

**BUH50**

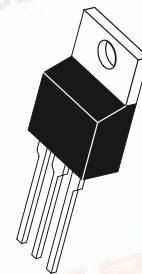
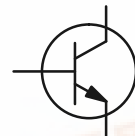
**POWER TRANSISTOR**  
**4 AMPERES**  
**800 VOLTS**  
**50 WATTS**

*Designer's™ Data Sheet*  
**SWITCHMODE NPN Silicon**  
**Planar Power Transistor**

The BUH50 has an application specific state-of-art die designed for use in 50 Watts HALOGEN electronic transformers and switchmode applications.

This high voltage/high speed transistor exhibits the following main feature:

- Improved Efficiency Due to Low Base Drive Requirements:
  - High and Flat DC Current Gain  $h_{FE}$
  - Fast Switching
- Motorola "6SIGMA" Philosophy Provides Tight and Reproducible Parametric Distributions
- Specified Dynamic Saturation Data
- Full Characterization at 125°C



**CASE 221A-06**  
**TO-220AB**

**MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Sustaining Voltage	$V_{CEO}$	500	Vdc
Collector-Base Breakdown Voltage	$V_{CBO}$	800	Vdc
Collector-Emitter Breakdown Voltage	$V_{CES}$	800	Vdc
Emitter-Base Voltage	$V_{EBO}$	9	Vdc
Collector Current — Continuous	$I_C$	4	Adc
— Peak (1)	$I_{CM}$	8	
Base Current — Continuous	$I_B$	2	Adc
— Peak (1)	$I_{BM}$	4	
*Total Device Dissipation @ $T_C = 25^\circ\text{C}$	$P_D$	50	Watt
*Derate above 25°C		0.4	W/°C
Operating and Storage Temperature	$T_J, T_{stg}$	-65 to 150	°C

**THERMAL CHARACTERISTICS**

Thermal Resistance			°C/W
— Junction to Case	$R_{\theta JC}$	2.5	
— Junction to Ambient	$R_{\theta JA}$	62.5	
Maximum Lead Temperature for Soldering Purposes: 1/8" from case for 5 seconds	$T_L$	260	°C

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

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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.



# BUH50

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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### OFF CHARACTERISTICS

Collector–Emitter Sustaining Voltage (I <sub>C</sub> = 100 mA, L = 25 mH)	V <sub>CEO(sus)</sub>	500			Vdc
Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CEO</sub> , I <sub>B</sub> = 0)	I <sub>CEO</sub>			100	μAdc
Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CEs</sub> , V <sub>EB</sub> = 0)	I <sub>CES</sub>			100 1000	μAdc
Emitter–Cutoff Current (V <sub>EB</sub> = 9 Vdc, I <sub>C</sub> = 0)	I <sub>EBO</sub>			100	μAdc

### ON CHARACTERISTICS

Base–Emitter Saturation Voltage (I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0.33 Adc) (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0.66 Adc) 25°C (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0.66 Adc) 100°C	V <sub>BE(sat)</sub>		0.86 0.94 0.85	1.2 1.6 1.5	Vdc
Collector–Emitter Saturation Voltage (I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0.33 Adc)	V <sub>CE(sat)</sub>	@ T <sub>C</sub> = 25°C	0.2	0.5	Vdc
(I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0.66 Adc)		@ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 125°C	0.32 0.29	0.6 0.7	
(I <sub>C</sub> = 3 Adc, I <sub>B</sub> = 1 Adc)		@ T <sub>C</sub> = 25°C	0.5	1	
DC Current Gain (I <sub>C</sub> = 1 Adc, V <sub>CE</sub> = 5 Vdc)	h <sub>FE</sub>	@ T <sub>C</sub> = 25°C	7	13	—
(I <sub>C</sub> = 2 Adc, V <sub>CE</sub> = 5 Vdc)		@ T <sub>C</sub> = 25°C	5	10	—

### DYNAMIC CHARACTERISTICS

Current Gain Bandwidth (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f = 1 MHz)	f <sub>T</sub>	4			MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1 MHz)	C <sub>ob</sub>		50	100	pF
Input Capacitance (V <sub>EB</sub> = 8 Vdc)	C <sub>ib</sub>		850	1200	pF

### DYNAMIC SATURATION VOLTAGE

Dynamic Saturation Voltage: Determined 1 μs and 3 μs respectively after rising I <sub>B1</sub> reaches 90% of final I <sub>B1</sub>	I <sub>C</sub> = 1 A I <sub>B1</sub> = 0.33 A V <sub>CC</sub> = 300 V	@ 1 μs	@ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 125°C	V <sub>CE(dsat)</sub>	1.75 5		V
		@ 3 μs	@ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 125°C		0.3 0.5		V
	I <sub>C</sub> = 2 A I <sub>B1</sub> = 0.66 A V <sub>CC</sub> = 300 V	@ 1 μs	@ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 125°C	6 14		V	
		@ 3 μs	@ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 125°C	0.75 4		V	

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

Characteristic	Symbol	Min	Typ	Max	Unit
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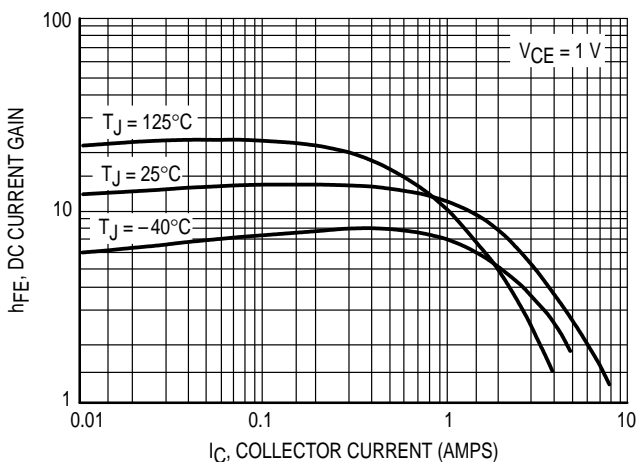
**SWITCHING CHARACTERISTICS: Resistive Load** (D.C.  $\leq 10\%$ , Pulse Width = 20  $\mu\text{s}$ )

Turn-on Time	$I_C = 2 \text{ Adc}$ , $I_{B1} = 0.4 \text{ Adc}$ $I_{B2} = 0.4 \text{ Adc}$ $V_{CC} = 125 \text{ Vdc}$	@ $T_C = 25^\circ\text{C}$	$t_{on}$		95	250	ns
Turn-off Time		@ $T_C = 25^\circ\text{C}$	$t_{off}$		2.5	3.5	$\mu\text{s}$
Turn-on Time	$I_C = 2 \text{ Adc}$ , $I_{B1} = 0.4 \text{ Adc}$ $I_{B2} = 1 \text{ Adc}$ $V_{CC} = 125 \text{ Vdc}$	@ $T_C = 25^\circ\text{C}$	$t_{on}$		110	250	ns
Turn-off Time		@ $T_C = 25^\circ\text{C}$	$t_{off}$		0.95	2	$\mu\text{s}$
Turn-on Time	$I_C = 1 \text{ Adc}$ , $I_{B1} = 0.3 \text{ Adc}$ $I_{B2} = 0.3 \text{ Adc}$ $V_{CC} = 125 \text{ Vdc}$	@ $T_C = 25^\circ\text{C}$	$t_{on}$		100	200	ns
Turn-off Time		@ $T_C = 25^\circ\text{C}$	$t_{off}$		2.9	3.5	$\mu\text{s}$

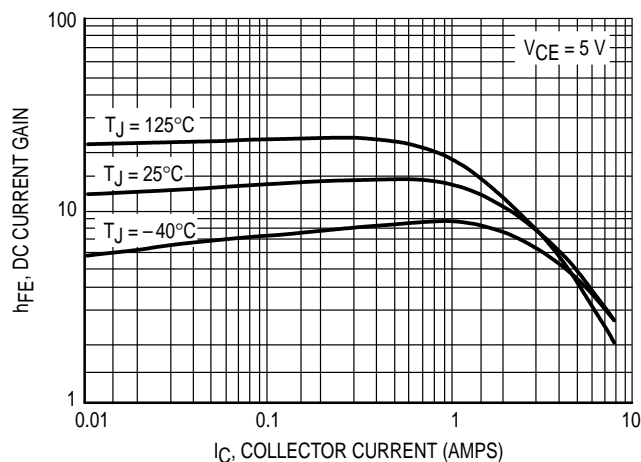
**SWITCHING CHARACTERISTICS: Inductive Load** ( $V_{clamp} = 300 \text{ V}$ ,  $V_{CC} = 15 \text{ V}$ ,  $L = 200 \mu\text{H}$ )

Fall Time	$I_C = 2 \text{ Adc}$ $I_{B1} = 0.4 \text{ Adc}$ $I_{B2} = 1 \text{ Adc}$	@ $T_C = 25^\circ\text{C}$ @ $T_C = 125^\circ\text{C}$	$t_f$		80 95	150	ns
Storage Time		@ $T_C = 25^\circ\text{C}$ @ $T_C = 125^\circ\text{C}$	$t_s$		1.2 1.7	2.5	$\mu\text{s}$
Crossover Time		@ $T_C = 25^\circ\text{C}$ @ $T_C = 125^\circ\text{C}$	$t_c$		150 180	300	ns
Fall Time	$I_C = 2 \text{ Adc}$ $I_{B1} = 0.66 \text{ Adc}$ $I_{B2} = 1 \text{ Adc}$	@ $T_C = 25^\circ\text{C}$ @ $T_C = 125^\circ\text{C}$	$t_f$		90 100	150	ns
Storage Time		@ $T_C = 25^\circ\text{C}$ @ $T_C = 125^\circ\text{C}$	$t_s$		1.7 2.5	2.75	$\mu\text{s}$
Crossover Time		@ $T_C = 25^\circ\text{C}$ @ $T_C = 125^\circ\text{C}$	$t_c$		190 220	350	ns

**TYPICAL STATIC CHARACTERISTICS**

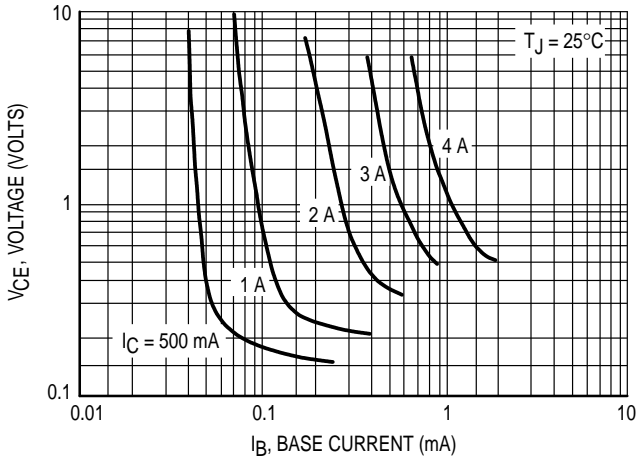


**Figure 1. DC Current Gain @ 1 Volt**

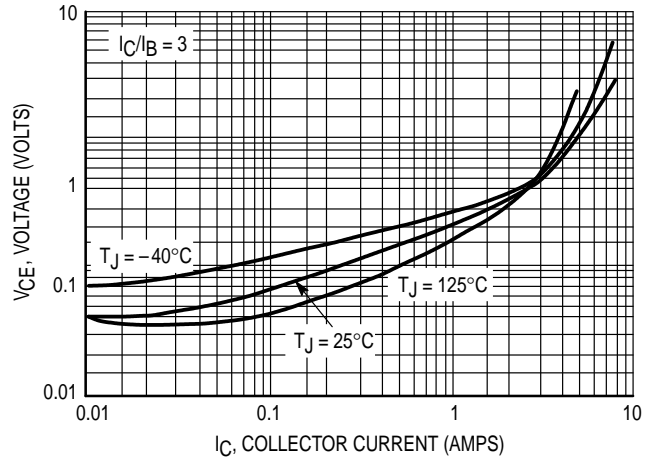


**Figure 2. DC Current Gain @ 5 Volt**

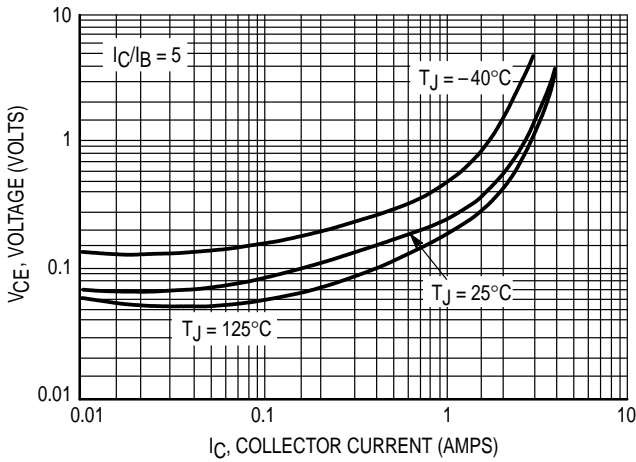
**TYPICAL STATIC CHARACTERISTICS**



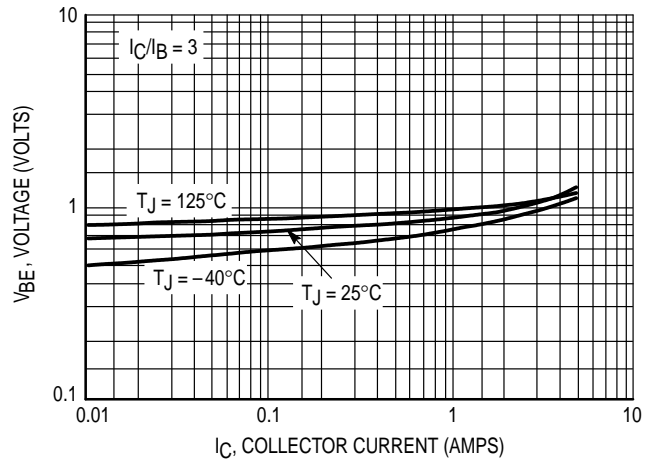
**Figure 3. Collector Saturation Region**



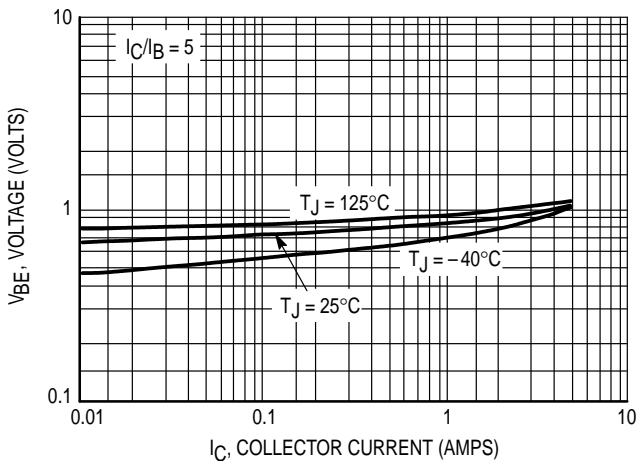
**Figure 4. Collector-Emitter Saturation Voltage**



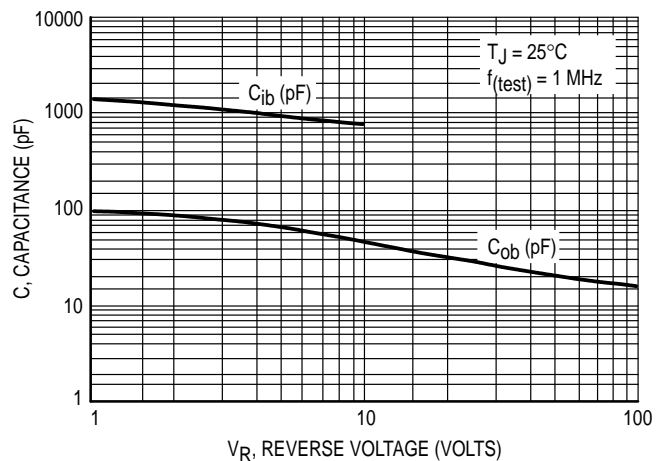
**Figure 5. Collector-Emitter Saturation Voltage**



**Figure 6. Base-Emitter Saturation Region**



**Figure 7. Base-Emitter Saturation Region**



**Figure 8. Capacitance**

TYPICAL SWITCHING CHARACTERISTICS

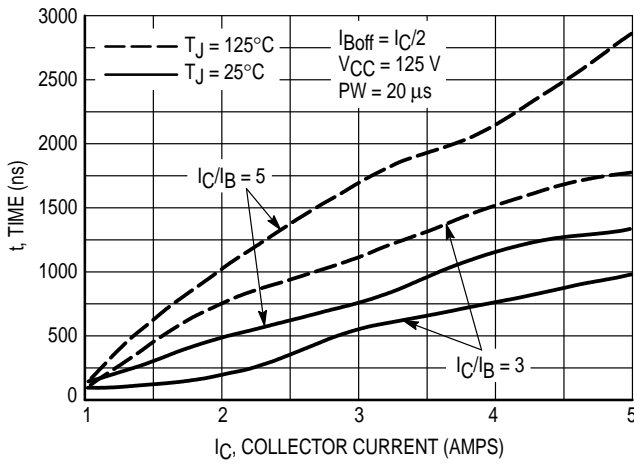


Figure 9. Resistive Switching,  $t_{on}$

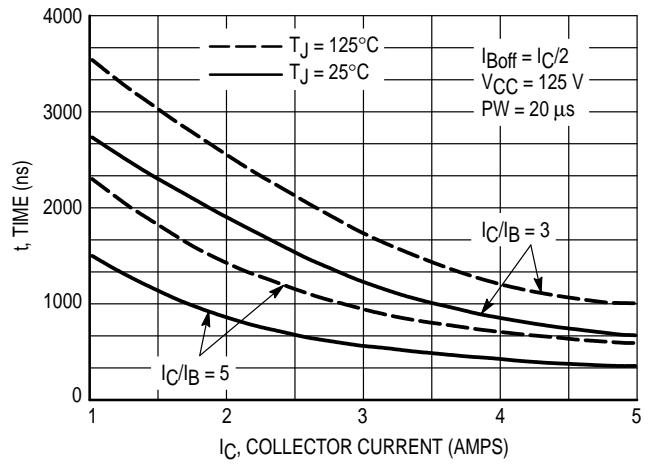


Figure 10. Resistive Switch Time,  $t_{off}$

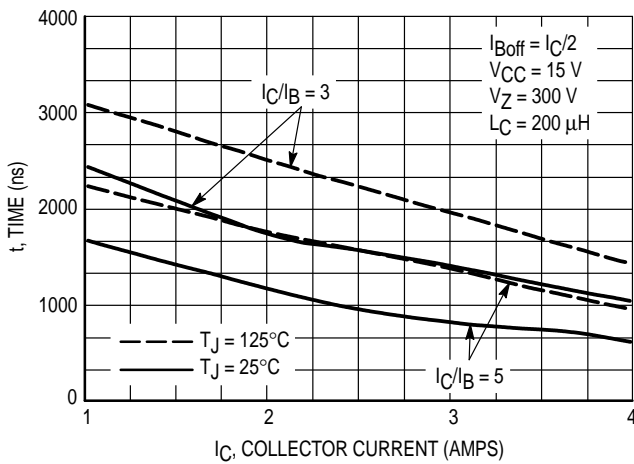


Figure 11. Inductive Storage Time,  $t_{si}$

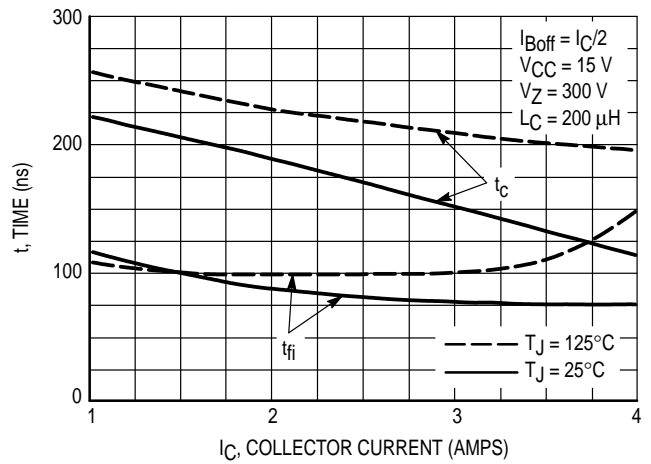


Figure 12. Inductive Storage Time,  $t_c$  &  $t_{fi}$  @  $I_C/I_B = 3$

TYPICAL CHARACTERISTICS

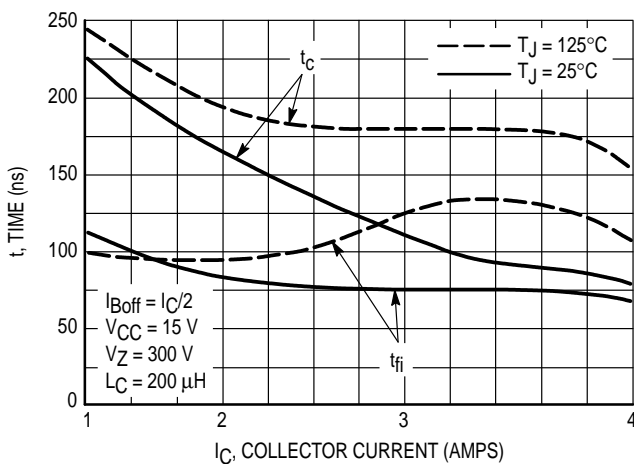


Figure 13. Inductive Switching,  $t_c$  &  $t_{fi}$  @  $I_C/I_B = 5$

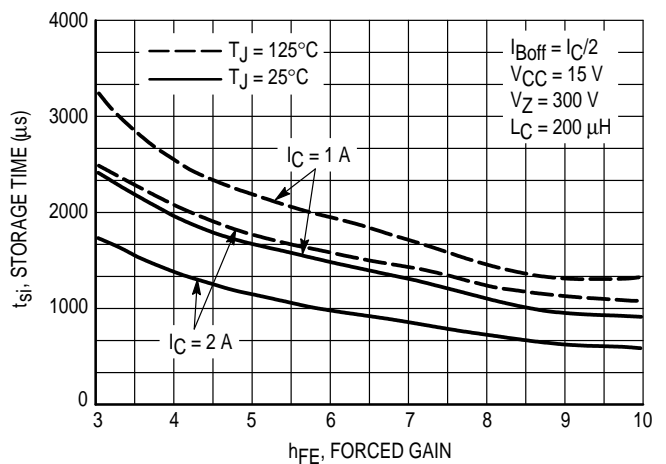
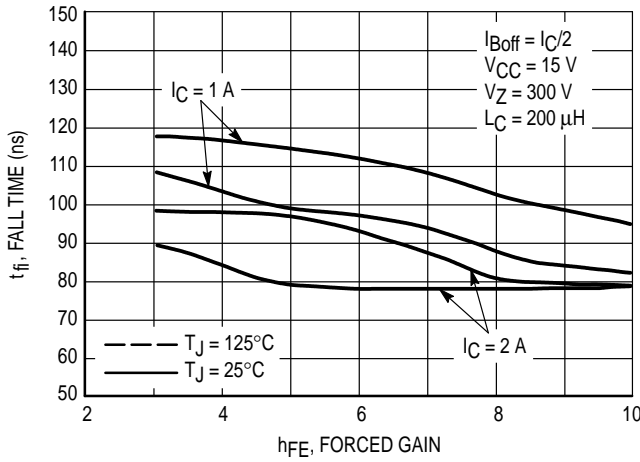
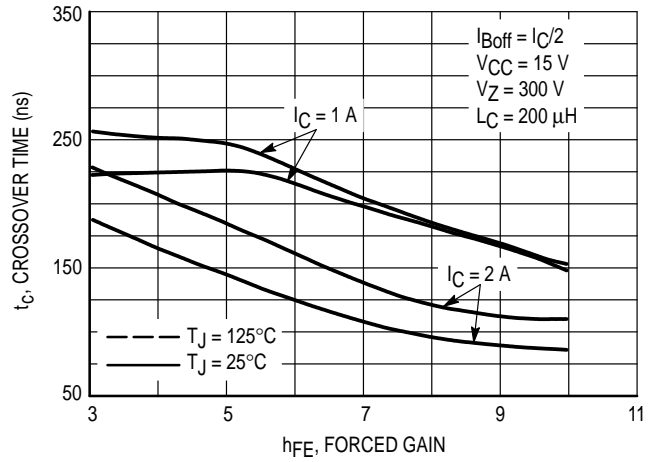


Figure 14. Inductive Storage Time

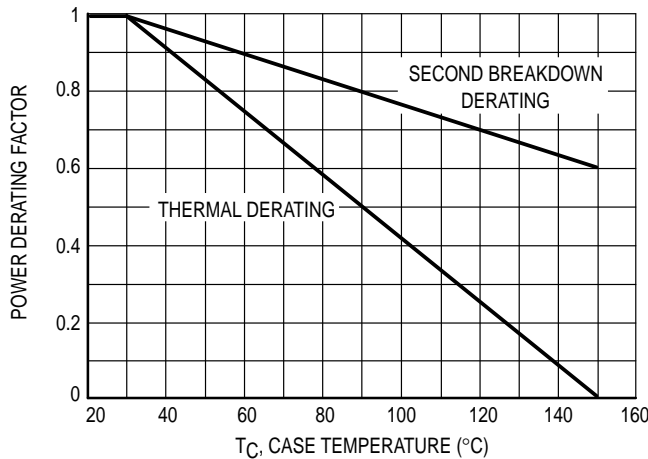
**TYPICAL CHARACTERISTICS**



**Figure 15. Inductive Fall Time**



**Figure 16. Inductive Crossover Time**

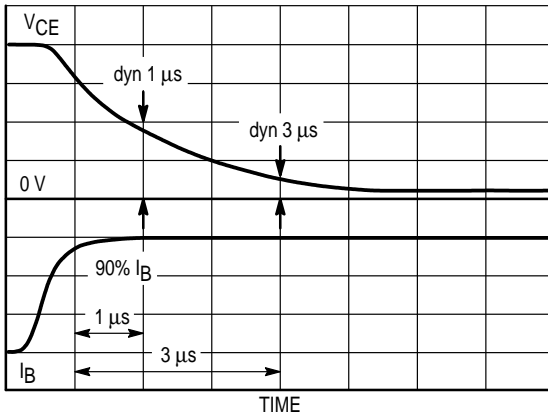


**Figure 17. Forward Power Derating**

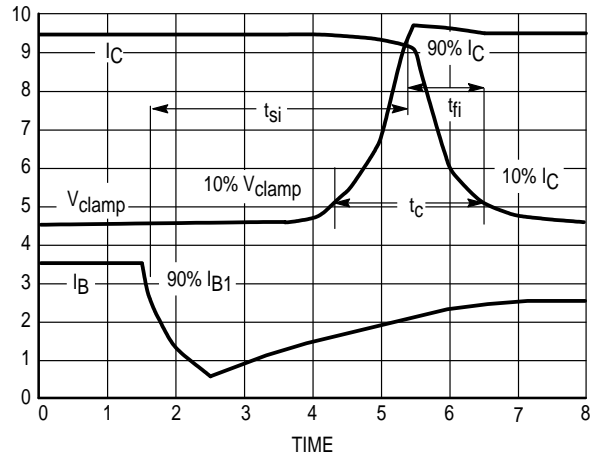
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C-V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 20 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  $T_C > 25^\circ\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 20 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 22. 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 21). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

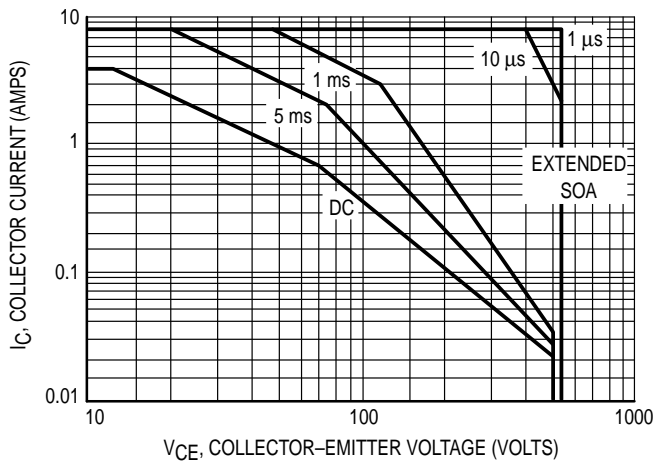
**TYPICAL CHARACTERISTICS**



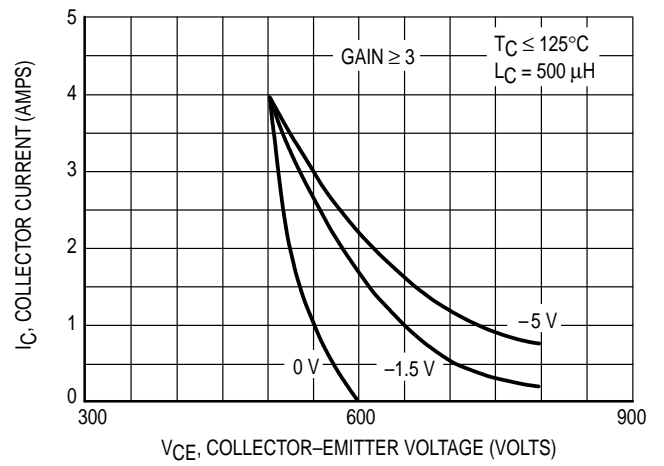
**Figure 18. Dynamic Saturation Voltage**



**Figure 19. Inductive Switching Measurements**



**Figure 20. Forward Bias Safe Operating Area**

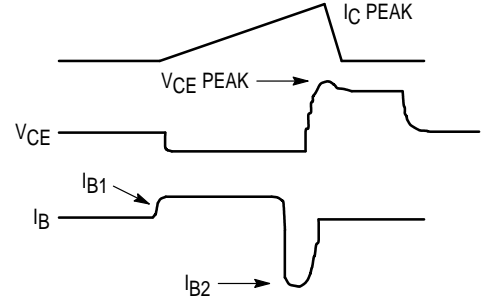
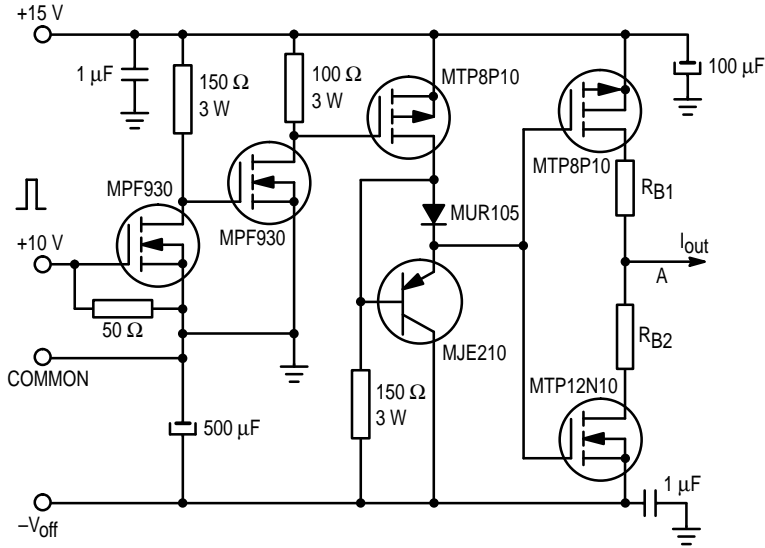


**Figure 21. Reverse Bias Safe Operating Area**

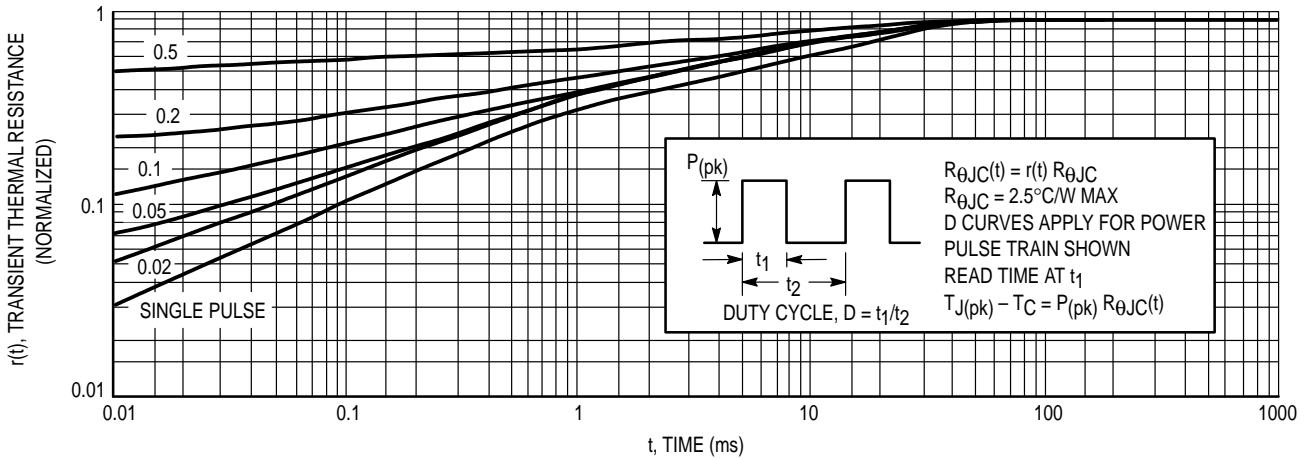
**BUH50**

**TYPICAL CHARACTERISTICS**

**Table 1. Inductive Load Switching Drive Circuit**



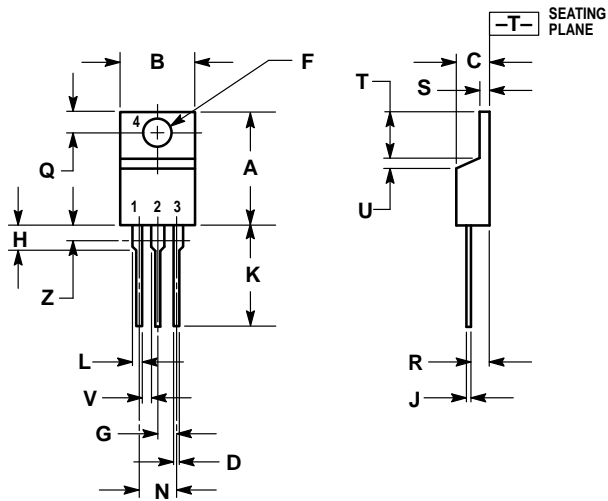
$V_{(BR)CEO(sus)}$	Inductive Switching	RBSOA
$L = 10 \text{ mH}$	$L = 200 \mu\text{H}$	$L = 500 \mu\text{H}$
$R_{B2} = \infty$	$R_{B2} = 0$	$R_{B2} = 0$
$V_{CC} = 20 \text{ Volts}$	$V_{CC} = 15 \text{ Volts}$	$V_{CC} = 15 \text{ Volts}$
$I_C(pk) = 100 \text{ mA}$	$R_{B1}$ selected for desired $I_{B1}$	$R_{B1}$ selected for desired $I_{B1}$



**Figure 22. Typical Thermal Response ( $Z_{\theta JC}(t)$ ) for BUH50**



**PACKAGE DIMENSIONS**




- 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.

DIM	INCHES		MILLIMETERS	
	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

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

**CASE 221A-06  
 TO-220AB  
 ISSUE Y**

## BUH50

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