

D.2 BIPOLAR TRANSISTORS

2N3903/2N3904 General-Purpose npn Transistors*

2N3903
2N3904

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE
TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	40	V _{dc}
Collector-Base Voltage	V _{CBO}	60	V _{dc}
Emitter-Base Voltage	V _{EBO}	6.0	V _{dc}
Collector Current — Continuous	I _C	200	mA _{dc}
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	625 2.8	mW mW/°C
*Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-55 to +150	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	83.3	°C/W
Thermal Resistance, Junction to Ambient	R _{θJA}	200	°C/W

*Indicates Data in addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I _C = 1.0 mA _{dc} , I _B = 0)	V _{(BR)CEO}	40	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{(BR)CBO}	60	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{(BR)EBO}	6.0	—	V _{dc}
Base Cutoff Current (V _{CE} = 30 V _{dc} , V _{EB} = 3.0 V _{dc})	I _{BL}	—	50	nA _{dc}
Collector Cutoff Current (V _{CE} = 30 V _{dc} , V _{EB} = 3.0 V _{dc})	I _{CEX}	—	50	nA _{dc}
ON CHARACTERISTICS				
DC Current Gain(1) (I _C = 0.1 mA _{dc} , V _{CE} = 1.0 V _{dc})	h _{FE}	20	—	—
		2N3903	40	—
(I _C = 1.0 mA _{dc} , V _{CE} = 1.0 V _{dc})	h _{FE}	35	—	—
		2N3903	70	—
(I _C = 10 mA _{dc} , V _{CE} = 1.0 V _{dc})	h _{FE}	50	150	—
		2N3903	100	300
(I _C = 50 mA _{dc} , V _{CE} = 1.0 V _{dc})	h _{FE}	30	—	—
		2N3903	60	—
(I _C = 100 mA _{dc} , V _{CE} = 1.0 V _{dc})	h _{FE}	15	—	—
		2N3903	30	—
Collector-Emitter Saturation Voltage(1) (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})	V _{CE(sat)}	—	0.2 0.3	V _{dc}
Base-Emitter Saturation Voltage(1) (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})	V _{BE(sat)}	0.65	0.85 0.95	V _{dc}
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 20 V _{dc} , f = 100 MHz)	f _T	250 300	—	MHz

2N3903, 2N3904

ELECTRICAL CHARACTERISTICS (continued) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$)	C_{ob}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$)	C_{ib}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{ie}	1.0 1.0	8.0 10	k ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{re}	0.1 0.5	5.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{fe}	50 100	200 400	—
Output Admittance ($I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$)	h_{oe}	1.0	40	μmhos
Noise Figure ($I_C = 100\ \mu\text{A}, V_{CE} = 5.0\text{ Vdc}, R_S = 1.0\text{ k ohms}, f = 10\text{ Hz to }15.7\text{ kHz}$)	NF	—	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Delay Time ($V_{CC} = 3.0\text{ Vdc}, V_{BE} = 0.5\text{ Vdc}, I_C = 10\text{ mAdc}, I_{B1} = 1.0\text{ mAdc}$)	t_d	—	35	ns
Rise Time ($V_{CC} = 3.0\text{ Vdc}, I_C = 10\text{ mAdc}, I_{B1} = 1.0\text{ mAdc}$)	t_r	—	35	ns
Storage Time ($V_{CC} = 3.0\text{ Vdc}, I_C = 10\text{ mAdc}, I_{B1} = I_{B2} = 1.0\text{ mAdc}$)	t_s	—	175 200	ns
Fall Time ($V_{CC} = 3.0\text{ Vdc}, I_C = 10\text{ mAdc}, I_{B1} = I_{B2} = 1.0\text{ mAdc}$)	t_f	—	50	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

*Courtesy of Motorola, used by permission.

Unit
Vdc
Vdc
Vdc
mAdc
mW
mW/C
Watts
mW/C
°C

Unit
°C/W
°C/W

Unit

Vdc
Vdc
nAdc
nAdc

Vdc
Vdc
MHz