

Esame di Stato di abilitazione alla professione di Ingegnere

Sezione B

**Settore dell'Informazione
Prova Pratica: Classe 9, Ingegneria Elettronica**

II sessione 2009

Il Candidato progetti un amplificatore di tensione a singolo transistore che soddisfi le seguenti specifiche:

- alimentazione con una singola tensione continua di 10 V;
- guadagno di tensione $V_u / V_i = 10$;
- banda passante a -3 dB estesa da 100 Hz a 20 kHz;
- dinamica d'uscita pari a 2 V picco-picco su un carico da $10 \text{ k}\Omega$;

Le specifiche su guadagno e dinamica valgono per segnali d'ingresso di 1 kHz.

Il progetto deve garantire che le specifiche su guadagno, banda e dinamica d'uscita vengano soddisfatte entro un margine del $\pm 10\%$ a temperatura ambiente, usando componenti passivi che appartengono alla serie standard E12.

Il Candidato giustifichi la scelta della soluzione circuitale e dei componenti adottati, discutendo in particolare la sensibilità delle specifiche di progetto alle tolleranze dei parametri del transistore. Il candidato proponga infine una possibile modifica qualitativa all'amplificatore per ottenere un segnale d'uscita in fase col segnale di ingresso.

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°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	W mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

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	$^\circ\text{C}/\text{W}$

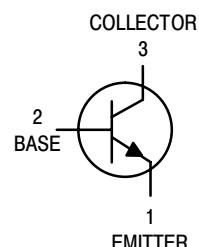
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Indicates Data in addition to JEDEC Requirements.

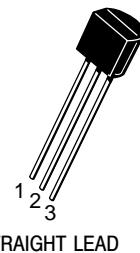


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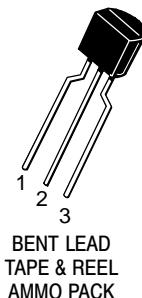
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TO-92
CASE 29
STYLE 1

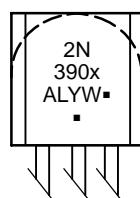


STRAIGHT LEAD
BULK PACK



BENT LEAD
TAPE & REEL
AMMO PACK

MARKING DIAGRAMS



x = 3 or 4
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
■ = Pb-Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 3 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 ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 2) ($I_C = 1.0 \text{ mA}, I_B = 0$)	$V_{(\text{BR})\text{CEO}}$	40	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}, I_E = 0$)	$V_{(\text{BR})\text{CBO}}$	60	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}, I_C = 0$)	$V_{(\text{BR})\text{EBO}}$	6.0	–	Vdc
Base Cutoff Current ($V_{\text{CE}} = 30 \text{ Vdc}, V_{\text{EB}} = 3.0 \text{ Vdc}$)	I_{BL}	–	50	nAdc
Collector Cutoff Current ($V_{\text{CE}} = 30 \text{ Vdc}, V_{\text{EB}} = 3.0 \text{ Vdc}$)	I_{CEX}	–	50	nAdc

ON CHARACTERISTICS

DC Current Gain (Note 2) ($I_C = 0.1 \text{ mA}, V_{\text{CE}} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mA}, V_{\text{CE}} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mA}, V_{\text{CE}} = 1.0 \text{ Vdc}$) ($I_C = 50 \text{ mA}, V_{\text{CE}} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mA}, V_{\text{CE}} = 1.0 \text{ Vdc}$)	2N3903 2N3904 2N3903 2N3904 2N3903 2N3904 2N3903 2N3904 2N3903 2N3904	h_{FE}	20 40 35 70 50 100 30 60 15 30	– – – – 150 300 – – – –	– – – – –
Collector-Emitter Saturation Voltage (Note 2) ($I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$) ($I_C = 50 \text{ mA}, I_B = 5.0 \text{ mA}$)		$V_{\text{CE}(\text{sat})}$	– –	0.2 0.3	Vdc
Base-Emitter Saturation Voltage (Note 2) ($I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$) ($I_C = 50 \text{ mA}, I_B = 5.0 \text{ mA}$)		$V_{\text{BE}(\text{sat})}$	0.65 –	0.85 0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain – Bandwidth Product ($I_C = 10 \text{ mA}, V_{\text{CE}} = 20 \text{ Vdc}, f = 100 \text{ MHz}$)	2N3903 2N3904	f_T	250 300	– –	MHz
Output Capacitance ($V_{\text{CB}} = 5.0 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$)		C_{obo}	–	4.0	pF
Input Capacitance ($V_{\text{EB}} = 0.5 \text{ Vdc}, I_C = 0, f = 1.0 \text{ MHz}$)		C_{ibo}	–	8.0	pF
Input Impedance ($I_C = 1.0 \text{ mA}, V_{\text{CE}} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	2N3903 2N3904	h_{ie}	1.0 1.0	8.0 10	k Ω
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA}, V_{\text{CE}} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	2N3903 2N3904	h_{re}	0.1 0.5	5.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}, V_{\text{CE}} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)	2N3903 2N3904	h_{fe}	50 100	200 400	–
Output Admittance ($I_C = 1.0 \text{ mA}, V_{\text{CE}} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)		h_{oe}	1.0	40	μmhos
Noise Figure ($I_C = 100 \mu\text{A}, V_{\text{CE}} = 5.0 \text{ Vdc}, R_S = 1.0 \text{ k} \Omega, f = 1.0 \text{ kHz}$)	2N3903 2N3904	NF	– –	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Delay Time	$(V_{\text{CC}} = 3.0 \text{ Vdc}, V_{\text{BE}} = 0.5 \text{ Vdc}, I_C = 10 \text{ mA}, I_{B1} = 1.0 \text{ mA})$	t_d	–	35	ns
		t_r	–	35	ns
Storage Time	$(V_{\text{CC}} = 3.0 \text{ Vdc}, I_C = 10 \text{ mA}, I_{B1} = I_{B2} = 1.0 \text{ mA})$	t_s	– –	175 200	ns
		t_f	–	50	ns

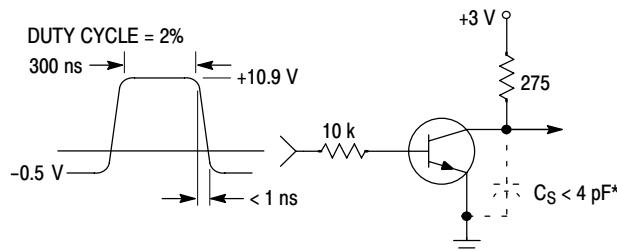
2. Pulse Test: Pulse Width $\leq 300 \mu\text{s}$; Duty Cycle $\leq 2\%$.

2N3903, 2N3904

ORDERING INFORMATION

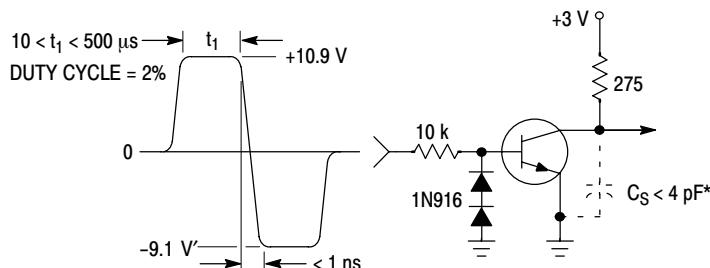
Device	Package	Shipping [†]
2N3903RLRM	TO-92	2000 / Ammo Pack
2N3904	TO-92	5000 Units / Bulk
2N3904G	TO-92 (Pb-Free)	5000 Units / Bulk
2N3904RLRA	TO-92	2000 / Tape & Reel
2N3904RLRAG	TO-92 (Pb-Free)	2000 / Tape & Reel
2N3904RLRM	TO-92	2000 / Ammo Pack
2N3904RLRMG	TO-92 (Pb-Free)	2000 / Ammo Pack
2N3904RLRP	TO-92	2000 / Ammo Pack
2N3904RLRPG	TO-92 (Pb-Free)	2000 / Ammo Pack
2N3904RL1G	TO-92 (Pb-Free)	2000 / Tape & Reel
2N3904ZL1	TO-92	2000 / Ammo Pack
2N3904ZL1G	TO-92 (Pb-Free)	2000 / 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.



* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit



* Total shunt capacitance of test jig and connectors

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

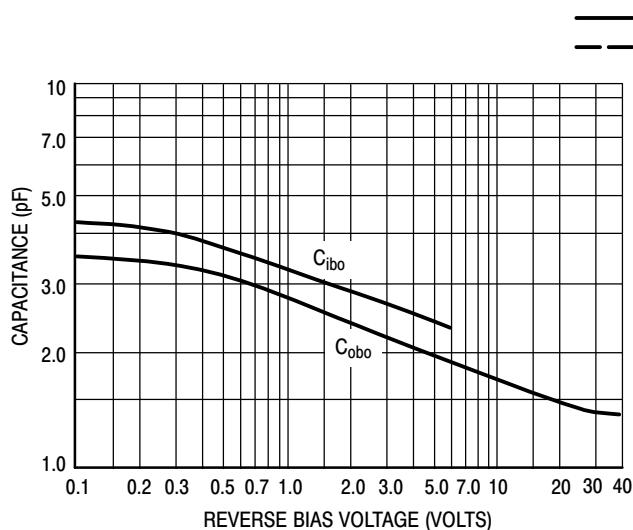


Figure 3. Capacitance

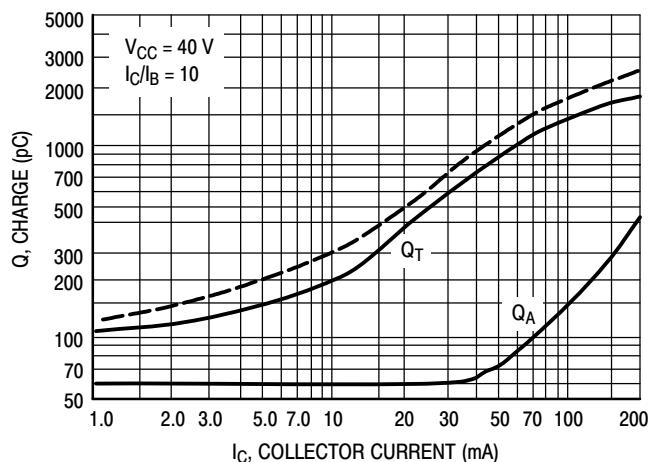


Figure 4. Charge Data

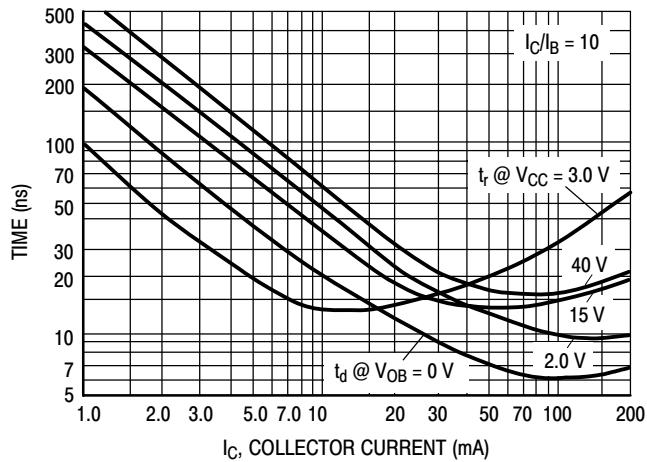


Figure 5. Turn-On Time

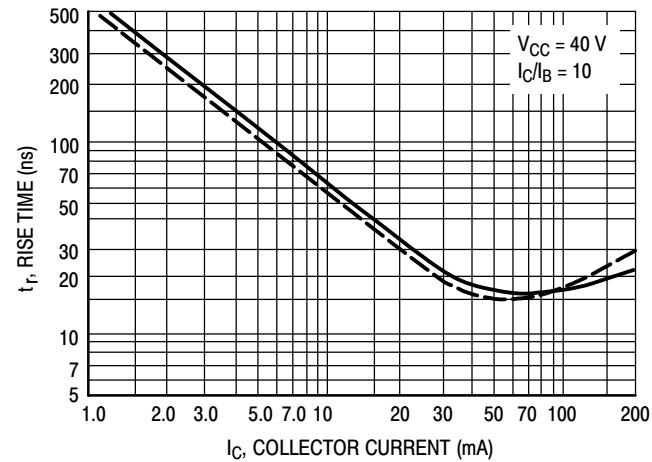


Figure 6. Rise Time

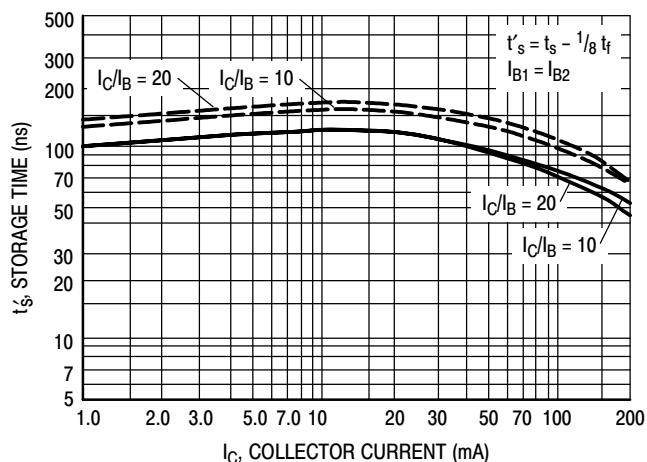


Figure 7. Storage Time

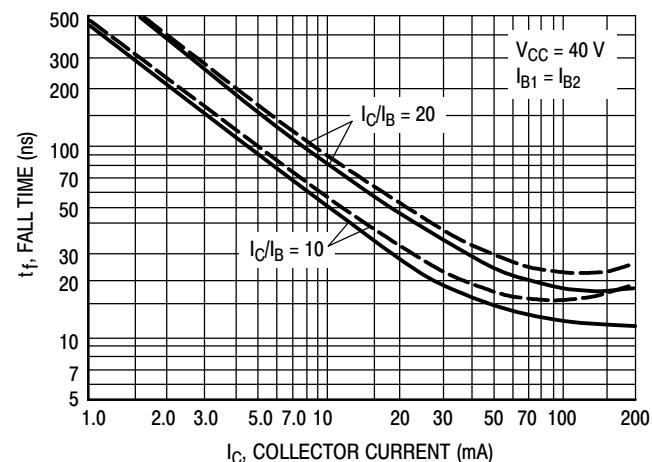


Figure 8. Fall Time

TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

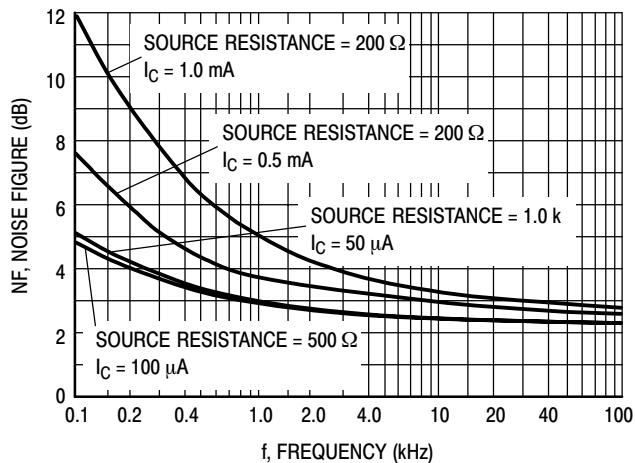


Figure 9.

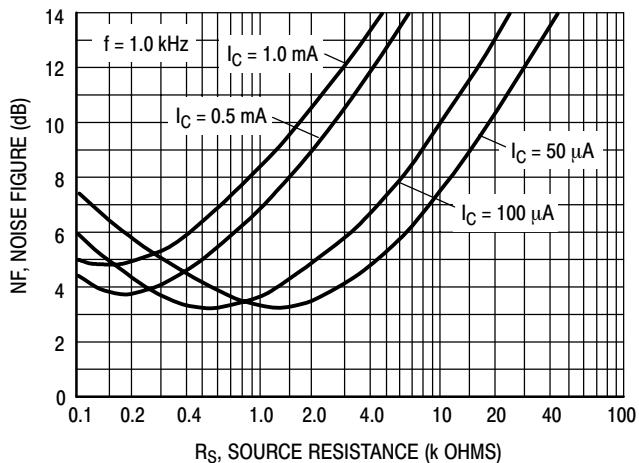


Figure 10.

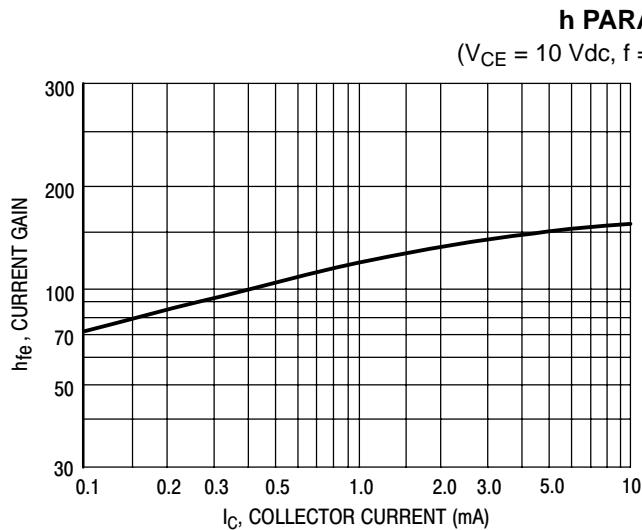


Figure 11. Current Gain

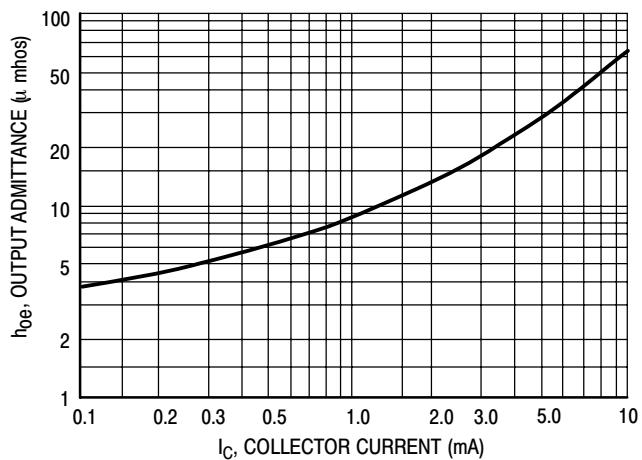


Figure 12. Output Admittance

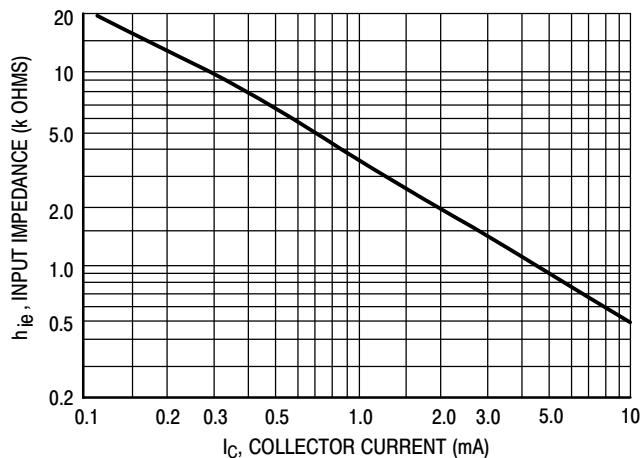


Figure 13. Input Impedance

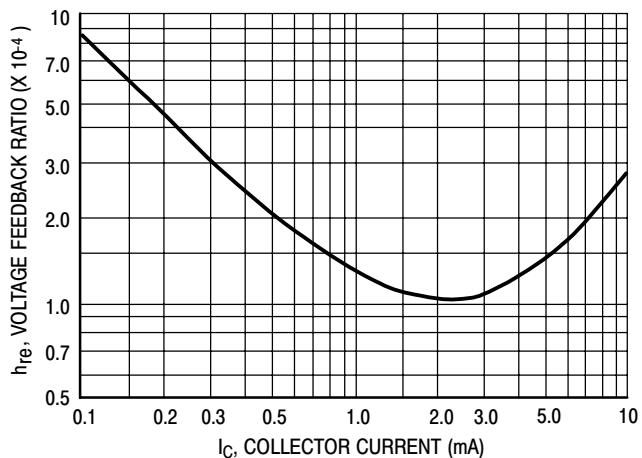


Figure 14. Voltage Feedback Ratio

2N3903, 2N3904

TYPICAL STATIC CHARACTERISTICS

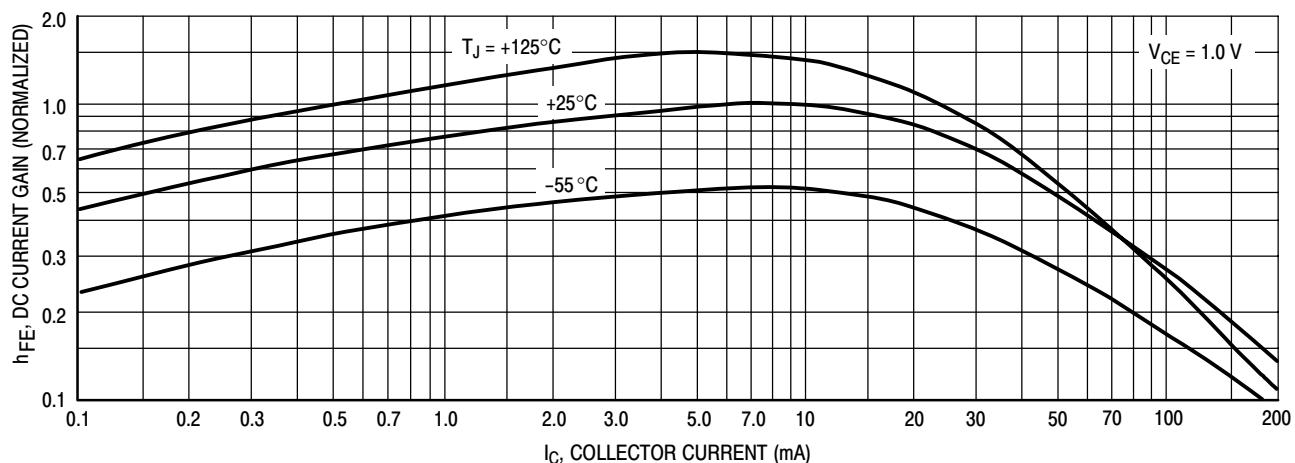


Figure 15. DC Current Gain

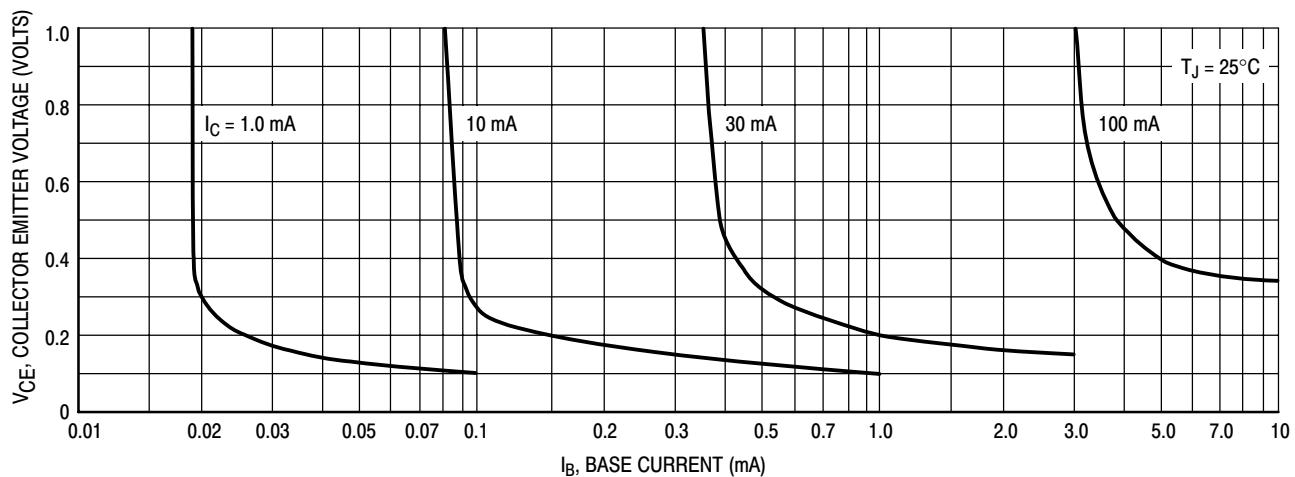


Figure 16. Collector Saturation Region

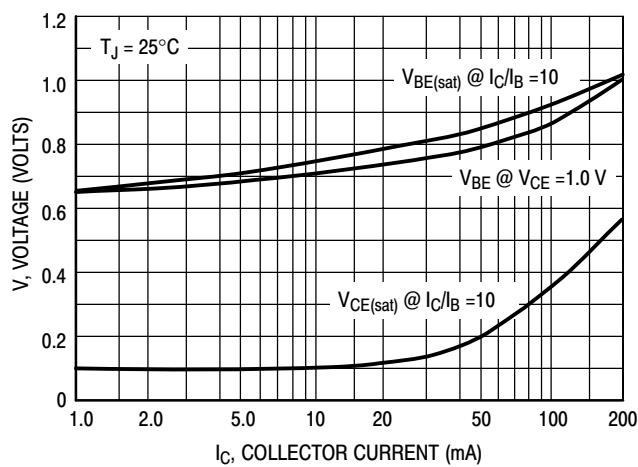


Figure 17. "ON" Voltages

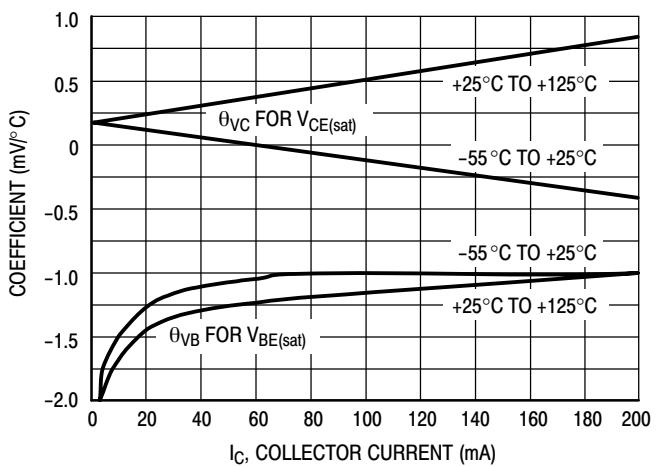
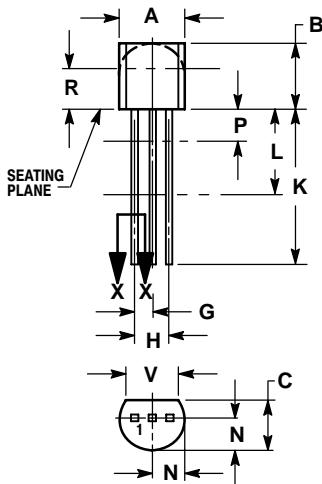


Figure 18. Temperature Coefficients

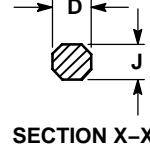
PACKAGE DIMENSIONS

TO-92 (TO-226)
CASE 29-11
ISSUE AMSTRAIGHT LEAD
BULK PACK

NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.021	0.407	0.533
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	---	12.70	---
L	0.250	---	6.35	---
N	0.080	0.105	2.04	2.66
P	---	0.100	---	2.54
R	0.115	---	2.93	---
V	0.135	---	3.43	---

BENT LEAD
TAPE & REEL
AMMO PACK

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	MILLIMETERS	
	MIN	MAX
A	4.45	5.20
B	4.32	5.33
C	3.18	4.19
D	0.40	0.54
G	2.40	2.80
J	0.39	0.50
K	12.70	---
N	2.04	2.66
P	1.50	4.00
R	2.93	---
V	3.43	---



STYLE 1:
PIN 1. Emitter
2. Base
3. Collector

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Sales Representative

2N3906

Preferred Device

General Purpose Transistors

PNP Silicon

Features

- Pb-Free Packages are Available*

MAXIMUM RATINGS

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Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_A = 60^\circ\text{C}$	P_D	250	mW
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	W mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS (Note 1)

Characteristic	Symbol	Max	Unit
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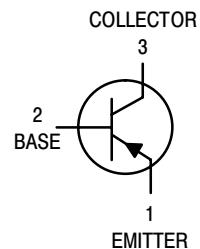
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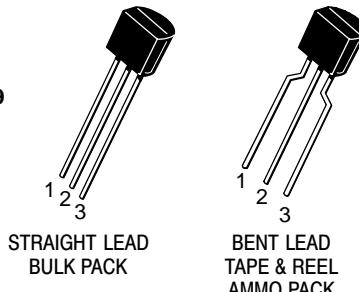


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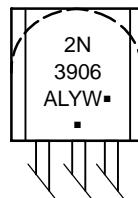
<http://onsemi.com>



TO-92
CASE 29
STYLE 1



MARKING DIAGRAM



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Y = Year
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■ = Pb-Free Package

(Note: Microdot may be in either location)

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2N3906

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

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector – Emitter Breakdown Voltage (Note 2)	(I _C = 1.0 mA, I _B = 0)	V _{(BR)CEO}	40	–	Vdc
Collector – Base Breakdown Voltage	(I _C = 10 µA, I _E = 0)	V _{(BR)CBO}	40	–	Vdc
Emitter – Base Breakdown Voltage	(I _E = 10 µA, I _C = 0)	V _{(BR)EBO}	5.0	–	Vdc
Base Cutoff Current	(V _{CE} = 30 Vdc, V _{EB} = 3.0 Vdc)	I _{BL}	–	50	nA
Collector Cutoff Current	(V _{CE} = 30 Vdc, V _{EB} = 3.0 Vdc)	I _{CEX}	–	50	nA

ON CHARACTERISTICS (Note 2)

DC Current Gain	(I _C = 0.1 mA, V _{CE} = 1.0 Vdc) (I _C = 1.0 mA, V _{CE} = 1.0 Vdc) (I _C = 10 mA, V _{CE} = 1.0 Vdc) (I _C = 50 mA, V _{CE} = 1.0 Vdc) (I _C = 100 mA, V _{CE} = 1.0 Vdc)	h _{FE}	60 80 100 60 30	– – 300 – –	–
Collector – Emitter Saturation Voltage	(I _C = 10 mA, I _B = 1.0 mA) (I _C = 50 mA, I _B = 5.0 mA)	V _{CE(sat)}	– –	0.25 0.4	Vdc
Base – Emitter Saturation Voltage	(I _C = 10 mA, I _B = 1.0 mA) (I _C = 50 mA, I _B = 5.0 mA)	V _{BE(sat)}	0.65 –	0.85 0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current – Gain – Bandwidth Product	(I _C = 10 mA, V _{CE} = 20 Vdc, f = 100 MHz)	f _T	250	–	MHz
Output Capacitance	(V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz)	C _{obo}	–	4.5	pF
Input Capacitance	(V _{EB} = 0.5 Vdc, I _C = 0, f = 1.0 MHz)	C _{ibo}	–	10	pF
Input Impedance	(I _C = 1.0 mA, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{ie}	2.0	12	kΩ
Voltage Feedback Ratio	(I _C = 1.0 mA, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{re}	0.1	10	X 10 ⁻⁴
Small-Signal Current Gain	(I _C = 1.0 mA, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	100	400	–
Output Admittance	(I _C = 1.0 mA, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{oe}	3.0	60	µmhos
Noise Figure	(I _C = 100 µA, V _{CE} = 5.0 Vdc, R _S = 1.0 kΩ, f = 1.0 kHz)	NF	–	4.0	dB

SWITCHING CHARACTERISTICS

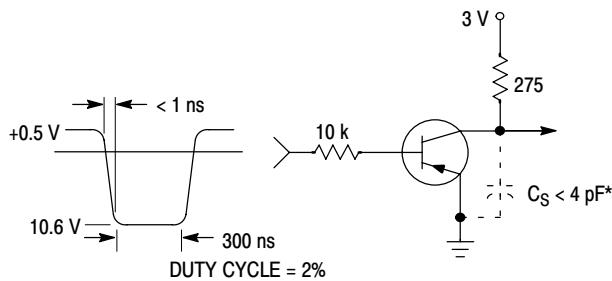
Delay Time	(V _{CC} = 3.0 Vdc, V _{BE} = 0.5 Vdc, I _C = 10 mA, I _{B1} = 1.0 mA)	t _d	–	35	ns
Rise Time		t _r	–	35	ns
Storage Time	(V _{CC} = 3.0 Vdc, I _C = 10 mA, I _{B1} = I _{B2} = 1.0 mA)	t _s	–	225	ns
Fall Time	(V _{CC} = 3.0 Vdc, I _C = 10 mA, I _{B1} = I _{B2} = 1.0 mA)	t _f	–	75	ns

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

ORDERING INFORMATION

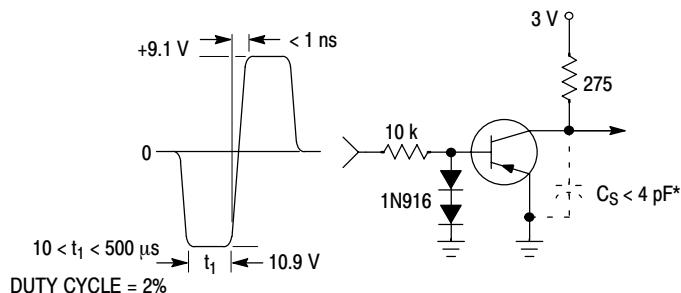
Device	Package	Shipping [†]
2N3906	TO-92	5000 Units / Bulk
2N3906G	TO-92 (Pb-Free)	5000 Units / Bulk
2N3906RL1	TO-92	5000 Units / Bulk
2N3906RL1G	TO-92 (Pb-Free)	5000 Units / Bulk
2N3906RLRA	TO-92	2000 / Tape & Reel
2N3906RLRAG	TO-92 (Pb-Free)	2000 / Tape & Reel
2N3906RLRM	TO-92	2000 / Ammo Pack
2N3906RLRMG	TO-92 (Pb-Free)	2000 / Ammo Pack
2N3906RLRP	TO-92	2000 / Tape & Reel
2N3906RLRPG	TO-92 (Pb-Free)	2000 / Tape & Reel

[†]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.



* Total shunt capacitance of test jig and connectors

Figure 1. Delay and Rise Time Equivalent Test Circuit



* Total shunt capacitance of test jig and connectors

Figure 2. Storage and Fall Time Equivalent Test Circuit

TYPICAL TRANSIENT CHARACTERISTICS

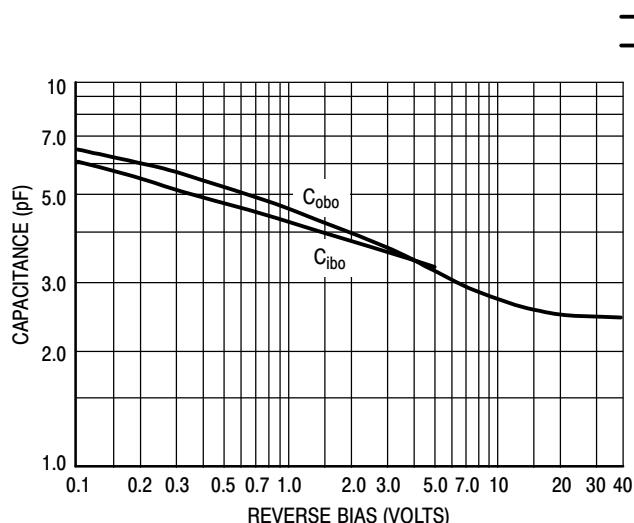


Figure 3. Capacitance

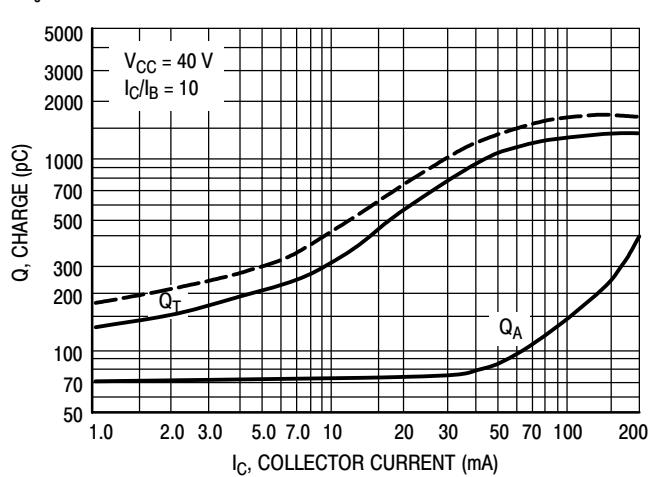


Figure 4. Charge Data

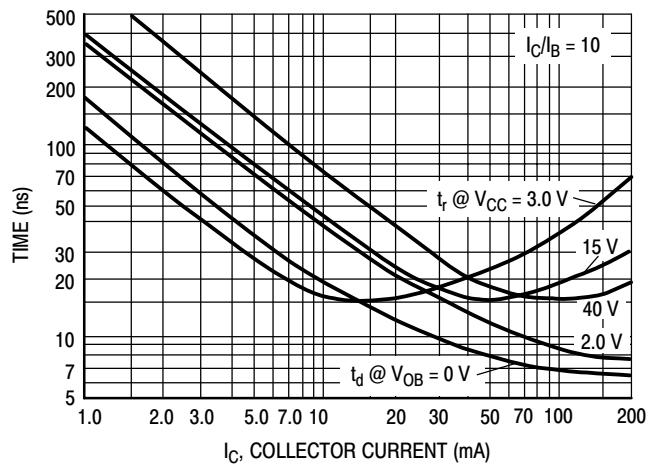


Figure 5. Turn-On Time

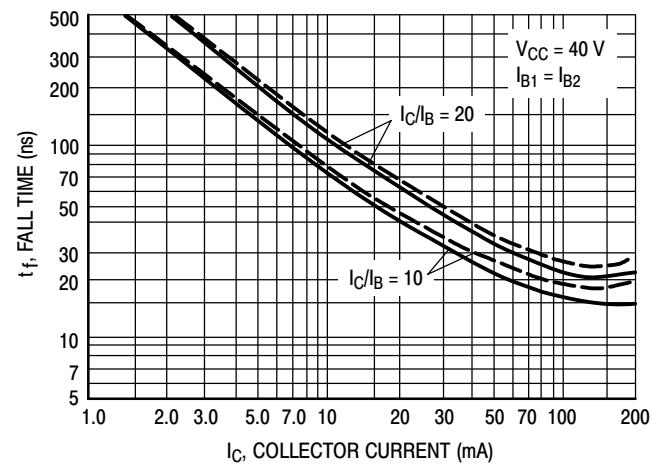


Figure 6. Fall Time

TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

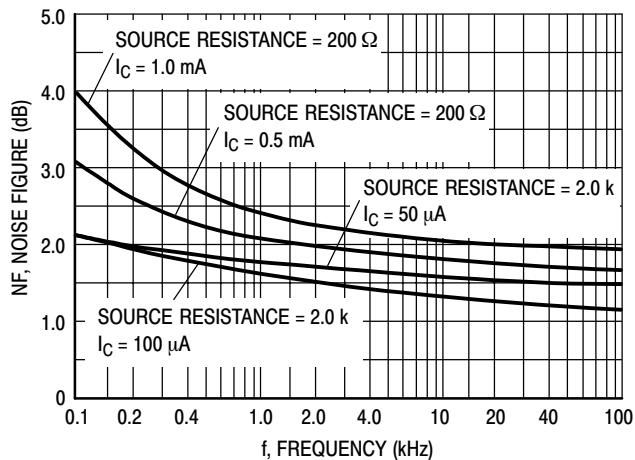


Figure 7.

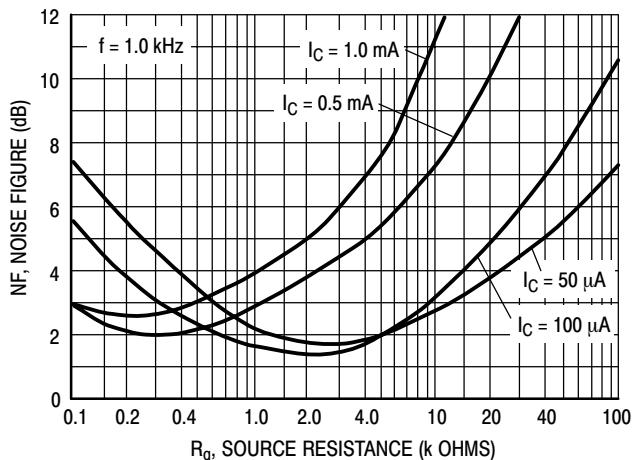


Figure 8.

h PARAMETERS

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

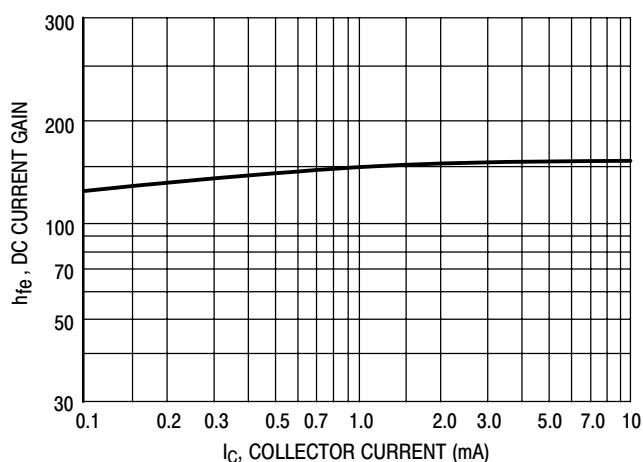


Figure 9. Current Gain

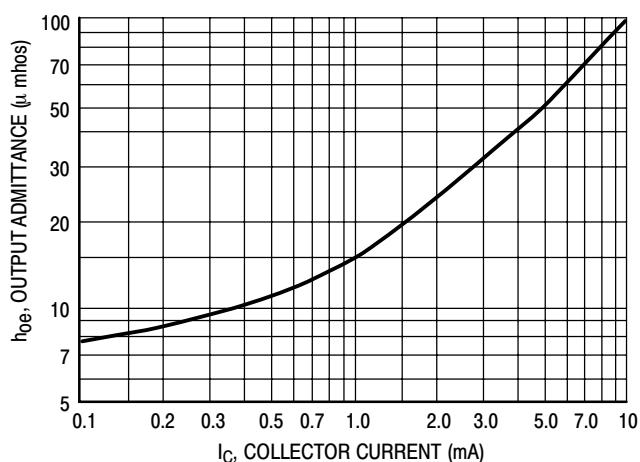


Figure 10. Output Admittance

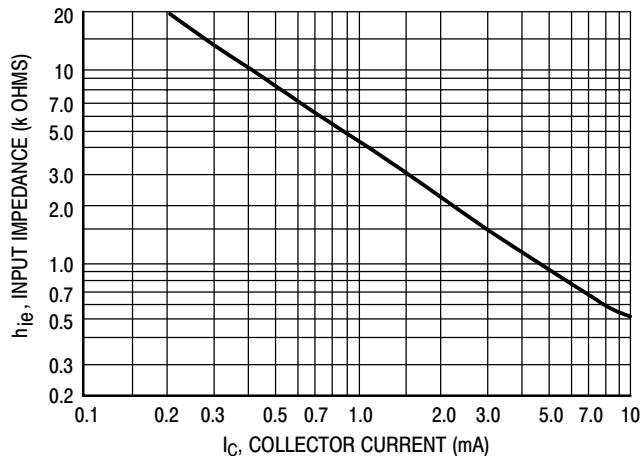


Figure 11. Input Impedance

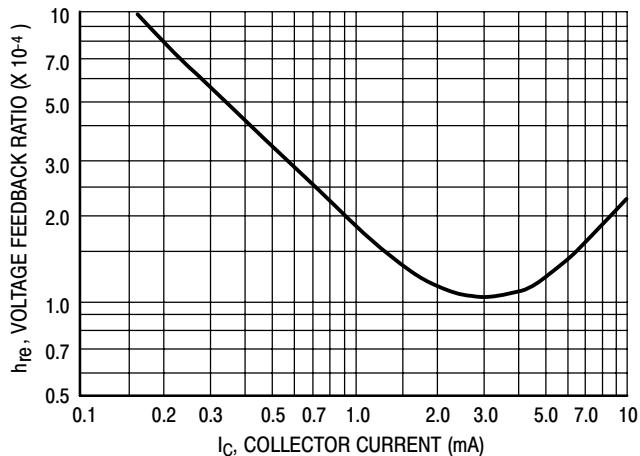


Figure 12. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

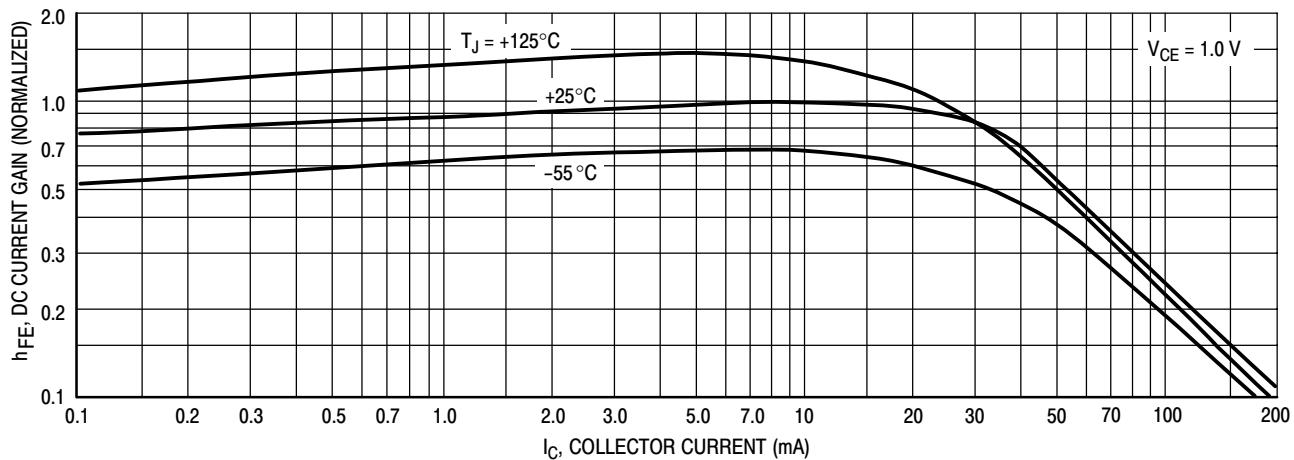


Figure 13. DC Current Gain

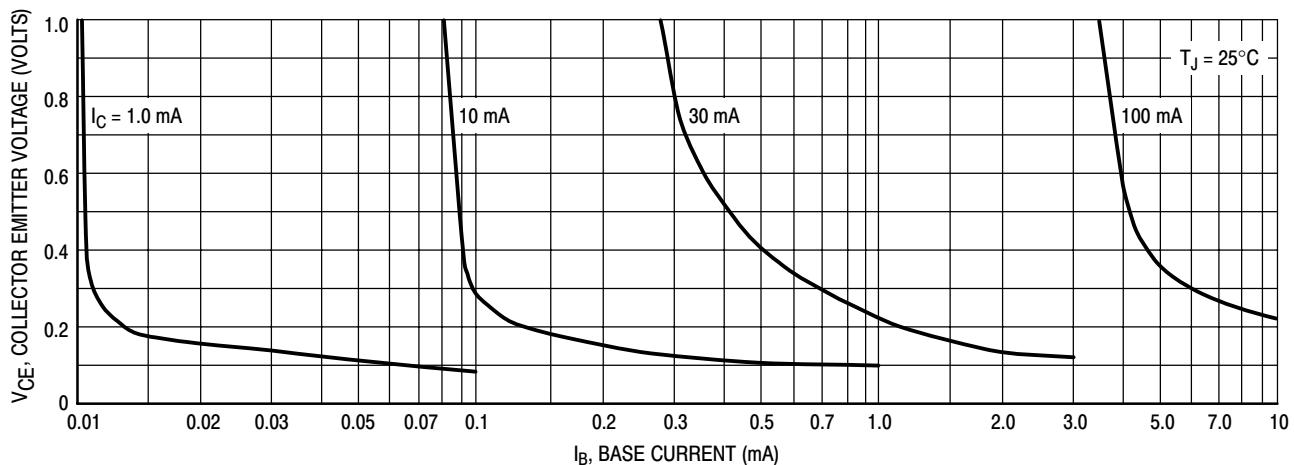


Figure 14. Collector Saturation Region

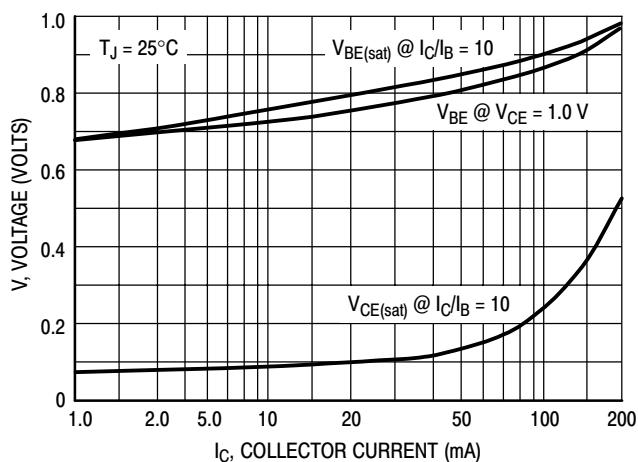


Figure 15. "ON" Voltages

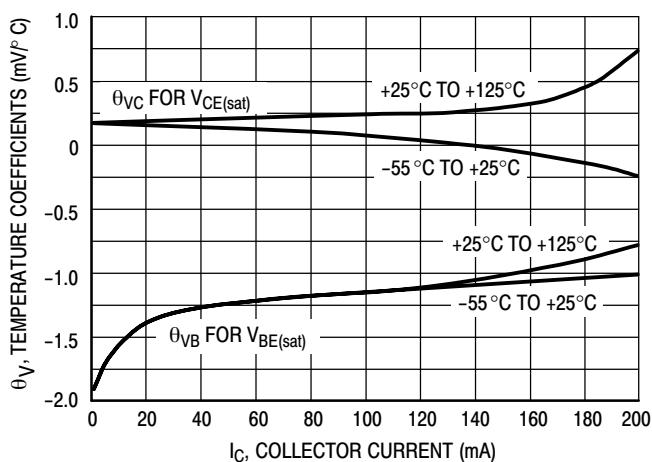
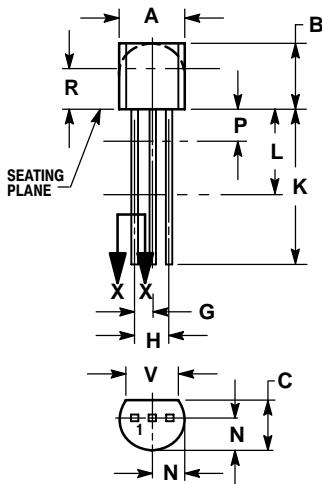
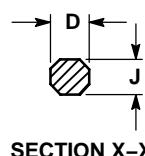


Figure 16. Temperature Coefficients

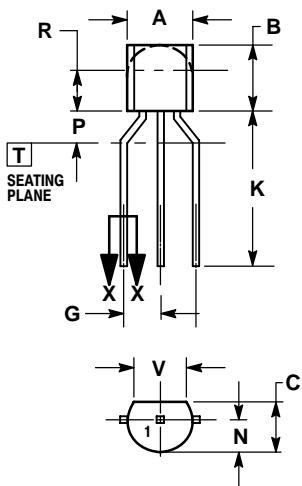
PACKAGE DIMENSIONS

TO-92 (TO-226)
CASE 29-11
ISSUE AM

STRAIGHT LEAD BULK PACK



BENT LEAD TAPE & REEL AMMO PACK



SECTION X-X

NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.021	0.407	0.533
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	---	12.70	---
L	0.250	---	6.35	---
N	0.080	0.105	2.04	2.66
P	---	0.100	---	2.54
R	0.115	---	2.93	---
V	0.135	---	3.43	---

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	MILLIMETERS	
	MIN	MAX
A	4.45	5.20
B	4.32	5.33
C	3.18	4.19
D	0.40	0.54
G	2.40	2.80
J	0.39	0.50
K	12.70	---
N	2.04	2.66
P	1.50	4.00
R	2.93	---
V	3.43	---

STYLE 1:
PIN 1. Emitter
2. Base
3. Collector

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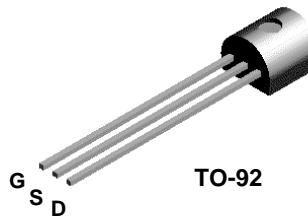
Phone: 81-3-5773-3850

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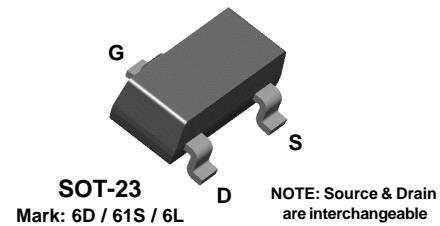
For additional information, please contact your local
Sales Representative



**2N5457
2N5458
2N5459**



**MMBF5457
MMBF5458
MMBF5459**



N-Channel General Purpose Amplifier

This device is a low level audio amplifier and switching transistors, and can be used for analog switching applications. Sourced from Process 55.

Absolute Maximum Ratings*

TA = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{DG}	Drain-Gate Voltage	25	V
V_{GS}	Gate-Source Voltage	- 25	V
I_{GF}	Forward Gate Current	10	mA
T_J, T_{stg}	Operating and Storage Junction Temperature Range	-55 to +150	°C

* These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

NOTES:

- 1) These ratings are based on a maximum junction temperature of 150 degrees C.
- 2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Thermal Characteristics

TA = 25°C unless otherwise noted

Symbol	Characteristic	Max		Units
		2N5457-5459	*MMBF5457-5459	
P_D	Total Device Dissipation Derate above 25°C	625 5.0	350 2.8	mW mW/°C
$R_{\theta JC}$	Thermal Resistance, Junction to Case	125		°C/W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	357	556	°C/W

* Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06."

N-Channel General Purpose Amplifier

(continued)

Electrical Characteristics

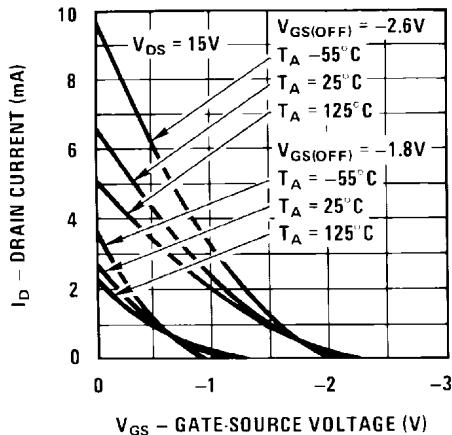
TA = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units	
OFF CHARACTERISTICS							
V _{(BR)GSS}	Gate-Source Breakdown Voltage	I _G = 10 µA, V _{DS} = 0	- 25			V	
I _{GSS}	Gate Reverse Current	V _{GS} = -15 V, V _{DS} = 0 V _{GS} = -15 V, V _{DS} = 0, T _A = 100°C			- 1.0 - 200	nA nA	
V _{GS(off)}	Gate-Source Cutoff Voltage	V _{DS} = 15 V, I _D = 10 nA	5457	- 0.5	- 6.0	V	
			5458	- 1.0	- 7.0	V	
			5459	- 2.0	- 8.0	V	
V _{GS}	Gate-Source Voltage	V _{DS} = 15 V, I _D = 100 µA V _{DS} = 15 V, I _D = 200 µA V _{DS} = 15 V, I _D = 400 µA	5457 5458 5459		- 2.5 - 3.5 - 4.5	V V V	
ON CHARACTERISTICS							
I _{DSS}	Zero-Gate Voltage Drain Current*	V _{DS} = 15 V, V _{GS} = 0	5457 5458 5459	1.0 2.0 4.0	3.0 6.0 9.0	5.0 9.0 16	mA mA mA
SMALL SIGNAL CHARACTERISTICS							
g _{fs}	Forward Transfer Conductance*	V _{DS} = 15 V, V _{GS} = 0, f = 1.0 kHz	5457 5458 5459	1000 1500 2000		5000 5500 6000	µmhos µmhos µmhos
g _{os}	Output Conductance*	V _{DS} = 15 V, V _{GS} = 0, f = 1.0 kHz			10	50	µmhos
C _{iss}	Input Capacitance	V _{DS} = 15 V, V _{GS} = 0, f = 1.0 MHz			4.5	7.0	pF
C _{rss}	Reverse Transfer Capacitance	V _{DS} = 15 V, V _{GS} = 0, f = 1.0 MHz			1.5	3.0	pF
NF	Noise Figure	V _{DS} = 15 V, V _{GS} = 0, f = 1.0 kHz, R _G = 1.0 megohm, BW = 1.0 Hz				3.0	dB

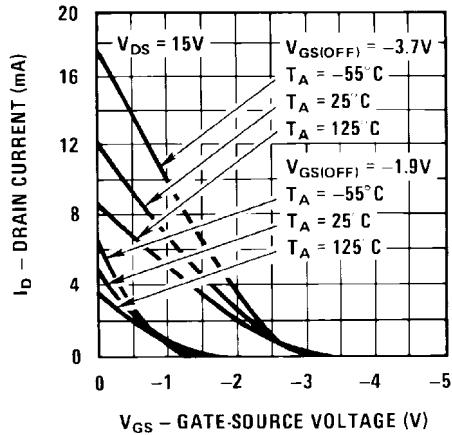
*Pulse Test: Pulse Width \leq 300 ms, Duty Cycle \leq 2%

Typical Characteristics

Transfer Characteristics



Transfer Characteristics

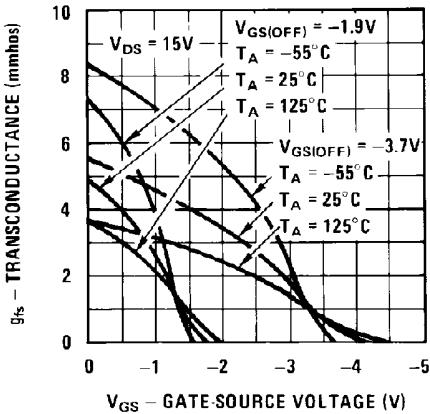


N-Channel General Purpose Amplifier

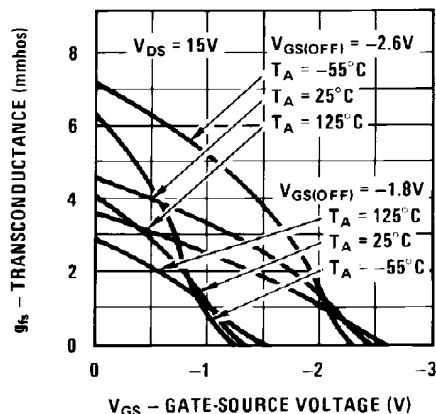
(continued)

Typical Characteristics (continued)

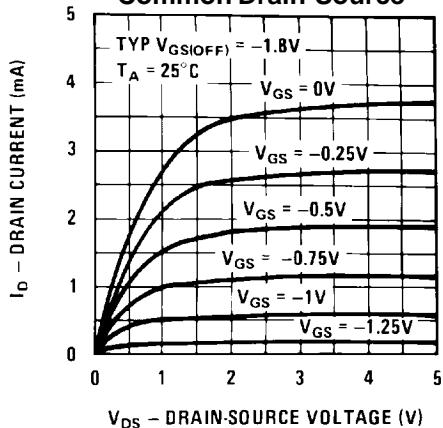
Transfer Characteristics



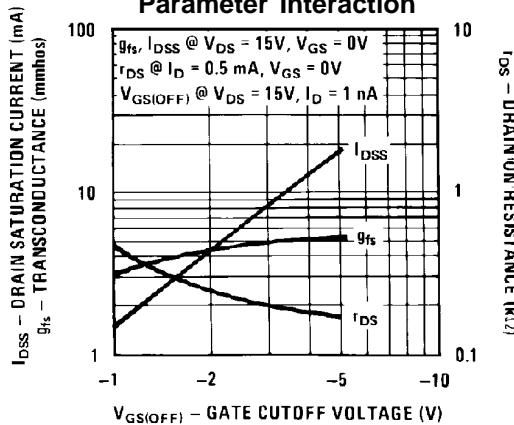
Transfer Characteristics



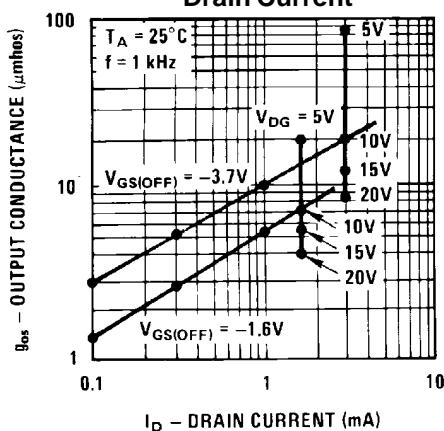
Common Drain-Source



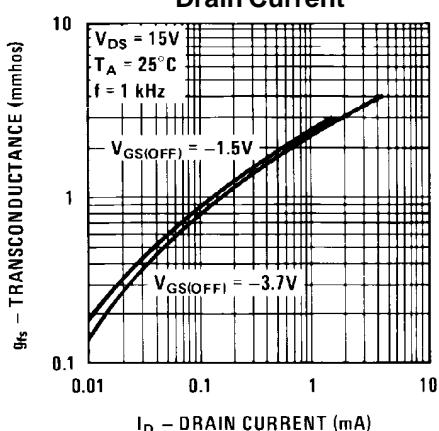
Parameter Interaction



Output Conductance vs. Drain Current



Transconductance vs. Drain Current

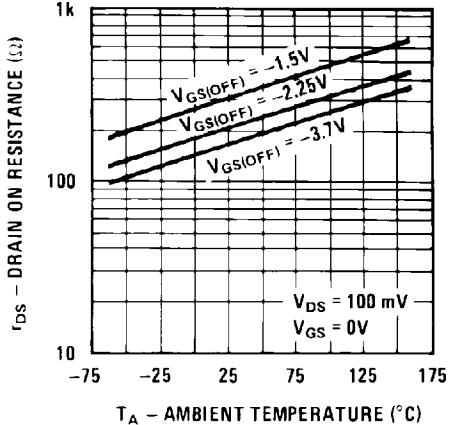


N-Channel General Purpose Amplifier

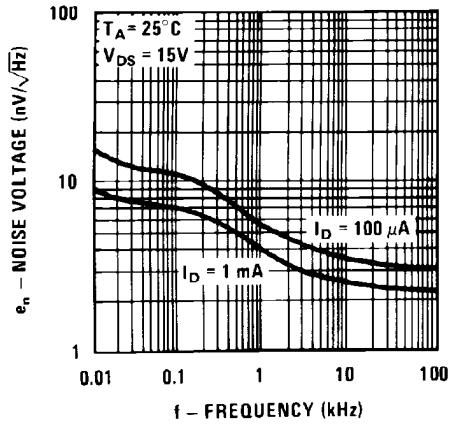
(continued)

Typical Characteristics (continued)

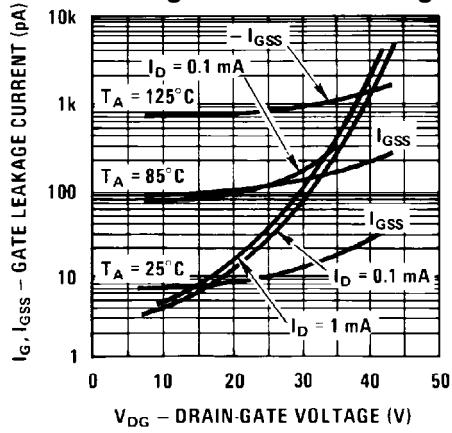
Channel Resistance vs. Temperature



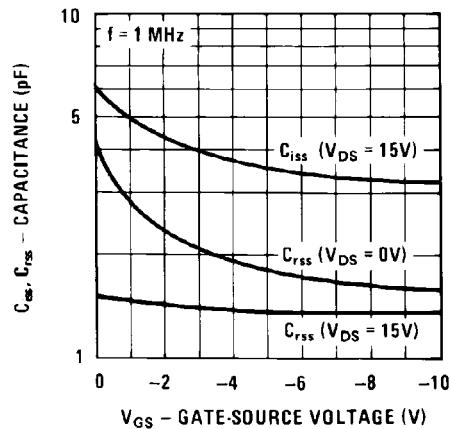
Noise Voltage vs. Frequency



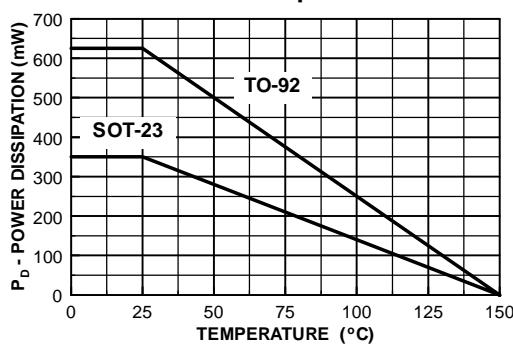
Leakage Current vs. Voltage



Capacitance vs. Voltage



Power Dissipation vs. Ambient Temperature



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PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

2N7000

Preferred Device

Small Signal MOSFET 200 mAmps, 60 Volts N-Channel TO-92

Features

- AEC Qualified
- PPAP Capable
- Pb-Free Packages are Available*

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage ($R_{GS} = 1.0 \text{ M}\Omega$)	V_{DGR}	60	Vdc
Gate-Source Voltage - Continuous - Non-repetitive ($t_p \leq 50 \mu\text{s}$)	V_{GS} V_{GSM}	± 20 ± 40	Vdc Vpk
Drain Current - Continuous - Pulsed	I_D I_{DM}	200 500	mAdc
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Operating and Storage Temperature Range	T_J , T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$
Maximum Lead Temperature for Soldering Purposes, 1/16" from case for 10 seconds	T_L	300	$^\circ\text{C}$

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.



ON Semiconductor®

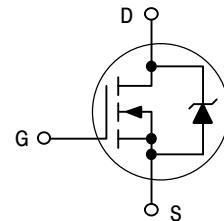
<http://onsemi.com>

200 mAMPS

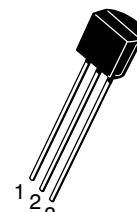
60 VOLTS

$R_{DS(on)} = 5 \Omega$

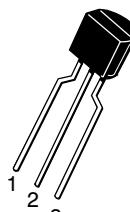
N-Channel



TO-92
CASE 29
STYLE 22

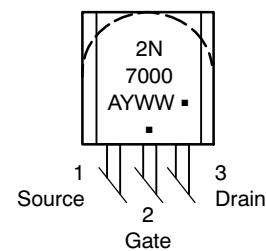


STRAIGHT LEAD
BULK PACK



BENT LEAD
TAPE & REEL
AMMO PACK

MARKING DIAGRAM AND PIN ASSIGNMENT



A = Assembly Location
Y = Year
WW = Work Week
▪ = Pb-Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 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.

2N7000

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V _{GS} = 0, I _D = 10 µAdc)	V _{(BR)DSS}	60	-	Vdc
Zero Gate Voltage Drain Current (V _{DS} = 48 Vdc, V _{GS} = 0) (V _{DS} = 48 Vdc, V _{GS} = 0, T _J = 125°C)	I _{DSS}	-	1.0 1.0	µAdc mAdc
Gate-Body Leakage Current, Forward (V _{GSF} = 15 Vdc, V _{DS} = 0)	I _{GSSF}	-	-10	nAdc

ON CHARACTERISTICS (Note 1)

Gate Threshold Voltage (V _{DS} = V _{GS} , I _D = 1.0 mA)	V _{GS(th)}	0.8	3.0	Vdc
Static Drain-Source On-Resistance (V _{GS} = 10 Vdc, I _D = 0.5 Adc) (V _{GS} = 4.5 Vdc, I _D = 75 mA)	r _{DS(on)}	- -	5.0 6.0	Ω
Drain-Source On-Voltage (V _{GS} = 10 Vdc, I _D = 0.5 Adc) (V _{GS} = 4.5 Vdc, I _D = 75 mA)	V _{DS(on)}	- -	2.5 0.45	Vdc
On-State Drain Current (V _{GS} = 4.5 Vdc, V _{DS} = 10 Vdc)	I _{d(on)}	75	-	mA
Forward Transconductance (V _{DS} = 10 Vdc, I _D = 200 mA)	g _{fs}	100	-	µmhos

DYNAMIC CHARACTERISTICS

Input Capacitance	(V _{DS} = 25 V, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	-	60	pF
Output Capacitance		C _{oss}	-	25	
Reverse Transfer Capacitance		C _{rss}	-	5.0	

SWITCHING CHARACTERISTICS (Note 1)

Turn-On Delay Time	(V _{DD} = 15 V, I _D = 500 mA, R _G = 25 Ω, R _L = 30 Ω, V _{gen} = 10 V)	t _{on}	-	10	ns
Turn-Off Delay Time		t _{off}	-	10	

1. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

ORDERING INFORMATION

Device	Package	Shipping [†]
2N7000	TO-92	1000 Units / Bulk
2N7000G	TO-92 (Pb-Free)	1000 Units / Bulk
2N7000RLRA	TO-92	2000 Tape & Reel
2N7000RLRAG	TO-92 (Pb-Free)	2000 Tape & Reel
2N7000RLRMG	TO-92 (Pb-Free)	2000 Tape & Ammo Box
2N7000RLRPG	TO-92 (Pb-Free)	2000 Tape & Ammo Box

[†]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.

2N7000

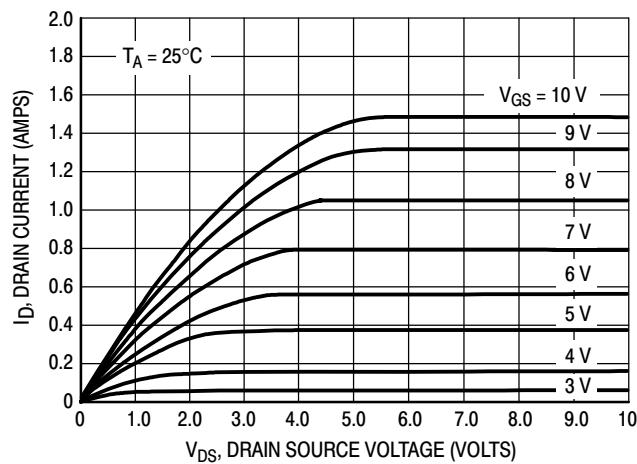


Figure 1. Ohmic Region

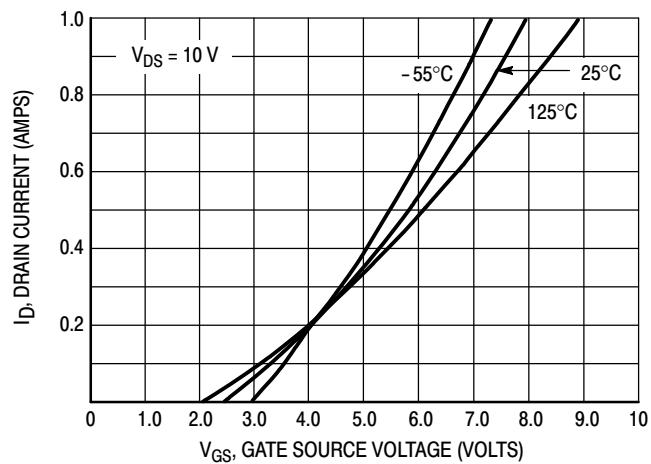


Figure 2. Transfer Characteristics

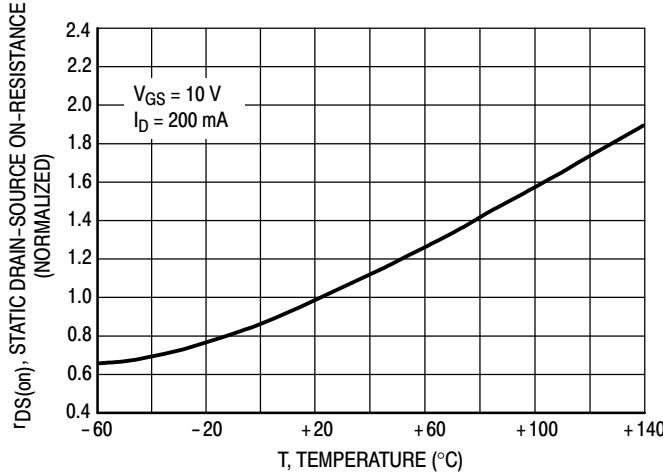


Figure 3. Temperature versus Static Drain-Source On-Resistance

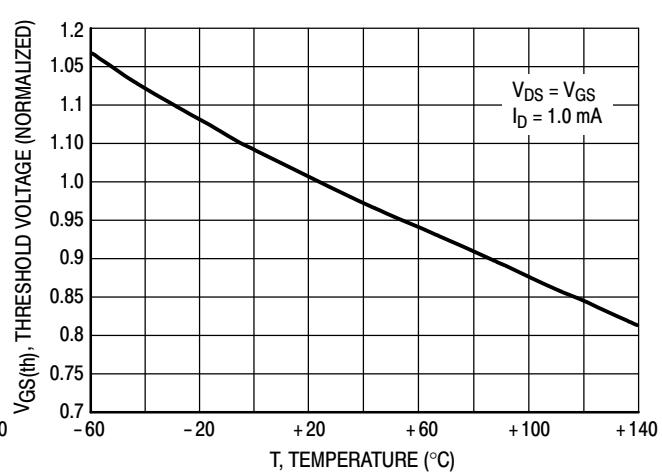
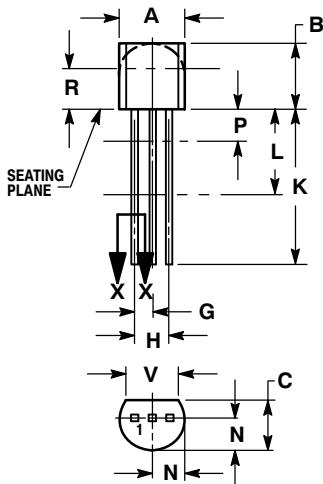


Figure 4. Temperature versus Gate Threshold Voltage

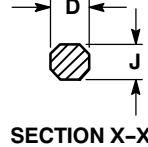
PACKAGE DIMENSIONS

TO-92 (TO-226)
CASE 29-11
ISSUE AMSTRAIGHT LEAD
BULK PACK

NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.021	0.407	0.533
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	---	12.70	---
L	0.250	---	6.35	---
N	0.080	0.105	2.04	2.66
P	---	0.100	---	2.54
R	0.115	---	2.93	---
V	0.135	---	3.43	---

BENT LEAD
TAPE & REEL
AMMO PACK

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	MILLIMETERS	
	MIN	MAX
A	4.45	5.20
B	4.32	5.33
C	3.18	4.19
D	0.40	0.54
G	2.40	2.80
J	0.39	0.50
K	12.70	---
N	2.04	2.66
P	1.50	4.00
R	2.93	---
V	3.43	---

STYLE 2:
 PIN 1. SOURCE
 2. GATE
 3. DRAIN

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