

MD6001, F (SILICON)

MD6002, F

MD6003, F

MQ6001, MQ6002

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose switches and amplifiers, front end detectors, and temperature compensation amplifiers, where complementary devices are required.

- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.4 \text{ Vdc (Max) @ } I_C = 150 \text{ mAdc}$
- Fast Switching Times – $t_{on} = 28 \text{ ns (Typ)}$ and $t_{off} = 72 \text{ ns (Typ)}$
- DC Current Gain Specified – $0.1 \text{ mAdc to } 300 \text{ mAdc}$
- High Current-Gain-Bandwidth Product –
 $f_T = 340 \text{ MHz (Typ) @ } I_C = 50 \text{ mAdc}$

MAXIMUM RATINGS

Rating	Symbol	MD6003 MD6003F	MD6001,F MD6002,F MQ6001,2	Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	50	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ MD6001,2,3 MD6001F,2F,3F MQ6001,2 Derate above 25°C MD6001,2,3 MD6001F,2F,3F MQ6001,2	P_D	575 350 400 3.29 2.0 2.28	625 400 600 3.57 2.28 3.42	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ MD6001,2,3 MD6001F,2F,3F MQ6001,2 Derate above 25°C MD6001,2,3 MD6001F,2F,3F MQ6001,2	P_D	1.8 1.0 0.9 10.3 5.71 5.13	2.5 2.0 3.6 14.3 11.4 20.5	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient MD6001,2,3 MD6001F,2F,3F MQ6001,2	$R_{\theta JA(1)}$	304 500 438	280 438 292	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case MD6001,2,3 MD6001F,2F,3F MQ6001,2	$R_{\theta JC}$	97 175 195	70 87.5 48.8	$^\circ\text{C/W}$
Coupling Factor MD6001,2,3 MD6001F,2F,3F MQ6001,2 (Q1-Q2) (Q1-Q3 or Q1-Q4)		Junction to Ambient	Junction to Case	%
		84 75 57 55	44 0 0 0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN, PNP SILICON MULTIPLE TRANSISTORS

**MD6001
MD6002
MD6003**

SEATING PLANE

STYLE 1:
PIN 1: COLLECTOR
2: BASE
3: EMITTER
4: OMITTED
5: EMITTER
6: BASE
7: COLLECTOR
8: OMITTED

CASE 654-07

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
E	5.08 BSC		0.200 BSC	
F	0.71	0.86	0.028	0.034
G	0.74	1.14	0.029	0.045
H	12.70		0.500	
J	45° BSC		45° BSC	
K	2.54 BSC		0.100 BSC	

**MD6001F
MD6002F
MD6003F**

SEATING PLANE

STYLE 1:
PIN 1: BASE
2: EMITTER
3: BASE
4: COLLECTOR
5: COLLECTOR

CASE 610A-03

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
E	0.08	0.15	0.003	0.006
F	1.27 BSC		0.050 BSC	
G		0.89		0.035
H	3.81		0.150	
J	2.54 BSC		0.100 BSC	
K	1.27		0.050	

**MQ6001
MQ6002**

SEATING PLANE

STYLE 1:
PIN 1: COLLECTOR
2: BASE
3: EMITTER
4: NOT CONNECTED
5: EMITTER
6: BASE
7: COLLECTOR
8: COLLECTOR
9: BASE
10: EMITTER
11: NOT CONNECTED
12: EMITTER
13: BASE
14: COLLECTOR

CASE 607-04

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	6.99	0.240	0.275
B	0.76	2.03	0.030	0.080
C	0.25	0.48	0.010	0.019
D	0.08	0.15	0.003	0.006
E	1.27 BSC		0.050 BSC	
F	0.13	0.89	0.005	0.035
G		0.38		0.015
H	18.80		0.740	
J	0.25		0.010	
K		0.38		0.015
L	7.62	8.38	0.300	0.330

MD6001,F, MD6002,F, MD6003,F, MQ6001, MQ6002 (continued)

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1) \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
 $R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
 P_{D1} thru 4 is the power dissipation in die 1 through 4
 $K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2) R_{\theta (EFF)} = \Delta T_{J1} / P_{DT}$$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3) \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4) R_{\theta (EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) / 4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$) MD6003,F MD6001,F, MD6002,F, MQ6001, MQ6002	BV_{CBO}	50 60	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
Collector-Cutoff Current ($V_{CB} = 40 \text{ Vdc}$, $I_E = 0$) MD6003,F	I_{CBO}	—	—	100	nA
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 3.0 \text{ Vdc}$) MD6003,F ($V_{CE} = 50 \text{ Vdc}$, $V_{BE(off)} = 3.0 \text{ Vdc}$) MD6001,F,2,F, MQ6001,2 ($V_{CE} = 50 \text{ Vdc}$, $V_{BE(off)} = 3.0 \text{ Vdc}$, $T_A = 150^\circ\text{C}$) MD6001,F,2,F, MQ6001,2	I_{CEV}	— — —	— — —	30 20 30	nAdc nAdc μAdc
Base Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 3.0 \text{ Vdc}$) MD6003,F ($V_{CE} = 50 \text{ Vdc}$, $V_{BE(off)} = 3.0 \text{ Vdc}$) MD6001,F,2,F, MQ6002,F	I_{BEV}	— —	— —	50 30	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 0.1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) MD6001,F, MQ6001 MD6002,F, MQ6002 ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) MD6001,F, MQ6001 MD6003,F MQ6002,F, MQ6002 ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) MD6001,F, MQ6001 MD6002,F, MQ6002 ($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) MD6001,F, MQ6001 MD6003,F MD6002,F, MQ6002 ($I_C = 300 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) MD6001,F, MQ6001 All Other Devices ($I_C = 150 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) MD6001,F, MQ6001 MD6002,F, MQ6002	h_{FE}	20 35 25 40 50 35 75 40 70 100 20 30 20 50	80 70 90 70 100 70 110 — 110 200 — 90 80 —	— — — — — — — 120 — 300 — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) All Devices ($I_C = 300 \text{ mAdc}$, $I_B = 30 \text{ mAdc}$) MD6001, MD6002,F, MQ6001,2	$V_{CE(sat)}$	— —	0.3 0.59	0.4 1.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) All Devices ($I_C = 300 \text{ mAdc}$, $I_B = 30 \text{ mAdc}$) MD6001, MD6002,F, MQ6001,2	$V_{BE(sat)}$	— —	1.02 1.25	1.3 2.0	Vdc

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

ELECTRICAL CHARACTERISTICS (continued)**DYNAMIC CHARACTERISTICS**

Current-Gain-Bandwidth Product ($I_C = 50$ mA dc, $V_{CE} = 20$ V dc, $f = 100$ MHz)	f_T	200	340	—	MHz
Output Capacitance ($V_{CB} = 10$ V dc, $I_E = 0$, $f = 100$ kHz)	C_{ob}	—	5.6	8.0	pF
Input Capacitance ($V_{BE} = 2.0$ V dc, $I_C = 0$, $f = 100$ kHz)	C_{ib}	—	16	30	pF

SWITCHING CHARACTERISTICS

Turn-On Time	(V _{CC} = 30 V dc, V _{BE(off)} = 0 V dc, I _C = 150 mA dc, I _{B1} = 15 mA dc) MD6001F,2F, MQ6001,2	t _{on}	—	28	60	ns
Delay Time		t _d	—	—	20	ns
Rise Time		t _r	—	—	40	ns
Turn-Off Time	(V _{CC} = 30 V dc, I _C = 150 mA dc, I _{B1} = I _{B2} = 15 mA dc) MD6001F,2F, MQ6001,2	t _{off}	—	72	350	ns
Storage Time		t _s	—	—	280	ns
Fall Time		t _f	—	—	70	ns

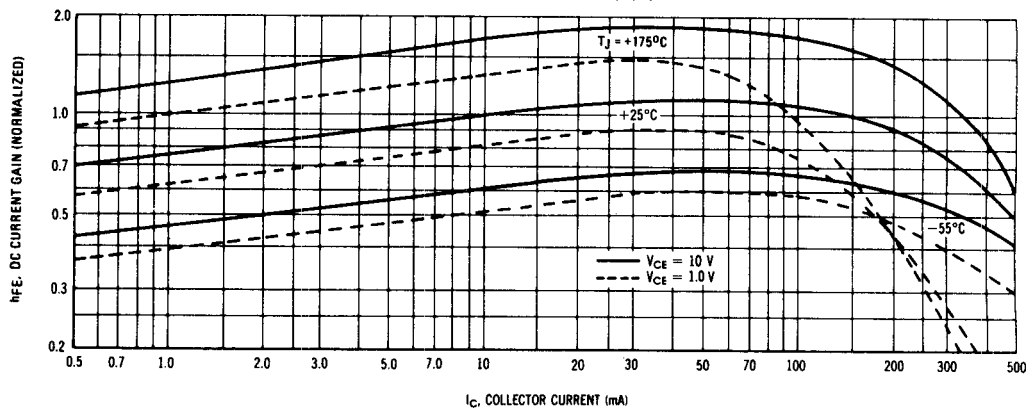
FIGURE 1 — DC CURRENT GAIN

FIGURE 2 - "ON" VOLTAGES

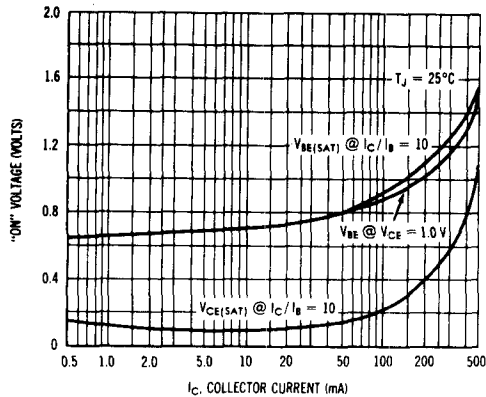
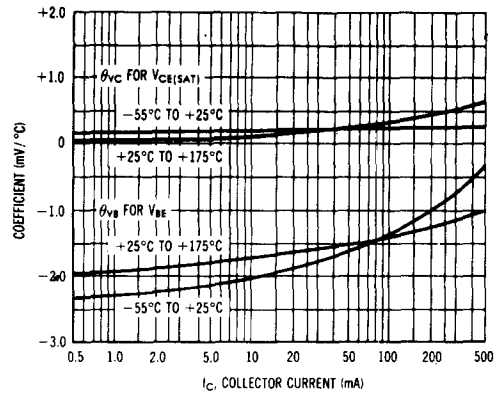


FIGURE 3 - TEMPERATURE COEFFICIENTS



NOISE FIGURE
 $V_{CE} = 10 \text{ V}$, $T_A = 25^\circ\text{C}$

FIGURE 4 - FREQUENCY EFFECTS

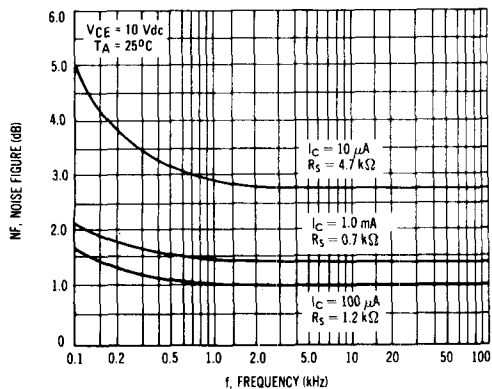


FIGURE 5 - SOURCE RESISTANCE EFFECTS

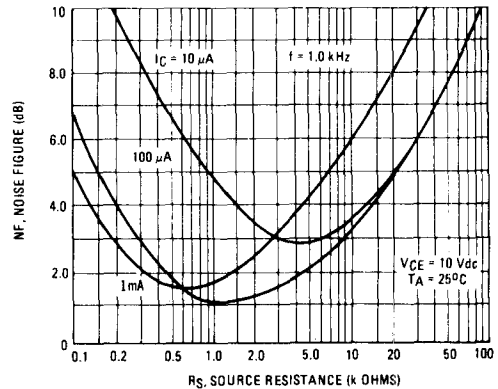


FIGURE 6 - CURRENT-GAIN BANDWIDTH PRODUCT

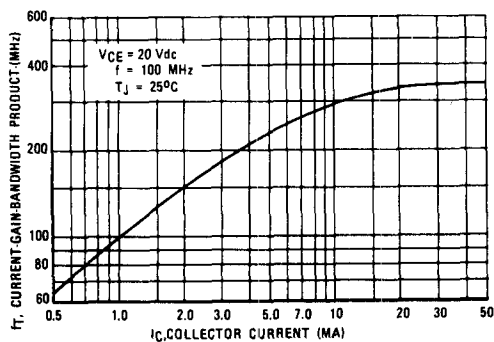


FIGURE 7 - CAPACITANCE

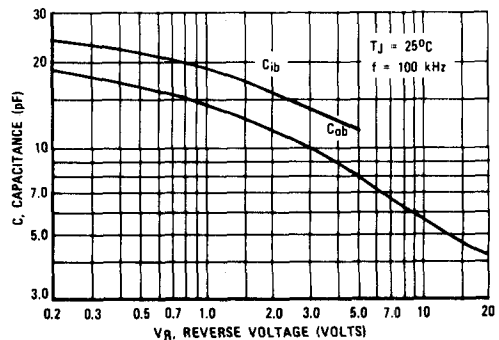


FIGURE 8 – TURN ON TIME

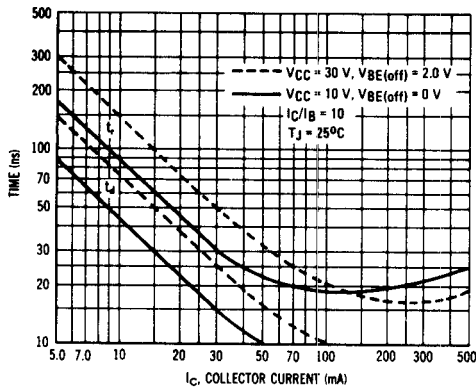


FIGURE 9 – CHARGE DATA

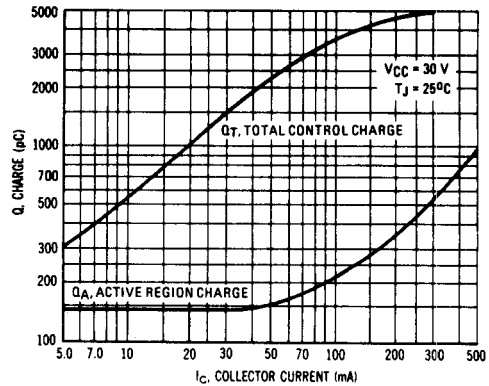


FIGURE 10 – STORAGE TIME

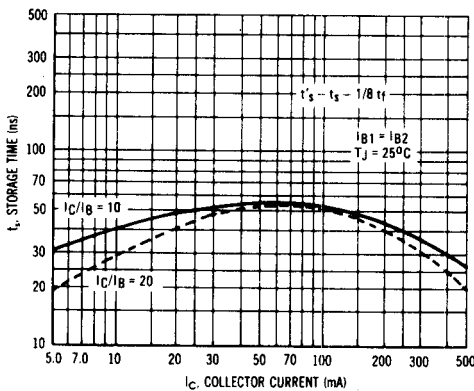


FIGURE 11 – FALL TIME

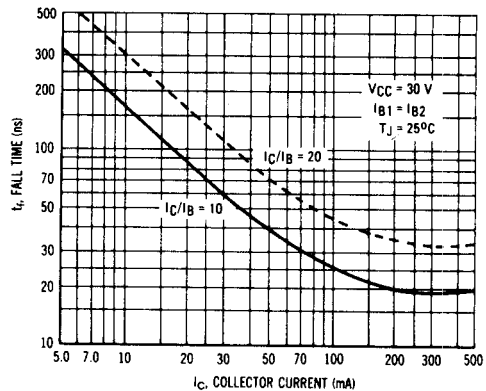


FIGURE 12 – DELAY AND RISE TIME TEST CIRCUIT

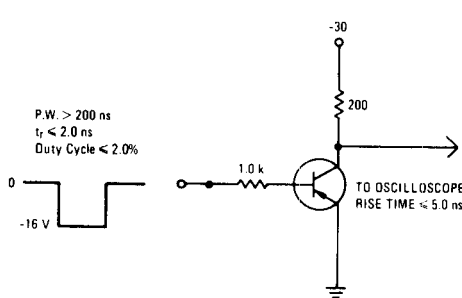


FIGURE 13 – STORAGE AND FALL TIME TEST CIRCUIT

