MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

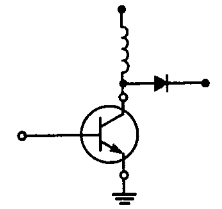
MJ16018 MJH16018

Designer's Data Sheet

NPN Silicon Power Transistors

1.5 kV Switchmode III Series

POWER TRANSISTORS
10 AMPERES
800 VOLTS
125 and 175 WATTS



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 μs 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

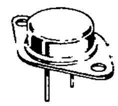
MAXIMUM RATINGS

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 — Peak(1)	I_C I_{CM}	10 15		Adc
Base Current — Continuous — Peak(1)	I_B I_{BM}	8 12		Adc
Total Power Dissipation @ T_C = 25°C @ T_C = 100°C Derate above T_C = 25°C	P_D	175 100 1	125 50 1	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to 200	–55 to 150	°C

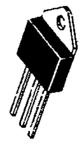
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max		Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1	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 μs, Duty Cycle ≤ 10%.



CASE 1-06
TO-204AA
MJ16018



CASE 340-02
TO-218AC
MJH16018

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T-33-13

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

Characteristic			Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS[1]							
Collector-Emitter Sustaining Voltage (Table 1) (I_C = 50 mA, I_B = 0)			$V_{CEO(sus)}$	800	—	—	Vdc
Collector Cutoff Current (V_{CEV} = 1500 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CEV} = 1500 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 100°C)			I_{CEV}	— —	— —	0.25 1.5	mAdc
Collector Cutoff Current (V_{CE} = 1500 Vdc, R_{BE} = 50 Ω, T_C = 100°C)			I_{CER}	—	—	2.5	mAdc
Emitter Cutoff Current (V_{EB} = 6 Vdc, I_C = 0)			I_{EBO}	—	—	0.1	mAdc
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 Adc, I_B = 2 Adc) (I_C = 10 Adc, I_B = 5 Adc) (I_C = 5 Adc, I_B = 2 Adc, T_C = 100°C)			$V_{CE(sat)}$	— — —	— — —	1 5 1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 2 Adc) (I_C = 5 Adc, I_B = 2 Adc, T_C = 100°C)			$V_{BE(sat)}$	— —	— —	1.5 1.5	Vdc
DC Current Gain (I_C = 5 Adc, V_{CE} = 5 Vdc)			h_{FE}	4	—	—	—
DYNAMIC CHARACTERISTICS							
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f_{test} = 1 kHz)			C_{ob}	—	—	450	pF
SWITCHING CHARACTERISTICS							
Inductive Load (Table 1)							
Storage Time	Baker Clamped (I_C = 5 Adc, I_{B1} = 2 Adc, $V_{BE(off)}$ = 2 Vdc, $V_{CE(pk)}$ = 400 Vdc) PW = 25 μs	(T_J = 25°C)	t_{sv}	—	4000	8000	ns
Fall Time			t_{fi}	—	60	200	
Crossover Time			t_c	—	90	300	
Storage Time		(T_J = 100°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 Adc, V_{CC} = 250 Vdc, I_{B1} = 2 Adc, I_{B2} = 2 Adc, R_{B2} = 3 Ω, PW = 25 μs, Duty Cycle ≤ 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 μs, Duty Cycle ≤ 2%.

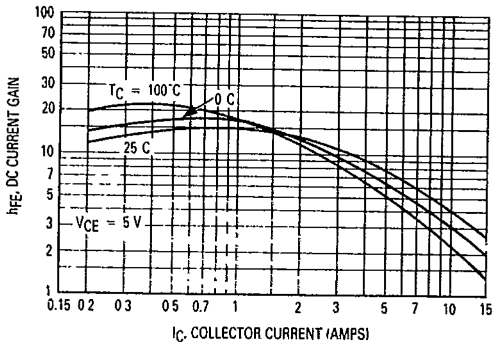

Figure 1. DC Current Gain

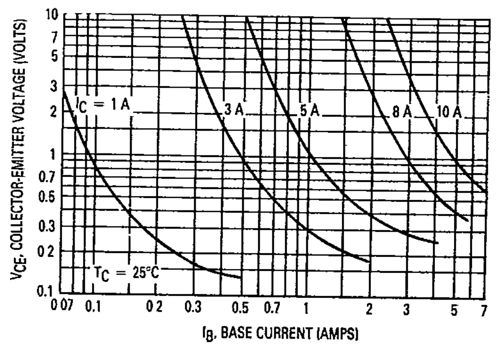

Figure 2. Collector Saturation Region

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TYPICAL STATIC CHARACTERISTICS

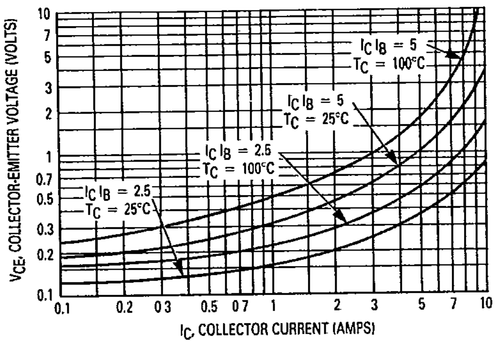

Figure 3. Collector-Emitter Saturation Region

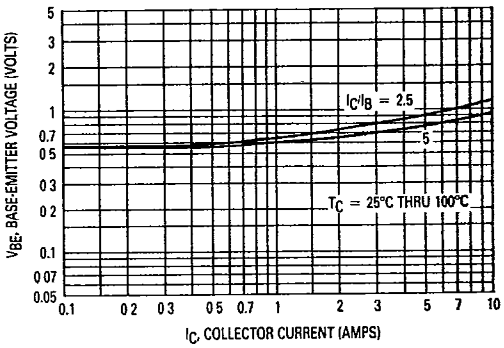

Figure 4. Base-Emitter Saturation Region

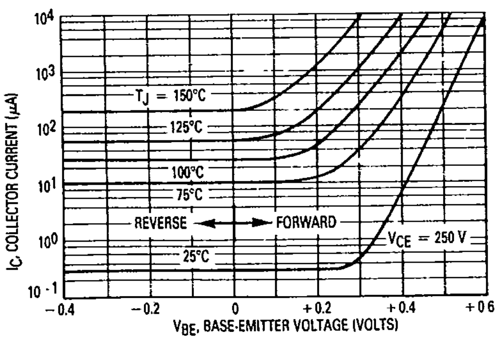

Figure 5. Collector Cutoff Region

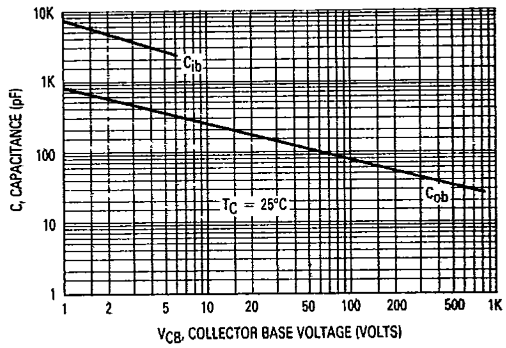

Figure 6. Typical Capacitance

TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS

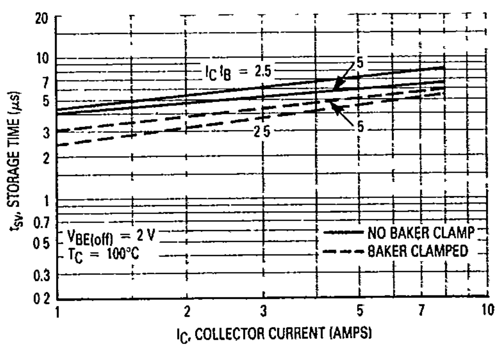

Figure 7. Storage Time

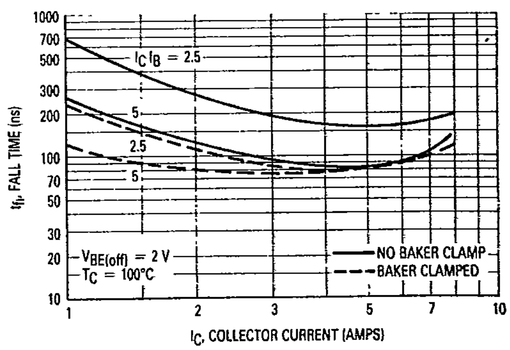

Figure 8. Inductive Switching Fall Time

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TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS

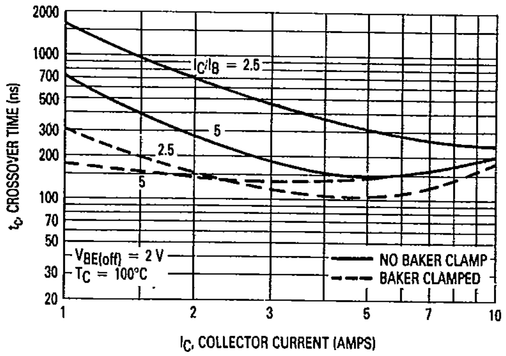

Figure 9. Inductive Switching Crossover Time

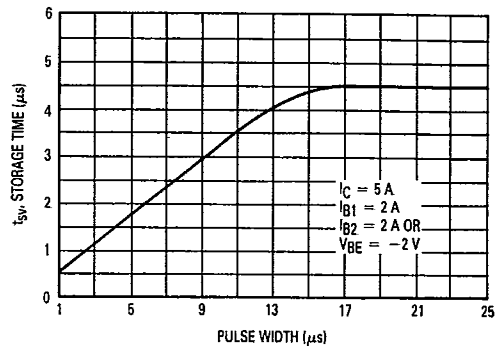

Figure 10. (t_{sv}) Storage Time versus I_{B1} Pulse Width

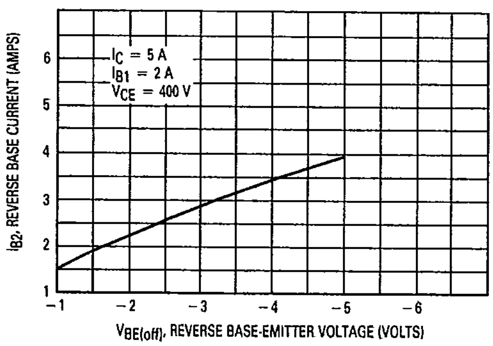

Figure 11. Reverse Base Current versus Off Voltage

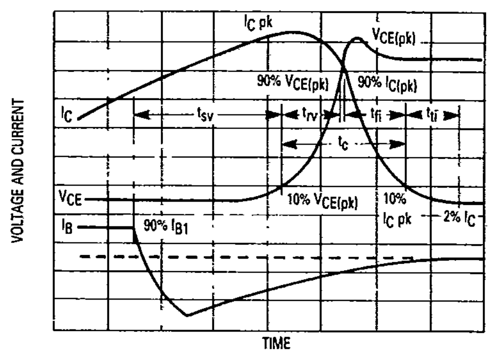

Figure 12. Inductive Switching Measurements

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GUARANTEED SAFE OPERATING AREA LIMITS

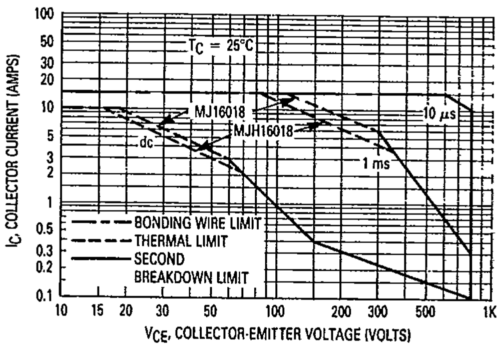

Figure 13. Maximum Forward Bias Safe Operating Area

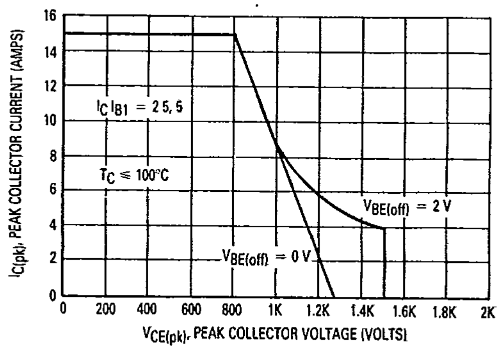

Figure 14. Maximum Reverse Bias Safe Operating Area

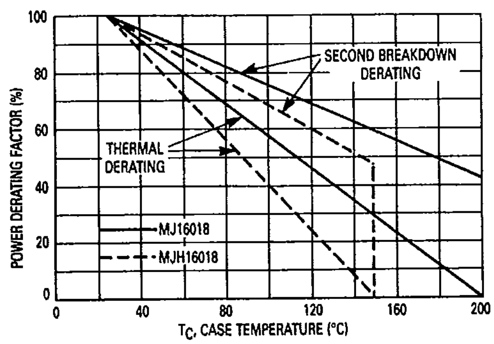

Figure 15. Power Derating

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°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°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.

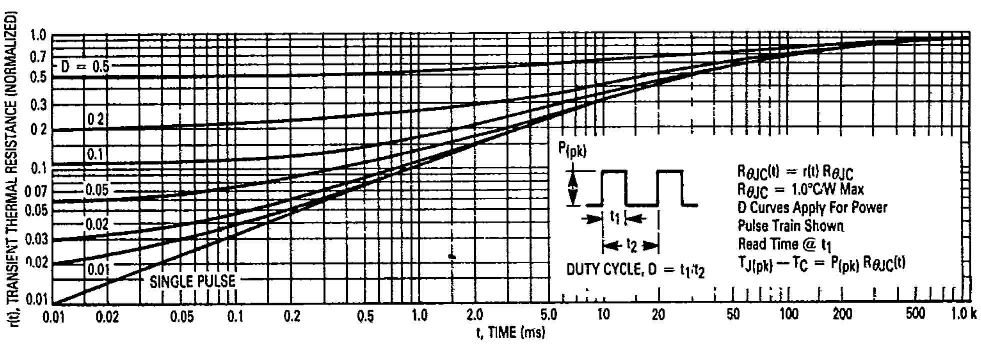

Figure 16. Thermal Response

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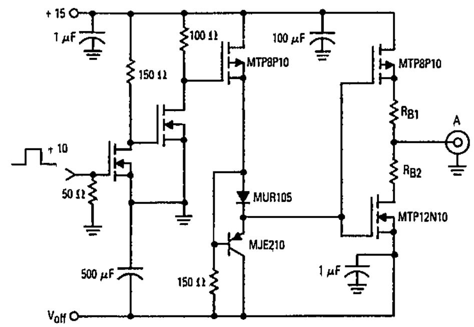
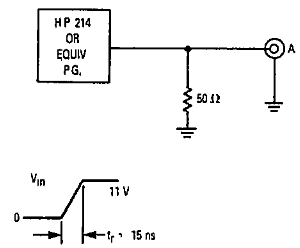
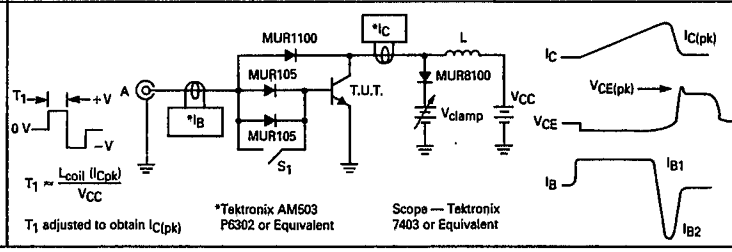
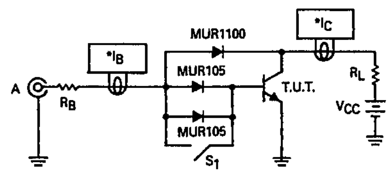
Table 1. Test Conditions for Dynamic Performance

	$V_{CEO(sus)}$	RBSOA	Inductive Switching	Resistive Switching
Input Conditions	Drive Circuit  Note. Adjust V_{off} to obtain desired $V_{BE(off)}$ at Point A.			For t_d and t_r:  For t_s and t_f: Use Inductive Switching Drive Circuit
Circuit Values	L = 10 mH R_{B2} = ∞ V_{CC} = 20 Volts $I_{(pk)}$ = 50 mA S_1 Closed	L = 200 µH R_{B2} = 0 V_{CC} = 20 Volts R_{B1} selected for desired I_{B1} S_1 Closed	L = 200 µH R_{B2} = 0 when $V_{BE(off)}$ is specified or selected for desired I_{B2} V_{CC} ≈ 20 Volts, Adjusted to obtain desired IC R_{B1} selected for desired I_{B1} S_1 = Open for baker clamp condition	for t_d and t_r V_{CC} = 250 Volts R_B selected for desired I_{B1} R_L selected for desired I_C for t_s and t_f V_{CC} = 250 Volts R_B = 0 R_{B1} & R_{B2} selected for I_{B1} & I_{B2} R_L selected for desired I_C
Test Circuit	 $T_1 \approx \frac{L_{coil}(I_{Cpk})}{V_{CC}}$ T_1 adjusted to obtain $I_{C(pk)}$ *Tektronix AM503 P6302 or Equivalent Scope — Tektronix 7403 or Equivalent			 *Tektronix AM503 P6302 or Equivalent

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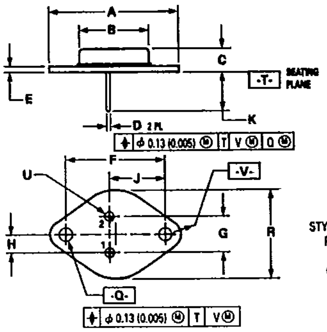
T-91-01

OUTLINE DIMENSIONS

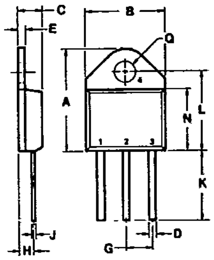


STYLE 1:
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

NOTES
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982
2. CONTROLLING DIMENSION: INCH.
3. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-204AA OUTLINE SHALL APPLY.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	6.35	8.25	0.250	0.325
D	0.97	1.09	0.038	0.043
E	1.40	1.77	0.055	0.070
F	30.15 BSC		1.187 BSC	
G	10.92 BSC		0.430 BSC	
H	5.46 BSC		0.215 BSC	
J	16.89 BSC		0.665 BSC	
K	11.18	12.19	0.440	0.480
Q	3.84	4.19	0.151	0.165
R	—	26.67	—	1.050
U	4.83	5.33	0.190	0.210
V	3.84	4.19	0.151	0.165

CASE 1-06
TO-204AA
MJ16018



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	20.32	21.08	0.800	0.830
B	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
H	2.41	3.20	0.095	0.126
J	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
Q	4.04	4.22	0.159	0.166

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

CASE 340-02
TO-218AC
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