BUL147

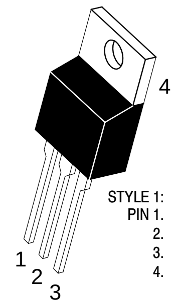
SWITCHMODE™

NPN Bipolar Power Transistor For Switching Power Supply Applications

POWER TRANSISTOR
8.0 AMPERES
700 VOLTS
45 and 125 WATTS

The BUL147 have an applications specific state–of–the–art die designed for use in electric fluorescent lamp ballasts to 180 Watts and in Switchmode Power supplies for all types of electronic equipment. These high–voltage/high–speed transistors offer the following:

- Improved Efficiency Due to Low Base Drive Requirements:
  - High and Flat DC Current Gain
  - Fast Switching
  - No Coil Required in Base Circuit for Turn–Off (No Current Tail)
- Parametric Distributions are Tight and Consistent Lot–to–Lot
- Two Package Choices: Standard TO–220 or Isolated TO–220



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

BUL147
CASE 221A–09
TO–220AB

MAXIMUM RATINGS

Rating	Symbol	BUL147	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}	8.0 16	Adc
Base Current — Continuous — Peak(1)	I_B I_{BM}	4.0 8.0	Adc
Total Device Dissipation (T_C = 25°C) Derate above 25°C	P_D	125 1.0	Watts W/°C
Operating and Storage Temperature	T_J, T_{stg}	– 65 to 150	°C

THERMAL CHARACTERISTICS

Rating	Symbol	BUL44	Unit
Thermal Resistance — Junction to Case — Junction to Ambient	$R_{\theta JC}$ $R_{\theta JA}$	1.0 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 = 2.0 Adc, I_B = 0.2 Adc)	$V_{BE(sat)}$	—	0.82	1.1	Vdc
(I_C = 4.5 Adc, I_B = 0.9 Adc)		—	0.92	1.25	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)		—	0.25	0.5	
(T_C = 125°C)		—	0.3	0.5	
(I_C = 4.5 Adc, I_B = 0.9 Adc)		—	0.35	0.7	
(T_C = 125°C)		—	0.35	0.8	
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	14	—	34	—
(T_C = 125°C)		—	30	—	
(I_C = 4.5 Adc, V_{CE} = 1.0 Vdc)		8.0	12	—	
(T_C = 125°C)		7.0	11	—	
(I_C = 2.0 Adc, V_{CE} = 1.0 Vdc) (T_C = 25°C to 125°C)		10	18	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		10	20	—	
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	—	14	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	100	175	pF
Input Capacitance (V_{EB} = 8.0 V)	C_{ib}	—	1750	2500	pF
Dynamic Saturation Voltage: Determined 1.0 µs and 3.0 µs respectively after rising I_{B1} reaches 90% of final I_{B1} (see Figure 18) — (I_C = 2.0 Adc, I_{B1} = 200 mAdc, V_{CC} = 300 V) 1.0 µs	$V_{CE(dsat)}$	—	3.0	—	Volts
(T_C = 125°C)		—	5.5	—	
3.0 µs		—	0.8	—	
(T_C = 125°C)		—	1.4	—	
(I_C = 5.0 Adc, I_{B1} = 0.9 Adc, V_{CC} = 300 V) 1.0 µs		—	3.3	—	
(T_C = 125°C)		—	8.5	—	
3.0 µs		—	0.4	—	
(T_C = 125°C)		—	1.0	—	

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

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

Turn–On Time	(I_C = 2.0 Adc, I_{B1} = 0.2 Adc I_{B2} = 1.0 Adc, V_{CC} = 300 V) (T_C = 125°C)	t_{on}	— —	200 190	350 —	ns
Turn–Off Time	(T_C = 125°C)	t_{off}	— —	1.0 1.6	2.5 —	μs
Turn–On Time	(I_C = 4.5 Adc, I_{B1} = 0.9 Adc I_{B1} = 2.25 Adc, V_{CC} = 300 V) (T_C = 125°C)	t_{on}	— —	85 100	150 —	ns
Turn–Off Time	(T_C = 125°C)	t_{off}	— —	1.5 2.0	2.5 —	μs

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

Fall Time	(I_C = 2.0 Adc, I_{B1} = 0.2 Adc I_{B2} = 1.0 Adc) (T_C = 125°C)	t_{fi}	— —	100 120	180 —	ns
Storage Time	(T_C = 125°C)	t_{si}	— —	1.3 1.9	2.5 —	μs
Crossover Time	(T_C = 125°C)	t_c	— —	210 230	350 —	ns
Fall Time	(I_C = 4.5 Adc, I_{B1} = 0.9 Adc I_{B2} = 2.25 Adc) (T_C = 125°C)	t_{fi}	— —	80 100	150 —	ns
Storage Time	(T_C = 125°C)	t_{si}	— —	1.6 2.1	3.2 —	μs
Crossover Time	(T_C = 125°C)	t_c	— —	170 200	300 —	ns
Fall Time	(I_C = 4.5 Adc, I_{B1} = 0.9 Adc I_{B2} = 0.9 Adc) (T_C = 125°C)	t_{fi}	60 —	— 150	180 —	ns
Storage Time	(T_C = 125°C)	t_{si}	2.6 —	— 4.3	3.8 —	μs
Crossover Time	(T_C = 125°C)	t_c	— —	200 330	350 —	ns

TYPICAL STATIC CHARACTERISTICS

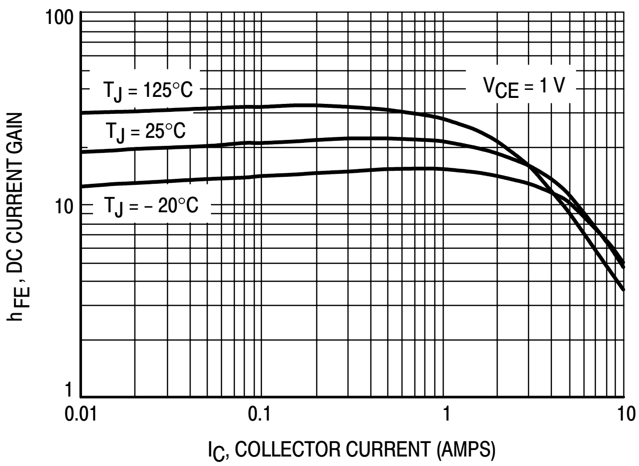


Figure 1. DC Current Gain @ 1 Volt

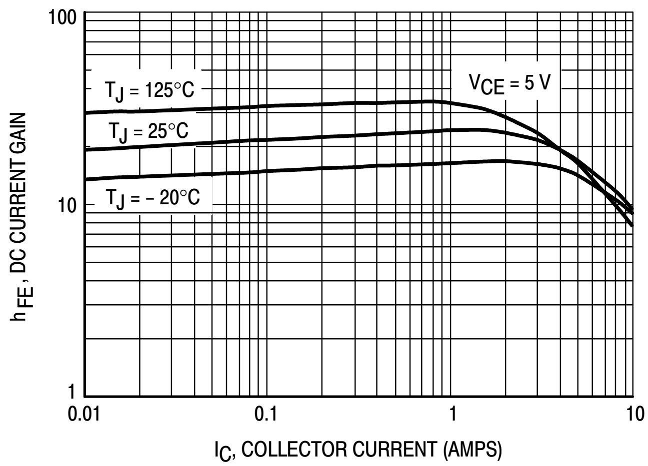


Figure 2. DC Current Gain @ 5 Volts

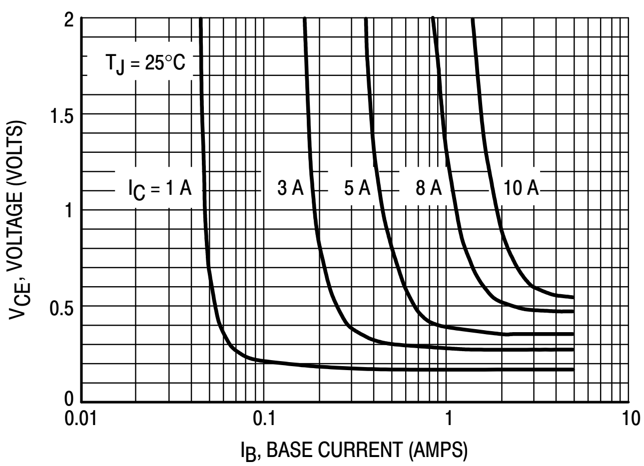


Figure 3. Collector Saturation Region

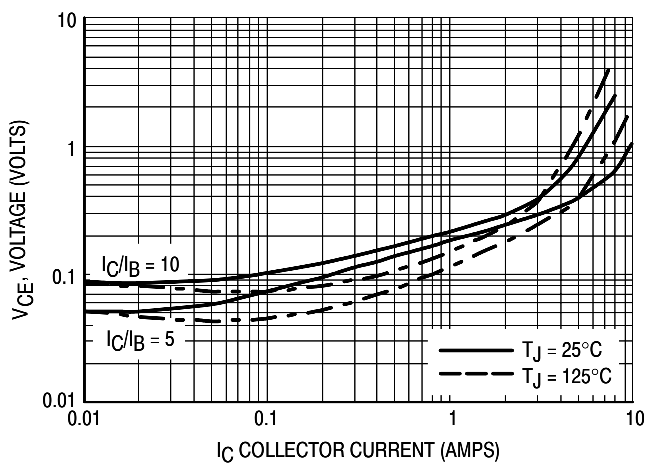


Figure 4. Collector−Emitter Saturation Voltage

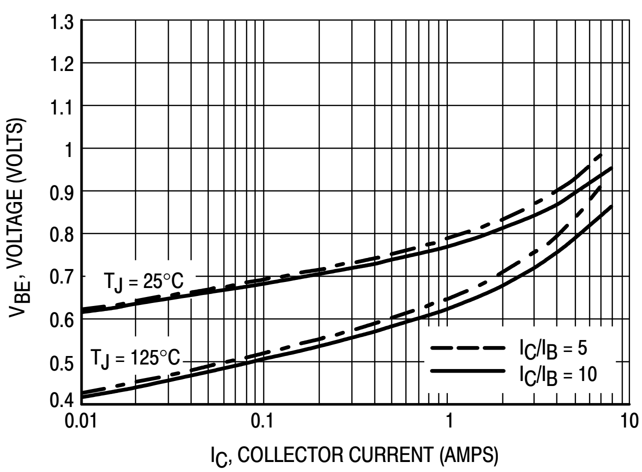


Figure 5. Base−Emitter Saturation Region

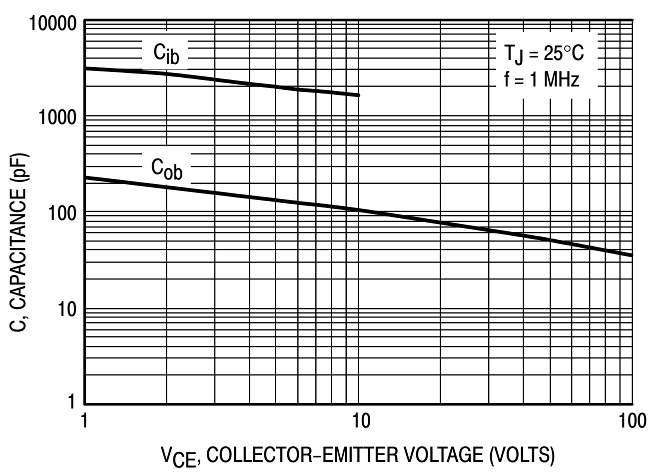


Figure 6. Capacitance

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

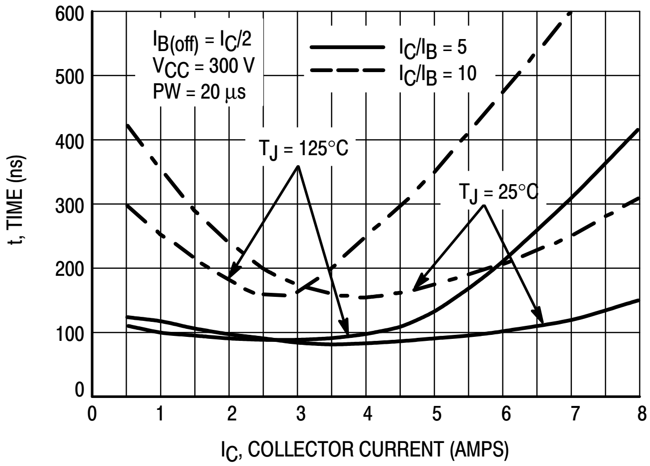


Figure 7. Resistive Switching, t_{on}

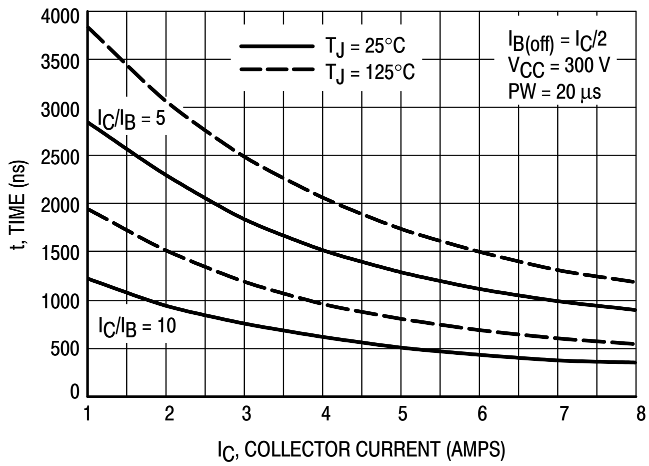


Figure 8. Resistive Switching, t_{off}

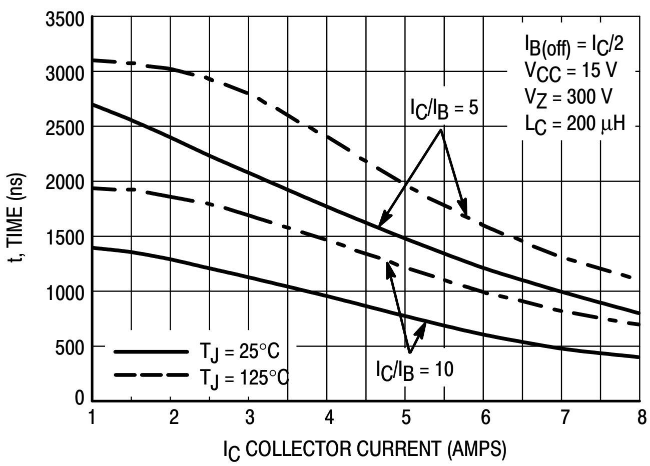


Figure 9. Inductive Storage Time, t_{si}

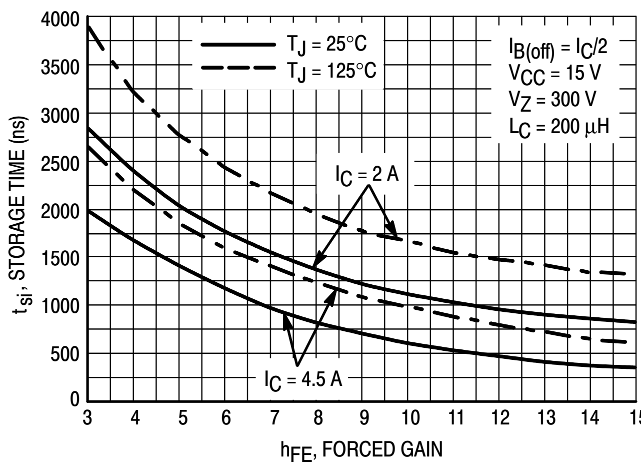


Figure 10. Inductive Storage Time, $t_{si}(h_{FE})$

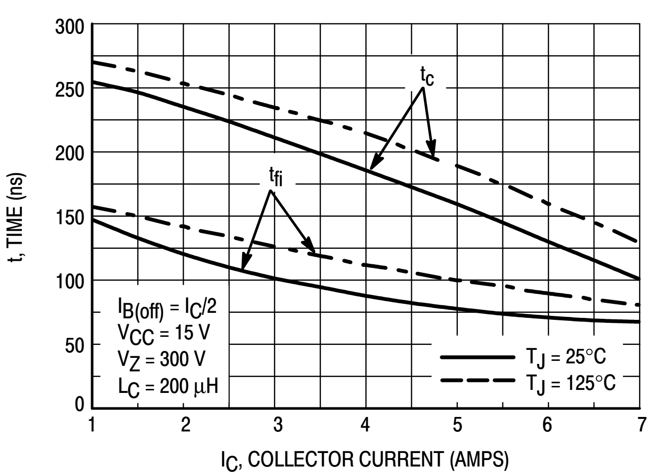


Figure 11. Inductive Switching, t_c and t_{fi}
$I_C/I_B = 5$

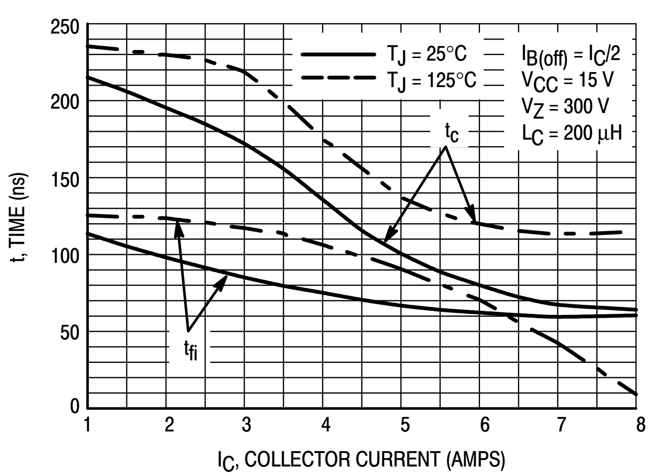


Figure 12. Inductive Switching, t_c and t_{fi}
$I_C/I_B = 10$

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

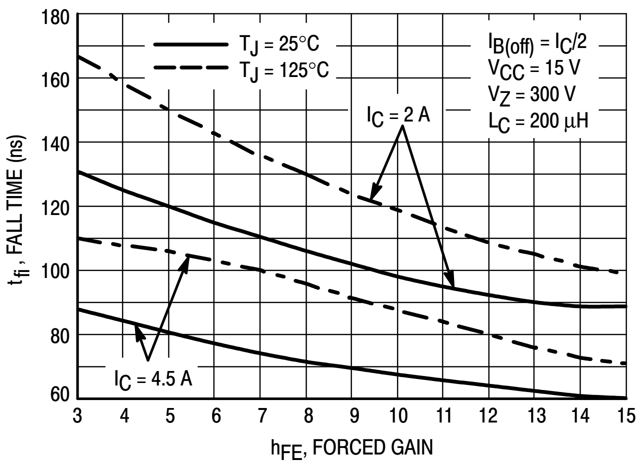


Figure 13. Inductive Fall Time

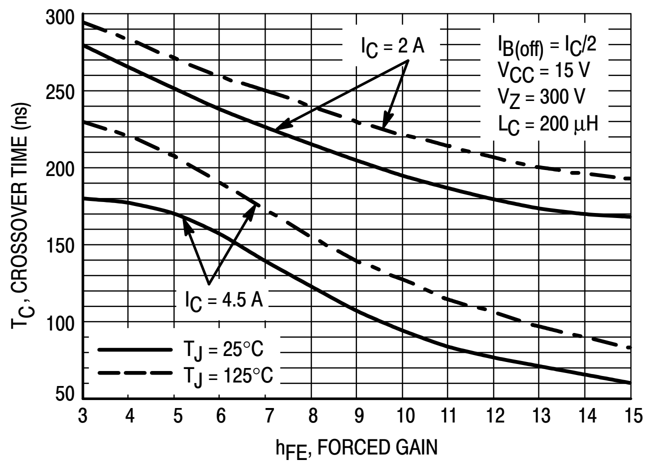


Figure 14. Inductive Crossover Time

GUARANTEED SAFE OPERATING AREA INFORMATION

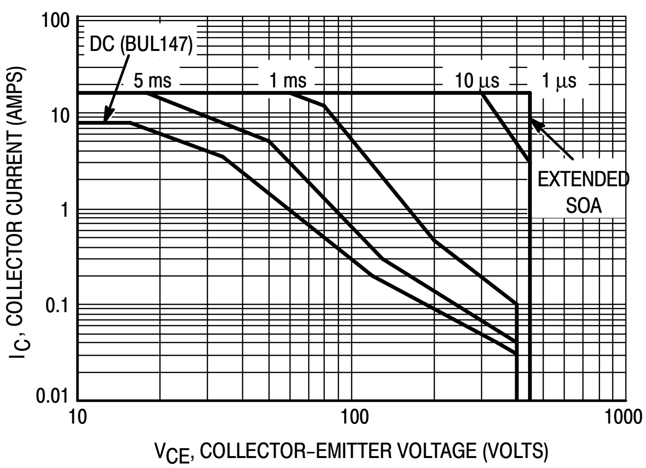


Figure 15. Forward Bias Safe Operating Area

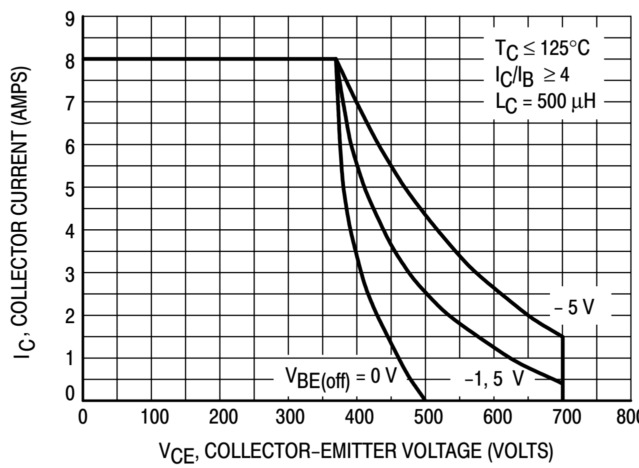


Figure 16. Reverse Bias Switching Safe Operating Area

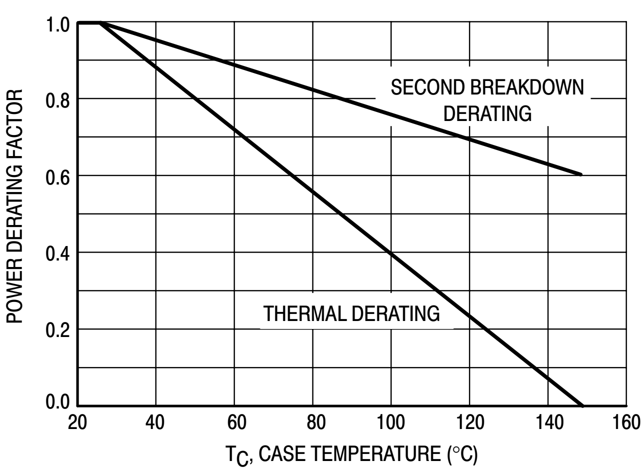


Figure 17. Forward Bias Power Derating

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 in 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 and NO TAG. At any case temperatures, thermal limitations will reduce the power that 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.

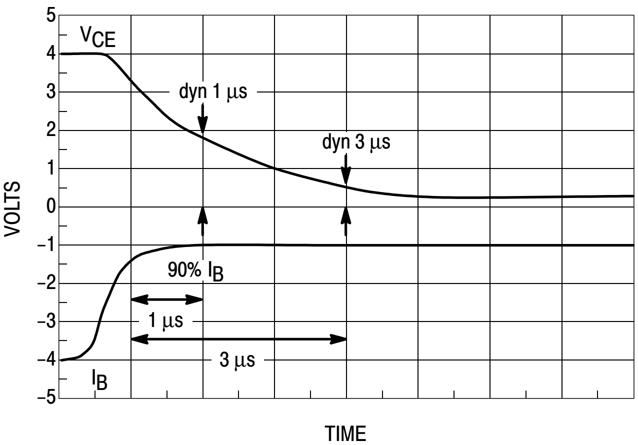


Figure 18. Dynamic Saturation Voltage Measurements

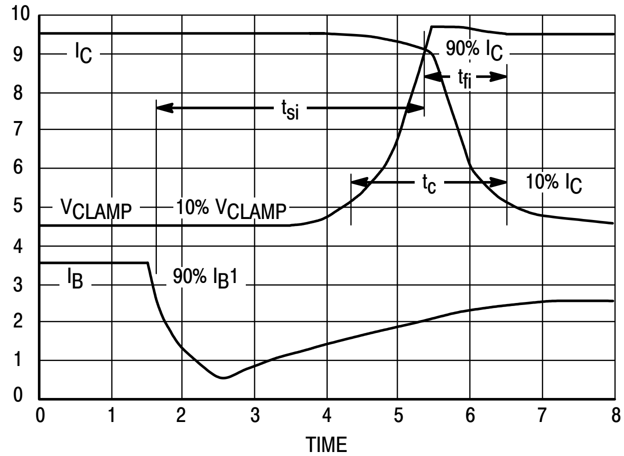
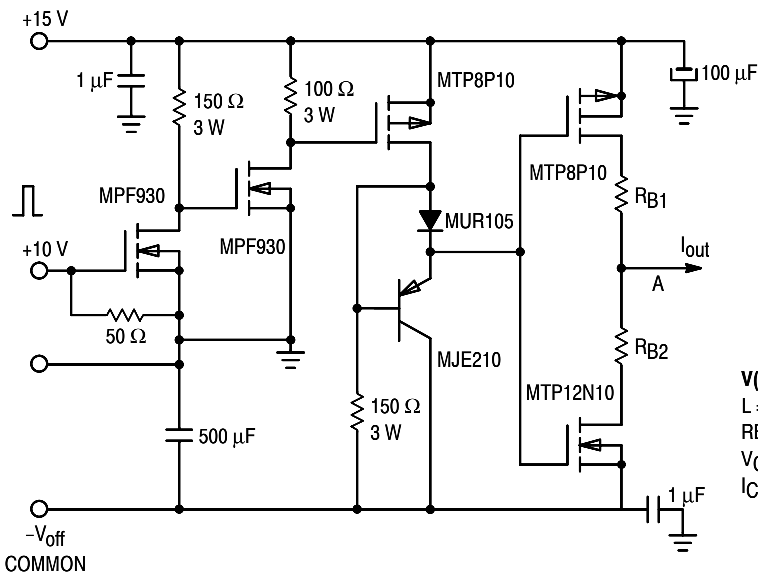
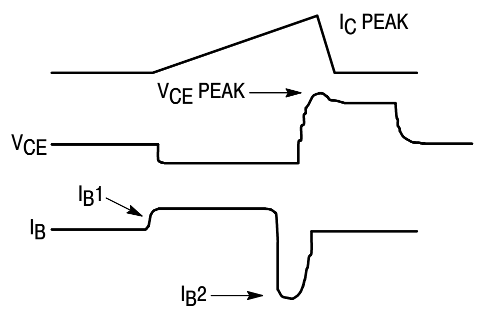


Figure 19. Inductive Switching Measurements





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

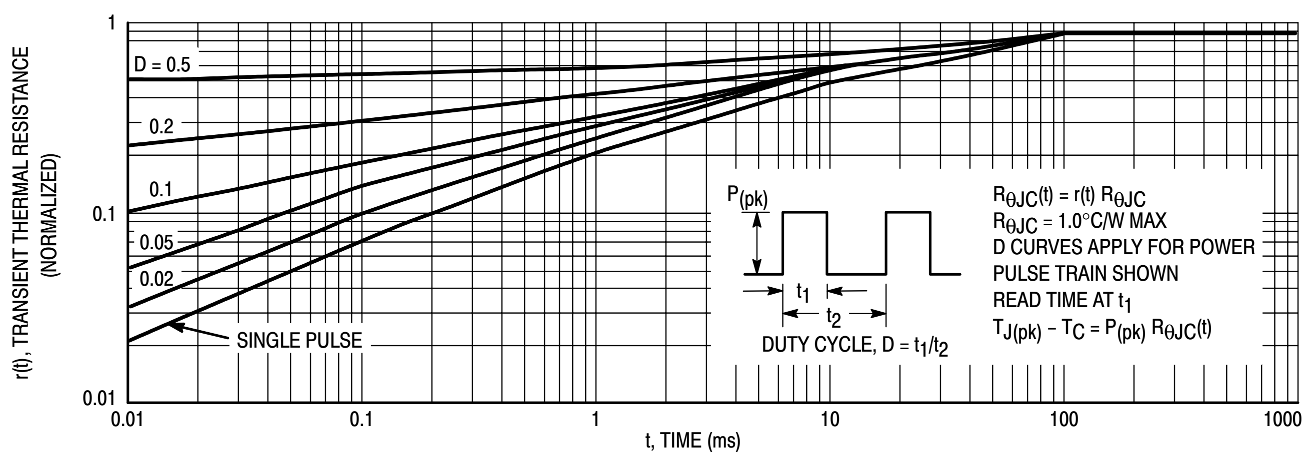
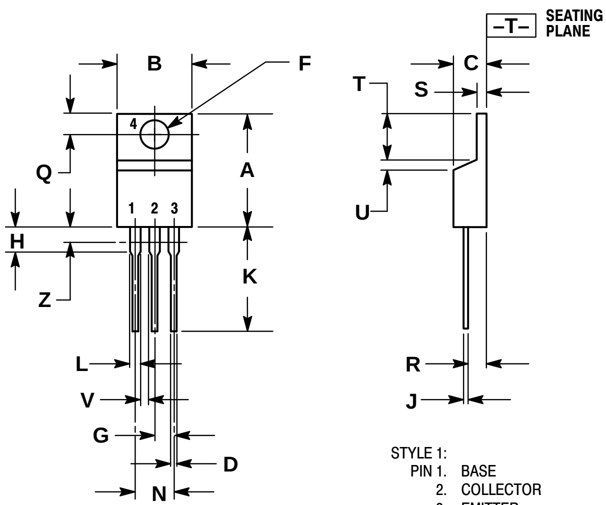


Figure 20. Typical Thermal Response ($Z_{\theta JC}(t)$) for BUL147

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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