High Speed, High Gain Bipolar NPN Power Transistor

with Integrated Collector-Emitter Diode and Built-in Efficient Antisaturation Network

BUL45D2G

The BUL45D2G 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. It's characteristics make it also suitable for PFC application.

Features

- Low Base Drive Requirement
- High Peak DC Current Gain
- 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
- These Devices are Pb−Free and are RoHS Compliant*

MAXIMUM RATINGS

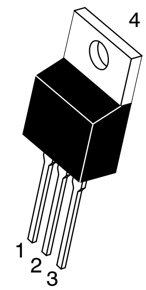
Symbol	Rating	Value	Unit
V_{CEO}	Collector−Emitter Sustaining Voltage	400	Vdc
V_{CBO}	Collector−Base Breakdown Voltage	700	Vdc
V_{CES}	Collector−Emitter Breakdown Voltage	700	Vdc
V_{EBO}	Emitter−Base Voltage	12	Vdc
I_C	Collector Current − Continuous	5	Adc
I_{CM}	Collector Current − Peak (Note 1)	10	Adc
I_B	Base Current − Continuous	2	Adc
I_{BM}	Base Current − Peak (Note 1)	4	Adc
P_D	Total Device Dissipation @ T_C = 25°C Derate above 25°C	 75 0.6	 W W/°C
T_J, T_{stg}	Operating and Storage Temperature	−65 to +150	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

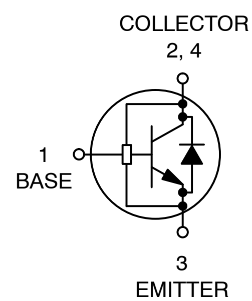
1. Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

*For additional information on our Pb−Free strategy and soldering details, please download the **onsemi** Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

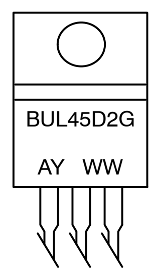
**POWER TRANSISTOR
5.0 AMPERES,
700 VOLTS, 75 WATTS**



**TO−220
CASE 221A
STYLE 1**



MARKING DIAGRAM



A = Assembly Location
Y = Year
WW = Work Week
G = Pb−Free Package

ORDERING INFORMATION

Device	Package	Shipping
BUL45D2G	TO−220 (Pb−Free)	50 Units / Rail

THERMAL CHARACTERISTICS

Symbol	Characteristics	Max	Unit
$R_{\theta JC}$	Thermal Resistance, Junction−to−Case	1.65	°C/W
$R_{\theta JA}$	Thermal Resistance, Junction−to−Ambient	62.5	°C/W
T_L	Maximum Lead Temperature for Soldering Purposes 1/8″ from Case for 5 Seconds	260	°C

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

Symbol	Characteristic	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector−Emitter Sustaining Voltage (I_C = 100 mA, L = 25 mH)	400	450	–	Vdc
V_{CBO}	Collector−Base Breakdown Voltage (I_{CBO} = 1 mA)	700	910	–	Vdc
V_{EBO}	Emitter−Base Breakdown Voltage (I_{EBO} = 1 mA)	12	14.1	–	Vdc
I_{CEO}	Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)	–	–	100	μAdc
I_{CES}	Collector Cutoff Current (V_{CE} = Rated V_{CES}, V_{EB} = 0) @ T_C = 25°C @ T_C = 125°C (V_{CE} = 500 V, V_{EB} = 0) @ T_C = 125°C	 – – –	 – – –	 100 500 100	μAdc
I_{EBO}	Emitter−Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	–	–	100	μAdc
ON CHARACTERISTICS					
$V_{BE(sat)}$	Base−Emitter Saturation Voltage (I_C = 0.8 Adc, I_B = 80 mAdc) @ T_C = 25°C @ T_C = 125°C (I_C = 2 Adc, I_B = 0.4 Adc) @ T_C = 25°C @ T_C = 125°C	 – – – –	 0.8 0.7 0.89 0.79	 1 0.9 1 0.9	Vdc
$V_{CE(sat)}$	Collector−Emitter Saturation Voltage (I_C = 0.8 Adc, I_B = 80 mAdc) @ T_C = 25°C @ T_C = 125°C (I_C = 2 Adc, I_B = 0.4 Adc) @ T_C = 25°C @ T_C = 125°C (I_C = 0.8 Adc, I_B = 40 mAdc) @ T_C = 25°C @ T_C = 125°C	 – – – – – –	 0.28 0.32 0.32 0.38 0.46 0.62	 0.4 0.5 0.5 0.6 0.75 1	Vdc
h_{FE}	DC Current Gain (I_C = 0.8 Adc, V_{CE} = 1 Vdc) @ T_C = 25°C @ T_C = 125°C (I_C = 2 Adc, V_{CE} = 1 Vdc) @ T_C = 25°C @ T_C = 125°C	 22 20 10 7	 34 29 14 9.5	 – – – –	–
DIODE CHARACTERISTICS					
V_{EC}	Forward Diode Voltage (I_{EC} = 1 Adc) @ T_C = 25°C @ T_C = 125°C (I_{EC} = 2 Adc) @ T_C = 25°C @ T_C = 125°C (I_{EC} = 0.4 Adc) @ T_C = 25°C @ T_C = 125°C	 – – – – – –	 1.04 0.7 1.2 – 0.85 0.62	 1.5 – 1.6 – 1.2 –	V

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

DIODE CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Unit
T_{fr}	Forward Recovery Time (see Figure 27)				ns
	(I_F = 1 Adc, di/dt = 10 A/μs) @ T_C = 25°C	–	330	–	
	(I_F = 2 Adc, di/dt = 10 A/μs) @ T_C = 25°C	–	360	–	
	(I_F = 0.4 Adc, di/dt = 10 A/μs) @ T_C = 25°C	–	320	–	

DYNAMIC CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Unit
f_T	Current Gain Bandwidth (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1 MHz)	–	13	–	MHz
C_{ob}	Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	–	50	75	pF
C_{ib}	Input Capacitance (V_{EB} = 8 Vdc)	–	340	500	pF

DYNAMIC SATURATION VOLTAGE

Symbol	Characteristic	Conditions	Time	Temperature	Min	Typ	Max	Unit
$V_{CE(dsat)}$	Dynamic Saturation Voltage: Determined 1 μs and 3 μs respectively after rising I_{B1} reaches 90% of final I_{B1}	I_C = 1 A, I_{B1} = 100 mA, V_{CC} = 300 V	@ 1 μs	@ T_C = 25°C	–	3.7	–	V
				@ T_C = 125°C	–	9.4	–	
			@ 3 μs	@ T_C = 25°C	–	0.35	–	V
				@ T_C = 125°C	–	2.7	–	
		I_C = 2 A, I_{B1} = 0.8 A, V_{CC} = 300 V	@ 1 μs	@ T_C = 25°C	–	3.9	–	V
				@ T_C = 125°C	–	12	–	
			@ 3 μs	@ T_C = 25°C	–	0.4	–	V
				@ T_C = 125°C	–	1.5	–	

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

Symbol	Characteristic	Conditions	Temperature	Min	Typ	Max	Unit
t_{on}	Turn–on Time	I_C = 2 Adc, I_{B1} = 0.4 Adc, I_{B2} = 1 Adc, V_{CC} = 300 Vdc	@ T_C = 25°C	–	90	150	ns
			@ T_C = 125°C	–	105	–	
t_{off}	Turn–off Time		@ T_C = 25°C	–	1.15	1.3	μs
			@ T_C = 125°C	–	1.5	–	
t_{on}	Turn–on Time	I_C = 2 Adc, I_{B1} = 0.4 Adc, I_{B2} = 0.4 Adc, V_{CC} = 300 Vdc	@ T_C = 25°C	–	90	150	ns
			@ T_C = 125°C	–	110	–	
t_{off}	Turn–off Time		@ T_C = 25°C	2.1	–	2.4	μs
			@ T_C = 125°C	–	3.1	–	

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

Symbol	Characteristic	Conditions	Temperature	Min	Typ	Max	Unit
t_f	Fall Time	I_C = 1 Adc, I_{B1} = 100 mAdc, I_{B2} = 500 mAdc	@ T_C = 25°C	–	90	150	ns
			@ T_C = 125°C	–	93	–	
t_s	Storage Time		@ T_C = 25°C	–	0.72	0.9	μs
			@ T_C = 125°C	–	1.05	–	
t_c	Crossover Time		@ T_C = 25°C	–	95	150	ns
			@ T_C = 125°C	–	95	–	
t_f	Fall Time	I_C = 2 Adc, I_{B1} = 0.4 Adc, I_{B2} = 0.4 Adc	@ T_C = 25°C	–	80	150	ns
			@ T_C = 125°C	–	105	–	
t_s	Storage Time		@ T_C = 25°C	1.95	–	2.25	μs
			@ T_C = 125°C	–	2.9	–	
t_c	Crossover Time		@ T_C = 25°C	–	225	300	ns
			@ T_C = 125°C	–	450	–	

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

TYPICAL STATIC CHARACTERISTICS

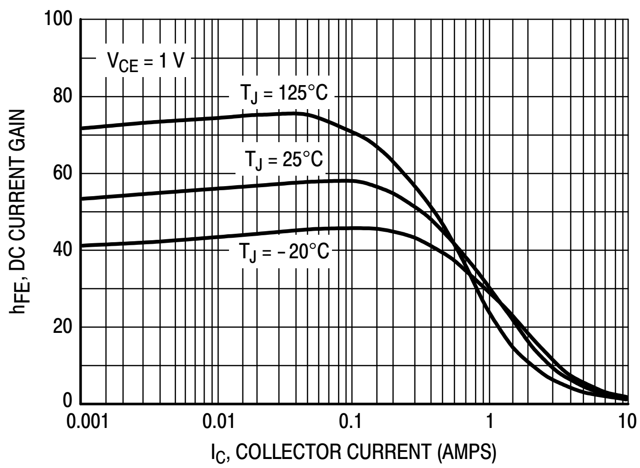


Figure 1. DC Current Gain @ 1 Volt

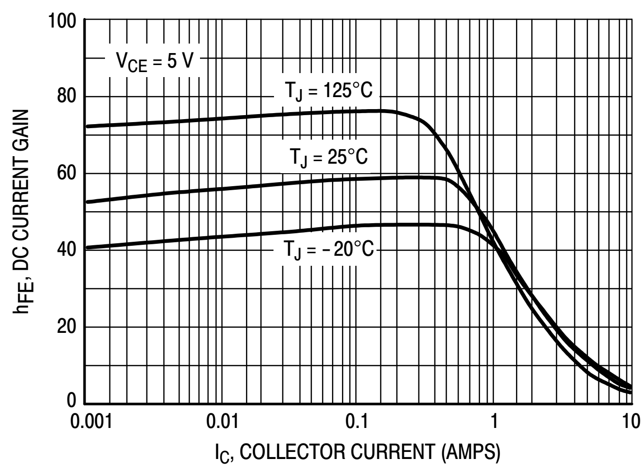


Figure 2. DC Current Gain @ 5 Volt

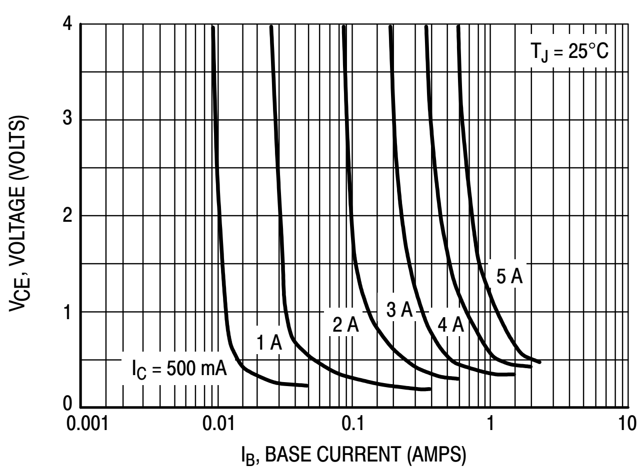


Figure 3. Collector Saturation Region

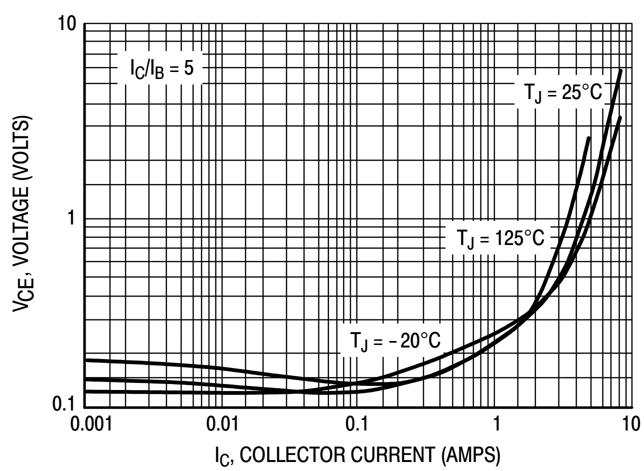


Figure 4. Collector−Emitter Saturation Voltage

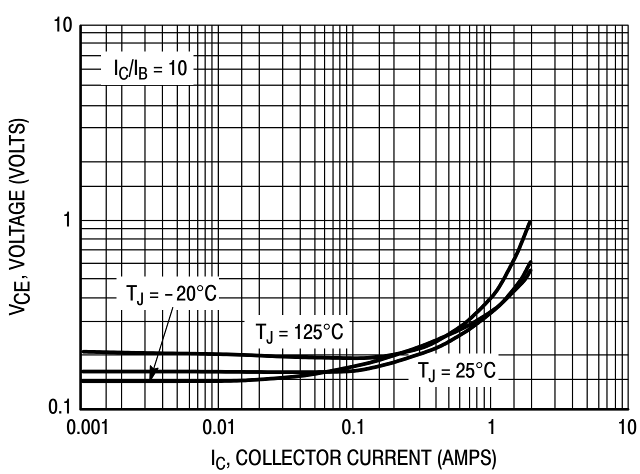


Figure 5. Collector−Emitter Saturation Voltage

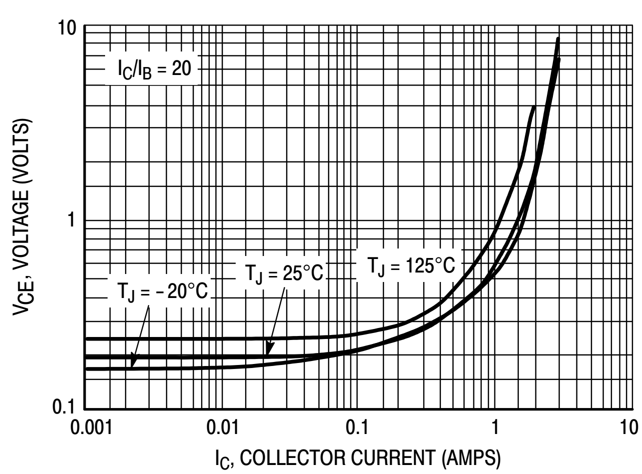


Figure 6. Collector−Emitter Saturation Voltage

TYPICAL STATIC CHARACTERISTICS (continue)

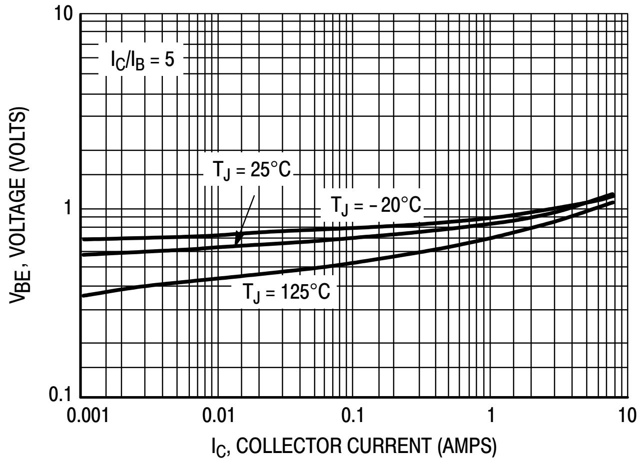


Figure 7. Base−Emitter Saturation Region

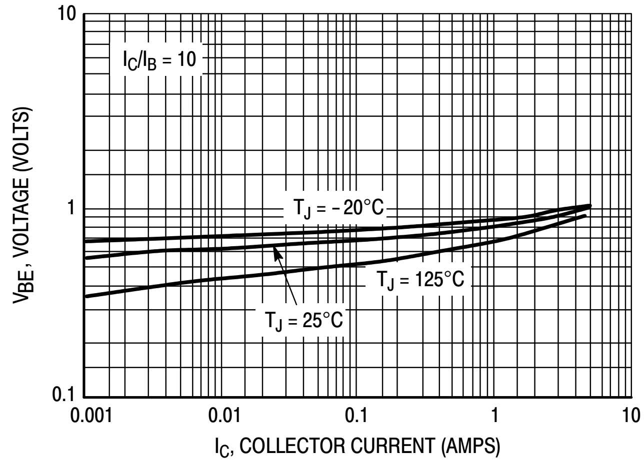


Figure 8. Base−Emitter Saturation Region

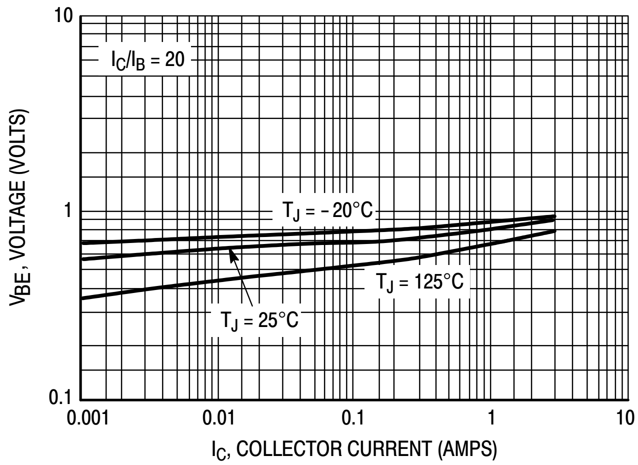


Figure 9. Base−Emitter Saturation Region

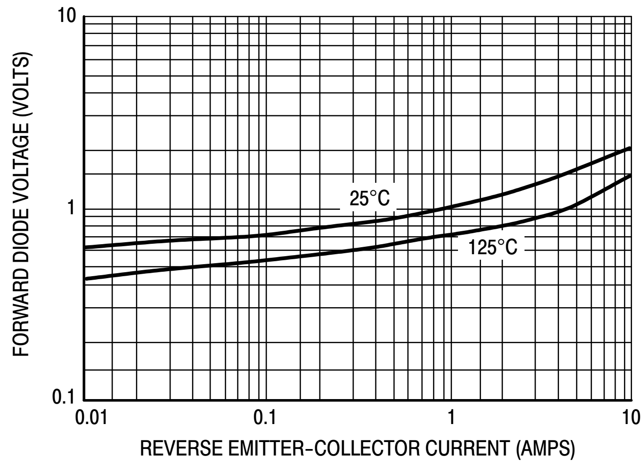


Figure 10. Forward Diode Voltage

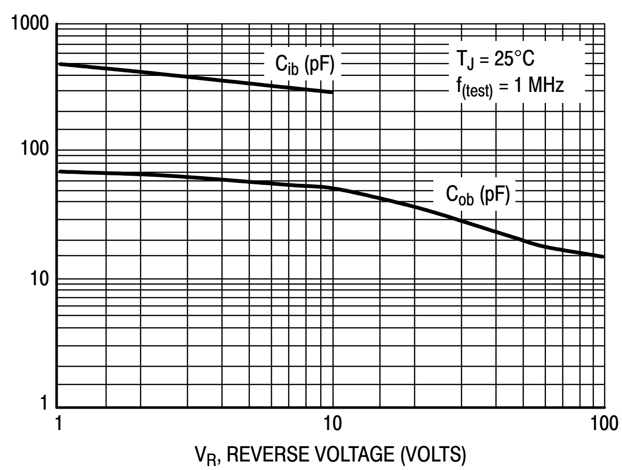


Figure 11. Capacitance

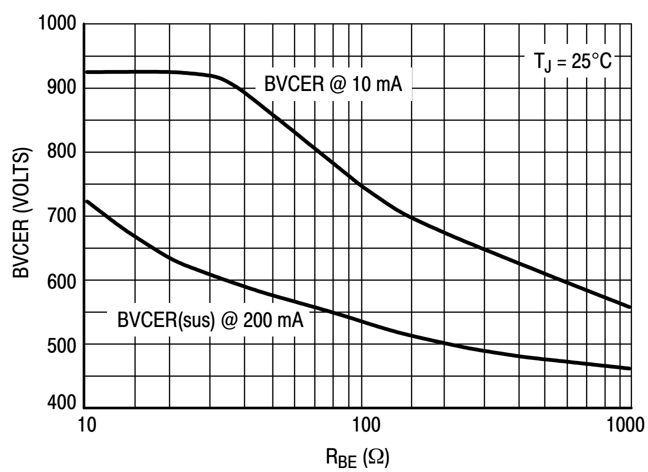


Figure 12. BVCER = f(ICER)

TYPICAL SWITCHING CHARACTERISTICS

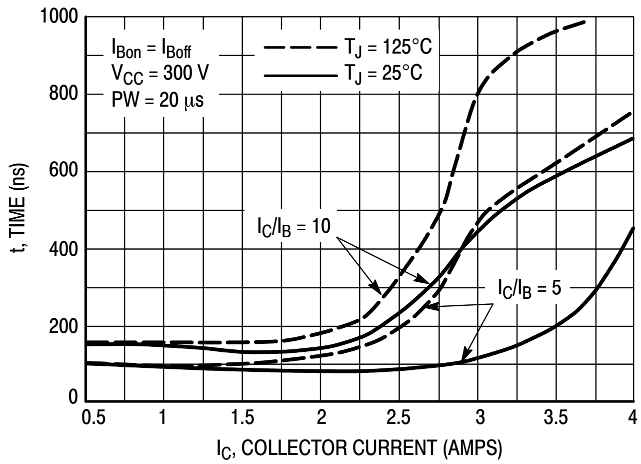


Figure 13. Resistive Switch Time, t_{on}

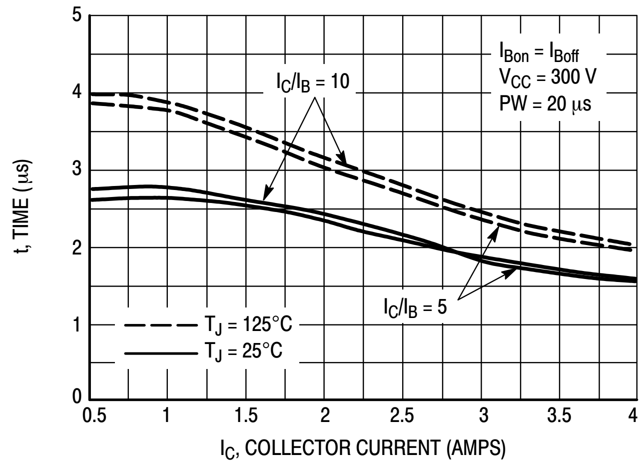


Figure 14. Resistive Switch Time, t_{off}

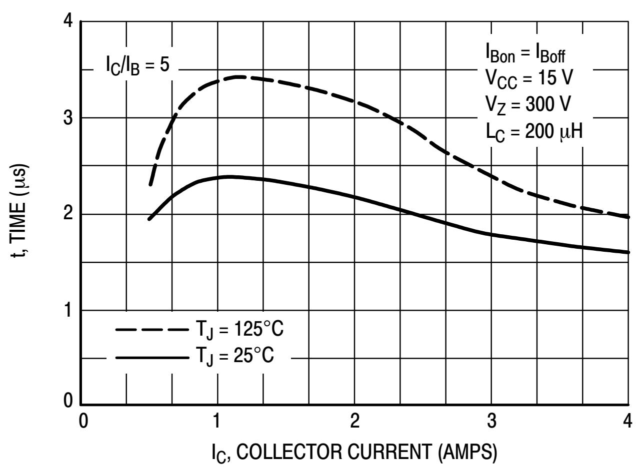


Figure 15. Inductive Storage Time,
t_{si} @ I_C/I_B = 5

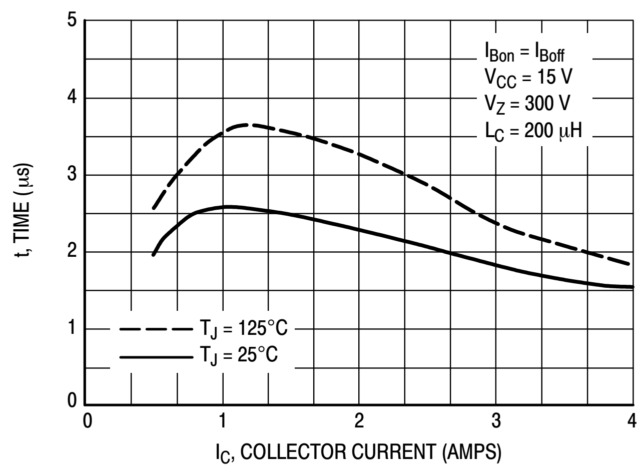


Figure 16. Inductive Storage Time,
t_{si} @ I_C/I_B = 10

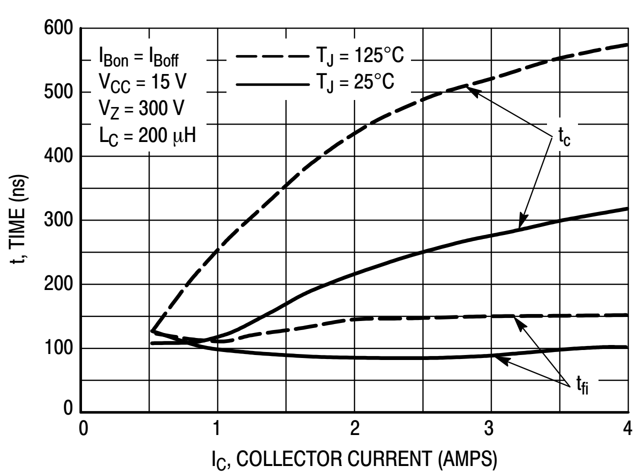


Figure 17. Inductive Switching,
t_c & t_{fi} @ I_C/I_B = 5

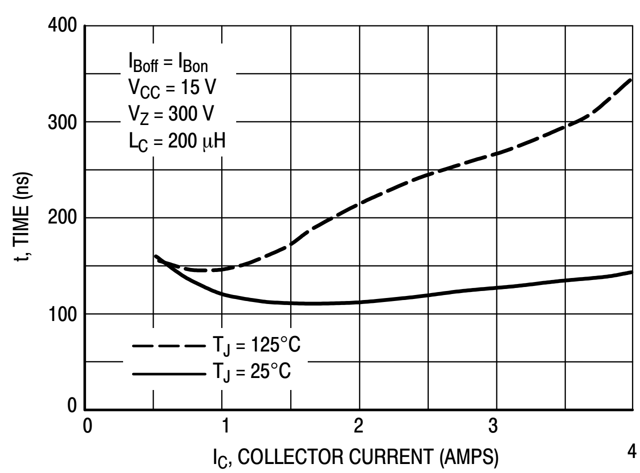


Figure 18. Inductive Switching,
t_{fi} @ I_C/I_B = 10

TYPICAL SWITCHING CHARACTERISTICS (continue)

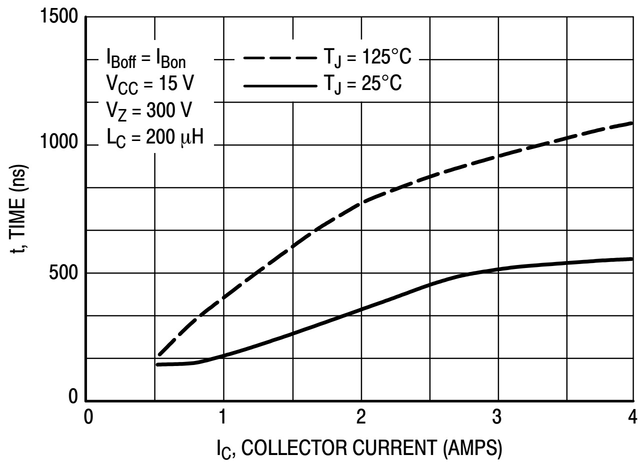


Figure 19. Inductive Switching, t_c @ I_C/I_B = 10

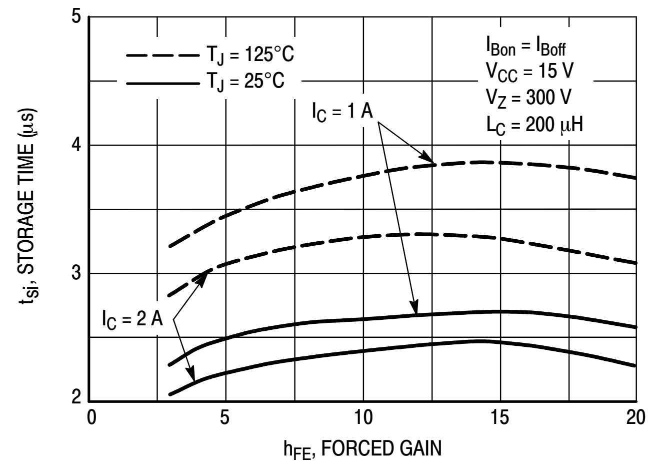


Figure 20. Inductive Storage Time

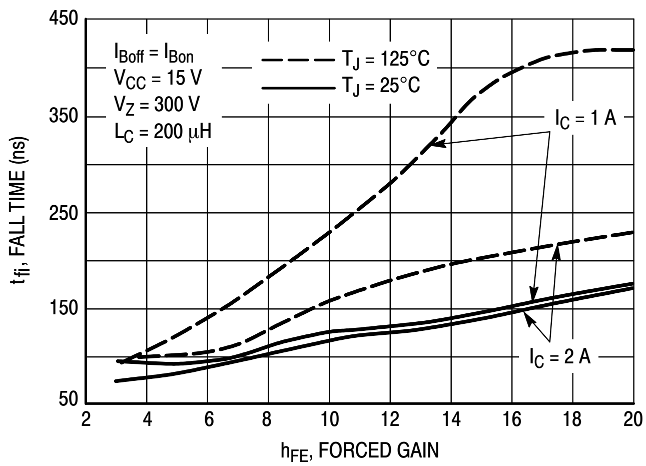


Figure 21. Inductive Fall Time

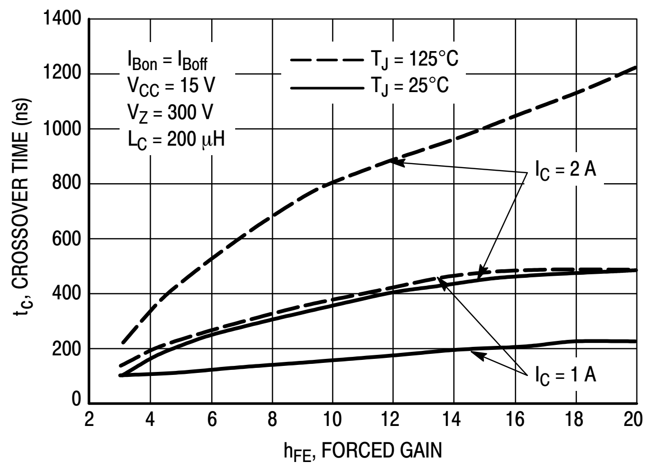


Figure 22. Inductive Crossover Time

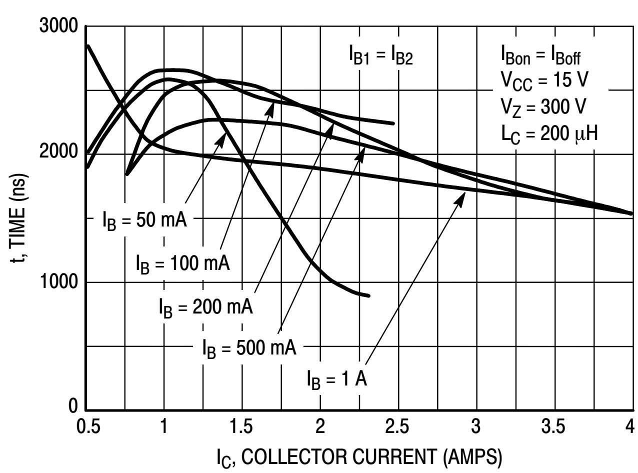


Figure 23. Inductive Storage Time, t_{si}

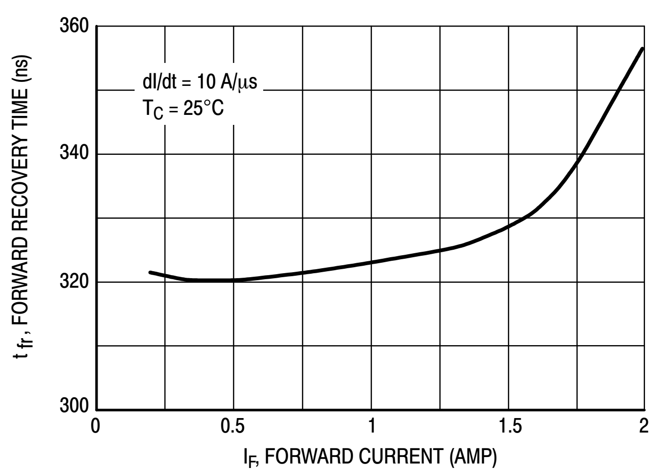


Figure 24. Forward Recovery Time t_{fr}

TYPICAL SWITCHING CHARACTERISTICS (continue)

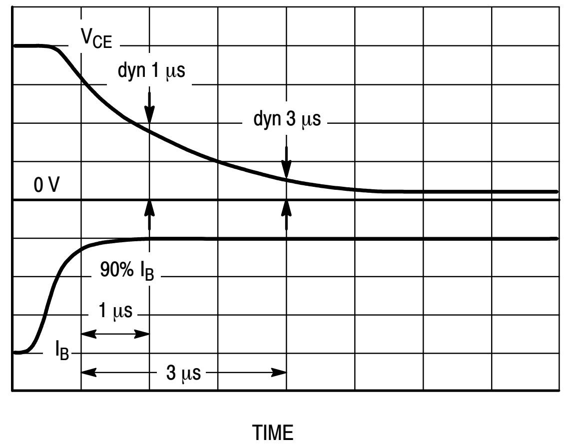


Figure 25. Dynamic Saturation Voltage Measurements

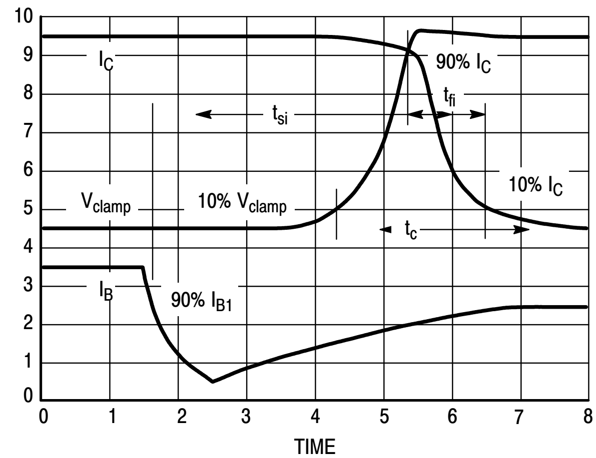


Figure 26. Inductive Switching Measurements

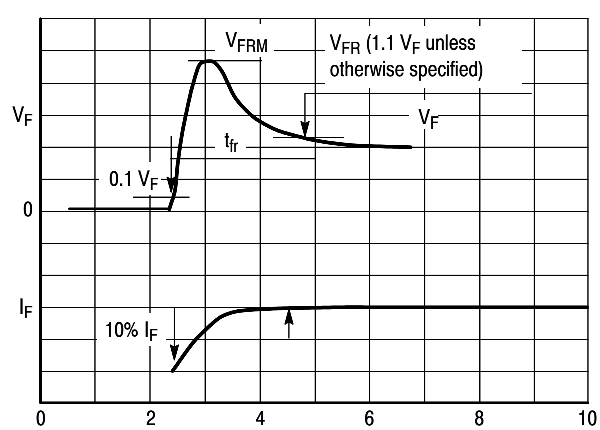
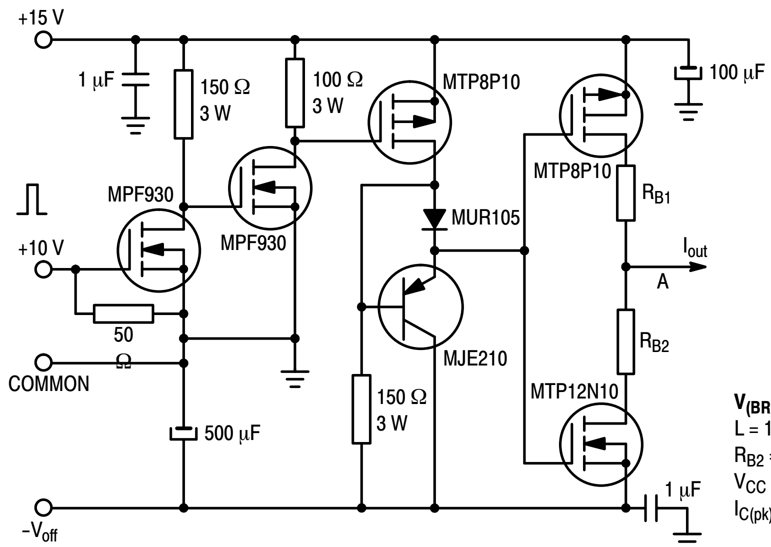
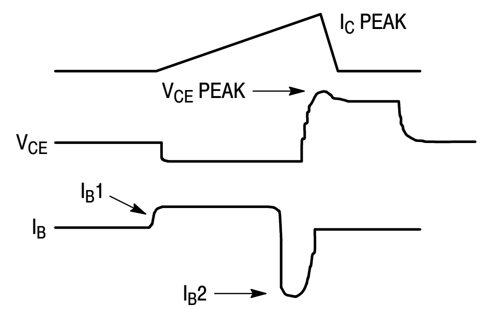


Figure 27. t_{fr} Measurements

TYPICAL SWITCHING CHARACTERISTICS (continue)

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

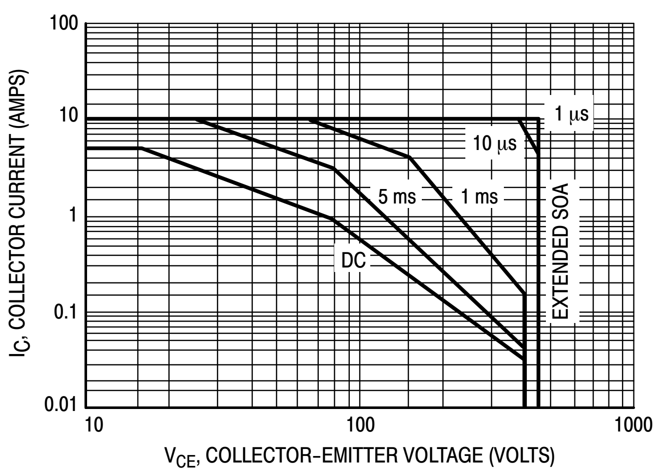


Figure 28. Forward Bias Safe Operating Area

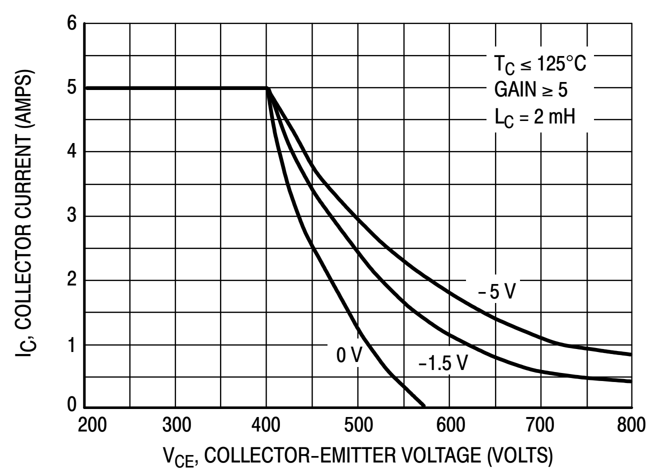


Figure 29. Reverse Bias Safe Operating Area

TYPICAL CHARACTERISTICS (continue)

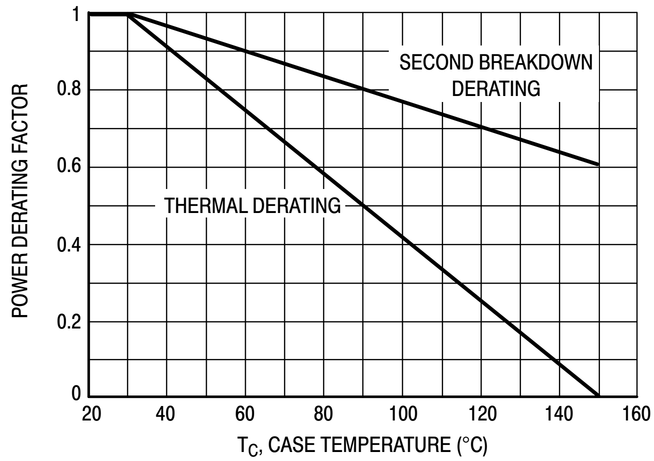


Figure 30. Forward Bias Power Derating

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 28 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 28 may be found at any case temperature by using the appropriate curve on Figure 30.

$T_{J(pk)}$ may be calculated from the data in Figure 31. 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 29). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

TYPICAL THERMAL RESPONSE

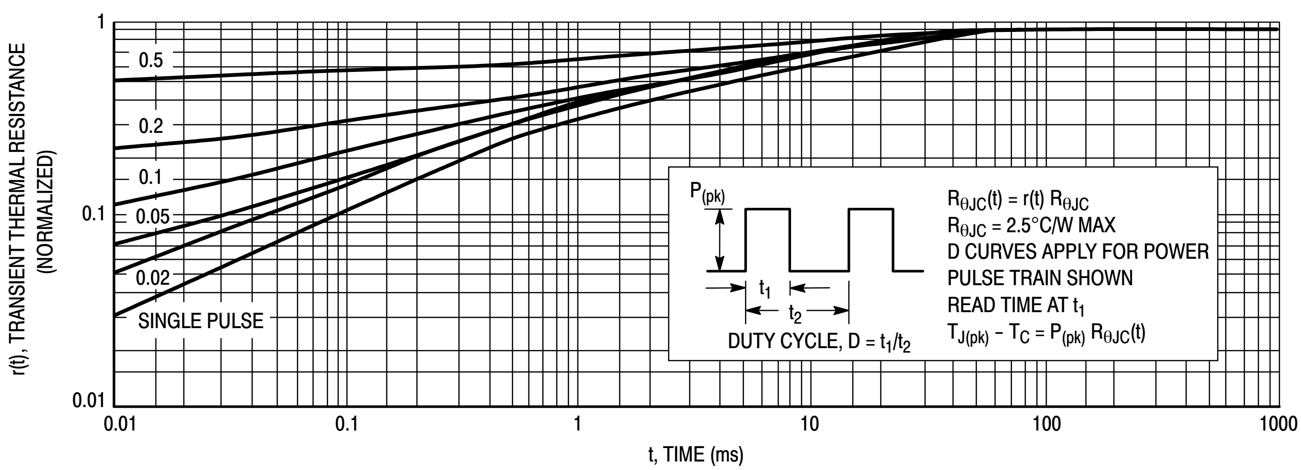


Figure 31. Typical Thermal Response ($Z_{\theta JC}(t)$) for BUL45D2

ADDITIONAL INFORMATION

TECHNICAL PUBLICATIONS:
Technical Library: www.onsemi.com/design/resources/technical−documentation
onsemi Website: www.onsemi.com

ONLINE SUPPORT: www.onsemi.com/support
For additional information, please contact your local Sales Representative at www.onsemi.com/support/sales