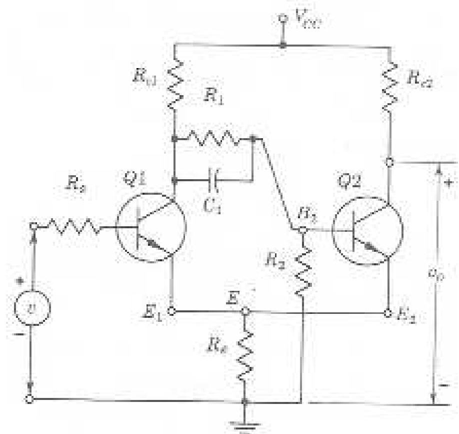
Schmitt Trigger Circuit: (Emitter Coupled Binary)

A most important bistable circuit is indicated in the given figure. It is named as Schmitt trigger circuit.

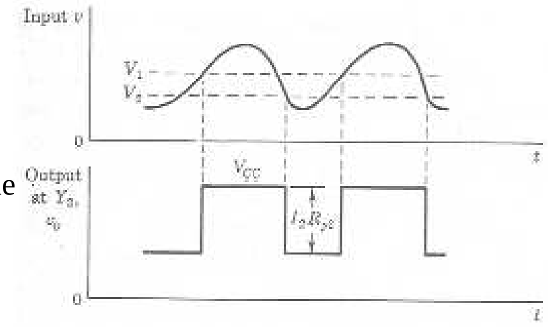


Schmitt trigger produces unsymmetrical square waves by taking any arbitrary input waveform.

Here the coupling from the output of The second stage to the input of the first Stage is missing and that feedback is obtained now through the resistor R_e.

here also we have two stable states.

Operation:



Initially (at V_s=0V) ,Q1 OFF & Q2 ON

Then $V_O = V_{CC} - I_{C2}R_{C2}$ = low value

If applied input voltage is increases ,at a particular value Of applied voltage Q1 starts conducting.

Due to the regenerative feedback Q2 stops conducting.

So now the new state of the device is Q1 ON & Q2 OFF.

Then $V_O = V_{CC}$

The input voltage at which Q1 starts conducting is known as **Upper Triggering Point (UTP).** It is denoted as V_1.

If still the applied voltage is increases the device will remains in Q1 ON & Q2 OFF.

Now if input voltage is decreases , then again at a particular instant Q1 stops conducting and Q2 starts conducting.

So now the state of the device is Q1 OFF & Q2 ON

The input voltage at which Q2 starts conducting is known as **Lower Triggering Point (LTP).** it is denoted as V_2.

The difference between UTP & LTP is known as Hysteresis voltage(V_H)

$$V_H = V_1 - V_2$$

If loop gain is equal to unity, the input voltage at which Q1 starts conducting at the same level only Q2 starts conducting. then hysteresis voltage is zero.

But if loop gain is greater than unity (practical case) , the input voltage at which Q1 starts conducting is more compared to the voltage at which Q2 starts conducting.

Here hysteresis voltage is not equal to zero.(V_1>V_2)

Analysis of Schmitt Trigger Circuit:

Calculation of V_1 (UTP):

We know V_1 is the value of input voltage at which Q1 just starts conducting.

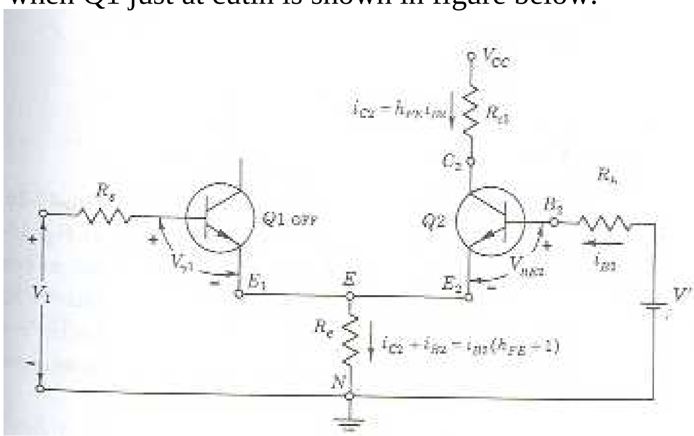
So to determine V_1 we need to consider the state of the device is

Q1 OFF & Q2 ON

if v =$V_{1,}$ voltage across the emitter junction of Q1 is equal to the cutin voltage($V_{\gamma 1}$)

the circuit for calculating the current in Q2 when Q1 just at cutin is shown in figure below.

We have replaced V_{CC}, R_{C1},R_1,R_2 by the Thevenin's equivalent $V^{'}$ in series with R_b Between the base of Q2 and ground,



Where $V^{'} = \dfrac{V_{CC} R_2}{R_C + R_1 + R_2}$

$$R_b = \frac{R_2 (R_{C1} + R_1)}{R_{C1} + R_1 + R_2} \text{-----------------(1)}$$

It is possible for Q2 to be in its active region or to be in saturation region. we shall assume For the present that Q2 is in its active region, and hence

$$i_{C2} = h_{FE} i_{B2} \text{ and } i_{C2} + i_{B2} = (h_{FE} + 1) i_{B2}$$

Applying KVL to the base circuit of Q2 we find

$$V^{'} - V_{BE2} = [R_b + R_e (1 + h_{FE})] i_{B2}$$

Solving for $V_{EN} = (i_{C2} + i_{B2}) R_e$, we obtain

$$V_{EN} = V_{EN1} = V_{EN2} = (V^{'} - V_{BE2}) \frac{R_e (1 + h_{FE})}{R_b + R_e (1 + h_{FE})} \text{----------(2)}$$

And finally

$$V_1 = V_{EN} + V_{\gamma 1} \text{--------(3)}$$

If $R_e(1+h_{FE}) >> R_b$ then $V_1 = V^{'} + V_{\gamma 1} - V_{BE(active)}$ -------(4)

Since $V_{BE2} = V_{BE(active)}$

By using typical values,

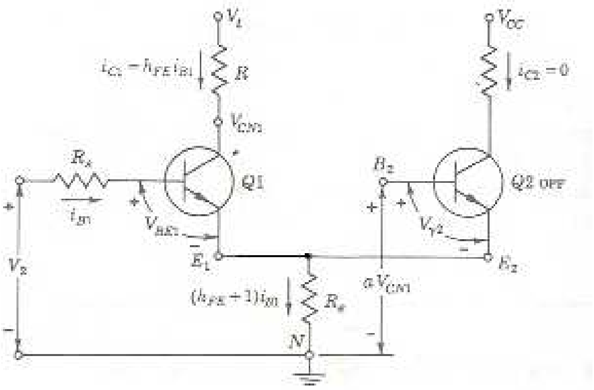
$V_1 \approx V^{'} - 0.1$ ------------(5)

Calculation of V_2(LTP):

The voltage V_2 , defined as the input voltage at which Q2 resumes conducting, is calculated from the figure below.

So to determine V_2 we need to consider the state of the device is

Q1 ON & Q2 OFF



In order to take into account the loading of R_1 and R_2 at the collector of Q1 we have replaced R_1, R_2, R_{C1} and V_{CC} by the thevenin's equivalent voltage V_t and R,

Where $$V_t = \frac{V_{CC}(R_2 + R_1)}{R_{C1} + R_1 + R_2}$$

$$R = \frac{R_{C1}(R_2 + R_1)}{R_{C1} + R_1 + R_2} \text{---------(6)}$$

The voltage ratio from the first collector to the second base is a , where

$$a = \frac{R_2}{R_1 + R_2} \text{--------(7)}$$

In the above circuit the input signal to Q1 decreasing, and when it reaches V_2 then Q2 comes out of cutoff.

KVL around the base circuit of Q2 is ,

$$-aV_{CN1} + V_{\gamma 2} + (i_{B1} + i_{C1})R_e = 0$$

Where $V_{CN1} = V_t - i_{C1}R$, and $i_{C1} = h_{FE} i_{B1}$ for Q1 in the active region.

We obtain ,using V' from the above analysis,

$$i_{C1} = \frac{aV_t - V_{\gamma 2}}{aR + R_e^{'}} = \frac{V^{'} - V_{\gamma 2}}{aR + R_e^{'}}$$

Where $R_e^{'} = R_e(1 + \frac{1}{h_{FE}})$ --------(8)

From the above figure,

$$V_2 = i_{B1}R_e + V_{BE1} + (i_{B1} + i_{C1})R_e = V_{BE1} + i_{C1}\left(R_e^{'} + \frac{R_S}{h_{FE}}\right)$$

$$V_2 = V_{BE1} + \frac{R_e^{'} + \frac{R_S}{h_{FE}}}{aR + R_e}(V^{'} - V_{\gamma 2}) \text{ -------(9)}$$

Since h_{FE} is a large number , $R_e^{'} \approx R_e$, and it may well be that $\frac{R_S}{h_{FE}} << R_e$

Hence the above equation will becomes,

$$V_2 = V_{BE1} + \frac{R_e}{aR + R_e}(V^{'} - V_{\gamma 2}) \text{ -------(10)}$$