2N2857

The RF Line

NPN SILICON
RF SMALL-SIGNAL
TRANSISTORS

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

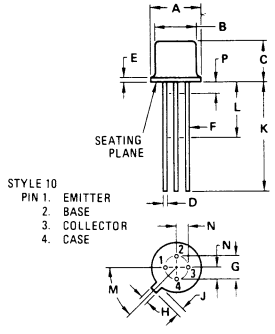
- High Current-Gain–Bandwidth Product – f_T = 1.6 GHz (Typ) @ I_C = 8.0 mAdc
- Low Collector-Base Time Constant – $r_b'C_c$ = 15 ps (Max) @ I_E = 2.0 mAdc
- Characterized with Scattering Parameters
- Ideal for Micro-Power Applications

3

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current – Continuous	I_C	40	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.72	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage** (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	–	150	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product ① (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	1000	–	1900	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	–	0.7	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	50	–	220	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$r_b'C_c$	4.0	–	15	ps
Noise Figure (Figure 1)	NF				dB
(I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, R_S = 50 ohms, f = 450 MHz) ②		–	5.8	–	
(I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 450 MHz)		–	4.1	4.5	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1)	G_{pe}				dB
(I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, f = 450 MHz) ②		–	11	–	
(I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)		12.5	–	19	
Power Output (Figure 2) (I_E = 12 mAdc, V_{CB} = 10 Vdc, f = 500 MHz)	P_{out}	30	–	–	mW

*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to JEDEC Registered Data.
① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
② Micro-Power Specifications.

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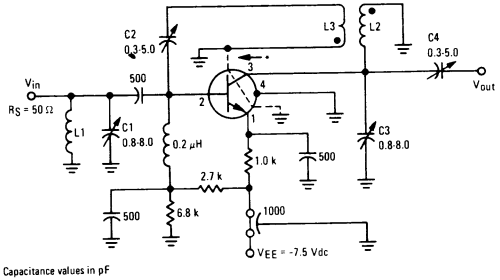
FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

* – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

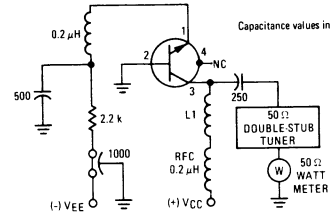
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 2 – TEST CIRCUIT FOR OSCILLATOR POWER OUTPUT



L1 – 3 turns #16 AWG wire, 3/8" O.D. 1-1/4" long.

FIGURE 3 – NOISE FIGURE versus FREQUENCY

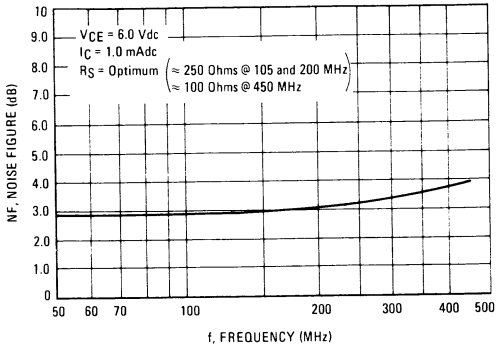


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

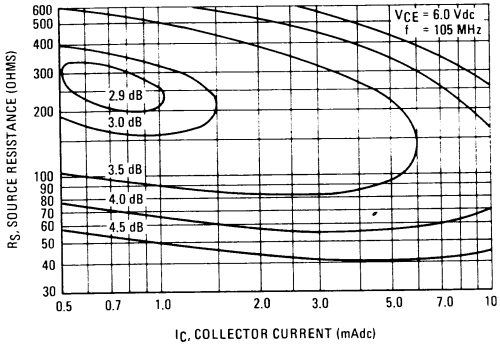


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

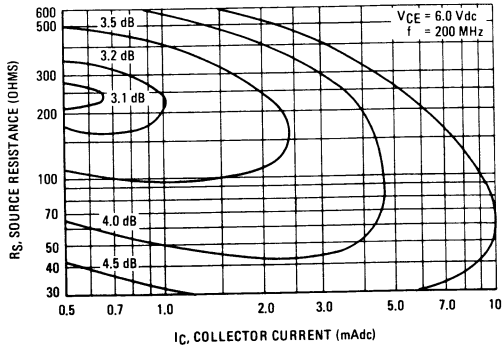


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

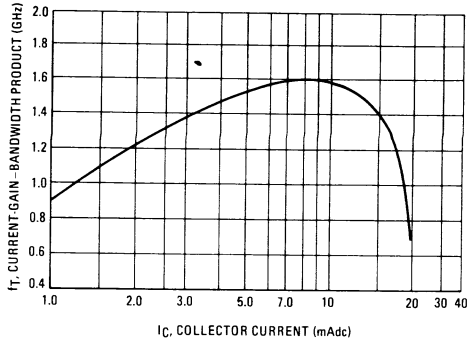


FIGURE 7 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

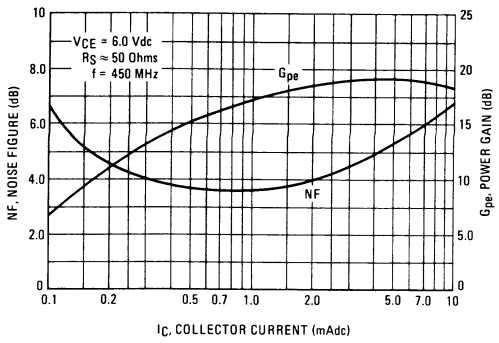


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

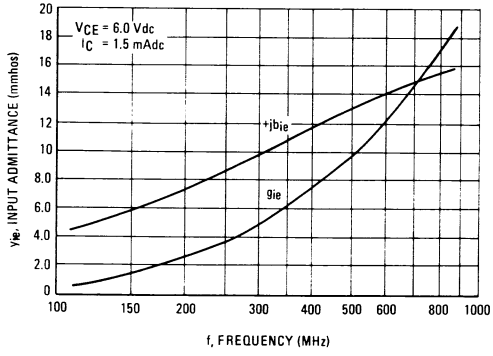


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

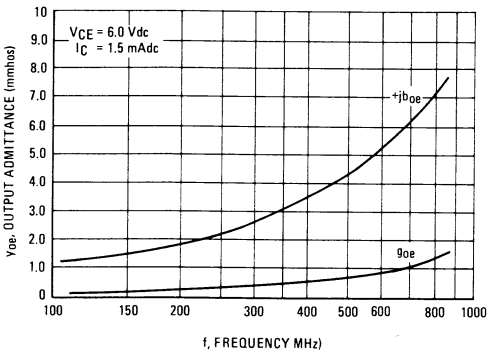


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

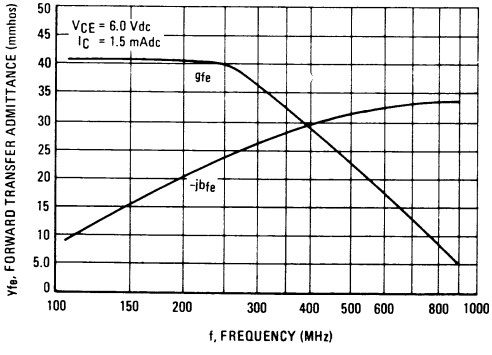


FIGURE 11 –REVERSE TRANSFER ADMITTANCE versus FREQUENCY

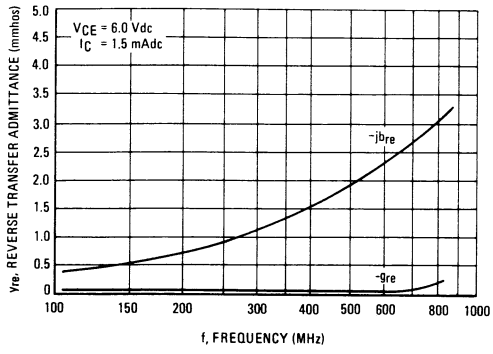


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FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

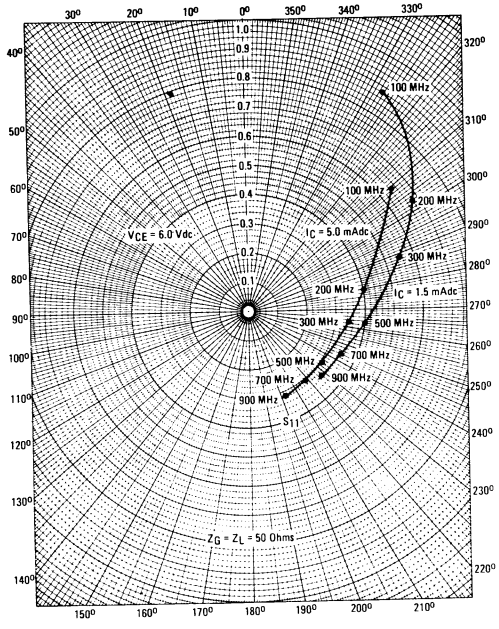


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

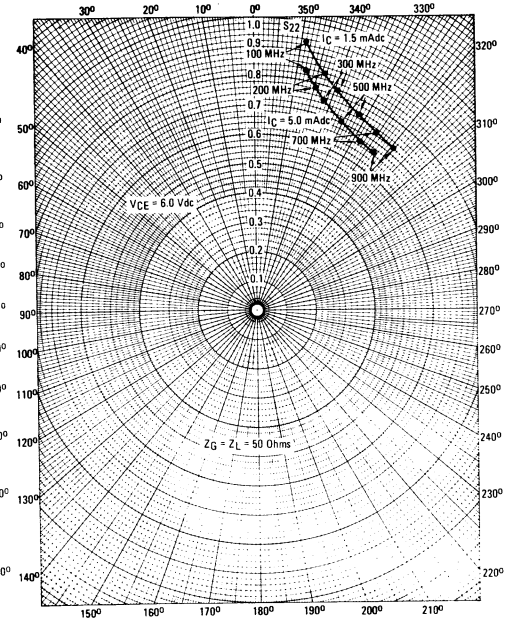


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

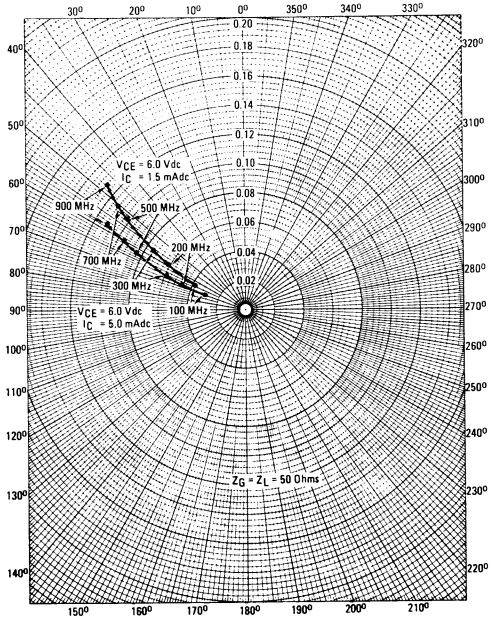


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

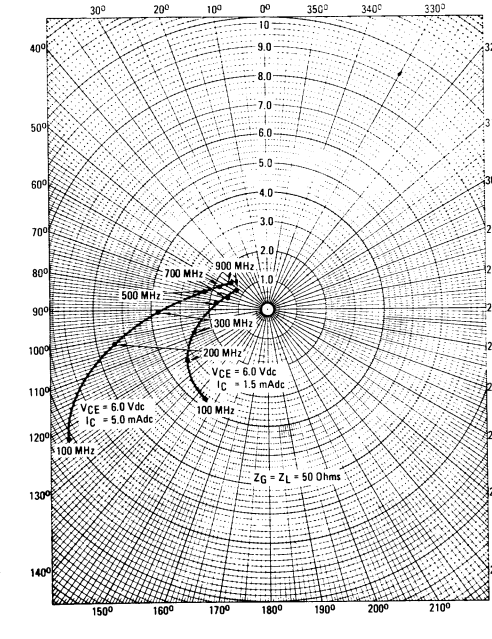
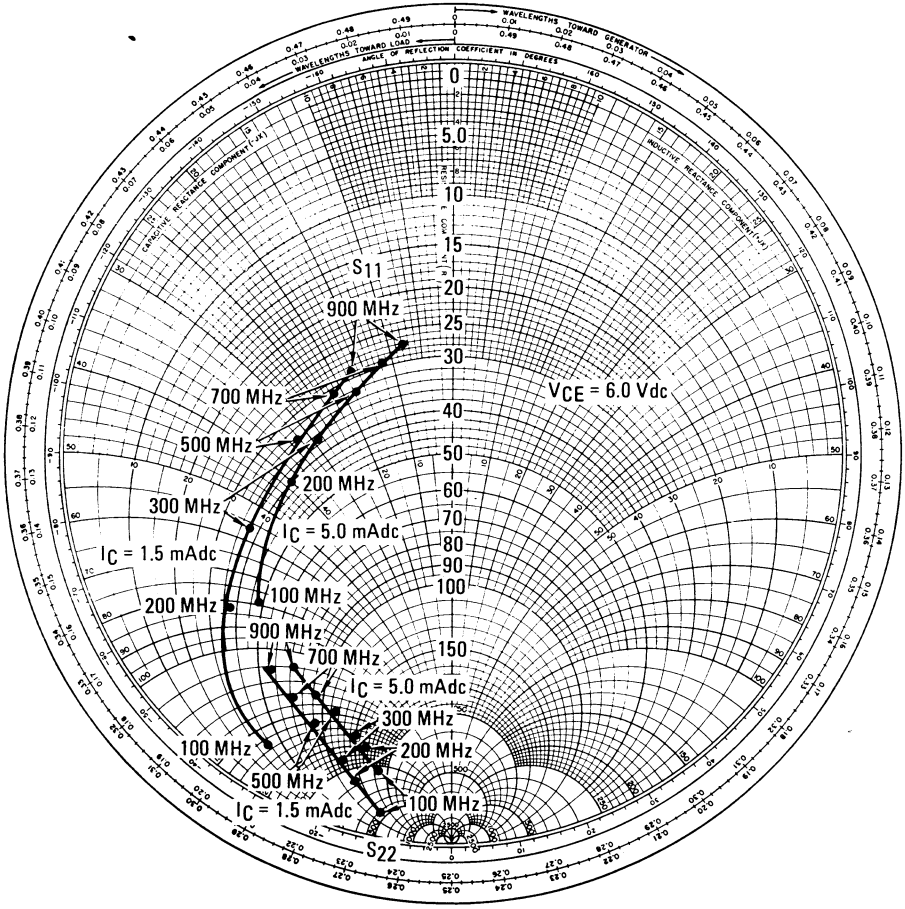


FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N3553

The RF Line

NPN SILICON HIGH-FREQUENCY TRANSISTOR

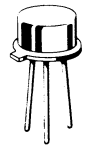
. . . designed for amplifier and oscillator applications in military and industrial equipment. Suitable for use as output, driver or pre-driver stages in VHF equipment.

- Specified 175 MHz, 28 Vdc Characteristics –
  Output Power = 2.5 Watts
  Minimum Gain = 10 dB
  Efficiency = 50%

2.5 W – 175 MHz

HIGH FREQUENCY TRANSISTOR

NPN SILICON



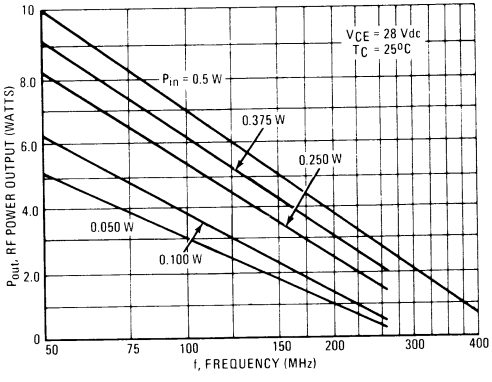
3

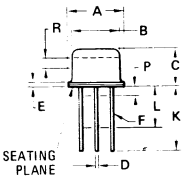
***MAXIMUM RATINGS**

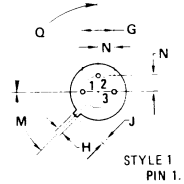
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	7.0 40	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.

FIGURE 1 – OUTPUT POWER versus FREQUENCY







STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

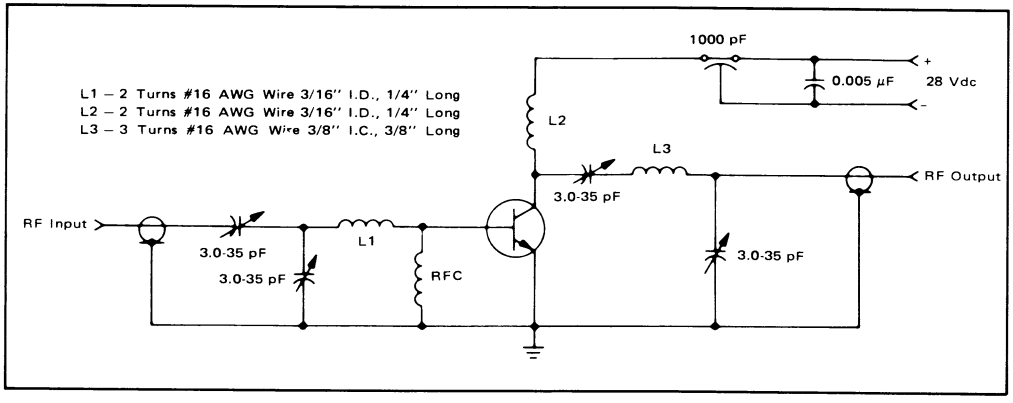
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{(BR)CEO(sus)}$	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	–	0.1	mAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 200°C) (V_{CE} = 65 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{CEX}	– –	– –	5.0 1.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–	–
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	–	500	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	8.0	10	pF
FUNCTIONAL TESTS					
Power Input (V_{CE} = 28 Vdc, P_{out} = 2.5 Watts, f = 175 MHz)	P_{in}	–	–	0.25	Watt
Common-Emitter Amplifier Power Gain (V_{CE} = 28 Vdc, P_{out} = 2.5 Watts, f = 175 MHz)	G_{pe}	10	–	–	dB
Collector Efficiency (V_{CE} = 28 Vdc, P_{out} = 2.5 Watts, f = 175 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data

(1) Pulsed thru a 25 mH inductor.

FIGURE 2 – 175 MHz TEST CIRCUIT SCHEMATIC



2N3866
2N3866A

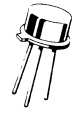
The RF Line

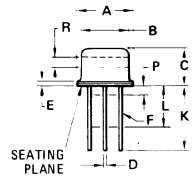
1.0 W — 400 MHz
HIGH FREQUENCY TRANSISTOR
NPN SILICON

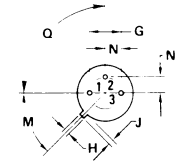
NPN SILICON HIGH FREQUENCY TRANSISTOR

. . . designed for amplifier and oscillator applications in military and industrial equipment. Suitable for use as output, driver or pre-driver stages in VHF and UHF equipment.

- Specified 400 MHz, 28 Vdc Characteristics —
  Output Power = 1.0 Watt
  Minimum Gain = 10 dB
  Efficiency = 45%
- Large Signal Series Equivalent Impedances
- S-Parameter Characterization







DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79-02
TO-39

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate Above 25^oC	P_D	5.0 28.6	Watts $mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

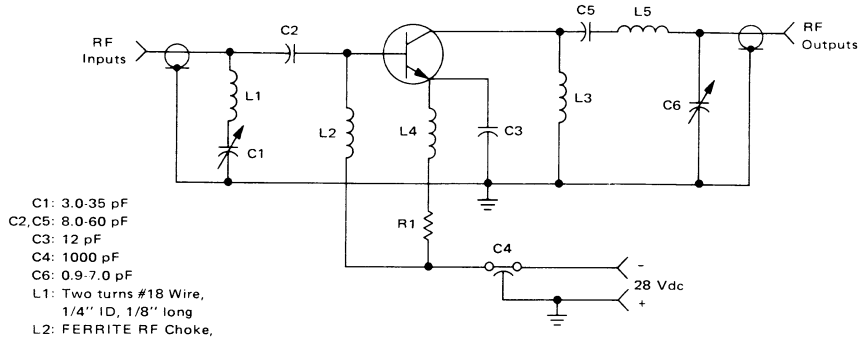
*Indicates JEDEC Registered Data

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{CEO(sus)}$	30	—	Vdc
Collector-Base Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ω)		$V_{CER(sus)}$	55	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)		I_{CEO}	—	0.02	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)		I_{EBO}	—	0.1	mAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = −1.5 Vdc (Rev.), T_C = 200°C)		I_{CEX}	—	5.0	mAdc
(V_{CE} = 55 Vdc, V_{BE} = −1.5 Vdc (Rev.)			—	0.1	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	Both		5.0	—	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	2N3866		10	200	
	2N3866A		25	200	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	2N3866		500	—	
	2N3866A		800	—	
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	—	3.0	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)		G_{PE}	10	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)		η	45	—	%

*Indicates JEDEC Registered Data.

FIGURE 1 – 400 MHz TEST CIRCUIT SCHEMATIC



C1: 3.0-35 pF
C2,C5: 8.0-60 pF
C3: 12 pF
C4: 1000 pF
C6: 0.9-7.0 pF
L1: Two turns #18 Wire, 1/4" ID, 1/8" long
L2: FERRITE RF Choke, One Turn, z = 450 Ohms
L3,L4: RF Choke, 0.1 μH
L5: 2-3/4 Turns, #18 Wire, 1/4" ID, 3/16" long
R1: 5.6 Ohms

FIGURE 2 -- POWER OUTPUT versus FREQUENCY (Class C)

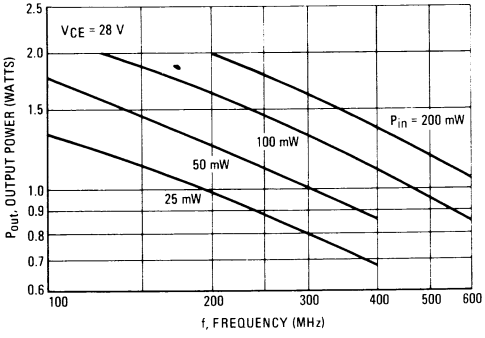


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

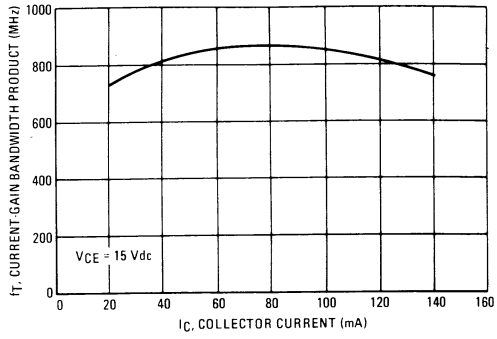


FIGURE 4 – COLLECTOR-BASE TIME CONSTANT

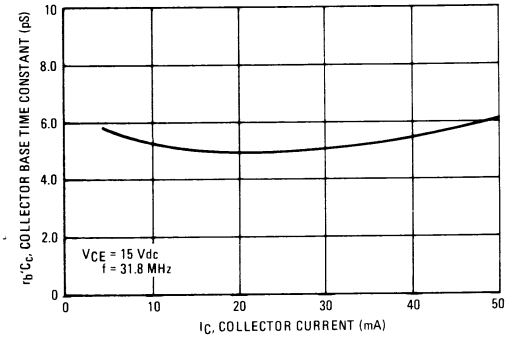


FIGURE 5 – OUTPUT CAPACITANCE

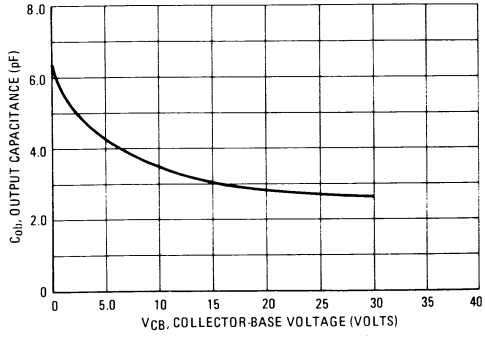


FIGURE 6 – OUTPUT POWER versus INPUT POWER (CLASS C)

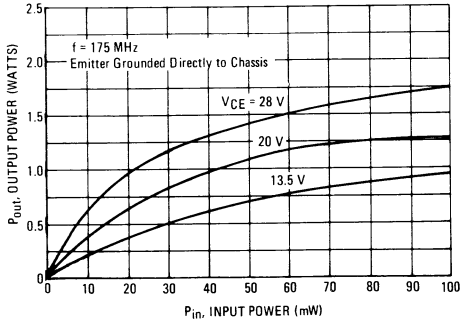


FIGURE 7 – SMALL-SIGNAL CURRENT GAIN

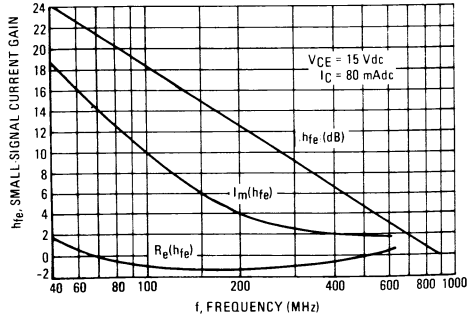


FIGURE 8 – LARGE-SIGNAL SERIES EQUIVALENT IMPEDANCES

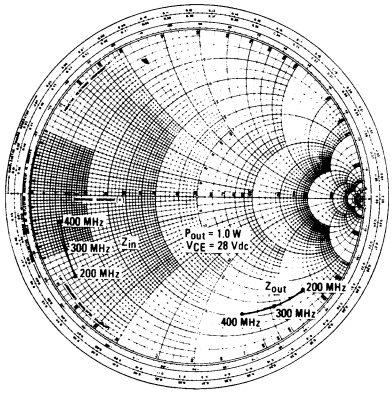


FIGURE 9 – S_{11} AND S_{22} versus FREQUENCY

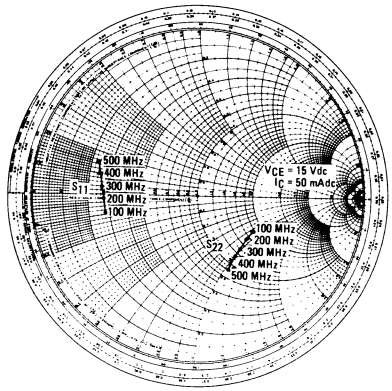


FIGURE 10 – S_{21} versus FREQUENCY

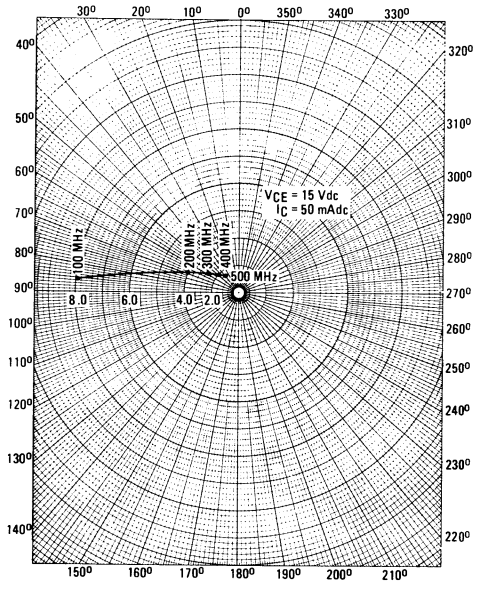
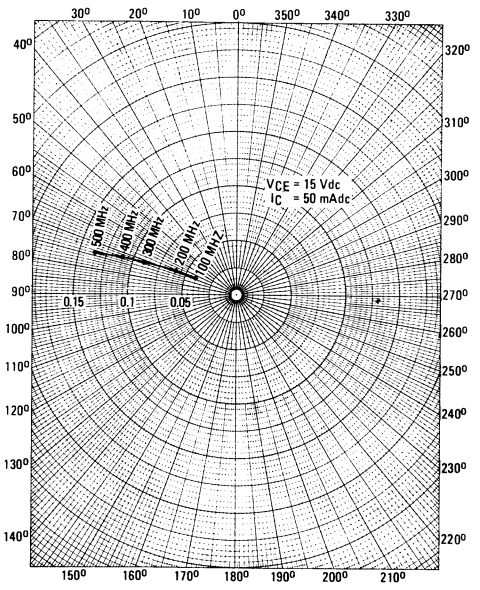


FIGURE 11 – S_{12} versus FREQUENCY



3

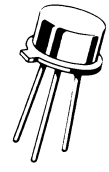
2N3924

NPN SILICON RF POWER TRANSISTORS

. . . optimized Annular* transistor for large-signal power-amplifier and driver applications to 300 MHz.

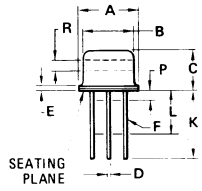
- Designed for 13.6-volt Operation
- Wide choice of min Power Outputs @ 175 MHz
  4 watts — 2N3924
- Multiple-Emitter Construction for Excellent High-Frequency Performance
- Guaranteed Safe Operating Area
  $V_{(BR)CEO(sus)}$ Measured at I_C = 200 mAdc

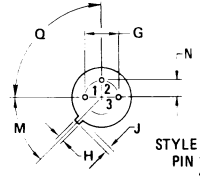
NPN SILICON RF POWER TRANSISTORS



2N3924
(TO-39)

Case 79





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-205AD

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	2N3924	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	0.5	Adc
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

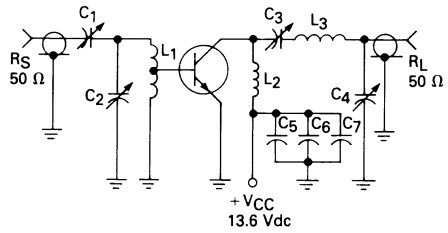
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Figure 2) (I_C = 200 mAdc)	$V_{(BR)CEO(sus)}$*	18	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.25 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	— —	0.1 5.0	mAdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 13.6 Vdc, f = 100 MHz	f_T	—	350	—	MHz
Output Capacitance (V_{CB} = 13.6 Vdc, I_E = 0, f = 100 kHz	C_{ob}	—	12.5	20	pF
FUNCTIONAL TESTS					
Power Input	Test Circuit Figure 1	P_{in}	—	—	1.0	Watt
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	6.0	7.3	—	dB
Collector Efficiency	P_{out} = 4.0 Watts	η	70	—	—	%

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

3

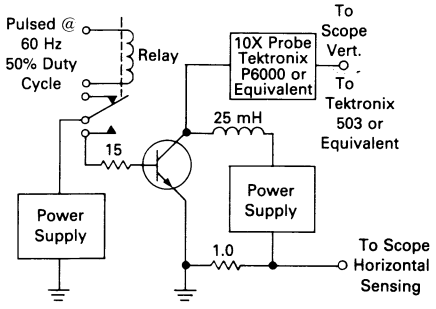
FIGURE 1 — 175 MHz TEST CIRCUIT



C_1, C_2, C_4 ..... 5–50 pF (Air variable)
C_3 .....7–100 pF (Air variable)
C_5 .....470 pF (Disc ceramic)
C_6 .....0.01 μF (Disc ceramic)
C_7 .....0.001 μF (Disc ceramic)

L_1 — 1½ turns #14 AWG tinned wire; ⅜" ID Air wound; winding length 3/16"; base tapped 1 turn from ground
L_2 — RFC
L_3 — 2 turns #14 AWG tinned wire; ¼" ID Air wound; winding length 3/16"

FIGURE 2 — PULSE TEST CIRCUIT



CLASS C DESIGN DATA FOR V_{CE} = 13.6 Vdc, T_C = 25°C

(Emitter Grounded Directly to the Chassis — No Tuned-Emitter Techniques Used)

FIGURE 3 — POWER OUTPUT versus FREQUENCY

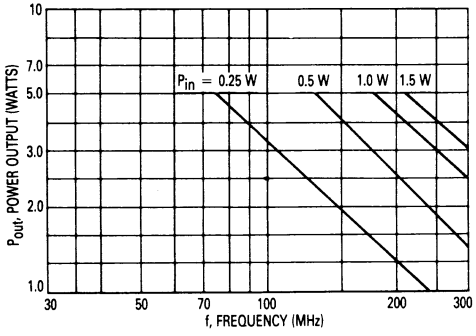


FIGURE 4 — POWER OUTPUT versus POWER INPUT

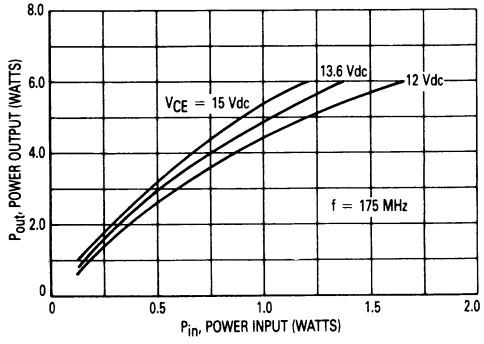


FIGURE 5 — PARALLEL EQUIVALENT INPUT RESISTANCE

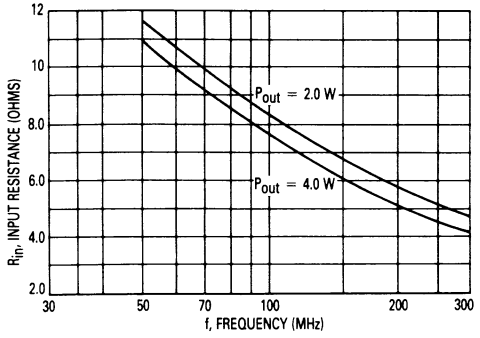


FIGURE 6 — PARALLEL EQUIVALENT INPUT CAPACITANCE

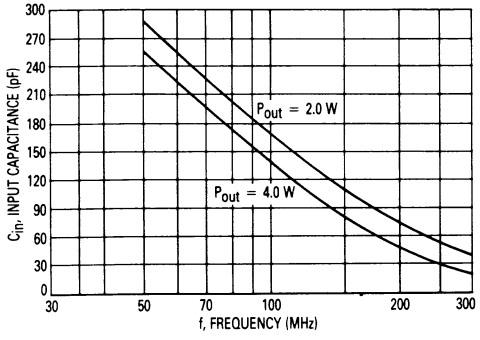
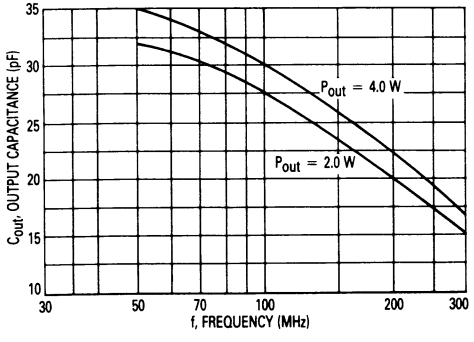


FIGURE 7 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3948

The RF Line

1.0 W – 400 MHz

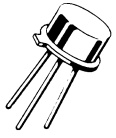
HIGH FREQUENCY TRANSISTOR

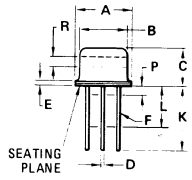
NPN SILICON

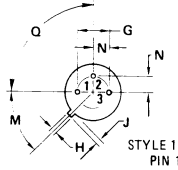
NPN SILICON HIGH-FREQUENCY TRANSISTOR

. . . designed for amplifier applications in industrial and commercial equipment. Suitable for use as output, driver or pre-driver stages in UHF equipment.

- Specified 400 MHz, 13.6 Vdc Characteristics –
  Output Power = 1.0 Watt
  Minimum Gain = 6.0 dB
  Efficiency = 45%







STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current – Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 5.71	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^oC/W$

*Indicates JEDEC Registered Data

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	0.1 100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_E = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	700	–	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	4.5	pF
FUNCTIONAL TEST				
Power Gain	(V_{CC} = 13.6 Vdc, f = 400 MHz, P_{in} = 0.25 W)	G_{pe}	6.0	–	dB
Output Power		P_{out}	1.0	–	Watt
Collector Efficiency		η	45	–	%

*Indicates JEDEC Registered Data

FIGURE 1 – 400 MHz RF AMPLIFIER TEST CIRCUIT

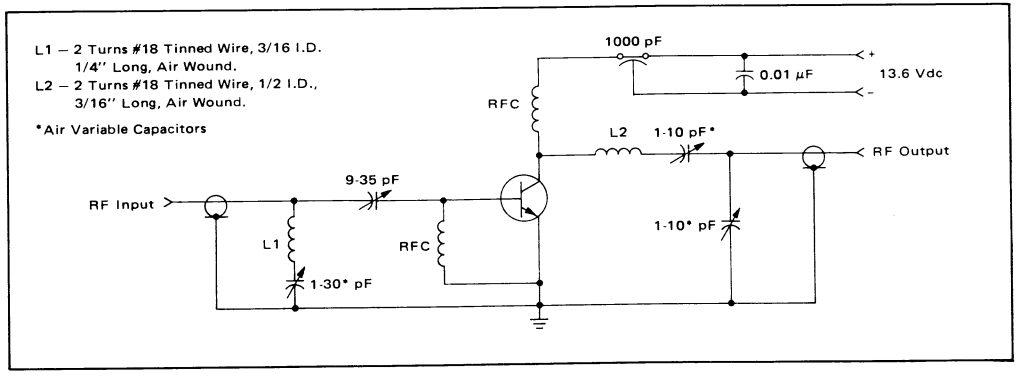


FIGURE 2 – OUTPUT POWER versus FREQUENCY

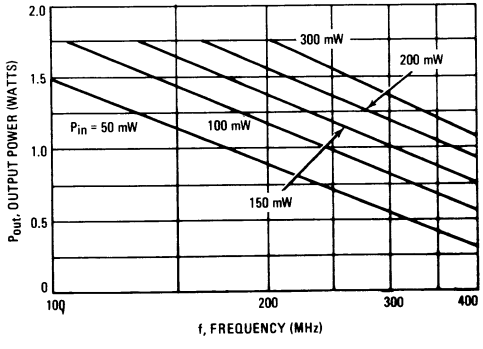
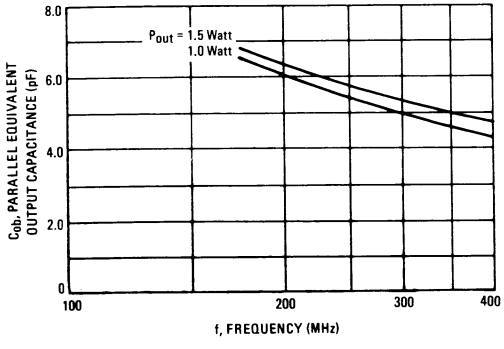


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3959
2N3960

The RF Line

1.8 GHz — 10 mAdc

HIGH FREQUENCY TRANSISTORS

NPN SILICON

NPN SILICON HIGH-FREQUENCY TRANSISTORS

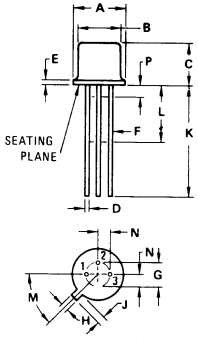
. . . designed for high-speed current-mode logic switching applications.

- High Current-Gain—Bandwidth Product — f_T = 1800 MHz (Typ) @ I_C = 10 mAdc
- Low Input and Output Capacitance — C_{ib} and C_{ob} = 2.5 pF (Max)
- Excellent Current-Mode Performance — t_r = 1.7 ns (Typ) @ I_C = 30 mAdc
- Low Collector-Base Time Constant — $r_b'C_c$ = 25 ps (Max) @ I_C = 10 mAdc — 2N3959

Current-Mode logic operation, because of the absence of storage time, offers improved high-speed performance for digital applications. In addition, the low impedance drive circuit offers improved delay, rise, and fall times.

The basic characteristics of importance in current-mode logic applications are Current-Gain—Bandwidth Product (f_T), Input and Output Capacitance (C_{ib} and C_{ob}), and Base Spreading Resistance (r'_b).

The 2N3959 and 2N3960 offer a combination of extremely high f_T values, low capacitances, and low base spreading resistance which results in exceptionally high speed in current-mode logic circuits.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.3	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	750 4.3	mW mW/°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 Ambient	$R_{\theta JA}$	0.436	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.233	°C/mW

*Indicates JEDEC Registered Data.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

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

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**							
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		–	$V_{(BR)CEO}$	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		–	$V_{(BR)CBO}$	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		–	$V_{(BR)EBO}$	4.5	–	–	Vdc
Collector Reverse Current		–	I_{CEX}				μAdc
(V_{CE} = 10 Vdc, V_{EB} = 2.0 Vdc)				–	–	0.005	
(V_{CE} = 10 Vdc, V_{EB} = 2.0 Vdc, T_A = 150°C)				–	–	5.0	
Base Cutoff Current (V_{CE} = 10 Vdc, V_{EB} = 2.0 Vdc)		–	I_{BL}	–	–	0.005	μAdc
Collector Forward Current (V_{CE} = 5.0 Vdc, V_{BE} = 0.4 Vdc)		–	I_{CEX}	–	–	1.0	μAdc
***ON CHARACTERISTICS**							
DC Current Gain		1	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)				25	–	–	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)				40	–	400	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)				25	–	–	
Collector-Emitter Saturation Voltage		–	$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)				–	–	0.2	
(I_C = 30 mAdc, I_B = 3.0 mAdc)				–	–	0.3	
Base-Emitter "on" Voltage		–	$V_{BE(on)}$				Vdc
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)				–	–	0.8	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)				–	–	1.0	
***DYNAMIC CHARACTERISTICS**							
Current-Gain–Bandwidth Product		2	f_T				MHz
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	2N3959			1000	–	–	
	2N3960			1300	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3959			1300	–	–	
	2N3960			1600	–	–	
(I_C = 30 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	2N3959			1000	–	–	
	2N3960			1200	–	–	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 1.0 MHz)		4	C_{ob}	–	2.0	2.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 MHz)		4	C_{ib}	–	1.5	2.5	pF
Collector-Base Time Constant		3	$r_b'C_c$				ps
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc)	2N3959			–	–	30	
	2N3960			–	–	50	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3959			–	–	25	
	2N3960			–	–	40	
(I_C = 30 mAdc, V_{CE} = 4.0 Vdc)	2N3959			–	–	30	
	2N3960			–	–	50	
SWITCHING CHARACTERISTICS (Figure 7)							
Turn-On Delay Time		–	$t_{d(on)}$				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)				–	2.4	–	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)				–	2.0	–	
Rise Time		–	t_r				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)	Both Devices			–	3.0	–	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)	2N3959			–	2.2	–	
	2N3960			–	1.7	–	
Turn-Off Delay Time		–	$t_{d(off)}$				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)				–	1.6	–	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)				–	1.6	–	
Fall Time		–	t_f				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)	Both Devices			–	3.3	–	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)	2N3959			–	2.3	–	
	2N3960			–	1.9	–	

*Indicates JEDEC Registered Data.

FIGURE 1 – TYPICAL DC CURRENT GAIN

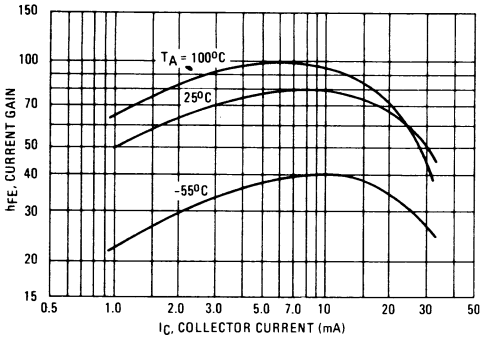


FIGURE 2 – TYPICAL CURRENT-GAIN – BANDWIDTH PRODUCT

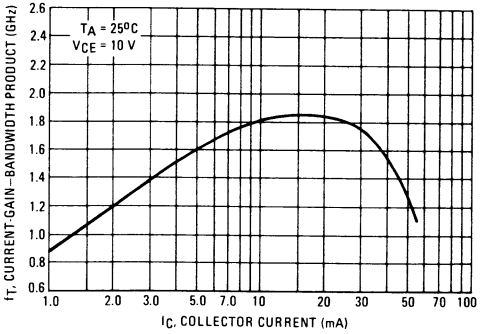


FIGURE 3 – TYPICAL COLLECTOR-BASE TIME CONSTANT

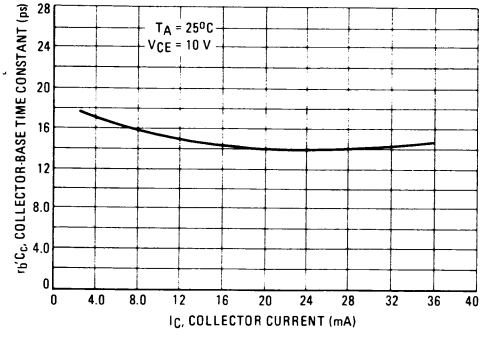
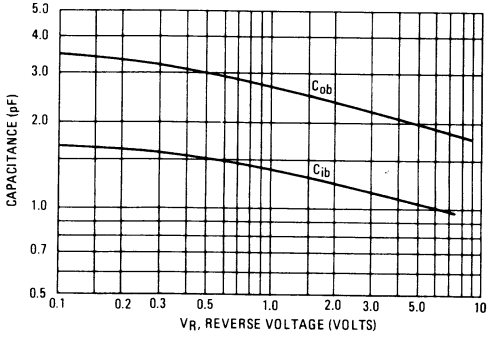


FIGURE 4 – TYPICAL JUNCTION CAPACITANCE



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TURN-ON AND TURN-OFF TIMES

FIGURE 5 – V_{out} = 1.0 Vdc

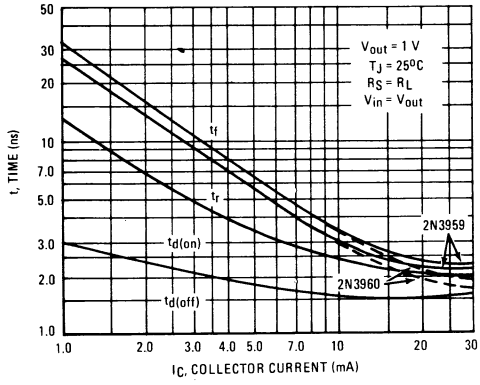


FIGURE 6 – V_{out} = 2.0 Vdc

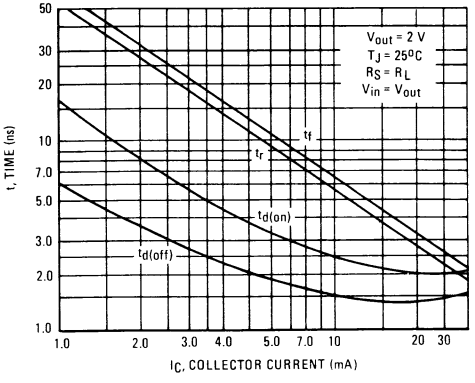
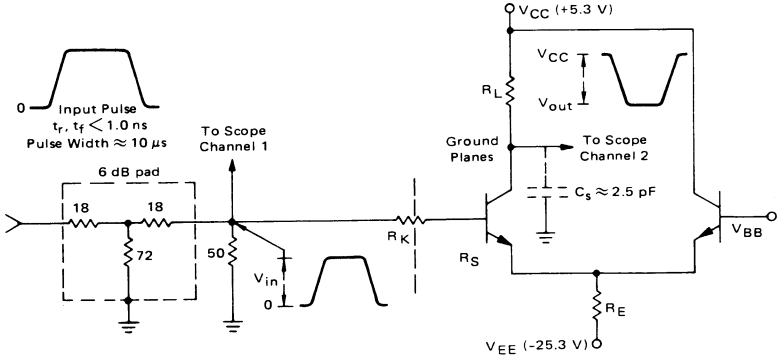


FIGURE 7 – SWITCHING TIMES TEST CIRCUIT



This test set up is designed to simulate a cascade of identical stages. ∴The source resistance (R_S) equals the load resistance (R_L). Values used in the test are shown in the table.

For V_{in} = V_{out} = 1 V, V_{BB} = +0.5 V, R_L & R_K values appropriately reduced.

V_{in} = V_{out} = 2 volts, V_{BB} = +1.0V			
I_C (mA)	R_E (kΩ)	R_L (Ω)	R_K (Ω)
1.0	24.0	2.0 k	2.0 k
3.0	8.2	680	680
10	2.4	200	180
30	0.8	68	36