

# Field Stop Trench IGBT With Soft Fast Recovery Diode and $V_{CE(sat)}$ , $V_{TH}$ Binning

650 V, 160 A

## AFGY160T65SPD-B4

### Features

- AEC-Q101 Qualified and PPAP Capable
- Very Low Saturation Voltage:  $V_{CE(sat)} = 1.6$  V (Typ.) @  $I_C = 160$  A
- Maximum Junction Temperature:  $T_J = 175^\circ\text{C}$
- Positive Temperature Co-Efficient
- Tight Parameter Distribution
- High Input Impedance
- 100% of the Parts are Dynamically Tested
- Short Circuit Ruggedness  $> 6$   $\mu\text{s}$  @  $25^\circ\text{C}$
- Copacked with Soft, Fast Recovery Extremefast Diode
- This Device is Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Benefits

- Very Low Conduction and Switching Losses for a High Efficiency Operation in Various Applications
- Rugged Transient Reliability
- Outstanding Parallel Operation Performance with Balance Current Sharing
- Low EMI

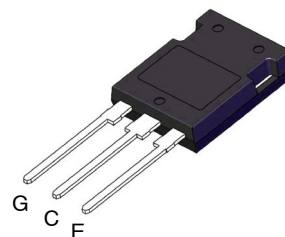
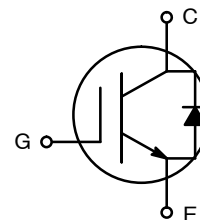
### Applications

- Traction Inverter for HEV/EV
- Auxiliary DC/AC Converter
- Motor Drives
- Other Power-Train Applications Requiring High Power Switch



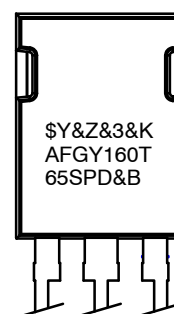
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TO-247-3LD  
CASE 340CU

### MARKING DIAGRAM



|               |                           |
|---------------|---------------------------|
| \$Y           | = ON Semiconductor Logo   |
| &Z            | = Assembly Plant Code     |
| &3            | = Date Code (Year & Week) |
| &K            | = Lot Traceability Code   |
| AFGY160T65SPD | = Specific Device Code    |
| &B            | = BIN Designator          |

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

# AFGY160T65SPD-B4

## ABSOLUTE MAXIMUM RATINGS

| Symbol               | Parameter                                                               | Ratings         | Unit             |
|----------------------|-------------------------------------------------------------------------|-----------------|------------------|
| $V_{CES}$            | Collector to Emitter Voltage                                            | 650             | V                |
| $V_{GES}$            | Gate to Emitter Voltage                                                 | $\pm 20$        | V                |
|                      | Transient Gate to Emitter Voltage                                       | $\pm 30$        | V                |
| $I_C$                | Collector Current @ $T_C = 25^\circ\text{C}$ (Note 1)                   | 240             | A                |
|                      | Collector Current @ $T_C = 100^\circ\text{C}$                           | 220             | A                |
| $I_{\text{Nominal}}$ | Nominal Current                                                         | 160             | A                |
| $I_{CM}$             | Pulsed Collector Current                                                | 480             | A                |
| $I_{FM}$             | Diode Forward Current @ $T_C = 25^\circ\text{C}$ (Note 1)               | 240             | A                |
|                      | Diode Forward Current @ $T_C = 100^\circ\text{C}$                       | 188             | A                |
| $P_D$                | Maximum Power Dissipation @ $T_C = 25^\circ\text{C}$                    | 882             | W                |
|                      | Maximum Power Dissipation @ $T_C = 100^\circ\text{C}$                   | 441             | W                |
| SCWT                 | Short Circuit Withstand Time @ $T_C = 25^\circ\text{C}$                 | 6               | $\mu\text{s}$    |
| $\Delta V/\Delta t$  | Voltage Transient Ruggedness (Note 2)                                   | 10              | V/ns             |
| $T_J$                | Operating Junction Temperature                                          | $-55$ to $+175$ | $^\circ\text{C}$ |
| $T_{\text{stg}}$     | Storage Temperature Range                                               | $-55$ to $+175$ | $^\circ\text{C}$ |
| $T_L$                | Maximum Lead Temp. for soldering Purposes, 1/8" from case for 5 seconds | 300             | $^\circ\text{C}$ |

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. Limited to bondwire.

2.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_{CE} = 480\text{ A}$ , Inductive load.

## THERMAL CHARACTERISTICS

| Symbol                  | Parameter                               | Typ. | Max. | Units              |
|-------------------------|-----------------------------------------|------|------|--------------------|
| $R_{\theta JC}$ (IGBT)  | Thermal Resistance, Junction to Case    | –    | 0.17 | $^\circ\text{C/W}$ |
| $R_{\theta JC}$ (Diode) | Thermal Resistance, Junction to Case    | –    | 0.32 | $^\circ\text{C/W}$ |
| $R_{\theta JA}$         | Thermal Resistance, Junction to Ambient | –    | 40   | $^\circ\text{C/W}$ |

## PACKAGE MARKING AND ORDERING INFORMATION

| Device Marking | Device           | Bin Designator | Packing Type | Qty per Tube/Reel* |
|----------------|------------------|----------------|--------------|--------------------|
| AFGY160T65SPDA | AFGY160T65SPD-B4 | A              | Tube         | 30                 |
| AFGY160T65SPDB | AFGY160T65SPD-B4 | B              | Tube         | 30                 |
| AFGY160T65SPDC | AFGY160T65SPD-B4 | C              | Tube         | 30                 |
| AFGY160T65SPDD | AFGY160T65SPD-B4 | D              | Tube         | 30                 |

\*Generally all tubes in one box will belong to the same bin. In rare and unusual cases there may be tubes from more than one bin inside one box. Such mixing would not be considered a quality excursion.

The primary container quantity (MPQ) for these binning products is 30 units and therefore partial box shipment can be expected.

# AFGY160T65SPD-B4

## ELECTRICAL CHARACTERISTICS OF THE IGBT ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|--------|-----------|-----------------|------|------|------|------|
|--------|-----------|-----------------|------|------|------|------|

### OFF CHARACTERISTICS

|                              |                                              |                                          |     |     |           |                           |
|------------------------------|----------------------------------------------|------------------------------------------|-----|-----|-----------|---------------------------|
| $BV_{CES}$                   | Collector to Emitter Breakdown Voltage       | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$ | 650 | –   | –         | V                         |
| $\Delta BV_{CES}/\Delta T_J$ | Temperature Coefficient of Breakdown Voltage | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$ | –   | 0.6 | –         | $\text{V}/^\circ\text{C}$ |
| $I_{CES}$                    | Collector Cut-Off Current                    | $V_{CE} = V_{CES}, V_{GE} = 0\text{ V}$  | –   | –   | 40        | $\mu\text{A}$             |
| $I_{GES}$                    | G–E Leakage Current                          | $V_{GE} = V_{GES}, V_{CE} = 0\text{ V}$  | –   | –   | $\pm 250$ | nA                        |

### ON CHARACTERISTICS

|                |                                                 |                                                                     |      |      |      |   |
|----------------|-------------------------------------------------|---------------------------------------------------------------------|------|------|------|---|
| $V_{GE(th)A}$  | G–E Threshold (Bin A)                           | $I_C = 160\text{ mA}; V_{CE} = V_{GE}$                              | 5.15 | 5.5  | 6.3  | V |
| $V_{CE(sat)A}$ | Collector to Emitter Saturation Voltage (Bin A) | $I_C = 160\text{ A}; V_{GE} = 15\text{ V}$                          | 1.5  | 1.6  | 1.67 | V |
| $V_{GE(th)B}$  | G–E Threshold (Bin B)                           | $I_C = 160\text{ mA}; V_{CE} = V_{GE}$                              | 5.15 | 5.5  | 6.3  | V |
| $V_{CE(sat)B}$ | Collector to Emitter Saturation Voltage (Bin B) | $I_C = 160\text{ A}; V_{GE} = 15\text{ V}$                          | 1.57 | 1.64 | 2.05 | V |
| $V_{GE(th)C}$  | G–E Threshold (Bin C)                           | $I_C = 160\text{ mA}; V_{CE} = V_{GE}$                              | 4.3  | 5.3  | 5.65 | V |
| $V_{CE(sat)C}$ | Collector to Emitter Saturation Voltage (Bin C) | $I_C = 160\text{ A}; V_{GE} = 15\text{ V}$                          | 1.5  | 1.6  | 1.67 | V |
| $V_{GE(th)D}$  | G–E Threshold (Bin D)                           | $I_C = 160\text{ mA}; V_{CE} = V_{GE}$                              | 4.3  | 5.3  | 5.65 | V |
| $V_{CE(sat)D}$ | Collector to Emitter Saturation Voltage (Bin D) | $I_C = 160\text{ A}; V_{GE} = 15\text{ V}$                          | 1.57 | 1.64 | 2.05 | V |
| $V_{GE(th)}$   | G–E Threshold                                   | $I_C = 160\text{ mA}; V_{CE} = V_{GE}$                              | 4.3  | 5.3  | 6.3  | V |
| $V_{CE(sat)}$  | Collector to Emitter Saturation Voltage         | $I_C = 160\text{ A}; V_{GE} = 15\text{ V}$                          | –    | 1.6  | 2.05 | V |
|                |                                                 | $I_C = 160\text{ A}; V_{GE} = 15\text{ V}; T_J = 175^\circ\text{C}$ | –    | 2.15 | –    | V |

### DYNAMIC CHARACTERISTICS

|           |                              |                                                               |   |      |   |          |
|-----------|------------------------------|---------------------------------------------------------------|---|------|---|----------|
| $C_{ies}$ | Input Capacitance            | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$ | – | 6710 | – | pF       |
| $C_{oes}$ | Output Capacitance           |                                                               | – | 450  | – | pF       |
| $C_{res}$ | Reverse Transfer Capacitance |                                                               | – | 55   | – | pF       |
| $R_G$     | Internal Gate Resistance     | $f = 1\text{ MHz}$                                            | – | 3    | – | $\Omega$ |

### SWITCHING CHARACTERISTICS

|              |                         |                                                                                                                                          |   |      |   |    |
|--------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------|---|------|---|----|
| $T_{d(on)}$  | Turn-On Delay Time      | $V_{CC} = 400\text{ V}, I_C = 160\text{ A}, R_G = 5\text{ }\Omega, V_{GE} = 15\text{ V}, \text{Inductive Load}, T_J = 25^\circ\text{C}$  | – | 53   | – | ns |
| $T_r$        | Rise Time               |                                                                                                                                          | – | 197  | – | ns |
| $T_{d(off)}$ | Turn-Off Delay Time     |                                                                                                                                          | – | 98   | – | ns |
| $T_f$        | Fall Time               |                                                                                                                                          | – | 141  | – | ns |
| $E_{on}$     | Turn-On Switching Loss  |                                                                                                                                          | – | 12.4 | – | mJ |
| $E_{off}$    | Turn-Off Switching Loss |                                                                                                                                          | – | 5.7  | – | mJ |
| $E_{ts}$     | Total Switching Loss    |                                                                                                                                          | – | 18.1 | – | mJ |
| $T_{d(on)}$  | Turn-On Delay Time      | $V_{CC} = 400\text{ V}, I_C = 160\text{ A}, R_G = 5\text{ }\Omega, V_{GE} = 15\text{ V}, \text{Inductive Load}, T_J = 175^\circ\text{C}$ | – | 52   | – | ns |
| $T_r$        | Rise Time               |                                                                                                                                          | – | 236  | – | ns |
| $T_{d(off)}$ | Turn-Off Delay Time     |                                                                                                                                          | – | 104  | – | ns |
| $T_f$        | Fall Time               |                                                                                                                                          | – | 204  | – | ns |
| $E_{on}$     | Turn-On Switching Loss  |                                                                                                                                          | – | 21   | – | mJ |
| $E_{off}$    | Turn-Off Switching Loss |                                                                                                                                          | – | 8.5  | – | mJ |
| $E_{ts}$     | Total Switching Loss    |                                                                                                                                          | – | 29.5 | – | mJ |

# AFGY160T65SPD-B4

## ELECTRICAL CHARACTERISTICS OF THE IGBT ( $T_J = 25^\circ\text{C}$ unless otherwise noted) (continued)

| Symbol                           | Parameter                | Test Conditions                                                            | Min. | Typ. | Max. | Unit |
|----------------------------------|--------------------------|----------------------------------------------------------------------------|------|------|------|------|
| <b>SWITCHING CHARACTERISTICS</b> |                          |                                                                            |      |      |      |      |
| $Q_g$                            | Total Gate Charge        | $V_{CE} = 400\text{ V}$ , $I_C = 160\text{ A}$ ,<br>$V_{GE} = 15\text{ V}$ | –    | 163  | 245  | nC   |
| $Q_{ge}$                         | Gate to Emitter Charge   |                                                                            | –    | 50   | –    | nC   |
| $Q_{gc}$                         | Gate to Collector Charge |                                                                            | –    | 49   | –    | 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.

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

| Symbol           | Parameter                     | Test Conditions                                                                     |                        | Min. | Typ. | Max. | Unit |
|------------------|-------------------------------|-------------------------------------------------------------------------------------|------------------------|------|------|------|------|
| V <sub>FM</sub>  | Diode Forward Voltage         | I <sub>F</sub> = 160 A                                                              | T <sub>J</sub> = 25°C  | –    | 1.4  | 1.7  | V    |
|                  |                               |                                                                                     | T <sub>J</sub> = 175°C | –    | 1.35 | –    |      |
| E <sub>rec</sub> | Reverse Recovery Energy       | V <sub>CE</sub> = 400 V, I <sub>F</sub> = 160 A,<br>ΔI <sub>F</sub> /Δt = 1000 A/μs | T <sub>J</sub> = 25°C  | –    | 598  | –    | μJ   |
|                  |                               |                                                                                     | T <sub>J</sub> = 175°C | –    | 4000 | –    |      |
| T <sub>rr</sub>  | Diode Reverse Recovery Time   |                                                                                     | T <sub>J</sub> = 25°C  | –    | 132  | –    | ns   |
|                  |                               |                                                                                     | T <sub>J</sub> = 175°C | –    | 245  | –    |      |
| Q <sub>rr</sub>  | Diode Reverse Recovery Charge |                                                                                     | T <sub>J</sub> = 25°C  | –    | 3.3  | –    | μC   |
|                  |                               |                                                                                     | T <sub>J</sub> = 175°C | –    | 12.5 | –    |      |

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 PERFORMANCE CHARACTERISTICS

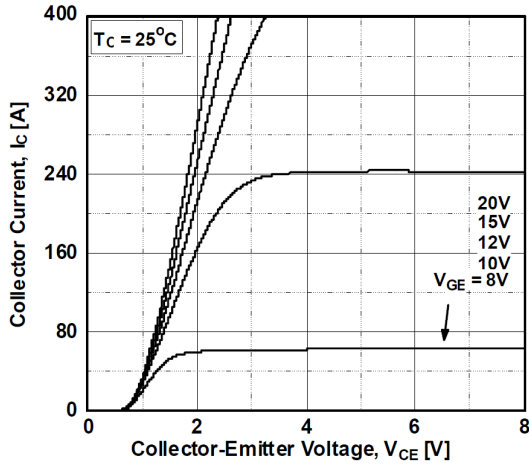


Figure 1. Typical Output Characteristics

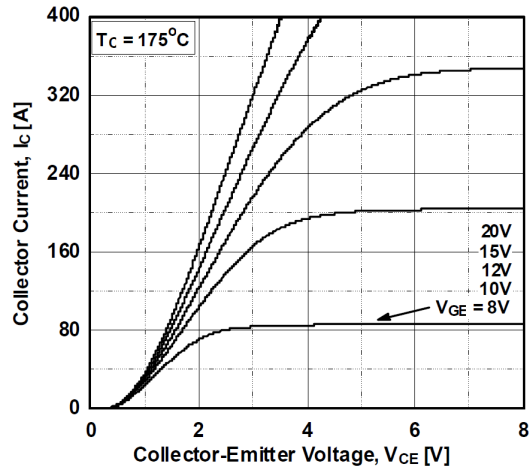


Figure 2. Typical Output Characteristics

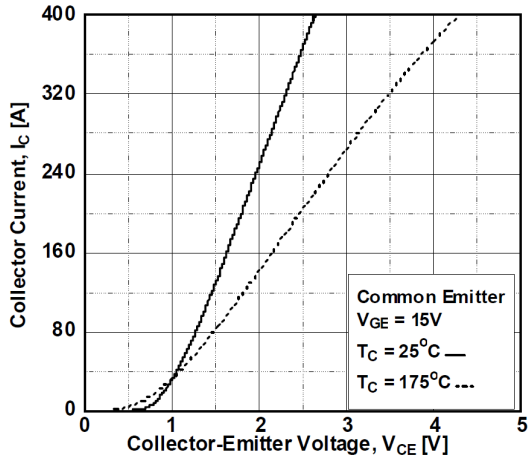


Figure 3. Typical Saturation Voltage Characteristics

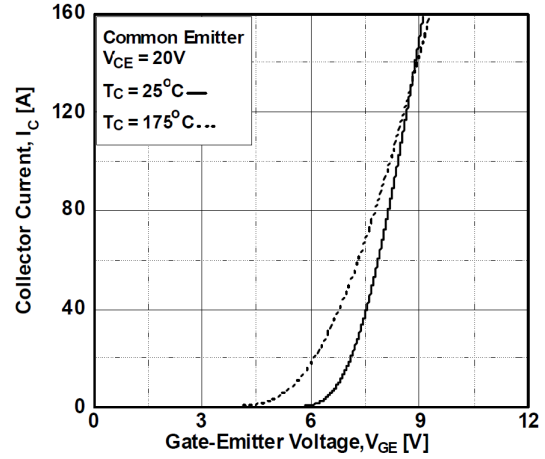


Figure 4. Transfer Characteristics

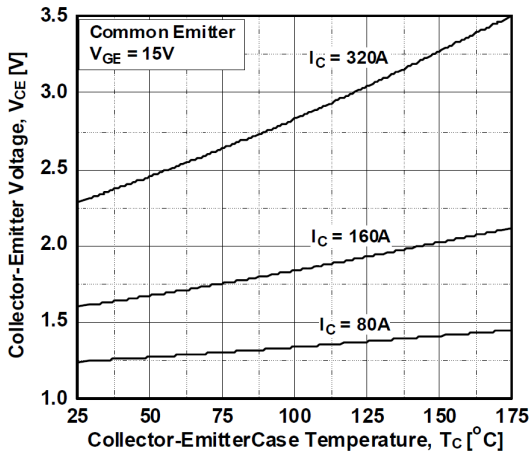


Figure 5. Saturation Voltage vs. Case Temperature at Variant Current Level

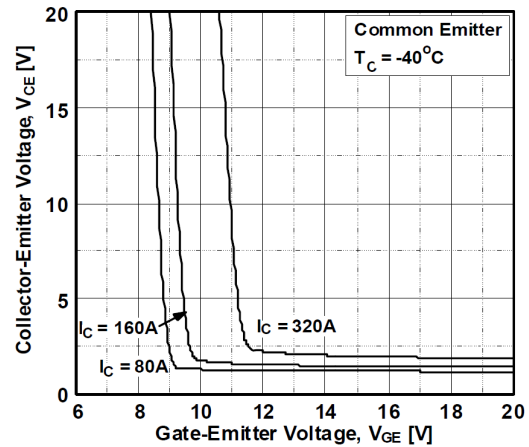


Figure 6. Saturation Voltage vs.  $V_{GE}$

TYPICAL PERFORMANCE CHARACTERISTICS

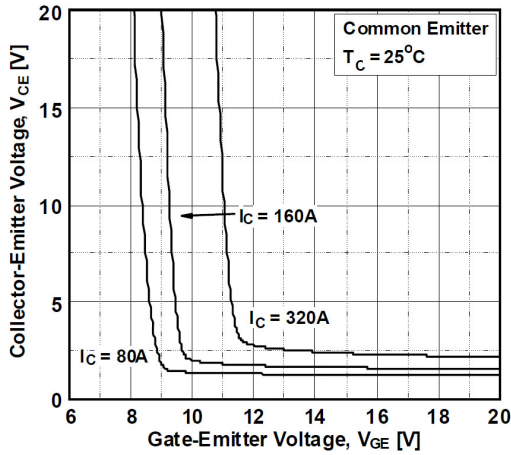


Figure 7. Saturation Voltage vs.  $V_{GE}$

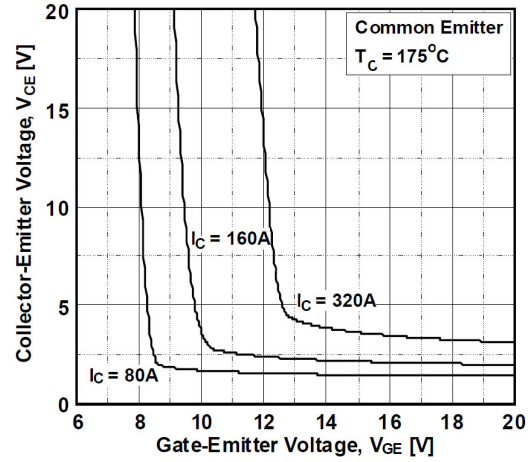


Figure 8. Saturation Voltage vs.  $V_{GE}$

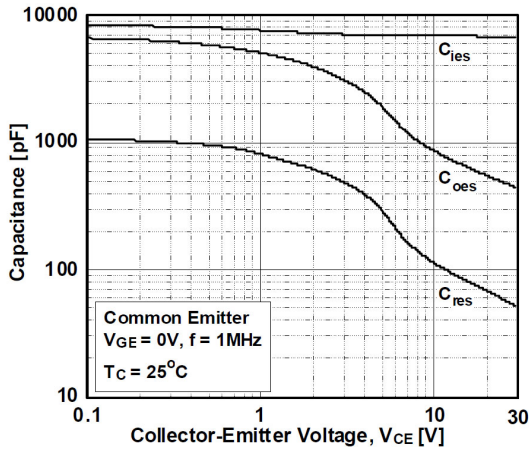


Figure 9. Capacitance Characteristics

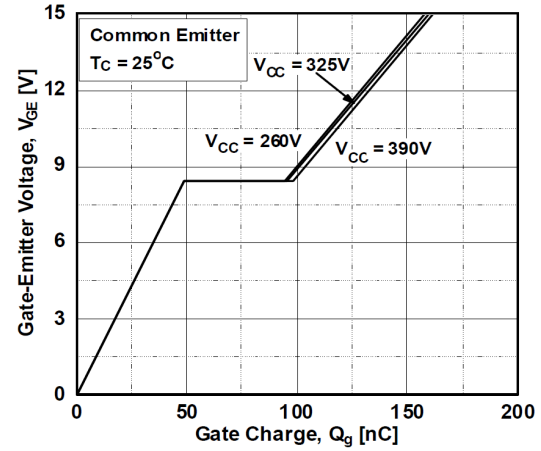


Figure 10. Gate Charge Characteristics

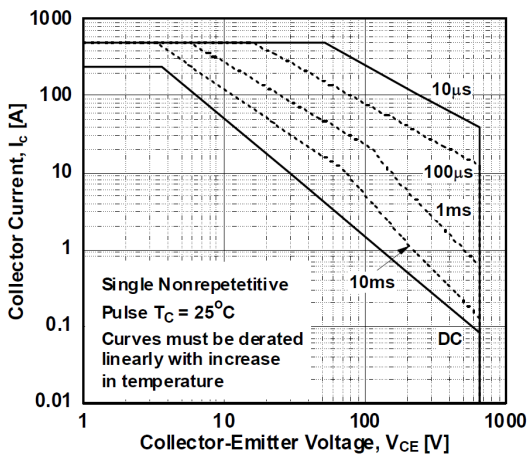


Figure 11. SOA Characteristics

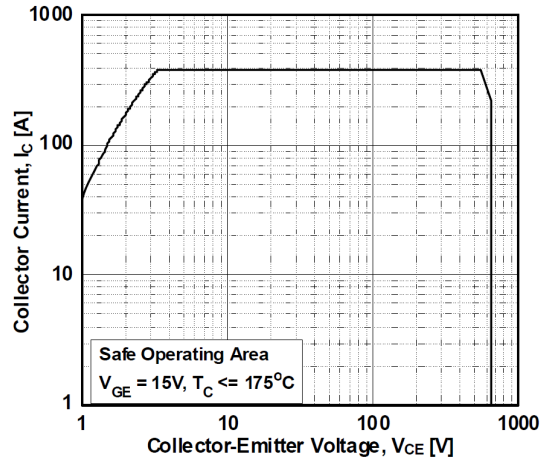


Figure 12. Turn Off Switching SOA Characteristics

TYPICAL PERFORMANCE CHARACTERISTICS

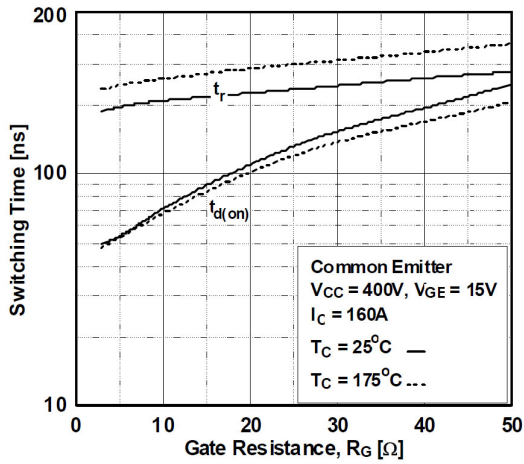


Figure 13. Turn-on Characteristics vs. Gate Resistance

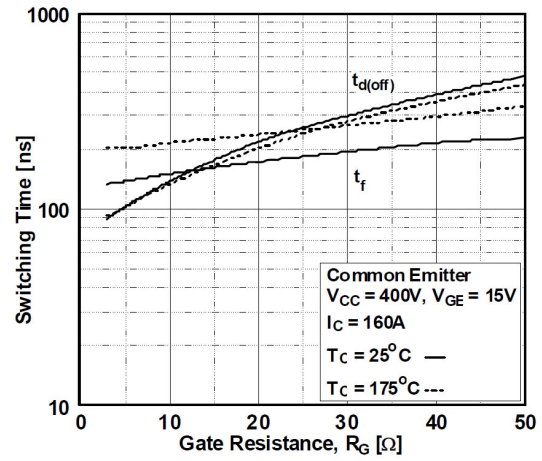


Figure 14. Turn-off Characteristics vs. Gate Resistance

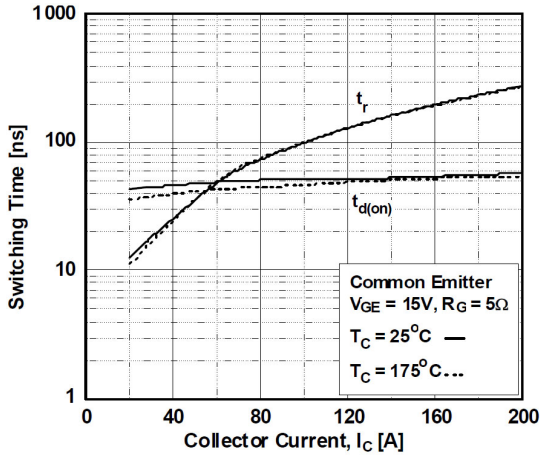


Figure 15. Turn-on Characteristics vs. Collector Current

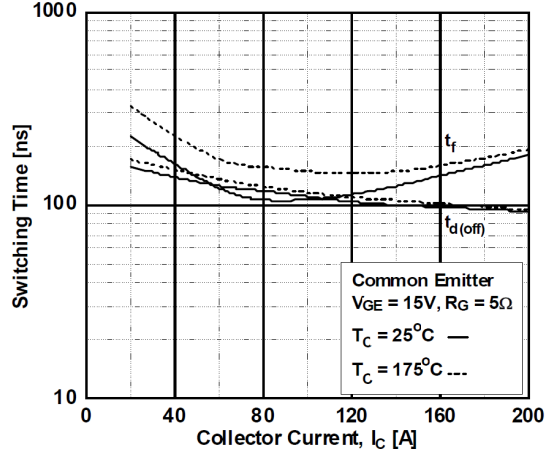


Figure 16. Turn-off Characteristics vs. Collector Current

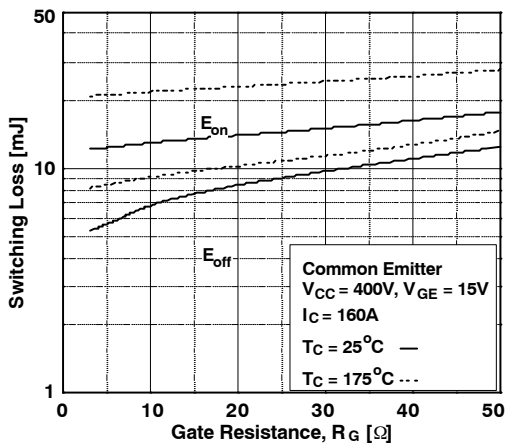


Figure 17. Switching Loss vs. Gate Resistance

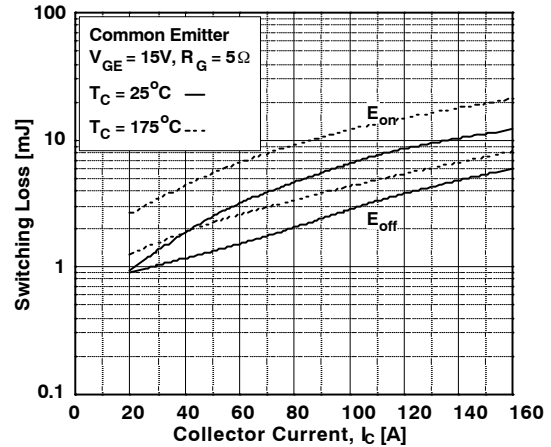


Figure 18. Switching Loss vs. Collector Current

TYPICAL PERFORMANCE CHARACTERISTICS

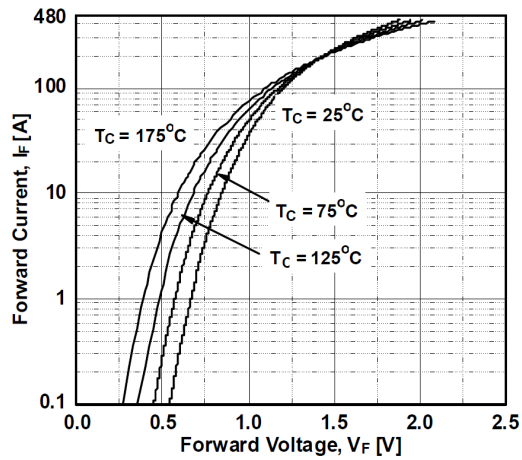


Figure 19. Forward Characteristics

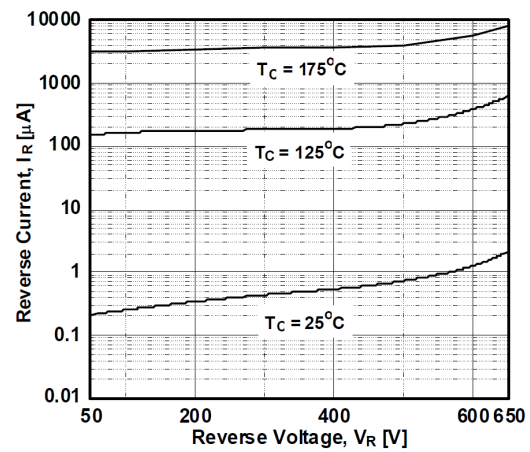


Figure 20. Reverse Current

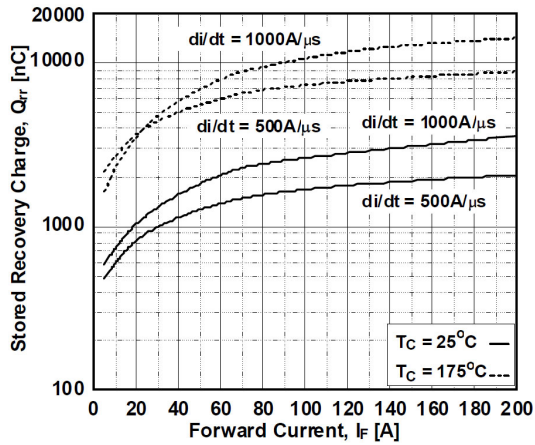


Figure 21. Stored Charge

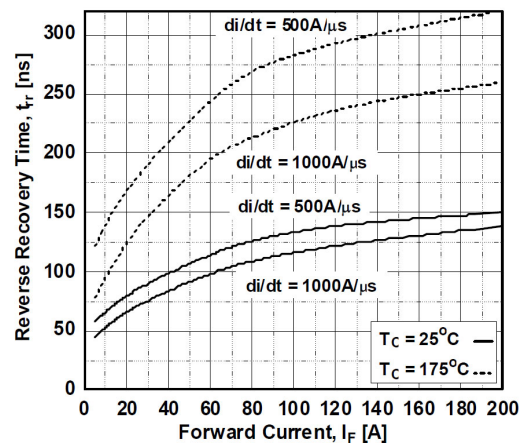


Figure 22. Reverse Recovery Time

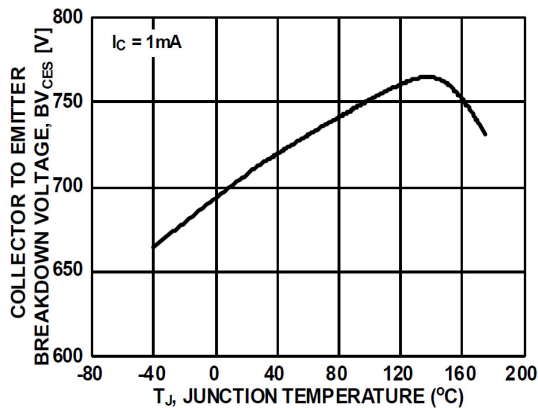


Figure 23. Collector to Emitter Breakdown Voltage vs. Junction Temperature



TYPICAL PERFORMANCE CHARACTERISTICS

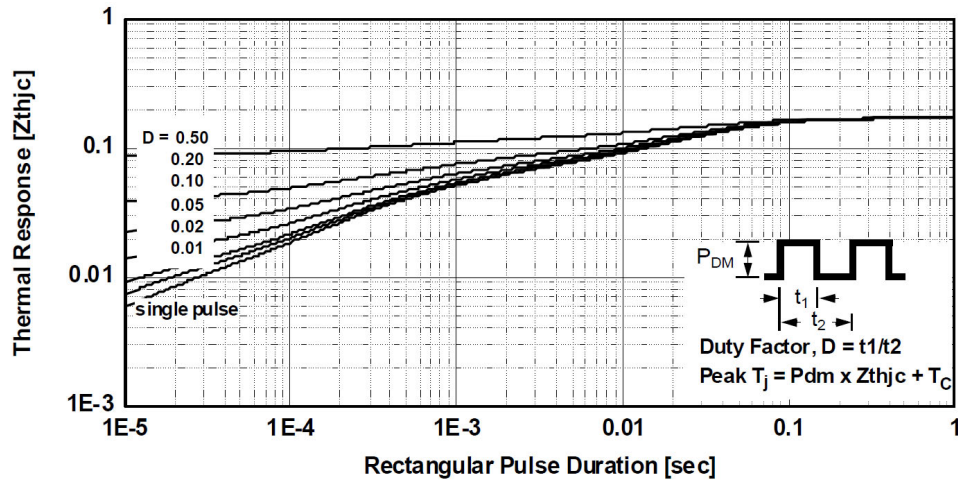


Figure 24. Transient Thermal Impedance of IGBT

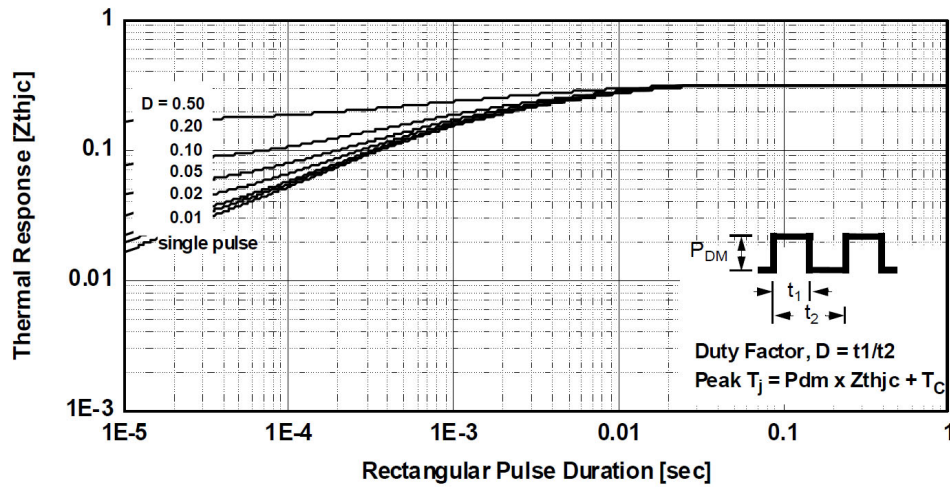


Figure 25. Transient Thermal Impedance of Diode

# MECHANICAL CASE OUTLINE

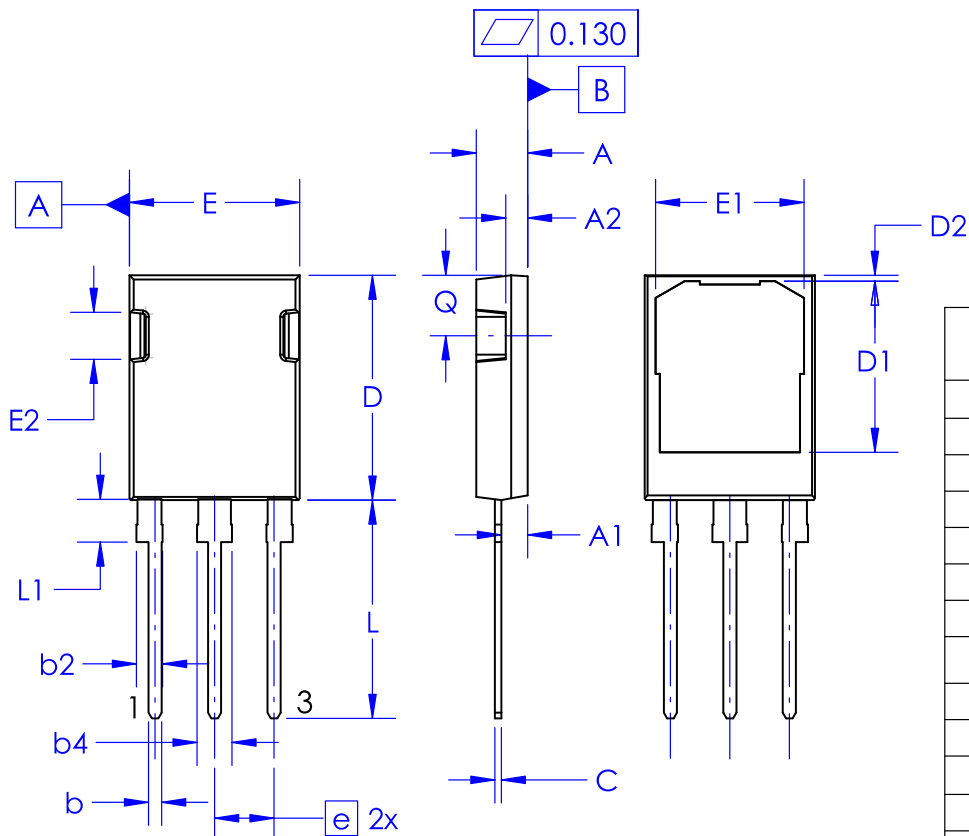
## PACKAGE DIMENSIONS

ON Semiconductor®



TO-247-3LD  
CASE 340CU  
ISSUE A

DATE 16 SEP 2019



| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN         | NOM   | MAX   |
| A   | 4.50        | 4.70  | 4.90  |
| A1  | 2.10        | 2.40  | 2.70  |
| A2  | 1.70        | 2.00  | 2.30  |
| b   | 1.00        | 1.20  | 1.400 |
| b2  | 2.20        | 2.40  | 2.60  |
| b4  | 3.00        | 3.20  | 3.40  |
| c   | 0.40        | 0.60  | 0.80  |
| D   | 20.40       | 20.60 | 20.80 |
| D1  | 15.47       | 15.67 | 15.87 |
| D2  | 0.25        | 0.55  | 0.85  |
| e   | 5.45 BSC    |       |       |
| E   | 15.40       | 15.60 | 15.80 |
| E1  | 13.40       | 13.60 | 13.80 |
| E2  | 4.12        | 4.30  | 4.52  |
| L   | 19.70       | 20.00 | 20.30 |
| L1  | 3.65        | 3.85  | 4.05  |
| Q   | 5.35        | 5.55  | 5.75  |

### NOTES:

- A. NO INDUSTRY STANDARDS APPLIES TO THIS PACKAGE.
- B. ALL DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR PROTRUSIONS.
- D. DRAWING CONFORMS TO ASME Y14.5-2009.

|                  |             |                                                                                                                                                                                     |
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