

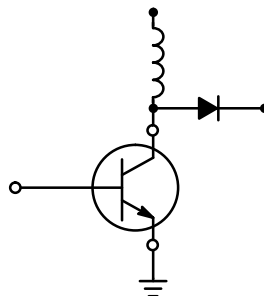
2N6836

Designer's™ Data Sheet

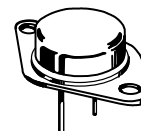
**Switchmode Series Ultra-Fast
NPN Silicon Power Transistors**

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.

- Switching Regulators
- Inverters
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times
 - 30 ns Inductive Fall Time — 75°C (Typ)
 - 50 ns Inductive Crossover Time — 75°C (Typ)
 - 600 ns Inductive Storage Time — 75°C (Typ)
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for:
 - Reverse-Biased SOA with Inductive Loads
 - Switching Times with Inductive Loads
 - Saturation Voltages
 - Leakage Currents



**15 AMPERE
NPN SILICON
POWER TRANSISTOR
450 VOLTS
175 WATTS**



**CASE 1-07
TO-204AA
(TO-3)**

MAXIMUM RATINGS (2)

Rating	Symbol	Max	Unit
Collector-Emitter Voltage	$V_{CEO(sus)}$	450	Vdc
Collector-Emitter Voltage	V_{CEV}	850	Vdc
Emitter Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	15	Adc
— Peak (1)	I_{CM}	20	
Base Current — Continuous	I_B	10	Adc
— Peak (1)	I_{BM}	15	
Total Power Dissipation @ $T_C = 25^\circ\text{C}$	P_D	175	Watts
@ $T_C = 100^\circ\text{C}$		100	
Derate above 25°C		1.0	W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS (2)

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5.0 Seconds	T_L	275	°C

- (1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.
 (2) Indicate JEDEC Registered Data.

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Designer's Data for "Worst Case" Conditions — The Designer's Data Sheet permits the design of most circuits entirely from the information presented. SOA Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

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 2) ($I_C = 100\text{ mA}$, $I_B = 0$)	$V_{CEO(sus)}$	450*	—	—	Vdc
Collector Cutoff Current ($V_{CEV} = 850\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$) ($V_{CEV} = 850\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$, $T_C = 100^\circ\text{C}$)	I_{CEV}	—	—	0.25* 1.5*	mAdc
Collector Cutoff Current ($V_{CE} = 850\text{ Vdc}$, $R_{BE} = 50\ \Omega$, $T_C = 100^\circ\text{C}$)	I_{CER}	—	—	2.5	mAdc
Emitter Cutoff Current ($V_{EB} = 6.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	1.0*	mAdc

SECOND BREAKDOWN

Second Breakdown Collector Current with Base Forward Biased	$I_{S/b}$	See Figure 15*			
Clamped Inductive SOA with Base Reverse Biased	RBSOA	See Figure 16			

ON CHARACTERISTICS (1)

Collector–Emitter Saturation Voltage ($I_C = 5.0\text{ Adc}$, $I_B = 0.7\text{ Adc}$) ($I_C = 10\text{ Adc}$, $I_B = 1.0\text{ Adc}$) ($I_C = 10\text{ Adc}$, $I_B = 1.0\text{ Adc}$, $T_C = 100^\circ\text{C}$)	$V_{CE(sat)}$	—	—	1.2 2.5* 3.0*	Vdc
Base–Emitter Saturation Voltage ($I_C = 10\text{ Adc}$, $I_B = 1.0\text{ Adc}$) ($I_C = 10\text{ Adc}$, $I_B = 1.0\text{ Adc}$, $T_C = 100^\circ\text{C}$)	$V_{BE(sat)}$	—	—	1.5* 1.5	Vdc
DC Current Gain ($I_C = 10\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 15\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	8.0* 5.0	—	30* —	—

DYNAMIC CHARACTERISTICS (2)

Current Gain — Bandwidth Product ($V_{CE} = 10\text{ Vdc}$, $I_C = 0.25\text{ Adc}$, $f_{test} = 10\text{ MHz}$)	f_T	10*	—	75*	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f_{test} = 1.0\text{ kHz}$)	C_{ob}	50*	—	400*	pF

SWITCHING CHARACTERISTICS

Resistive Load (Table 1)							
Delay Time	$(I_C = 10\text{ Adc}$, $V_{CC} = 250\text{ Vdc}$, $I_{B1} = 1.0\text{ Adc}$, $PW = 30\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$)	$(I_{B2} = 2.6\text{ Adc}$, $R_{B2} = 1.6\ \Omega)$	t_d	—	20	100*	ns
Rise Time			t_r	—	200	500*	
Storage Time			t_s	—	1200	3000*	
Fall Time			t_f	—	200	250*	
Storage Time			t_s	—	650	—	
Fall Time			t_f	—	80	—	
Inductive Load (Table 2)							
Storage Time	$(I_C = 10\text{ Adc}$, $I_{B1} = 1.0\text{ Adc}$, $V_{BE(off)} = 5.0\text{ Vdc}$, $V_{CE(pk)} = 400\text{ Vdc}$)	$(T_C = 100^\circ\text{C})$	t_{sv}	—	800	1500*	ns
Fall Time			t_{fi}	—	50	150*	
Crossover Time			t_c	—	90	200*	
Storage Time			t_{sv}	—	1050	—	
Fall Time			t_{fi}	—	70	—	
Crossover Time			t_c	—	120	—	

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

(2) $f_T = |S_{he}| f_{test}$.

* Indicates JEDEC Registered Limit.

TYPICAL STATIC CHARACTERISTICS

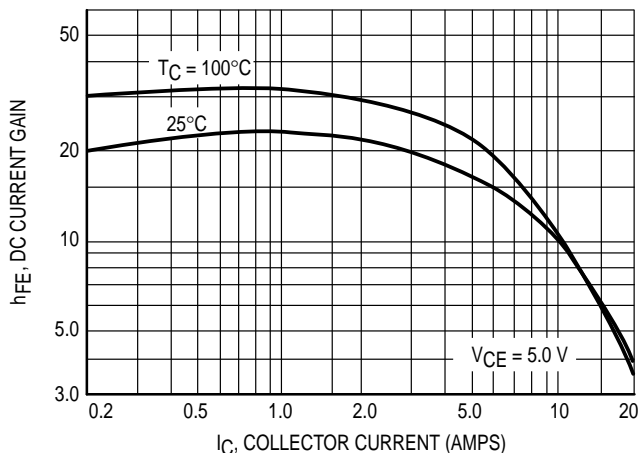


Figure 1. DC Current Gain

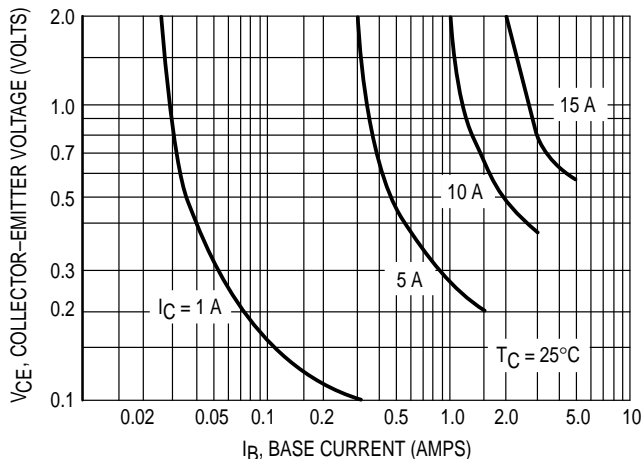


Figure 2. Collector Saturation Region

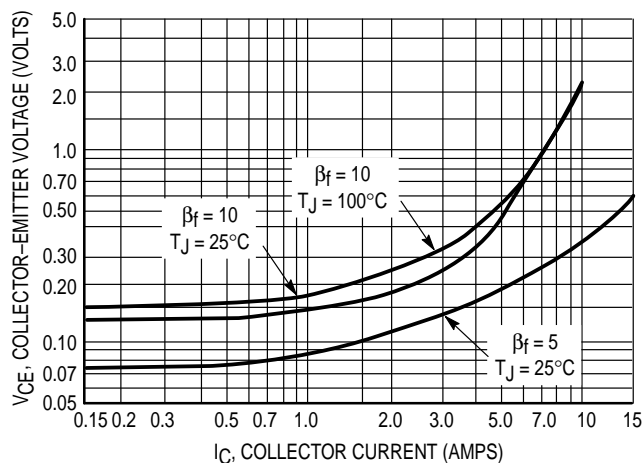


Figure 3. Collector-Emitter Saturation Voltage

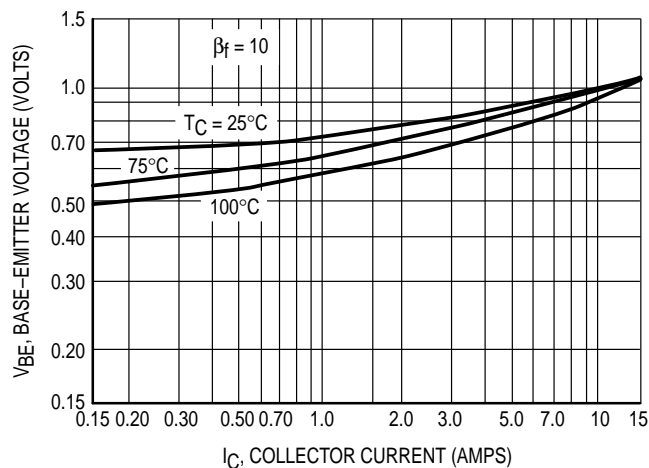


Figure 4. Base-Emitter Voltage

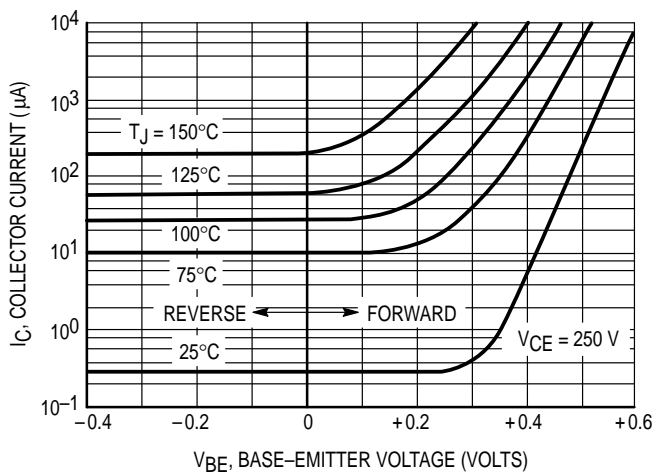


Figure 5. Collector Cutoff Region

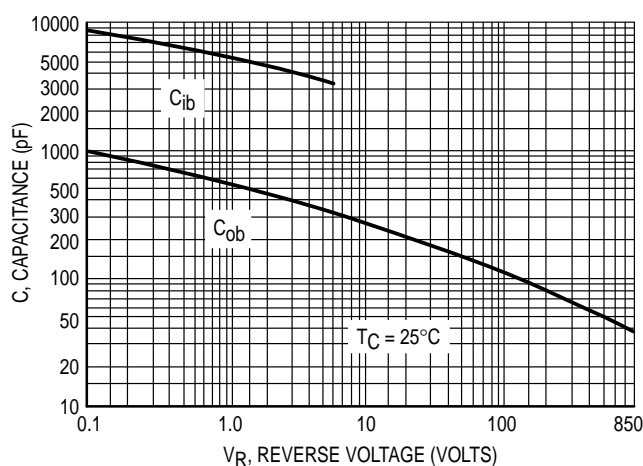
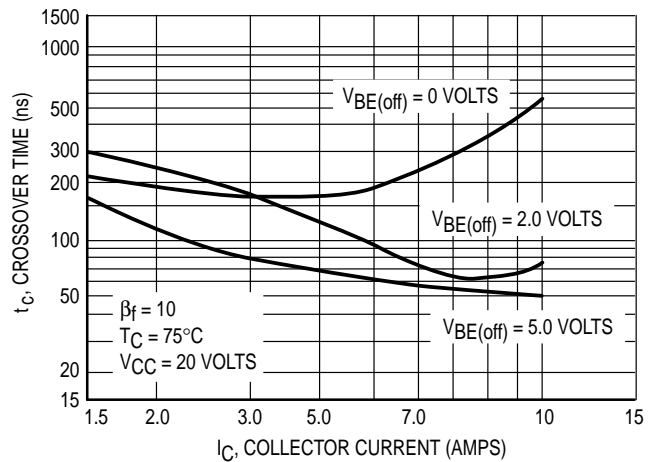
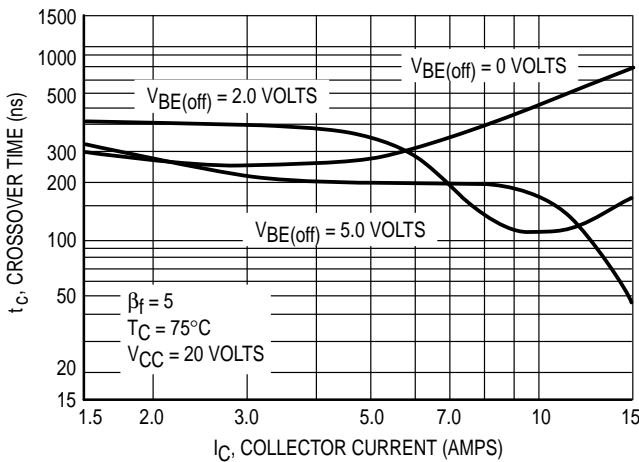
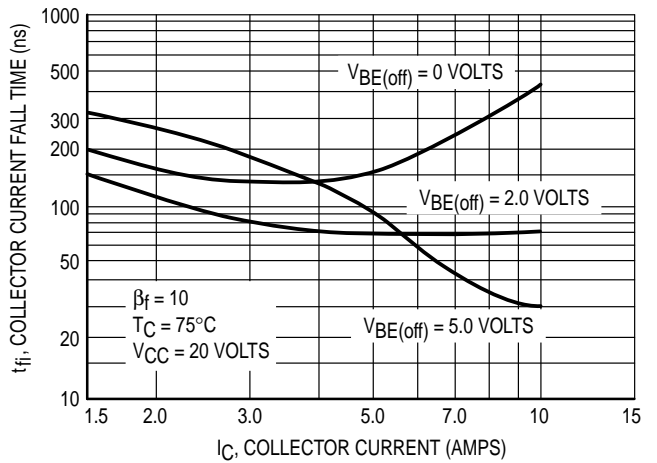
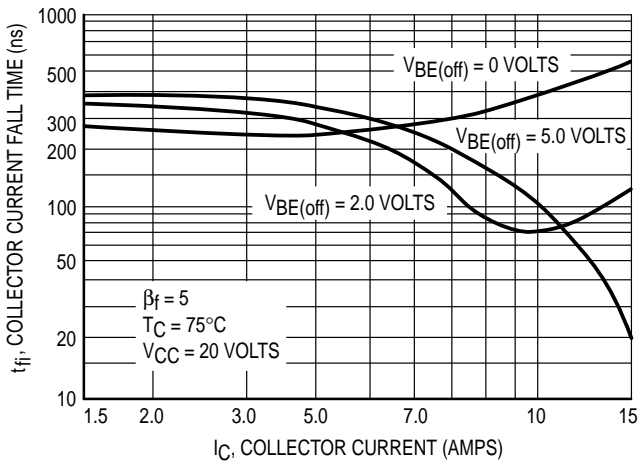
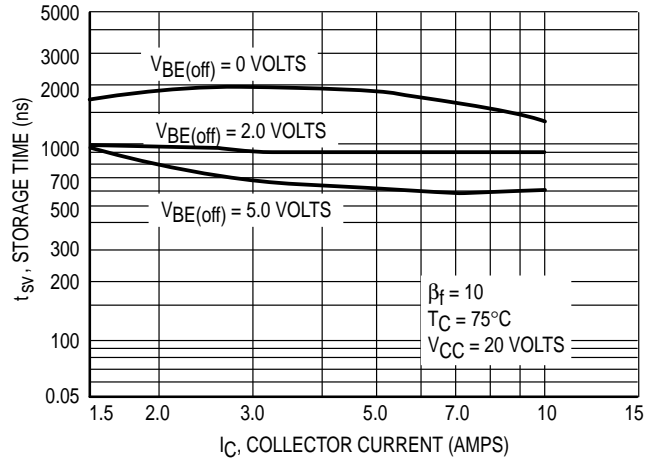
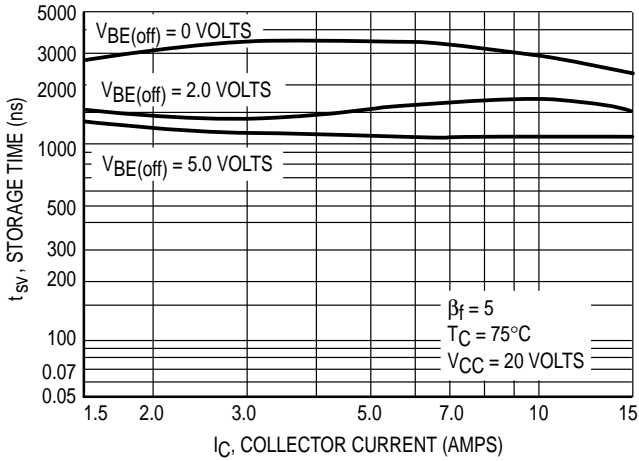


Figure 6. Capacitance

TYPICAL DYNAMIC CHARACTERISTICS



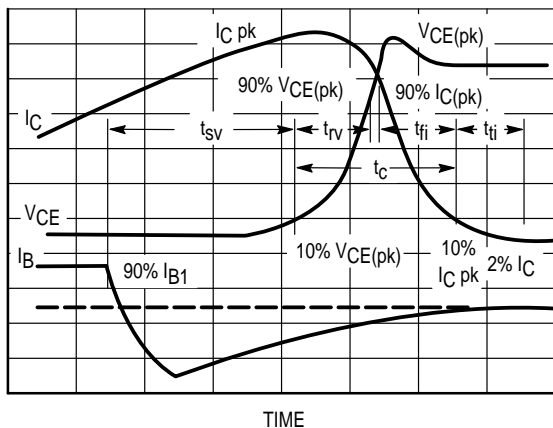


Figure 13. Inductive Switching Measurements

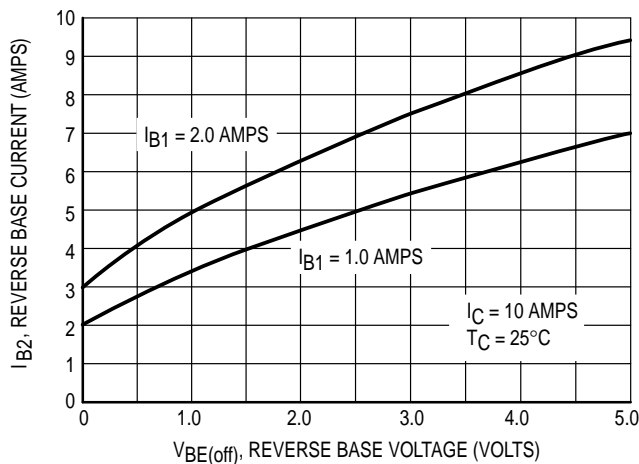


Figure 14. Peak Reverse Base Current

GUARANTEED SAFE OPERATING AREA LIMITS

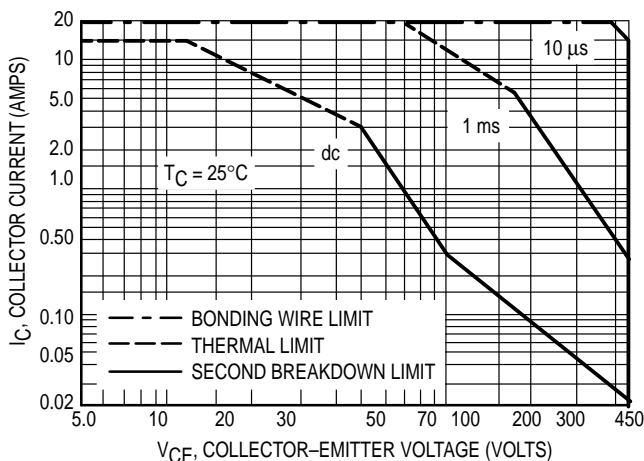


Figure 15. Maximum Forward Bias Safe Operating Area

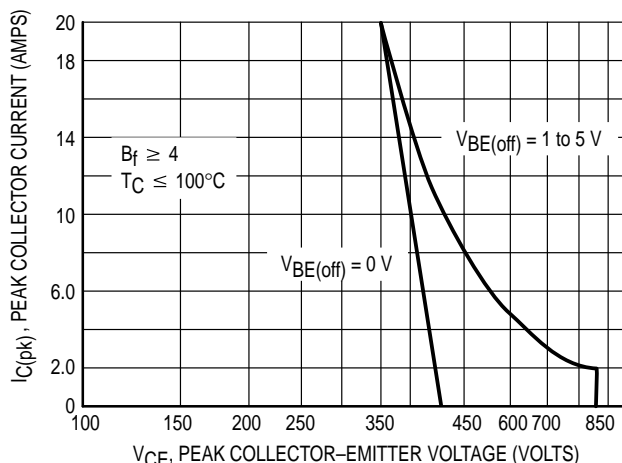


Figure 16. Maximum Reverse Bias Safe Operating Area

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 15 is based on $T_C = 25^\circ\text{C}$; $T_J(\text{pk})$ 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 15 may be found at any case temperature by using the appropriate curve on Figure 18.

$T_J(\text{pk})$ may be calculated from the data in Figure 17. 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, R_C 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 16 gives the RBSOA characteristics.

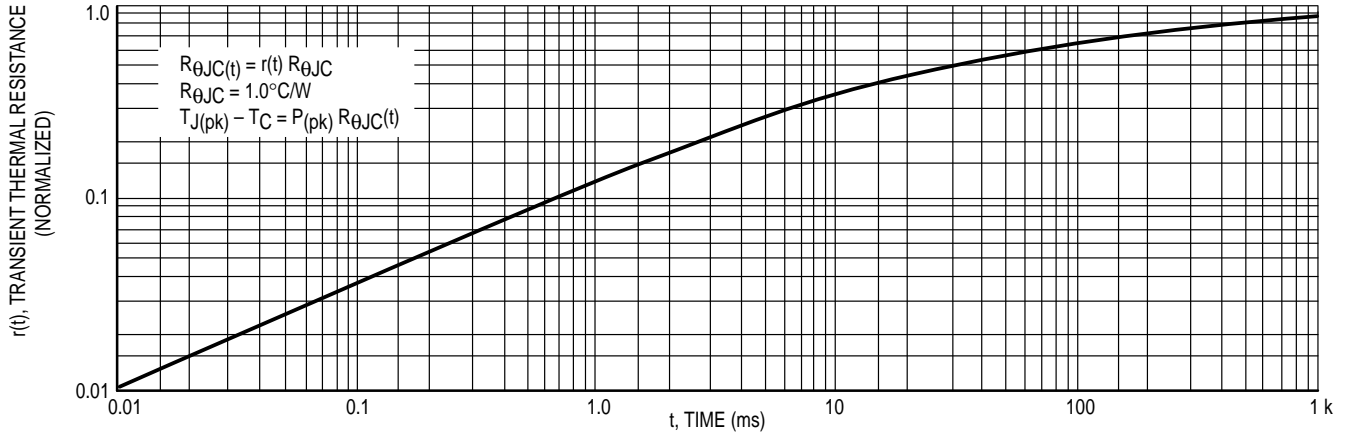


Figure 17. Thermal Response

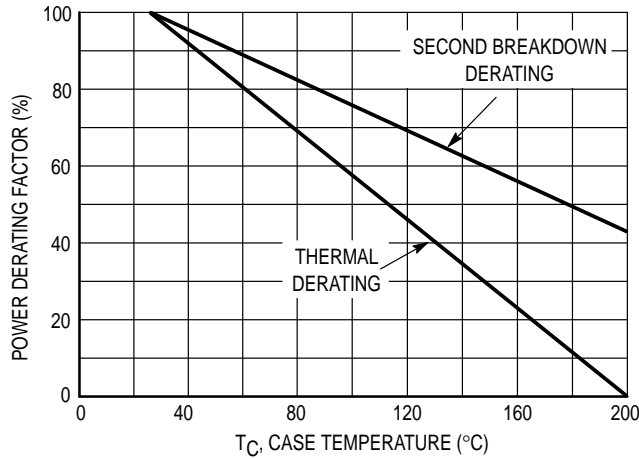
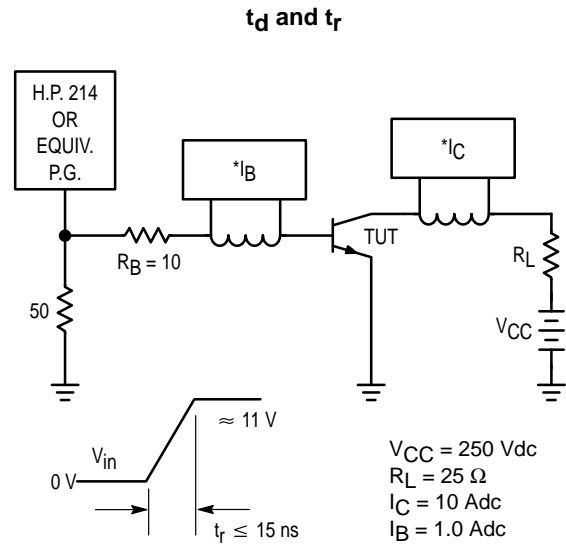
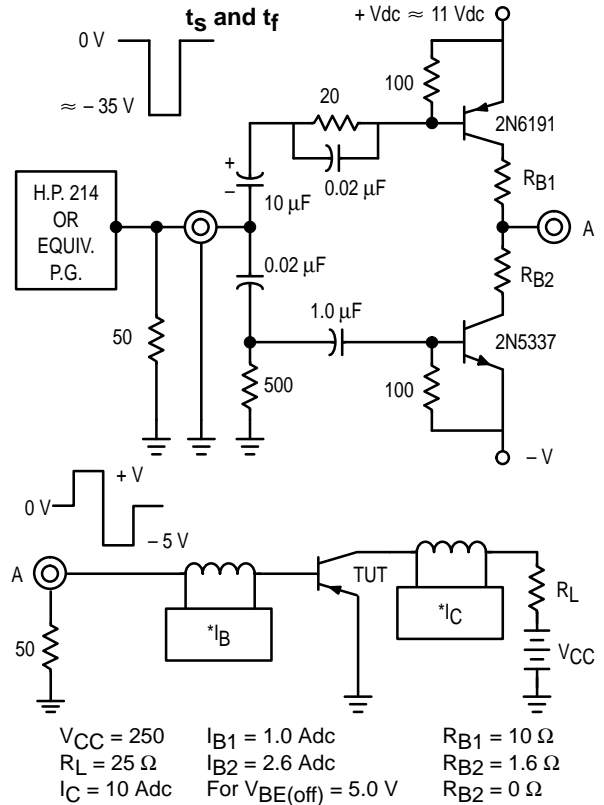


Figure 18. Power Derating

Table 1. Resistive Load Switching

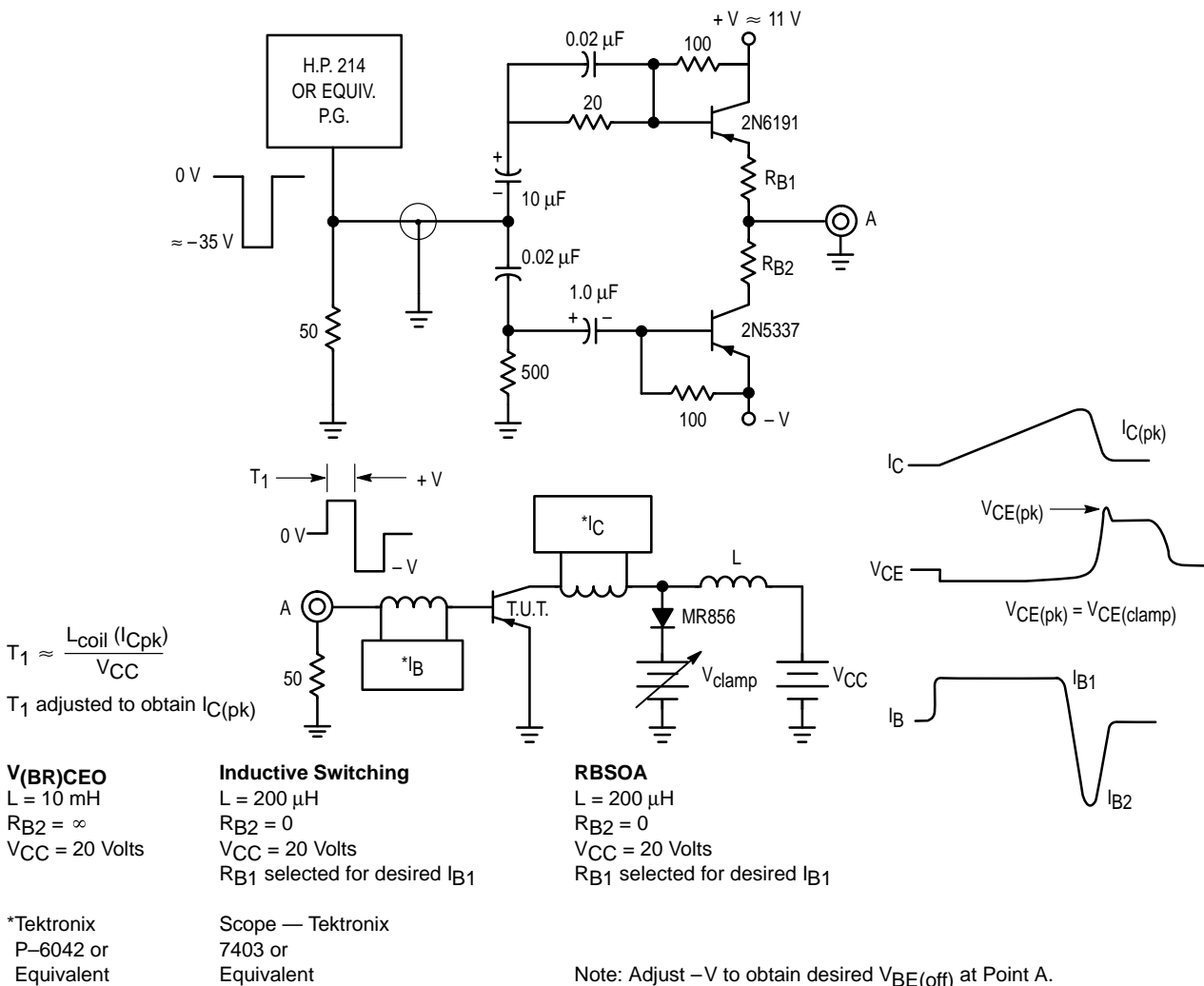


*Tektronix P-6042 or equivalent.



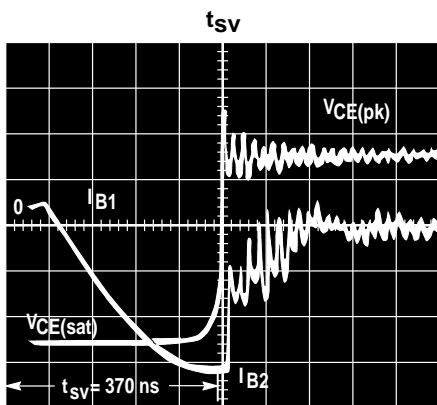
*NOTE: Adjust -V to obtain desired $V_{BE(off)}$ at Point A.

Table 2. Inductive Load Switching

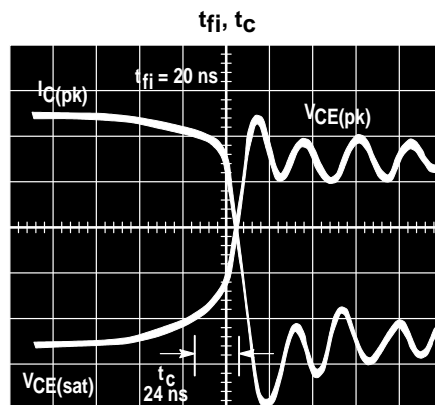


TYPICAL INDUCTIVE SWITCHING WAVEFORMS

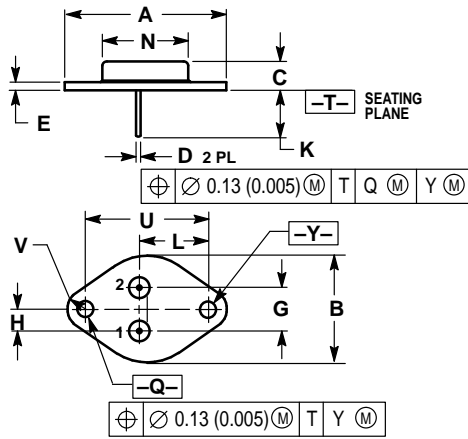
$I_{C(pk)} = 10 \text{ Amps}$
 $I_{B1} = 1.0 \text{ Amp}$
 $V_{BE(off)} = 5.0 \text{ Volts}$
 $V_{CE(pk)} = 400 \text{ Volts}$
 $T_C = 25^\circ\text{C}$
 Time Base = 100 ns/cm



$I_{C(pk)} = 10 \text{ Amps}$
 $I_{B1} = 1.0 \text{ Amp}$
 $V_{BE(off)} = 5.0 \text{ Volts}$
 $V_{CE(pk)} = 400 \text{ Volts}$
 $T_C = 25^\circ\text{C}$
 Time Base = 20 ns/cm



PACKAGE DIMENSIONS



- 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	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.550 REF		39.37 REF	
B	—	1.050	—	26.67
C	0.250	0.335	6.35	8.51
D	0.038	0.043	0.97	1.09
E	0.055	0.070	1.40	1.77
G	0.430 BSC		10.92 BSC	
H	0.215 BSC		5.46 BSC	
K	0.440	0.480	11.18	12.19
L	0.665 BSC		16.89 BSC	
N	—	0.830	—	21.08
Q	0.151	0.165	3.84	4.19
U	1.187 BSC		30.15 BSC	
V	0.131	0.188	3.33	4.77

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

CASE 1-07
 TO-204AA (TO-3)
 ISSUE Z

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