

# 2N3903, 2N3904

2N3903 is a Preferred Device

## General Purpose Transistors

### NPN Silicon

#### Features

- Pb-Free Packages are Available\*

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector – Emitter Voltage	$V_{CEO}$	40	Vdc
Collector – Base Voltage	$V_{CBO}$	60	Vdc
Emitter – Base Voltage	$V_{EBO}$	6.0	Vdc
Collector Current – Continuous	$I_C$	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	1.5 12	W mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$	-55 to +150	$^\circ\text{C}$

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

#### THERMAL CHARACTERISTICS (Note 1)

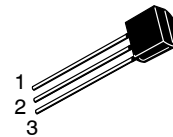
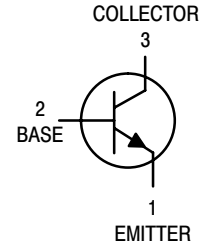
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$

1. Indicates Data in addition to JEDEC Requirements.



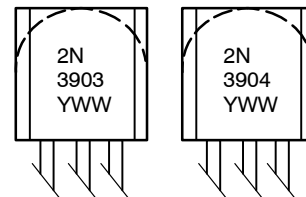
ON Semiconductor®

<http://onsemi.com>



TO-92  
CASE 29  
STYLE 1

#### MARKING DIAGRAMS



Y = Year  
WW = Work Week

#### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 61 of this data sheet.

**Preferred** devices are recommended choices for future use and best overall value.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

## 2N3903, 2N3904

### ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
<b>OFF CHARACTERISTICS</b>				
Collector–Emitter Breakdown Voltage (Note 2) (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , I <sub>B</sub> = 0)	V <sub>(BR)CEO</sub>	40	–	V <sub>dc</sub>
Collector–Base Breakdown Voltage (I <sub>C</sub> = 10 μA <sub>dc</sub> , I <sub>E</sub> = 0)	V <sub>(BR)CBO</sub>	60	–	V <sub>dc</sub>
Emitter–Base Breakdown Voltage (I <sub>E</sub> = 10 μA <sub>dc</sub> , I <sub>C</sub> = 0)	V <sub>(BR)EBO</sub>	6.0	–	V <sub>dc</sub>
Base Cutoff Current (V <sub>CE</sub> = 30 V <sub>dc</sub> , V <sub>EB</sub> = 3.0 V <sub>dc</sub> )	I <sub>BL</sub>	–	50	nA <sub>dc</sub>
Collector Cutoff Current (V <sub>CE</sub> = 30 V <sub>dc</sub> , V <sub>EB</sub> = 3.0 V <sub>dc</sub> )	I <sub>CEX</sub>	–	50	nA <sub>dc</sub>

### ON CHARACTERISTICS

DC Current Gain (Note 2)	h <sub>FE</sub>	2N3903	20	–	–
(I <sub>C</sub> = 0.1 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )					
		2N3904	40	–	
(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )		2N3903	35	–	
		2N3904	70	–	
(I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )		2N3903	50	150	
		2N3904	100	300	
(I <sub>C</sub> = 50 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )		2N3903	30	–	
		2N3904	60	–	
(I <sub>C</sub> = 100 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 V <sub>dc</sub> )		2N3903	15	–	
		2N3904	30	–	
Collector–Emitter Saturation Voltage (Note 2)	V <sub>CE(sat)</sub>		–	0.2	V <sub>dc</sub>
(I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B</sub> = 1.0 mA <sub>dc</sub> )					
(I <sub>C</sub> = 50 mA <sub>dc</sub> , I <sub>B</sub> = 5.0 mA <sub>dc</sub> )			–	0.3	
Base–Emitter Saturation Voltage (Note 2)	V <sub>BE(sat)</sub>		0.65	0.85	V <sub>dc</sub>
(I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B</sub> = 1.0 mA <sub>dc</sub> )					
(I <sub>C</sub> = 50 mA <sub>dc</sub> , I <sub>B</sub> = 5.0 mA <sub>dc</sub> )			–	0.95	

### SMALL–SIGNAL CHARACTERISTICS

Current–Gain–Bandwidth Product	2N3903	f <sub>T</sub>	250	–	MHz
(I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 20 V <sub>dc</sub> , f = 100 MHz)					
	2N3904		300	–	
Output Capacitance (V <sub>CB</sub> = 5.0 V <sub>dc</sub> , I <sub>E</sub> = 0, f = 1.0 MHz)		C <sub>obo</sub>	–	4.0	pF
Input Capacitance (V <sub>EB</sub> = 0.5 V <sub>dc</sub> , I <sub>C</sub> = 0, f = 1.0 MHz)		C <sub>ibo</sub>	–	8.0	pF
Input Impedance	2N3903	h <sub>ie</sub>	1.0	8.0	k Ω
(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 V <sub>dc</sub> , f = 1.0 kHz)					
	2N3904		1.0	10	
Voltage Feedback Ratio	2N3903	h <sub>re</sub>	0.1	5.0	X 10 <sup>–4</sup>
(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 V <sub>dc</sub> , f = 1.0 kHz)					
	2N3904		0.5	8.0	
Small–Signal Current Gain	2N3903	h <sub>fe</sub>	50	200	–
(I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 V <sub>dc</sub> , f = 1.0 kHz)					
	2N3904		100	400	
Output Admittance (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 V <sub>dc</sub> , f = 1.0 kHz)		h <sub>oe</sub>	1.0	40	μmhos
Noise Figure	2N3903	NF	–	6.0	dB
(I <sub>C</sub> = 100 μA <sub>dc</sub> , V <sub>CE</sub> = 5.0 V <sub>dc</sub> , R <sub>S</sub> = 1.0 k Ω, f = 1.0 kHz)					
	2N3904		–	5.0	

### SWITCHING CHARACTERISTICS

Delay Time	(V <sub>CC</sub> = 3.0 V <sub>dc</sub> , V <sub>BE</sub> = 0.5 V <sub>dc</sub> , I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B1</sub> = 1.0 mA <sub>dc</sub> )		t <sub>d</sub>	–	35	ns
Rise Time			t <sub>r</sub>	–	35	ns
Storage Time	(V <sub>CC</sub> = 3.0 V <sub>dc</sub> , I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B1</sub> = I <sub>B2</sub> = 1.0 mA <sub>dc</sub> )	2N3903	t <sub>s</sub>	–	175	ns
				2N3904	–	200
Fall Time			t <sub>f</sub>	–	50	ns

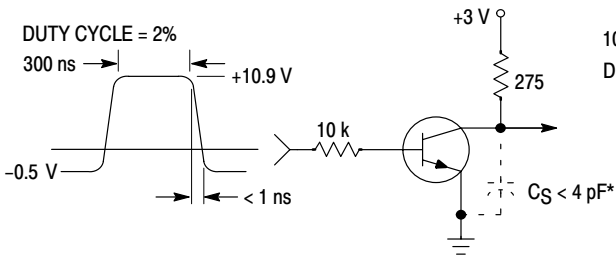
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%.

## 2N3903, 2N3904

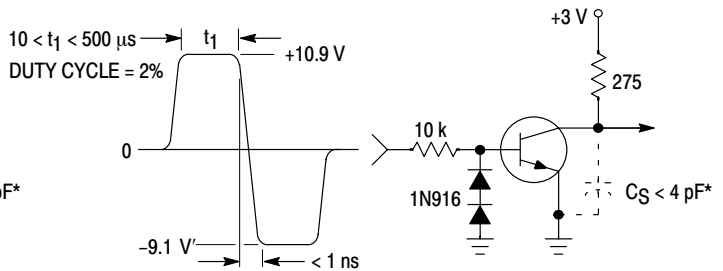
### ORDERING INFORMATION

Device	Package	Shipping†
2N3903	TO-92	5,000 Units / Box
2N3903RLRM	TO-92	2,000 / Ammo Pack
2N3904	TO-92	5,000 Units / Box
2N3904G	TO-92 (Pb-Free)	5,000 Units / Box
2N3904RLRA	TO-92	2,000 / Tape & Reel
2N3904RLRAG	TO-92 (Pb-Free)	2,000 / Tape & Reel
2N3904RLRE	TO-92	2,000 / Tape & Reel
2N3904RLRM	TO-92	2,000 / Ammo Pack
2N3904RLRMG	TO-92 (Pb-Free)	2,000 / Ammo Pack
2N3904RLRP	TO-92	2,000 / Ammo Pack
2N3904RLRPG	TO-92 (Pb-Free)	2,000 / Ammo Pack
2N3904RL1	TO-92	2,000 / Tape & Reel
2N3904ZL1	TO-92	2,000 / Ammo Pack

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



**Figure 1. Delay and Rise Time  
Equivalent Test Circuit**



**Figure 2. Storage and Fall Time  
Equivalent Test Circuit**

\* Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

—  $T_J = 25^\circ\text{C}$   
 - - -  $T_J = 125^\circ\text{C}$

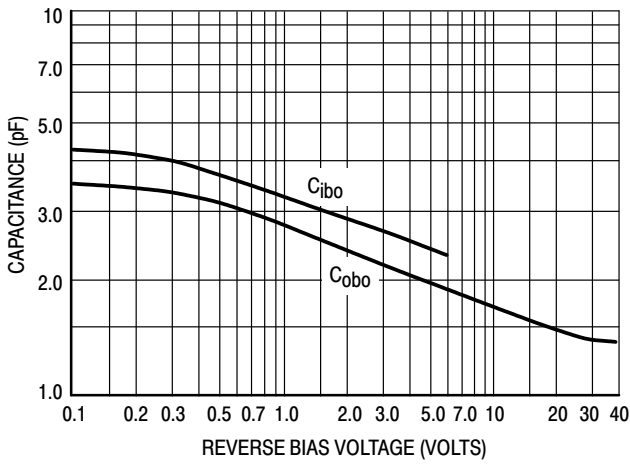


Figure 3. Capacitance

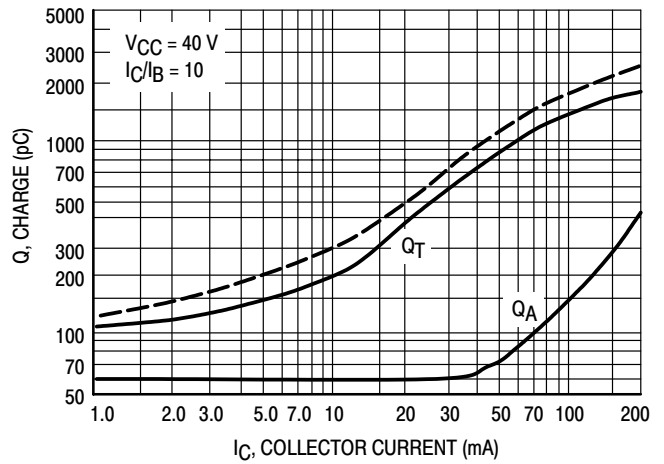


Figure 4. Charge Data

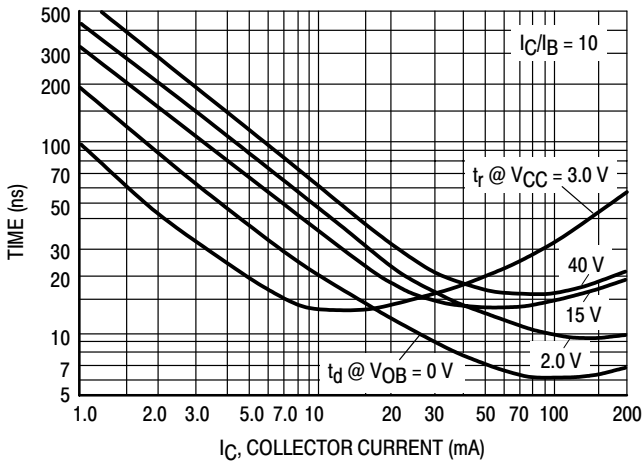


Figure 5. Turn-On Time

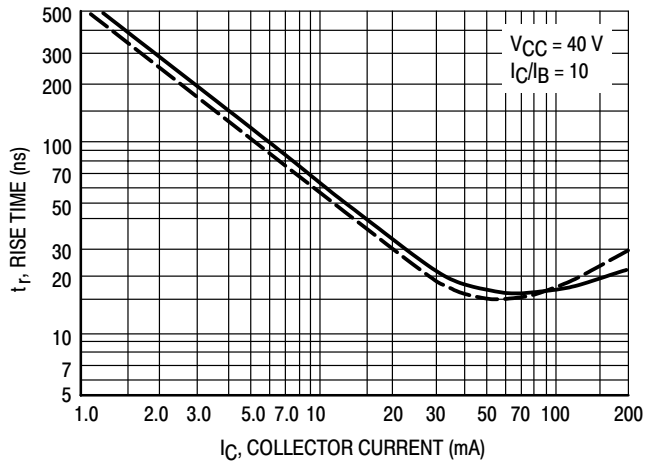


Figure 6. Rise Time

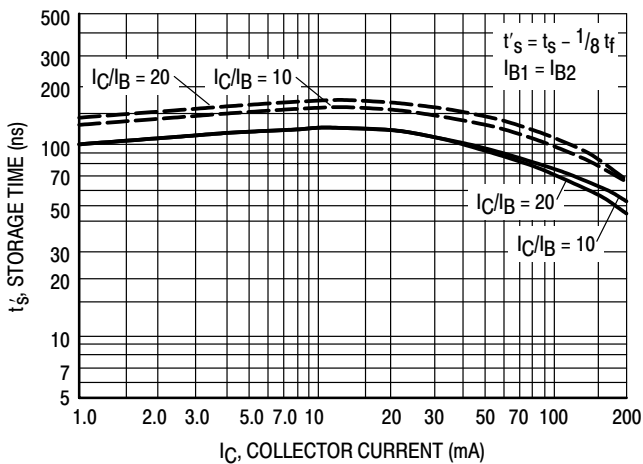


Figure 7. Storage Time

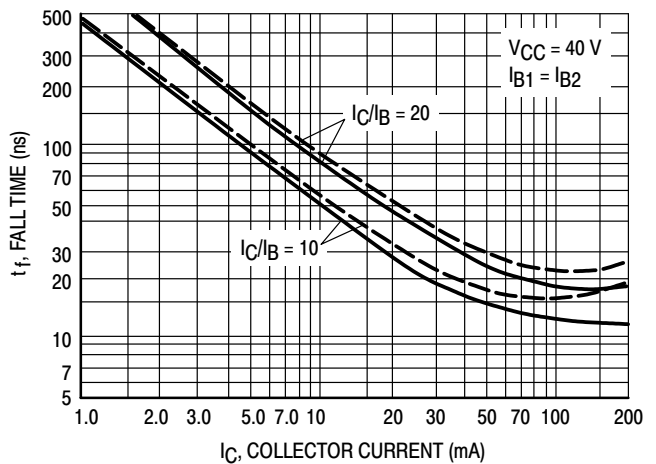


Figure 8. Fall Time

TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS  
NOISE FIGURE VARIATIONS

( $V_{CE} = 5.0$  Vdc,  $T_A = 25^\circ\text{C}$ , Bandwidth = 1.0 Hz)

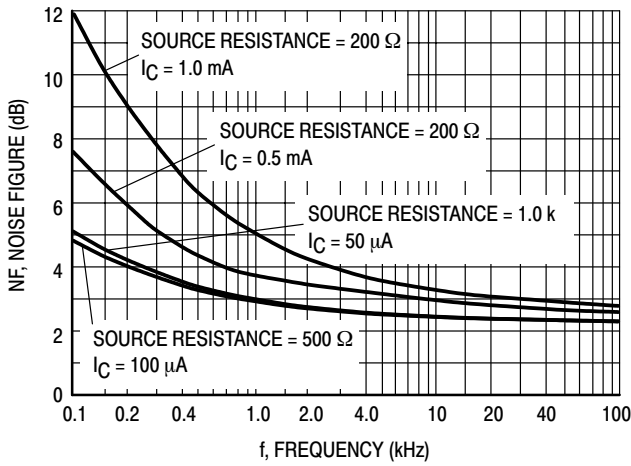


Figure 9.

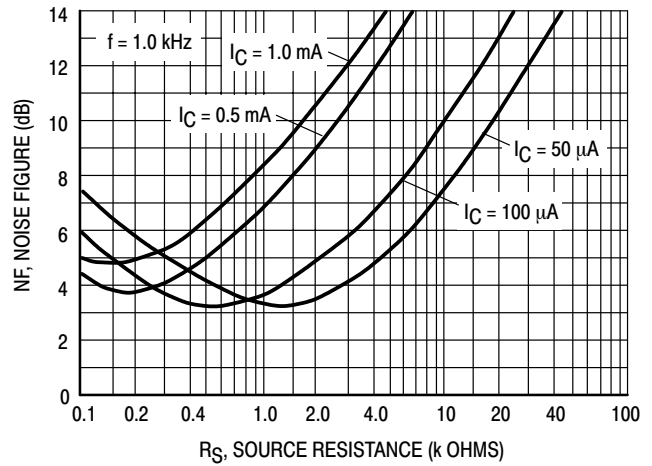


Figure 10.

h PARAMETERS

( $V_{CE} = 10$  Vdc,  $f = 1.0$  kHz,  $T_A = 25^\circ\text{C}$ )

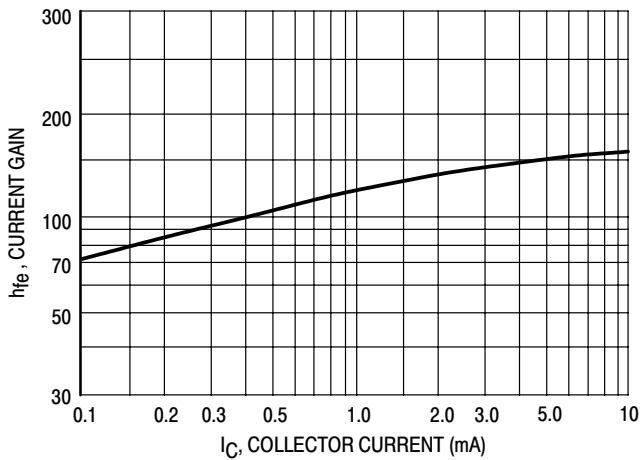


Figure 11. Current Gain

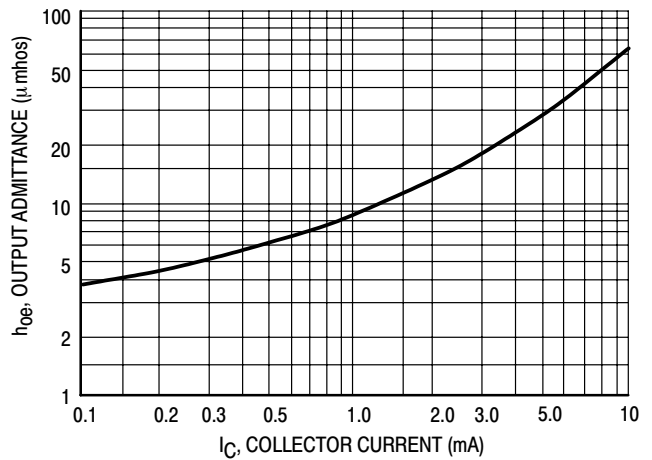


Figure 12. Output Admittance

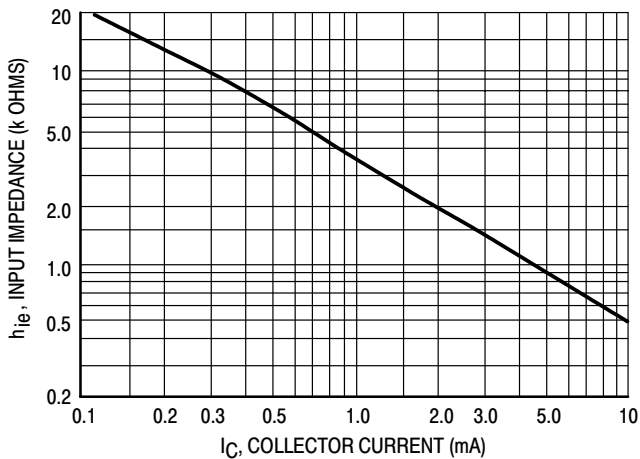


Figure 13. Input Impedance

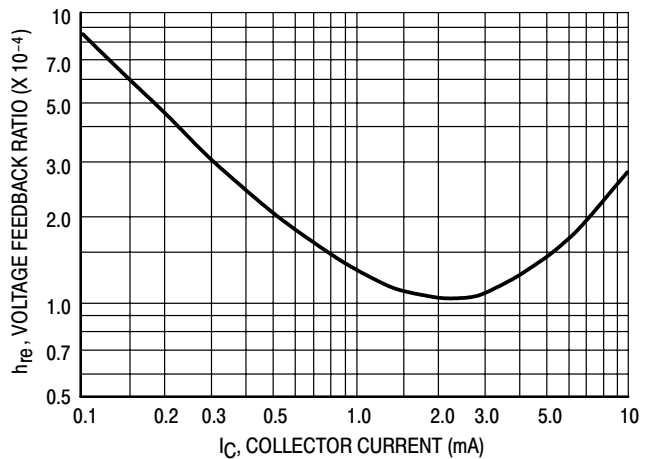


Figure 14. Voltage Feedback Ratio

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## TYPICAL STATIC CHARACTERISTICS

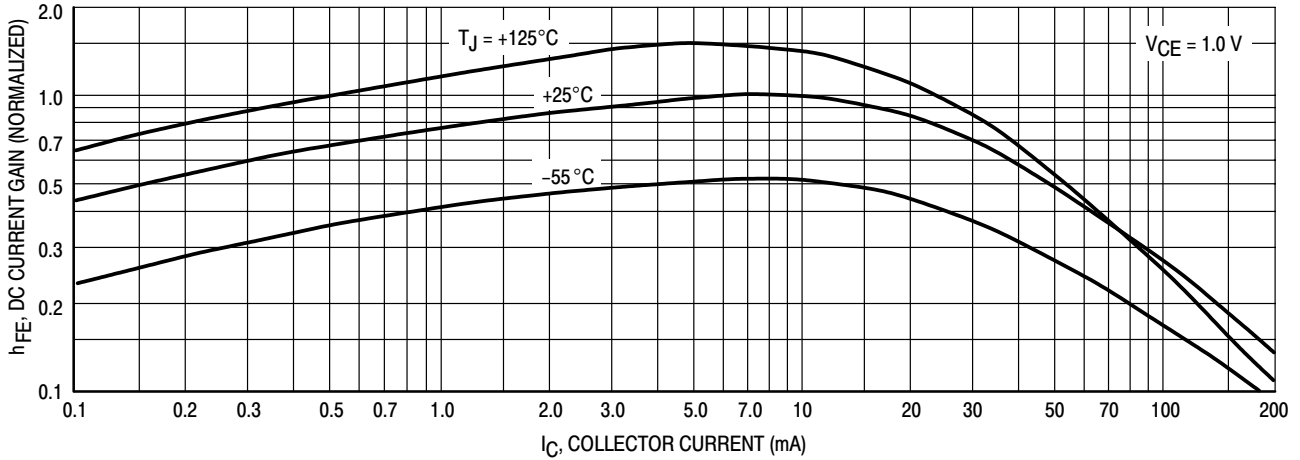


Figure 15. DC Current Gain

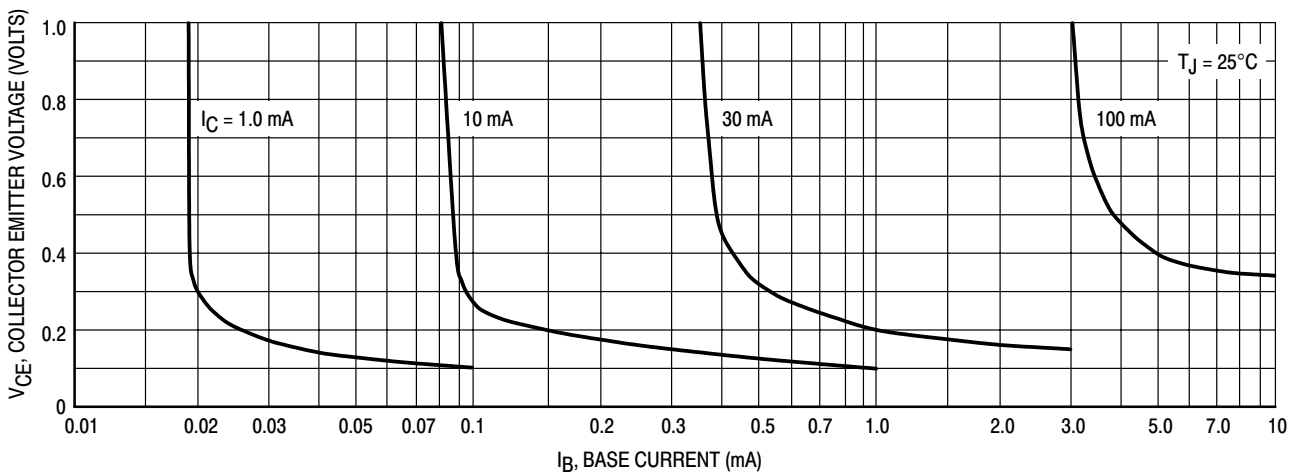


Figure 16. Collector Saturation Region

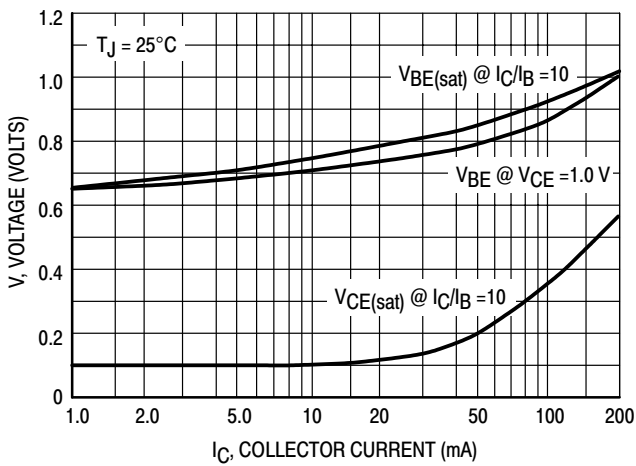


Figure 17. "ON" Voltages

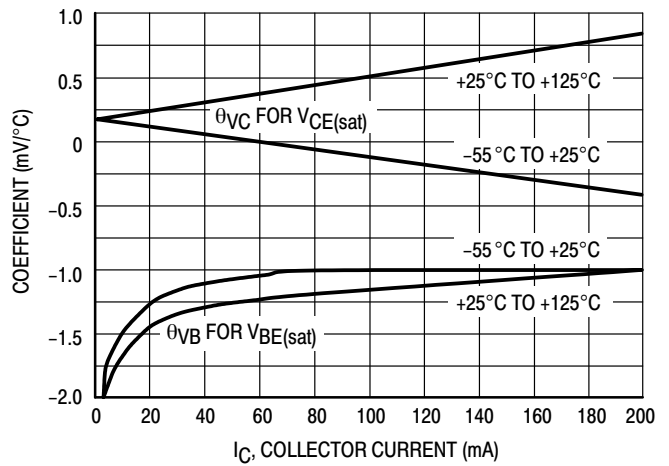


Figure 18. Temperature Coefficients