4.1 Two Transistor Analogy of SCR

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Assume that load resistance is connected between the anode and cathode terminals and a small voltage is applied at the gate and cathode terminals. When there is no gate voltage, the transistor 2 is in cut-off mode due to zero base current. Therefore, no current flows through the collector and hence the base of transistor T1. Hence, both transistors are open circuited and thereby no current flows through the load.And hence the base current at the transistor T1 drives the transistor into saturation mode.

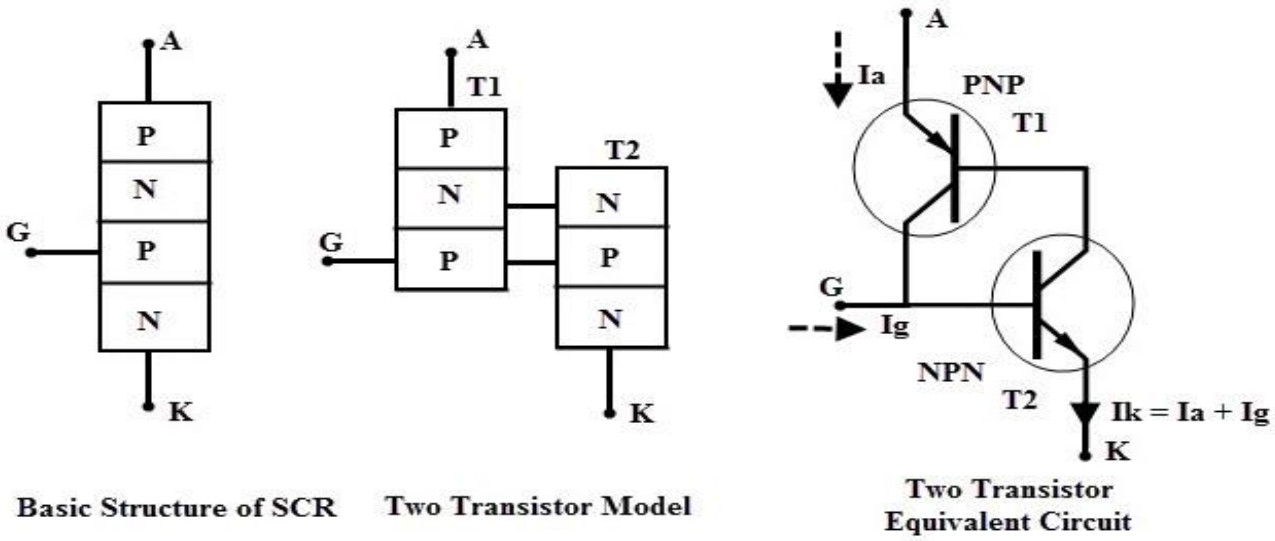

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Figure 4.1.1 Two Transistor Model

[Source: "Power Electronics Circuits, Devices and Applications" by M.H. Rashid, Page: 12]

From the above figure the base current of transistor T2 becomes the collector current of transistor T1 and vice-versa.

Hence

$I_{b2} = I_{c1}$ and $I_{c2} = I_{b1}$

Also current through the cathode terminal, $I_k = I_g + I_a$ ……(1)

For a transistor,

$I_{b1} = I_{e1} – I_{c1}$ ……(2)

and $I_{c1} = \alpha_1 I_{e1} + I_{co1}$……(3)

Where I_{co1} is the leakage current.

Substituting equation 3 in equation 2 we get

$I_{b1} = I_{e1} (1 – \alpha_1) – I_{co1}$ …….(4)

From the figure anode current is the emitter current of transistor T1,

$I_a = I_{e1}$

Then $I_{b1} = I_a (1 – \alpha_1) – I_{co1}$

And also for transistor T2

$I_{c2} = \alpha_2 I_{e2} + I_{co2}$

But $I_k = I_{e2}$

Therefore $I_{c2} = \alpha_2 I_k + I_{co2}$

$I_{c2} = \alpha_2 (I_g + I_a) + I_{co2}$ .....(5)

But $I_{b1} = I_{c2}$ .....(6)

Substituting the equations 4 and 5 in equation 6 we get

$I_a (1 – \alpha_1) – I_{co1} = \alpha_2 (I_g + I_a) + I_{co2}$

$I_a = [\alpha_2 I_g + I_{co1} + I_{co2}] / [1- (\alpha_1 + \alpha_2)]$

By assuming the leakage currents are negligible in both transistors we get

$I_a = [\alpha_2 I_g] / [1- (\alpha_1 + \alpha_2)]$

where α_1 and α_2 are the respective gains of the two transistors.