# SMJB5603T4G

*Product Preview*

# ESBC Rated NPN Silicon Transistor

ON Semiconductor®

www.onsemi.com

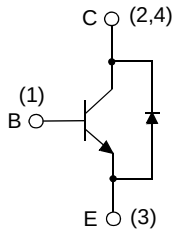
### Features

- 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

| $V_{CS(ON)}$ | Equiv. $R_{DS(ON)}$ | $I_C$ |
|---|---|---|
| 0.131 V | 0.261 Ω (Note 1) | 0.5 A |




(Internal Schematic Diagram)

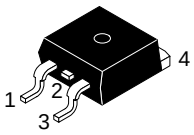
**MAXIMUM RATINGS** ($T_J$ = 25°C unless otherwise stated)

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector−Base Voltage | $V_{CBO}$ | 1500 | V |
| Collector−Emitter Voltage | $V_{CEO}$ | 800 | V |
| Emitter−Base Voltage | $V_{EBO}$ | 12 | V |
| Collector Current | $I_C$ | 2 | A |
| Collector Current (Pulse) | $I_{CP}$ | 3 | A |
| Base Current | $I_B$ | 1 | A |
| Base Current (Pulse) | $I_{BP}$ | 2 | A |
| Power Dissipation ($T_C$ = 25°C) | $P_D$ | 110 | W |
| Operating and Junction Temperature Range | $T_J$ | −55 to +125 | °C |
| Storage Temperature Range | $T_{STG}$ | −65 to +150 | °C |
| Avalanche Energy ($T_J$ = 25°C, 8 mH) | EAS | 3.5 | mJ |

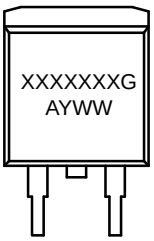
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Figure of Merit.

**MARKING DIAGRAM**




**$D^2PAK$**
**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.

**THERMAL CHARACTERISTICS** ($T_A$ = 25°C unless otherwise stated) (Note 2)

| Parameter | Symbol | Max | Unit |
|---|---|---|---|
| Thermal Resistance, Junction−to−Case | $R_{\theta JC}$ | 1.13 | °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°C unless otherwise stated) (Note 3)

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

## TYPICAL CHARACTERISTICS

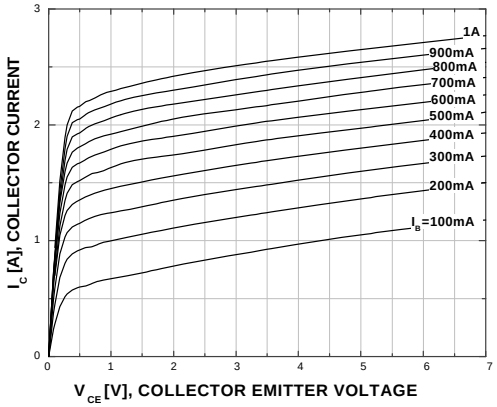



**Figure 1. Static Characteristic**

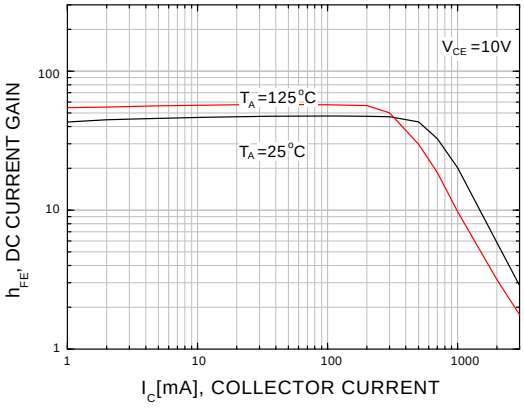



**Figure 2. DC Current Gain**

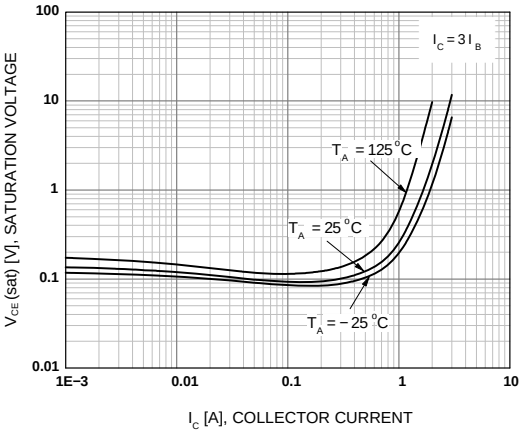



**Figure 3. Collector−Emitter Saturation Voltage $h_{FE}$ = 3**

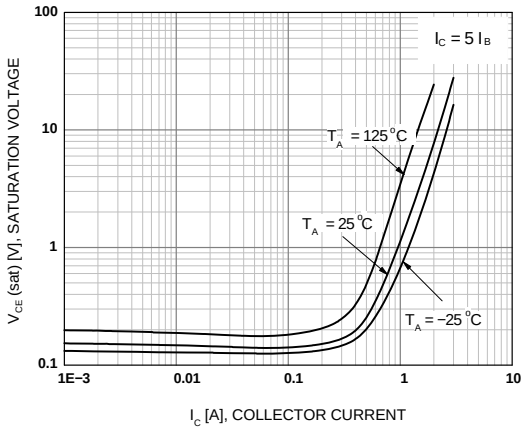



**Figure 4. Collector−Emitter Saturation Voltage $h_{FE}$ = 5**

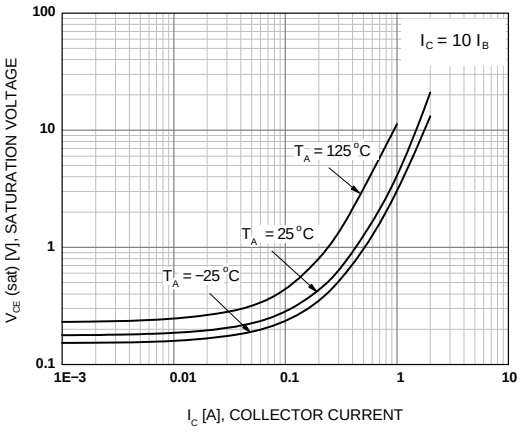



**Figure 5. Collector−Emitter Saturation Voltage $h_{FE}$ = 10**

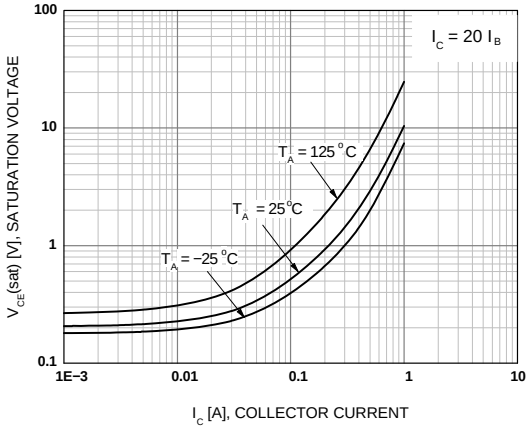



**Figure 6. Collector−Emitter Saturation Voltage $h_{FE}$ = 20**

## TYPICAL CHARACTERISTICS

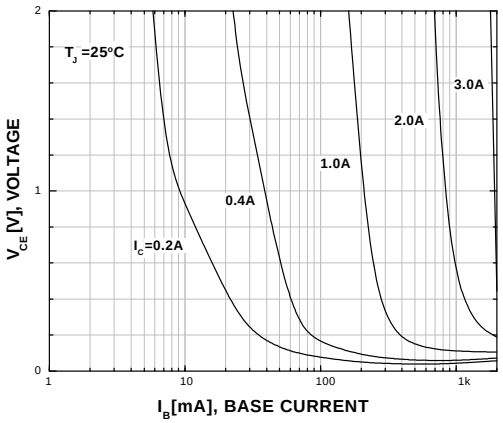



**Figure 7. Typical Collector Saturation Voltage**

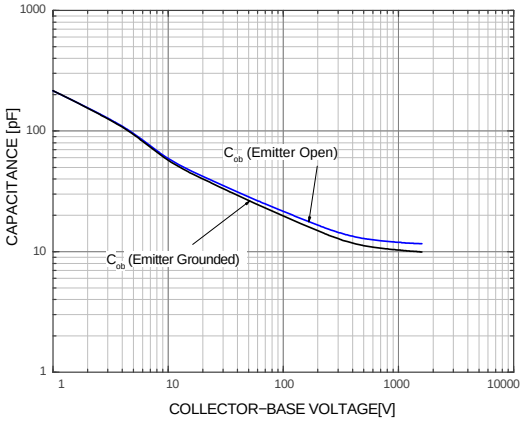



**Figure 8. Capacitance**

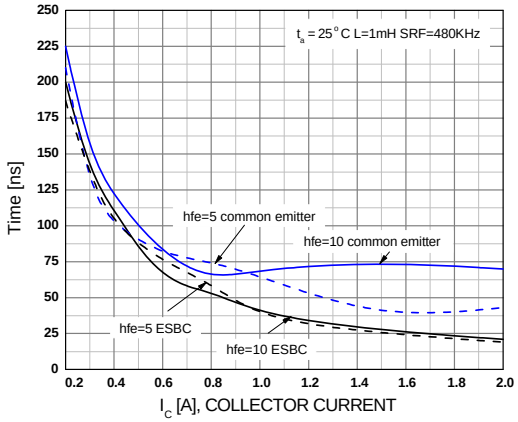



**Figure 9. Inductive Load Collector Current Fall−Time ($t_f$)**

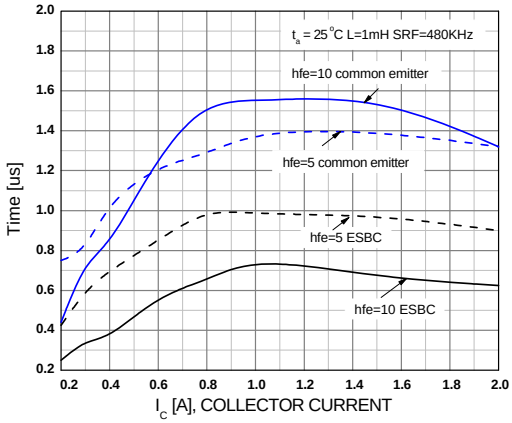



**Figure 10. Inductive Load Collector Current Storage−Time ($t_{stg}$)**

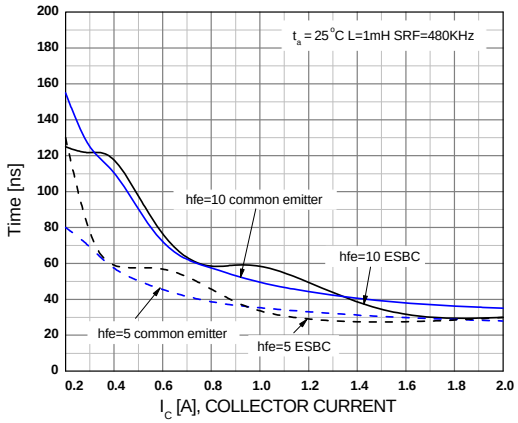



**Figure 11. Inductive Load Collector Voltage Fall−Time ($t_f$)**

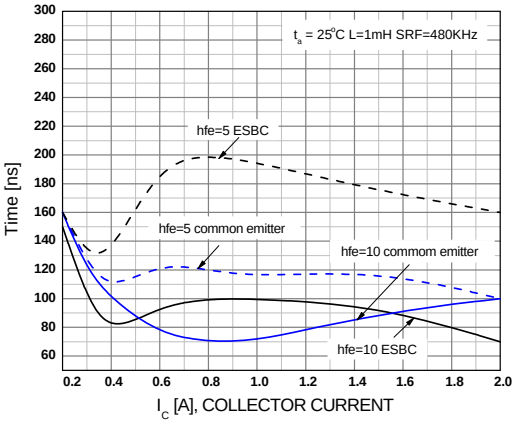



**Figure 12. Inductive Load Collector Voltage Rise−Time ($t_r$)**

## TYPICAL CHARACTERISTICS

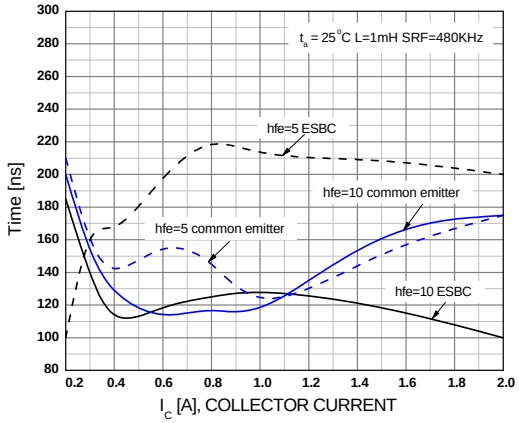



**Figure 13. Inductive Load Collector Current / Voltage Crossover ($t_c$)**

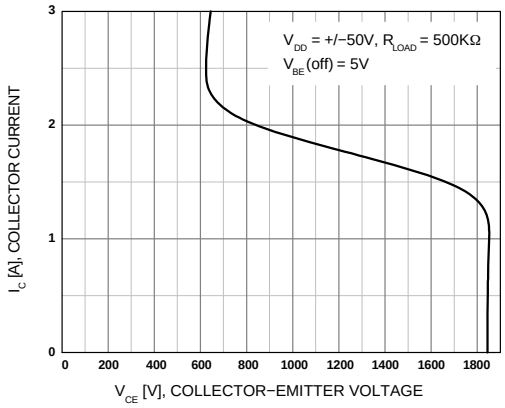



**Figure 14. BJT Reverse Bias Safe Operating Area**

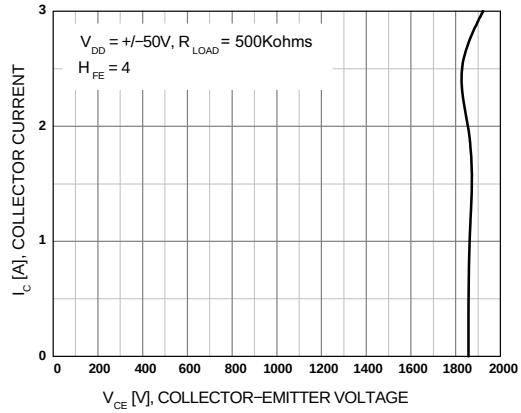



**Figure 15. ESBC RBSOA**

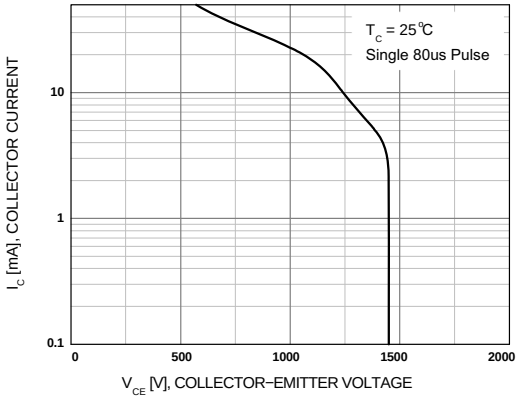



**Figure 16. Crossover Forward Bias Safe Operating Area (FBSOA)**

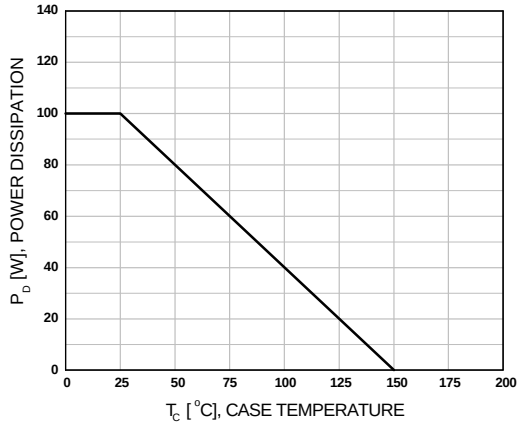



**Figure 17. Power Derating**

## Test Circuits

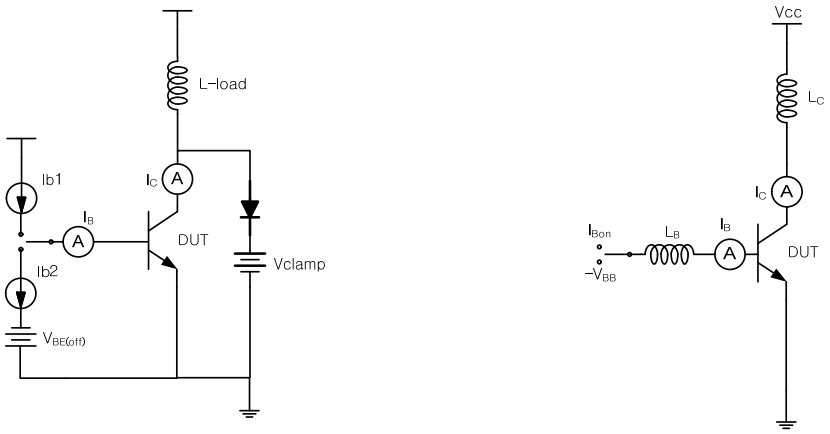



**Figure 18. Test Circuit for Inductive Load and Reverse Bias Safe Operating**

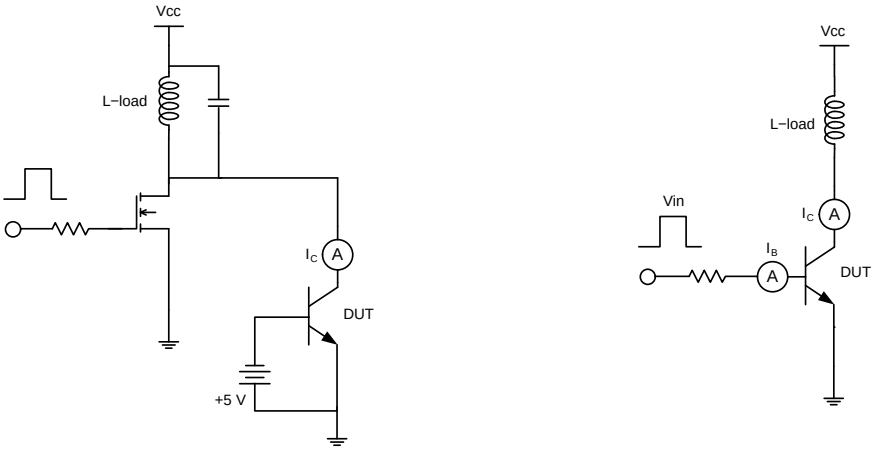



**Figure 19. Energy Rating Test Circuit**

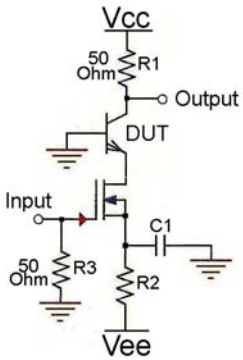



**Figure 20. $f_T$ Measurement**

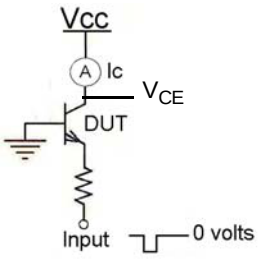



**Figure 21. FBSOA**

## Test Circuits (Continued)

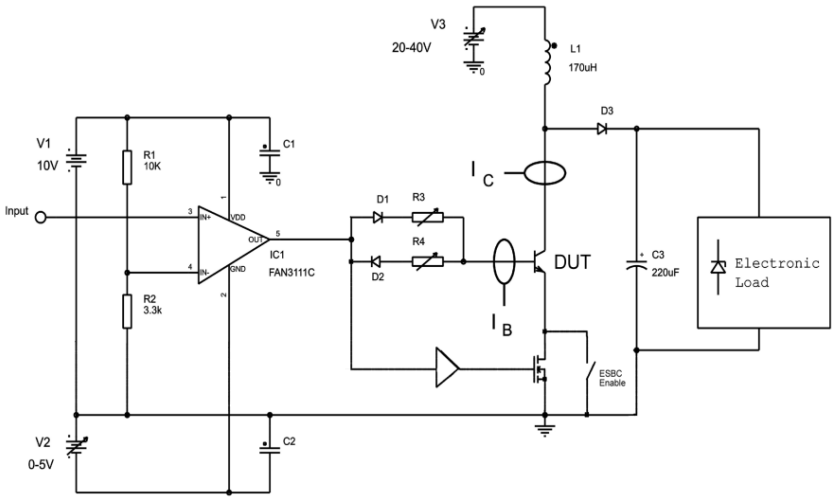



**Figure 22. Simplified Saturated Switch Driver Circuit**

## Functional Test Waveforms

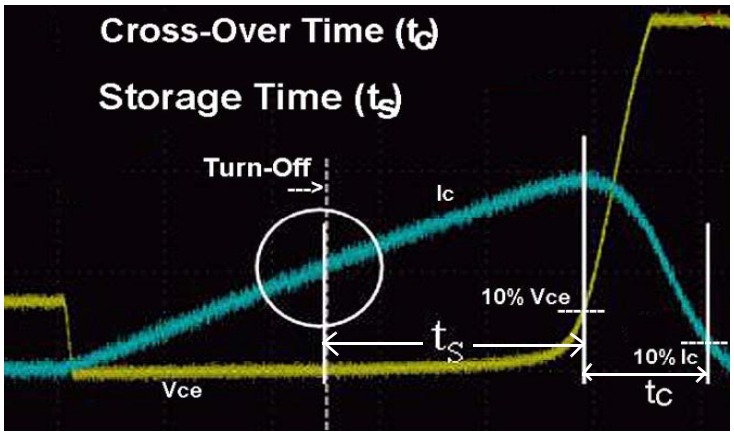



**Figure 23. Crossover Time Measurement**

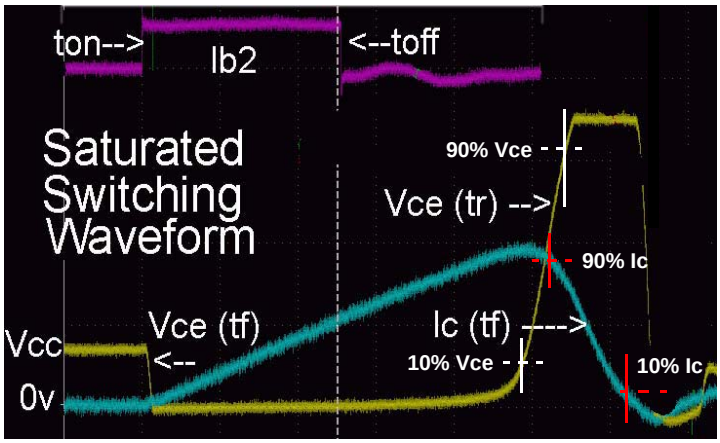



**Figure 24. Saturated Switching Waveform**

## Functional Test Waveforms (Continued)

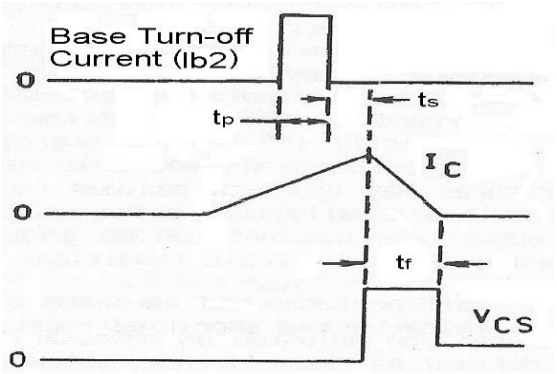



Figure 25. Storage Time − Common Emitter Base Turn−off (Ib2) to $I_C$ Fall−Time

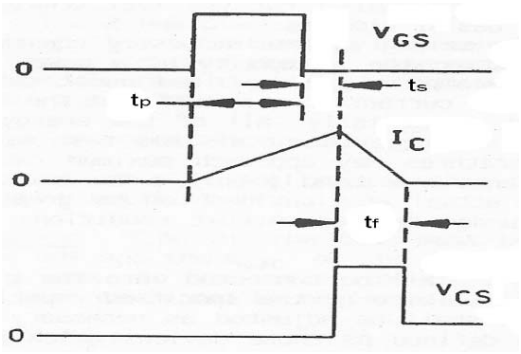
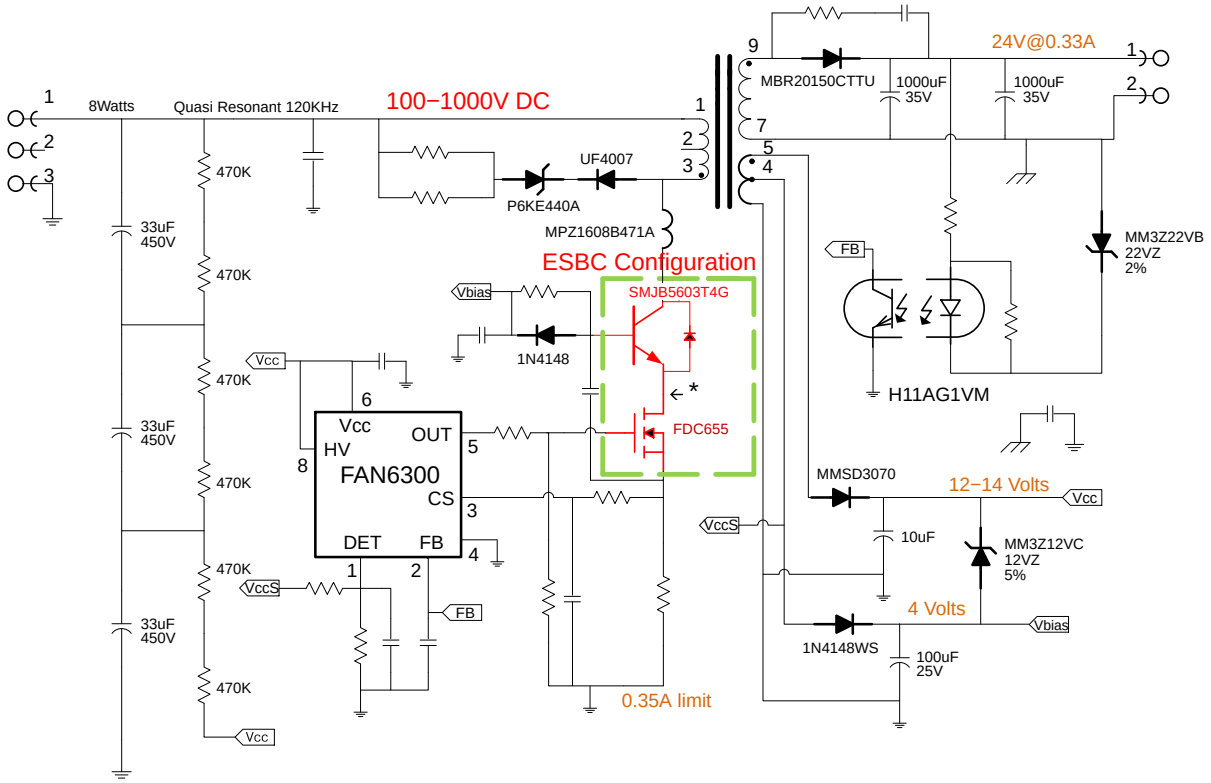



Figure 26. Storage Time − ESBC FET Gate (off) to $I_C$ Fall−Time

## 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

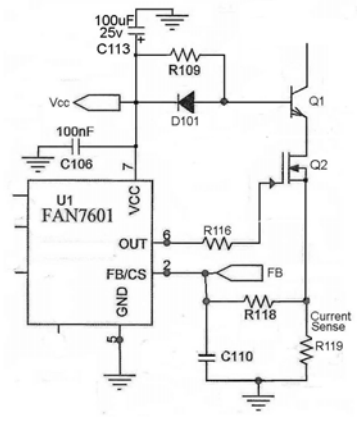



**Figure 28. $V_{CC}$ Derived**

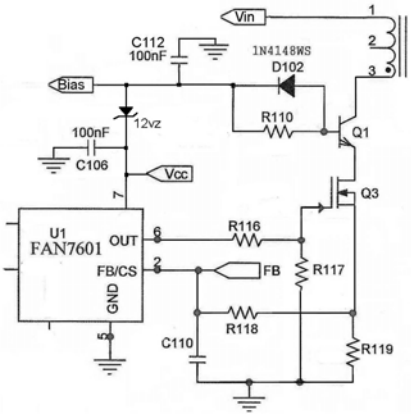



**Figure 29. $V_{bias}$ Supply Derived**

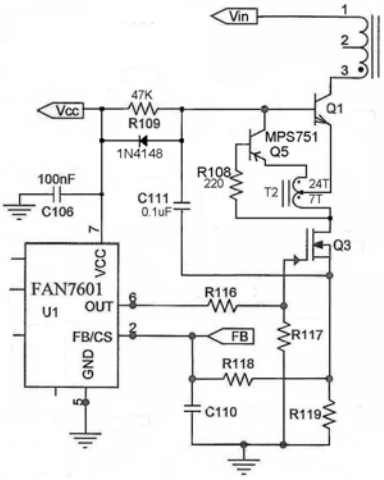
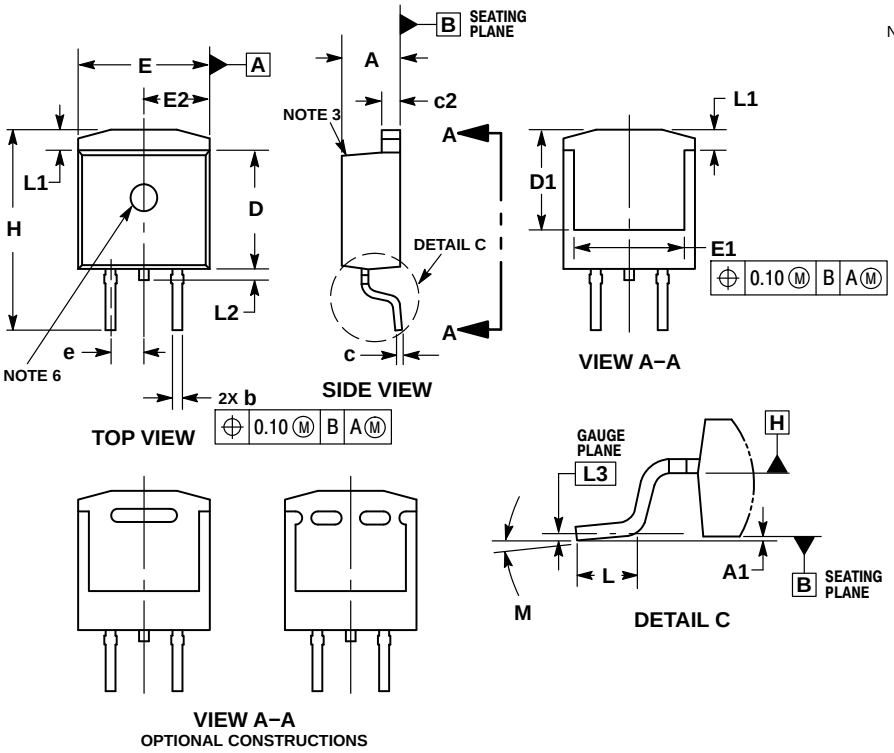



**Figure 30. Proportional Drive**

## PACKAGE DIMENSIONS

**D²PAK−3 (TO−263, 3−LEAD)**
CASE 418AJ
ISSUE B



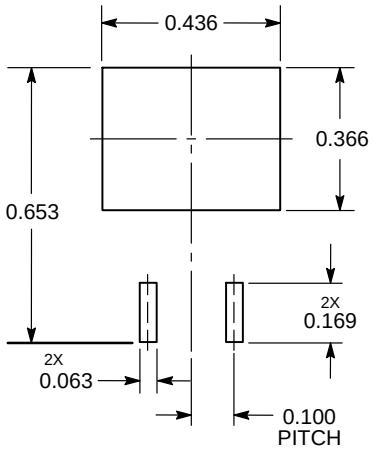



VIEW A−A
OPTIONAL CONSTRUCTIONS

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

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | 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° |

### RECOMMENDED SOLDERING FOOTPRINT*




DIMENSIONS: INCHES

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

## PUBLICATION ORDERING INFORMATION

**LITERATURE FULFILLMENT**:
Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
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**Fax**: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
**Email**: orderlit@onsemi.com

**N. American Technical Support**: 800−282−9855 Toll Free USA/Canada
**Europe, Middle East and Africa Technical Support:**
Phone: 421 33 790 2910

**ON Semiconductor Website**: **www.onsemi.com**

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