MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

T-31-19

2N3959
2N3960

The RF Line

1.8 GHz — 10 mAdc

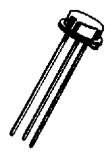
HIGH FREQUENCY TRANSISTORS

NPN SILICON

NPN SILICON HIGH-FREQUENCY TRANSISTORS

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

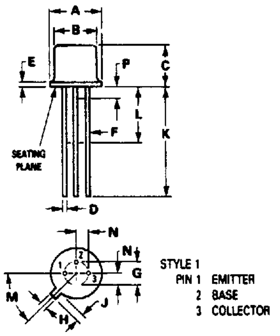
- High Current-Gain—Bandwidth Product — f_T = 1800 MHz (Typ) @ I_C = 10 mAdc
- Low Input and Output Capacitance — C_{ib} and C_{ob} = 2.5 pF (Max)
- Excellent Current-Mode Performance — t_r = 1.7 ns (Typ) @ I_C = 30 mAdc
- Low Collector-Base Time Constant — $r_b'C_c$ = 25 ps (Max) @ I_C = 10 mAdc — 2N3959



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.



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

CASE 22-03
TO-206AA
(TO-18)

*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

2

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 (V_{CE} = 10 Vdc, V_{EB} = 2.0 Vdc) (V_{CE} = 10 Vdc, V_{EB} = 2.0 Vdc, T_A = 150°C)	–	I_{CEX}	 – –	 – –	 0.005 5.0	μAdc
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 (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 30 mAdc, V_{CE} = 1.0 Vdc)	1	h_{FE}	 25 40 25	 – – –	 – 400 –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc)	–	$V_{CE(sat)}$	 – –	 – –	 0.2 0.3	Vdc
Base-Emitter "on" Voltage (I_C = 1 0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 30 mAdc, V_{CE} = 1.0 Vdc)	–	$V_{BE(on)}$	 – –	 – –	 0.8 1 0	Vdc
***DYNAMIC CHARACTERISTICS**						
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz) 2N3959 2N3960 (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N3959 2N3960 (I_C = 30 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz) 2N3959 2N3960	2	f_T	 1000 1300 1300 1600 1000 1200	 – – – – – –	 – – – – – –	MHz
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 (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc) 2N3959 2N3960 (I_C = 10 mAdc, V_{CE} = 10 Vdc) 2N3959 2N3960 (I_C = 30 mAdc, V_{CE} = 4.0 Vdc) 2N3959 2N3960	3	$r_b'C_c$	 – – – – – –	 – – – – – –	 30 50 25 40 30 50	ps
SWITCHING CHARACTERISTICS (Figure 7)						
Turn-On Delay Time (I_C = 10 mAdc, V_{out} = 1.0 Vdc) (I_C = 30 mAdc, V_{out} = 1.0 Vdc)	–	$t_{d(on)}$	 – –	 2.4 2.0	 – –	ns
Rise Time (I_C = 10 mAdc, V_{out} = 1.0 Vdc) Both Devices (I_C = 30 mAdc, V_{out} = 1.0 Vdc) 2N3959 2N3960	–	t_r	 – – –	 3.0 2.2 1.7	 – – –	ns
Turn-Off Delay Time (I_C = 10 mAdc, V_{out} = 1.0 Vdc) (I_C = 30 mAdc, V_{out} = 1.0 Vdc)	–	$t_{d(off)}$	 – –	 1.6 1.8	 – –	ns
Fall Time (I_C = 10 mAdc, V_{out} = 1.0 Vdc) Both Devices (I_C = 30 mAdc, V_{out} = 1.0 Vdc) 2N3959 2N3960	–	t_f	 – – –	 3.3 2.3 1 9	 – – –	ns

*Indicates JEDEC Registered Data

MOTOROLA SC (XSTRS/R F) 46E D ■ 6367254 0094043 0 ■MOT6

FIGURE 1 – TYPICAL DC CURRENT GAIN

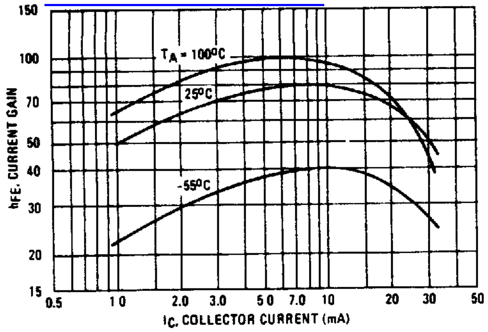


FIGURE 2 – TYPICAL CURRENT-GAIN – BANDWIDTH PRODUCT

T-31-19

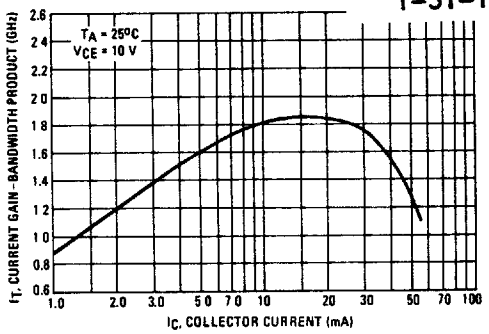


FIGURE 3 – TYPICAL COLLECTOR-BASE TIME CONSTANT

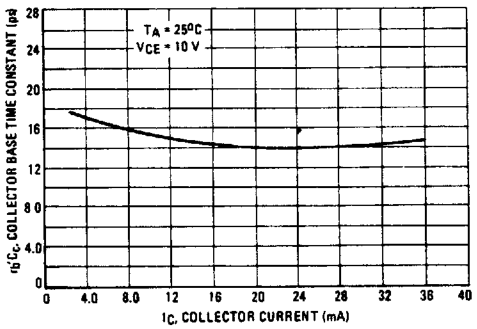
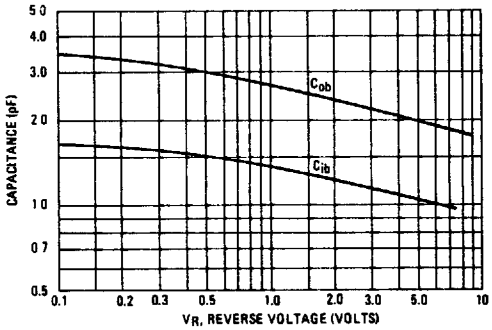


FIGURE 4 – TYPICAL JUNCTION CAPACITANCE



2

T-31-19

2

TURN-ON AND TURN-OFF TIMES

FIGURE 5 – V_{out} = 1.0 Vdc

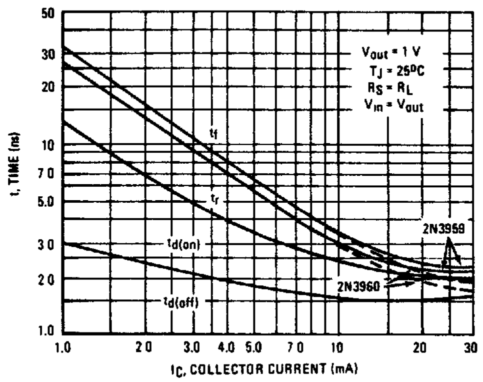


FIGURE 6 – V_{out} = 2.0 Vdc

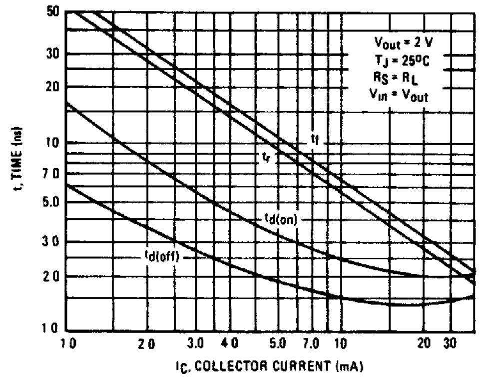
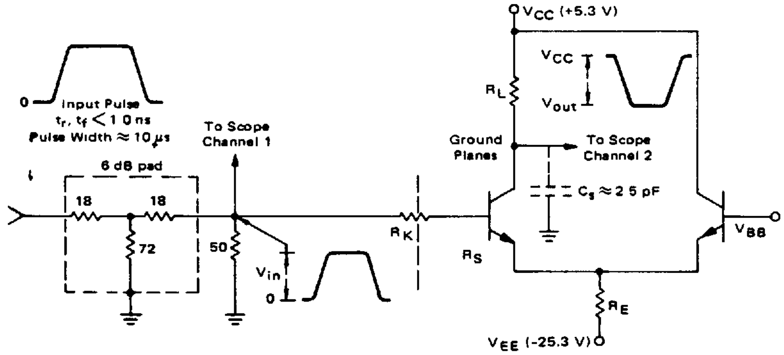


FIGURE 7 – SWITCHING TIMES TEST CIRCUIT



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