrow R_e = 500\Omega$

$I_c = \frac{V_{cc}/2}{R_c + R_e} = \frac{10V}{5.5k} = 1.82\,mA \Rightarrow r_e = \frac{25}{1.82} = 13.8$

↑ not units correctness R_e

10 Remark: actual values might be 5.1k & 510Ω ⇒ $I_c = 1.70$

$r_e = 14\Omega$

$V_E = (1.82\,mA)(500) = .91\,V$

$V_B = V_E + .6 = \underline{1.51\,V}$ $\quad I_B = \frac{1.82\,mA}{150} = \underline{12\,\mu A}$

Method 1 $(\beta+1)(r_e + R_E) = 150 \cdot 500 = 75K \rightarrow R_{B1} \| R_{B2} = 7.5K$

$\frac{V_B}{V_{cc}} = \frac{1.51}{20} = \frac{R_{B1} \| R_{B2}}{R_{B1}} \Rightarrow R_{B1} = \frac{7.5k}{1.51/20} = 99\,K$

$I_B = \frac{.276}{7.5k} = 36.8\,\mu A$

$R_{B2}: \frac{1}{R_{B2}} = \frac{1}{R_{B1} \| R_{B2}} - \frac{1}{R_{B1}} \Rightarrow R_{B2} = 8.1\,K$

$Z_{in} = R_{B1} \| R_{B2} \| (\beta+1)(r_e + R_E) = 6.8\,K$

(↑ 99, ↑ 8.1, 75k)

droop = .276V

IF $V_E = .7\,(.91) = .637 \Rightarrow V_B = 1.237$

whereas voltage divider zero current output = $\frac{8.1}{107.1}\,20 = 1.513$

$I_c = \frac{.637V}{.5K} = 1.27\,mA$ $\quad \beta = \frac{1.27\,mA}{.0368} = \boxed{35}$

method 2

$R_{B2} = \frac{1.51V}{9 \times 12\,\mu A} = 14\,K$

$R_{B1} = \frac{20 - 1.51}{10 \times 12\,\mu A} = 154\,K$

$R_{B1} \| R_{B2} = \underline{12.8\,K}$

$V_T = \frac{14}{168} \cdot 20 = 1.667\,V$

if V_B actual $= 1.237$ $\quad$ droop $= 1.667 - 1.237 = .430\,V = (R_{B1} \| R_{B2})\,I_B$ $\quad I_B = 33.6\,\mu A$

$\beta = \frac{1.27\,mA}{.0336\,mA} = \boxed{38}$

it is highly unlikely that a transistor spec "typical" β=150 would in fact have β=35 so these circuits should be OK for all such transistors

68 caps — $C_{out} = \frac{1}{\omega R_o}$ = $\frac{1}{2\pi \cdot 20 \cdot 5000}$ = 1.6 μF

$C_{in} = \frac{10}{\omega Z_{in}}$ = $\frac{10}{2\pi \cdot 20 \cdot 6800}$ = 12 μF

↖ Method 1: 6.8K

method 2: $\frac{1}{14} + \frac{1}{154} + \frac{1}{75}$ ⇒ 11K

⇒ $\frac{10}{2\pi \cdot 20 \cdot 11{,}000}$ = 7.2 μF