HW4: Keeyan Hoghsheros

1) FAN-OUT ECL inverter:

a) $\beta = 20$

$$I_E = \frac{-(-5 + .7 + 9)}{1240} = 2.94\text{mA}$$

$$I_B = I_E/_{\beta+1} = 2.74\text{mA}/_{21} = 130\mu\text{A}$$

$$I_{2E} = -(-5+.9)/_{2k\Omega} = 2.05\text{mA}$$

$$I_E'' = 14.01\text{mA}$$

$$\boxed{I_{OAV} = 14.01 - 2.04 = 11.96\text{mA}}$$

$$\boxed{N = 11.96/.130 = 92}$$

b) $I_B' = 1/2\, I_E'/_{21} = 65\mu\text{A}$

$$N = 11.96/.065 = \boxed{184}$$

c) N = ~~84~~

d) N = 100

2) ECL inverter

a) Q2 off, Q1 on

$I_{C1} = I_{E1} \cdot \beta/(\beta+1) = 1.982mA$

$I_{B3} = I_{E3}/(\beta+1) = 2mA/11 = .18mA$

$I_{2C1} = I_{C1} + I_{B3} = 2mA$

$V_{C1} = 0 - 2mA \cdot 500 = -1V$

$\boxed{V_{OL} = V_{E3} = V_{C1} - .8 = -1.8V}$

b) Q_1 off $I_0 = 0$, $I_{E3} = 2mA$ $I_{B3} = .18mA$

$V_{B3} = -500 \cdot (18mA) = .09V$

$\boxed{V_{OH} = V_{E3} = -.09 + .8 = -0.89V}$

c) $V_{REF} = (-1.8V + -.89V)/2 = -1.35V$

$V_{R3} = -(-1.35 + .8) = .55V$

$R_3 = .55/2mA = \boxed{275\Omega}$

d) $P_{R2} = 0$

$P_{Q2} = 0$

$P_{Q1} = 1.2mW$

$P_{R1} = 2mW$

$P_{R3} = .8mW$

$P_0 = 1.6mW$

$P_{Q3} = 3.6mW$

$P_{R4} = 4mW$

$= \boxed{13.2mW}$

$V_{B1} = -1.6V$

$V_{C1} = -1V$, $V_{CE} = .6V$

$I = 2mA$

e) $V_{REF} = (-1.8 - .89)/2 = -1.35$

$V_r = -1.35 + .8 = .55V$

$R_3 = .55/2mA = \boxed{275\Omega}$

f) $I_{C1} + I_{B3} = 2mA$

$V_{C1} = -1V$ $V_{E3} = -1V$

3) ECL GATE

a) $V_{OH} = 0V$

b) Q_4 ~~off~~ on, Q_3 off

$V_E = -1.2 - .8 = -2V$

$I_E = (5 - 2 + 5)/1K = 3mA$

$V_{OL} = -3mA \cdot 400 = \boxed{1.2V}$

c) Q_1 & Q_4 off Q_2 & Q_3 on

$V_{B3} = -.8$

$\boxed{V_o = V_{OH} = 0V}$

d) Q_4 off rest on

$V_{B3} = -.8$

$\boxed{V_o = V_{OH} = 0V}$

c) Q_4 on rest off

$V_{B3} = -2V$

$\boxed{V_o = V_{OL} = -1.2V}$

4) ECL GATE

a) Q_4 off; $V_{OH} = -500mA \cdot 400 = \boxed{-0.2V}$

b) Q_3 off, Q_4 on

$V_E = -2V$; $I_{E4} = 3/1k = 3mA$

$I_{C4} = 3mA \cdot \beta/(\beta+1) = 2.7mA + .5 = \boxed{3.2mA}$

$V_{OL} = 3.2mA \cdot 460 = \boxed{-1.5V}$

c) $V_{IL} = -1.2 - 5 + 5 - 1$

$-1.2 + 7 = \boxed{-0.5}$

d) worst case: one high input, one low input

$V_{E3} = -1.7$

$I_{E3} = (5 - 1.7)/1K = 3.3mA$

$I_{B3} = 3.3/11 = 0.3mA$

$I_{R12} = (5 - .9)/10K = .41mA$

$I_{E1} = .41 + .3 = .71mA$

$I_{B1} = I_{iH} = .71/(\beta+1) = \boxed{64\mu A}$

5) a) NOR GATE

b) $V_{iL} = -1.3 + .2 = -1.1V$

c) $V_{iH} = -.9 - .2 - .5 = -1.9V$

d) $V_{E12} = -1.9V$

$I_{C1} = (5 - 1.9)/1k = 3.1mA$

$I_{1H} = I_{B1} = 3.1mA/11 = 0.25mA$

e) Q2 off Q1 & Q3 on

$I_{B3} = I_{R1} = .1/460 = 250uA$

$I_E = (\beta+1) \cdot 250uA = 7.75mA$

$I_{123} = (5 - .9)/5k$

$= .82mA$