
Etapas de Salida y Amplificadores de Potencia (3a. parte)

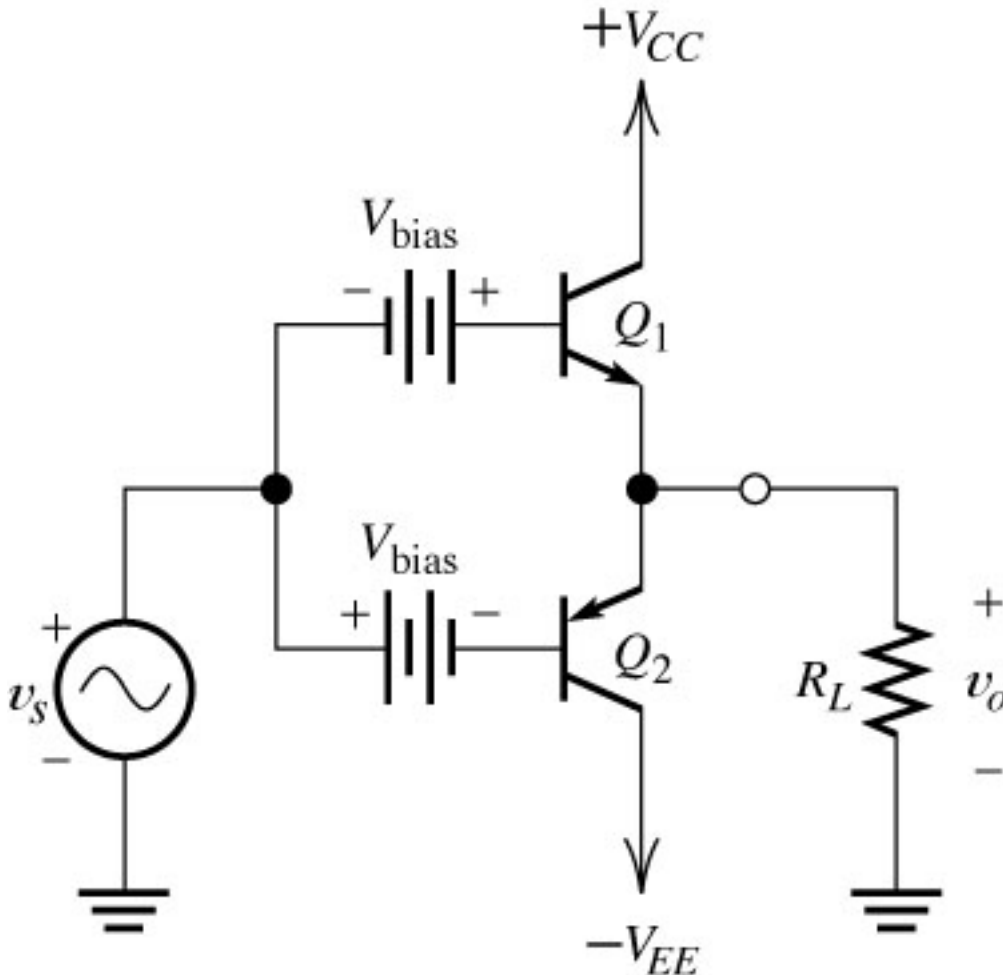
Algunas de las figuras de esta presentación fueron tomadas de las páginas de internet de los autores de los textos:

A.S. Sedra and K.C. Smith, *Microelectronic Circuits*. New York, NY: Oxford University Press, 1998.

A.R. Hambley, *Electronics: A Top-Down Approach to Computer-Aided Circuit Design*. Englewood Cliffs, NJ: Prentice Hall, 2000.

D. Neamen, *Electronic Circuit Analysis and Design with CD-ROM*. New York, NY: McGraw Hill, 2000.

Etapas de Salida Clase AB



Si $v_S = 0$ V, $v_O = 0$ V

$V_{bias} = V_{BE1}$, y $V_{bias} = V_{EB2}$

$$i_N = i_P = I_S e^{\frac{V_{bias}}{V_T}} = I_Q$$

Si $v_S > 0$ V

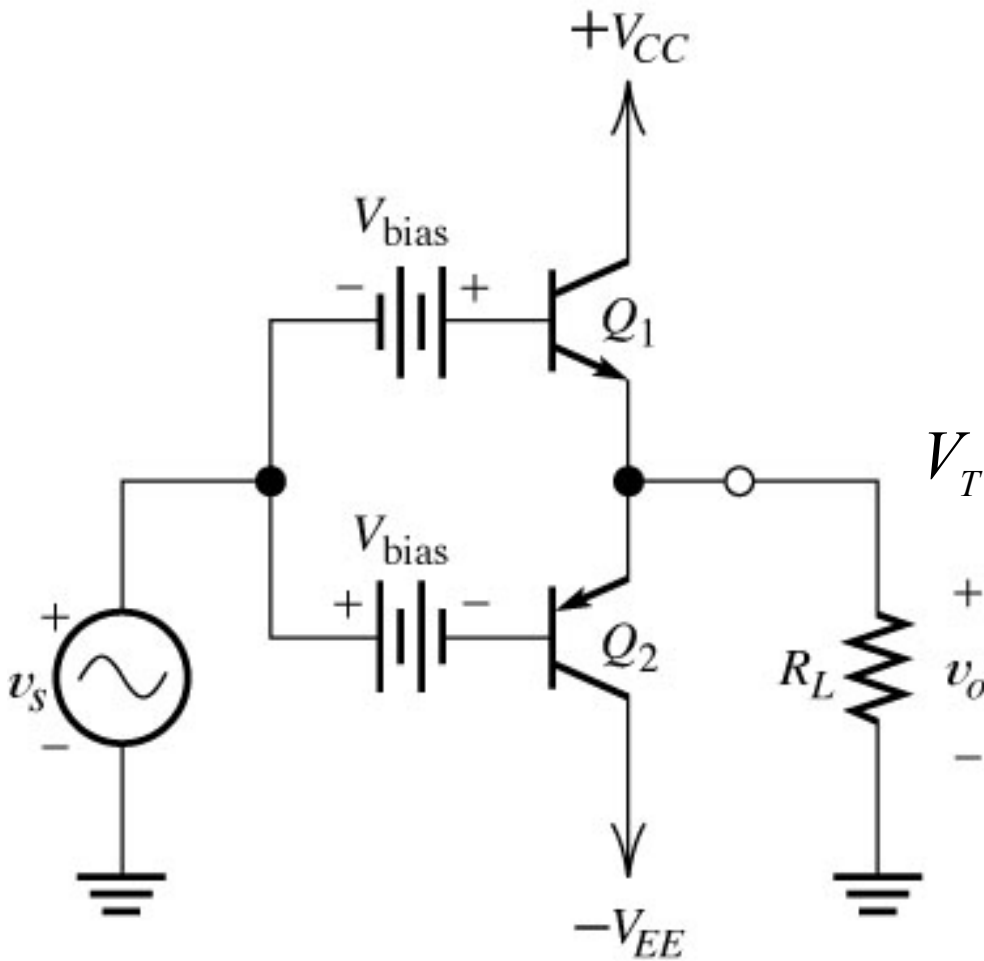
$$v_O = v_S + V_{bias} - v_{BE1}$$

Si $v_S < 0$ V

$$v_O = v_S - V_{bias} - v_{BE2}$$

Como v_{BE1} y v_{EB2} son
aprox. constantes, $v_S \approx v_O$

Etapas de Salida Clase AB (cont.)



$$i_N = i_P = I_S e^{\frac{V_{bias}}{V_T}} = I_Q$$

$$V_{bias} - v_{BE1} - v_{EB2} + V_{bias} = 0$$

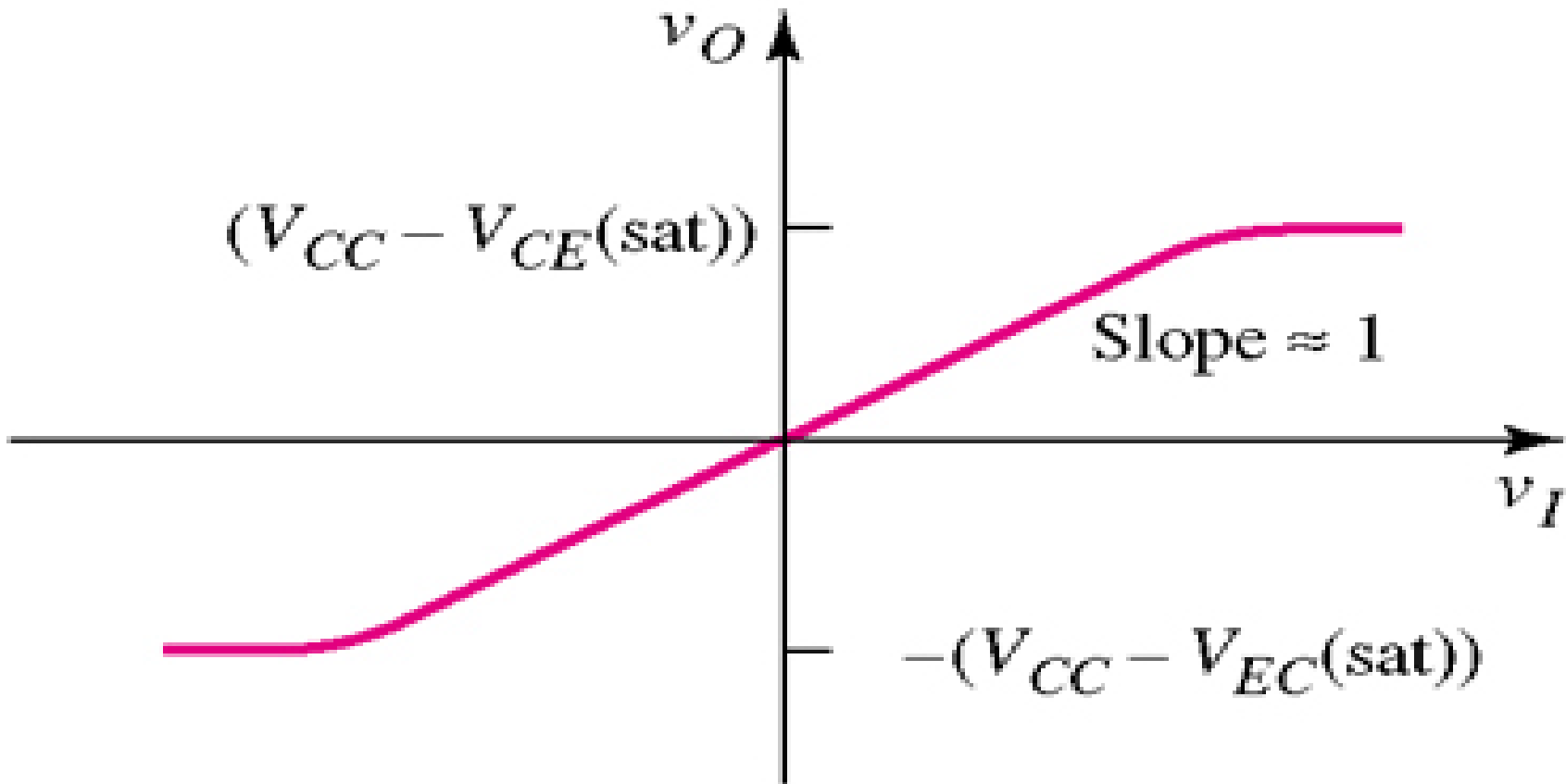
$$v_{BE1} + v_{EB2} = 2V_{bias}$$

$$V_T \ln\left(\frac{i_N}{I_S}\right) + V_T \ln\left(\frac{i_P}{I_S}\right) = 2V_T \ln\left(\frac{I_Q}{I_S}\right)$$

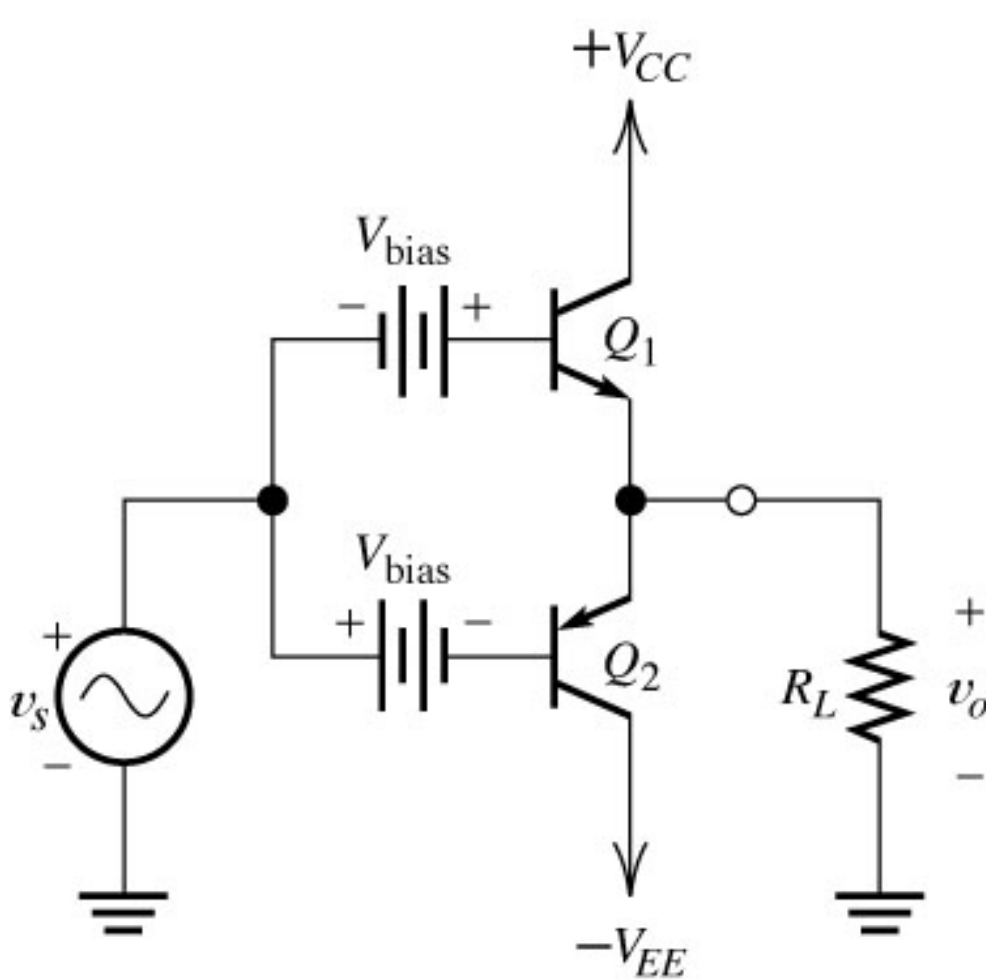
$$i_N i_P = I_Q^2$$

$$i_N - i_P = i_L$$

Curva de Transferencia del Amp. Clase AB



Desbordamiento Térmico del Clase AB

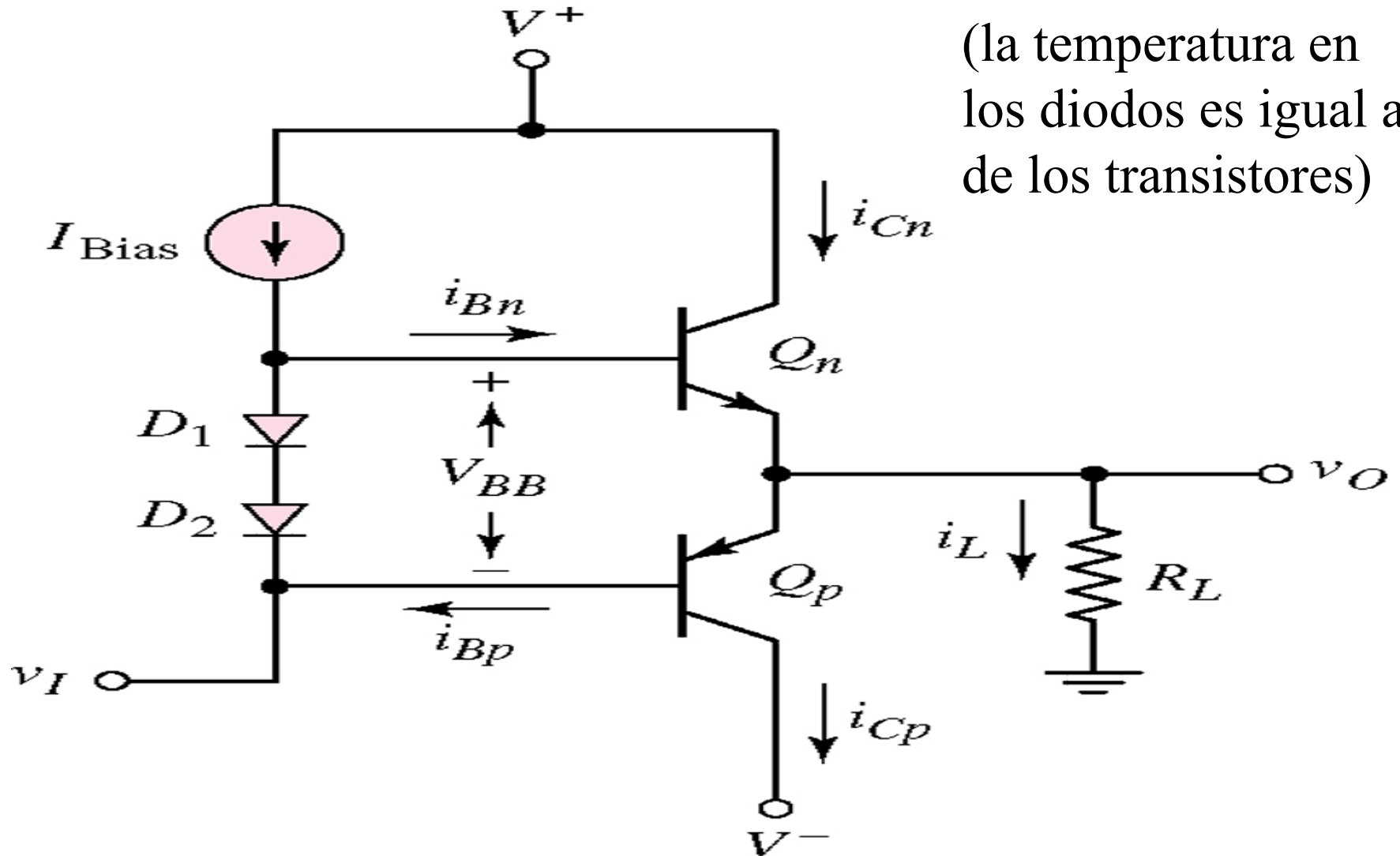


$$i_N = i_P = I_S e^{\frac{V_{bias}}{V_T}} = I_Q$$

Si la temperatura de los transistores (T_Q) aumenta, I_Q aumenta, lo que hace que T_Q aumente, por lo que I_Q aumenta aún más, ...

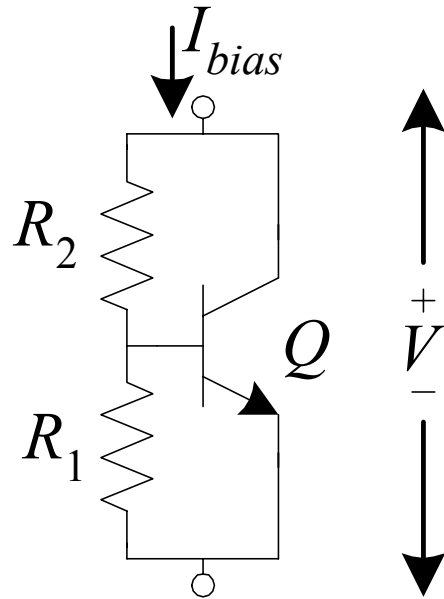
Q_1 y Q_2 pueden quemarse si se elige un V_{bias} demasiado alto ($V_{bias} = V_{BEon}$)

Clase AB Polarizado con Diodos



(la temperatura en los diodos es igual a de los transistores)

Multiplicador de Diodos



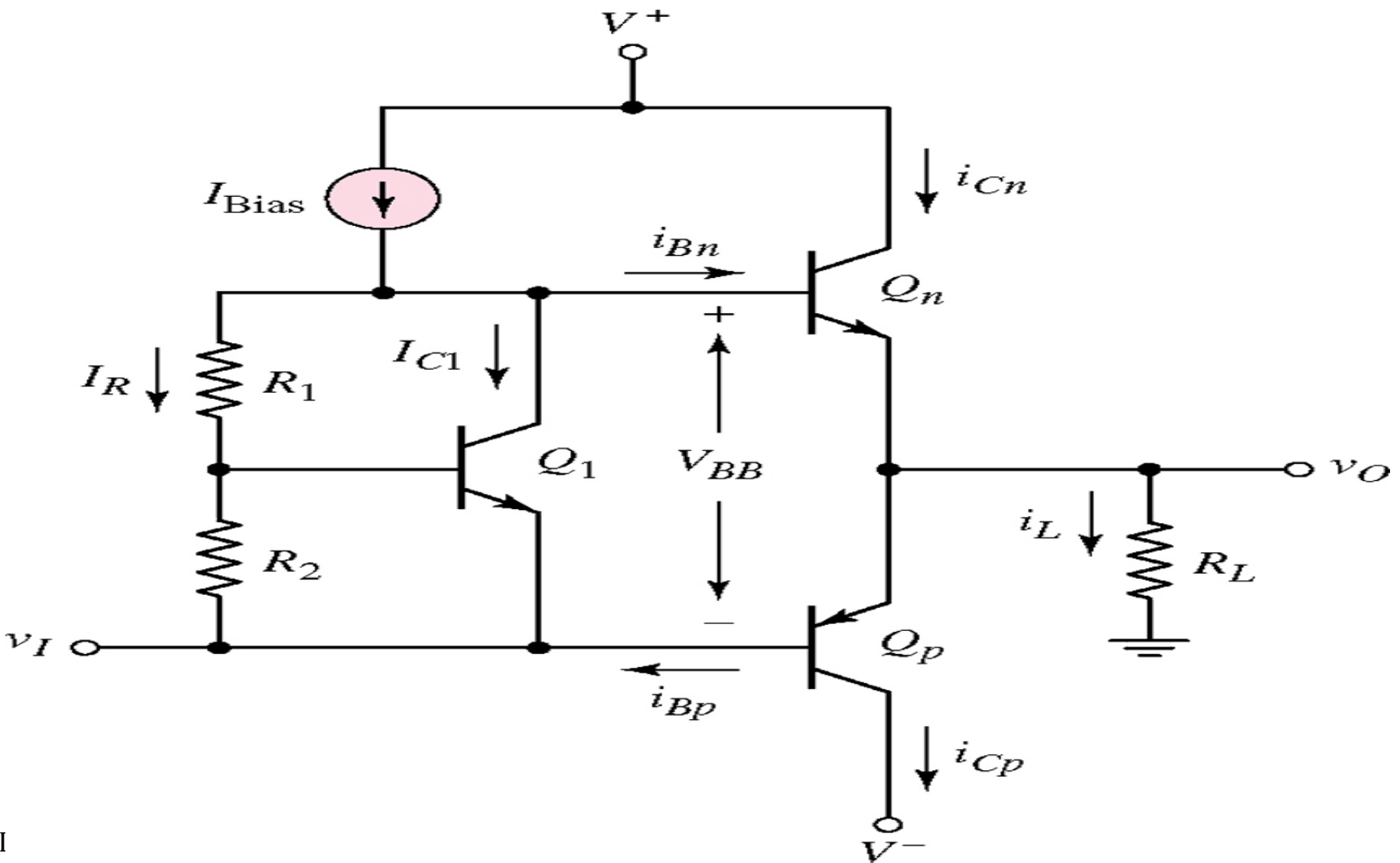
$$I_{R_1} = \frac{V_{BE}}{R_1}$$

$$V \approx \frac{V_{BE}}{R_1} (R_1 + R_2) = V_{BE} \left(1 + \frac{R_2}{R_1}\right)$$

$$V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right)$$

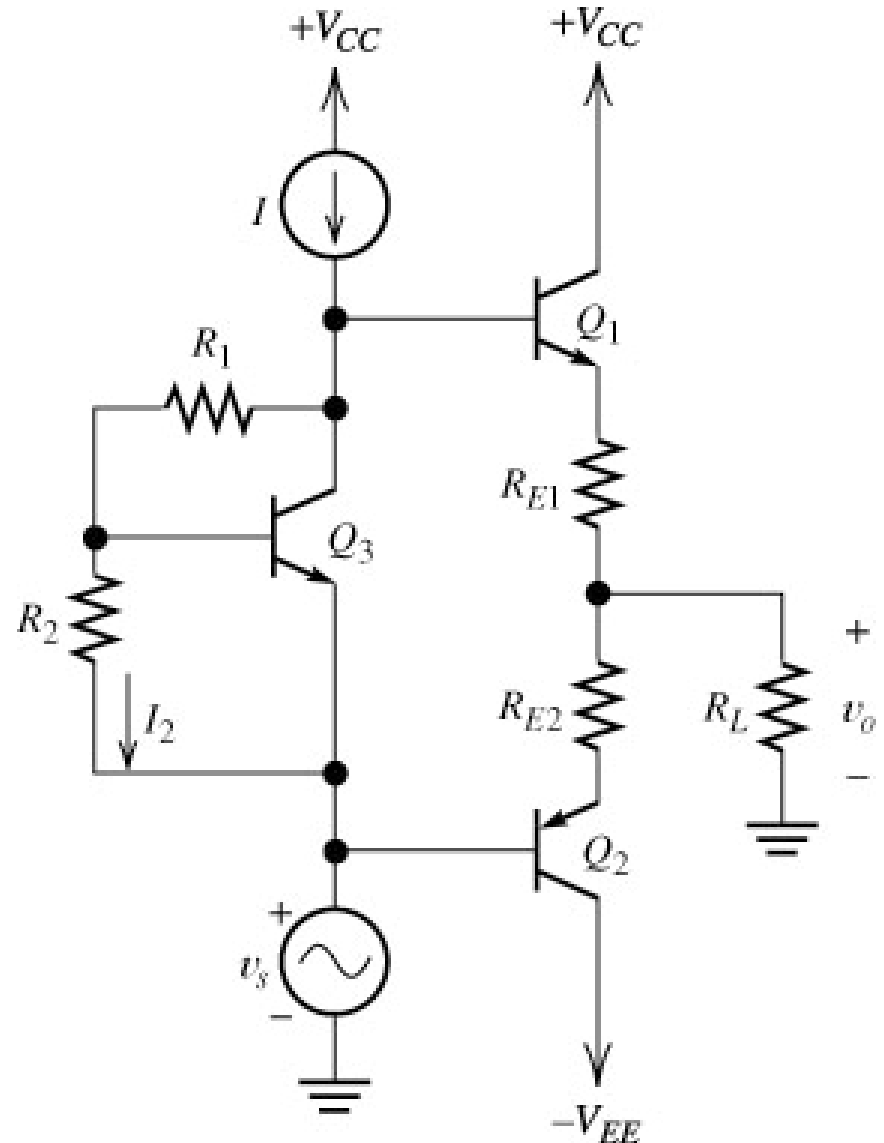
$$I_C = I_{bias} - \frac{V_{BE}}{R_1}$$

Clase AB con Multiplicador de Diodos

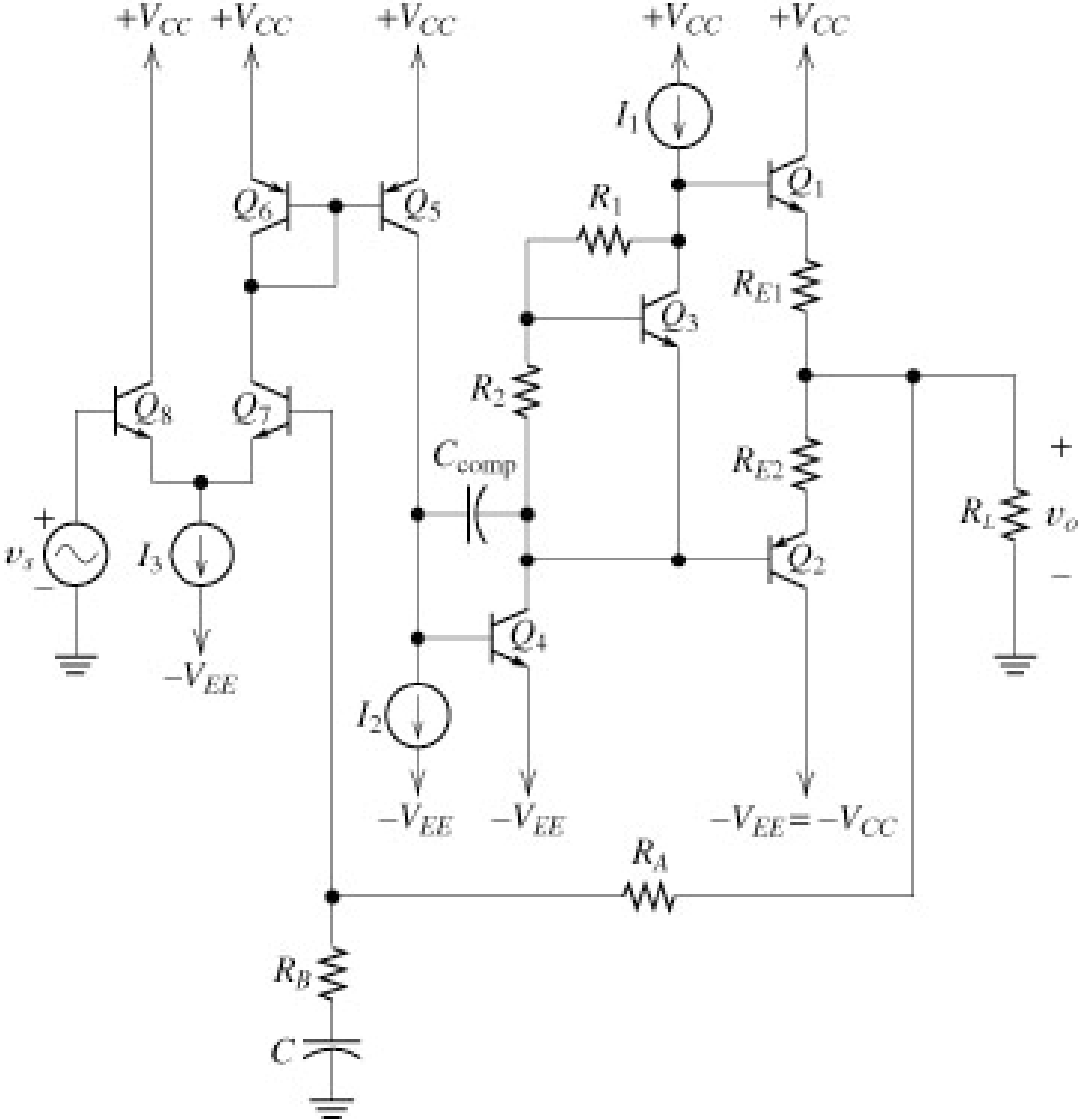


Clase AB con Resistencias de Comp. y M. de D.

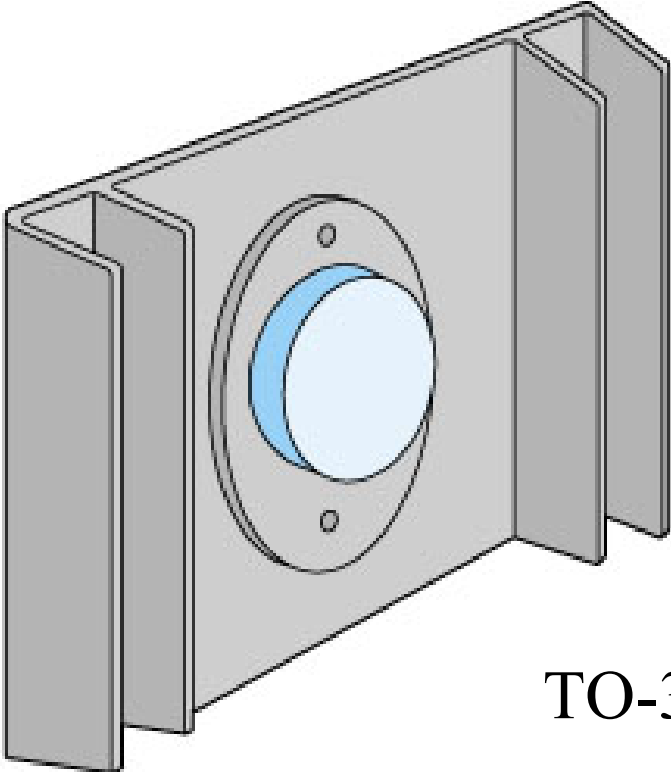
R_{E1} y R_{E2} son pequeñas, y ayudan a compensar el efecto de desbordamiento térmico (y a proteger contra cortos circuitos)



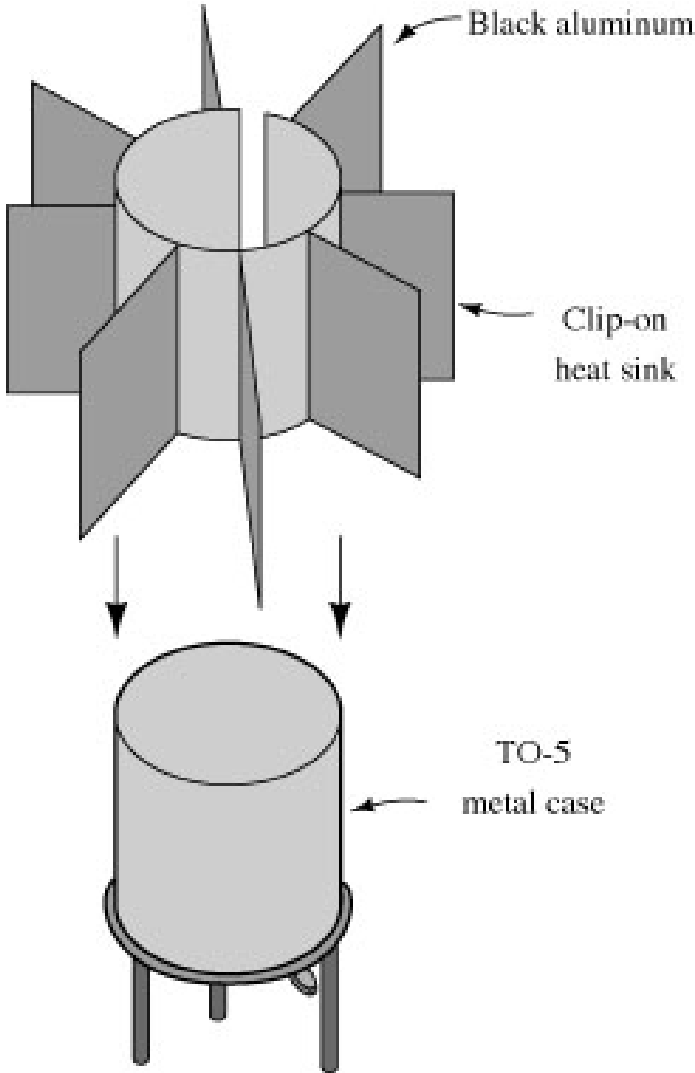
Amplificador de Potencia Clase AB



Transistores de Potencia - Encapsulados -

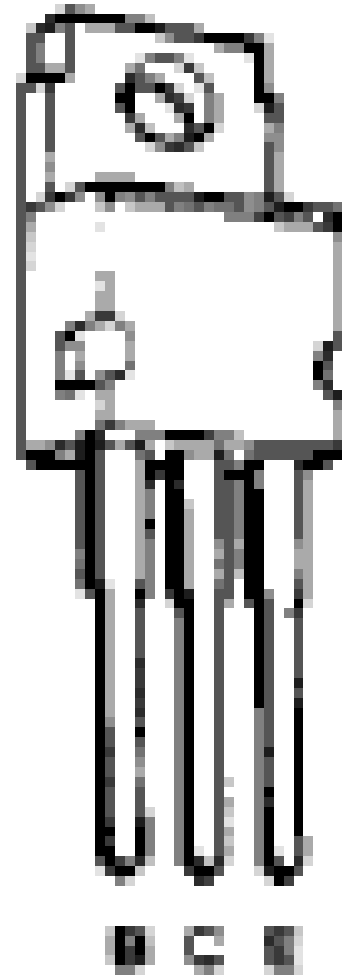


TO-3

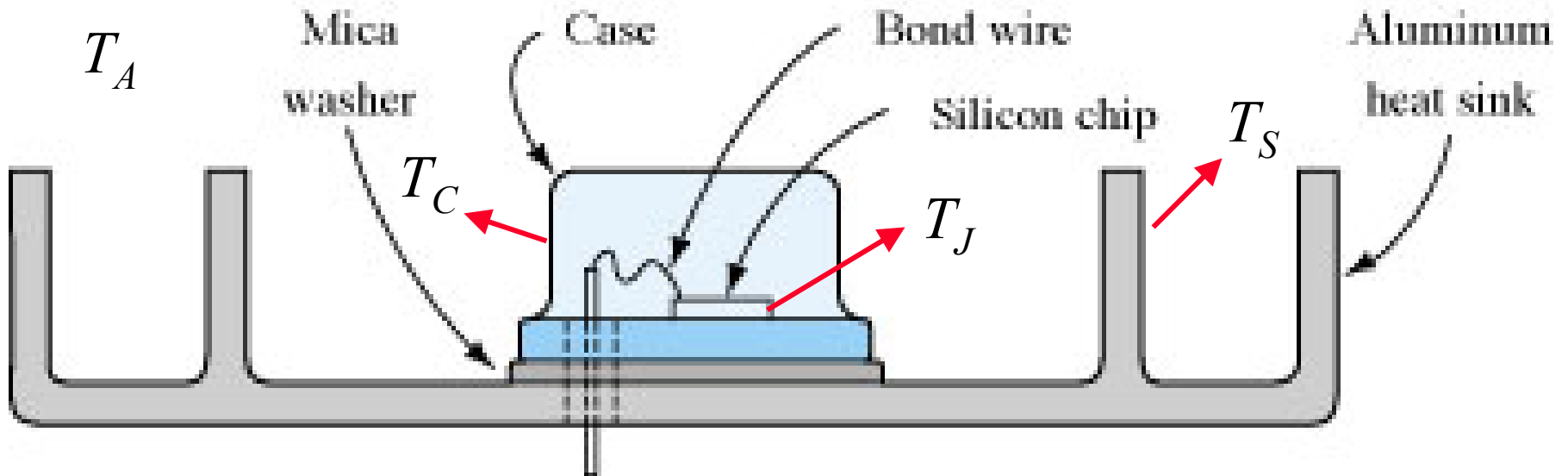


Transistores de Potencia - Encapsulados -

TO-220



Transistores de Potencia - Disipador -



T_A temperatura del medio ambiente

T_S temperatura del disipador

T_C temperatura del encapsulado

T_J temperatura de la unión C-B

Circuitos Térmicos

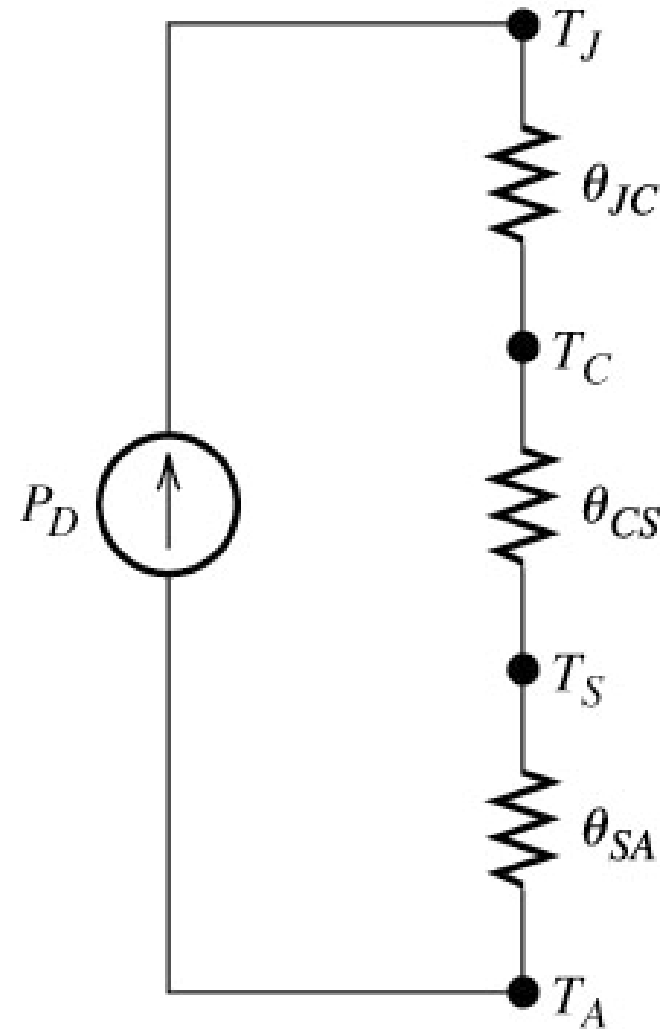
θ_{JA} resistencia térmica de la unión al medio ambiente

θ_{JC} resistencia térmica de la unión al encapsulado

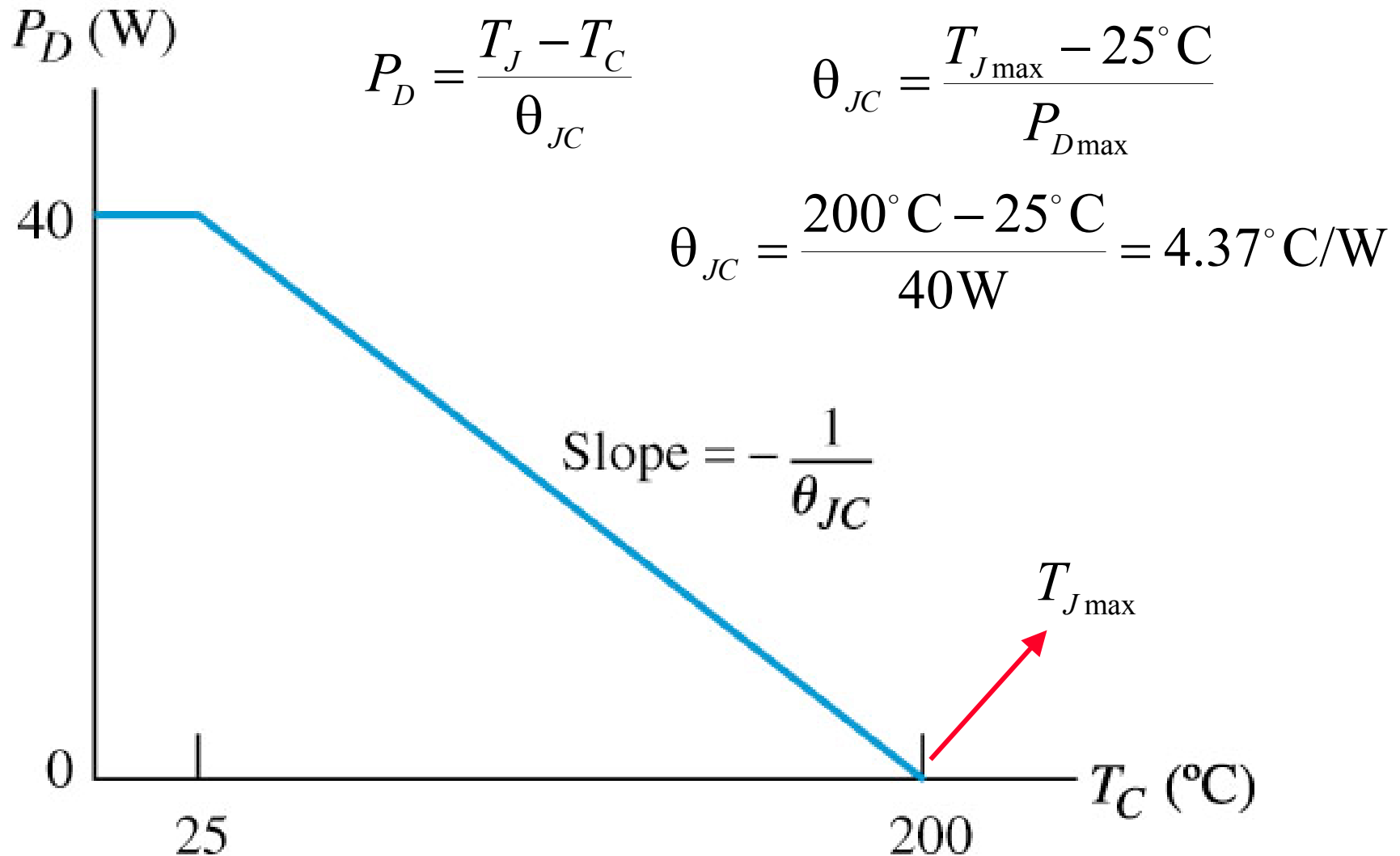
θ_{CS} resistencia térmica del encapsulado al disipador

θ_{SA} resistencia térmica del disipador al medio ambiente

$$P_D = \frac{T_J - T_A}{\theta_{JA}} = \frac{T_J - T_A}{\theta_{JC} + \theta_{CS} + \theta_{SA}}$$



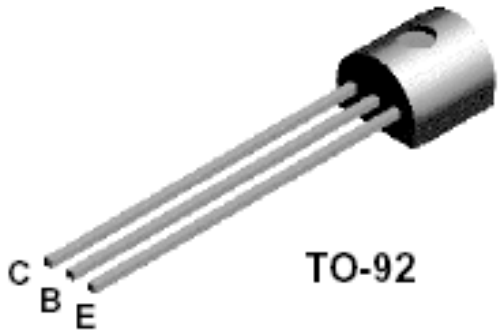
Capacidad de Disipación de Potencia



Ejemplos

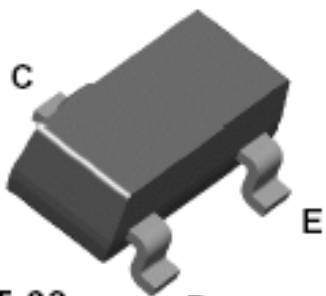


2N3904



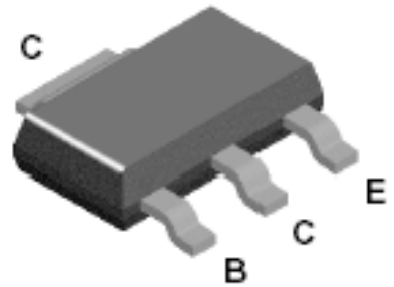
TO-92

MMBT3904



SOT-23
Mark: 1A

PZT3904

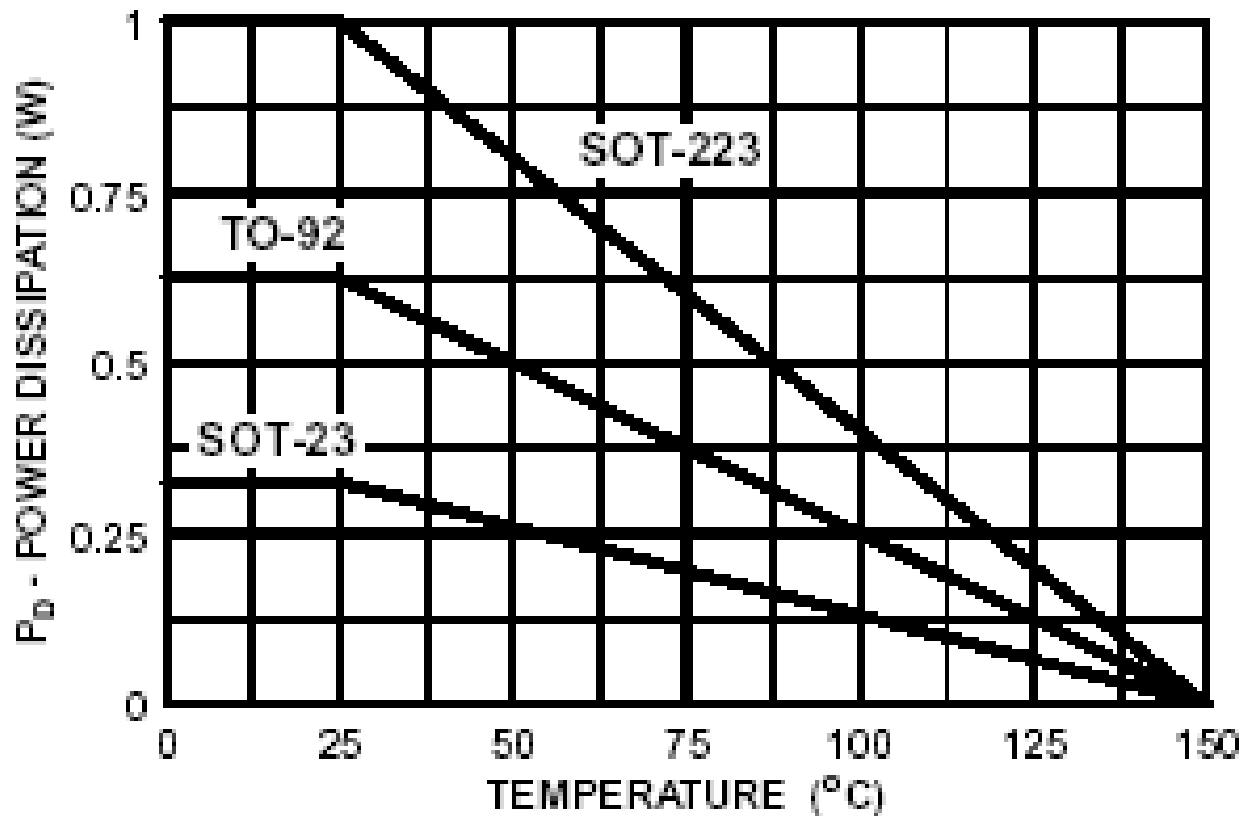


SOT-223

Ejemplos (cont.)

BJT 3904

Power Dissipation vs Ambient Temperature



Valores Típicos de Resistencias Térmicas

$$\theta_{CS} \quad (^\circ\text{C}/\text{W})$$

Encapsulado	Contacto directo	Con DC4	Con DC4 y mica aislante
TO-3	0.5 – 0.7	0.3 – 0.5	0.4 – 0.6
TO-220	1 – 1.3	0.6 – 0.8	0.8 – 1.1
TO-202	1.5 – 2	0.9 – 1.2	1.2 – 1.7

DC4: Dow Corning 4 (grasa térmica de silicio)

$$\theta_{CA\acute{t}ipica} = 40 \text{ }^\circ\text{C}/\text{W} \text{ (sin disipador)}$$

Calculando la Temperatura de la Unión T_J

$$P_D = \frac{T_J - T_A}{\theta_{JA}} = \frac{T_J - T_A}{\theta_{JC} + \theta_{CS} + \theta_{SA}}$$

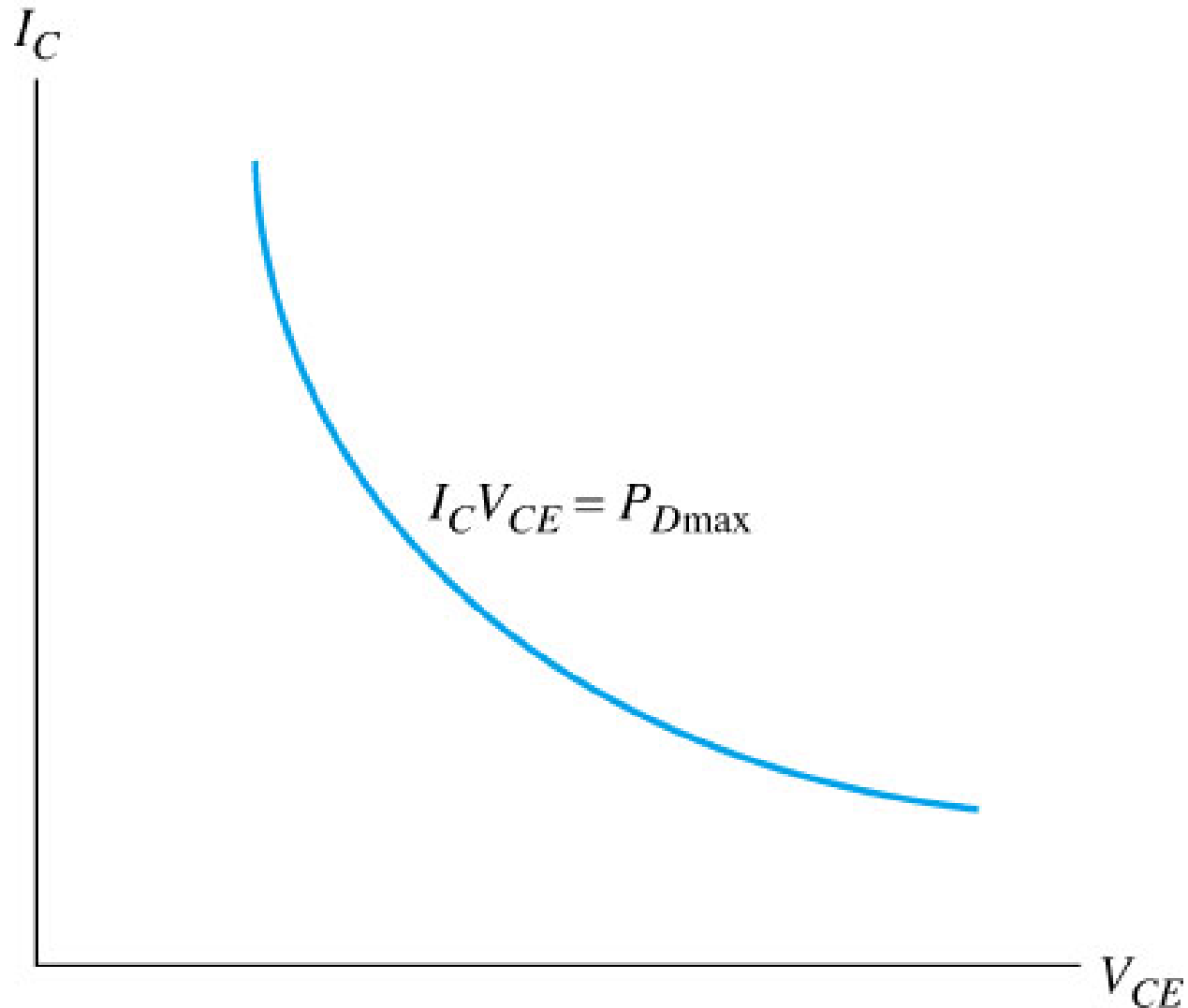
$$\theta_{JC} = \frac{T_{J\max} - 25^\circ \text{C}}{P_{D\max}}$$

θ_{CS} depende del tipo de encapsulado y condiciones mecánicas (mica, grasa térmica, tornillos, etc.)

θ_{SA} depende de las características del disipador

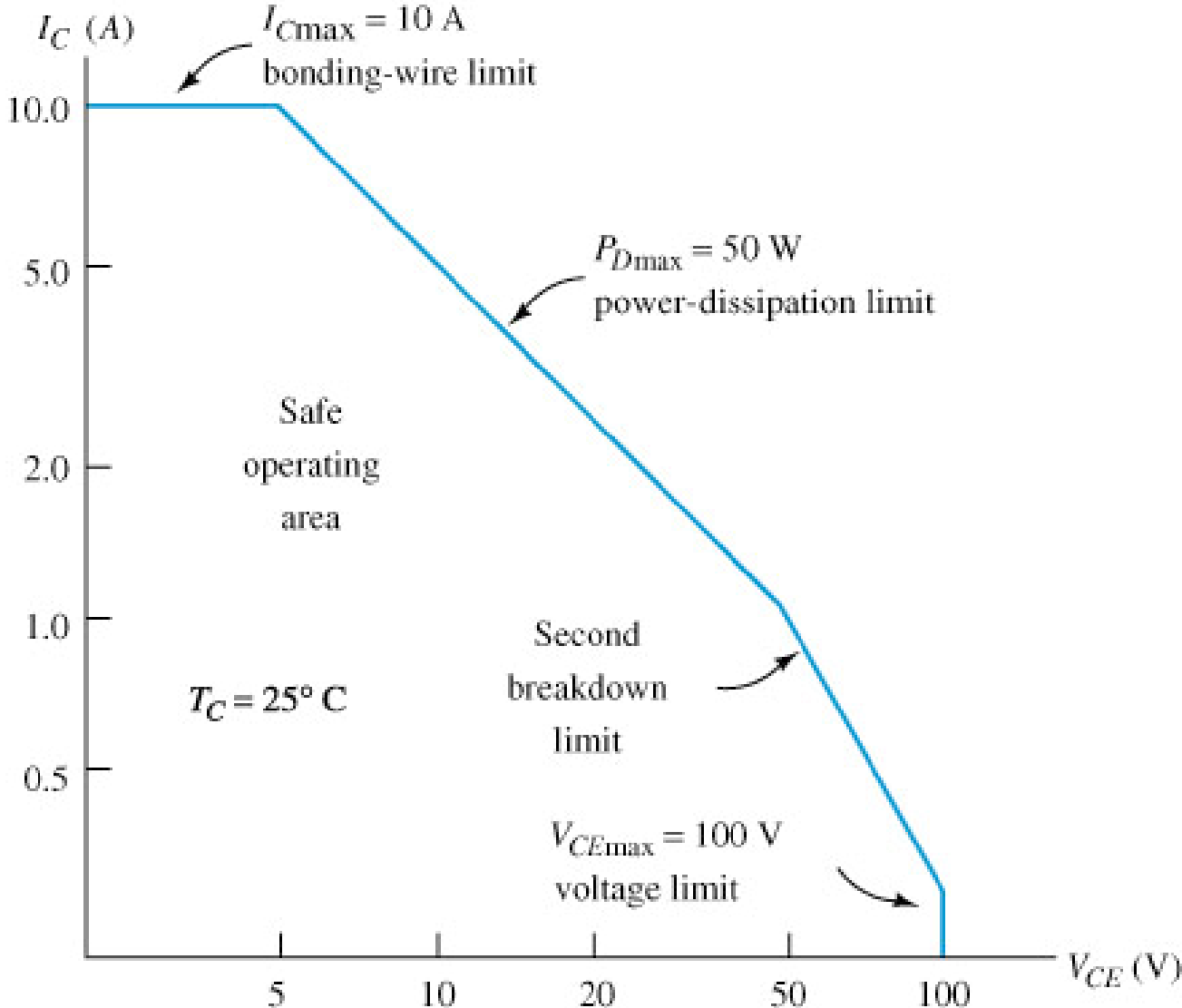
$$T_J = \theta_{JA} P_D + T_A$$

Máxima Potencia de Disipación a 25° C



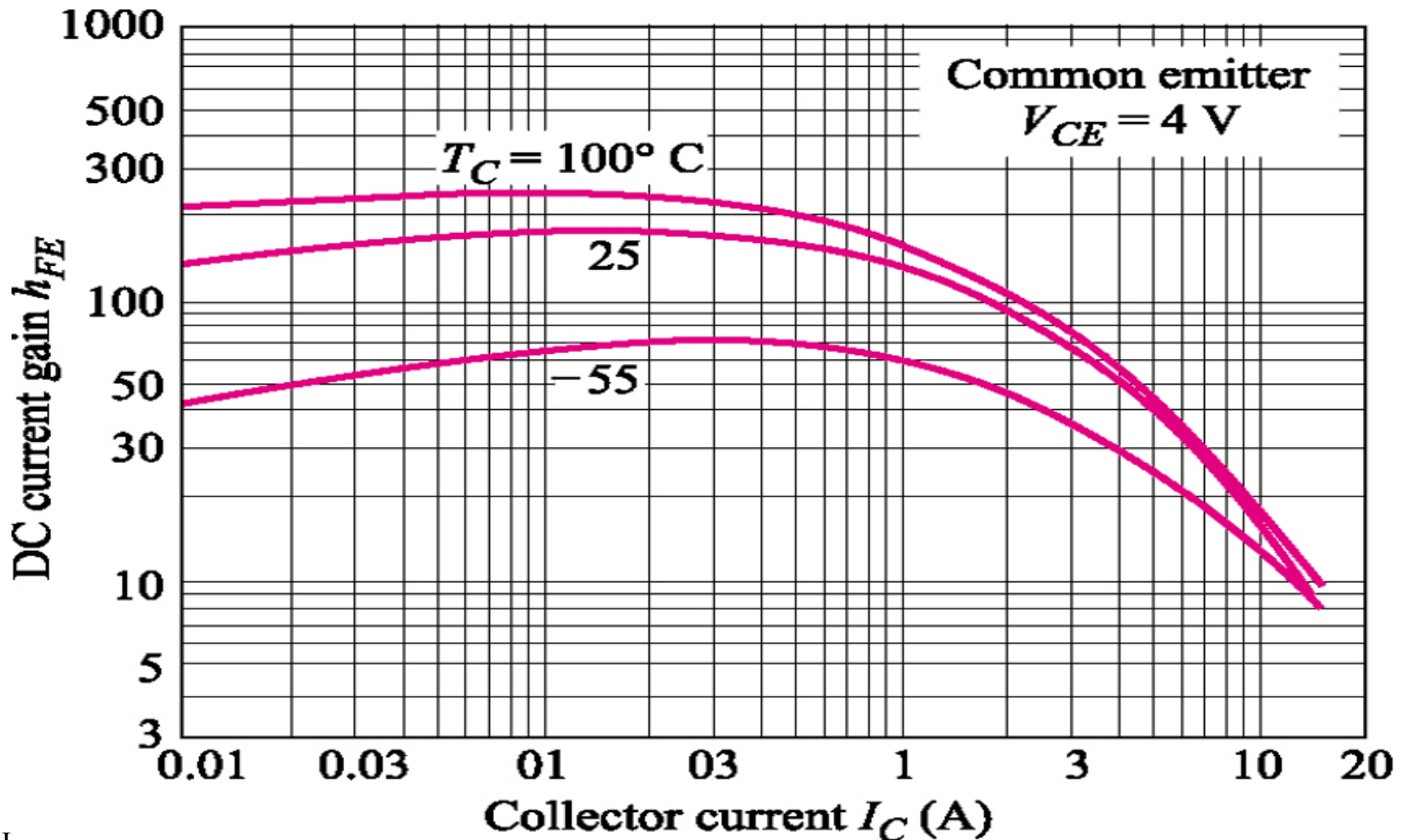
Región de Operación Segura del Transistor

BJT de 50W,
10A, 100V



Especificaciones en los Transistores de Potencia

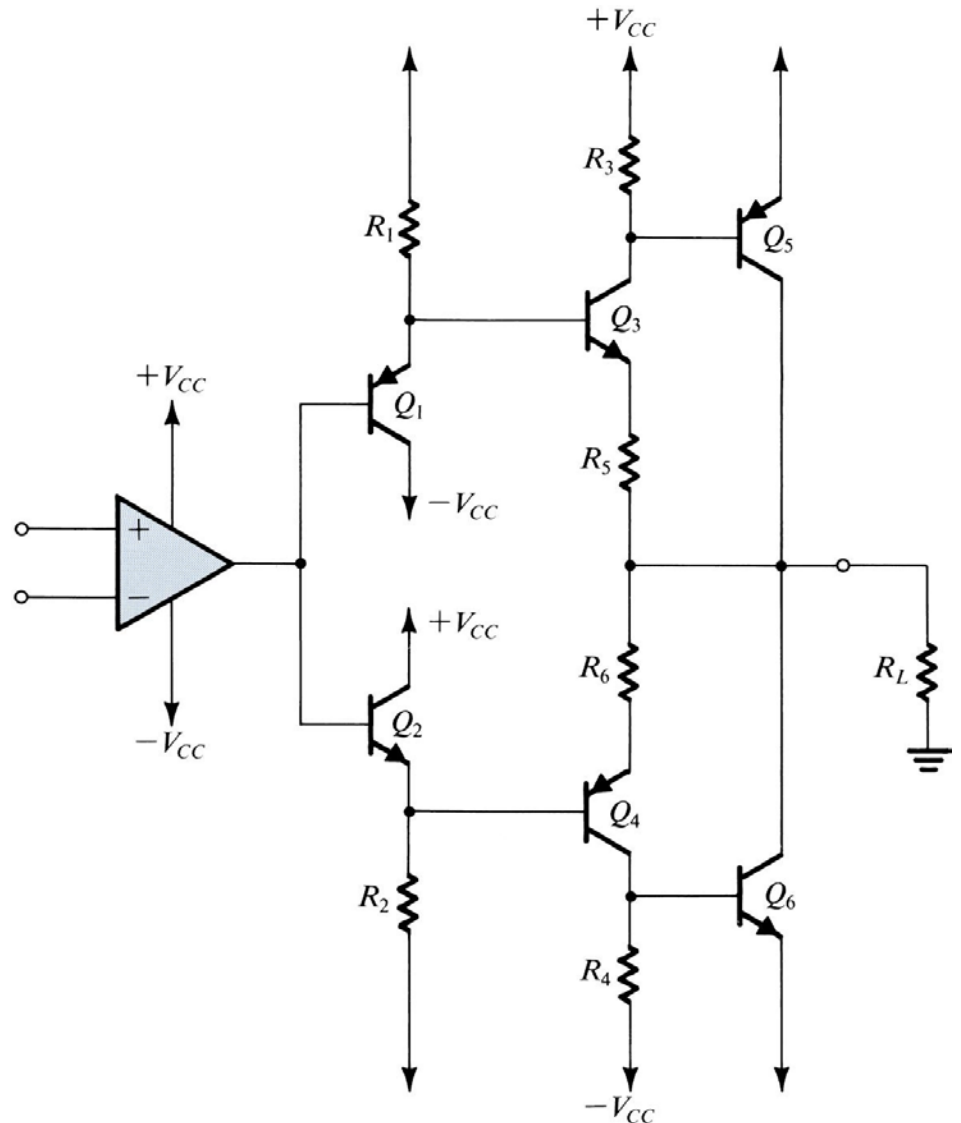
(2N3055)



Op-Amps de Potencia

Por ejemplo,

LH0101 (National Semiconductors), 2A, 40W



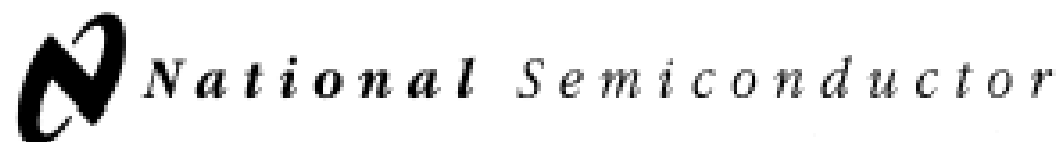
LH0101 - National Semiconductors (cont.)

TABLE I. LH0101 Typical Performance
Characteristics at 25°C Ambient, ± 15V Supply

Parameter	Conditions	Value
Output Current		2A
Input Offset Voltage		5 mV
Input Bias Current		50 pA
Input Offset Current		25 pA
Input Resistance		$10^{12}\Omega$
Large Signal Voltage Gain		200V/mV
Output Voltage Swing	$R_L = 100\Omega$	$\pm 12.5V$
	$R_L = 10\Omega$	$\pm 11.6V$
	$R_L = 5\Omega$	$\pm 11V$
Slew Rate	$A_V = +1$	$10/V\mu s$
Full Power Bandwidth	$A_V = +1, R_L = 10\Omega$	300 kHz
Small Signal Rise Time	$A_V = +1, R_L = 10\Omega$	10 ns
Small Signal Settling		
Time to 0.01%	$V_{IN} = 10V, A_V = +1$	$2\mu s$
Gain Bandwidth		4 MHz
Harmonic Distortion	$f = 1\text{ kHz}, P_O = 1W$	0.005%
	$R_L = 10\Omega, A_V = +1$	
	$f = 20\text{ kHz}, P_O = 1W$	0.05%
	$R_L = 10\Omega, A_V = +1$	

Amplificadores de Potencia de Audio

August 2000



LM380 2.5W Audio Power Amplifier

General Description

The LM380 is a power audio amplifier for consumer applications. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows ground referenced input signals. The output automatically self-centers to one-half the supply voltage.

The output is short circuit proof with internal thermal limiting. The package outline is standard dual-in-line. The LM380N uses a copper lead frame. The center three pins on either side comprise a heat sink. This makes the device easy to use in standard PC layouts.

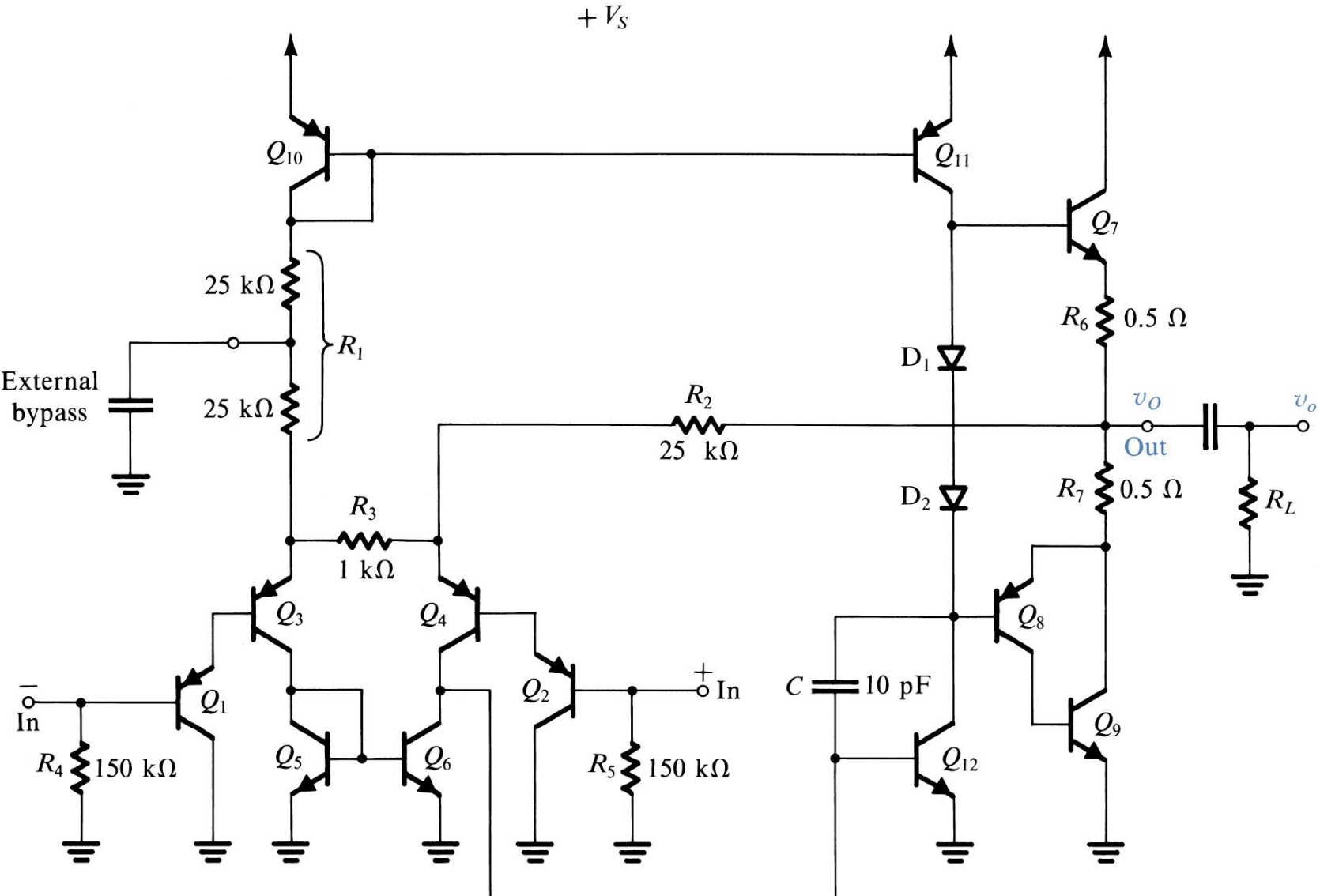
Uses include simple phonograph amplifiers, intercoms, line drivers, teaching machine outputs, alarms, ultrasonic drivers, TV sound systems, AM-FM radio, small servo drivers, power converters, etc.

A selected part for more power on higher supply voltages is available as the LM384. For more information see AN-69.

Features

- Wide supply voltage range: 10V-22V
- Low quiescent power drain: 0.13W ($V_S = 18V$)
- Voltage gain fixed at 50
- High peak current capability: 1.3A
- Input referenced to GND
- High input impedance: 150k Ω
- Low distortion
- Quiescent output voltage is at one-half of the supply voltage
- Standard dual-in-line package

LM380



LM380 – Operación en C.D.

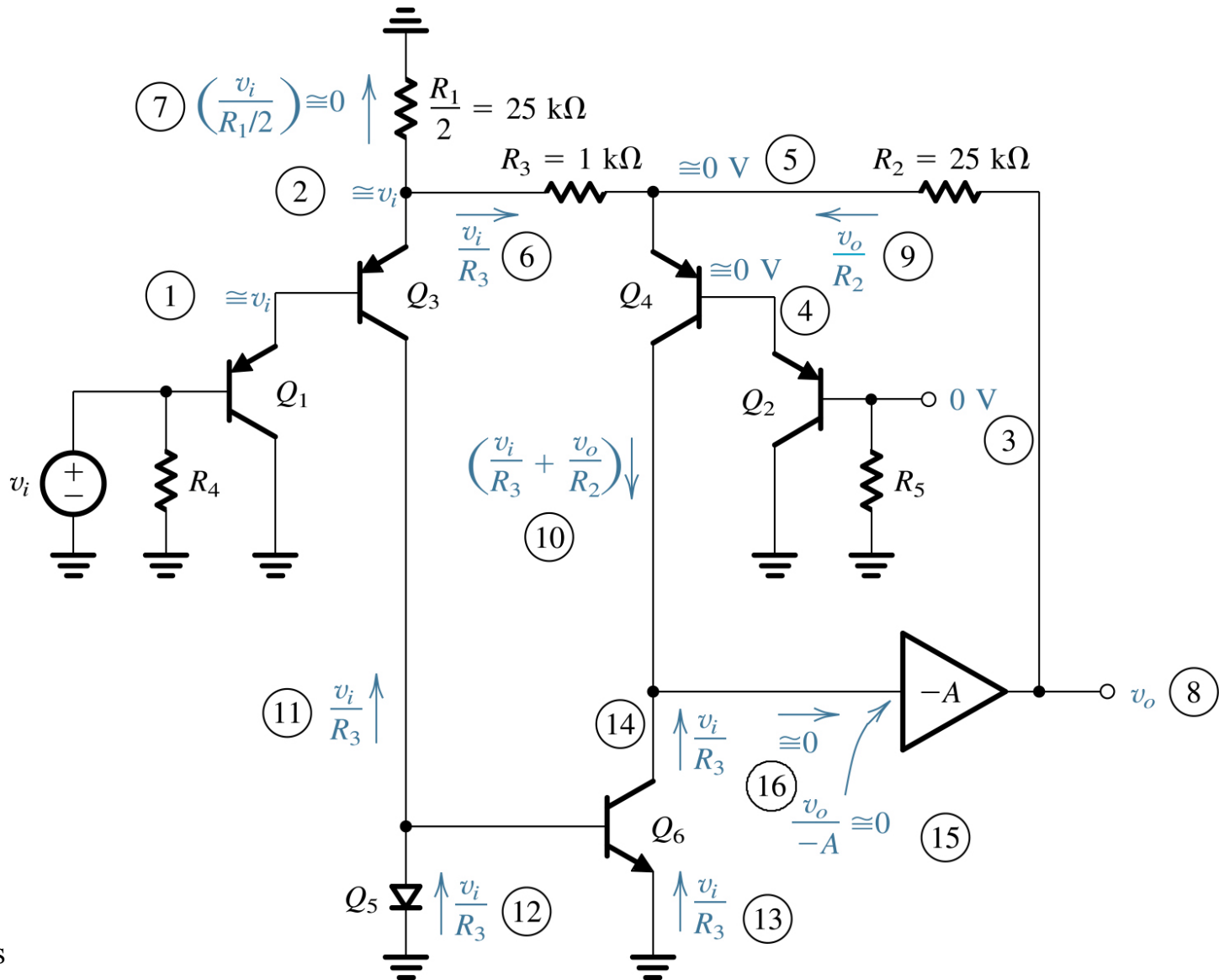
$$I_3 \approx \frac{V_S - V_{EB10} - V_{EB3} - V_{EB1}}{R_1} \approx \frac{V_S - 3V_{EB}}{R_1}$$

$$I_4 \approx \frac{V_O - V_{EB4} - V_{EB2}}{R_2} \approx \frac{V_O - 2V_{EB}}{R_2}$$

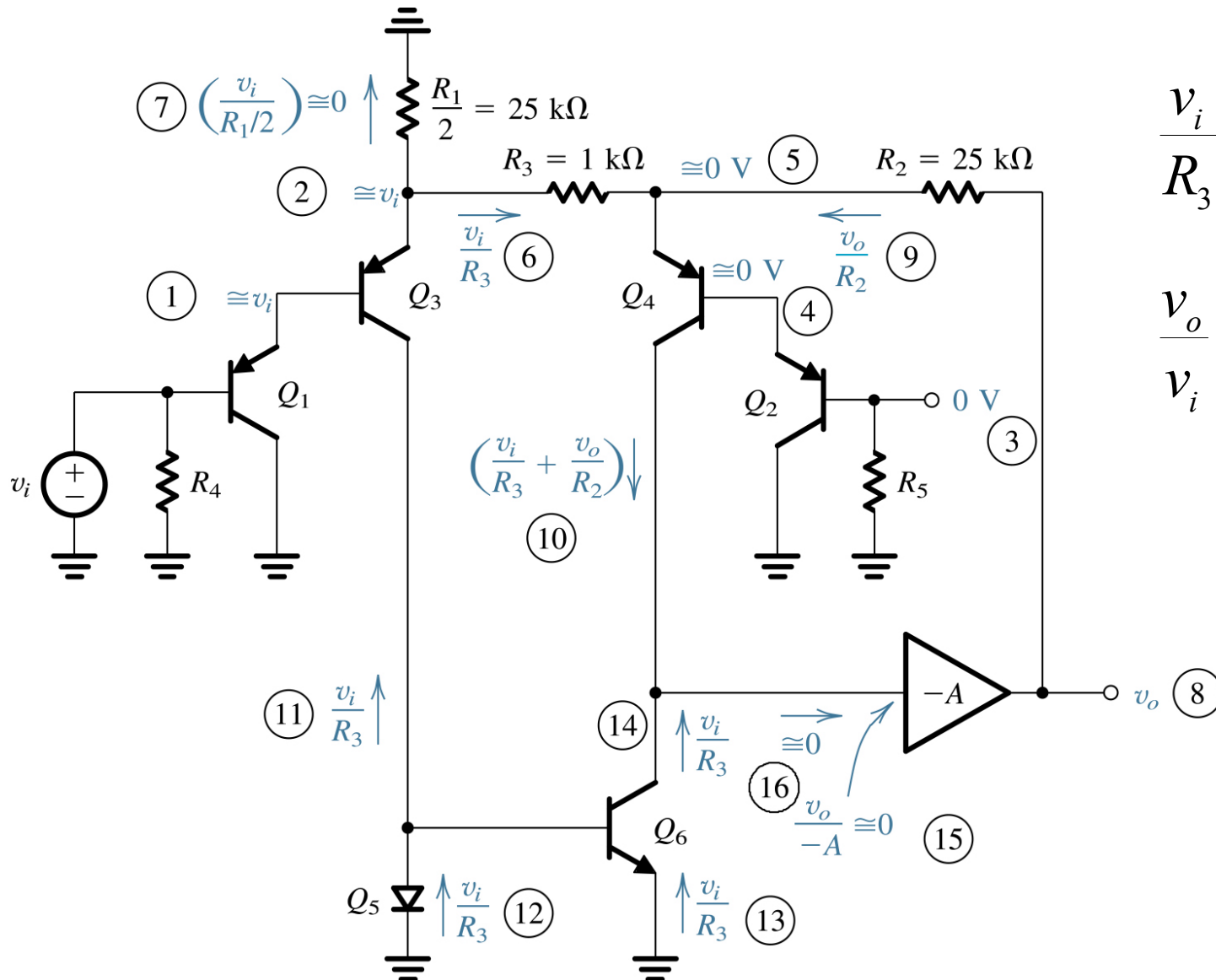
$$I_3 = I_4 \text{ y como } R_1 = 2R_2$$

$$V_O \approx 0.5(V_S - V_{EB}) \approx 0.5V_S$$

LM380 – Operación en Señal Pequeña



LM380 – Operación en Señal Pequeña (cont.)



$$\frac{v_i}{R_3} + \frac{v_o}{R_2} + \frac{v_i}{R_3} = 0$$

$$\frac{v_o}{v_i} = -\frac{2R_2}{R_3} = -50$$

$$\left| \frac{v_o}{v_i} \right| = 34\text{dB}$$

LM380 (cont.)

Electrical Characteristics (Note 2)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$P_{OUT(RMS)}$	Output Power	$R_L = 8\Omega$, THD = 3% (Notes 4, 5)	2.5			W
A_V	Gain		40	50	60	V/V
V_{OUT}	Output Voltage Swing	$R_L = 8\Omega$		14		V_{P-P}
Z_{IN}	Input Resistance			150k		Ω
THD	Total Harmonic Distortion	(Notes 5, 6)		0.2		%
PSRR	Power Supply Rejection Ratio	(Note 3)		38		dB
V_S	Supply Voltage		10		22	V
BW	Bandwidth	$P_{OUT} = 2W$, $R_L = 8\Omega$		100k		Hz
I_Q	Quiescent Supply Current			7	25	mA
V_{OUTQ}	Quiescent Output Voltage		8	9.0	10	V
I_{BIAS}	Bias Current	Inputs Floating		100		nA
I_{SC}	Short Circuit Current			1.3		A

Note 1: "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits.

Note 2: $V_S = 18V$ and $T_A = 25^\circ C$ unless otherwise specified.

Note 3: Rejection ratio referred to the output with $C_{BYPASS} = 5 \mu F$.

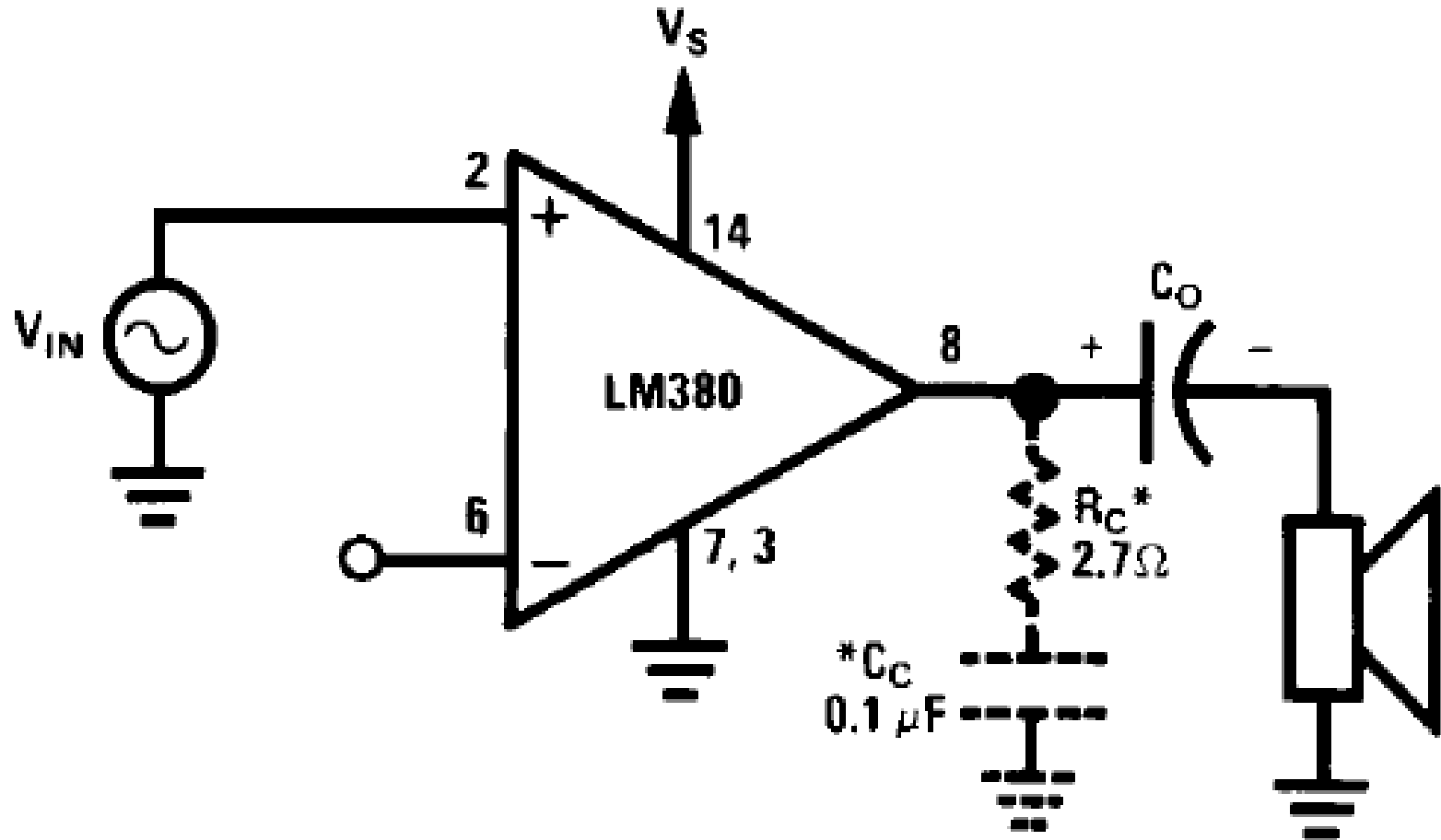
Note 4: With device Pins 3, 4, 5, 10, 11, 12 soldered into a 1/16" epoxy glass board with 2 ounce copper foil with a minimum surface of 6 square inches.

Note 5: $C_{BYPASS} = 0.47 \mu F$ on Pin 1.

Note 6: The maximum junction temperature of the LM380 is $150^\circ C$.

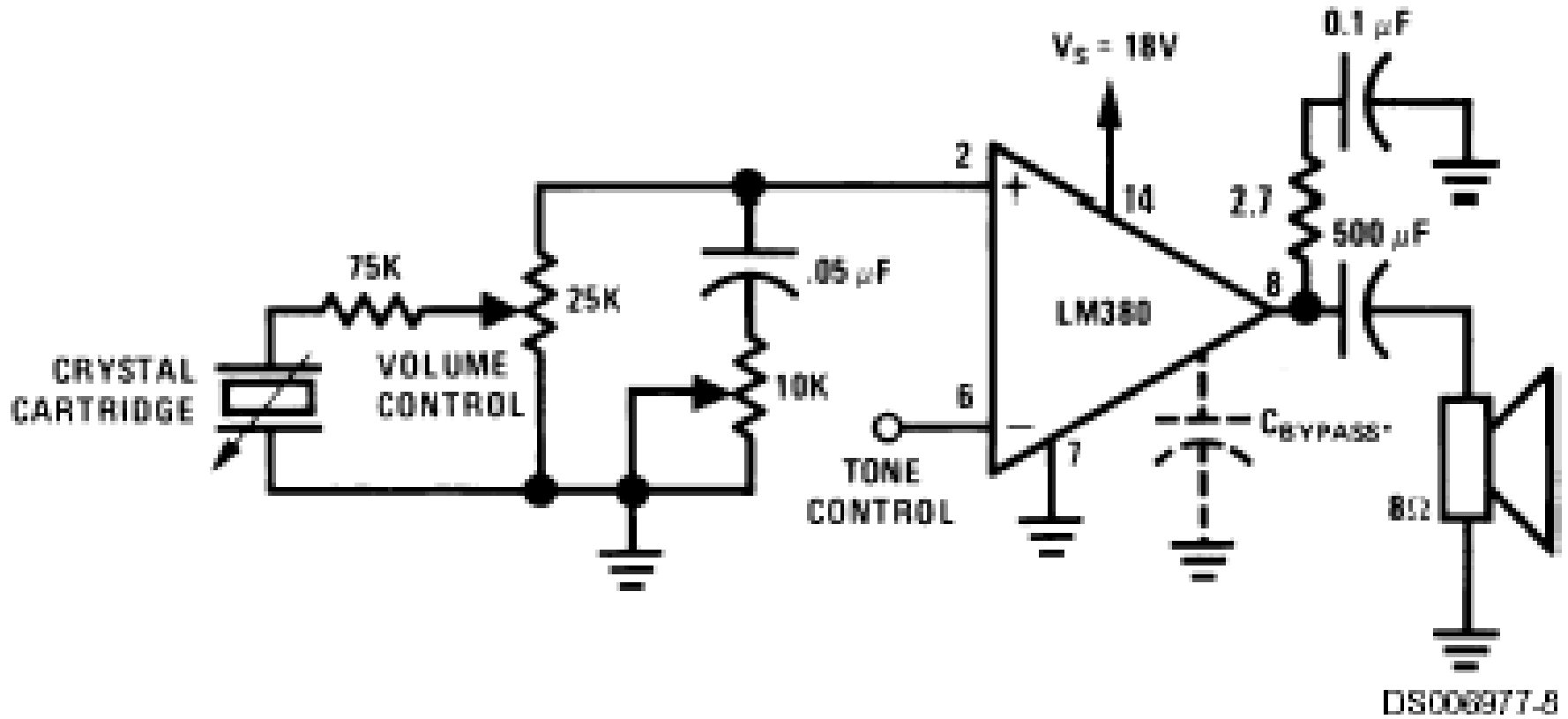
Note 7: The package is to be derated at $15^\circ C/W$ junction to heat sink pins for 14-pin pkg; $75^\circ C/W$ for 8-pin.

LM380 – Algunas Aplicaciones Típicas



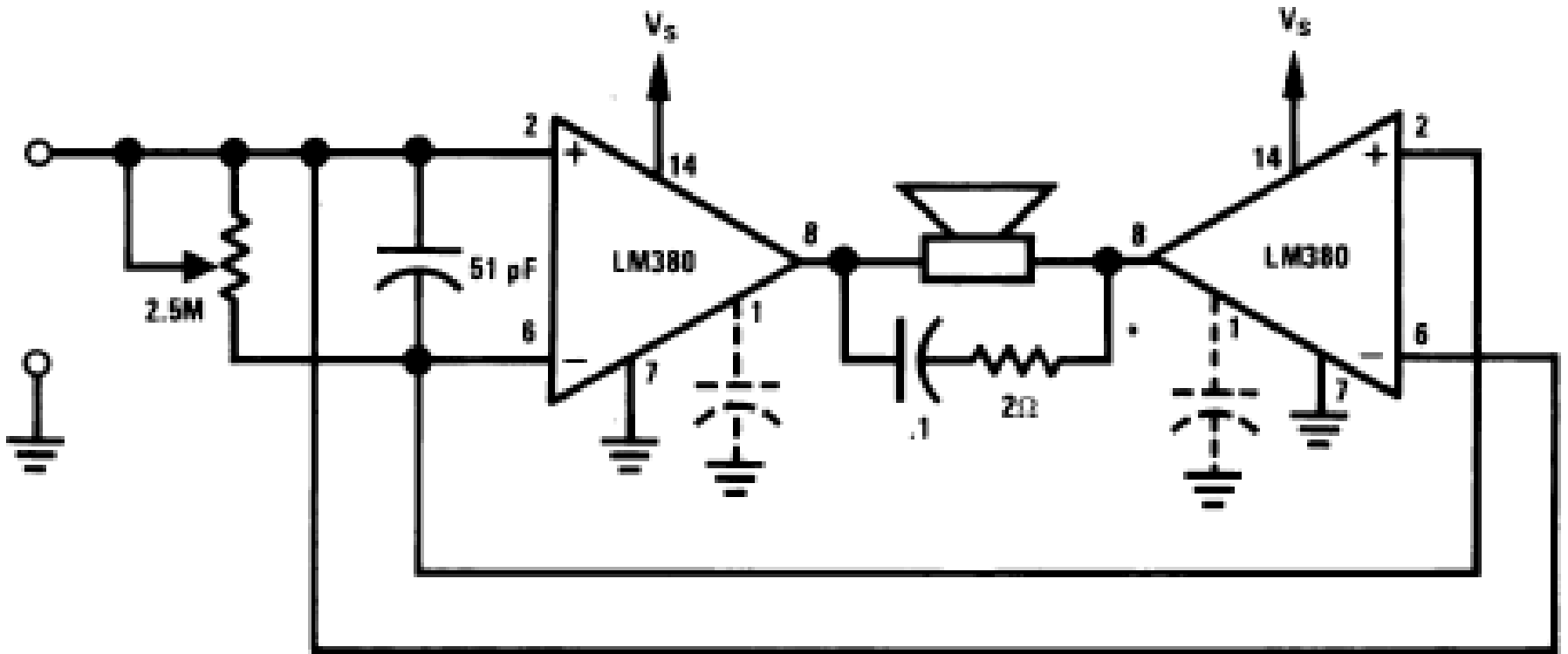
LM380 – Algunas Aplicaciones Típicas

Phono Amplifier



LM380 – Algunas Aplicaciones Típicas (cont.)

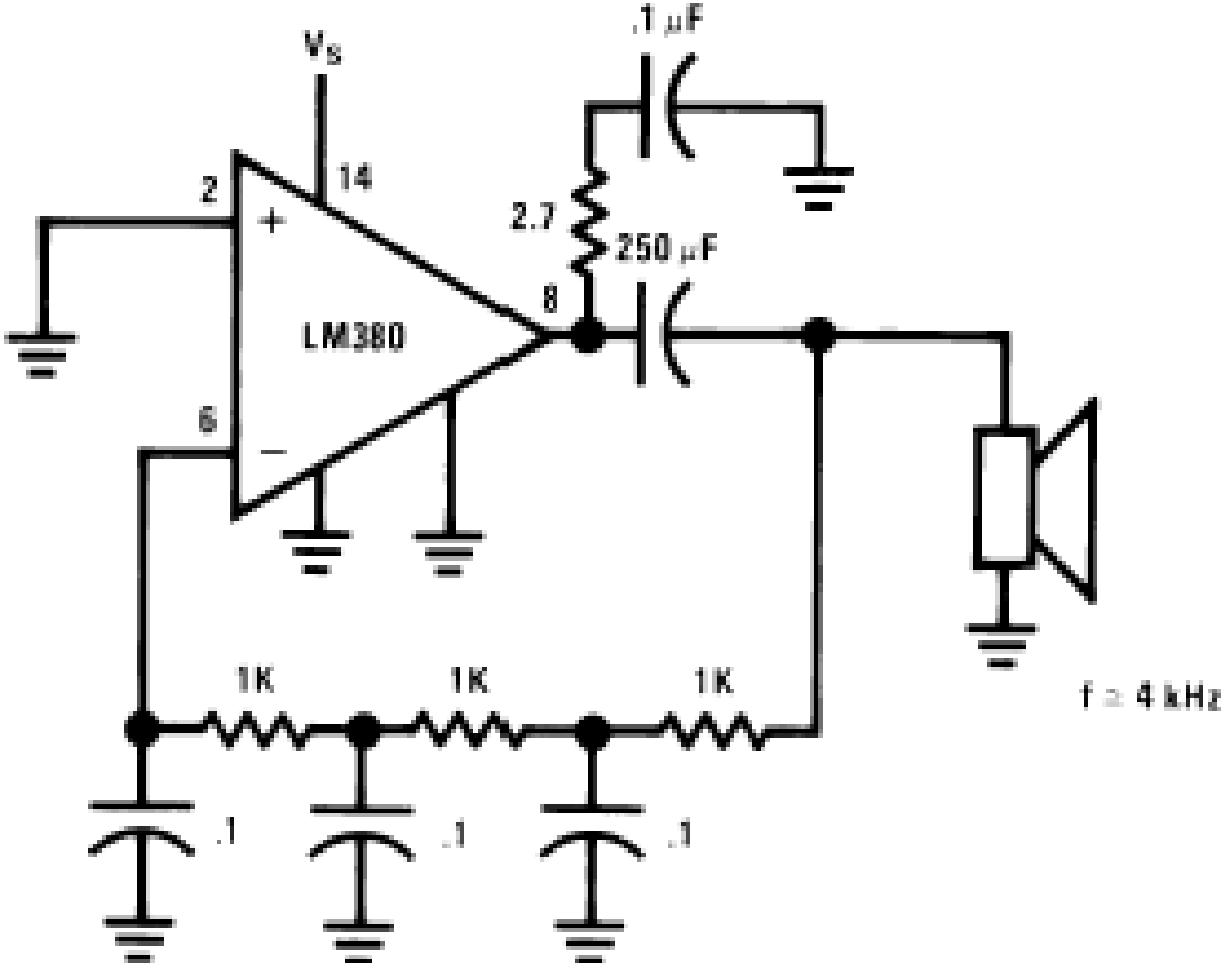
Bridge Amplifier



DS006977-9

LM380 – Algunas Aplicaciones Típicas (cont.)

Phase Shift Oscillator



Ejercicios de Tarea

Resolver problemas 9.19, 9.21, 9.23, 9.25, 9.27 y 9.29 del libro de texto