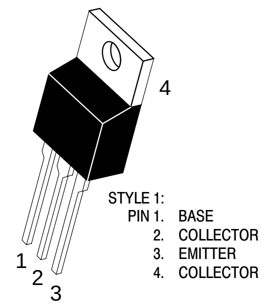
BUL44

SWITCHMODE™
NPN Bipolar Power Transistor
For Switching Power Supply Applications

POWER TRANSISTOR
2.0 AMPERES
700 VOLTS
40 and 100 WATTS

The BUL44 have an applications specific state–of–the–art die designed for use in 220 V line operated Switchmode Power supplies and electronic light ballasts. These high voltage/high speed transistors offer the following:

- Improved Efficiency Due to Low Base Drive Requirements:
  - High and Flat DC Current Gain h_{FE}
  - Fast Switching
  - No Coil Required in Base Circuit for Turn–Off (No Current Tail)
- Full Characterization at 125°C
- Tight Parametric Distributions are Consistent Lot–to–Lot



BUL44
CASE 221A–06
TO–220AB

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Sustaining Voltage	V_{CEO}	400	Vdc
Collector–Emitter Breakdown Voltage	V_{CES}	700	Vdc
Emitter–Base Voltage	V_{EBO}	9.0	Vdc
Collector Current — Continuous — Peak(1)	I_C I_{CM}	2.0 5.0	Adc
Base Current — Continuous — Peak(1)	I_B I_{BM}	1.0 2.0	Adc
Total Device Dissipation (T_C = 25°C) Derate above 25°C	P_D	50 0.4	Watts W/°C
Operating and Storage Temperature	T_J, T_{stg}	– 65 to 150	°C

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Thermal Resistance — Junction to Case — Junction to Ambient	$R_{\theta JC}$ $R_{\theta JA}$	2.5 62.5	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8″ from Case for 5 Seconds	T_L	260	°C

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Sustaining Voltage (I_C = 100 mA, L = 25 mH)	$V_{CEO(sus)}$	400	—	—	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)	I_{CEO}	—	—	100	µAdc
Collector Cutoff Current (V_{CE} = Rated V_{CES}, V_{EB} = 0)	I_{CES}	—	—	100	µAdc
(T_C = 125°C)		—	—	500	
(V_{CE} = 500 V, V_{EB} = 0) (T_C = 125°C)		—	—	100	
Emitter Cutoff Current (V_{EB} = 9.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	µAdc
ON CHARACTERISTICS					
Base–Emitter Saturation Voltage (I_C = 0.4 Adc, I_B = 40 mAdc)	$V_{BE(sat)}$	—	0.85	1.1	Vdc
(I_C = 1.0 Adc, I_B = 0.2 Adc)		—	0.92	1.25	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 0.4 Adc, I_B = 40 mAdc)		—	0.20	0.5	
(T_C = 125°C)		—	0.20	0.5	
(I_C = 1.0 Adc, I_B = 0.2 Adc)		—	0.25	0.6	
(T_C = 125°C)		—	0.25	0.6	
DC Current Gain	h_{FE}				—
(I_C = 0.2 Adc, V_{CE} = 5.0 Vdc)		14	—	34	
(T_C = 125°C)		—	32	—	
(I_C = 0.4 Adc, V_{CE} = 1.0 Vdc)		12	20	—	
(T_C = 125°C)		12	20	—	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		8.0	14	—	
(T_C = 125°C)		7.0	13	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		10	22	—	
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	—	13	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{OB}	—	38	60	pF
Input Capacitance (V_{EB} = 8.0 V)	C_{IB}	—	380	600	pF
Dynamic Saturation Voltage: Determined 1.0 µs and 3.0 µs respectively after rising I_{B1} reaches 90% of final I_{B1}	$V_{CE(dsat)}$				Vdc
(I_C = 0.4 Adc, I_{B1} = 40 mAdc, V_{CC} = 300 V) 1.0 µs		—	2.5	—	
(T_C = 125°C)		—	2.7	—	
(I_C = 0.4 Adc, I_{B1} = 40 mAdc, V_{CC} = 300 V) 3.0 µs		—	1.3	—	
(T_C = 125°C)		—	1.15	—	
(I_C = 1.0 Adc, I_{B1} = 0.2 Adc, V_{CC} = 300 V) 1.0 µs		—	3.2	—	
(T_C = 125°C)		—	7.5	—	
(I_C = 1.0 Adc, I_{B1} = 0.2 Adc, V_{CC} = 300 V) 3.0 µs		—	1.25	—	
(T_C = 125°C)		—	1.6	—	

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

(continued)

SWITCHING CHARACTERISTICS: Resistive Load (D.C. ≤ 10%, Pulse Width = 20 μs)

Turn–On Time	(I_C = 0.4 Adc, I_{B1} = 40 mAdc I_{B2} = 0.2 Adc, V_{CC} = 300 V) (T_C = 125°C)	t_{on}	— —	40 40	100 —	ns
Turn–Off Time	(I_C = 0.4 Adc, I_{B1} = 40 mAdc I_{B2} = 0.2 Adc, V_{CC} = 300 V) (T_C = 125°C)	t_{off}	— —	1.5 2.0	2.5 —	μs
Turn–On Time	(I_C = 1.0 Adc, I_{B1} = 0.2 Adc I_{B1} = 0.5 Adc, V_{CC} = 300 V) (T_C = 125°C)	t_{on}	— —	85 85	150 —	ns
Turn–Off Time	(I_C = 1.0 Adc, I_{B1} = 0.2 Adc I_{B2} = 0.5 Adc, V_{CC} = 300 V) (T_C = 125°C)	t_{off}	— —	1.75 2.10	2.5 —	μs

SWITCHING CHARACTERISTICS: Inductive Load (V_{clamp} = 300 V, V_{CC} = 15 V, L = 200 μH)

Fall Time	(I_C = 0.4 Adc, I_{B1} = 40 mAdc I_{B2} = 0.2 Adc) (T_C = 125°C)	t_{fi}	— —	125 120	200 —	ns
Storage Time	(T_C = 125°C)	t_{si}	— —	0.7 0.8	1.25 —	μs
Crossover Time	(T_C = 125°C)	t_c	— —	110 110	200 —	ns
Fall Time	(I_C = 1.0 Adc, I_{B1} = 0.2 Adc I_{B2} = 0.5 Adc) (T_C = 125°C)	t_{fi}	— —	110 120	175 —	ns
Storage Time	(T_C = 125°C)	t_{si}	— —	1.7 2.25	2.75 —	μs
Crossover Time	(T_C = 125°C)	t_c	— —	180 210	300 —	ns
Fall Time	(I_C = 0.8 Adc, I_{B1} = 160 mAdc I_{B2} = 160 mAdc) (T_C = 125°C)	t_{fi}	70 —	— 180	170 —	ns
Storage Time	(T_C = 125°C)	t_{si}	2.6 —	— 4.2	3.8 —	μs
Crossover Time	(T_C = 125°C)	t_c	— —	190 350	300 —	ns

TYPICAL STATIC CHARACTERISTICS

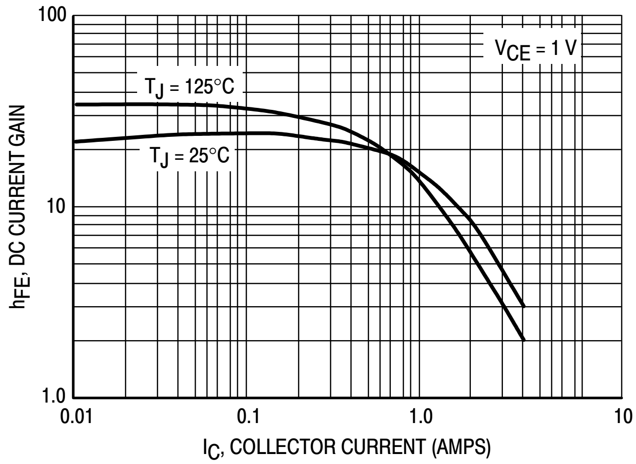


Figure 1. DC Current Gain at 1 Volt

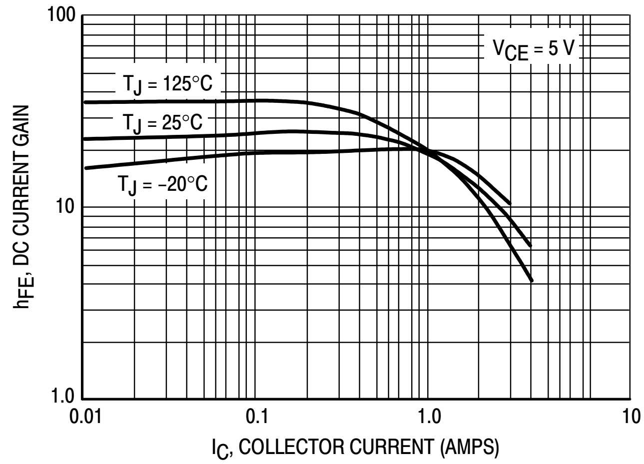


Figure 2. DC Current Gain at 5 Volts

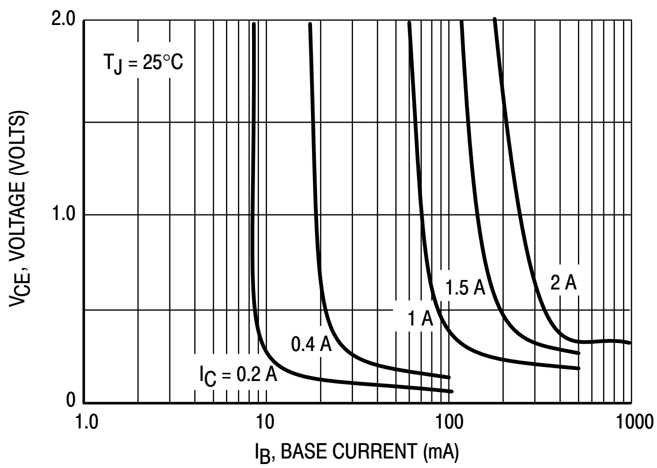


Figure 3. Collector Saturation Region

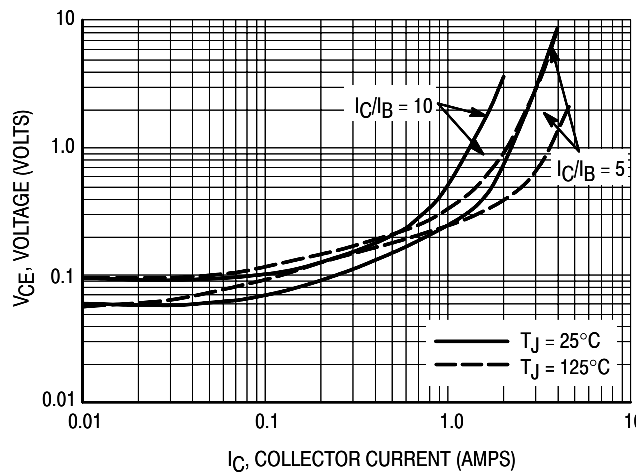


Figure 4. Collector–Emitter Saturation Voltage

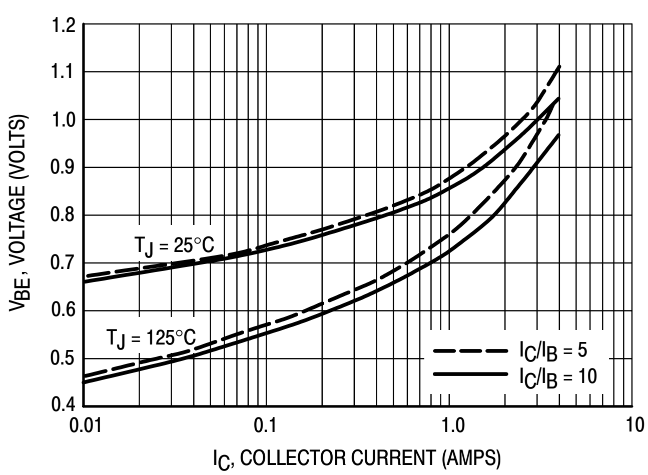


Figure 5. Base–Emitter Saturation Region

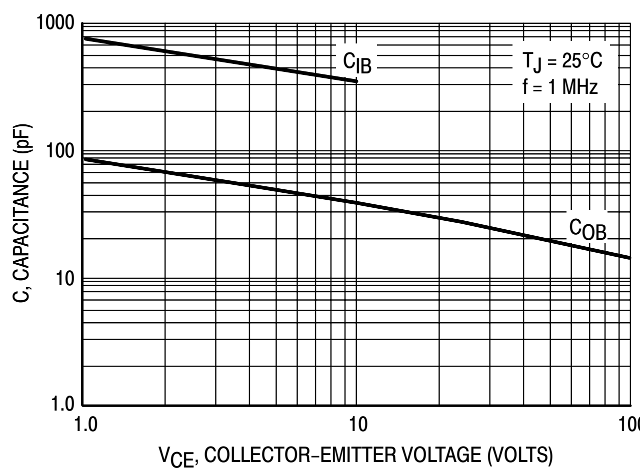


Figure 6. Capacitance

TYPICAL SWITCHING CHARACTERISTICS
($I_{B2} = I_C/2$ for all switching)

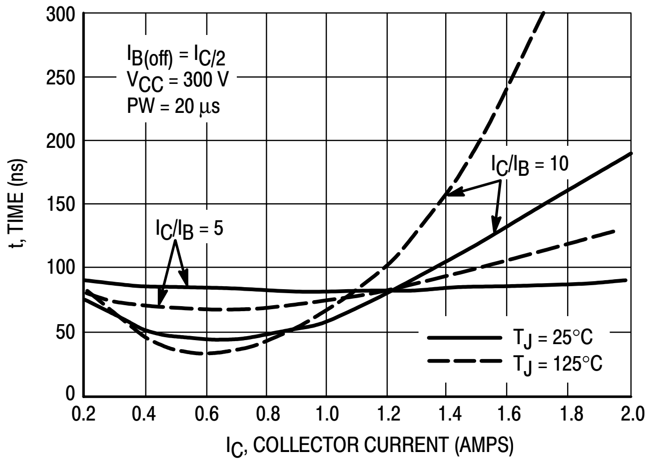


Figure 7. Resistive Switching, t_{on}

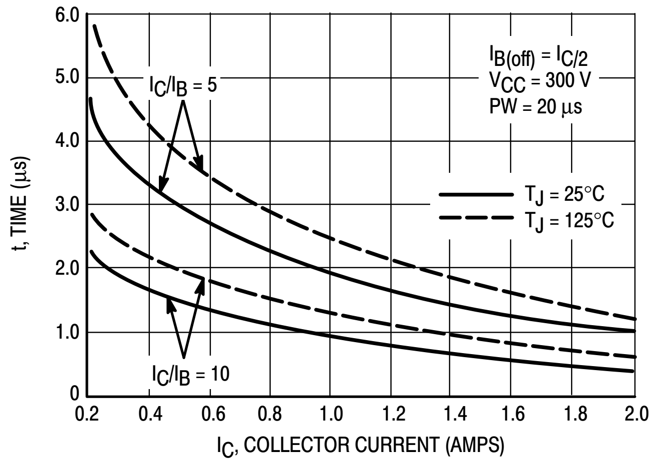


Figure 8. Resistive Switching, t_{off}

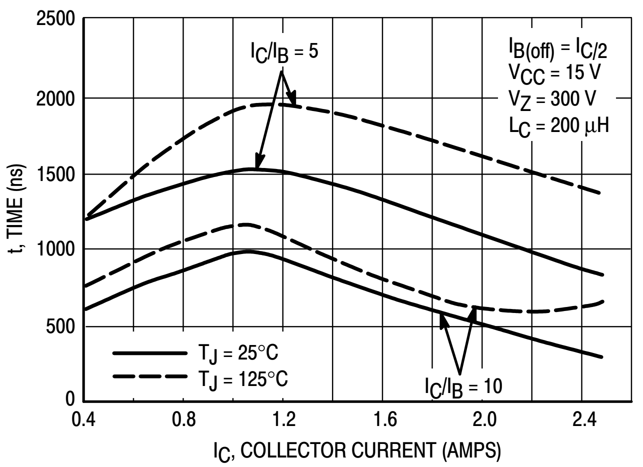


Figure 9. Inductive Storage Time, t_{si}

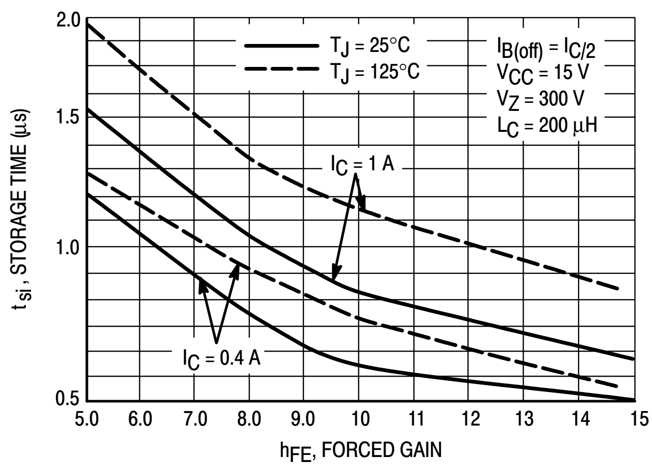


Figure 10. Inductive Storage Time

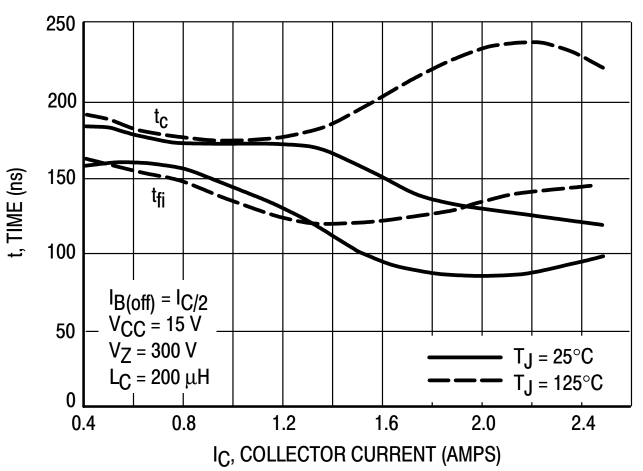


Figure 11. Inductive Switching, t_c and t_{fi} $I_C/I_B = 5$

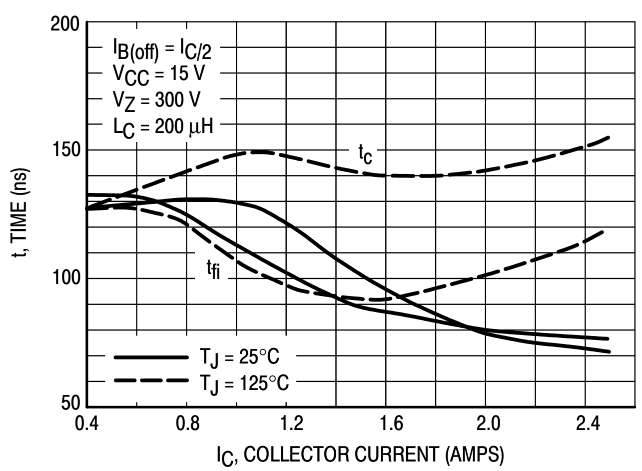


Figure 12. Inductive Switching, t_c and t_{fi} $I_C/I_B = 10$

TYPICAL SWITCHING CHARACTERISTICS
($I_{B2} = I_C/2$ for all switching)

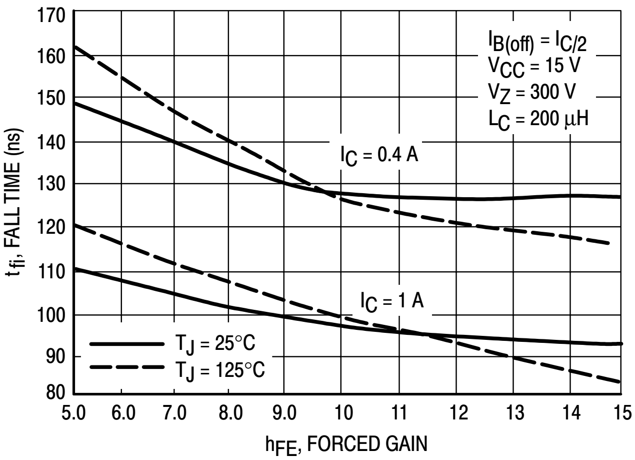


Figure 13. Inductive Fall Time

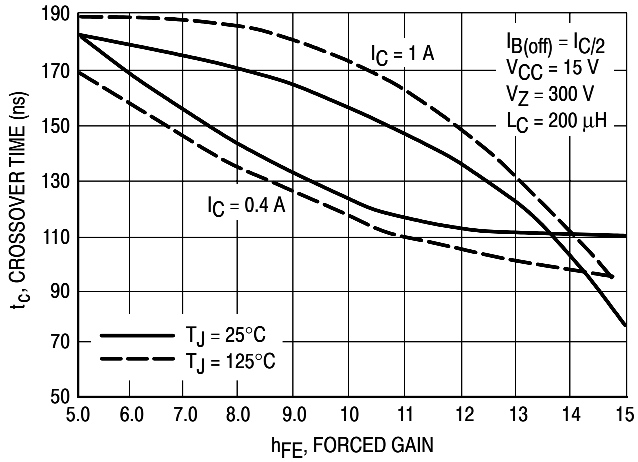


Figure 14. Inductive Crossover Time

GUARANTEED SAFE OPERATING AREA INFORMATION

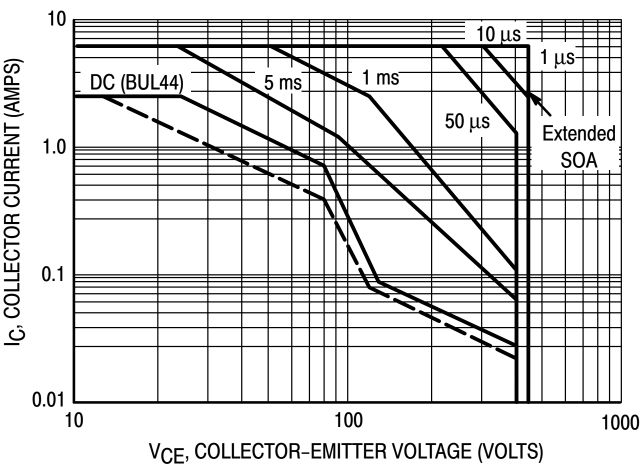


Figure 15. Forward Bias Safe Operating Area

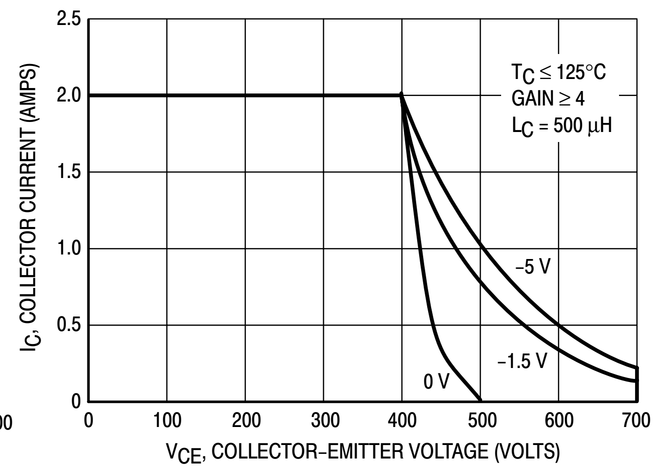


Figure 16. Reverse Bias Switching Safe Operating Area

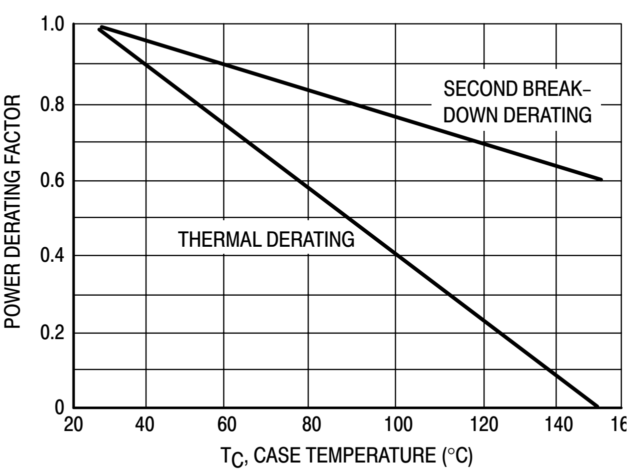


Figure 17. Forward Bias Power Derating

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°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 > 25°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 17. $T_{J(PK)}$ may be calculated from the data in figure 20. At any case temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown. For inductive loads, high voltage and current must be sustained simultaneously during turn–off with the base–to–emitter junction reverse–biased. The safe level is specified as a reverse–biased safe operating area (Figure 16). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

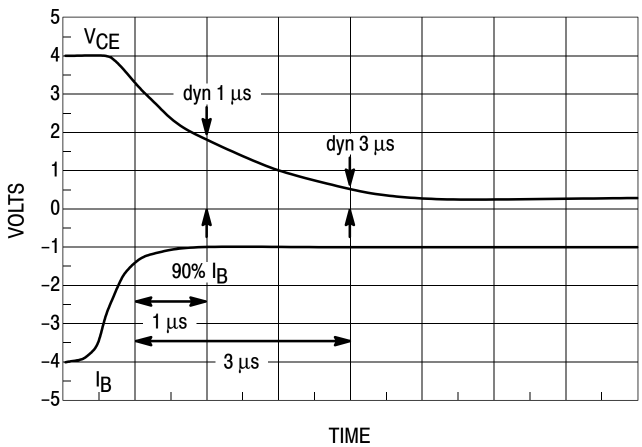


Figure 18. Dynamic Saturation Voltage Measurements

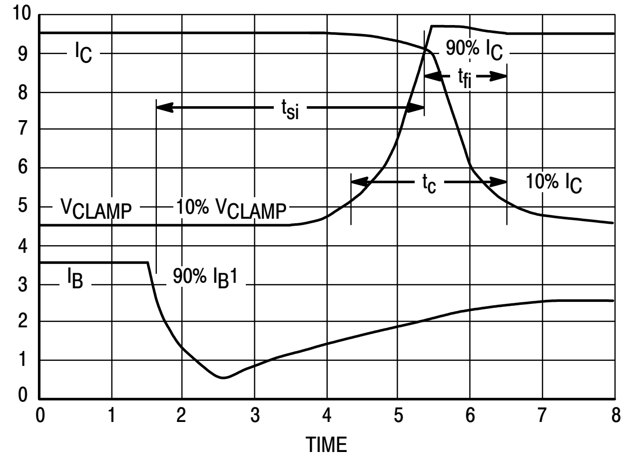
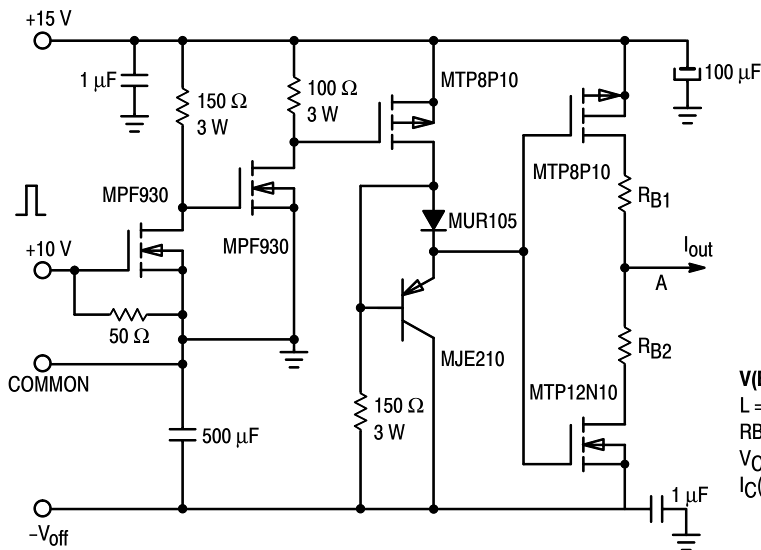
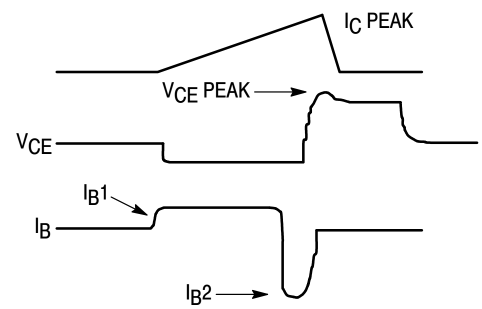


Figure 19. Inductive Switching Measurements





V(BR)CEO(sus)	INDUCTIVE SWITCHING	RBSOA
L = 10 mH	L = 200 μH	L = 500 μH
RB2 = ∞	RB2 = 0	RB2 = 0
V_{CC} = 20 VOLTS	V_{CC} = 15 VOLTS	V_{CC} = 15 VOLTS
I_C(pk) = 100 mA	RB1 SELECTED FOR DESIRED I_{B1}	RB1 SELECTED FOR DESIRED I_{B1}

Table 1. Inductive Load Switching Drive Circuit

TYPICAL THERMAL RESPONSE

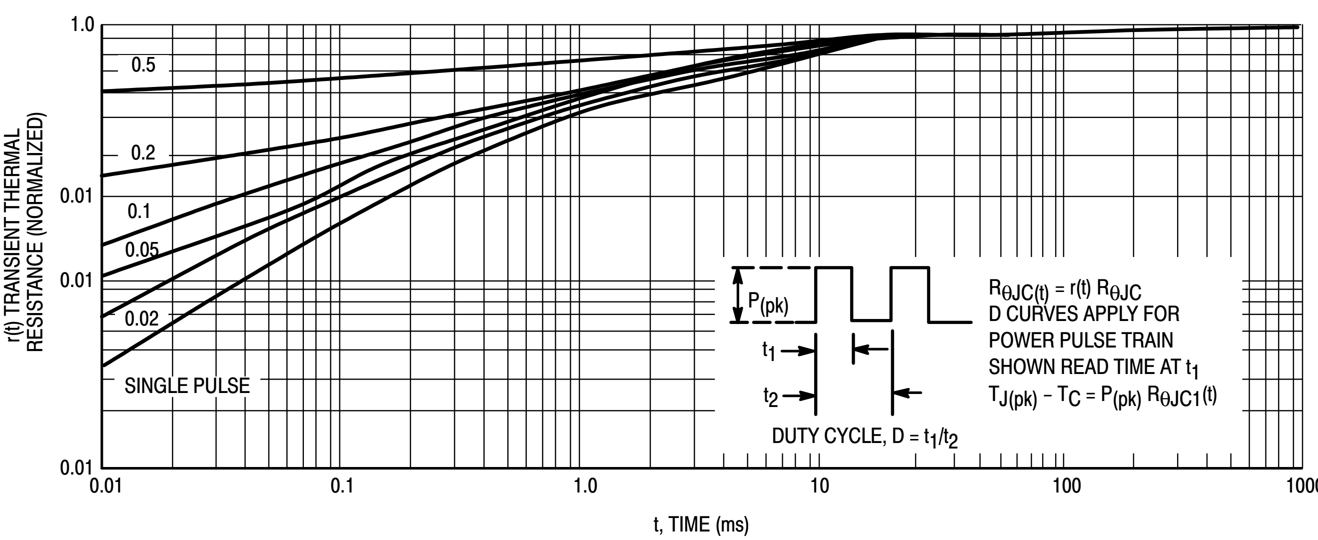
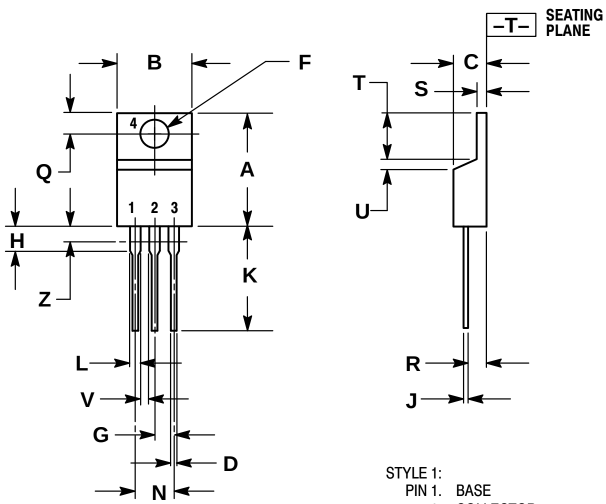


Figure 20. Typical Thermal Response ($Z_{\theta JC}(t)$) for BUL44

PACKAGE DIMENSIONS

TO–220AB
CASE 221A–09
ISSUE AA



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

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	---	1.15	---
Z	---	0.080	---	2.04

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