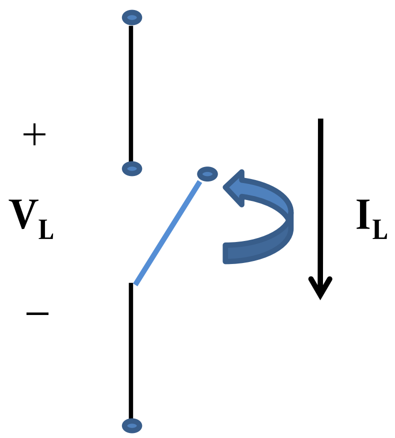
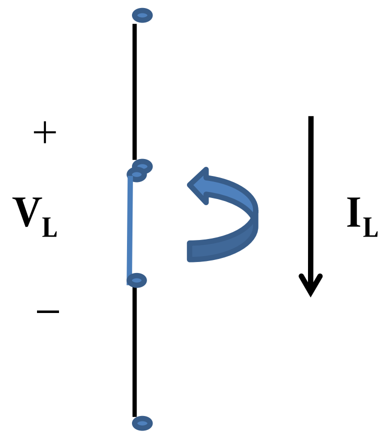
Transistor Bipolar

Llave Ideal



OFF



ON

$R_{OFF} = \infty \Rightarrow I_L = 0$

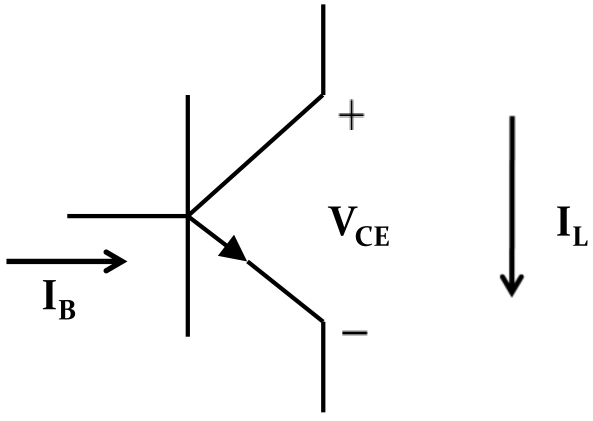
$R_{ON} = 0 \Rightarrow V_L = 0$

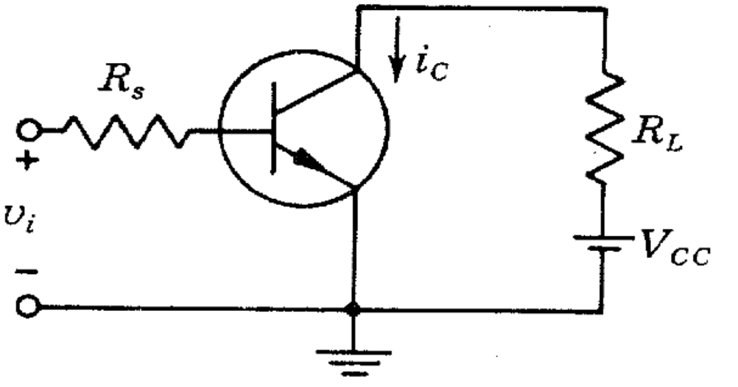
No disipa Potencia

$t_{ON} = t_{OFF} = 0$ → Tiempo de Conmutación

Energía de Accionamiento = 0

TRANSISTOR COMO LLAVE





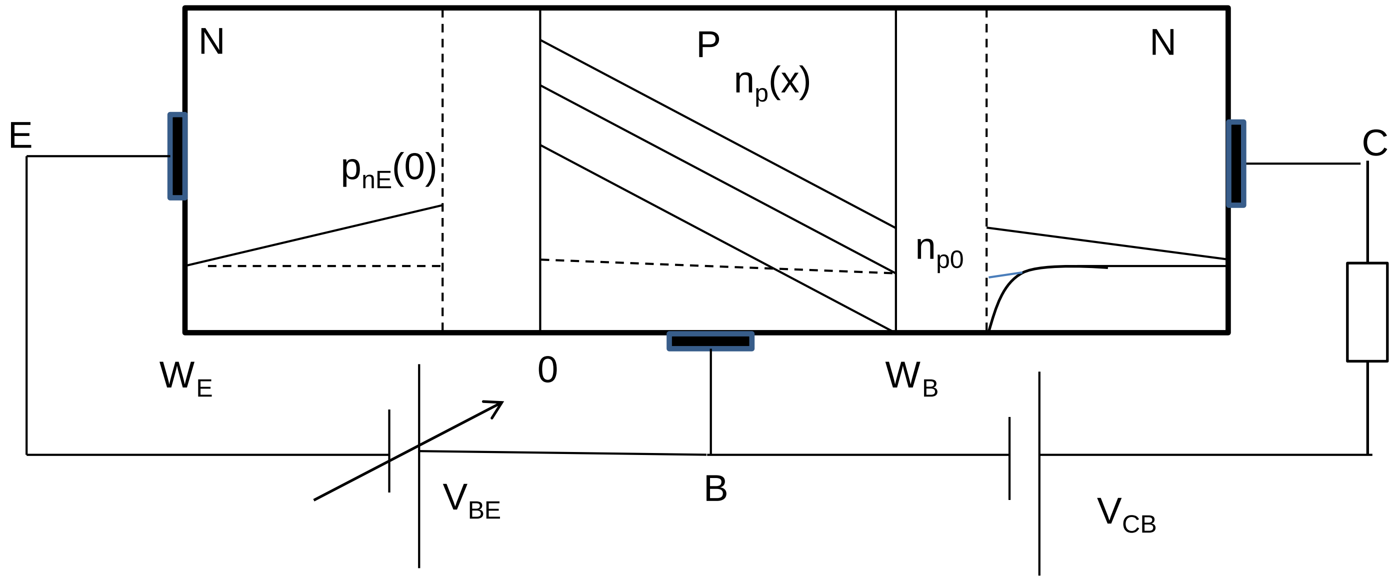
(a)

OFF:: $I_B = 0 \Rightarrow I_L = I_{CBo} \approx \mu A \Rightarrow$ **Junturas Inversas**

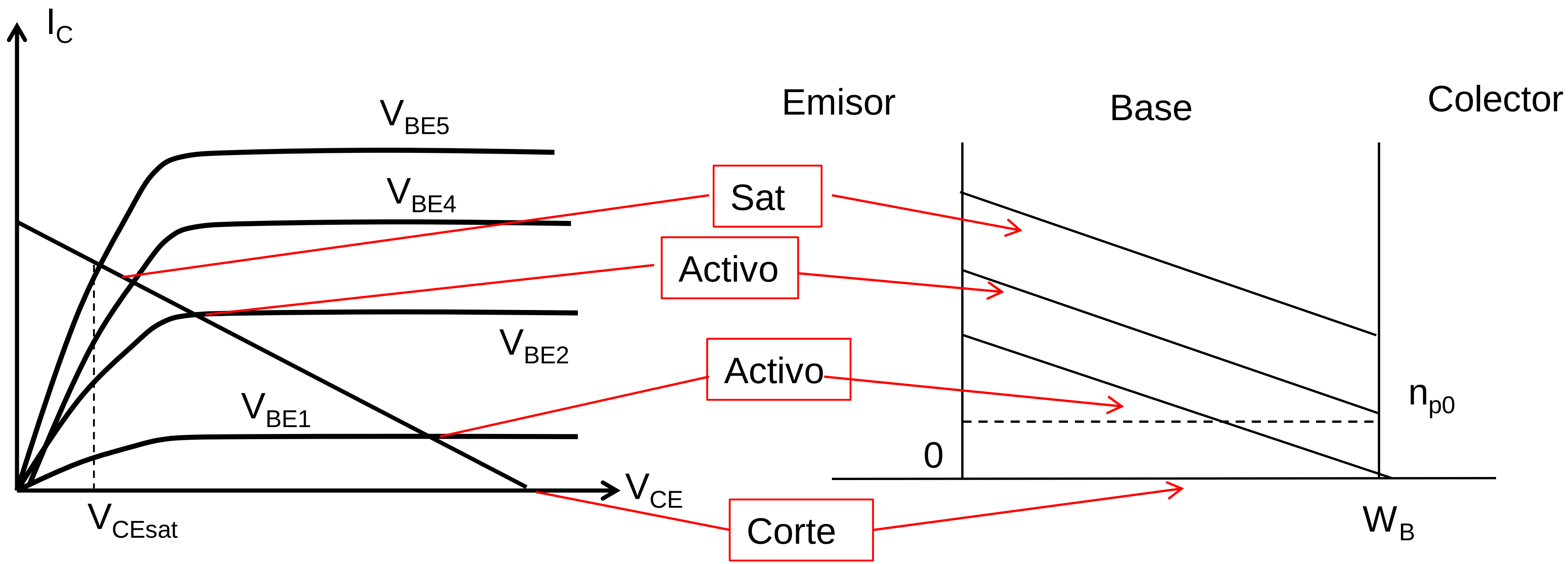
ON: $I_B \neq 0 \Rightarrow V_L = V_{CESAT} \approx 0{,}1\ V \Rightarrow$ **Junturas Directas**

ON a OFF => Saturación a Corte

OFF a ON => Corte a Saturación

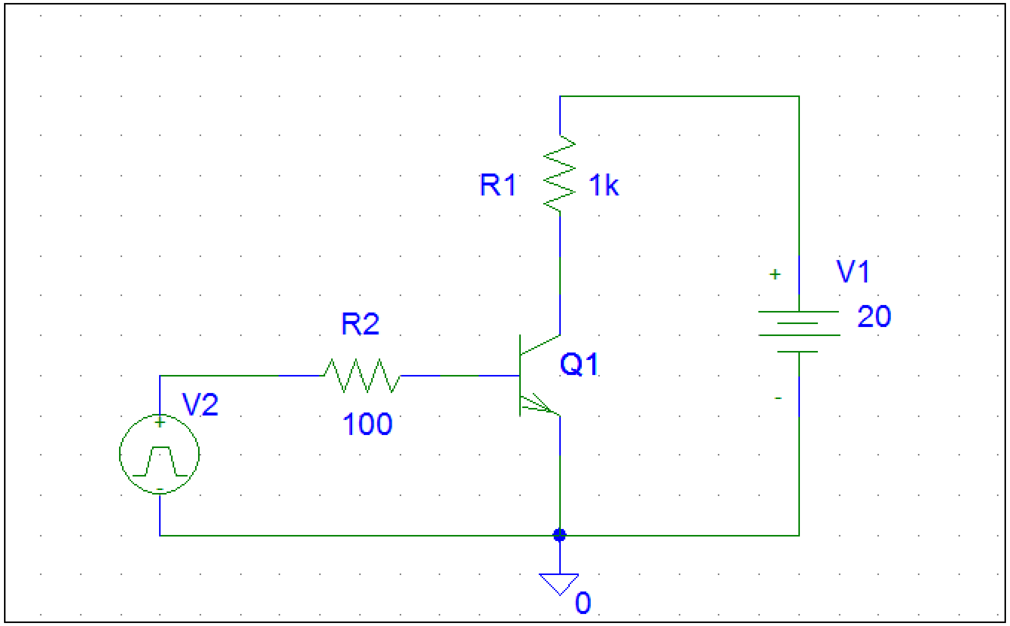


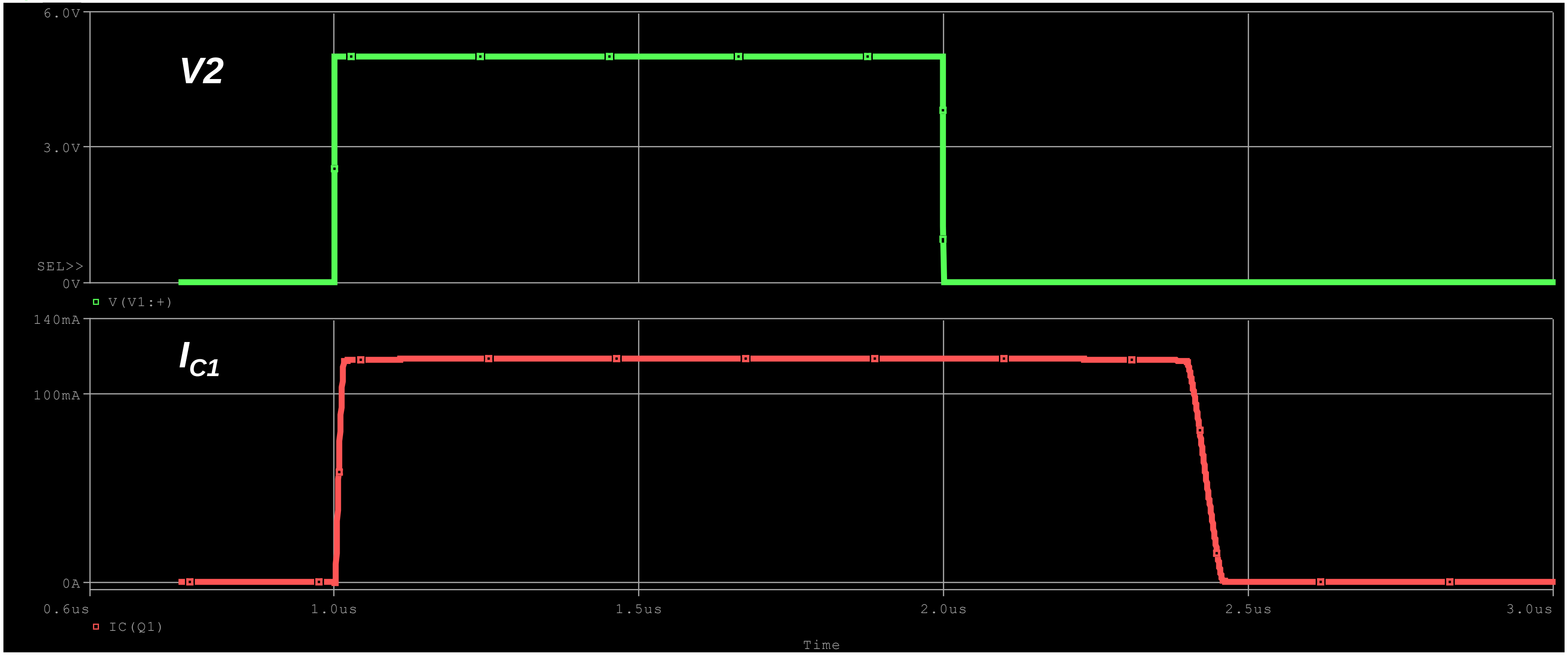
N
P
N
$n_p(x)$
E
C
$p_{nE}(0)$
n_{p0}
W_E
0
W_B
V_{BE}
B
V_{CB}



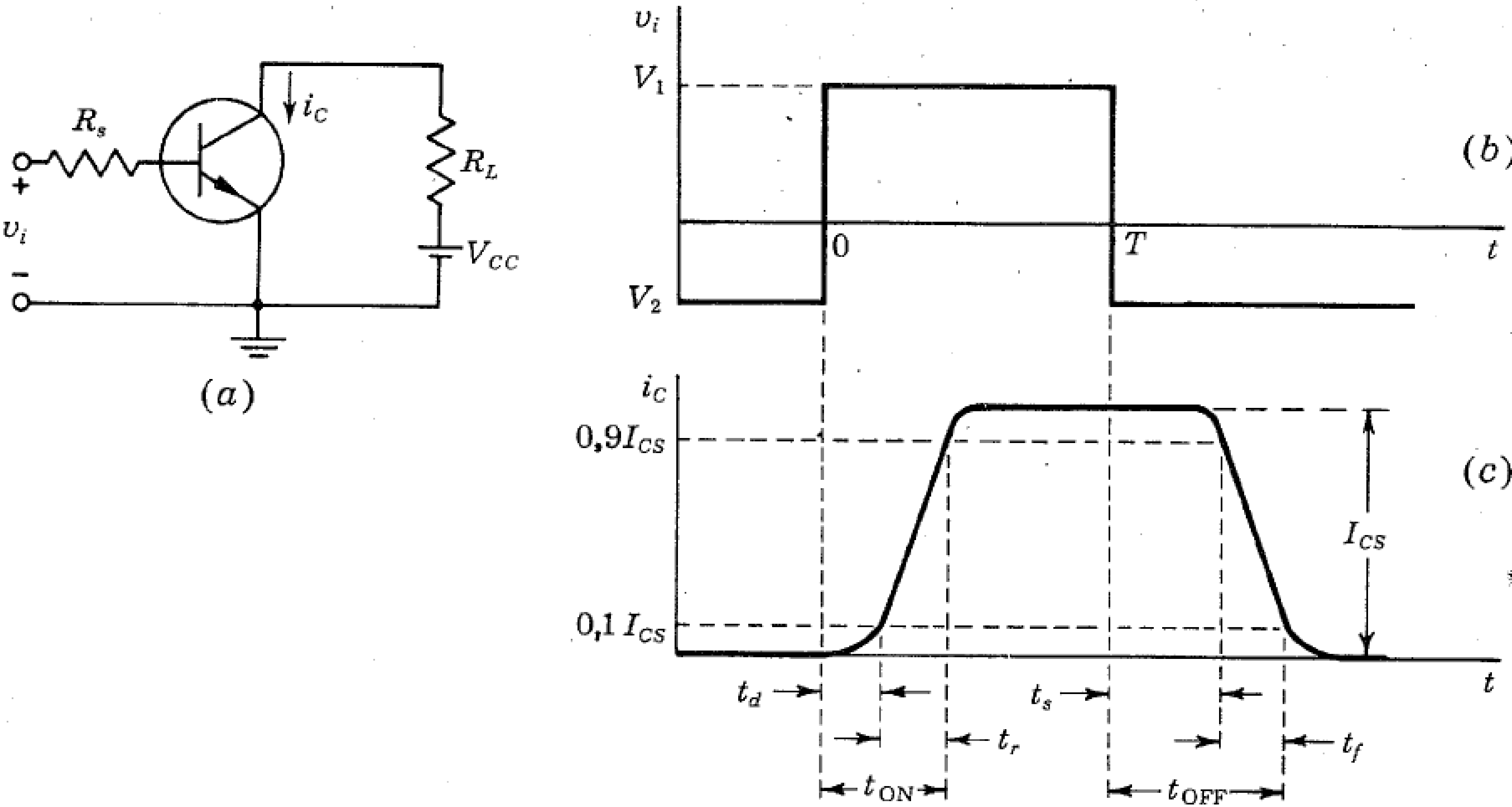
I_C
Emisor
Base
Colector
V_{BE5}
V_{BE4}
Sat
Activo
V_{BE2}
Activo
V_{BE1}
n_{p0}
0
V_{CE}
V_{CEsat}
Corte
W_B

TIEMPOS DE CONMUTACION

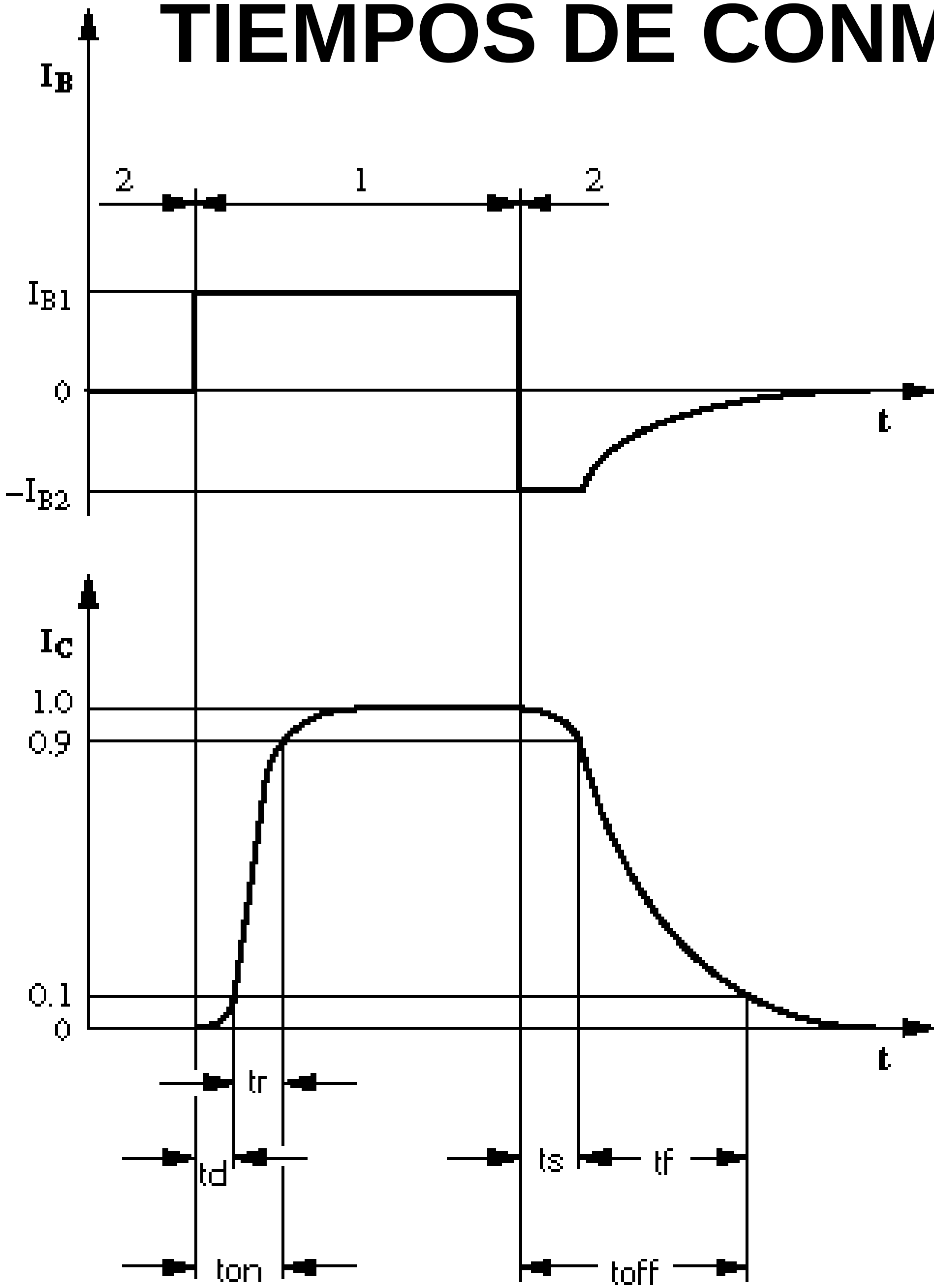




TIEMPOS DE CONMUTACION



TIEMPOS DE CONMUTACION



I_c vs I_B

Tipos de Transistores

- **TRANSISTORES**
  - **Potencia**
    - **Baja frecuencia**
    - **Conmutación (Switching)**
    - **Radio frecuencia**
  - **Señal**
    - **Baja Frecuencia**
    - **Radio frecuencia**

Complementary Silicon Power Transistors

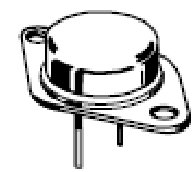
. . . designed for general–purpose switching and amplifier applications.

- DC Current Gain — h_{FE} = 20 – 70 @ I_C = 4 Adc
- Collector–Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.1 Vdc (Max) @ I_C = 4 Adc
- Excellent Safe Operating Area

NPN
2N3055*
PNP
MJ2955*

*Motorola Preferred Device

15 AMPERE
POWER TRANSISTORS
COMPLEMENTARY
SILICON
60 VOLTS
115 WATTS



CASE 1–07
TO–204AA
(TO–3)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	60	Vdc
Collector–Emitter Voltage	V_{CER}	70	Vdc
Collector–Base Voltage	V_{CB}	100	Vdc
Emitter–Base Voltage	V_{EB}	7	Vdc
Collector Current — Continuous	I_C	15	Adc
Base Current	I_B	7	Adc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.657	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.52	°C/W

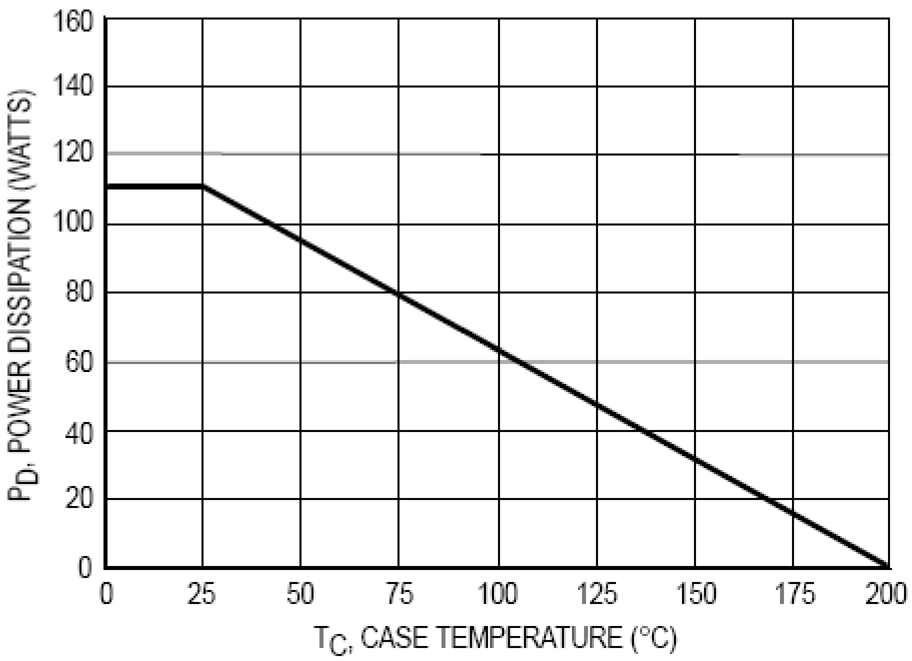


Figure 1. Power Derating

2N3055, MJ2955

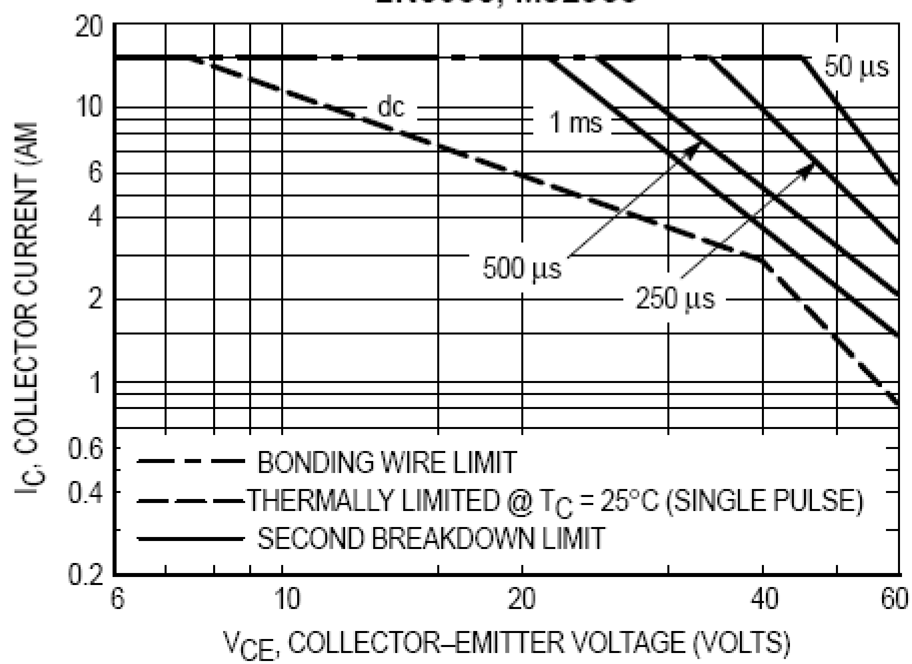
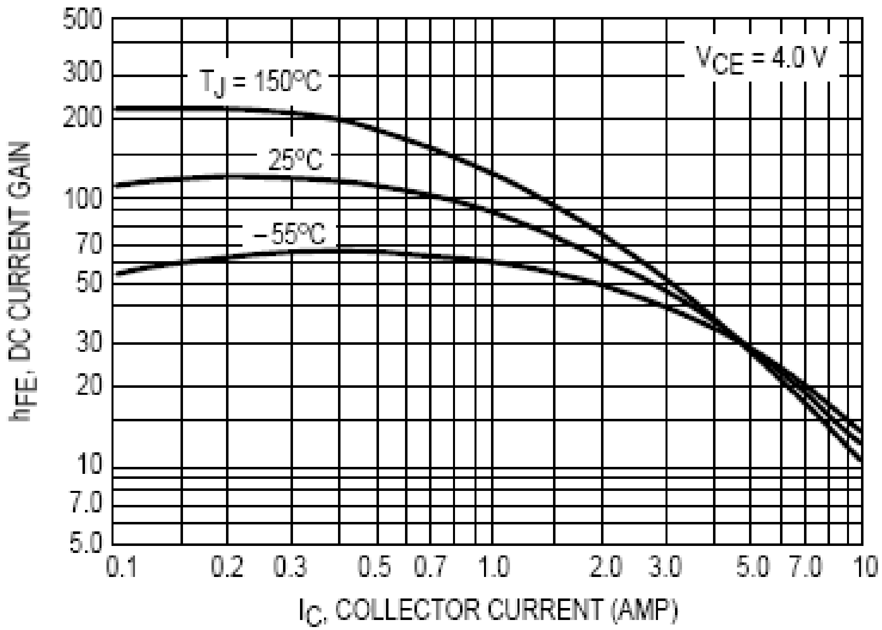


Figure 2. Active Region Safe Operating Area

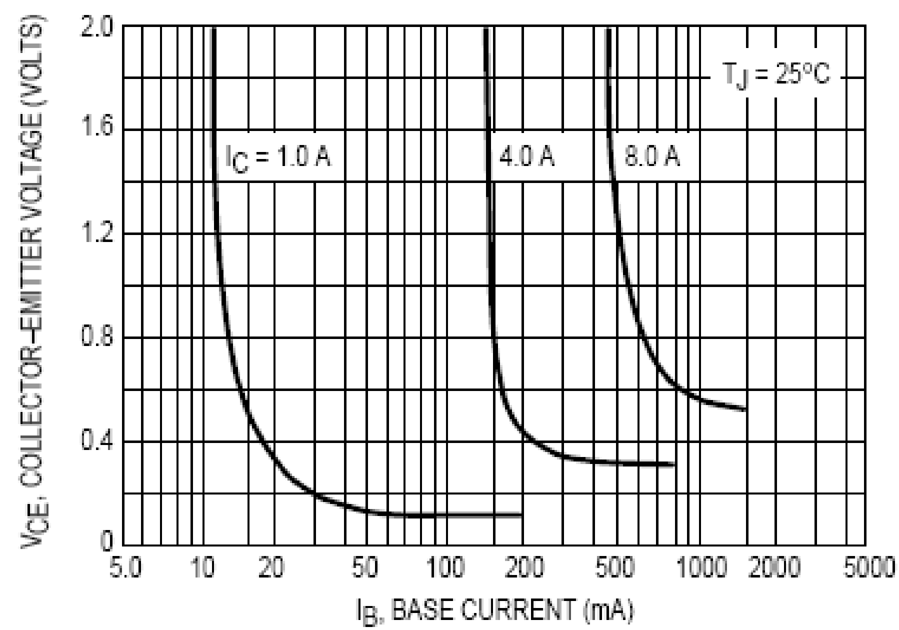
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**				
Collector–Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	—	Vdc
Collector–Emitter Sustaining Voltage (1) (I_C = 200 mAdc, R_{BE} = 100 Ohms)	$V_{CER(sus)}$	70	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	—	0.7	mAdc
Collector Cutoff Current (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	 — —	 1.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	—	5.0	mAdc
***ON CHARACTERISTICS (1)**				
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	 20 5.0	 70 —	—
Collector–Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 400 mAdc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$	 — 	 1.1 3.0	Vdc
Base–Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	—	1.5	Vdc

NPN
2N3055



500
300
200
100
70
50
30
20
10
7.0
5.0
h_{FE}, DC CURRENT GAIN
T_J = 150°C
25°C
−55°C
V_{CE} = 4.0 V
0.1
0.2
0.3
0.5
0.7
1.0
2.0
3.0
5.0
7.0
10
I_C, COLLECTOR CURRENT (AMP)



2.0
1.6
1.2
0.8
0.4
0
V_{CE}, COLLECTOR–EMITTER VOLTAGE (VOLTS)
T_J = 25°C
I_C = 1.0 A
4.0 A
8.0 A
5.0
10
20
50
100
200
500
1000
2000
5000
I_B, BASE CURRENT (mA)

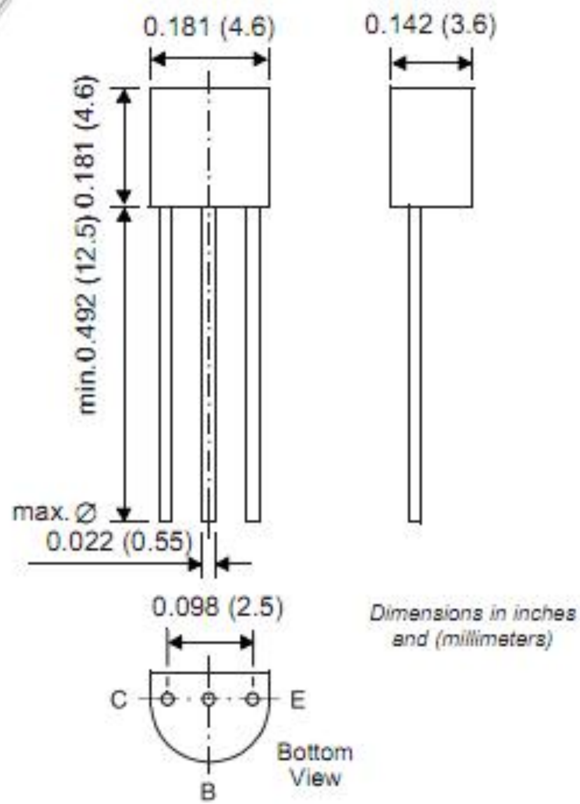
VISHAY

BC546 thru BC548

Vishay Semiconductors
formerly General Semiconductor

Small Signal Transistors (NPN)

TO-226AA (TO-92)



Features

- NPN Silicon Epitaxial Planar Transistors
- These transistors are subdivided into three groups A, B, and C according to their current gain. The type BC546 is available in groups A and B, however, the types BC547 and BC548 can be supplied in all three groups. As complementary types the PNP transistors BC556...BC558 are recommended.
- On special request, these transistors are also manufactured in the pin configuration TO-18.

Mechanical Data

Case: TO-92 Plastic Package
Weight: approx. 0.18g
Packaging Codes/Options:
E6/Bulk – 5K per container, 20K/box
E7/4K per Ammo mag., 20K/box

Maximum Ratings & Thermal Characteristics

Ratings at 25°C ambient temperature unless otherwise specified.

Parameter		Symbol	Value	Unit
Collector-Base Voltage	BC546 BC547 BC548	V_{CBO}	80 50 30	V
Collector-Emitter Voltage	BC546 BC547 BC548	V_{CES}	80 50 30	V
Collector-Emitter Voltage	BC546 BC547 BC548	V_{CEO}	65 45 30	V
Emitter-Base Voltage	BC546, BC547 BC548	V_{EBO}	6 5	V
Collector Current		I_C	100	mA
Peak Collector Current		I_{CM}	200	mA
Peak Base Current		I_{BM}	200	mA
Peak Emitter Current		$-I_{EM}$	200	mA
Power Dissipation at T_{amb} = 25°C		P_{tot}	500(1)	mW
Thermal Resistance Junction to Ambient Air		$R_{\Theta JA}$	250(1)	°C/W
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_S	–65 to +150	°C

Note: (1) Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

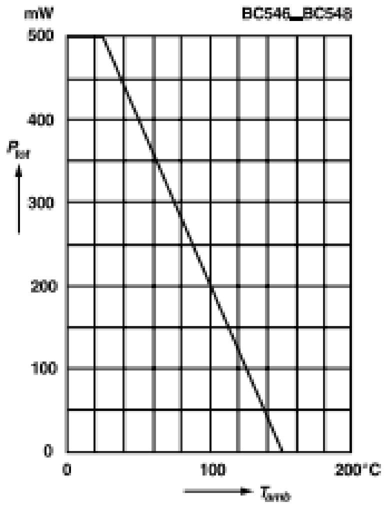
Electrical Characteristics (T_J = 25°C unless otherwise noted)

Parameter		Symbol	Test Condition	Min	Typ	Max	Unit
Small Signal Current Gain	Current gain group A B C	h_{fe}	V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz	— — —	220 330 600	— — —	—
Input Impedance	Current gain group A B C	h_{ie}	V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz	1.6 3.2 6	2.7 4.5 8.7	4.5 8.5 15	kΩ
Output Admittance	Current gain group A B C	h_{oe}	V_{CE} = 5 V, I_C = 2 mA, f = 1kHz	— — —	18 30 60	30 60 110	µS
Reverse Voltage Transfer Ratio	Current gain group A B C	h_{re}	V_{CE} = 5 V, I_C = 2 mA, f = 1kHz	— — —	$1.5 \cdot 10^{-4}$ $2 \cdot 10^{-4}$ $3 \cdot 10^{-4}$	— — —	—
DC Current Gain	Current gain group A B C	h_{FE}	V_{CE} = 5 V, I_C = 10 µA	— — —	90 150 270	— — —	—
	Current gain group A B C		V_{CE} = 5 V, I_C = 2 mA	110 200 420	180 290 500	220 450 800	
	Current gain group A B C		V_{CE} = 5 V, I_C = 100 mA	— — —	120 200 400	— — —	
Collector Saturation Voltage		V_{CEsat}	I_C = 10 mA, I_B = 0.5 mA I_C = 100 mA, I_B = 5 mA	— —	80 200	200 600	mV
Base Saturation Voltage		V_{BEsat}	I_C = 10 mA, I_B = 0.5 mA I_C = 100 mA, I_B = 5 mA	— —	700 900	— —	mV
Base-Emitter Voltage		V_{BE}	V_{CE} = 5 V, I_C = 2 mA V_{CE} = 5 V, I_C = 10 mA	580 —	660 —	700 720	mV
Collector-Emitter Cutoff Current	BC546 BC547 BC548 BC546 BC547 BC548	I_{CES}	V_{CE} = 80 V V_{CE} = 50 V V_{CE} = 30 V V_{CE} = 80 V, T_j = 125°C V_{CE} = 50 V, T_j = 125°C V_{CE} = 30 V, T_j = 125°C	— — — — — —	0.2 0.2 0.2 — — —	15 15 15 4 4 4	nA nA nA µA µA µA
Gain-Bandwidth Product		f_T	V_{CE} = 5 V, I_C = 10 mA, f = 100 MHz	—	300	—	MHz
Collector-Base Capacitance		C_{CBO}	V_{CB} = 10 V, f = 1 MHz	—	3.5	6	pF
Emitter-Base Capacitance		C_{EBO}	V_{EB} = 0.5 V, f = 1 MHz	—	9	—	pF
Noise Figure	BC546, BC547 BC548	F	V_{CE} = 5 V, I_C = 200 µA, R_G = 2 kΩ, f = 1 kHz, Δf = 200 Hz	—	2	10	dB

Ratings and Characteristic Curves (T_A = 25°C unless otherwise noted)

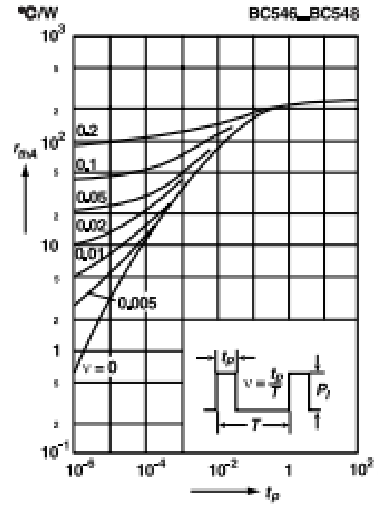
Admissible power dissipation versus temperature

Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case

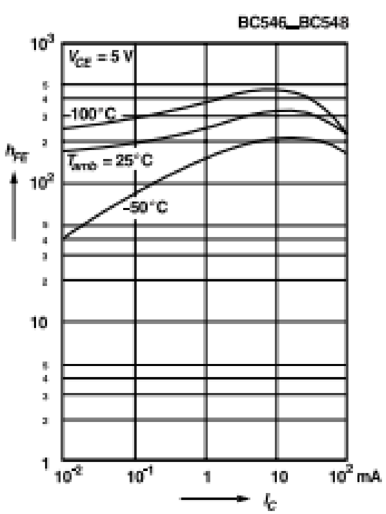


Pulse thermal resistance versus pulse duration

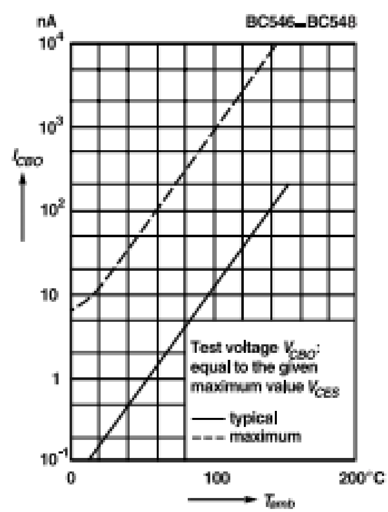
Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case



DC current gain versus collector current

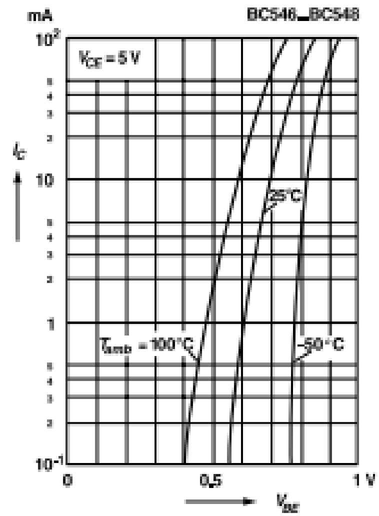


Collector-base cutoff current versus ambient temperature

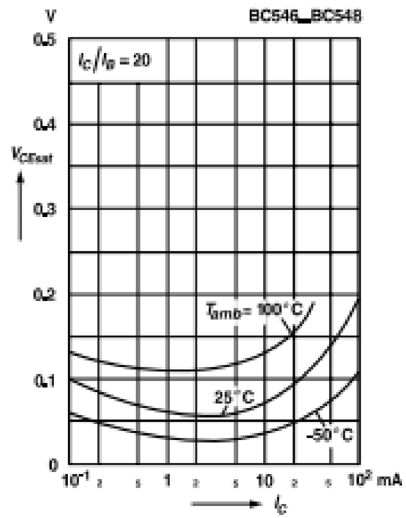


Ratings and Characteristic Curves (T_A = 25°C unless otherwise noted)

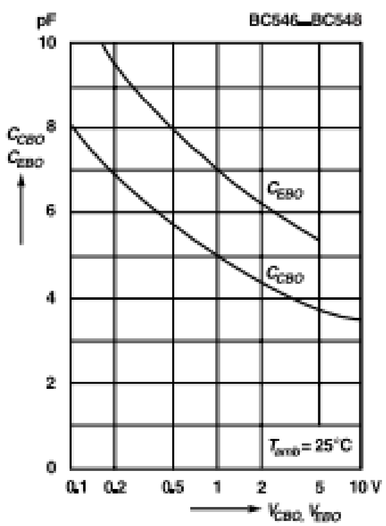
Collector current versus base-emitter voltage



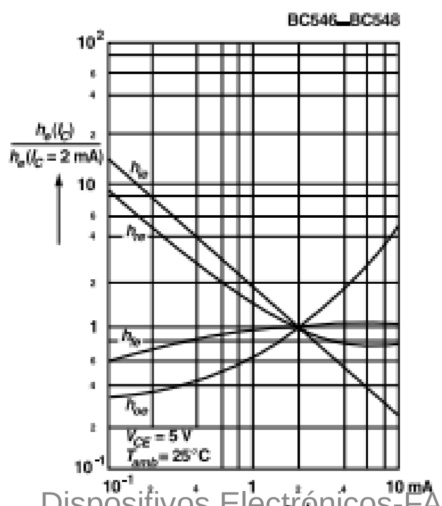
Collector saturation voltage versus collector current



Collector-base capacitance, Emitter-base capacitance versus reverse bias voltage



Relative h-parameters versus collector current



Ratings and Characteristic Curves (T_A = 25°C unless otherwise noted)

Gain-bandwidth product versus collector current

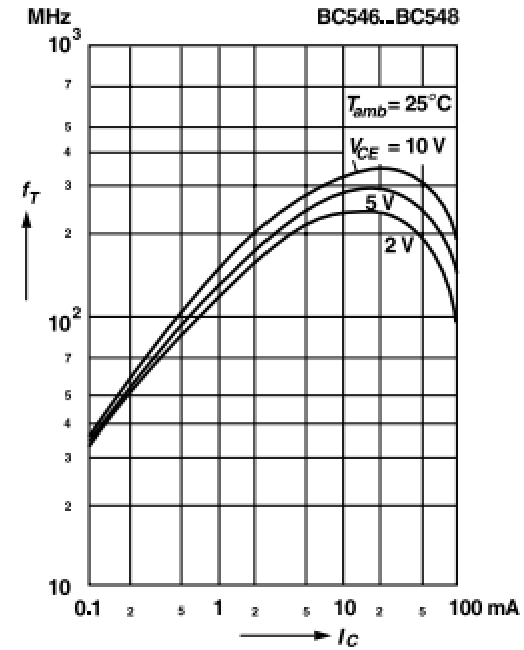
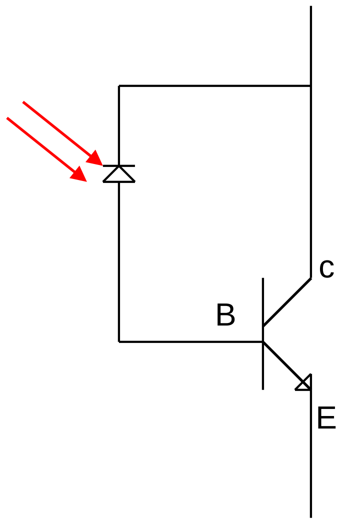
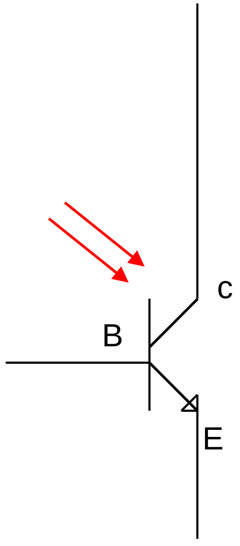
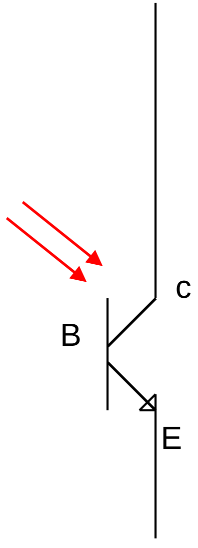


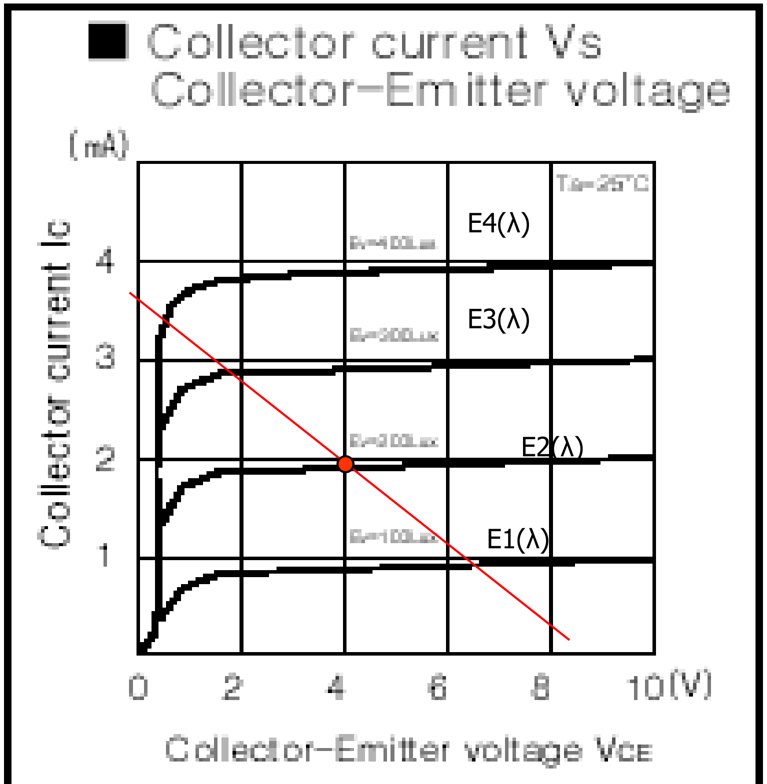
FOTO TRANSISTOR

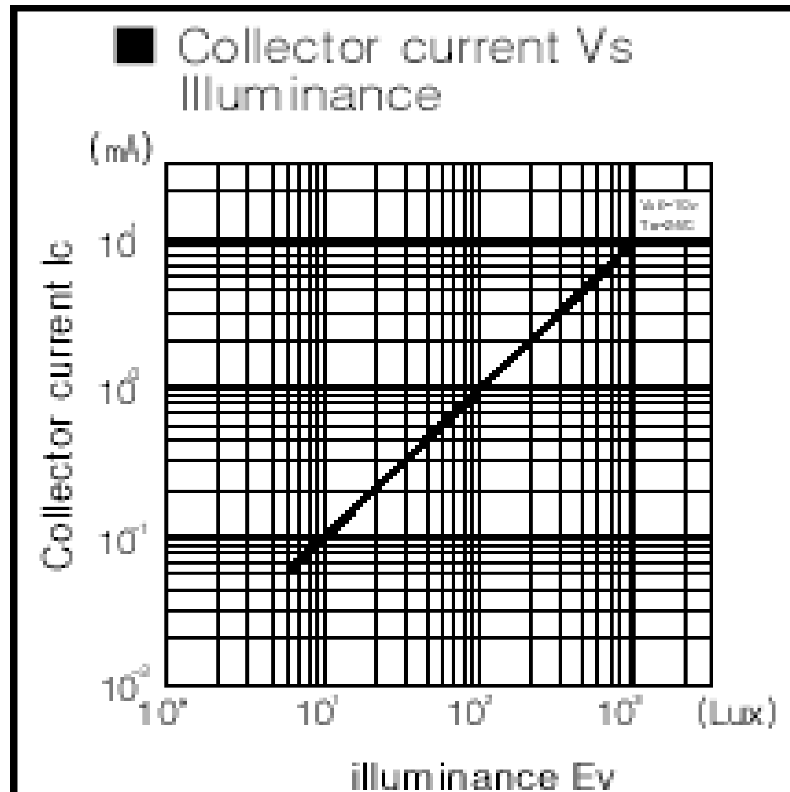




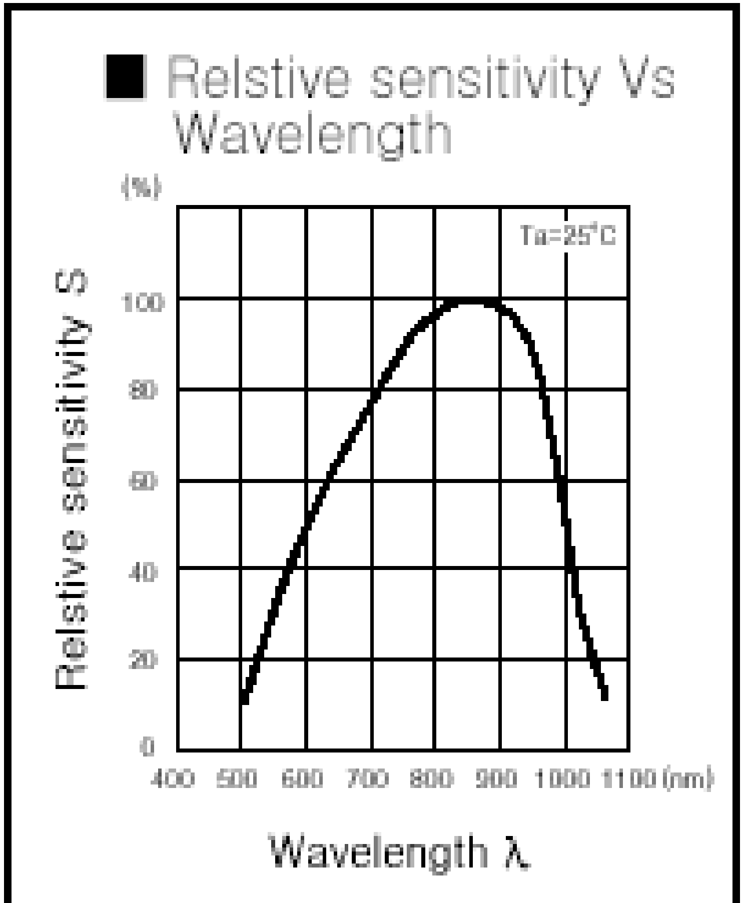


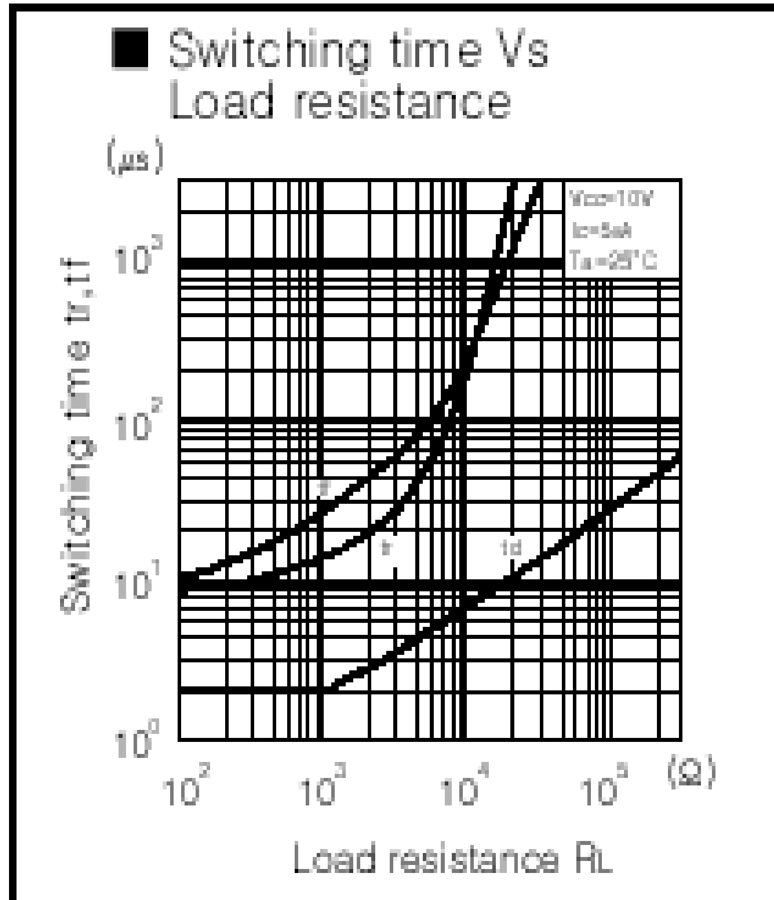
CARACTERISTICAS

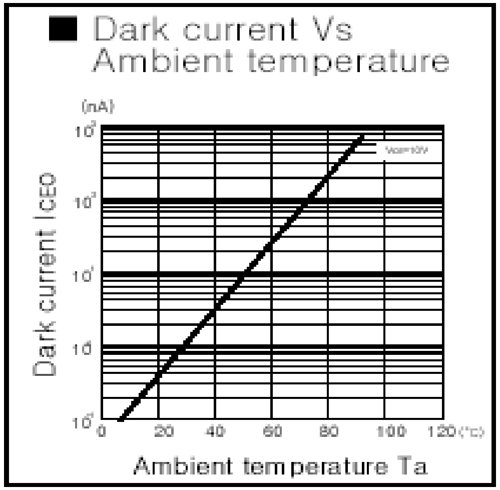


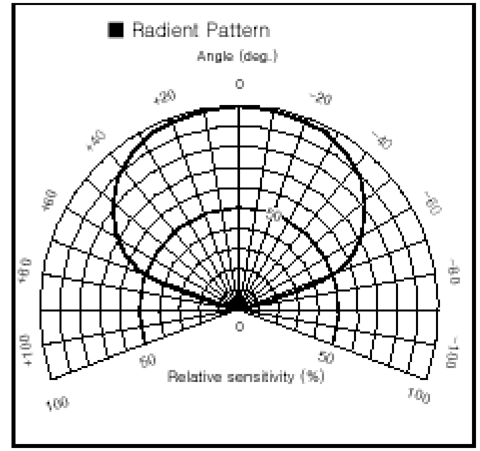


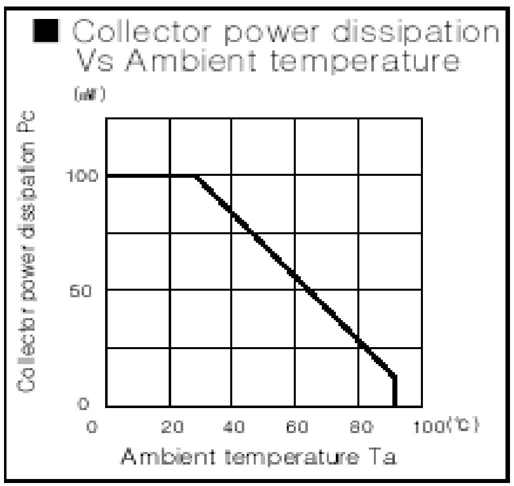
CARACTERISTICAS

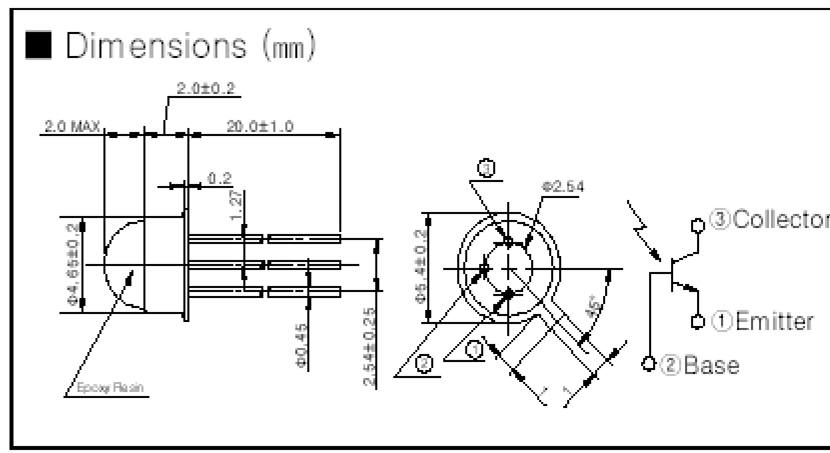




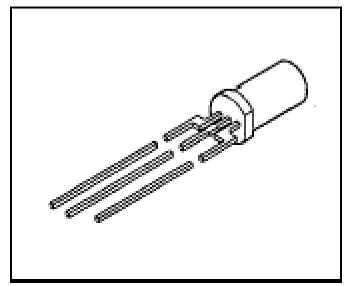

Dark current Vs Ambient temperature
(nA)
Dark current ICEO
0
20
40
60
80
100
120 (°C)
Ambient temperature Ta

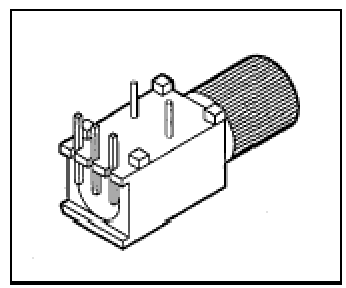

Radient Pattern
Angle (deg.)
0
+20
-20
+40
-40
+60
-60
+80
-80
+100
-100
Relative sensitivity (%)
50
100


Collector power dissipation Vs Ambient temperature
Collector power dissipation Pc
100
50
0
20
40
60
80
100(°C)
Ambient temperature Ta


Dimensions (mm)
2.0±0.2
2.0 MAX
20.0±1.0
0.2
1.27
Φ4.65±0.2
Φ0.45
2.54±0.25
Epoxy Resin
Φ2.54
Φ5.4±0.2
45°
③Collector
①Emitter
②Base

Plastic Fiber Optic Phototransistor Detector	**SFH350**
Plastic Connector Housing	**SFH350V**





Features

- 2.2 mm Aperture holds Standard 1000 Micron Plastic Fiber
- No Fiber Stripping Required
- Good Linearity
- Sensitive in visible and near IR Range
- Molded Microlens for Efficient Coupling

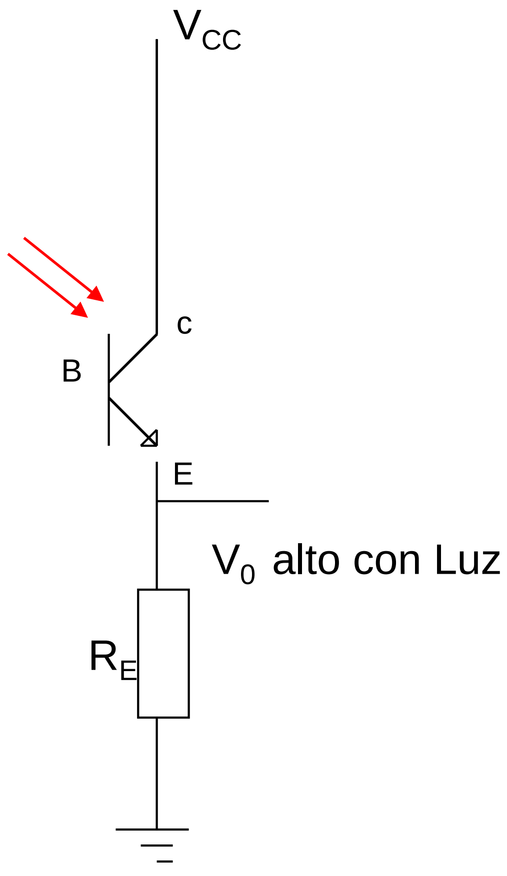
Plastic Connector Housing

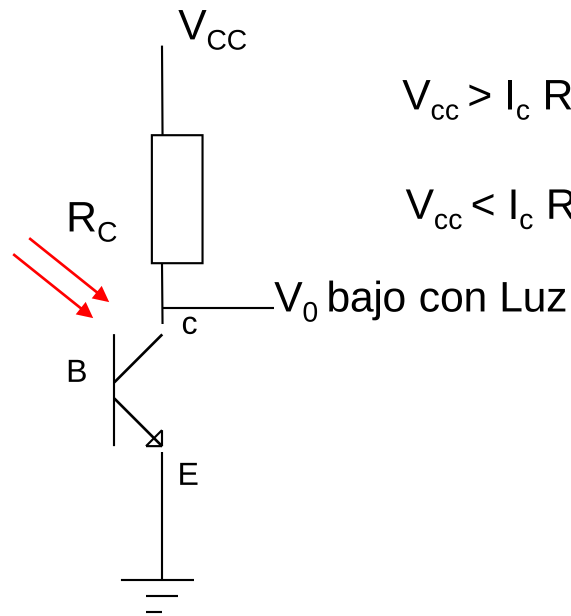
- Mounting Screw Attached to the Connector
- Interference Free Transmission from light-Tight Housing
- Transmitter and Receiver can be flexibly positioned
- No Cross Talk
- Auto insertable and Wave solderable
- Supplied in Tubes

Applications

- Household Electronics
- Power Electronics
- Optical Networks
- Light Barriers

CIRCUITOS TIPICOS

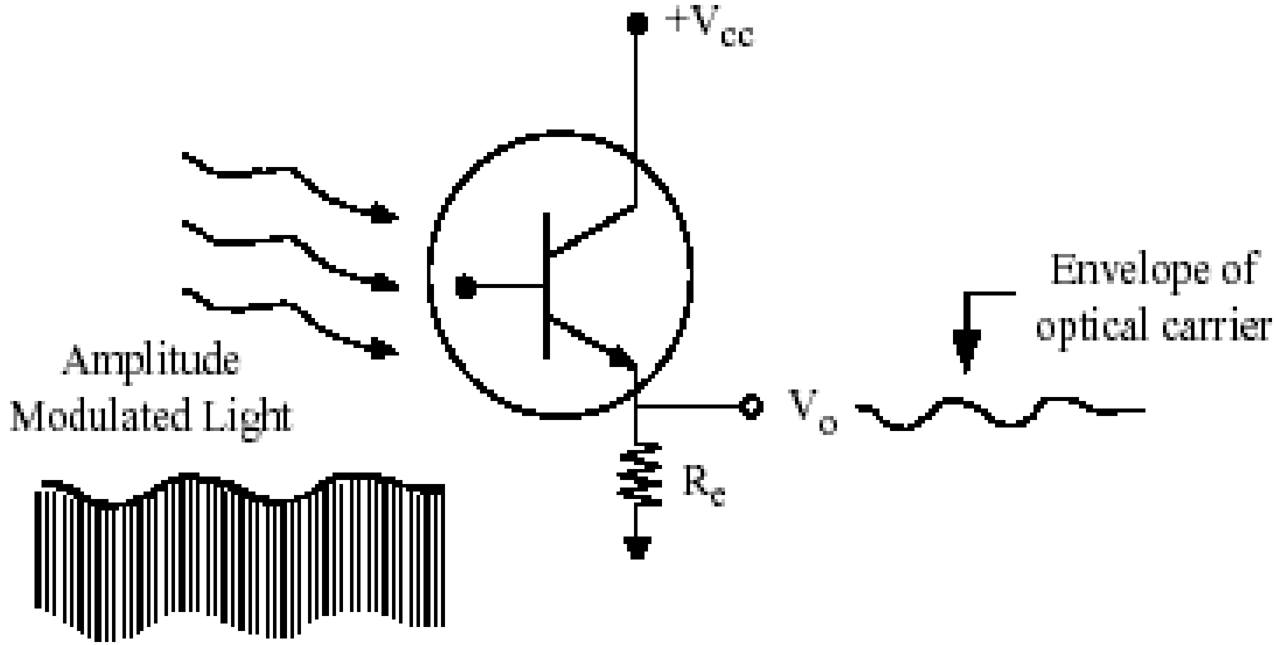




$V_{cc} > I_c R_c$ Modo activo

$V_{cc} < I_c R_c$ Modo llave

DEMODULADOR



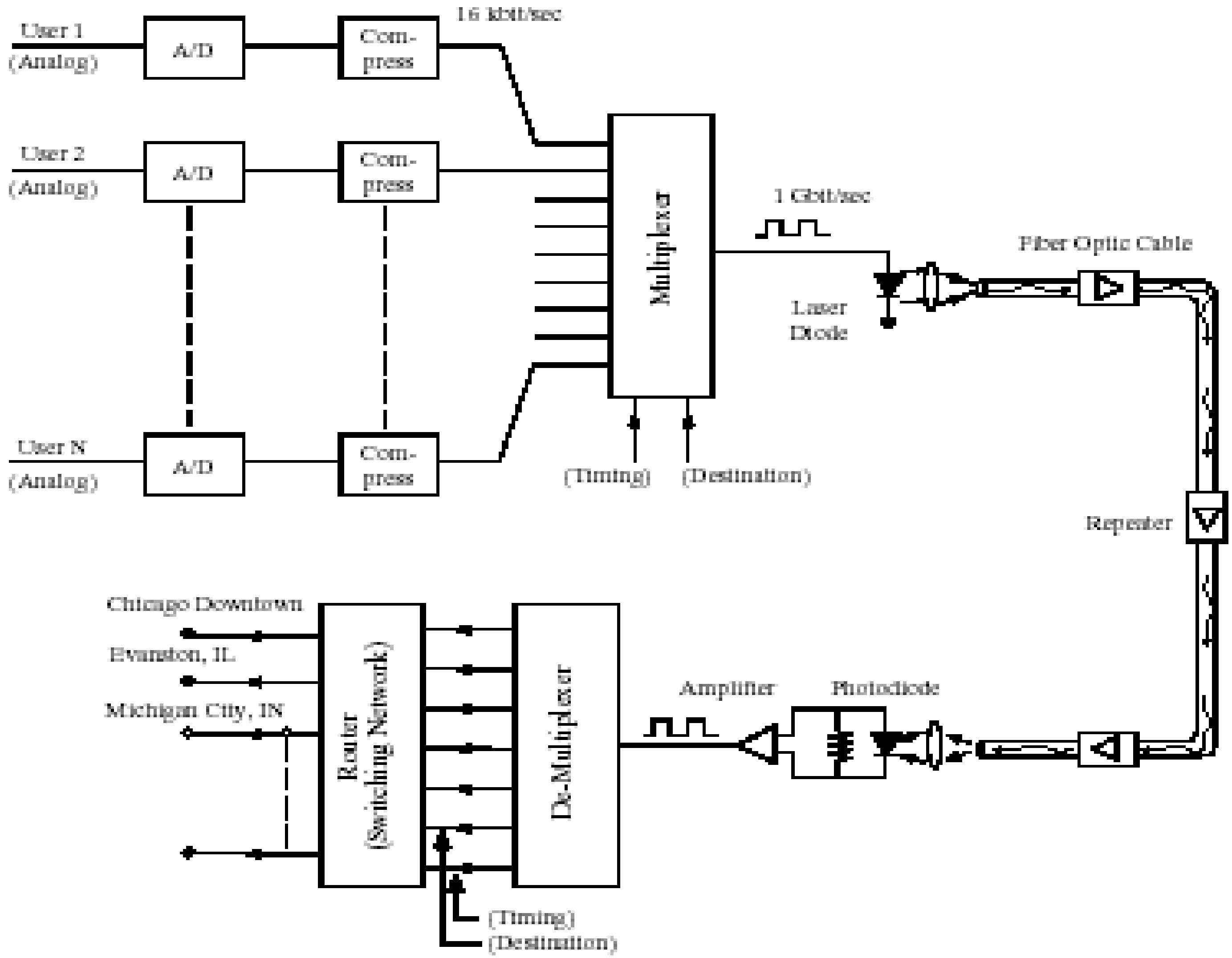
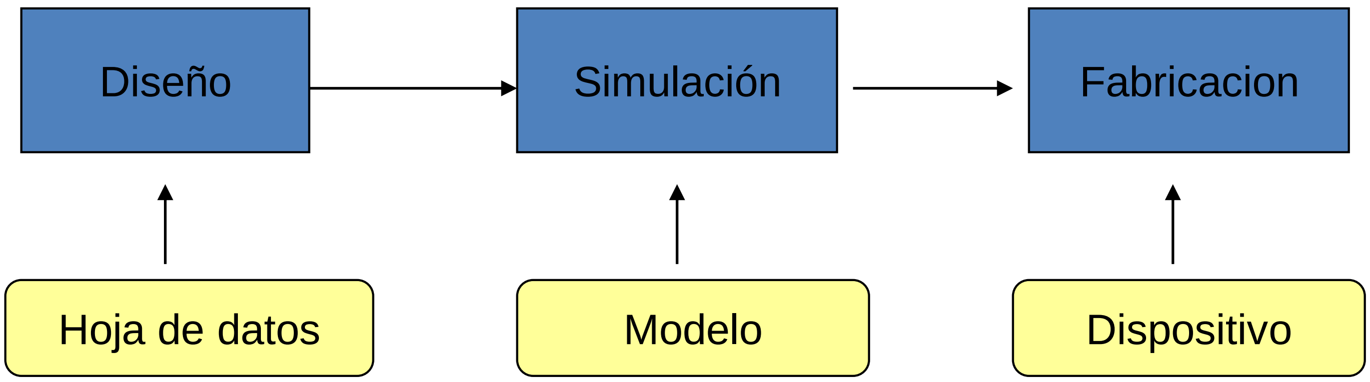


Figure 6: The optical digital telephone system.

Esquema del Proceso de Diseño de Circuitos



Niveles de Datos para el Diseño

- ***Manual con las hojas de datos (Máximos Absolutos y Características Eléctricas)***
- ***Modelo matemático y parámetros del modelo para simulación***
- ***Datos físicos del dispositivo (Tamaño, Montaje)***

Evolución del Modelo Matemático del TBJ

- **Eber & Moll Clasico (1954): Primer modelo. Funcionamiento ideal del TBJ. Solo efectos DC. Relación exponencial V - I.**
- **Eber & Moll 1: Modelo modificado para simulación en computadoras**
- **Eber & Moll 2: Efectos Capacitivos y Resistencia Parásitas**
- **Eber & Moll 3: Modulación de ancho de base y Recombinación en Base**
- **Gummel Poon (1970): Modificación del E&M 3 para facilitar la simulación en computadoras**

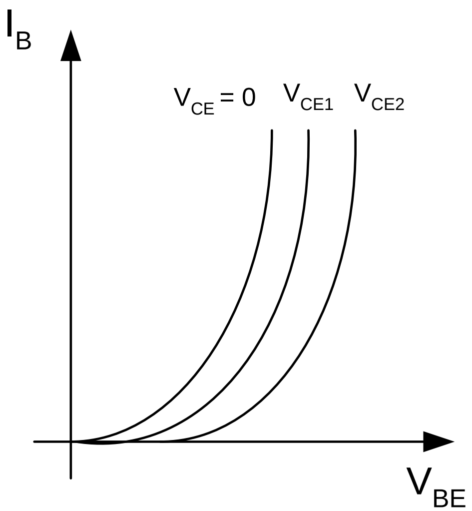
Conclusiones

- **Los tres niveles de datos necesarios para el diseño requiere el conocimiento de los modelos matemáticos de dispositivos.**
- **Los fabricantes de dispositivos están publicando como datos de sus dispositivos los parámetros del modelo matemático.**
- **El conocimiento de un dispositivo hoy, además de su funcionamiento visto desde sus terminales y la física del mismo, debe incluir el manejo de modelos.**
- **Debemos capacitar al estudiante en un solido manejo de modelos y técnicas de simulación eléctrica como herramienta de diseño.**

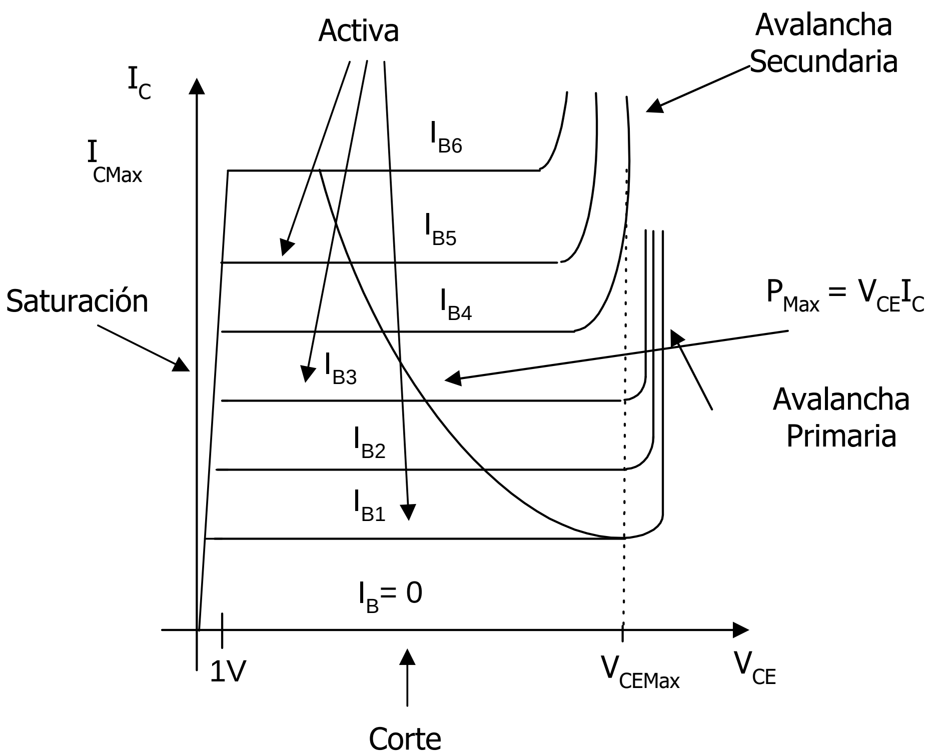
Utilice el modelo mas simple que cumpla la tarea de diseño

Características Eléctricas del Transistor Bipolar

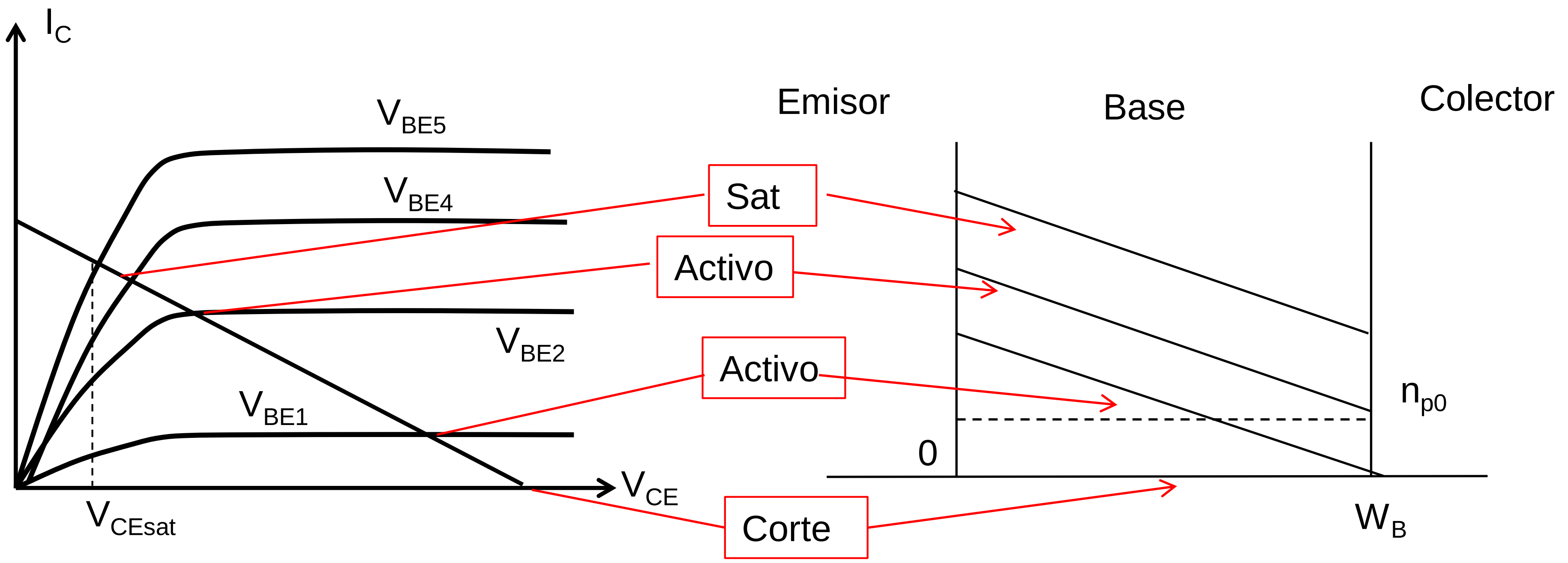
Características reales (NPN)



Característica de Entrada



Característica de Salida



I_C
V_{BE5}
V_{BE4}
V_{BE2}
V_{BE1}
V_{CE}
V_{CEsat}
Sat
Activo
Activo
Corte
Emisor
Base
Colector
n_{p0}
0
W_B