

# AFGB40T65SQDN

## IGBT for Automotive Applications, 650 V, 40 A, D<sup>2</sup>PAK

### Features

- Maximum Junction Temperature:  $T_J = 175^\circ\text{C}$
- High Speed Switching Series
- $V_{CE(sat)} = 1.6\text{ V (Typ.) @ } I_C = 40\text{ A}$
- 100% of the Part are Dynamically Tested (Note 1)
- AEC-Q101 Qualified
- These Devices are Pb-Free and are RoHS Compliant

### Typical Applications

- Automotive On Board Charger
- Automotive DC/DC Converter for HEV

### ABSOLUTE MAXIMUM RATINGS

( $T_J = 25^\circ\text{C}$  unless otherwise stated)

| Parameter   | Symbol         | Value      | Unit             |
|---|----------------|------------|------------------|
| Collector to Emitter Voltage                          | $V_{CES}$      | 650        | V                |
| Gate-to-Emitter Voltage                               | $V_{GES}$      | $\pm 20$   | V                |
| Transient Gate-to-Emitter Voltage                     | $V_{GES}$      | $\pm 30$   | V                |
| Collector Current – $T_C = 25^\circ\text{C}$          | $I_C$          | 80         | A                |
| Collector Current – $T_C = 100^\circ\text{C}$         |                | 40         | A                |
| Pulsed Collector Current (Note 2)                     | $I_{CM}$       | 160        | A                |
| Diode Forward Current – $T_C = 25^\circ\text{C}$      | $I_F$          | 40         | A                |
| Diode Forward Current – $T_C = 100^\circ\text{C}$     |                | 20         | A                |
| Pulsed Diode Maximum Forward Current (Note 2)         | $I_{FM}$       | 160        | A                |
| Maximum Power Dissipation – $T_C = 25^\circ\text{C}$  | $P_D$          | 238        | W                |
| Maximum Power Dissipation – $T_C = 100^\circ\text{C}$ |                | 119        | W                |
| Operating Junction and Storage Temperature            | $T_J, T_{stg}$ | -55 to 175 | $^\circ\text{C}$ |

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.

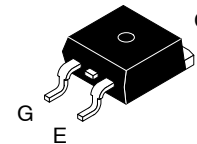
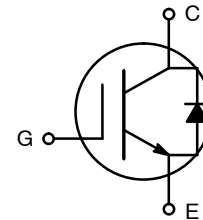
1.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 120\text{ A}$ ,  $R_G = 100\ \Omega$ , Inductive Load.
2. Repetitive rating: pulse width limited by max. Junction temperature.
3. Surface-mounted on FR4 board using 1 in<sup>2</sup> pad size, 1 oz Cu pad.
4. The entire application environment impacts the thermal resistance values shown, they are not constants and are only valid for the particular conditions noted.



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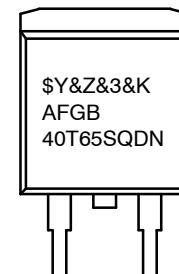
[www.onsemi.com](http://www.onsemi.com)

| $BV_{CES}$ | $V_{CE(sat)}$ TYP | $I_C$ MAX |
|------------|-------------------|-----------|
| 650 V      | 1.6 V             | 160 A     |



D<sup>2</sup>PAK-3  
CASE 418AJ

### MARKING DIAGRAM



$\$Y$  = ON Semiconductor Logo  
 $\&Z$  = Assembly Plant Code  
 $\&3$  = 3-Digit Data Code  
 $\&K$  = 2-Digit Lot Traceability Code  
 AFGB40T65SQDN = Specific Device Code

### ORDERING INFORMATION

| Device        | Package            | Shipping†                  |
|---------------|--------------------|----------------------------|
| AFGB40T65SQDN | D <sup>2</sup> PAK | 800 Units /<br>Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

# AFGB40T65SQDN

## THERMAL CHARACTERISTICS

| Parameter                                      | Symbol          | Max  | Unit |
|--|-----------------|------|------|
| Thermal Resistance Junction-to-Case, for IGBT  | $R_{\theta JC}$ | 0.63 | °C/W |
| Thermal Resistance Junction-to-Case, for Diode | $R_{\theta JC}$ | 1.55 |      |
| Thermal Resistance Junction-to-Ambient         | $R_{\theta JA}$ | 40   |      |

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

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------|--------|----------------|-----|-----|-----|------|
|-----------|--------|----------------|-----|-----|-----|------|

### OFF CHARACTERISTICS

|  |                             |   |     |     |           |               |
|--|-----------------------------|---|-----|-----|-----------|---------------|
| Collector to Emitter Breakdown Voltage       | $BV_{CES}$                  | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$              | 650 | -   | -         | V             |
| Temperature Coefficient of Breakdown Voltage | $\Delta V_{CES}/\Delta T_J$ | $I_C = 1\text{ mA}$ , Reference to $25^\circ\text{C}$ | -   | 0.6 | -         | V/°C          |
| Collector Cut-Off Current                    | $I_{CES}$                   | $V_{CE} = V_{CES}, V_{GE} = 0\text{ V}$               | -   | -   | 250       | $\mu\text{A}$ |
| G-E Leakage Current                          | $I_{GES}$                   | $V_{GE} = V_{GES}, V_{CE} = 0\text{ V}$               | -   | -   | $\pm 400$ | nA            |

### ON CHARACTERISTICS

|   |               |  |     |      |     |   |
|---|---------------|--|-----|------|-----|---|
| Gate Threshold Voltage                  | $V_{GE(th)}$  | $V_{GE} = V_{CE}, I_C = 40\text{ mA}$                              | 2.6 | 4.5  | 6.4 | V |
| Collector to Emitter Saturation Voltage | $V_{CE(sat)}$ | $I_C = 40\text{ A}, V_{GE} = 15\text{ V}, T_C = 25^\circ\text{C}$  | -   | 1.6  | 2.1 | V |
|   |               | $I_C = 40\text{ A}, V_{GE} = 15\text{ V}, T_C = 175^\circ\text{C}$ | -   | 1.92 | -   | V |

### DYNAMIC CHARACTERISTIC

|                              |           |   |   |      |   |    |
|------------------------------|-----------|---|---|------|---|----|
| Input Capacitance            | $C_{ies}$ | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$ | - | 2495 | - | pF |
| Output Capacitance           | $C_{oes}$ |   | - | 50   | - |    |
| Reverse Transfer Capacitance | $C_{res}$ |   | - | 9    | - |    |

### SWITCHING CHARACTERISTIC

|                          |              |   |   |       |   |    |
|--------------------------|--------------|---|---|-------|---|----|
| Turn-On Delay Time       | $t_{d(on)}$  | $V_{CC} = 400\text{ V}, I_C = 40\text{ A}, R_G = 6\ \Omega,$<br>$V_{GE} = 15\text{ V}$ , Inductive Load,<br>$T_C = 25^\circ\text{C}$  | - | 17.6  | - | ns |
| Rise Time                | $t_r$        |   | - | 19.2  | - | ns |
| Turn-Off Delay Time      | $t_{d(off)}$ |   | - | 75.2  | - | ns |
| Fall Time                | $t_f$        |   | - | 9.6   | - | ns |
| Turn-On Switching Loss   | $E_{on}$     |   | - | 0.858 | - | mJ |
| Turn-Off Switching Loss  | $E_{off}$    |   | - | 0.229 | - | mJ |
| Total Switching Loss     | $E_{ts}$     |   | - | 1.087 | - | mJ |
| Turn-On Delay Time       | $t_{d(on)}$  | $V_{CC} = 400\text{ V}, I_C = 40\text{ A}, R_G = 6\ \Omega,$<br>$V_{GE} = 15\text{ V}$ , Inductive Load,<br>$T_C = 175^\circ\text{C}$ | - | 16    | - | ns |
| Rise Time                | $t_r$        |   | - | 22.4  | - | ns |
| Turn-Off Delay Time      | $t_{d(off)}$ |   | - | 81.6  | - | ns |
| Fall Time                | $t_f$        |   | - | 20.8  | - | ns |
| Turn-On Switching Loss   | $E_{on}$     |   | - | 1.14  | - | mJ |
| Turn-Off Switching Loss  | $E_{off}$    |   | - | 0.484 | - | mJ |
| Total Switching Loss     | $E_{ts}$     |   | - | 1.624 | - | mJ |
| Total Gate Charge        | $Q_g$        | $V_{CE} = 400\text{ V}, I_C = 40\text{ A}, V_{GE} = 15\text{ V}$  | - | 76    | - | nC |
| Gate to Emitter Charge   | $Q_{ge}$     |   | - | 14    | - | nC |
| Gate to Collector Charge | $Q_{gc}$     |   | - | 17    | - | nC |

# AFGB40T65SQDN

## ELECTRICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$ unless otherwise stated) (continued)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------|--------|----------------|-----|-----|-----|------|
|-----------|--------|----------------|-----|-----|-----|------|

### ELECTRICAL CHARACTERISTIC OF THE DIODE ( $T_J = 25^\circ\text{C}$ unless otherwise stated)

|                               |                 |   |   |      |     |               |
|-------------------------------|-----------------|---|---|------|-----|---------------|
| Diode Forward Voltage         | V <sub>FM</sub> | $I_F = 20\text{ A}$   | - | 1.5  | 2.1 | V             |
| Reverse Recovery Energy       | $E_{rec}$       | $I_F = 20\text{ A}$<br>$dI_F/dt = 200\text{ A}/\mu\text{s}$ , $T_C = 25^\circ\text{C}$  | - | 22.3 | -   | $\mu\text{J}$ |
| Diode Reverse Recovery Time   | $t_{rr}$        |   | - | 131  | -   | ns            |
| Diode Reverse Recovery Charge | $Q_{rr}$        |   | - | 348  | -   | nC            |
| Reverse Recovery Energy       | $E_{rec}$       | $I_F = 20\text{ A}$<br>$dI_F/dt = 200\text{ A}/\mu\text{s}$ , $T_C = 175^\circ\text{C}$ | - | 100  | -   | $\mu\text{J}$ |
| Diode Reverse Recovery Time   | $t_{rr}$        |   | - | 245  | -   | ns            |
| Diode Reverse Recovery Charge | $Q_{rr}$        |   | - | 961  | -   | nC            |

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.

# AFGB40T65SQDN

## TYPICAL CHARACTERISTICS

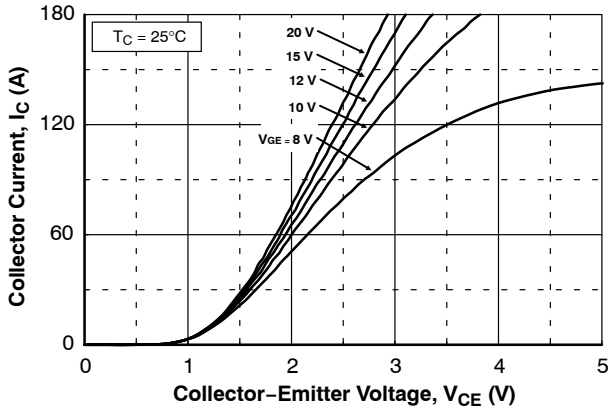


Figure 1. Typical Output Characteristics (25°C)

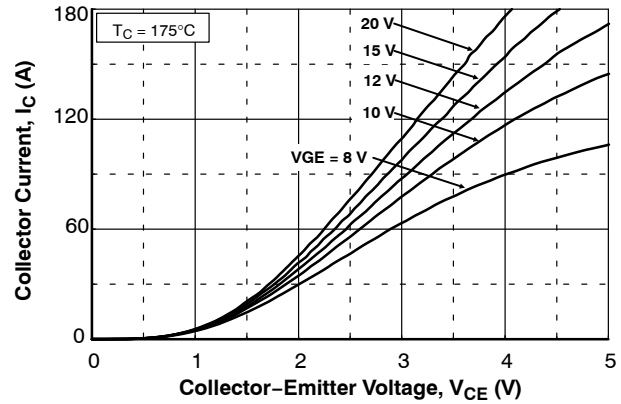


Figure 2. Typical Output Characteristics (175°C)

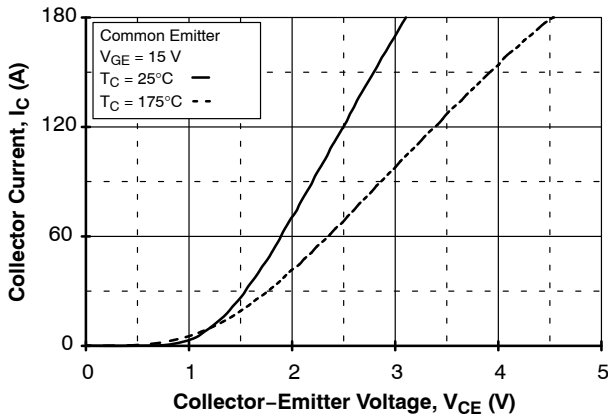


Figure 3. Typical Saturation Voltage Characteristics

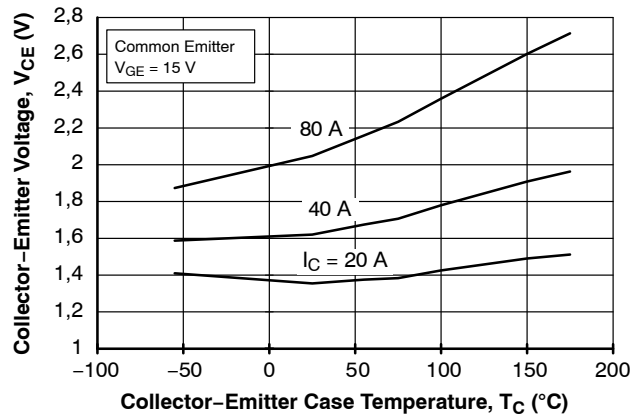


Figure 4. Saturation Voltage vs Case Temperature at Variant Current Level

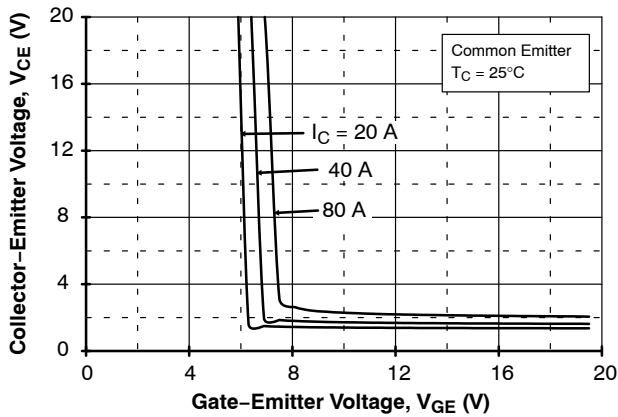


Figure 5. Saturation Voltage vs  $V_{GE}$  (25°C)

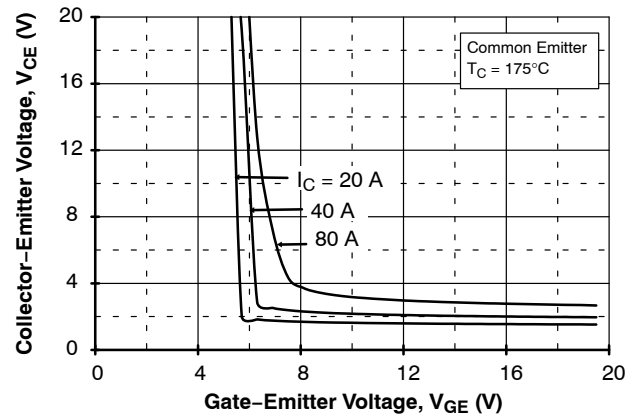


Figure 6. Saturation Voltage vs  $V_{GE}$  (175°C)

# AFGB40T65SQDN

## TYPICAL CHARACTERISTICS

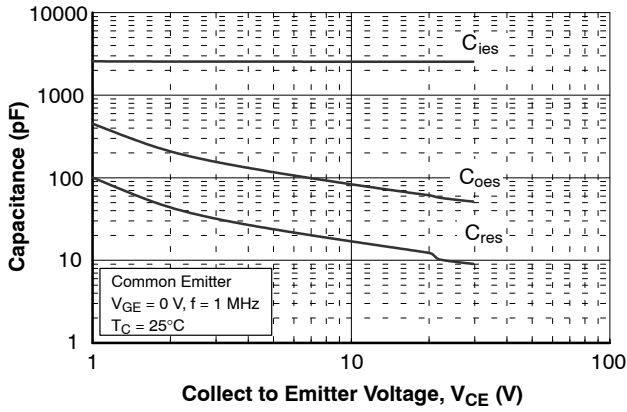


Figure 7. Capacitance Characteristics

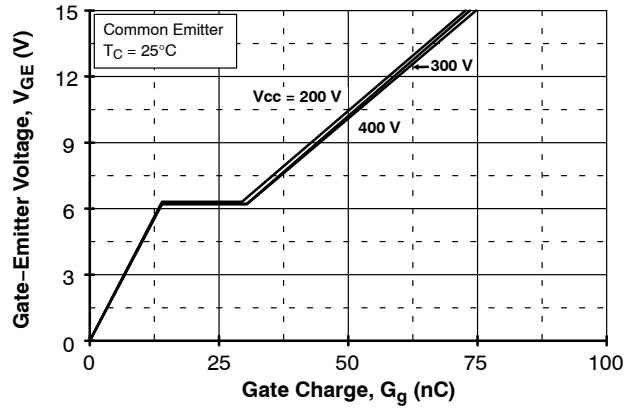


Figure 8. Gate Charge Characteristics

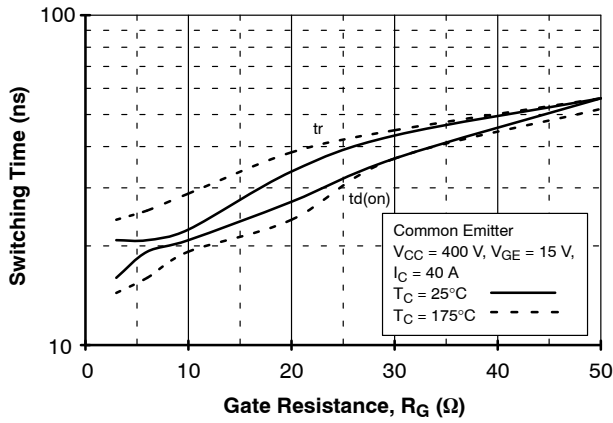


Figure 9. Turn-On Characteristics vs Gate Resistance

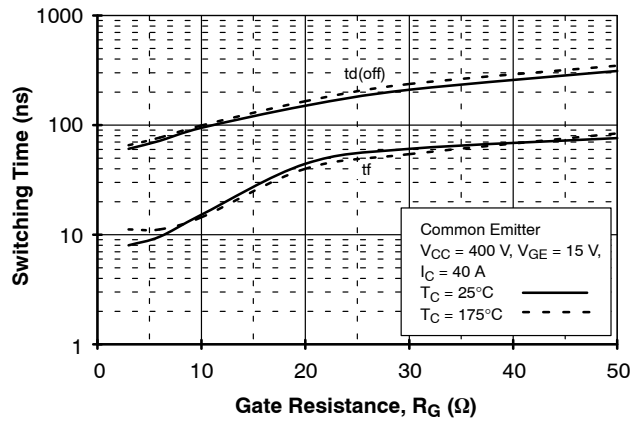


Figure 10. Turn-Off Characteristics vs Gate Resistance

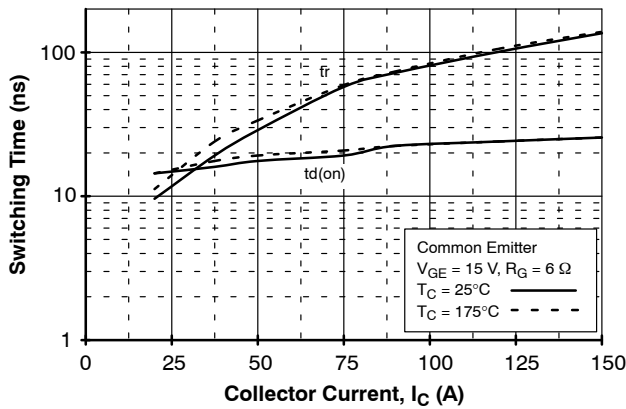


Figure 11. Turn-On Characteristics vs Collector Current

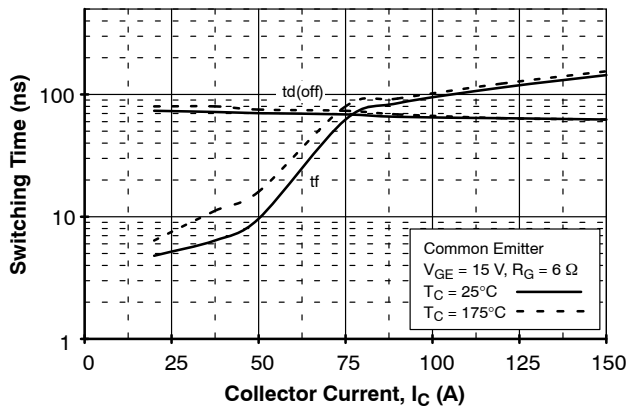


Figure 12. Turn-Off Characteristics vs Collector Current

# AFGB40T65SQDN

## TYPICAL CHARACTERISTICS

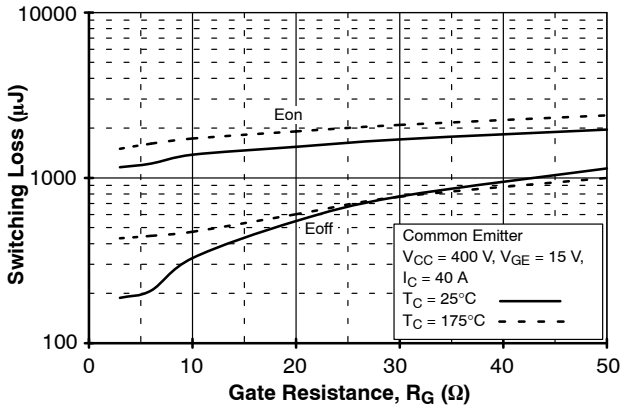


Figure 13. Switching Loss vs Gate Resistance

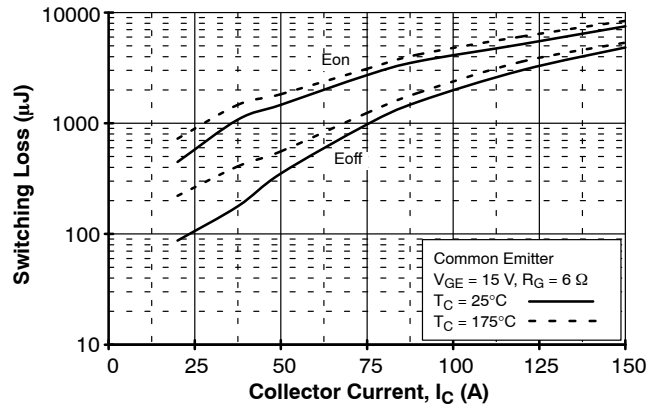


Figure 14. Switching Loss vs Collector Current

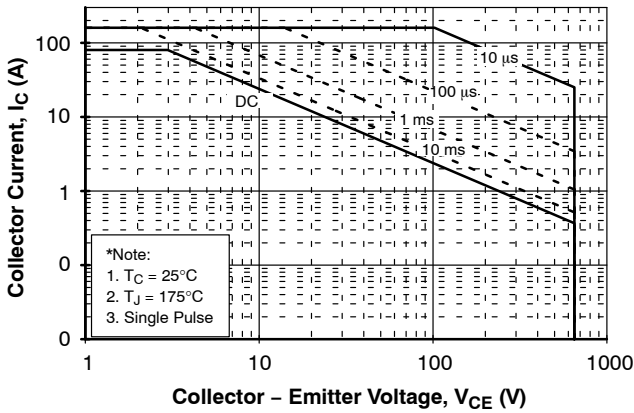


Figure 15. SOA Characteristics

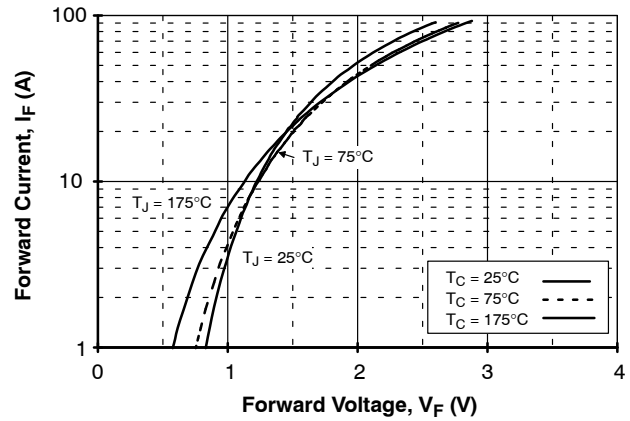


Figure 16. Forward Characteristics

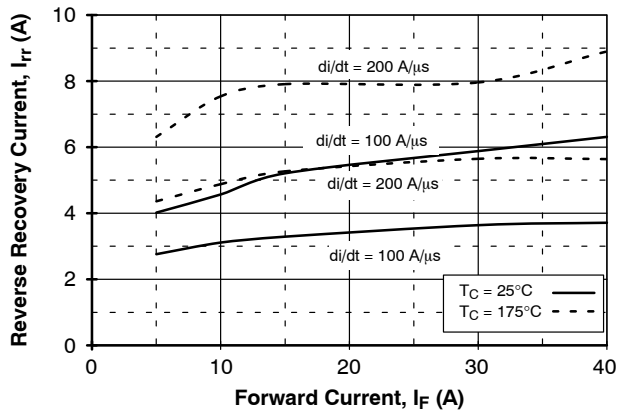


Figure 17. Reverse Recovery Current

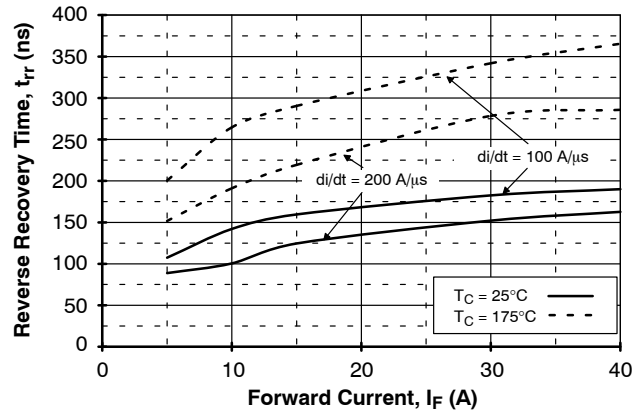


Figure 18. Reverse Recovery Time

# AFGB40T65SQDN

## TYPICAL CHARACTERISTICS

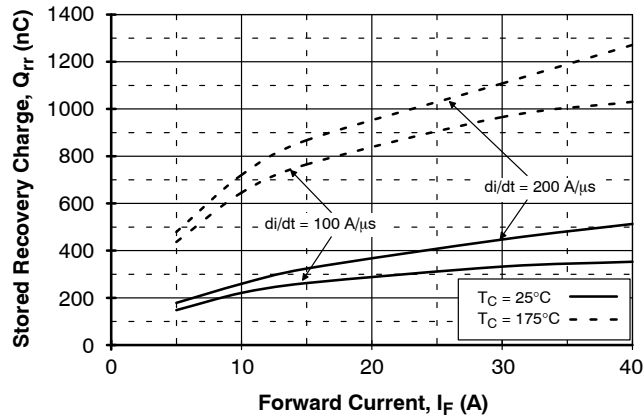


Figure 19. Stored Charge

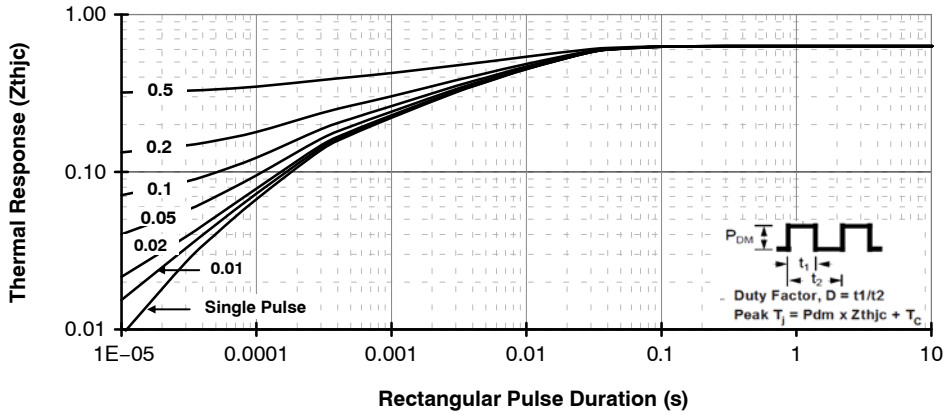


Figure 20. Transient Thermal Impedance of IGBT

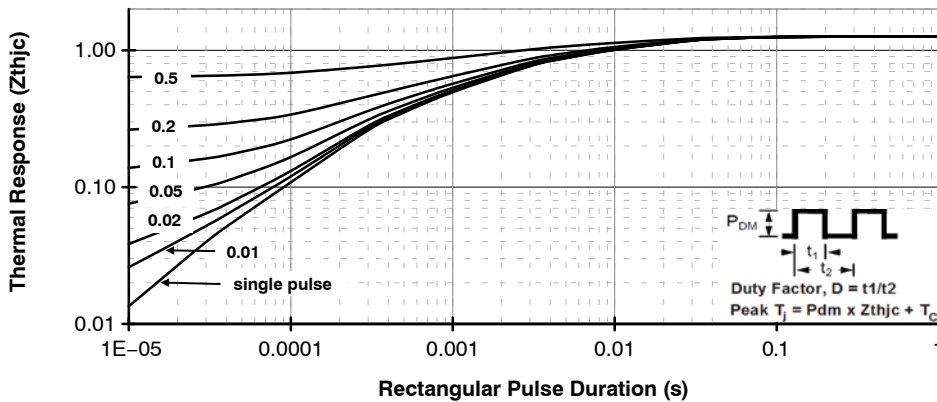
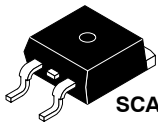


Figure 21. Transient Thermal Impedance of Diode

# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

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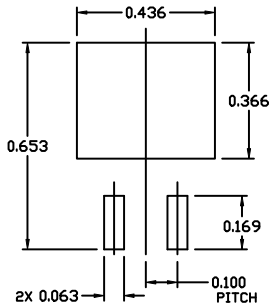
SCALE 1:1

### D<sup>2</sup>PAK-3 (TO-263, 3-LEAD)

#### CASE 418AJ

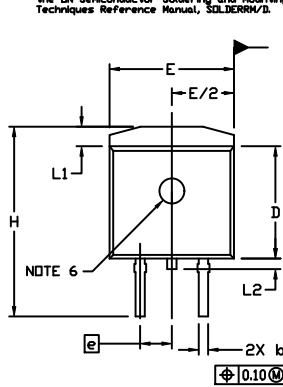
#### ISSUE F

DATE 11 MAR 2021



#### RECOMMENDED MOUNTING FOOTPRINT

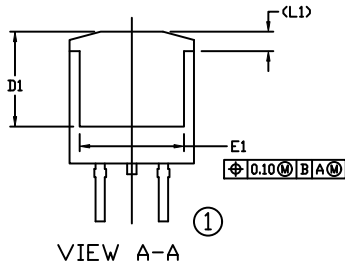
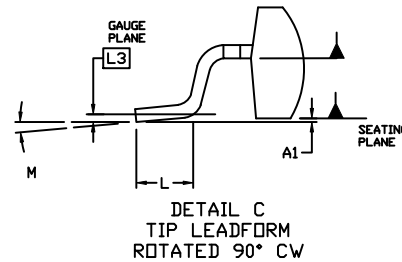
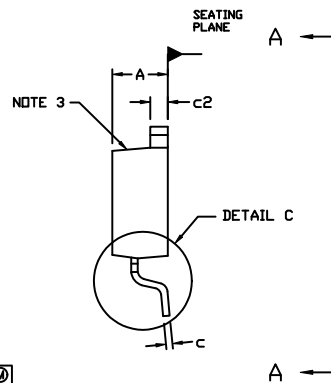
■ For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.



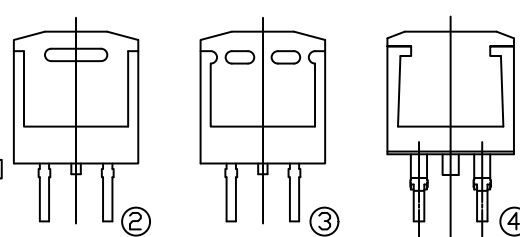
#### NOTES:

- DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
- CONTROLLING DIMENSION: INCHES
- CHAMFER OPTIONAL.
- 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.
- THERMAL PAD CONTOUR IS OPTIONAL WITHIN DIMENSIONS E, L1, D1, AND E1.
- OPTIONAL MOLD FEATURE.
- ①, ② ... OPTIONAL CONSTRUCTION FEATURE CALL OUTS.

| 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*    |

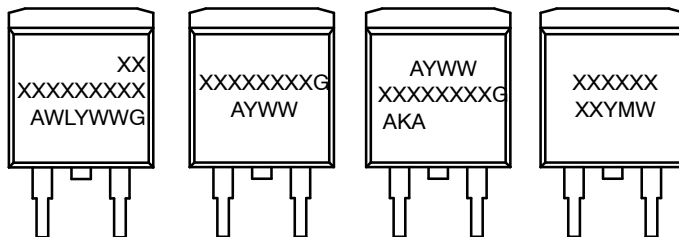


VIEW A-A



VIEW A-A  
OPTIONAL CONSTRUCTIONS

#### GENERIC MARKING DIAGRAMS\*



IC

Standard

Rectifier

SSG

- XXXXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- Y = Year
- WW = Work Week
- W = Week Code (SSG)
- M = Month Code (SSG)
- G = Pb-Free Package
- AKA = Polarity Indicator

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

|                  |                                       |  |
|------------------|---------------------------------------|--|
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| DESCRIPTION:     | D <sup>2</sup> PAK-3 (TO-263, 3-LEAD) | PAGE 1 OF 1  |

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