

# Hybrid IGBT, 50 A, 650 V

## AFGHL50T65SQDC

Using the novel field stop 4<sup>th</sup> generation IGBT technology and the 1.5<sup>th</sup> generation SiC Schottky Diode technology, AFGHL50T65SQDC offers the optimum performance with both low conduction and switching losses for high efficiency operations in various applications, especially totem pole bridgeless PFC and Inverter.

### Features

- AEC-Q101 Qualified
- Maximum Junction Temperature :  $T_J = 175^{\circ}\text{C}$
- Positive Temperature Co-efficient for Easy Parallel Operating
- High Current Capability
- Low Saturation Voltage:  $V_{CE(Sat)} = 1.6\text{ V (Typ.) @ } I_C = 50\text{ A}$
- Fast Switching
- Tighten Parameter Distribution
- No Reverse Recovery/No Forward Recovery

### Typical Applications

- Automotive
- On & Off Board Chargers
- DC-DC Converters
- PFC
- Industrial Inverter

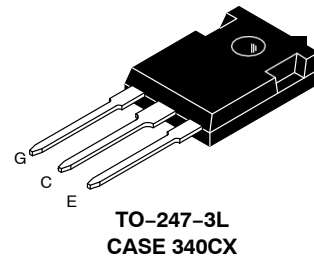
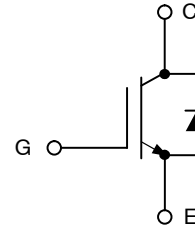
### MAXIMUM RATINGS

| Rating   | Symbol         | Value                 | Unit               |
|--|----------------|-----------------------|--------------------|
| Collector to Emitter Voltage   | $V_{CES}$      | 650                   | V                  |
| Gate to Emitter Voltage<br>Transient Gate to Emitter Voltage                               | $V_{GES}$      | $\pm 20$<br>$\pm 30$  | V                  |
| Collector Current<br>@ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$         | $I_C$          | 100<br>50             | A                  |
| Pulsed Collector Current (Note 1)  | $I_{LM}$       | 200                   | A                  |
| Pulsed Collector Current (Note 2)  | $I_{CM}$       | 200                   | A                  |
| Diode Forward Current<br>@ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$     | $I_F$          | 40<br>20              | A                  |
| Pulsed Diode Maximum Forward Current   | $I_{FM}$       | 200                   | A                  |
| Maximum Power Dissipation<br>@ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$ | $P_D$          | 238<br>119            | W                  |
| Operating Junction<br>/ Storage Temperature Range  | $T_J, T_{STG}$ | $\pm 55$ to<br>$+175$ | $^{\circ}\text{C}$ |
| Maximum Lead Temp. for Soldering<br>Purposes, 1/8" from case for 5 seconds                 | $T_L$          | 300                   | $^{\circ}\text{C}$ |

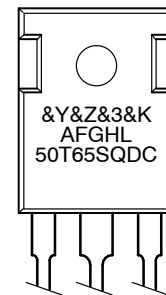
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 200\text{ A}$ ,  $R_G = 26\ \Omega$ , Inductive Load, 100% Tested.
2. Repetitive Rating: pulse width limited by max. Junction temperature.

50 A, 650 V  
 $V_{CESat} = 1.6\text{ V (Typ.)}$



### MARKING DIAGRAM



&Y = onsemi Logo  
&Z = Assembly Plant Code  
&3 = 3-Digit Data Code  
&K = 2-Digit Lot Traceability Code  
AFGHL50T65SQDC = Specific Device Code

### ORDERING INFORMATION

| Device         | Package   | Shipping        |
|----------------|-----------|-----------------|
| AFGHL50T65SQDC | TO-247-3L | 30 Units / Rail |

# AFGHL50T65SQDC

## THERMAL CHARACTERISTICS

| Rating   | Symbol          | Value | Unit                 |
|--|-----------------|-------|----------------------|
| Thermal resistance junction-to-case, for IGBT  | $R_{\theta JC}$ | 0.63  | $^{\circ}\text{C/W}$ |
| Thermal resistance junction-to-case, for Diode | $R_{\theta JC}$ | 1.55  | $^{\circ}\text{C/W}$ |
| Thermal resistance junction-to-ambient         | $R_{\theta JA}$ | 40    | $^{\circ}\text{C/W}$ |

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

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

### OFF CHARACTERISTICS

|   |  |                                      |     |     |           |                             |
|---|--|--------------------------------------|-----|-----|-----------|-----------------------------|
| Collector-emitter breakdown voltage, gate-emitter short-circuited | $V_{GE} = 0\text{ V}$ ,<br>$I_C = 1\text{ mA}$     | $BV_{CES}$                           | 650 | –   | –         | V                           |
| Temperature Coefficient of Breakdown Voltage                      | $V_{GE} = 0\text{ V}$ ,<br>$I_C = 1\text{ mA}$     | $\frac{\Delta BV_{CES}}{\Delta T_J}$ | –   | 0.6 | –         | $\text{V}/^{\circ}\text{C}$ |
| Collector-emitter cut-off current, gate-emitter short-circuited   | $V_{GE} = 0\text{ V}$ ,<br>$V_{CE} = 650\text{ V}$ | $I_{CES}$                            | –   | –   | 250       | $\mu\text{A}$               |
| Gate leakage current, collector-emitter short-circuited           | $V_{GE} = 20\text{ V}$ ,<br>$V_{CE} = 0\text{ V}$  | $I_{GES}$                            | –   | –   | $\pm 400$ | nA                          |

### ON CHARACTERISTICS

|                                      |   |               |        |            |          |   |
|--------------------------------------|---|---------------|--------|------------|----------|---|
| Gate-emitter threshold voltage       | $V_{GE} = V_{CE}$ , $I_C = 50\text{ mA}$  | $V_{GE(th)}$  | 3.4    | 4.9        | 6.4      | V |
| Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$<br>$V_{GE} = 15\text{ V}$ , $I_C = 50\text{ A}$ ,<br>$T_J = 175^{\circ}\text{C}$ | $V_{CE(sat)}$ | –<br>– | 1.6<br>1.9 | 2.1<br>– | V |

### DYNAMIC CHARACTERISTICS

|                              |  |           |   |      |   |    |
|------------------------------|--|-----------|---|------|---|----|
| Input capacitance            | $V_{CE} = 30\text{ V}$ ,<br>$V_{GE} = 0\text{ V}$ ,<br>$f = 1\text{ MHz}$    | $C_{ies}$ | – | 3098 | – | pF |
| Output capacitance           |  | $C_{oes}$ | – | 265  | – |    |
| Reverse transfer capacitance |  | $C_{res}$ | – | 9    | – |    |
| Gate charge total            | $V_{CE} = 400\text{ V}$ ,<br>$I_C = 50\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ | $Q_g$     | – | 94   | – | nC |
| Gate to emitter charge       |  | $Q_{ge}$  | – | 18   | – |    |
| Gate to collector charge     |  | $Q_{gc}$  | – | 23   | – |    |

### SWITCHING CHARACTERISTICS

|                         |   |              |   |      |   |               |
|-------------------------|---|--------------|---|------|---|---------------|
| Turn-on delay time      | $T_J = 25^{\circ}\text{C}$<br>$V_{CC} = 400\text{ V}$ ,<br>$I_C = 12.5\text{ A}$<br>$R_G = 4.7\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load | $t_{d(on)}$  | – | 17.6 | – | ns            |
| Rise time               |   | $t_r$        | – | 6.4  | – |               |
| Turn-off delay time     |   | $t_{d(off)}$ | – | 94.4 | – |               |
| Fall time               |   | $t_f$        | – | 14.4 | – |               |
| Turn-on switching loss  |   | $E_{on}$     | – | 131  | – | $\mu\text{J}$ |
| Turn-off switching loss |   | $E_{off}$    | – | 96   | – |               |
| Total switching loss    |   | $E_{ts}$     | – | 227  | – |               |
| Turn-on delay time      | $T_J = 25^{\circ}\text{C}$<br>$V_{CC} = 400\text{ V}$ ,<br>$I_C = 25\text{ A}$<br>$R_G = 4.7\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load   | $t_{d(on)}$  | – | 19.2 | – | ns            |
| Rise time               |   | $t_r$        | – | 11.2 | – |               |
| Turn-off delay time     |   | $t_{d(off)}$ | – | 89.6 | – |               |
| Fall time               |   | $t_f$        | – | 6.4  | – |               |
| Turn-on switching loss  |   | $E_{on}$     | – | 311  | – | $\mu\text{J}$ |
| Turn-off switching loss |   | $E_{off}$    | – | 141  | – |               |
| Total switching loss    |   | $E_{ts}$     | – | 452  | – |               |



# AFGHL50T65SQDC

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

| Parameter                 | Test Conditions  | Symbol              | Min. | Typ.         | Max.      | Unit          |
|---------------------------|--|---------------------|------|--------------|-----------|---------------|
| SWITCHING CHARACTERISTICS |  |                     |      |              |           |               |
| Turn-on delay time        | $T_J = 175^{\circ}\text{C}$<br>$V_{CC} = 400\text{ V}$<br>$I_C = 12.5\text{ A}$<br>$R_G = 4.7\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load | $t_{d(\text{on})}$  | –    | 16           | –         | ns            |
| Rise time                 |  | $t_r$               | –    | 8            | –         |               |
| Turn-off delay time       |  | $t_{d(\text{off})}$ | –    | 107.2        | –         |               |
| Fall time                 |  | $t_f$               | –    | 53.6         | –         |               |
| Turn-on switching loss    |  | $E_{\text{on}}$     | –    | 157          | –         | $\mu\text{J}$ |
| Turn-off switching loss   |  | $E_{\text{off}}$    | –    | 193          | –         |               |
| Total switching loss      |  | $E_{\text{ts}}$     | –    | 350          | –         |               |
| Turn-on delay time        | $T_J = 175^{\circ}\text{C}$<br>$V_{CC} = 400\text{ V}$<br>$I_C = 25\text{ A}$<br>$R_G = 4.7\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load   | $t_{d(\text{on})}$  | –    | 17.6         | –         | ns            |
| Rise time                 |  | $t_r$               | –    | 14.4         | –         |               |
| Turn-off delay time       |  | $t_{d(\text{off})}$ | –    | 99.2         | –         |               |
| Fall time                 |  | $t_f$               | –    | 9.6          | –         |               |
| Turn-on switching loss    |  | $E_{\text{on}}$     | –    | 350          | –         | $\mu\text{J}$ |
| Turn-off switching loss   |  | $E_{\text{off}}$    | –    | 328          | –         |               |
| Total switching loss      |  | $E_{\text{ts}}$     | –    | 678          | –         |               |
| DIODE CHARACTERISTICS     |  |                     |      |              |           |               |
| Forward voltage           | $I_F = 20\text{ A}$<br>$I_F = 20\text{ A}, T_J = 175^{\circ}\text{C}$  | $V_F$               | –    | 1.45<br>1.83 | 1.75<br>– | V             |
| Total Capacitance         | $V_R = 400\text{ V}, f = 1\text{ MHz}$   | C                   | –    | 103          | –         | pF            |
|                           | $V_R = 600\text{ V}, f = 1\text{ MHz}$   |                     | –    | 99           | –         |               |

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 CHARACTERISTICS

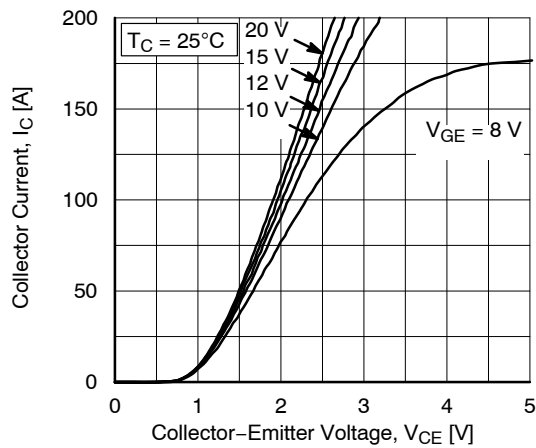


Figure 1. Typical Output Characteristics  
( $T_C = 25^\circ\text{C}$ )

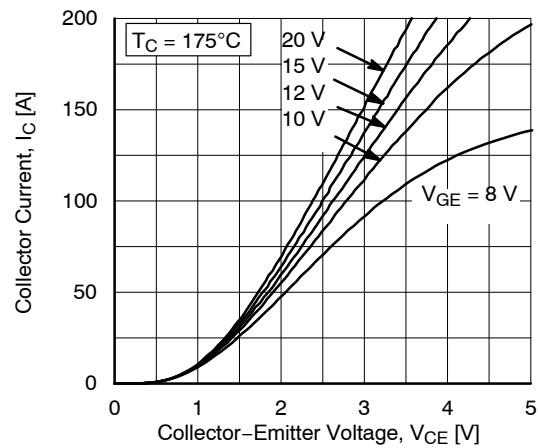


Figure 2. Typical Output Characteristics  
( $T_C = 175^\circ\text{C}$ )

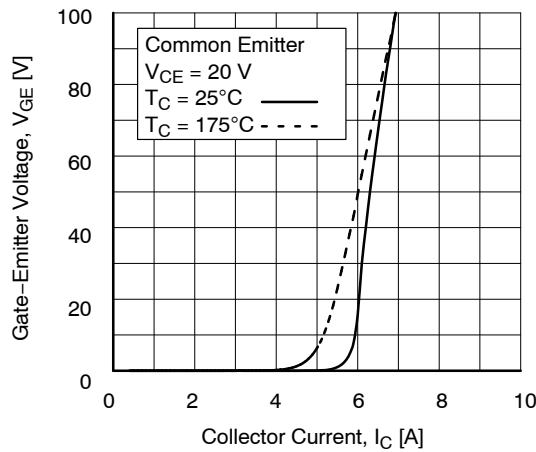


Figure 3. Transfer Characteristics

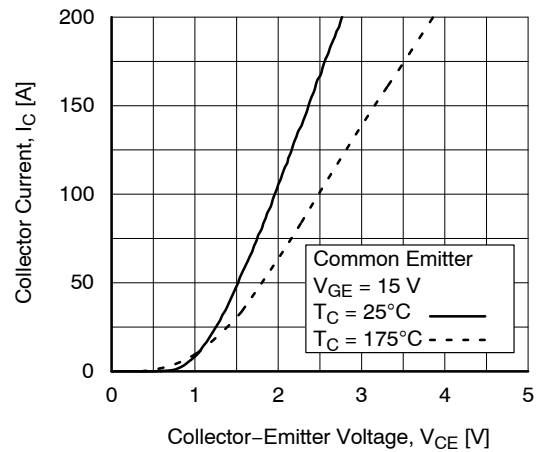


Figure 4. Typical Saturation Voltage  
Characteristics

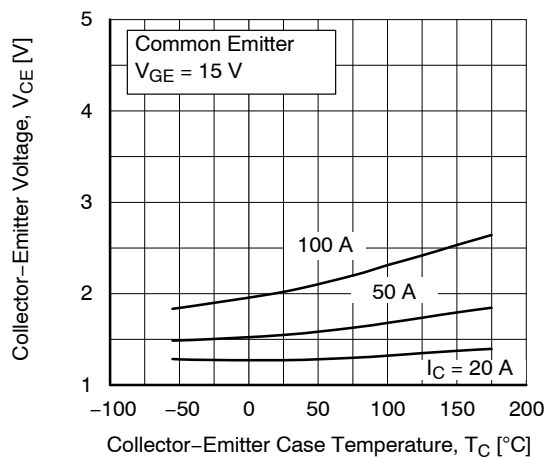


Figure 5. Saturation Voltage vs. Case Temperature  
at Variant Current Level

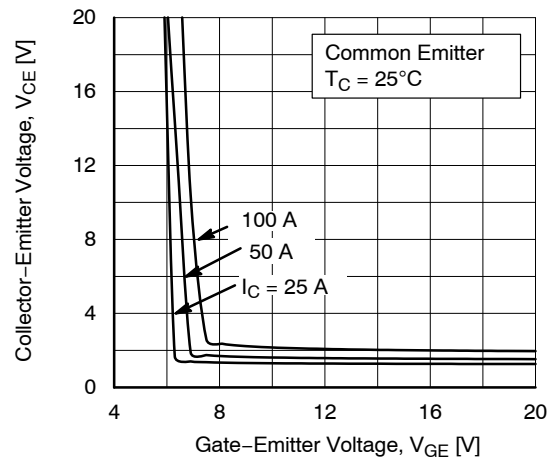


Figure 6. Saturation Voltage vs.  $V_{GE}$  ( $T_C = 25^\circ\text{C}$ )

TYPICAL CHARACTERISTICS (continued)

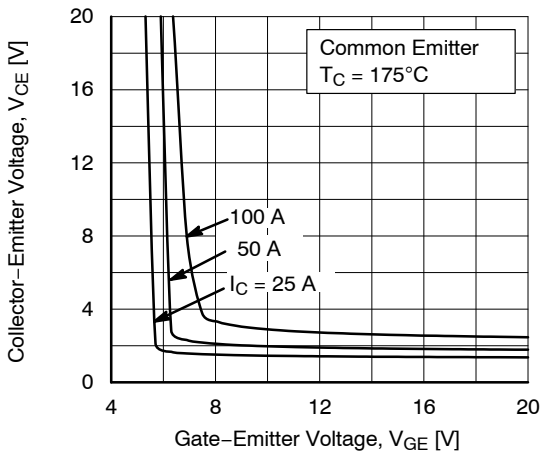


Figure 7. Saturation Voltage vs.  $V_{GE}$  ( $T_C = 175^\circ\text{C}$ )

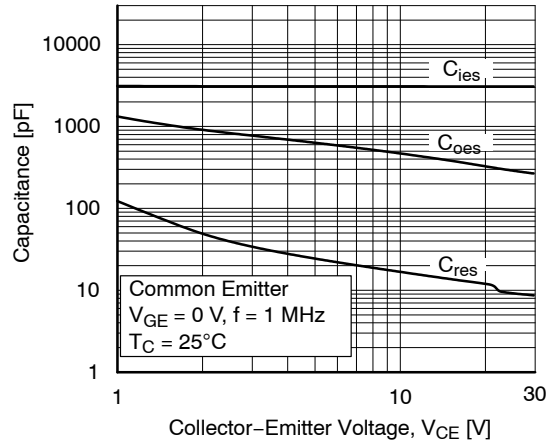


Figure 8. Capacitance Characteristics

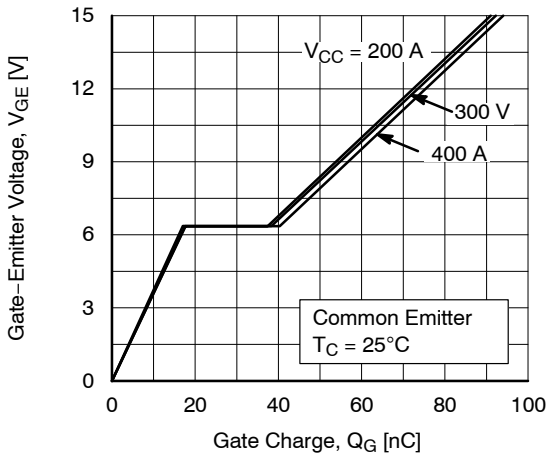


Figure 9. Gate Charge Characteristics ( $T_C = 25^\circ\text{C}$ )

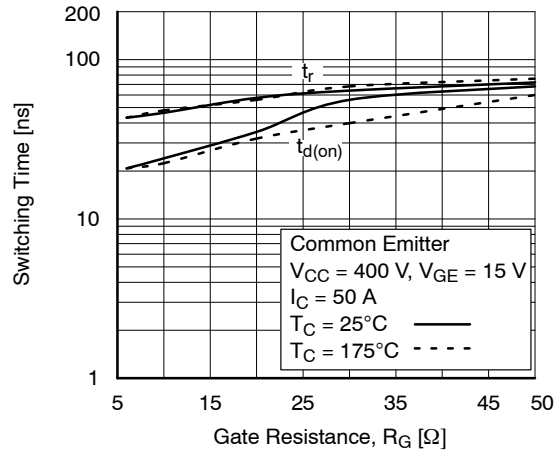


Figure 10. Turn-on Characteristics vs. Gate Resistance

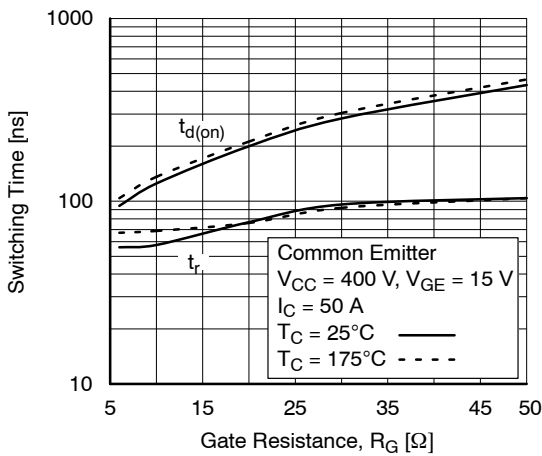


Figure 11. Turn-Off Characteristics vs. Resistance

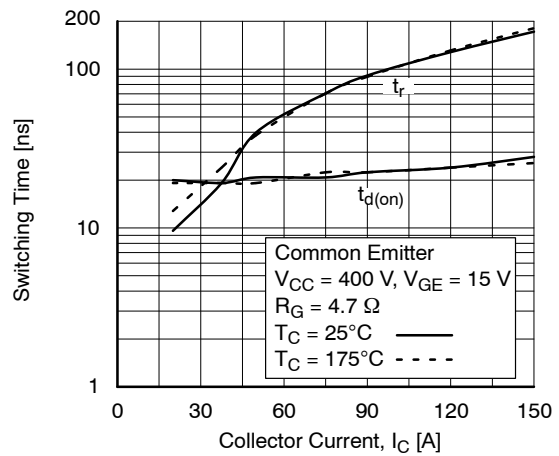


Figure 12. Turn-On Characteristics vs. Collector Current

TYPICAL CHARACTERISTICS (continued)

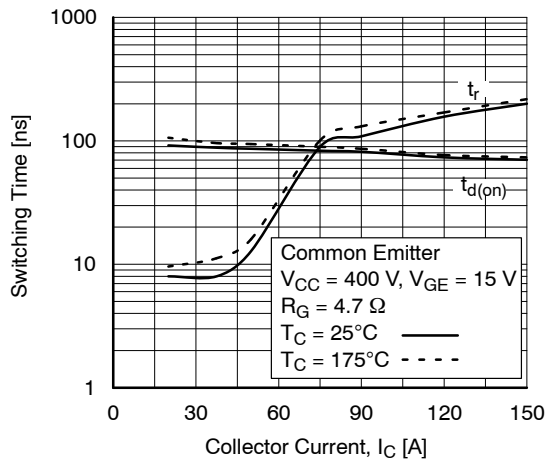


Figure 13. Turn-Off Characteristics vs. Collector Current

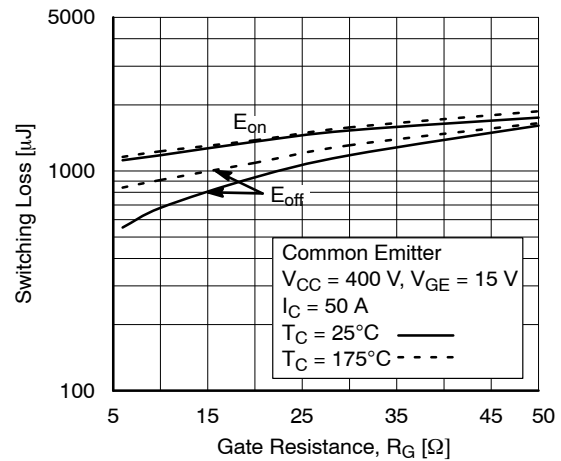


Figure 14. Switching Loss vs. Gate Resistance

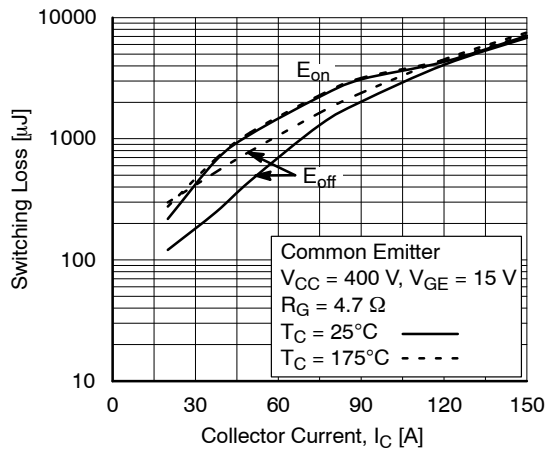


Figure 15. Switching Loss vs. Collector Current

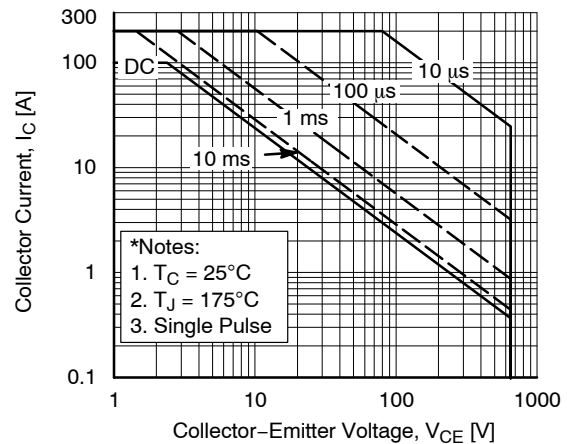


Figure 16. SOA Characteristics (FBSOA)

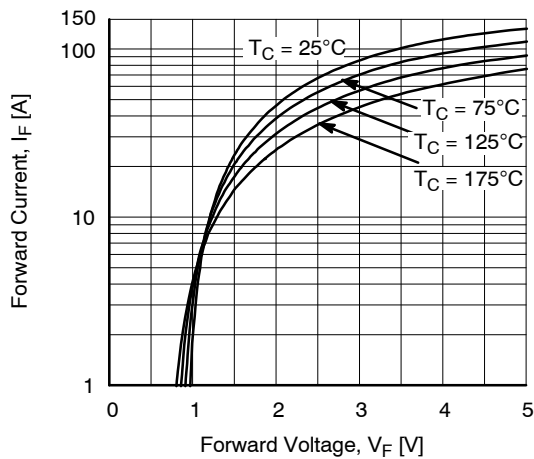


Figure 17. (Diode) Forward Characteristics vs. (Normal I-V)

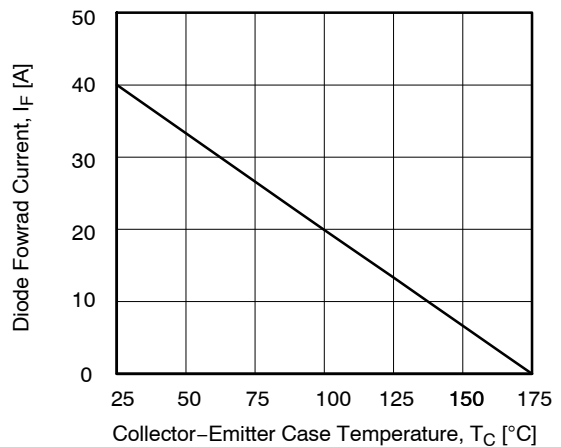
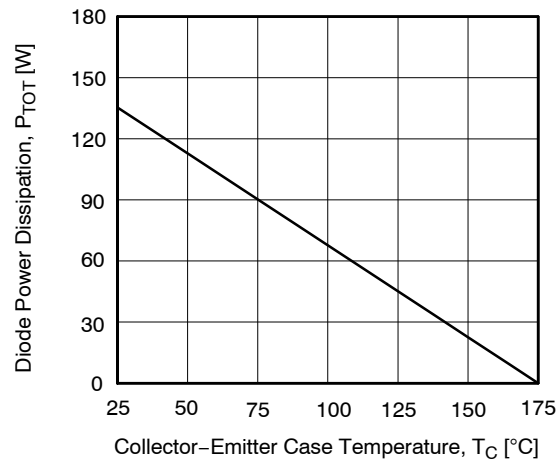


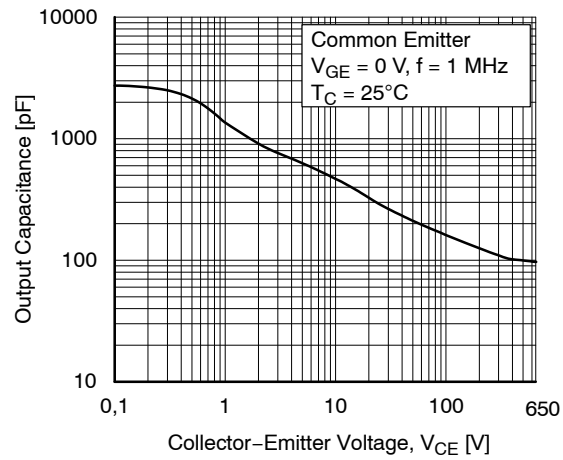
Figure 18. (Diode) Current Derating

# AFGHL50T65SQDC

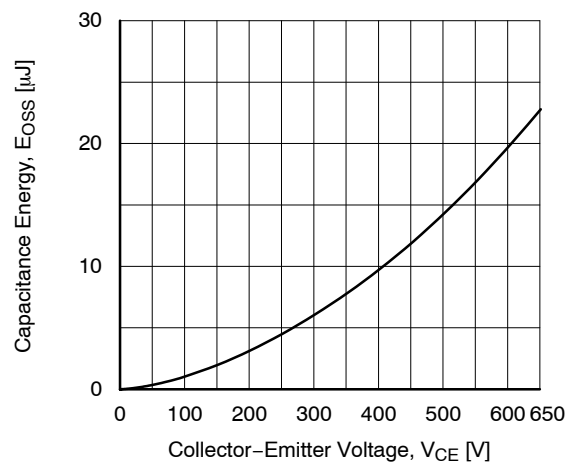
## TYPICAL CHARACTERISTICS (continued)



**Figure 19. (Diode) Power Derating**

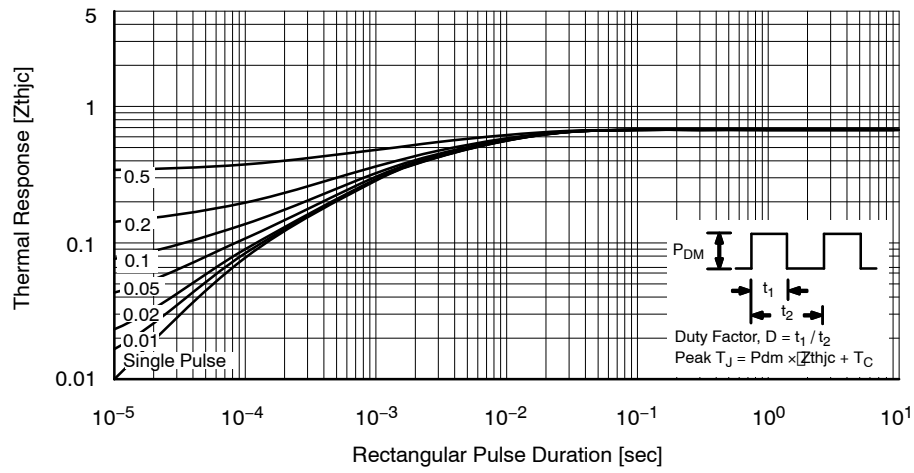


**Figure 20. (Diode) Output Capacitance (Coes) vs. Reverse Voltage**

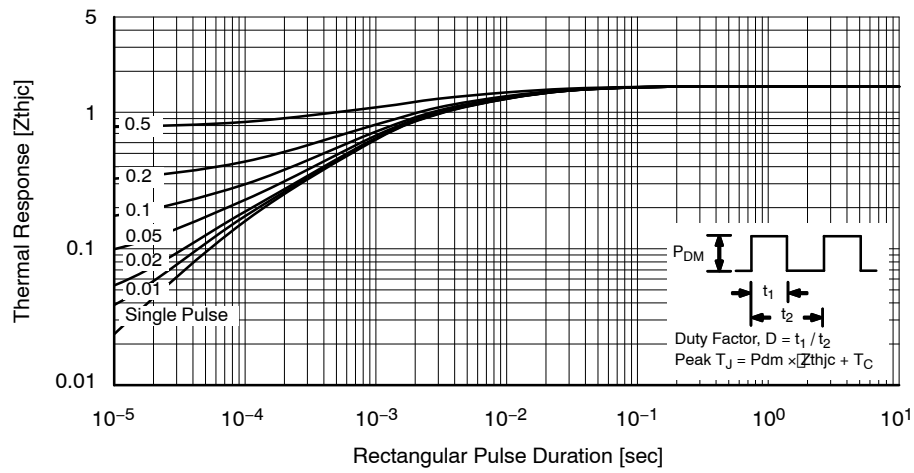


**Figure 21. Output Capacitance Stored Energy**

# AFGHL50T65SQDC



**Figure 22. Transient Thermal Impedance of IGBT**

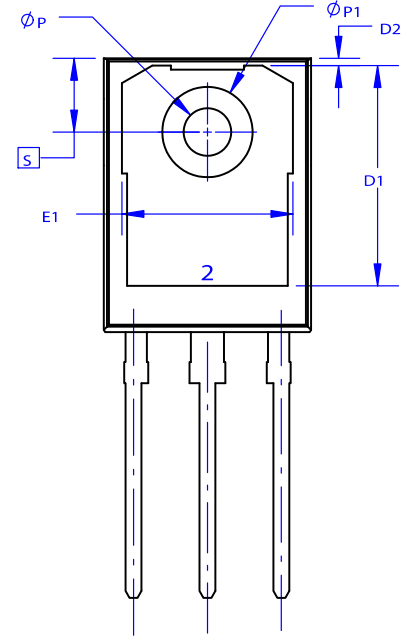
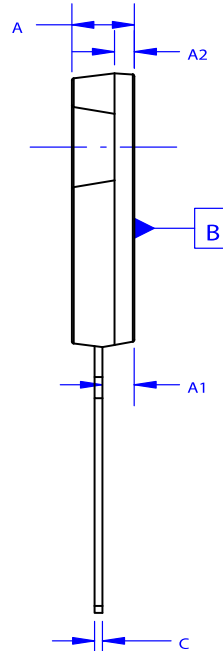
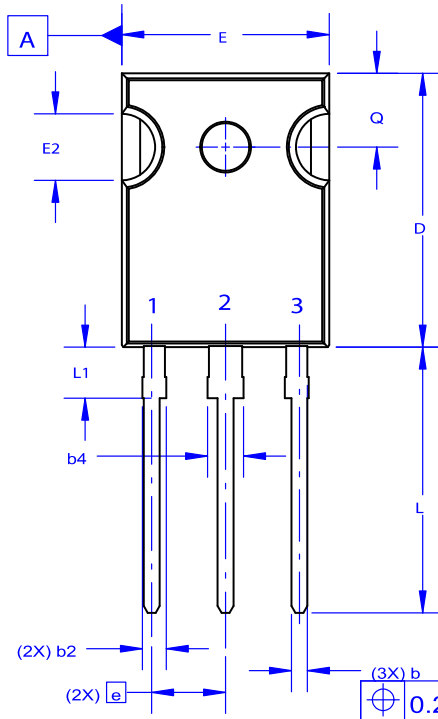


**Figure 23. Transient Thermal Impedance of Diode**



**TO-247-3LD**  
**CASE 340CX**  
**ISSUE A**

DATE 06 JUL 2020



NOTES: UNLESS OTHERWISE SPECIFIED.

- A. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.  
B. ALL DIMENSIONS ARE IN MILLIMETERS.  
C. DRAWING CONFORMS TO ASME Y14.5 - 2009.  
D. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.  
E. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.

**GENERIC**  
**MARKING DIAGRAM\***


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

\*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.

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN         | NOM   | MAX   |
| A   | 4.58        | 4.70  | 4.82  |
| A1  | 2.20        | 2.40  | 2.60  |
| A2  | 1.40        | 1.50  | 1.60  |
| D   | 20.32       | 20.57 | 20.82 |
| E   | 15.37       | 15.62 | 15.87 |
| E2  | 4.96        | 5.08  | 5.20  |
| e   | ~           | 5.56  | ~     |
| L   | 19.75       | 20.00 | 20.25 |
| L1  | 3.69        | 3.81  | 3.93  |
| ØP  | 3.51        | 3.58  | 3.65  |
| Q   | 5.34        | 5.46  | 5.58  |
| S   | 5.34        | 5.46  | 5.58  |
| b   | 1.17        | 1.26  | 1.35  |
| b2  | 1.53        | 1.65  | 1.77  |
| b4  | 2.42        | 2.54  | 2.66  |
| c   | 0.51        | 0.61  | 0.71  |
| D1  | 13.08       | ~     | ~     |
| D2  | 0.51        | 0.93  | 1.35  |
| E1  | 12.81       | ~     | ~     |
| ØP1 | 6.60        | 6.80  | 7.00  |

|                         |                    |   |
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