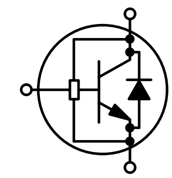
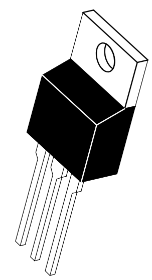
BUL44D2

POWER TRANSISTORS
2 AMPERES
700 VOLTS
50 WATTS





CASE 221A–09
TO–220AB

High Speed, High Gain Bipolar NPN Power Transistor with Integrated Collector-Emitter Diode and Built-in Efficient Antisaturation Network

The BUL44D2 is state–of–art High Speed High gain BIPolar transistor (H2BIP). High dynamic characteristics and lot to lot minimum spread (±150 ns on storage time) make it ideally suitable for light ballast applications. Therefore, there is no need to guarantee an h_{FE} window.

Main features:

- Low Base Drive Requirement
- High Peak DC Current Gain (55 Typical) @ I_C = 100 mA
- **Extremely Low Storage Time Min/Max Guarantees Due to the H2BIP Structure which Minimizes the Spread**
- Integrated Collector–Emitter Free Wheeling Diode
- Fully Characterized and Guaranteed Dynamic $V_{CE(sat)}$
- “6 Sigma” Process Providing Tight and Reproductible Parameter Spreads

It’s characteristics make it also suitable for PFC application.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Sustaining Voltage	V_{CEO}	400	Vdc
Collector–Base Breakdown Voltage	V_{CBO}	700	Vdc
Collector–Emitter Breakdown Voltage	V_{CES}	700	Vdc
Emitter–Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous — Peak (1)	I_C I_{CM}	2 5	Adc
Base Current — Continuous — Peak (1)	I_B I_{BM}	1 2	Adc
*Total Device Dissipation @ T_C = 25°C *Derate above 25°C	P_D	50 0.4	Watt W/°C
Operating and Storage Temperature	T_J, T_{stg}	–65 to 150	°C

THERMAL CHARACTERISTICS

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

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

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	470		Vdc
Collector–Base Breakdown Voltage (I_{CBO} = 1 mA)		V_{CBO}	700	920		Vdc
Emitter–Base Breakdown Voltage (I_{EBO} = 1 mA)		V_{EBO}	12	14.5		Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)	@ T_C = 25°C @ T_C = 125°C	I_{CEO}			50 500	µAdc
Collector Cutoff Current (V_{CE} = Rated V_{CES}, V_{EB} = 0)	@ T_C = 25°C @ T_C = 125°C	I_{CES}			50 500	µAdc
(V_{CE} = 500 V, V_{EB} = 0)	@ T_C = 125°C				100	
Emitter–Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}			100	µAdc
ON CHARACTERISTICS						
Base–Emitter Saturation Voltage (I_C = 0.4 Adc, I_B = 40 mAdc)	@ T_C = 25°C @ T_C = 125°C	$V_{BE(sat)}$		0.78 0.65	0.9 0.8	Vdc
(I_C = 1 Adc, I_B = 0.2 Adc)	@ T_C = 25°C @ T_C = 125°C			0.87 0.76	1 0.9	
Collector–Emitter Saturation Voltage (I_C = 0.4 Adc, I_B = 40 mAdc)	@ T_C = 25°C @ T_C = 125°C	$V_{CE(sat)}$		0.25 0.27	0.4 0.5	Vdc
(I_C = 1 Adc, I_B = 0.2 Adc)	@ T_C = 25°C @ T_C = 125°C			0.28 0.35	0.5 0.6	
(I_C = 0.4 Adc, I_B = 20 mAdc)	@ T_C = 25°C @ T_C = 125°C			0.45 0.67	0.65 1	
DC Current Gain (I_C = 0.4 Adc, V_{CE} = 1 Vdc)	@ T_C = 25°C @ T_C = 125°C	h_{FE}	20 18	32 26		—
(I_C = 1 Adc, V_{CE} = 1 Vdc)	@ T_C = 25°C @ T_C = 125°C		10 7	14 9.5		
DIODE CHARACTERISTICS						
Forward Diode Voltage (I_{EC} = 1 Adc)	@ T_C = 25°C	V_{EC}		1.1	1.5	V
(I_{EC} = 0.4 Adc)	@ T_C = 25°C			0.9	1.2	
(I_{EC} = 0.2 Adc)	@ T_C = 25°C			0.8	1	
(I_{EC} = 0.2 Adc)	@ T_C = 125°C			0.6		
Forward Recovery Time (see Figure 22 bis) (I_F = 0.2 Adc, di/dt = 10 A/µs)	@ T_C = 25°C	T_{fr}		415		ns
(I_F = 0.4 Adc, di/dt = 10 A/µs)	@ T_C = 25°C			390		
(I_F = 1 Adc, di/dt = 10 A/µs)	@ T_C = 25°C			340		

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

Characteristic				Symbol	Min	Typ	Max	Unit
DYNAMIC SATURATION VOLTAGE								
Dynamic Saturation Voltage: Determined 1 µs and 3 µs respectively after rising I_{B1} reaches 90% of final I_{B1}	I_C = 0.4 A I_{B1} = 40 mA V_{CC} = 300 V	@ 1 µs	@ T_C = 25°C @ T_C = 125°C	$V_{CE(dsat)}$		3.3 6.8		V
		@ 3 µs	@ T_C = 25°C @ T_C = 125°C			0.5 1.3		V
	I_C = 1 A I_{B1} = 0.2 A V_{CC} = 300 V	@ 1 µs	@ T_C = 25°C @ T_C = 125°C			4.4 12.8		V
		@ 3 µs	@ T_C = 25°C @ T_C = 125°C			0.5 1.8		V
DYNAMIC CHARACTERISTICS								
Current Gain Bandwidth (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1 MHz)				f_T		13		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)				C_{ob}		50	75	pF
Input Capacitance (V_{EB} = 8 Vdc)				C_{ib}		240	500	pF
SWITCHING CHARACTERISTICS: Resistive Load (D.C. ≤ 10%, Pulse Width = 40 µs)								
Turn–on Time	I_C = 0.5 Adc, I_{B1} = 50 mAdc I_{B2} = 250 mAdc V_{CC} = 300 Vdc		@ T_C = 25°C @ T_C = 125°C	t_{on}		450 600	600	ns
Turn–off Time			@ T_C = 25°C @ T_C = 125°C	t_{off}	700	 1300	1000	ns
Turn–on Time	I_C = 1 Adc, I_{B1} = 0.2 Adc I_{B2} = 0.5 Adc V_{CC} = 300 Vdc		@ T_C = 25°C @ T_C = 125°C	t_{on}		90 105	150	ns
Turn–off Time			@ T_C = 25°C @ T_C = 125°C	t_{off}		1.1 1.5	1.25	µs

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

Characteristic			Symbol	Min	Typ	Max	Unit
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 = 25°C @ T_C = 125°C	t_f		110 105	150	ns
Storage Time		@ T_C = 25°C @ T_C = 125°C	t_s		0.55 0.70	0.75	μs
Crossover Time		@ T_C = 25°C @ T_C = 125°C	t_c		85 80	150	ns
Fall Time	I_C = 1 Adc I_{B1} = 0.2 Adc I_{B2} = 0.5 Adc	@ T_C = 25°C @ T_C = 125°C	t_f		100 90	150	ns
Storage Time		@ T_C = 25°C @ T_C = 125°C	t_s		1.05 1.45	1.5	μs
Crossover Time		@ T_C = 25°C @ T_C = 125°C	t_c		100 100	175	ns
Fall Time	I_C = 0.8 Adc I_{B1} = 160 mAdc I_{B2} = 160 mAdc	@ T_C = 25°C @ T_C = 125°C	t_f		110 180	150	ns
Storage Time		@ T_C = 25°C @ T_C = 125°C	t_s	2.05	 2.8	2.35	μs
Crossover Time		@ T_C = 25°C @ T_C = 125°C	t_c		180 400	300	ns
Fall Time	I_C = 0.4 Adc I_{B1} = 40 mAdc I_{B2} = 40 mAdc	@ T_C = 25°C @ T_C = 125°C	t_f		150 175	225	ns
Storage Time		@ T_C = 25°C @ T_C = 125°C	t_s	1.65	 2.2	1.95	μs
Crossover Time		@ T_C = 25°C @ T_C = 125°C	t_c		150 330	250	ns

TYPICAL STATIC CHARACTERISTICS

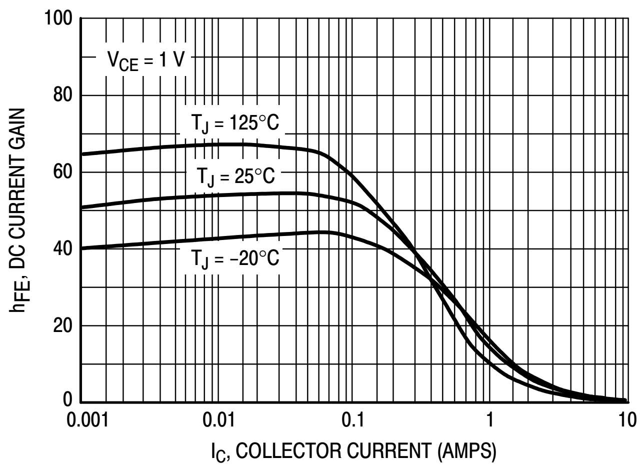


Figure 1. DC Current Gain @ 1 Volt

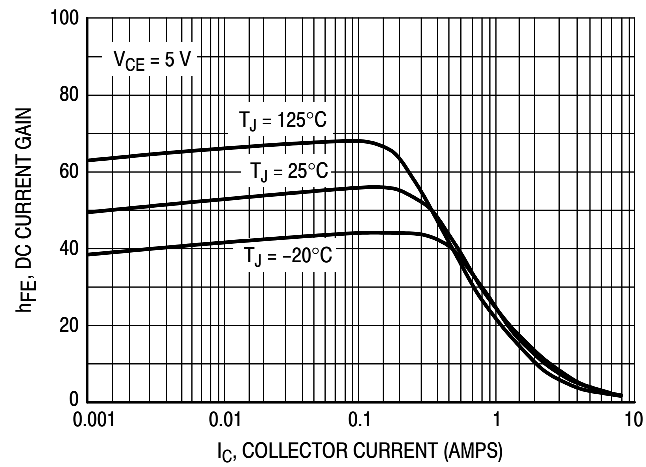


Figure 2. DC Current Gain @ 5 Volt

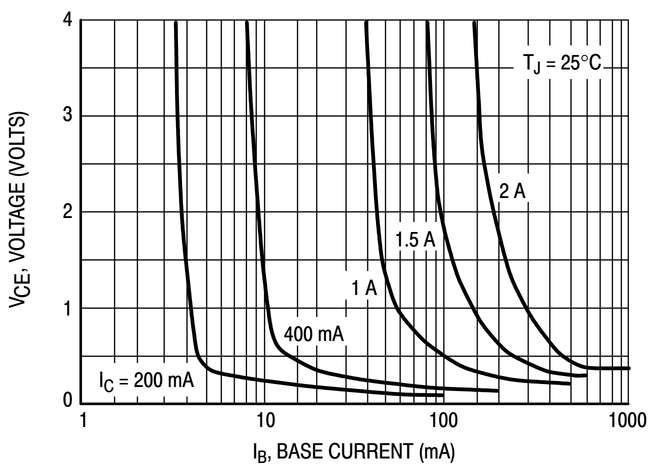


Figure 3. Collector Saturation Region

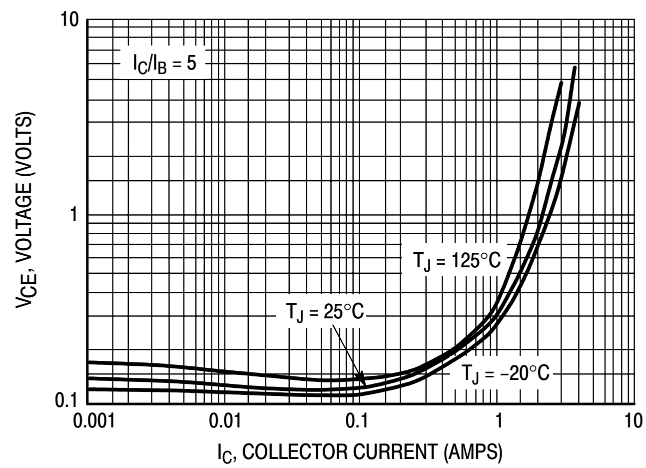


Figure 4. Collector–Emitter Saturation Voltage

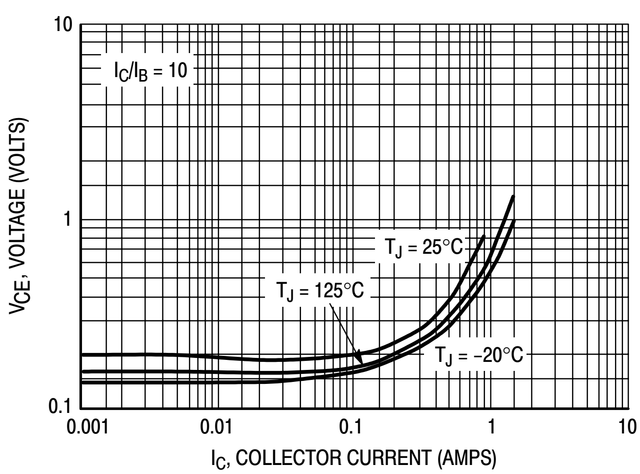


Figure 5. Collector–Emitter Saturation Voltage

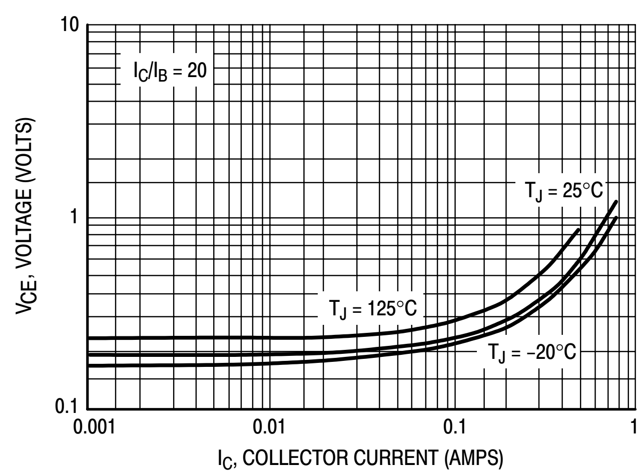


Figure 6. Collector–Emitter Saturation Voltage

TYPICAL STATIC CHARACTERISTICS

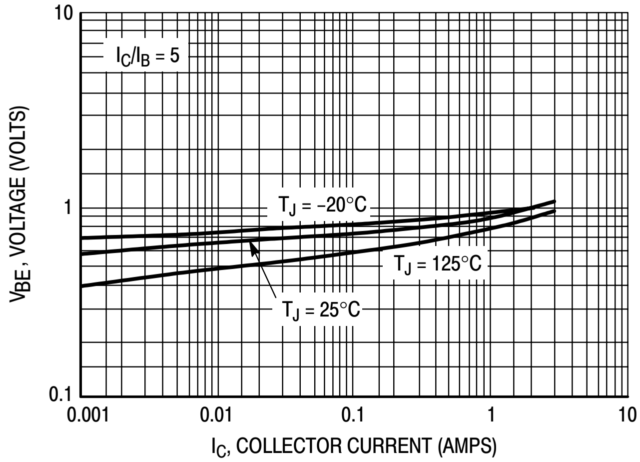


Figure 7A. Base−Emitter Saturation Region

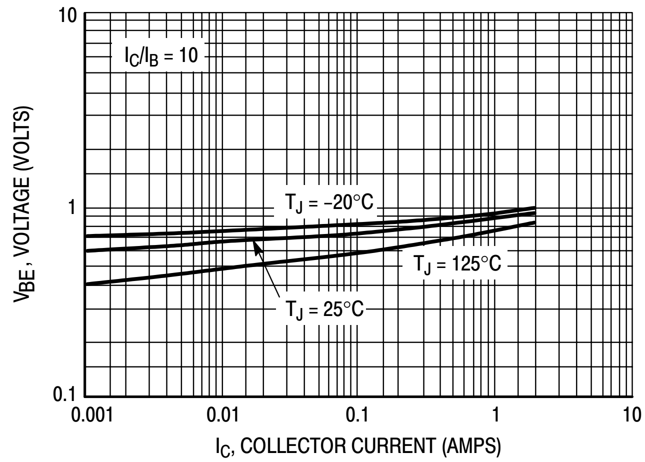


Figure 7B. Base−Emitter Saturation Region

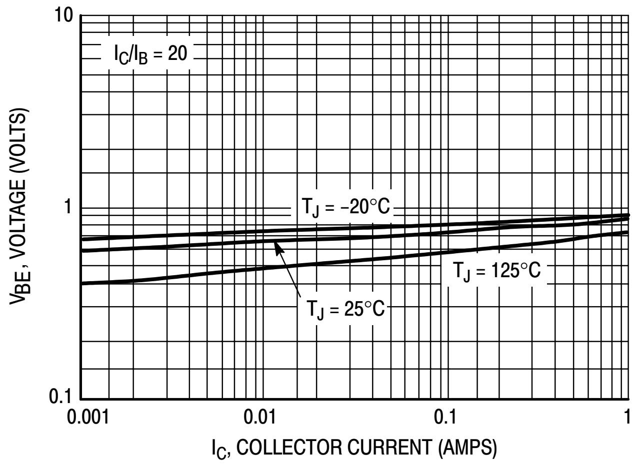


Figure 7. Base−Emitter Saturation Region

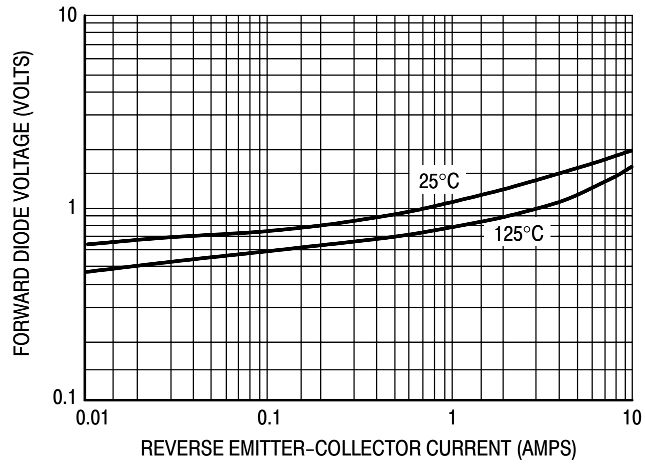


Figure 8. Forward Diode Voltage

TYPICAL SWITCHING CHARACTERISTICS

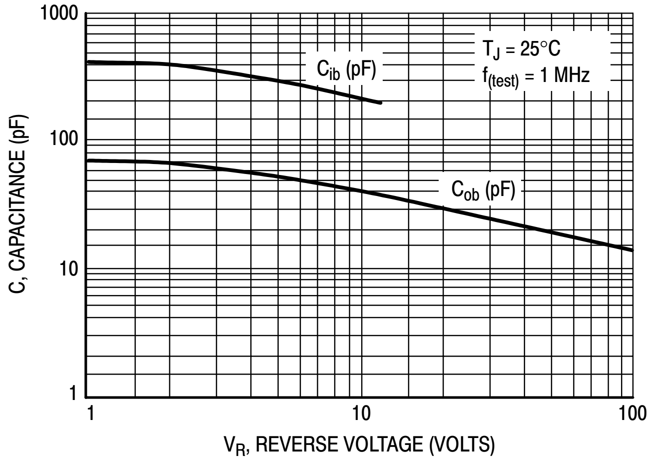


Figure 9. Capacitance

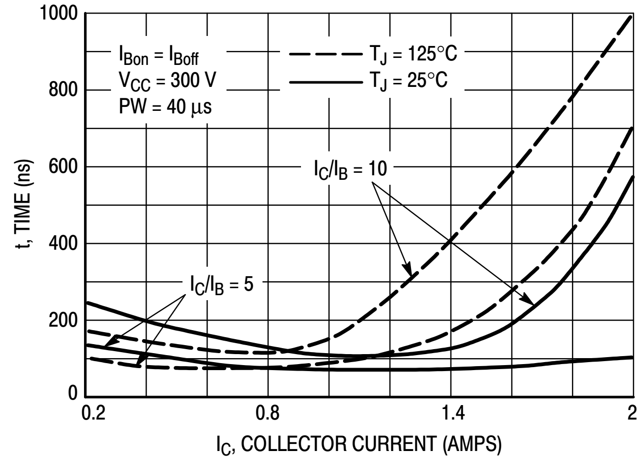


Figure 10. Resistive Switch Time, t_{on}

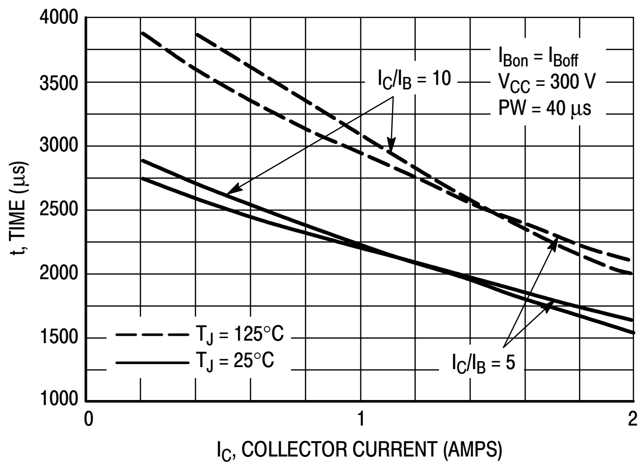


Figure 11. Resistive Switch Time, t_{off}

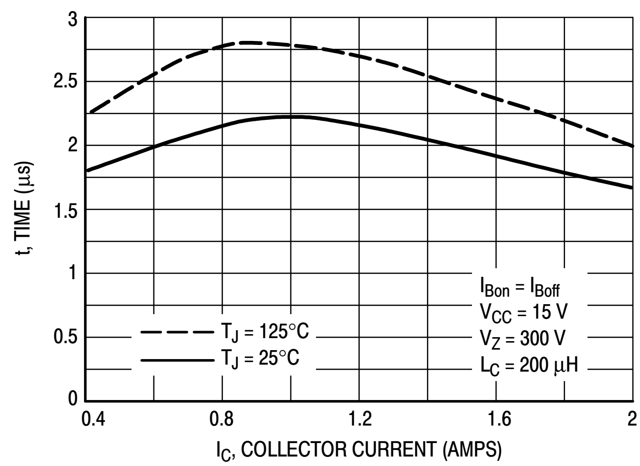


Figure 12. Inductive Storage Time, t_{si} @ $I_C/I_B = 5$

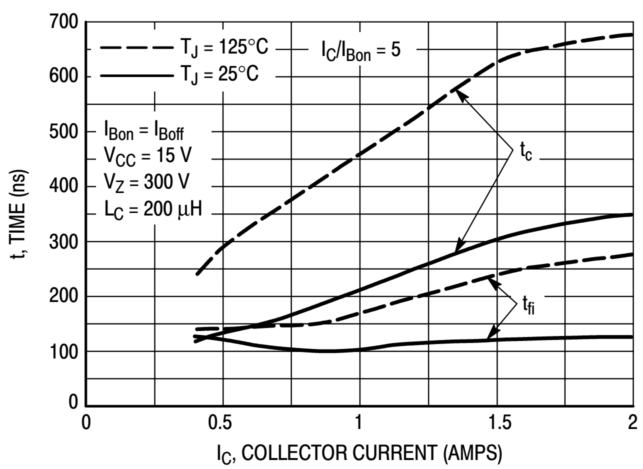


Figure 13. Inductive Switching, t_c & t_{fi} @ $I_C/I_B = 5$

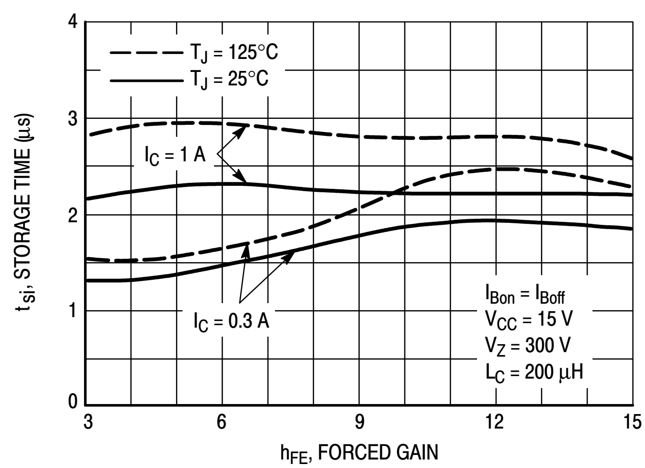


Figure 14. Inductive Storage Time

TYPICAL SWITCHING CHARACTERISTICS

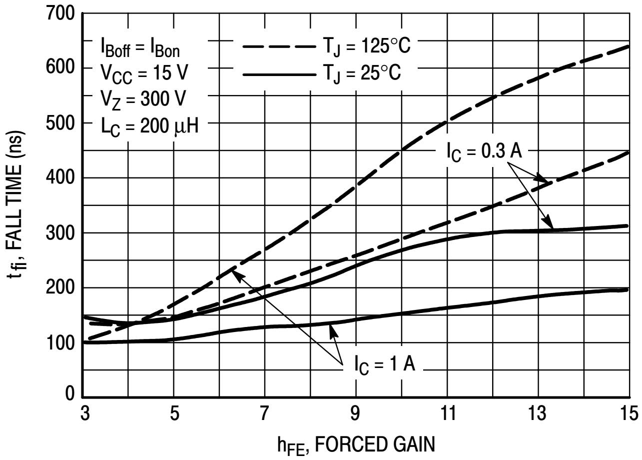


Figure 15. Inductive Fall Time

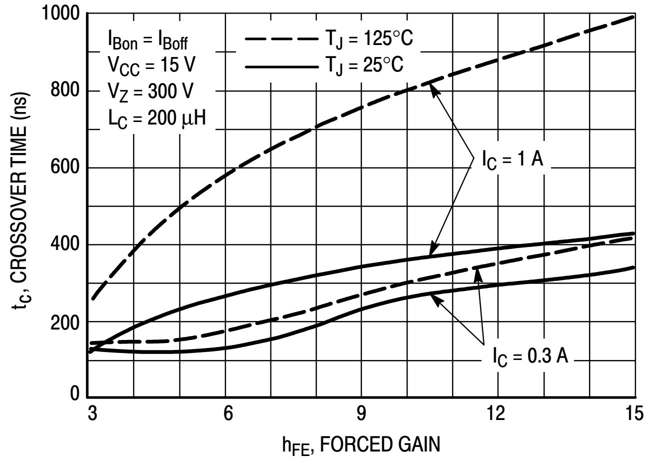


Figure 16. Inductive Crossover Time

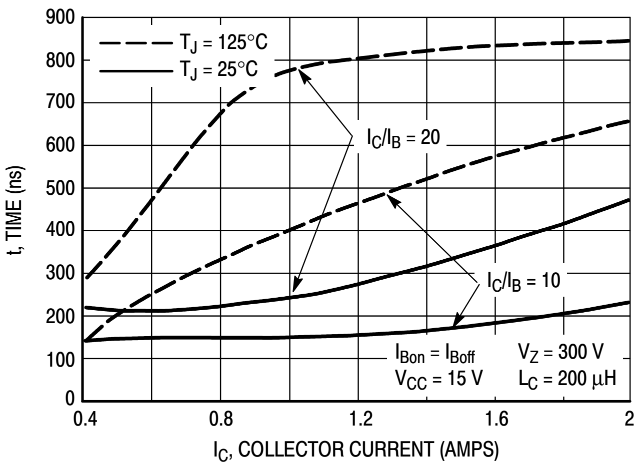


Figure 17. Inductive Switching, t_{fi}

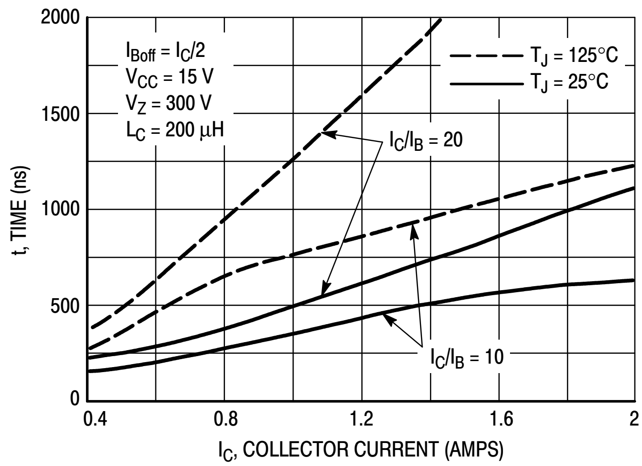


Figure 18. Inductive Switching, t_c

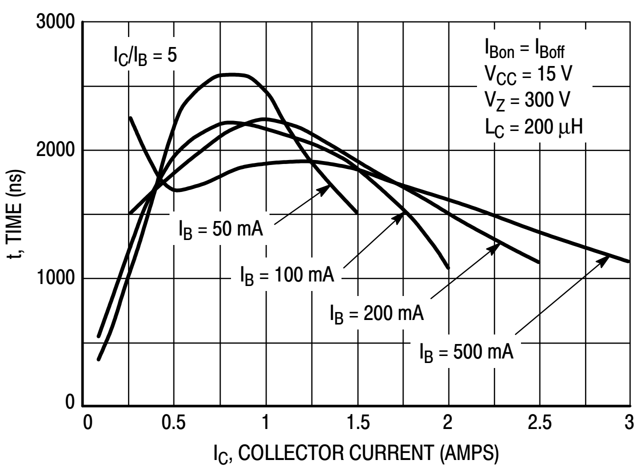


Figure 19. Inductive Storage Time, t_{si}

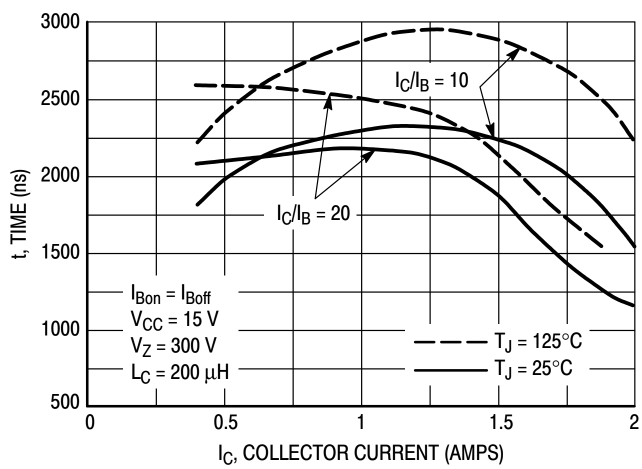


Figure 20. Inductive Storage Time, t_{si}

TYPICAL SWITCHING CHARACTERISTICS

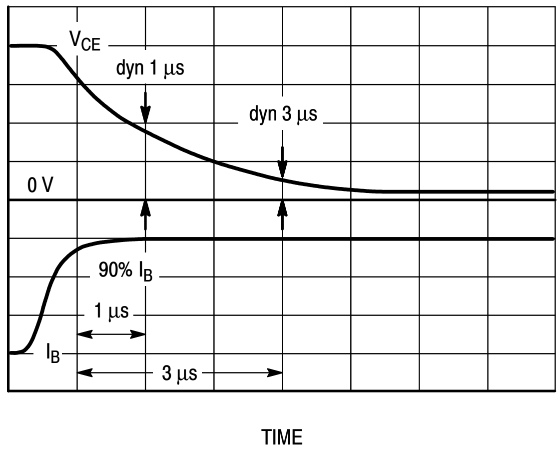


Figure 21. Dynamic Saturation Voltage Measurements

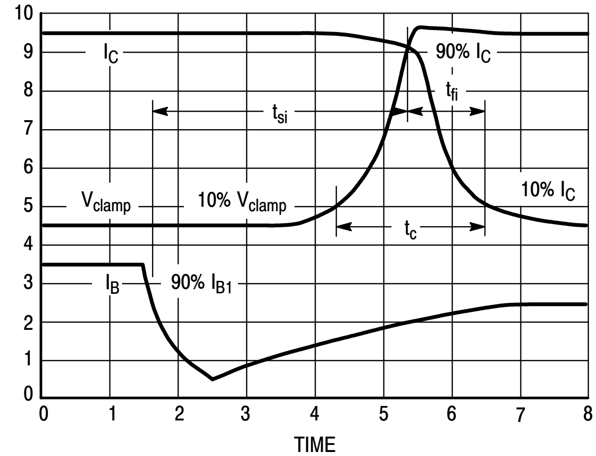


Figure 22. Inductive Switching Measurements

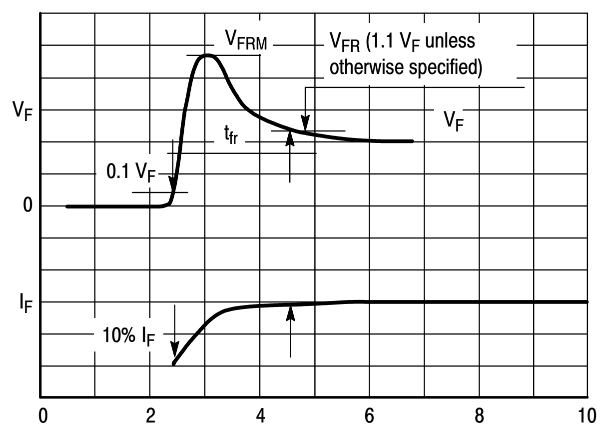
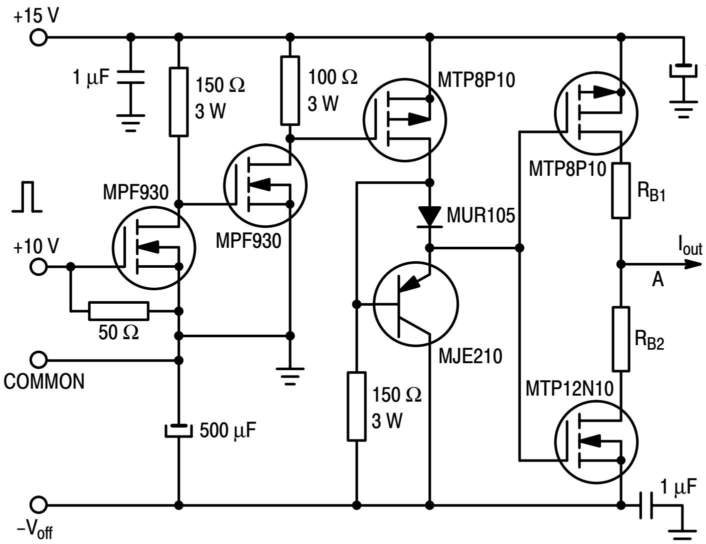
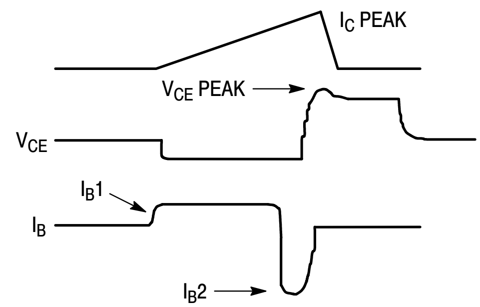


Figure 23. bis. t_{fr} Measurements

Table 1. Inductive Load Switching Drive Circuit





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

TYPICAL CHARACTERISTICS

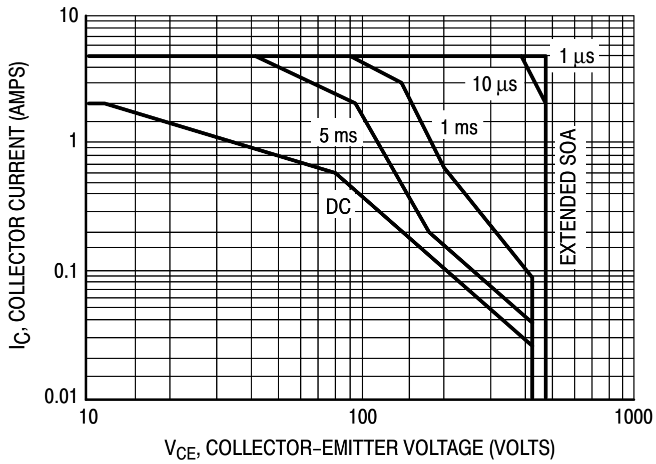


Figure 24. Forward Bias Safe Operating Area

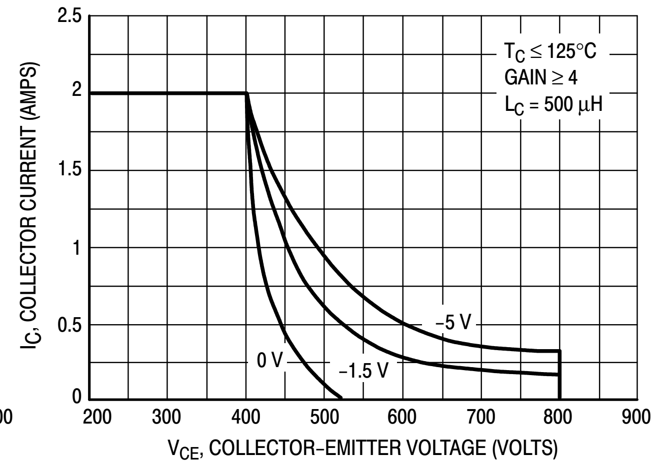


Figure 25. Reverse Bias Safe Operating Area

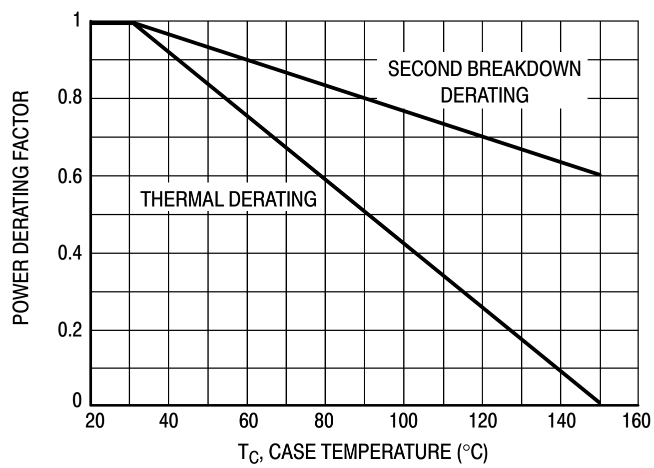


Figure 26. Forward Bias Power Derating

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 24 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 24 may be found at any case temperature by using the appropriate curve on Figure 26.

$T_{J(pk)}$ may be calculated from the data in Figure 27. 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 25). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

TYPICAL THERMAL RESPONSE

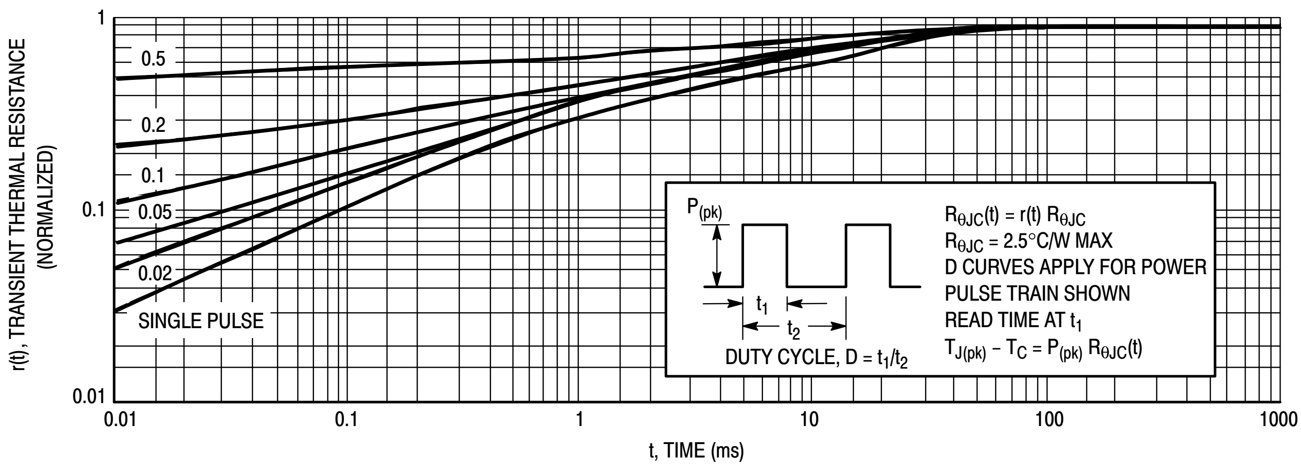


Figure 27. Typical Thermal Response ($Z_{\theta JC}(t)$) for BUL44D2

TYPICAL STATIC CHARACTERISTICS

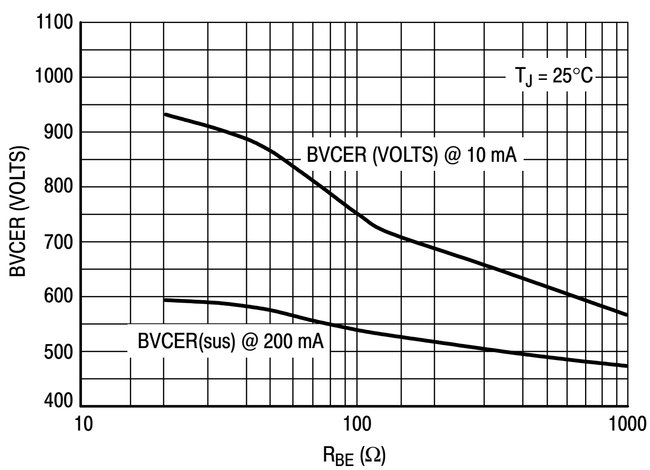


Figure 28. BVCER

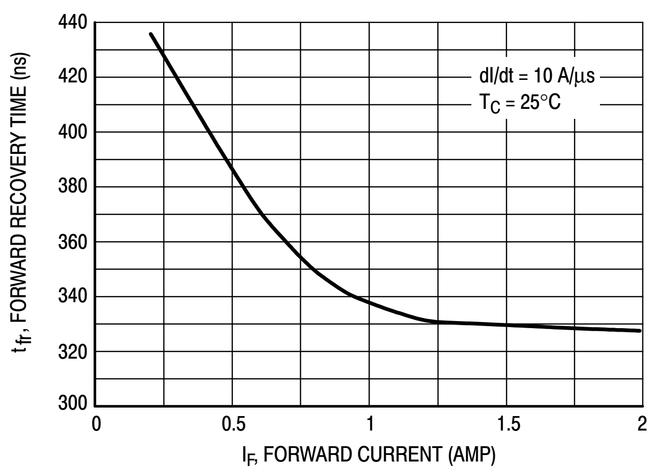
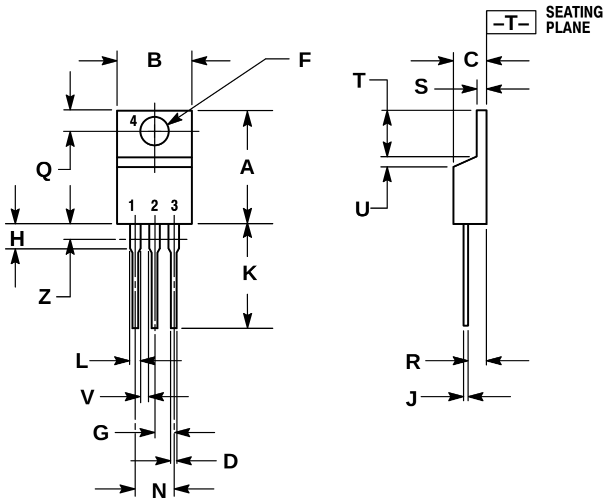


Figure 29. Forward Recovery Time t_{fr}

PACKAGE DIMENSIONS

TO–220AB
CASE 221A–09
ISSUE AA



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

Notes

Notes

PUBLICATION ORDERING INFORMATION

NORTH AMERICA Literature Fulfillment:
Literature Distribution Center for ON Semiconductor
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