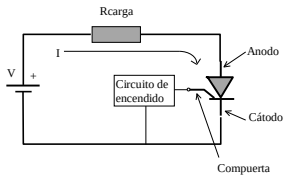
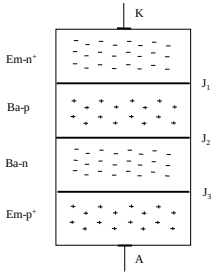
Tiristores

Función:



Estructura

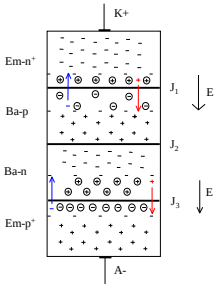


A = Anodo
K= Cátodo

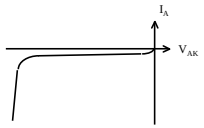
Em-n$^+$ = Emisor n
Ba-p = Base-p
Ba-n = Base-n
Em-p$^+$ = Emisor p

J_1 = Juntura Emisor n
J_2 = Juntura Base
J_3 = Juntura Emisor p

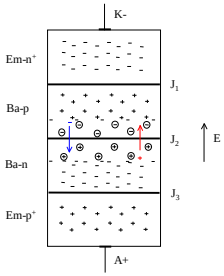
Bloqueo inverso

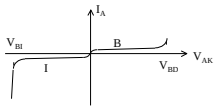


- Portadores n, mayoritarios
+ Portadores p, mayoritarios
- Portadores n, minoritarios
+ Portadores p, mayoritarios
⊖ Carga espacial: iones aceptores
⊕ Carga espacial: iones donores



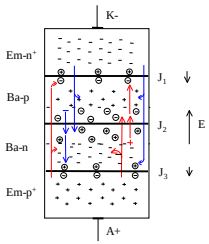
Bloqueo directo

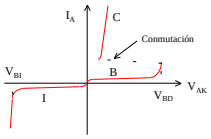




B: Bloqueo directo
I : Bloqueo inverso
V_{BD}: Voltaje de bloqueo directo
V_{BI} : Voltaje de bloqueo inverso

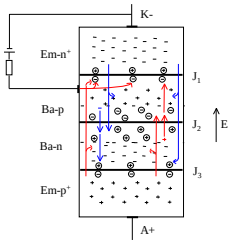
Conmutación

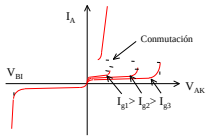




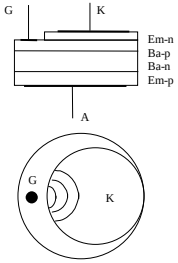
B: Bloqueo directo
I : Bloqueo inverso
C: Conducción
V_{BD}: Voltaje de bloqueo directo
V_{BI} : Voltaje de bloqueo inverso

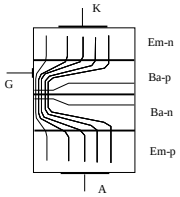
Conmutación controlada por compuerta





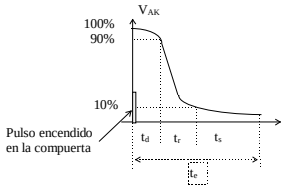
Conmutación: Transientes





$$di/dt \leq (di/dt)_{max}$$

Conmutación: Transientes



t_d = tiempo de retardo
t_r = tiempo de conmutación
t_s = tiempo de expansión
$t_e = t_d + t_r + t_s$ tiempo de encendido

Condición de conmutación

$I_{J3}^{p} = g_3 * I_A$ Eficiencia de inyección: $g_3 = \frac{I_p}{I_p + I_n}$

$I_{J2}^{p} = a_3 I_A$ con $a_3 = a_T g_3$

en que α_T es el factor de transporte

$I_{J2}^{p} = a_3 I_A + I_0^p$

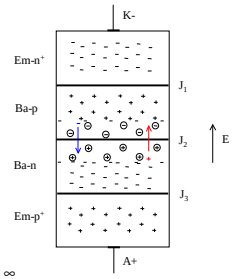
Análogamente para el flujo de electrones se tiene:

$I_{J2}^{n} = a_1 I_K + I_0^n$

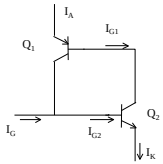
$I_{J2}^{p} + I_{J2}^{n} = a_3 I_A + a_1 I_K + I_0^p + I_0^n$

$I_{J2}^{p} + I_{J2}^{n} = I_A$ $\quad I_A = I_K$

$I_A = \frac{I_0^p + I_0^n}{1 - (a_3 + a_1)}$ $\quad a_3 + a_1 = 1$ $\quad I_A = \infty$



Modelo en base a transistores



$I_{C1} = a_1 I_A + I_{C01}$

$I_{B1} = I_A - I_{C1} = (1 - a_1 I_A) - I_{C01}$

$I_{C2} = a_2 I_K + I_{C02}$

pero .... $I_{B1} = I_{C2}$

$(1 - a_1 I_A) - I_{C01} = a_2 I_K + I_{C02}$

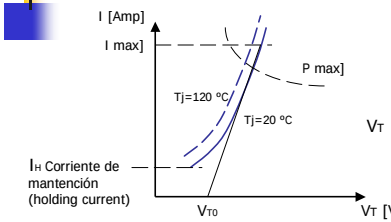
con ..... $I_K = I_A + I_G$

$(1 - a_1 I_A) - I_{C01} = a_2 (I_A + I_G) + I_{C02}$

luego

$I_A = \frac{a_2 I_G + I_{C01} + I_{C02}}{1 - (a_1 + a_2)}$

Curva característica de conducción



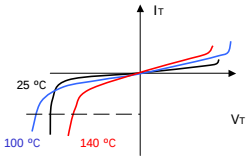
$V_T = V_{T0} + r_T I_T$

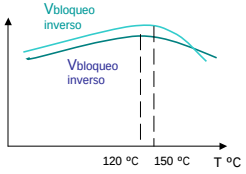
$P_{max} = 1/T \int V_T I_T \, dt = 1/T \int (V_{T0} + r_T I_T) I_T \, dt$

$= 1/T \, V_{T0} \int I_T \, dt + r_T \, 1/T \int I_T^2 \, dt$

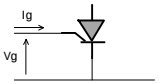
$P_{max} = P_{av} + r_T I_{ef}^2$

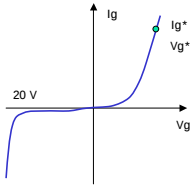
Voltaje de bloqueo

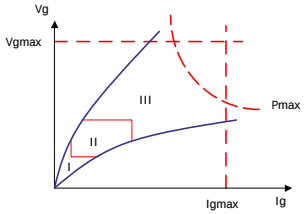




Curva característica de compuerta







I: en corte

II: en corte o conducción

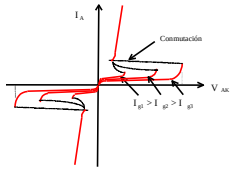
III: en conducción

Otros dispositivos de tres junturas

Tiristor optacoplado

Al inyectar fotones en la zona de transición que soporta el bloqueo directo, se aumenta la generación de pares electrón hueco y con ello la corriente inversa. Con ello se reduce el voltaje ánodo cátodo requerido para la conmuta

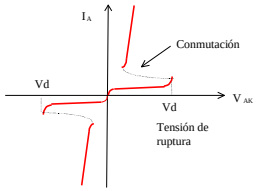
Triac



Triac: curva característica

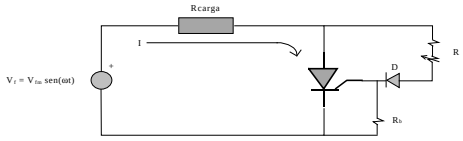
Otros dispositivos de tres junturas

Diac



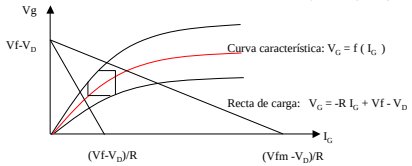
Diac: curva característica

Disparo resistivo



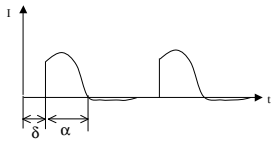
Limitación corriente de compuerta $R_{min} = (V_{fm} - V_D)/I_{GM}$

Limitación voltaje compuerta: $R_{min} = R_b (V_{fm} - V_{GM})/ V_{GM}$

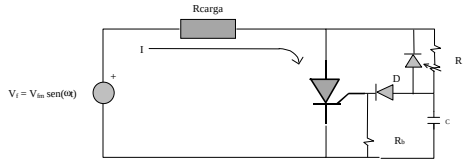


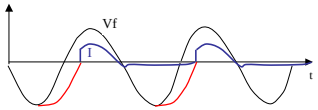
Disparo resistivo

Angulo de disparo: δ = [0 – 90°]
Angulo de conducción: α = [180 – 90°]

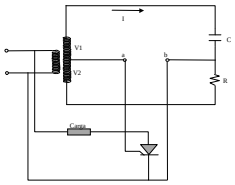


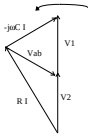
Disparo RC

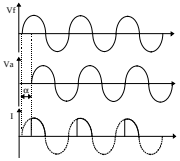




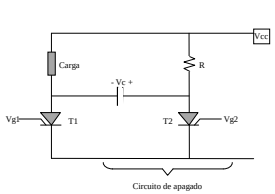
Encendido con transformador de pto. medio

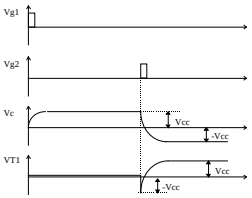




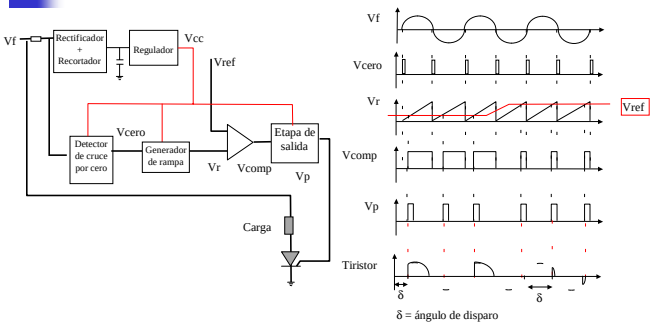


Apagado del tiristor alimentado con CC

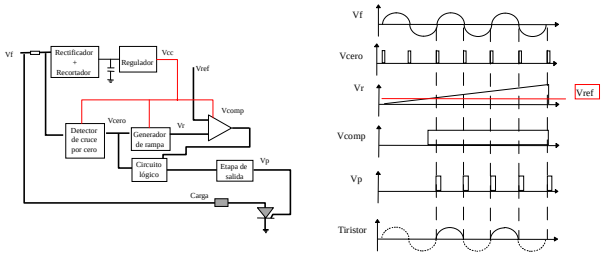




Control proporcional de fase



Control proporcional de Nº de ciclos



FIN