

# SMJB5603T4G

## Product Preview

# ESBC Rated NPN Silicon Transistor

### Features

- Low Equivalent On Resistance
- Very Fast Switch: 150 kHz
- Squared RBSOA: Up to 1500 V
- Avalanche Rated
- Low Driving Capacitance, No Miller Capacitance (Typ. 12 pF Capacitance at 200 V)
- Low Switching Losses
- Reliable HV Switch: No False Triggering due to High dv/dt Transients

### Applications

- High-Voltage and High-Speed Power Switches
- Emitter-Switched Bipolar/MOSFET Cascode (ESBC)
- Smart Meters, Smart Breakers, HV Industrial Power Supplies
- Motor Drivers and Ignition Drivers

### MAXIMUM RATINGS (T<sub>J</sub> = 25°C unless otherwise stated)

Parameter	Symbol	Value	Unit
Collector-Base Voltage	V <sub>CBO</sub>	1500	V
Collector-Emitter Voltage	V <sub>CEO</sub>	800	V
Emitter-Base Voltage	V <sub>EBO</sub>	12	V
Collector Current	I <sub>C</sub>	2	A
Collector Current (Pulse)	I <sub>CP</sub>	3	A
Base Current	I <sub>B</sub>	1	A
Base Current (Pulse)	I <sub>BP</sub>	2	A
Power Dissipation (T <sub>C</sub> = 25°C)	P <sub>D</sub>	110	W
Operating and Junction Temperature Range	T <sub>J</sub>	-55 to +125	°C
Storage Temperature Range	T <sub>STG</sub>	-65 to +150	°C
Avalanche Energy (T <sub>J</sub> = 25°C, 8 mH)	EAS	3.5	mJ

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.

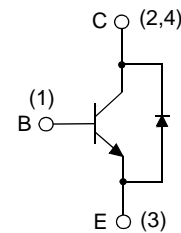
1. Figure of Merit.



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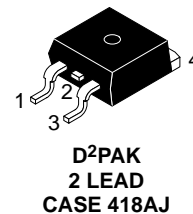
[www.onsemi.com](http://www.onsemi.com)

V <sub>CS(ON)</sub>	Equiv. R <sub>DS(ON)</sub>	I <sub>C</sub>
0.131 V	0.261 Ω (Note 1)	0.5 A

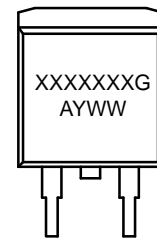


(Internal Schematic Diagram)

### MARKING DIAGRAM



D<sup>2</sup>PAK  
2 LEAD  
CASE 418AJ



XXXXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

### ORDERING INFORMATION

Device	Package	Shipping
SMJB5603T4G	D2-PAK 2L (TO-263)	800 / Tape & Reel

This document contains information on a product under development. ON Semiconductor reserves the right to change or discontinue this product without notice.

# SMJB5603T4G

## THERMAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ unless otherwise stated) (Note 2)

Parameter	Symbol	Max	Unit
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	1.13	$^\circ\text{C/W}$
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	76.42	

2. Device mounted on FR-4 PCB, board size = 76.2 mm x 114.3 mm, land pattern 12.70 mm x 9.45 mm, trace size = 10 mil.

## ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ unless otherwise stated) (Note 3)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	$BV_{CBO}$	$I_C = 0.5 \text{ mA}, I_E = 0$	1500	1689		V
Collector-Emitter Breakdown Voltage	$BV_{CEO}$	$I_C = 5 \text{ mA}, I_B = 0$	800	870		V
Emitter-Base Breakdown Voltage	$BV_{EBO}$	$I_E = 0.5 \text{ mA}, I_C = 0$	12.0	14.8		V
Collector Cut-off Current	$I_{CES}$	$V_{CE} = 1500 \text{ V}, V_{BE} = 0$		0.01	100	$\mu\text{A}$
Collector Cut-off Current	$I_{CEO}$	$V_{CE} = 800 \text{ V}, I_B = 0$		0.01	100	$\mu\text{A}$
Emitter Cut-off Current	$I_{EBO}$	$V_{EB} = 12 \text{ V}, I_C = 0$		0.05	500	$\mu\text{A}$
DC Current Gain	$h_{FE}$	$V_{CE} = 3 \text{ V}, I_C = 0.4 \text{ A}$	20	29	35	
		$V_{CE} = 10 \text{ V}, I_C = 5 \text{ mA}$	20	43		
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 0.25 \text{ A}, I_B = 0.05 \text{ A}$		0.16		V
		$I_C = 0.5 \text{ A}, I_B = 0.167 \text{ A}$		0.12		
		$I_C = 1 \text{ A}, I_B = 0.33 \text{ A}$		0.25		
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$		0.74	1.20	V
		$I_C = 2 \text{ A}, I_B = 0.4 \text{ A}$		0.85	1.20	
Input Capacitance	$C_{IB}$	$V_{EB} = 10 \text{ V}, I_C = 0, f = 1 \text{ MHz}$		745	1000	pF
Output Capacitance	$C_{OB}$	$V_{CB} = 200 \text{ V}, I_E = 0, f = 1 \text{ MHz}$		15		pF
Current Gain Bandwidth Product	$f_T$	$I_C = 0.1 \text{ A}, V_{CE} = 10 \text{ V}$		5		MHz
Diode Forward Voltage	$V_F$	$I_F = 0.4 \text{ A}$		0.76	1.20	V
		$I_F = 1 \text{ A}$		0.83	1.50	

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.

3. Pulse test: pulse width = 20  $\mu\text{s}$ , duty cycle  $\leq 10\%$ .

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## TYPICAL CHARACTERISTICS

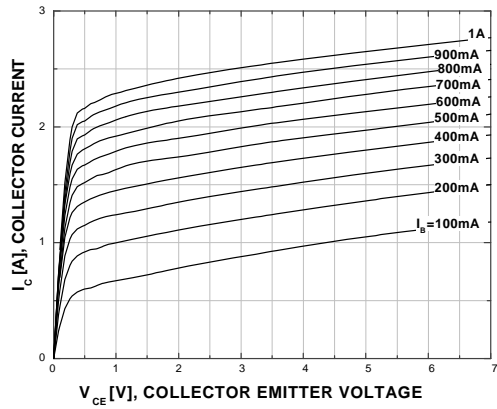


Figure 1. Static Characteristic

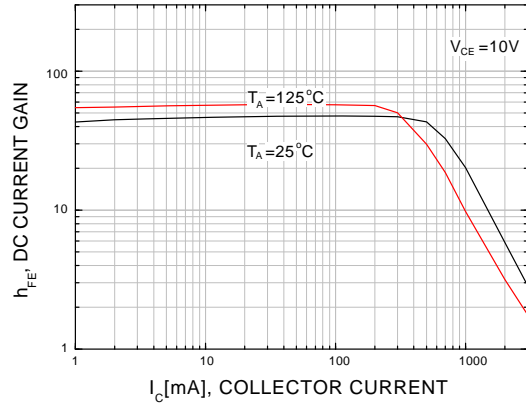


Figure 2. DC Current Gain

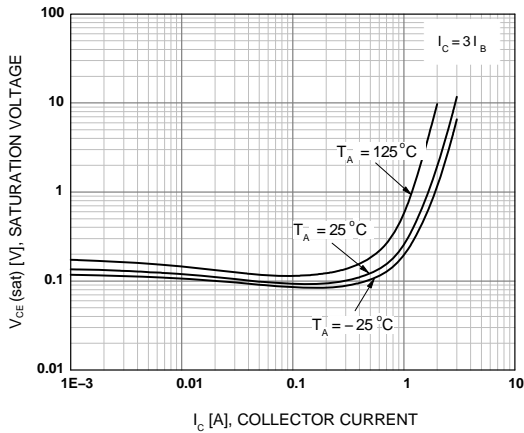


Figure 3. Collector-Emitter Saturation Voltage  
 $h_{FE} = 3$

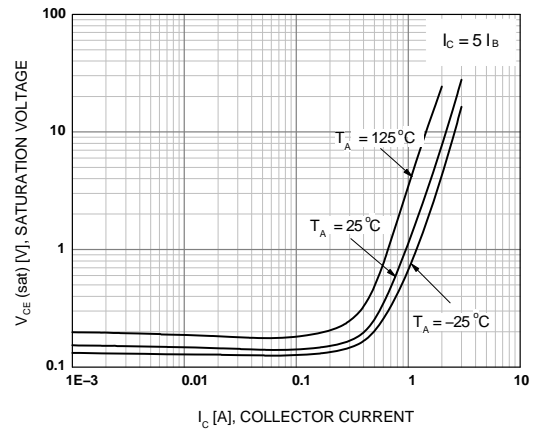


Figure 4. Collector-Emitter Saturation Voltage  
 $h_{FE} = 5$

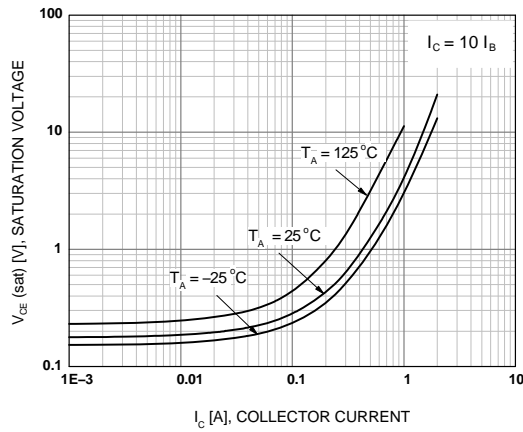


Figure 5. Collector-Emitter Saturation Voltage  
 $h_{FE} = 10$

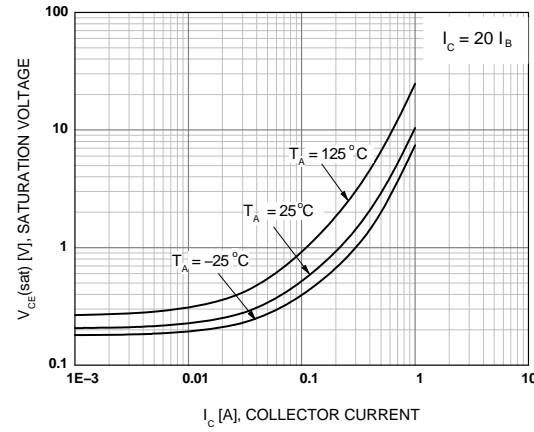


Figure 6. Collector-Emitter Saturation Voltage  
 $h_{FE} = 20$

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## TYPICAL CHARACTERISTICS

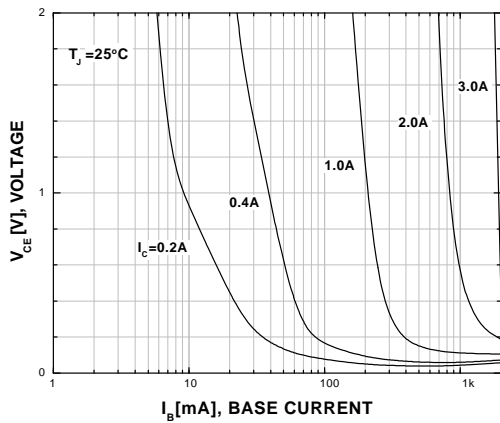


Figure 7. Typical Collector Saturation Voltage

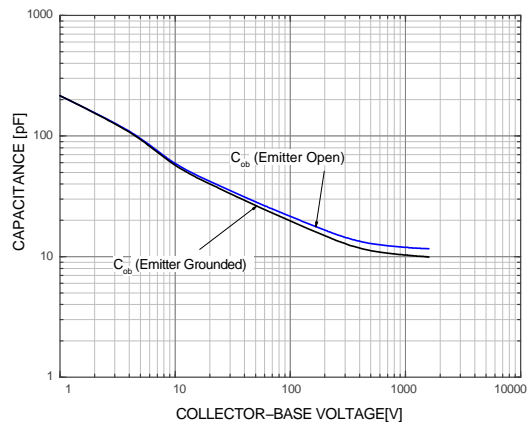


Figure 8. Capacitance

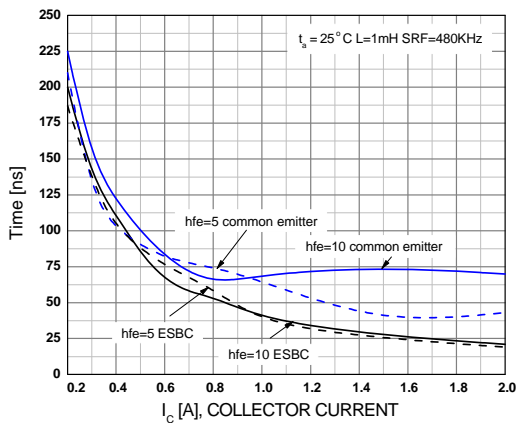


Figure 9. Inductive Load Collector Current Fall-Time ( $t_f$ )

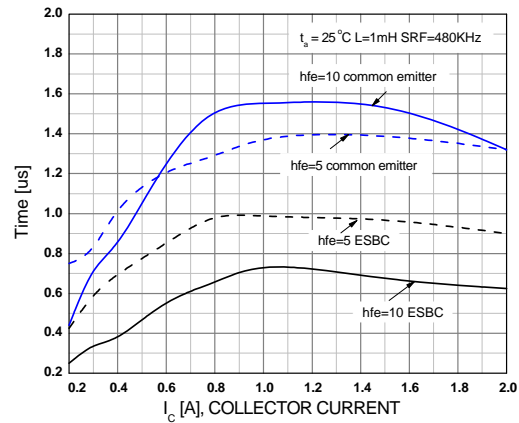


Figure 10. Inductive Load Collector Current Storage-Time ( $t_{stg}$ )

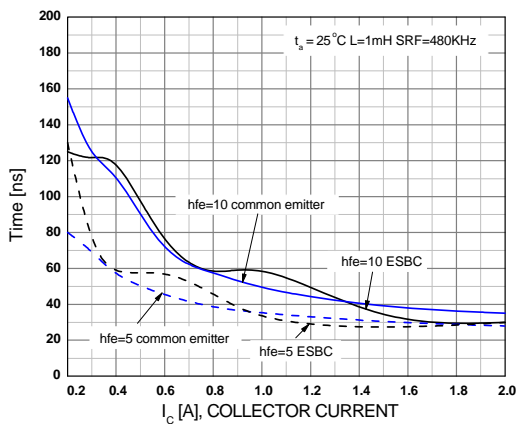


Figure 11. Inductive Load Collector Voltage Fall-Time ( $t_f$ )

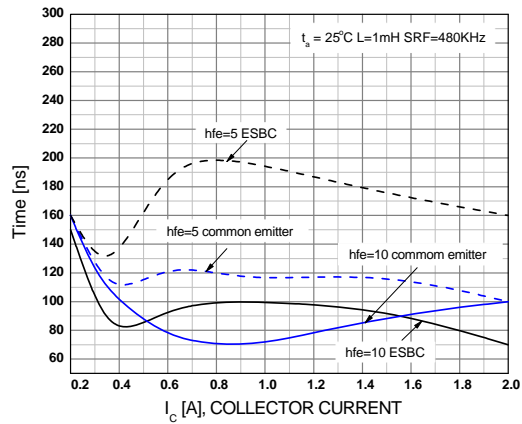


Figure 12. Inductive Load Collector Voltage Rise-Time ( $t_r$ )

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## TYPICAL CHARACTERISTICS

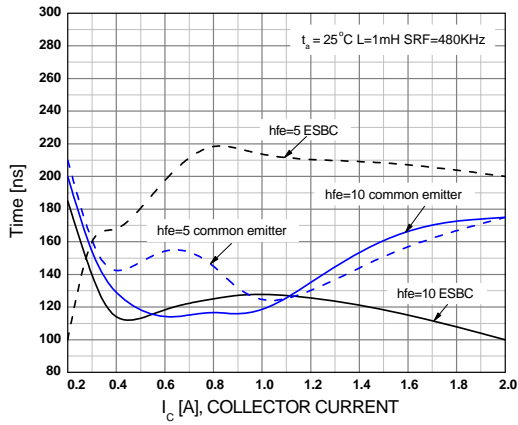


Figure 13. Inductive Load Collector Current / Voltage Crossover ( $t_c$ )

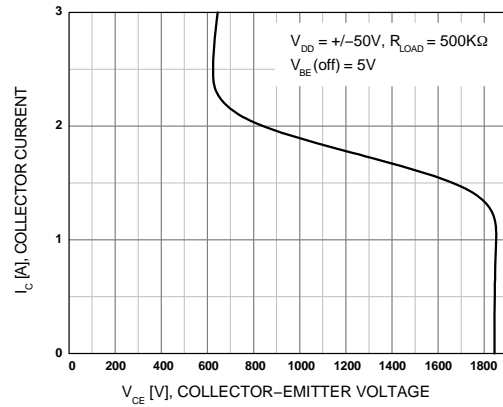


Figure 14. BJT Reverse Bias Safe Operating Area

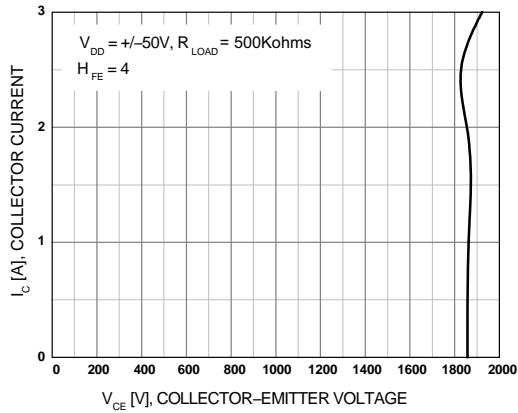


Figure 15. ESBC RBSOA

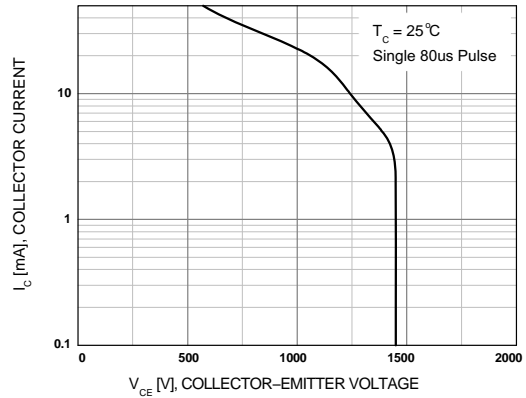


Figure 16. Crossover Forward Bias Safe Operating Area (FBSOA)

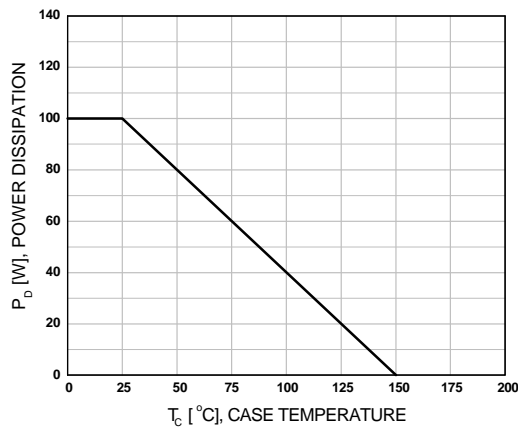


Figure 17. Power Derating

Test Circuits

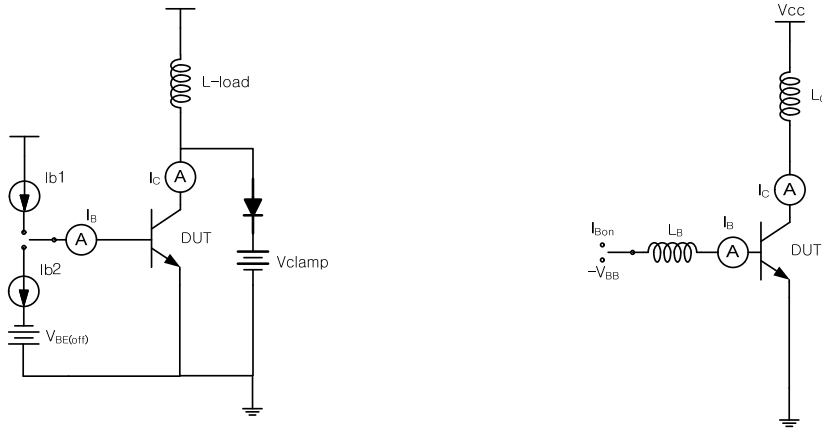


Figure 18. Test Circuit for Inductive Load and Reverse Bias Safe Operating

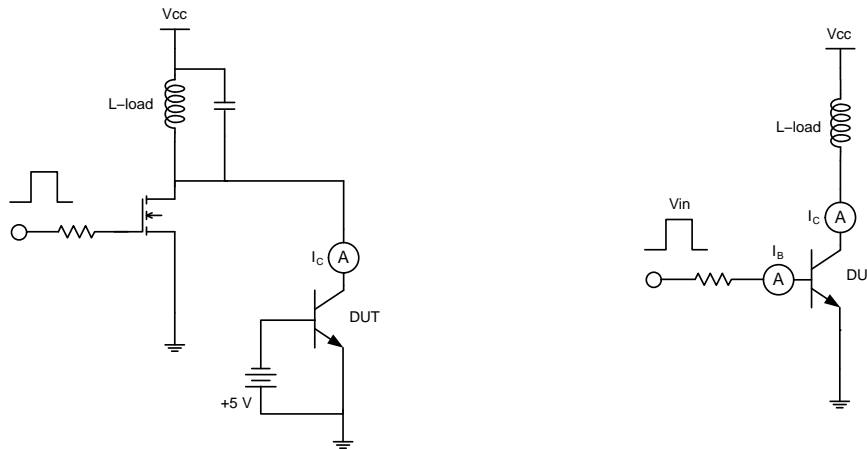


Figure 19. Energy Rating Test Circuit

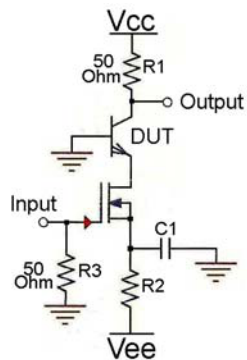


Figure 20.  $f_T$  Measurement

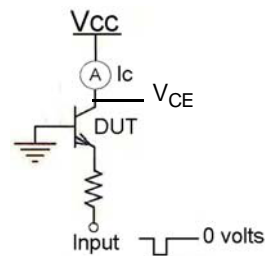


Figure 21. FBSOA

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## Test Circuits (Continued)

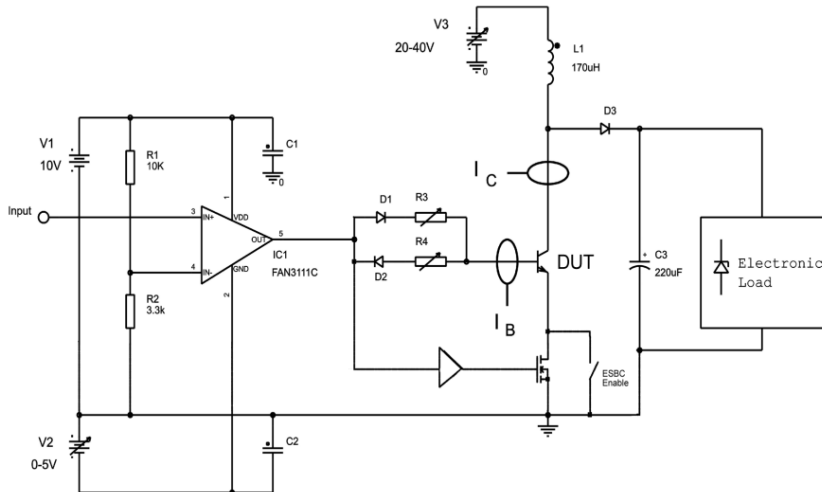


Figure 22. Simplified Saturated Switch Driver Circuit

## Functional Test Waveforms

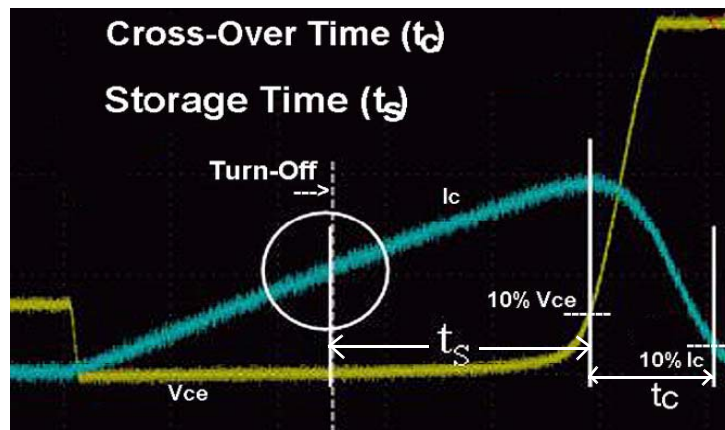


Figure 23. Crossover Time Measurement

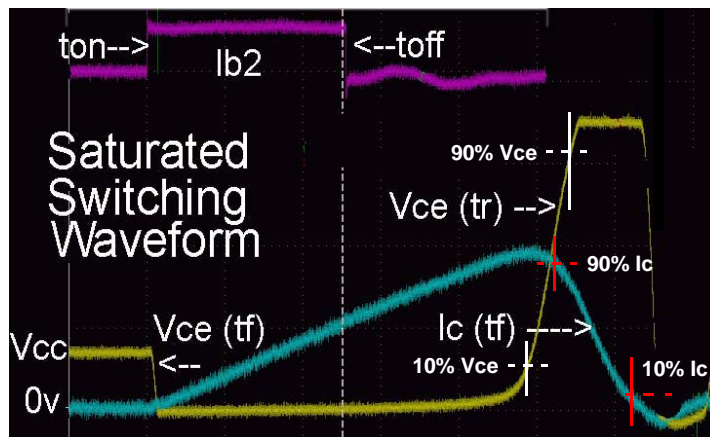


Figure 24. Saturated Switching Waveform

Functional Test Waveforms (Continued)

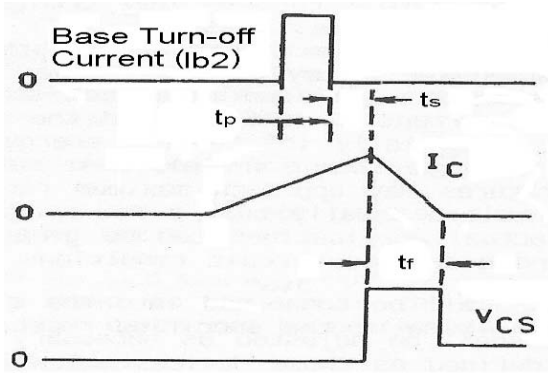


Figure 25. Storage Time - Common Emitter Base Turn-off ( $I_{b2}$ ) to  $I_C$  Fall-Time

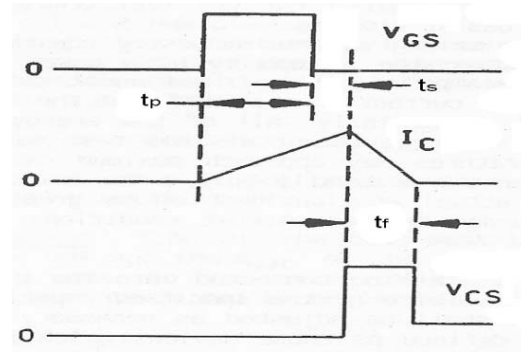
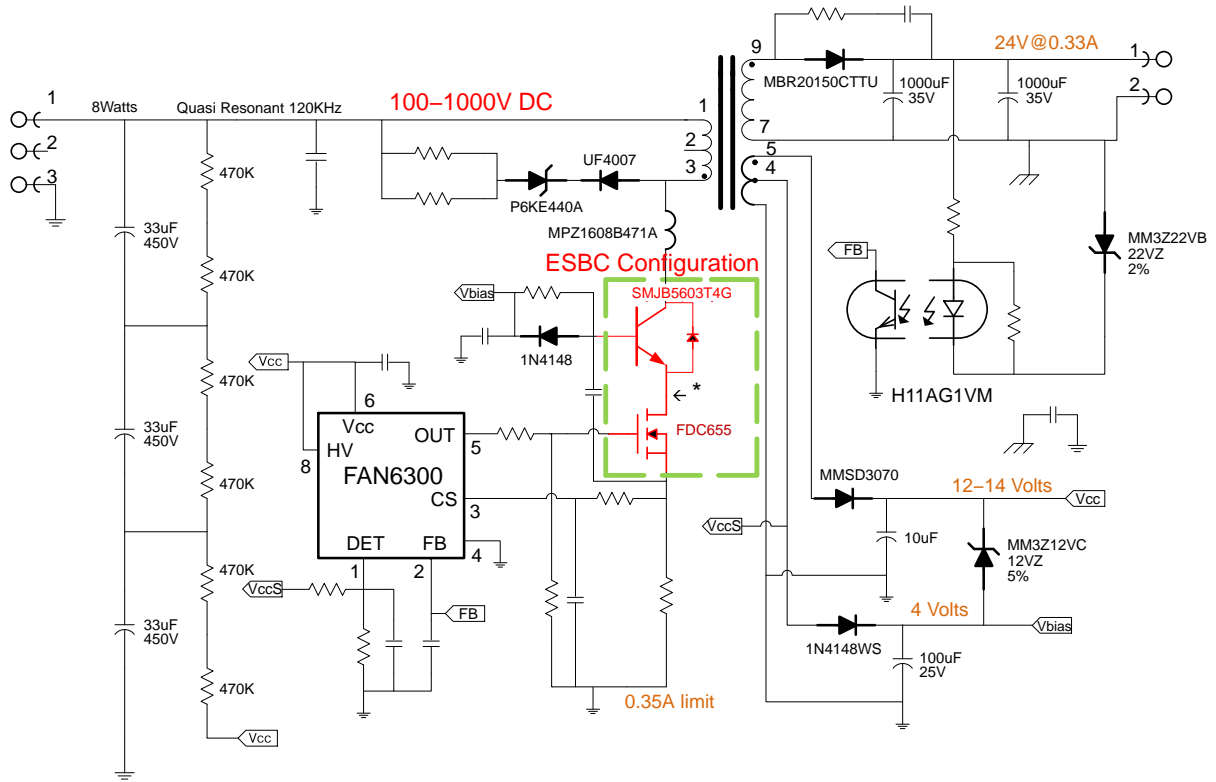


Figure 26. Storage Time - ESBC FET Gate (off) to  $I_C$  Fall-Time



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## Very Wide Input Voltage Range Supply



\* Make short as possible

Figure 27. 8 W; Secondary-Side Regulation: 3 Capacitor Input; Quasi Resonant

## Driving ESBC Switches

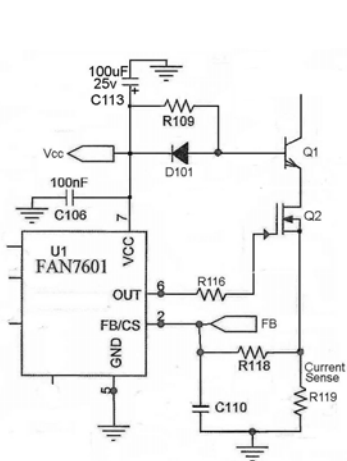


Figure 28.  $V_{CC}$  Derived

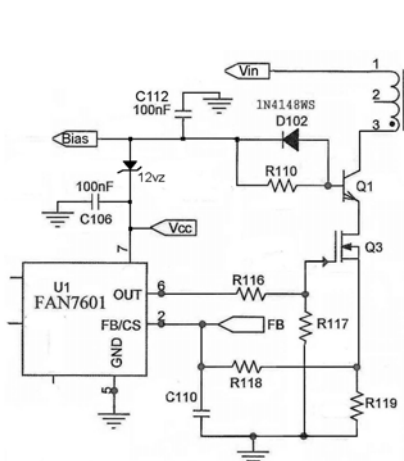


Figure 29.  $V_{bias}$  Supply Derived

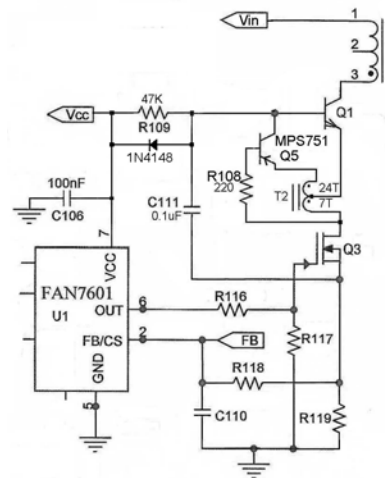
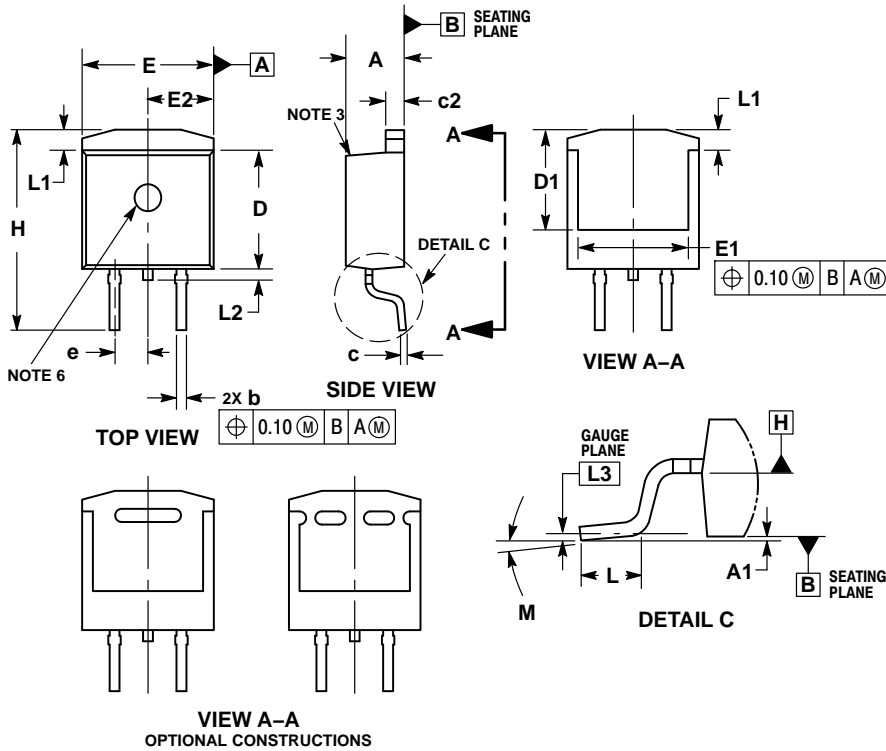


Figure 30. Proportional Drive

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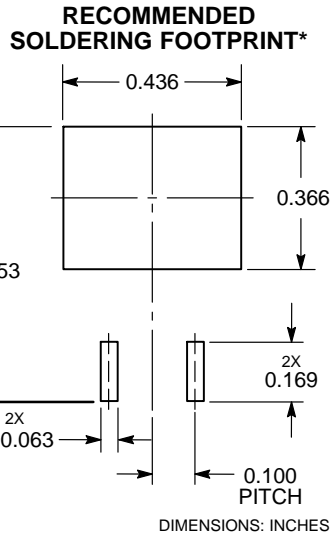
## PACKAGE DIMENSIONS

**D<sup>2</sup>PAK-3 (TO-263, 3-LEAD)**  
**CASE 418AJ**  
**ISSUE B**




- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: INCHES.
  3. CHAMFER OPTIONAL.
  4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005 PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
  5. THERMAL PAD CONTOUR IS OPTIONAL WITHIN DIMENSIONS E, L1, D1 AND E1.
  6. OPTIONAL MOLD FEATURE

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.160	0.190	4.06	4.83
A1	0.000	0.010	0.00	0.25
b	0.020	0.039	0.51	0.99
c	0.012	0.029	0.30	0.74
c2	0.045	0.065	1.14	1.65
D	0.330	0.380	8.38	9.65
D1	0.260	-----	6.60	-----
E	0.380	0.420	9.65	10.67
E1	0.245	-----	6.22	-----
e	0.100	BSC	2.54	BSC
H	0.575	0.625	14.60	15.88
L	0.070	0.110	1.78	2.79
L1	-----	0.066	-----	1.68
L2	-----	0.070	-----	1.78
L3	0.010	BSC	0.25	BSC
M	0°	8°	0°	8°



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

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