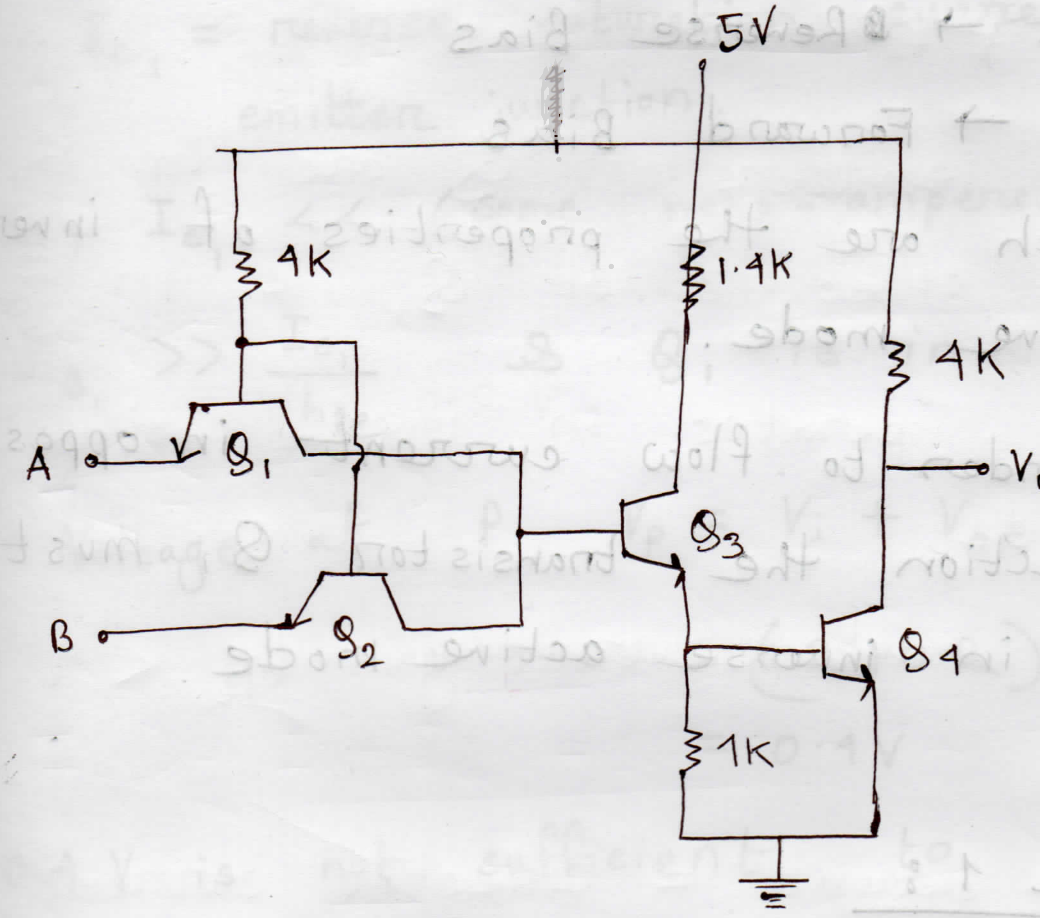
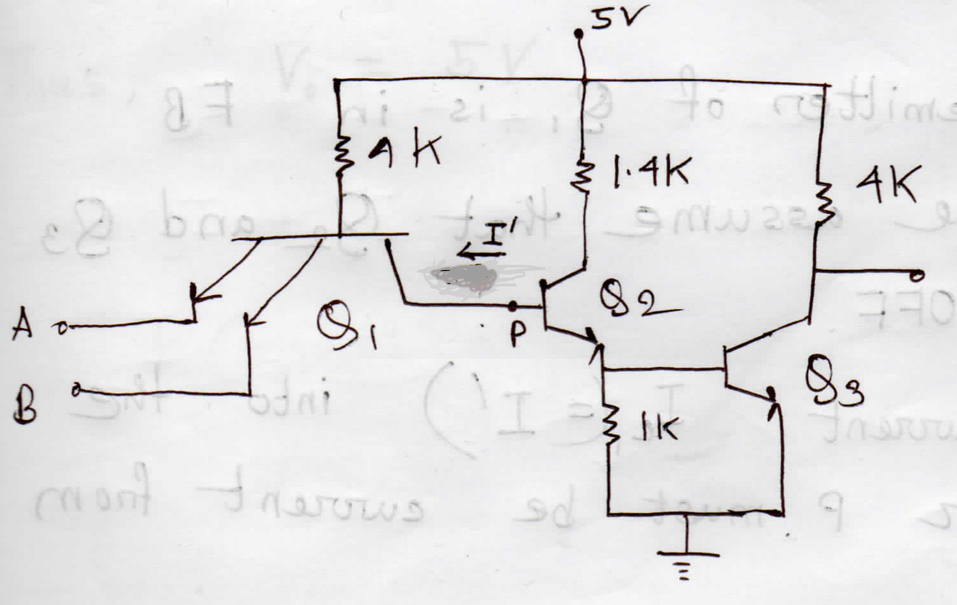
TTL or T^2L Gate



Equivalent ckt



Here, in Q_1,

BE → Reverse Bias

CB → Forward Bias

which are the properties of inverse active mode.

In order to flow current in opposite direction the transistor Q_1 must be in inverse active mode.

Case 1 :

$\exists V_i = 0.2V$

Then, emitter of Q_1 is in FB

And, we assume that Q_2 and Q_3 are OFF.

The current $I_{c_1} (= I')$ into the collector P must be current from emitter to base of Q_2

$\therefore I_{c_1}$ = reverse saturation current of emitter junction.

As, $I_{c_1} <<$ (some nano - amperes)

$I_{B_1} >> \frac{I_{c_1}}{h_{fe}}$ & Q_1 is in saturation.

$\therefore$ Voltage at P, $V_P = V_i + V_{CE(sat)}$

$= (0.2 + 0.2)\ V$

$= 0.4\ V$

0.4 V is not sufficient to put Q_2 & Q_3 ON.

Thus, $V_o = 5\ V$.

Case 2 :

$\forall\ V_i = 5V$

The emitters of Q_1 are in RB and collector of Q_1 is in FB.

$\therefore Q_1$ operates in inverse active mode

The (inverted) current gain, $h_{fe_1} < 1$

Now,

I/P current = collector current

$= h_{fe_1} * I_B$

Emitter current , $I' = I_B + I_C$

$= I_B + I_B * h_{fe}$

$= (1 + h_{fe}) I_B$

As, the direction is reversed for I'.

$$I' = -(1 + h_{fe}) I_B$$

This I' is large enough to draw Q_2 & Q_3 in saturation.

Thus, $V_0 = 0.2\ V$