

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA
Designer's Data Sheet
NPN Silicon Power Transistors
1.5 kV Switchmode III Series

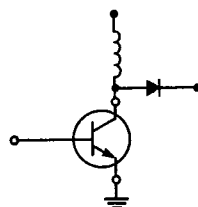
These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications.

Typical Applications:

- Switching Regulators
- Inverters
- Solenoids
- Relay Drivers
- Motor Controls
- Deflection Circuits

Features:

- Collector-Emitter Voltage — $V_{CEV} = 1500$ Vdc
- Fast Turn-Off Times
 - 80 ns Inductive Fall Time — 100°C (Typ)
 - 110 ns Inductive Crossover Time — 100°C (Typ)
 - 4.5 μ s Inductive Storage Time — 100°C (Typ)
- 100°C Performance Specified for:
 - Reverse-Biased SOA with Inductive Load
 - Switching Times with Inductive Loads
 - Saturation Voltages
 - Leakage Currents

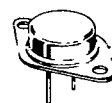
MJ16018
MJH16018
POWER TRANSISTORS
10 AMPERES
800 VOLTS
125 and 175 WATTS

MAXIMUM RATINGS

Rating	Symbol	MJ16018	MJH16018	Unit
Collector-Emitter Voltage	$V_{CEO(sus)}$	800		Vdc
Collector-Emitter Voltage	V_{CEV}	1500		Vdc
Emitter-Base Voltage	V_{EB}	6		Vdc
Collector Current — Continuous	I_C	10		Adc
— Peak(1)	I_{CM}	15		
Base Current — Continuous	I_B	8		Adc
— Peak(1)	I_{BM}	12		
Total Power Dissipation @ $T_C = 25^\circ\text{C}$	P_D	175	125	Watts
@ $T_C = 100^\circ\text{C}$		100	50	
Derate above $T_C = 25^\circ\text{C}$		1	1	W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to 200	-55 to 150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1	°C/W
Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	T_L	275	°C

(1) Pulse Test: Pulse Width = 5 μ s, Duty Cycle $\leq$ 10%.



CASE 1-06
TO-204AA
MJ16018



CASE 340-02
TO-218AC
MJH16018

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS(1)					
Collector-Emitter Sustaining Voltage (Table 1) ($I_C = 50\text{ mA}$, $I_B = 0$)	$V_{CE(sus)}$	800	—	—	Vdc
Collector Cutoff Current ($V_{CEV} = 1500\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$) ($V_{CEV} = 1500\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$, $T_C = 100^\circ\text{C}$)	I_{CEV}	—	—	0.25 1.5	mA
Collector Cutoff Current ($V_{CE} = 1500\text{ Vdc}$, $R_{BE} = 50\ \Omega$, $T_C = 100^\circ\text{C}$)	I_{CER}	—	—	2.5	mA
Emitter Cutoff Current ($V_{EB} = 6\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	0.1	mA

SECOND BREAKDOWN

Second Breakdown Collector Current with Base Forward Biased	$I_{S/b}$	See Figure 13			
Clamped Inductive SOA with Base Reverse Biased	$RBSOA$	See Figure 14			

ON CHARACTERISTICS(1)

Collector-Emitter Saturation Voltage ($I_C = 5\text{ Adc}$, $I_B = 2\text{ Adc}$) ($I_C = 10\text{ Adc}$, $I_B = 5\text{ Adc}$) ($I_C = 5\text{ Adc}$, $I_B = 2\text{ Adc}$, $T_C = 100^\circ\text{C}$)	$V_{CE(sat)}$	—	—	1 5 1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 5\text{ Adc}$, $I_B = 2\text{ Adc}$) ($I_C = 5\text{ Adc}$, $I_B = 2\text{ Adc}$, $T_C = 100^\circ\text{C}$)	$V_{BE(sat)}$	—	—	1.5 1.5	Vdc
DC Current Gain ($I_C = 5\text{ Adc}$, $V_{CE} = 5\text{ Vdc}$)	h_{FE}	4	—	—	—

DYNAMIC CHARACTERISTICS

Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f_{test} = 1\text{ kHz}$)	C_{ob}	—	—	450	pF
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SWITCHING CHARACTERISTICS

Inductive Load (Table 1)							
Storage Time	Baker Clamped ($I_C = 5\text{ Adc}$, $I_{B1} = 2\text{ Adc}$, $V_{BE(off)} = 2\text{ Vdc}$, $V_{CE(pk)} = 400\text{ Vdc}$, $PW = 25\text{ }\mu\text{s}$)	$(T_J = 25^\circ\text{C})$	t_{sv}	—	4000	8000	ns
Fall Time			t_{fi}	—	60	200	
Crossover Time			t_c	—	90	300	
Storage Time		$(T_J = 100^\circ\text{C})$	t_{sv}	—	4500	9000	
Fall Time			t_{fi}	—	80	250	
Crossover Time			t_c	—	110	375	
Resistive Load (Table 1)							
Delay Time	Baker Clamped ($I_C = 5\text{ Adc}$, $V_{CC} = 250\text{ Vdc}$, $I_{B1} = 2\text{ Adc}$, $I_{B2} = 2\text{ Adc}$, $R_{B2} = 3\text{ }\Omega$, $PW = 25\text{ }\mu\text{s}$, Duty Cycle $\leq 2\%$)		t_d	—	85	200	ns
Rise Time			t_r	—	900	2000	
Storage Time			t_s	—	4500	9000	
Fall Time			t_f	—	200	400	

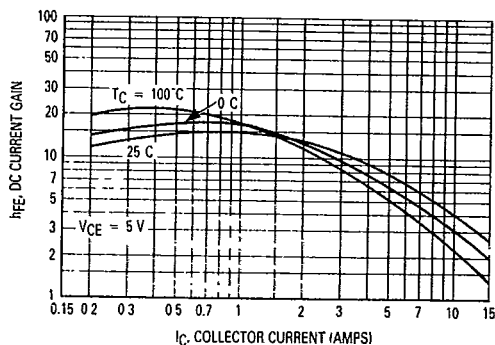
(1) Pulse Test: $PW = 300\ \mu\text{s}$, Duty Cycle $\leq 2\%$.

Figure 1. DC Current Gain

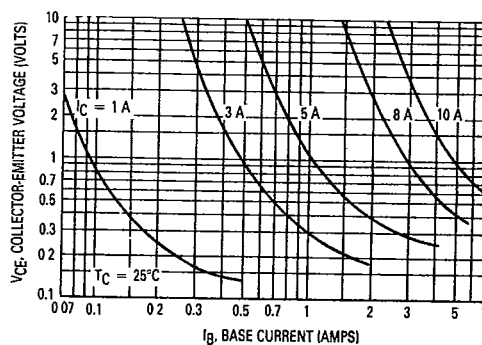


Figure 2. Collector Saturation Region

T-33-15
 T-33-13

TYPICAL STATIC CHARACTERISTICS

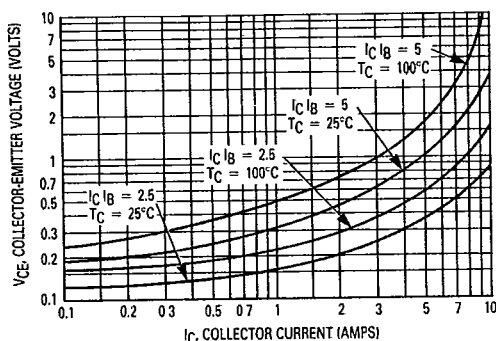


Figure 3. Collector-Emitter Saturation Region

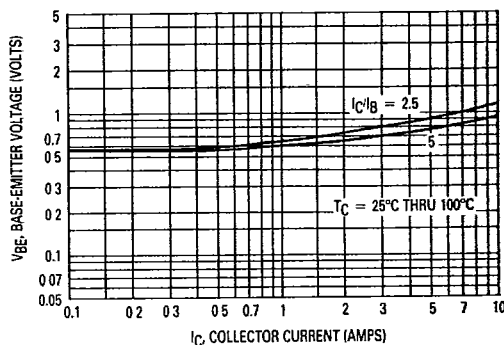


Figure 4. Base-Emitter Saturation Region

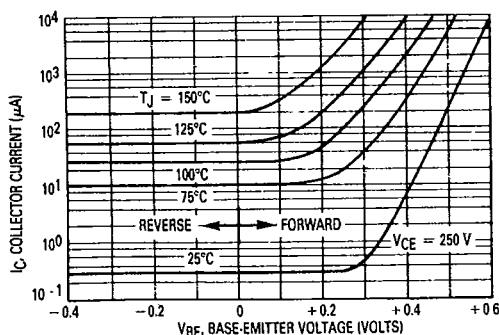


Figure 5. Collector Cutoff Region

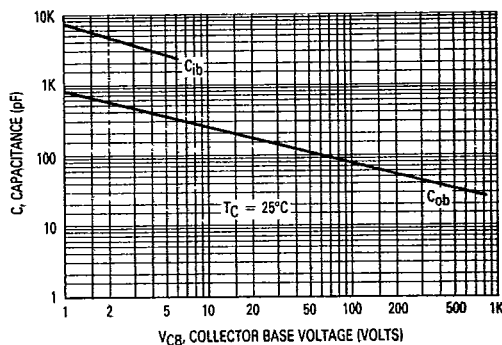


Figure 6. Typical Capacitance

TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS

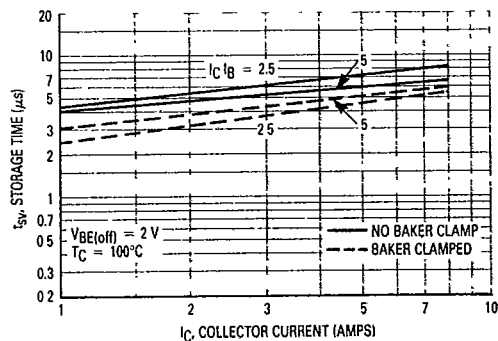


Figure 7. Storage Time

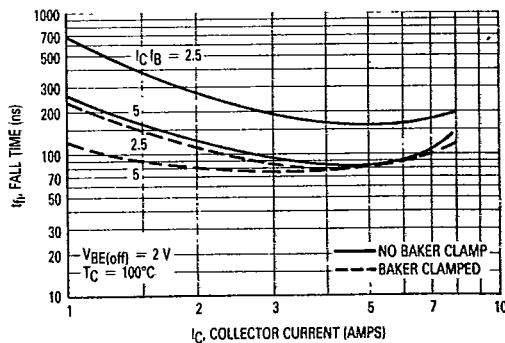


Figure 8. Inductive Switching Fall Time

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TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS

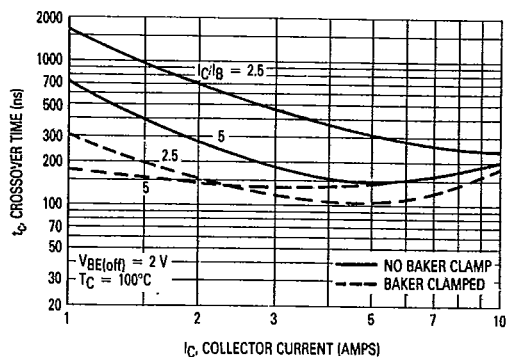


Figure 9. Inductive Switching Crossover Time

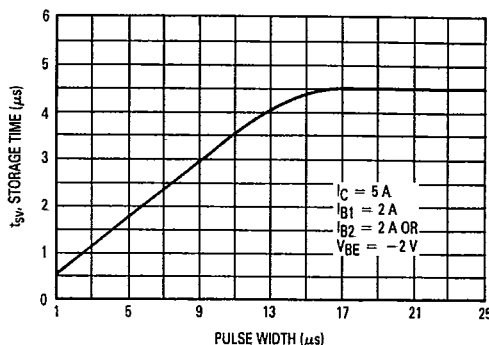


Figure 10. (t_{SV}) Storage Time versus I_{B1} Pulse Width

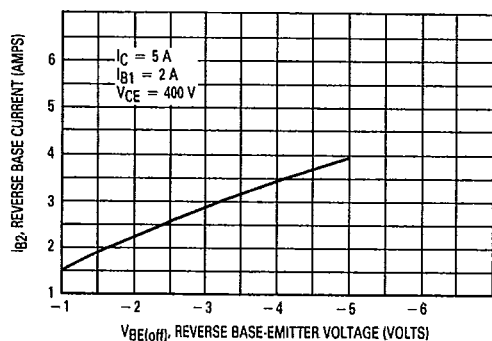


Figure 11. Reverse Base Current versus Off Voltage

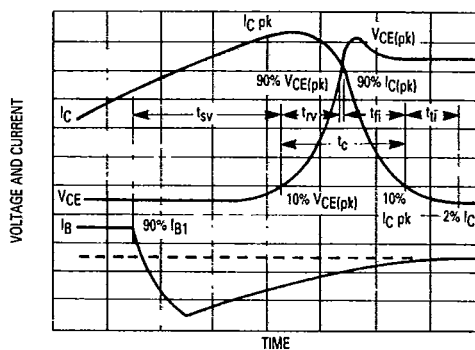


Figure 12. Inductive Switching Measurements

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GUARANTEED SAFE OPERATING AREA LIMITS

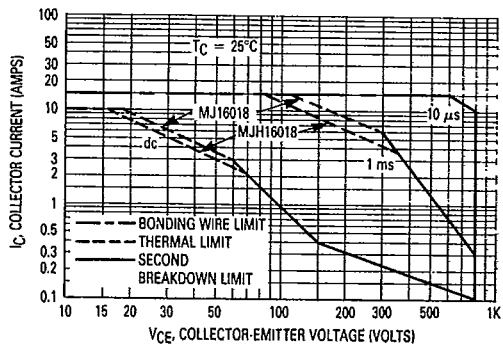


Figure 13. Maximum Forward Bias Safe Operating Area

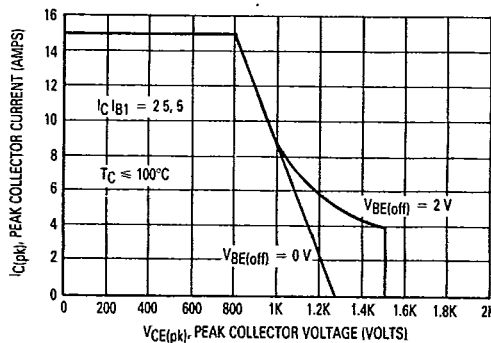


Figure 14. Maximum Reverse Bias Safe Operating Area

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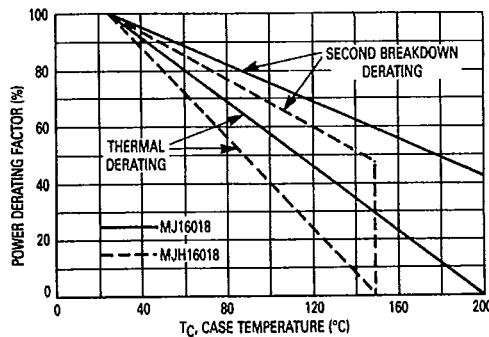
T-33-15
T-33-13
T-91-01

Figure 15. Power Derating

SAFE OPERATING AREA INFORMATION

FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on $T_C = 25^\circ\text{C}$; $T_J(pk)$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when $T_C \geq 25^\circ\text{C}$. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

$T_J(pk)$ may be calculated from the data in Figure 16. At high case temperatures, thermal limitations will

reduce the power that can be handled to values less than the limitations imposed by second breakdown.

REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.

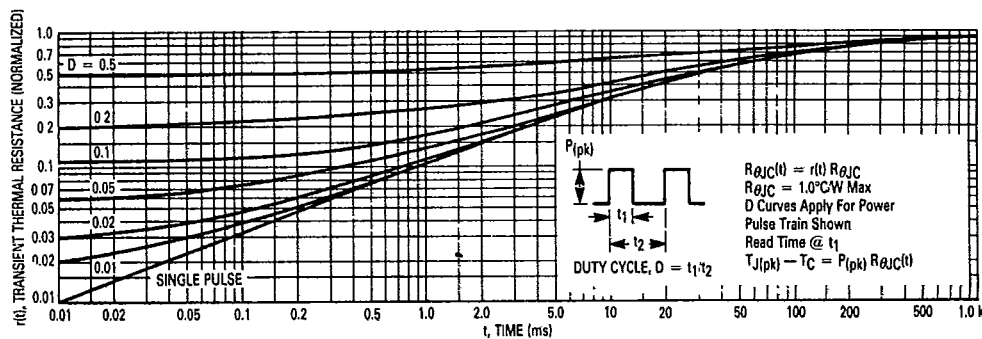


Figure 16. Thermal Response

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T-33-13

T-91-01

Table 1. Test Conditions for Dynamic Performance

V _{CEO} (sus)	RBSOA	Inductive Switching	Resistive Switching
Drive Circuit Note: Adjust V_{G1} to obtain desired $V_{GE(off)}$ at Point A.			
Input Conditions	Circuit Values $L = 10 \text{ mH}$ $R_{G2} = \infty$ $V_{CC} = 20 \text{ Volts}$ $I_{(pk)} = 50 \text{ mA}$ S_1 Closed	$L = 200 \mu\text{H}$ $R_{G2} = 0$ $V_{CC} = 20 \text{ Volts}$ R_{B1} selected for desired I_{B1} S_1 Closed	For t_d and t_r: For t_s and t_f, Use Inductive Switching Drive Circuit for t_d and t_r $V_{CC} = 250 \text{ Volts}$ R_G selected for desired I_{B1} R_L selected for desired I_C for t_s and t_f $V_{CC} = 250 \text{ Volts}$ $R_G = 0$ R_{B1} & R_{B2} selected for I_{B1} & I_{B2} R_L selected for desired I_C
Test Circuit T_1 adjusted to obtain $I_{C(pk)}$	$L = 200 \mu\text{H}$ $R_{G2} = 0$ $V_{CC} = 20 \text{ Volts}$ R_{B1} selected for desired I_{B1} S_1 Closed	$L = 200 \mu\text{H}$ $R_{G2} = 0$ when $V_{GE(off)}$ is specified or selected for desired I_{B2} $V_{CC} = 20 \text{ Volts}$, Adjusted to obtain desired I_C R_{B1} selected for desired I_{B1} $S_1 = \text{Open}$ for better clamp condition	for t_d and t_r $V_{CC} = 250 \text{ Volts}$ R_G selected for desired I_{B1} R_L selected for desired I_C for t_s and t_f $V_{CC} = 250 \text{ Volts}$ $R_G = 0$ R_{B1} & R_{B2} selected for I_{B1} & I_{B2} R_L selected for desired I_C

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OUTLINE DIMENSIONS

