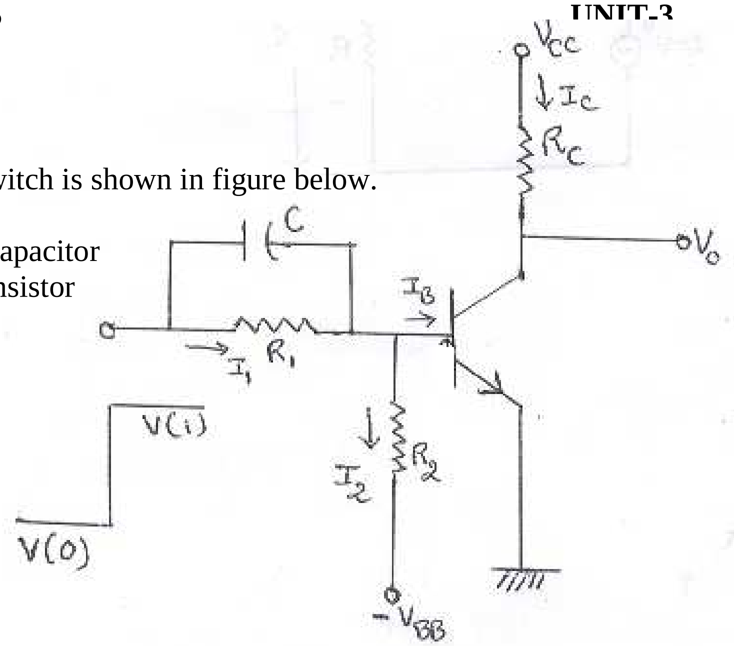
High speed transistor switch:

Circuit diagram for high speed transistor switch is shown in figure below.



In a simple transistor switch, by placing a capacitor In parallel with R_1 switching speed of a transistor Is greatly increases.

Since the base circuit will appears like a compensated Attenuator.

Operation of this circuit is same as the Operation of simple transistor switch.

Design of transistor switch:

In the above circuit diagram ,

V_{CC} must be high (to allow maximum output voltage swing)

V_{BB} is also high (to increase breakdown voltage of a transistor)

R_C must be low (for immediate charging of an output capacitance)

assume that , Transistor is in OFF state if input voltage is V(0)

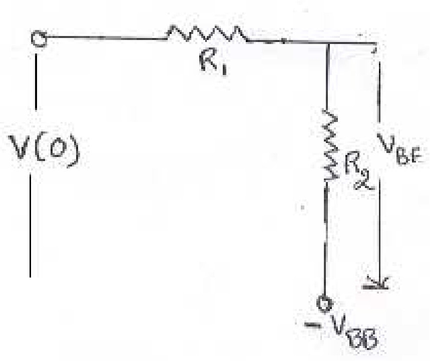
And it is in ON (saturation) state if input voltage is V(1).

We need to select proper values for R_1 & R_2 to satisfy the above conditions.

NOTE :

1. a transistor is said to be in cutoff (OFF) region when only
$$V_{BE} < V_{BE(cutoff)}$$
2. a transistor is said to be in saturation (ON) region when only
$$I_B \geq I_{B(\min)}$$
Where $$I_{B(\min)} = \frac{I_C}{h_{FE}}$$
3. if a transistor is in ON state , then $V_{BE} = V_{BE(sat)}$, $V_{CE} = V_{CE(sat)}$

Case(i) : If input voltage = V(0) then transistor must be in OFF state. Then the circuit diagram is redrawn as
(For DC analysis capacitor is replaced with an open circuit)



By using super position principle ,

V_{BE} = V_{BE} due to V(0) + V_{BE} due to -V_{BB}

V_{BE} due to V(0) = $\dfrac{V(0)R_2}{R_1+R_2}$

V_{BE} due to - V_{BB} = $\dfrac{-V_{BB}R_1}{R_1+R_2}$

$$V_{BE} = \frac{-V_{BB}R_1}{R_1+R_2} + \frac{V(0)R_2}{R_1+R_2}$$

a transistor is said to be in cutoff (OFF) region when only

$$V_{BE} < V_{BE(cutoff)}$$

So $\dfrac{-V_{BB}R_1}{R_1+R_2} + \dfrac{V(0)R_2}{R_1+R_2} < V_{BE(cutoff)}$ --------(1)

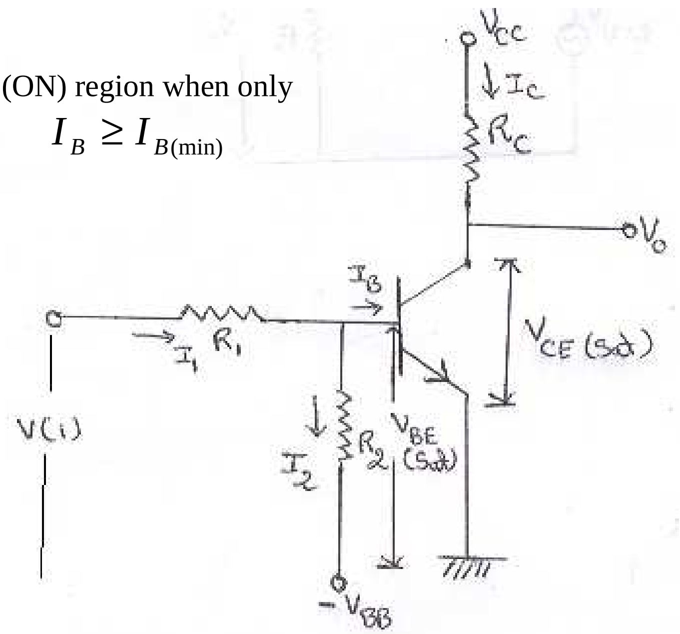
Case(ii) : If input voltage = V(1) then transistor must be in ON state. then the circuit diagram is redrawn as shown below.

a transistor is said to be in saturation (ON) region when only

$$I_B \geq I_{B(\min)}$$

$$I_{B(\min)} = \frac{I_C}{h_{FE}}$$

$$I_C = \frac{V_{CC} - V_{CE(sat)}}{R_C}$$



$$I_{B(\min)} = \frac{V_{CC} - V_{CE(sat)}}{R_C h_{FE}}$$

From the circuit shown , $I_B = I_1 - I_2$

$$I_B = \left(\frac{V(1) - V_{BE(sat)}}{R_1}\right) - \left(\frac{V_{BE(sat)} - (-V_{BB})}{R_2}\right)$$

Therefore, we know the necessary condition to keep the transistor in ON state is

$$\left(\frac{V(1) - V_{BE(sat)}}{R_1}\right) - \left(\frac{V_{BE(sat)} - (-V_{BB})}{R_2}\right) \geq \frac{V_{CC} - V_{CE(sat)}}{R_C h_{FE}} \text{--------(2)}$$

R_1 & R_2 values should be selected to satisfy equations (1) &(2)

Typical n-p-n transistor junction voltages at 25^0C :

	$V_{CE(sat)}$	$V_{BE(sat)}$	$V_{BE(active)}$	$V_{BE(cut\ in)}$	$V_{BE(cutoff)}$
Si	0.3V	0.7V	0.6V	0.5V	0.0V
Ge	0.1V	0.3V	0.2V	0.1V	-0.1V