

# IGBT - Power, Co-PAK, N-Channel, Field Stop VII (FS7), SCR, Power TO247-4L 1200 V, 1.42 V, 40 A AFGH4L40T120RWD

## Description

Using the novel field stop 7th generation IGBT technology and the Gen7 Diode in TO247 4-lead package, this device offers the optimum performance with low on state voltage and minimal switching losses for both hard and soft switching topologies in automotive applications.

## Features

- Extremely Efficient Trench with Field Stop Technology
- Maximum Junction Temperature –  $T_J = 175^{\circ}\text{C}$
- Short Circuit Rated and Low Saturation Voltage
- Fast Switching and Tightened Parameter Distribution
- AEC-Q101 Qualified, PPAP Available Upon Request
- These Device is Pb-Free, Halogen Free/BFR Free and is RoHS Compliant

## Applications

- Automotive E-compressor
- Automotive EV PTC Heater
- OBC

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

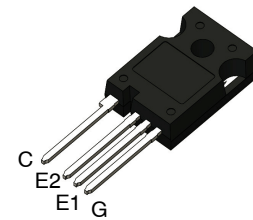
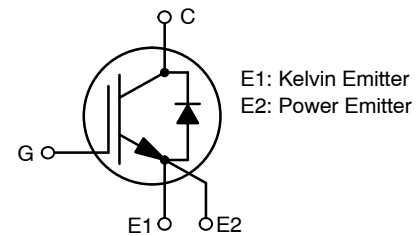
| Parameter                                                                                                      |                                                                        | Symbol            | Value             | Unit               |
|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|-------------------|-------------------|--------------------|
| Collector-to-Emitter Voltage                                                                                   |                                                                        | $V_{CE}$          | 1200              | V                  |
| Gate-to-Emitter Voltage                                                                                        |                                                                        | $V_{GE}$          | $\pm 20$          |                    |
| Transient Gate-to-Emitter Voltage                                                                              |                                                                        |                   | $\pm 30$          |                    |
| Collector Current                                                                                              | $T_C = 25^{\circ}\text{C}$                                             | $I_C$             | 80                | A                  |
|                                                                                                                | $T_C = 100^{\circ}\text{C}$                                            |                   | 40                |                    |
| Power Dissipation                                                                                              | $T_C = 25^{\circ}\text{C}$                                             | $P_D$             | 576               | W                  |
|                                                                                                                | $T_C = 100^{\circ}\text{C}$                                            |                   | 288               |                    |
| Pulsed Collector Current                                                                                       | $T_C = 25^{\circ}\text{C}$ ,<br>$t_p = 10\text{ }\mu\text{s}$ (Note 1) | $I_{CM}$          | 120               | A                  |
| Diode Forward Current                                                                                          | $T_C = 25^{\circ}\text{C}$                                             | $I_F$             | 80                |                    |
|                                                                                                                | $T_C = 100^{\circ}\text{C}$                                            |                   | 40                |                    |
| Pulsed Diode Forward Current                                                                                   | $T_C = 25^{\circ}\text{C}$ ,<br>$t_p = 10\text{ }\mu\text{s}$ (Note 1) | $I_{FM}$          | 120               |                    |
| Short Circuit Withstand Time<br>$V_{GE} = 15\text{ V}$ , $V_{CC} = 800\text{ V}$ , $T_C = 150^{\circ}\text{C}$ |                                                                        | $T_{SC}$          | 6                 | $\mu\text{s}$      |
| Operating Junction and Storage Temperature Range                                                               |                                                                        | $T_J$ , $T_{stg}$ | -55<br>to<br>+175 | $^{\circ}\text{C}$ |
| Lead Temperature for Soldering Purposes                                                                        |                                                                        | $T_L$             | 260               |                    |

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.

- Repetitive rating: Pulse width limited by max. junction temperature

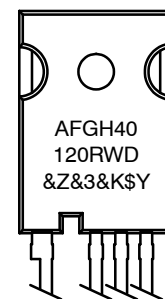
| $BV_{CES}$ | $V_{CE(sat)}$ TYP | $I_C$ MAX |
|------------|-------------------|-----------|
| 1200 V     | 1.42 V            | 40 A      |

## PIN CONNECTIONS



TO-247-4LD  
CASE 340CJ

## MARKING DIAGRAM



AFGH40120RWD = Specific Device Code  
&Z = Assembly Plant Code  
&3 = 3-Digit Date Code  
&K = 2-Digit Lot Traceability Code  
\$Y = onsemi Logo

## ORDERING INFORMATION

| Device          | Package                | Shipping        |
|-----------------|------------------------|-----------------|
| AFGH4L40T120RWD | TO-247-4L<br>(Pb-Free) | 30 Units / Rail |

# AFGH4L40T120RWD

## THERMAL CHARACTERISTICS

| Parameter                                      | Symbol          | Value | Unit |
|------------------------------------------------|-----------------|-------|------|
| Thermal Resistance, Junction-to-Case for IGBT  | $R_{\theta JC}$ | 0.26  | °C/W |
| Thermal Resistance, Junction-to-Case for Diode | $R_{\theta JC}$ | 0.46  |      |
| Thermal Resistance, Junction-to-Ambient        | $R_{\theta JA}$ | 40    |      |

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

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

### OFF CHARACTERISTICS

|                                                                |                                |                                                 |      |      |      |       |
|----------------------------------------------------------------|--------------------------------|-------------------------------------------------|------|------|------|-------|
| Collector-to-Emitter Breakdown Voltage                         | $BV_{CES}$                     | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$        | 1200 | –    | –    | V     |
| Collector-to-Emitter Breakdown Voltage Temperature Coefficient | $\Delta BV_{CES} / \Delta T_J$ | $V_{GE} = 0\text{ V}, I_C = 9.99\text{ mA}$     | –    | 1226 | –    | mV/°C |
| Zero Gate Voltage Collector Current                            | $I_{CES}$                      | $V_{GE} = 0\text{ V}, V_{CE} = V_{CES}$         | –    | –    | 40   | μA    |
| Gate-to-Emitter leakage Current                                | $I_{GES}$                      | $V_{GE} = \pm 20\text{ V}, V_{CE} = 0\text{ V}$ | –    | –    | ±400 | nA    |

### ON CHARACTERISTICS

|                                         |               |                                                                    |      |      |      |   |
|-----------------------------------------|---------------|--------------------------------------------------------------------|------|------|------|---|
| Gate-to-Emitter Threshold Voltage       | $V_{GE(th)}$  | $V_{GE} = V_{CE}, I_C = 40\text{ mA}, T_J = 25^\circ\text{C}$      | 5.03 | 5.93 | 6.83 | V |
| Collector-to-Emitter Saturation Voltage | $V_{CE(sat)}$ | $V_{GE} = 15\text{ V}, I_C = 40\text{ A}, T_J = 25^\circ\text{C}$  | –    | 1.42 | 1.75 | V |
|                                         |               | $V_{GE} = 15\text{ V}, I_C = 40\text{ A}, T_J = 175^\circ\text{C}$ | –    | 1.7  | –    |   |

### DYNAMIC CHARACTERISTICS

|                              |           |                                                                  |   |      |   |    |
|------------------------------|-----------|------------------------------------------------------------------|---|------|---|----|
| Input Capacitance            | $C_{IES}$ | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$    | – | 4713 | – | pF |
| Output Capacitance           | $C_{OES}$ |                                                                  | – | 195  | – | pF |
| Reverse Transfer Capacitance | $C_{RES}$ |                                                                  | – | 23.8 | – | pF |
| Total Gate Charge            | $Q_G$     | $V_{CE} = 600\text{ V}, V_{GE} = 15\text{ V}, I_C = 40\text{ A}$ | – | 171  | – | nC |
| Gate-to-Emitter Charge       | $Q_{GE}$  |                                                                  | – | 42.2 | – | nC |
| Gate-to-Collector Charge     | $Q_{GC}$  |                                                                  | – | 73.1 | – | nC |

### SWITCHING CHARACTERISTICS

|                         |              |                                                                                                                             |   |      |   |    |
|-------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------|---|------|---|----|
| Turn-On Delay Time      | $t_{d(on)}$  | $V_{CE} = 600\text{ V}$<br>$V_{GE} = 0/15\text{ V}$<br>$I_C = 20\text{ A}$<br>$R_G = 6\ \Omega$<br>$T_J = 25^\circ\text{C}$ | – | 53.5 | – | ns |
| Turn-Off Delay Time     | $t_{d(off)}$ |                                                                                                                             | – | 311  | – |    |
| Rise Time               | $t_r$        |                                                                                                                             | – | 27.8 | – |    |
| Fall Time               | $t_f$        |                                                                                                                             | – | 189  | – |    |
| Turn-On Switching Loss  | $E_{on}$     | $V_{CE} = 600\text{ V}$<br>$V_{GE} = 0/15\text{ V}$<br>$I_C = 40\text{ A}$<br>$R_G = 6\ \Omega$<br>$T_J = 25^\circ\text{C}$ | – | 1.26 | – | mJ |
| Turn-Off Switching Loss | $E_{off}$    |                                                                                                                             | – | 1.36 | – |    |
| Total Switching Loss    | $E_{ts}$     |                                                                                                                             | – | 2.61 | – |    |
| Turn-On Delay Time      | $t_{d(on)}$  |                                                                                                                             | – | 58.2 | – | ns |
| Turn-Off Delay Time     | $t_{d(off)}$ |                                                                                                                             | – | 258  | – |    |
| Rise Time               | $t_r$        |                                                                                                                             | – | 47.4 | – |    |
| Fall Time               | $t_f$        |                                                                                                                             | – | 122  | – |    |
| Turn-On Switching Loss  | $E_{on}$     |                                                                                                                             | – | 3.38 | – | mJ |
| Turn-Off Switching Loss | $E_{off}$    |                                                                                                                             | – | 1.7  | – |    |
| Total Switching Loss    | $E_{ts}$     |                                                                                                                             | – | 5.08 | – |    |

# AFGH4L40T120RWD

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

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

### SWITCHING CHARACTERISTICS

|                         |              |                                                                                                                              |   |      |   |    |
|-------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------|---|------|---|----|
| Turn-On Delay Time      | $t_{d(on)}$  | $V_{CE} = 600\text{ V}$<br>$V_{GE} = 0/15\text{ V}$<br>$I_C = 20\text{ A}$<br>$R_G = 6\ \Omega$<br>$T_J = 175^\circ\text{C}$ | – | 58.7 | – | ns |
| Turn-Off Delay Time     | $t_{d(off)}$ |                                                                                                                              | – | 433  | – |    |
| Rise Time               | $t_r$        |                                                                                                                              | – | 39.4 | – |    |
| Fall Time               | $t_f$        |                                                                                                                              | – | 376  | – |    |
| Turn-On Switching Loss  | $E_{on}$     |                                                                                                                              | – | 2.01 | – | mJ |
| Turn-Off Switching Loss | $E_{off}$    |                                                                                                                              | – | 2.52 | – |    |
| Total Switching Loss    | $E_{ts}$     |                                                                                                                              | – | 4.53 | – |    |
| Turn-On Delay Time      | $t_{d(on)}$  | $V_{CE} = 600\text{ V}$<br>$V_{GE} = 0/15\text{ V}$<br>$I_C = 40\text{ A}$<br>$R_G = 6\ \Omega$<br>$T_J = 175^\circ\text{C}$ | – | 65.7 | – | ns |
| Turn-Off Delay Time     | $t_{d(off)}$ |                                                                                                                              | – | 343  | – |    |
| Rise Time               | $t_r$        |                                                                                                                              | – | 64.7 | – |    |
| Fall Time               | $t_f$        |                                                                                                                              | – | 233  | – |    |
| Turn-On Switching Loss  | $E_{on}$     |                                                                                                                              | – | 5.45 | – | mJ |
| Turn-Off Switching Loss | $E_{off}$    |                                                                                                                              | – | 3.04 | – |    |
| Total Switching Loss    | $E_{ts}$     |                                                                                                                              | – | 8.49 | – |    |

### DIODE CHARACTERISTICS

|                       |       |                                              |   |      |      |   |
|-----------------------|-------|----------------------------------------------|---|------|------|---|
| Diode Forward Voltage | $V_F$ | $I_F = 40\text{ A}, T_J = 25^\circ\text{C}$  | – | 1.52 | 1.82 | V |
|                       |       | $I_F = 40\text{ A}, T_J = 175^\circ\text{C}$ | – | 1.53 | –    |   |

### DIODE SWITCHING CHARACTERISTICS, INDUCTIVE LOAD

|                               |           |                                                                                                               |   |      |   |    |
|-------------------------------|-----------|---------------------------------------------------------------------------------------------------------------|---|------|---|----|
| Reverse Recovery Time         | $t_{rr}$  | $V_R = 600\text{ V}, I_F = 20\text{ A},$<br>$di_F/dt = 500\text{ A}/\mu\text{s}$<br>$T_J = 25^\circ\text{C}$  | – | 145  | – | ns |
| Reverse Recovery Charge       | $Q_{rr}$  |                                                                                                               | – | 2055 | – | nC |
| Reverse Recovery Energy       | $E_{rec}$ |                                                                                                               | – | 0.49 | – | mJ |
| Peak Reverse Recovery Current | $I_{RRM}$ |                                                                                                               | – | 34   | – | A  |
| Reverse Recovery Time         | $t_{rr}$  | $V_R = 600\text{ V}, I_F = 40\text{ A},$<br>$di_F/dt = 500\text{ A}/\mu\text{s}$<br>$T_J = 25^\circ\text{C}$  | – | 182  | – | ns |
| Reverse Recovery Charge       | $Q_{rr}$  |                                                                                                               | – | 3527 | – | nC |
| Reverse Recovery Energy       | $E_{rec}$ |                                                                                                               | – | 0.67 | – | mJ |
| Peak Reverse Recovery Current | $I_{RRM}$ |                                                                                                               | – | 43.5 | – | A  |
| Reverse Recovery Time         | $t_{rr}$  | $V_R = 600\text{ V}, I_F = 20\text{ A},$<br>$di_F/dt = 500\text{ A}/\mu\text{s}$<br>$T_J = 175^\circ\text{C}$ | – | 204  | – | ns |
| Reverse Recovery Charge       | $Q_{rr}$  |                                                                                                               | – | 3606 | – | nC |
| Reverse Recovery Energy       | $E_{rec}$ |                                                                                                               | – | 1.07 | – | mJ |
| Peak Reverse Recovery Current | $I_{RRM}$ |                                                                                                               | – | 42.3 | – | A  |
| Reverse Recovery Time         | $t_{rr}$  | $V_R = 600\text{ V}, I_F = 40\text{ A},$<br>$di_F/dt = 500\text{ A}/\mu\text{s}$<br>$T_J = 175^\circ\text{C}$ | – | 253  | – | ns |
| Reverse Recovery Charge       | $Q_{rr}$  |                                                                                                               | – | 6542 | – | nC |
| Reverse Recovery Energy       | $E_{rec}$ |                                                                                                               | – | 1.52 | – | mJ |
| Peak Reverse Recovery Current | $I_{RRM}$ |                                                                                                               | – | 57.6 | – | A  |

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.

# AFGH4L40T120RWD

## TYPICAL CHARACTERISTICS

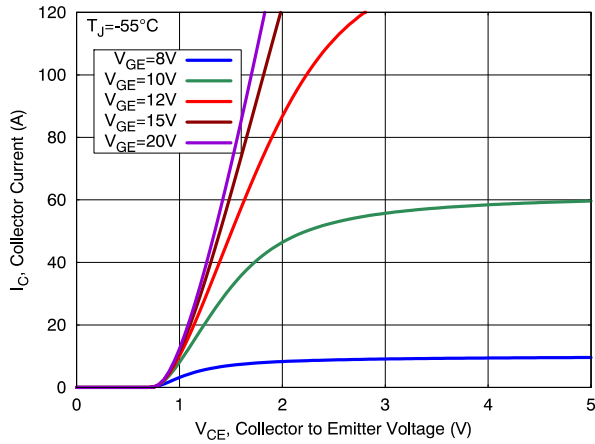


Figure 1. Output Characteristics

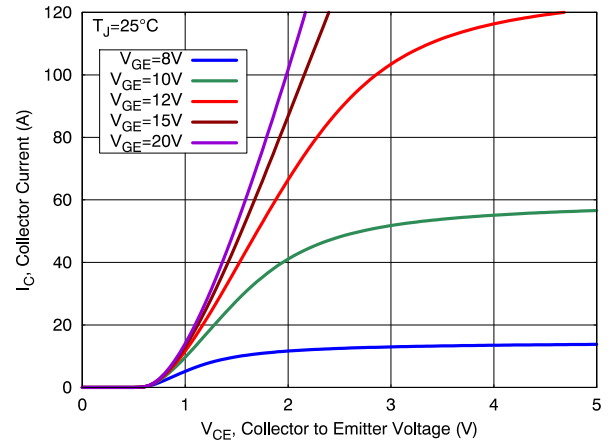


Figure 2. Output Characteristics

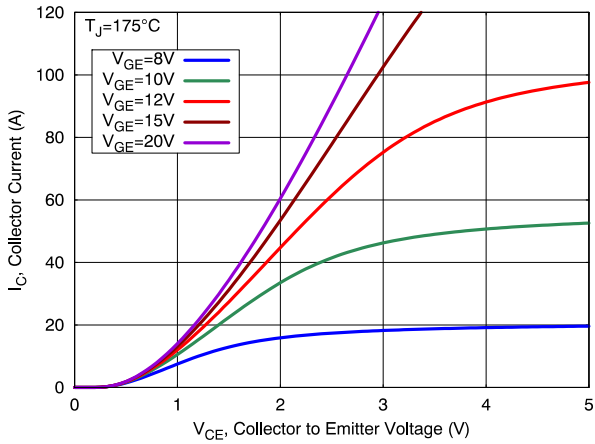


Figure 3. Output Characteristics

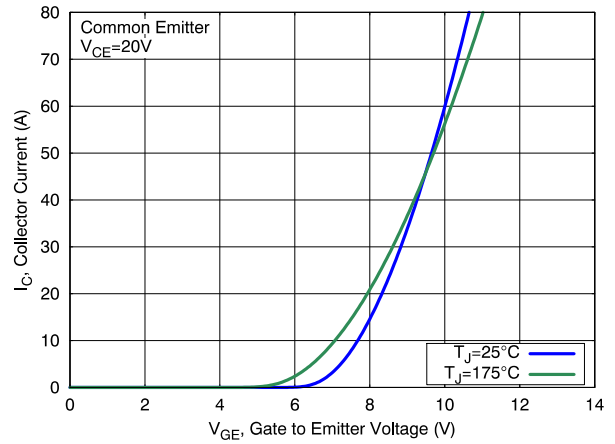


Figure 4. Transfer Characteristics

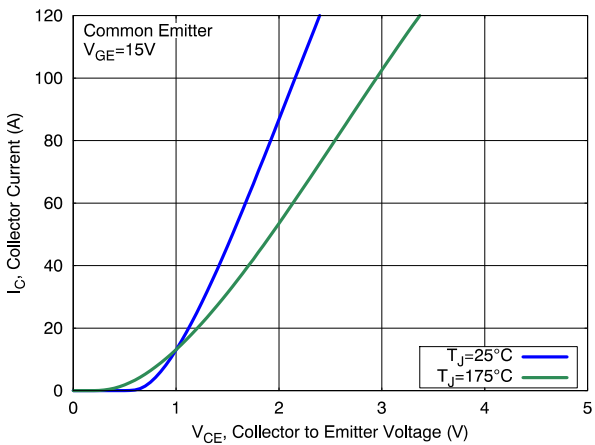


Figure 5. Saturation Characteristics

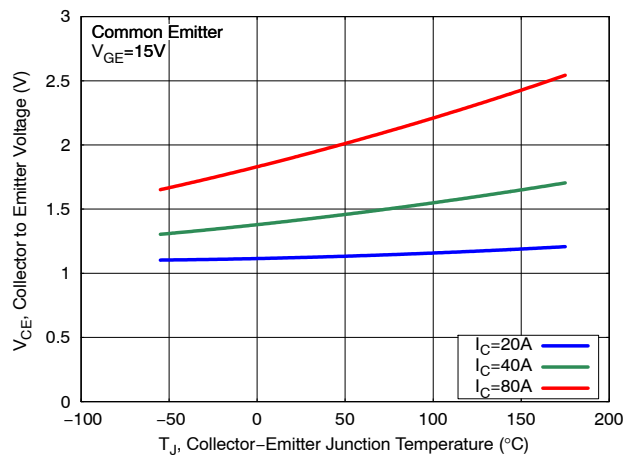


Figure 6. Saturation Voltage vs. Junction Temperature

# AFGH4L40T120RWD

## TYPICAL CHARACTERISTICS

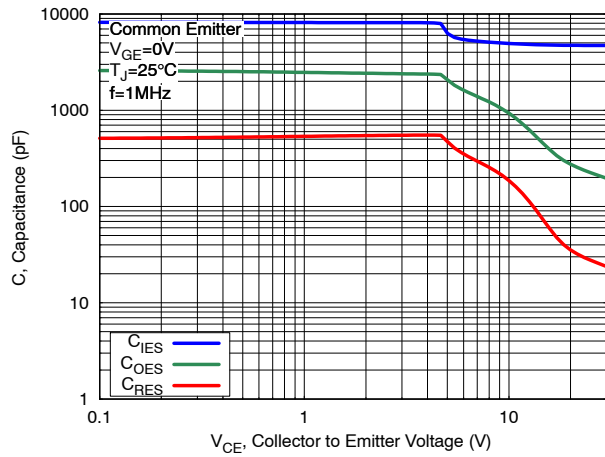


Figure 7. Capacitance Characteristics

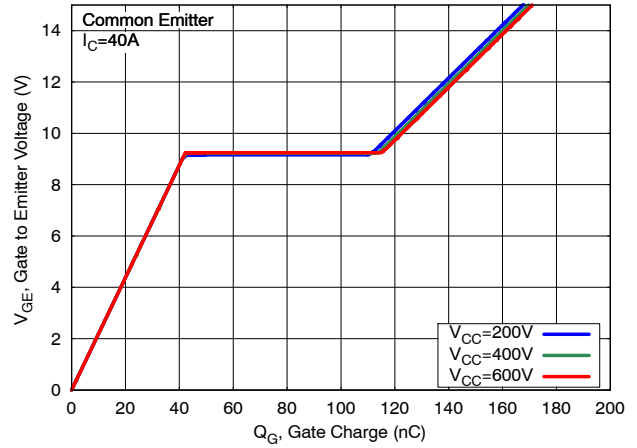


Figure 8. Gate Charge Characteristics

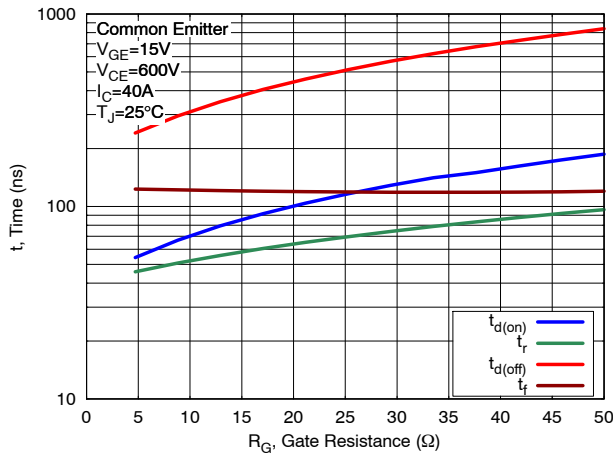


Figure 9. Switching Time vs Gate Resistance

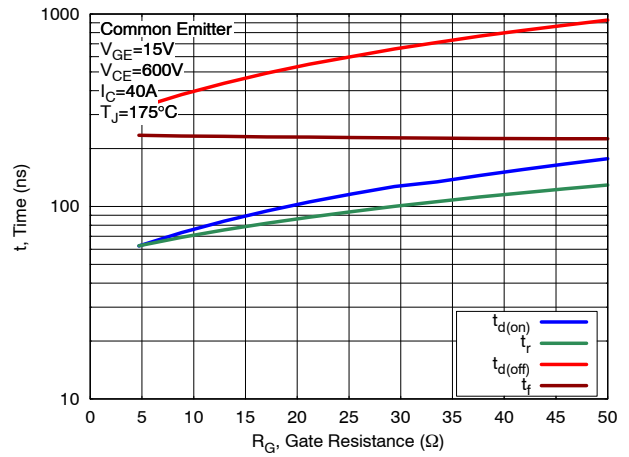


Figure 10. Switching Time vs Gate Resistance

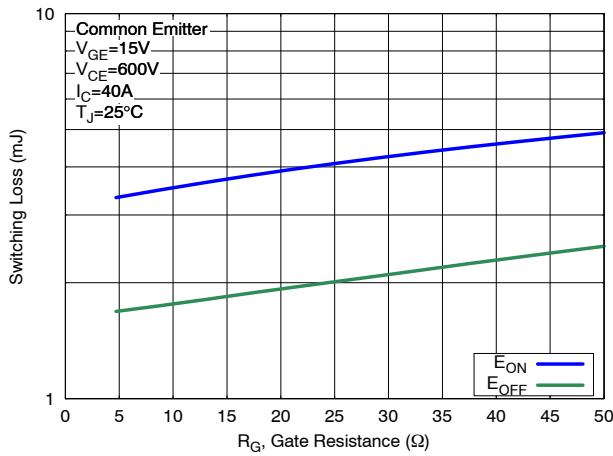


Figure 11. Switching Loss vs Gate Resistance

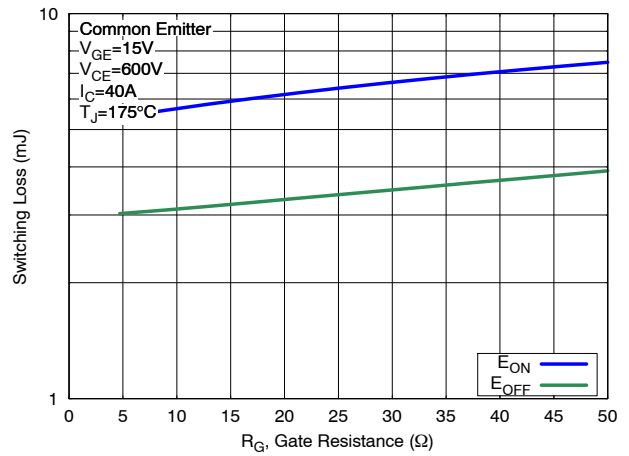


Figure 12. Switching Loss vs Gate Resistance

# AFGH4L40T120RWD

## TYPICAL CHARACTERISTICS

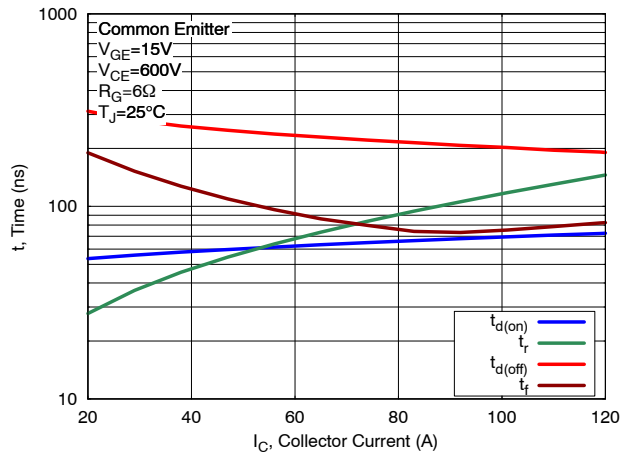


Figure 13. Switching Time vs Collector Current

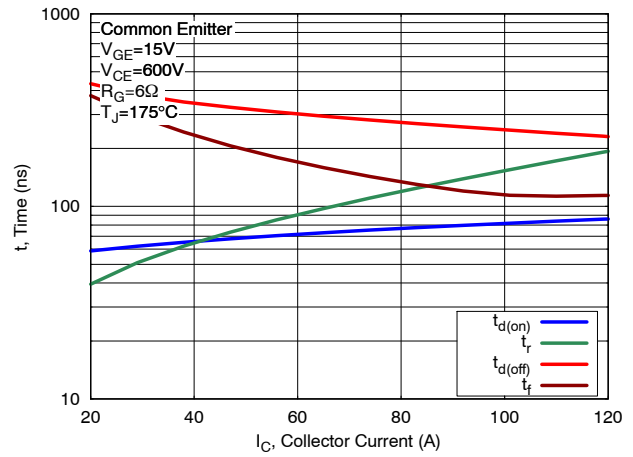


Figure 14. Switching Time vs Collector Current

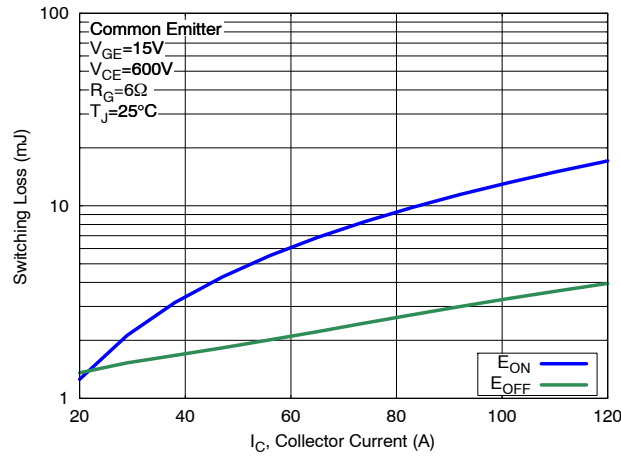


Figure 15. Switching Loss vs Collector Current

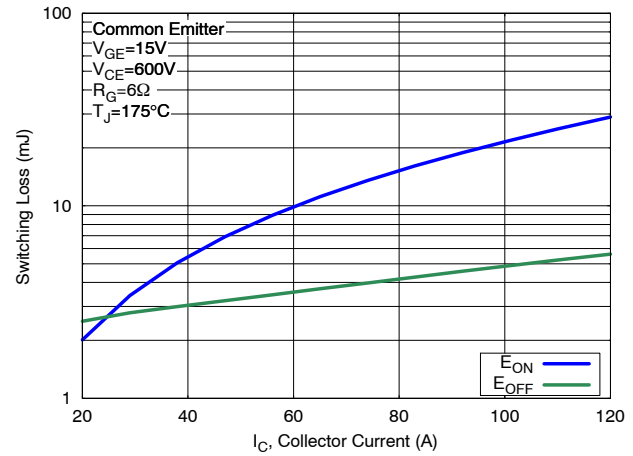


Figure 16. Switching Loss vs Collector Current

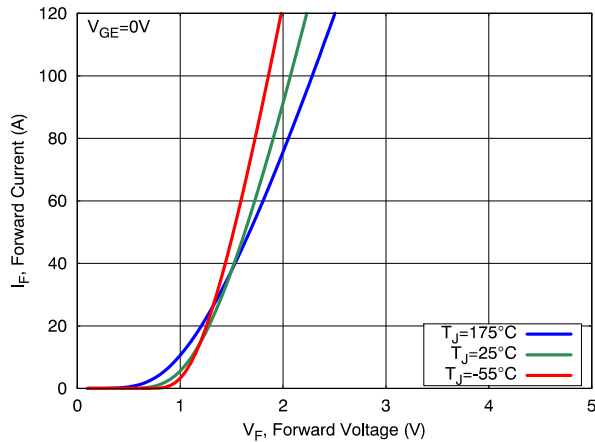


Figure 17. Diode Forward Characteristics

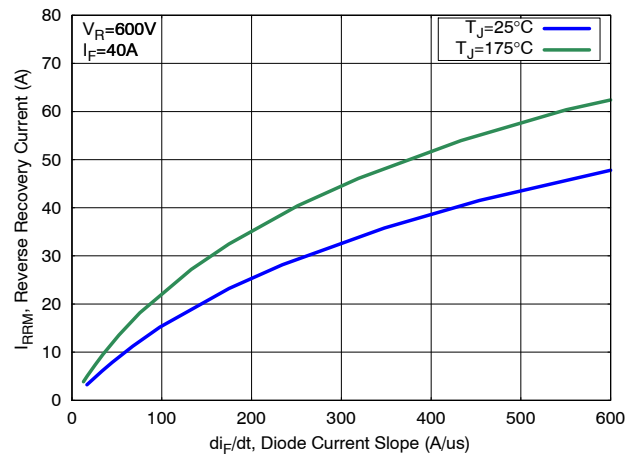


Figure 18. Diode Reverse Recovery Current

# AFGH4L40T120RWD

## TYPICAL CHARACTERISTICS

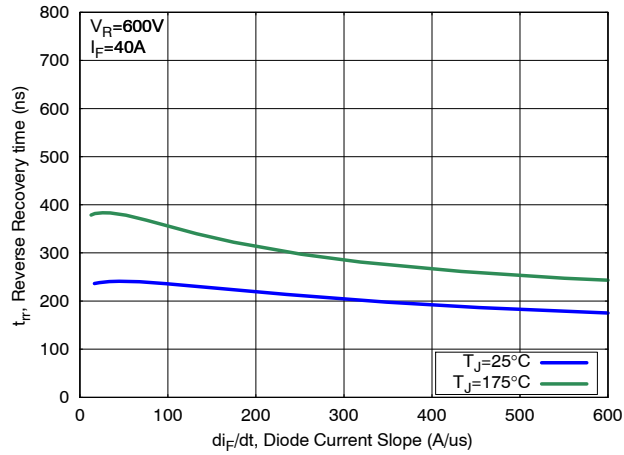


Figure 19. Diode Reverse Recovery Time

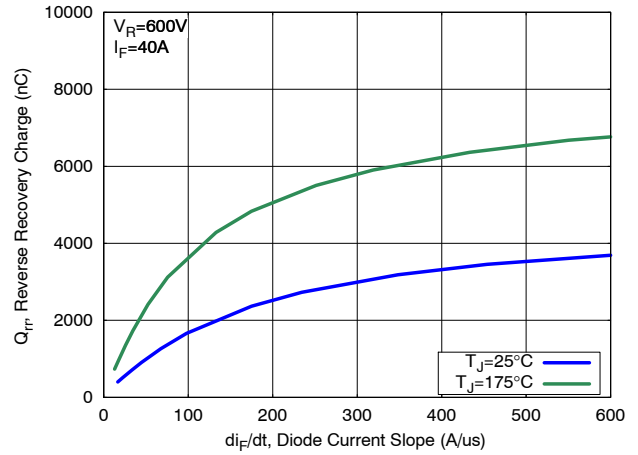


Figure 20. Diode Stored Charge Characteristics

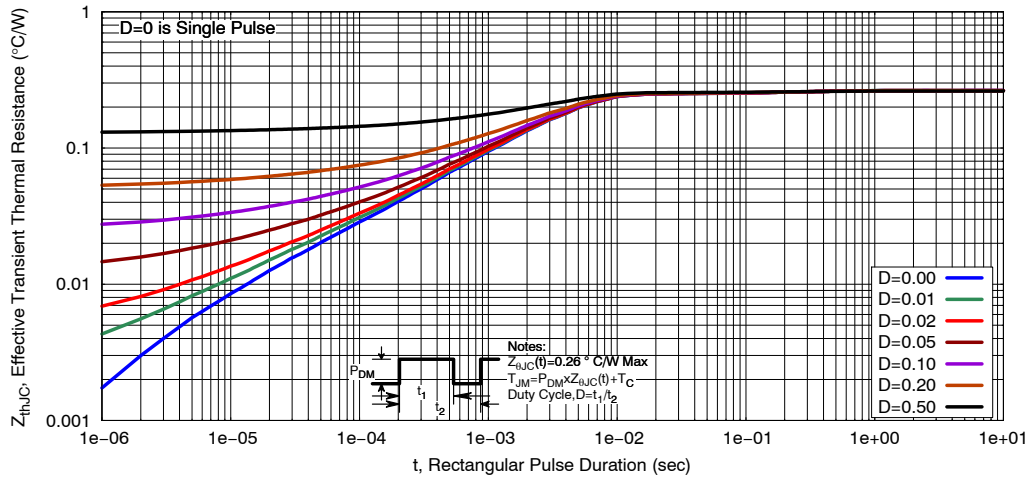


Figure 21. Transient Thermal Impedance of IGBT

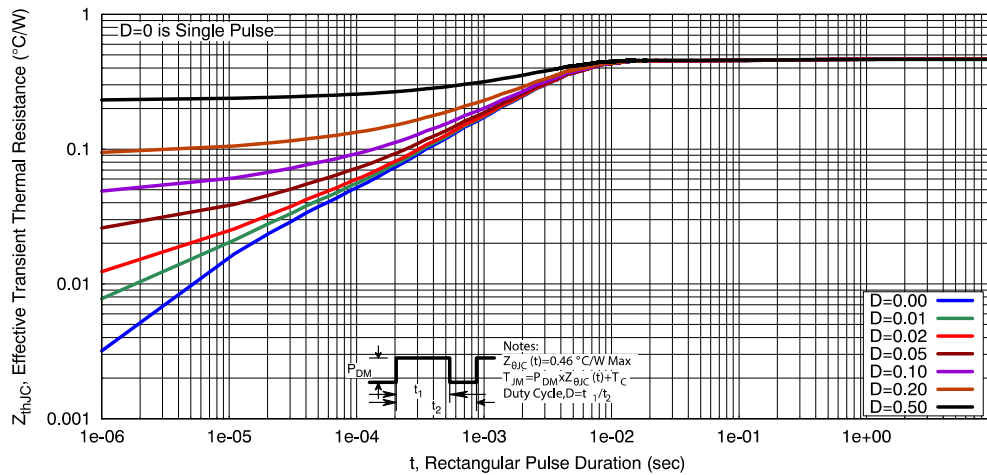
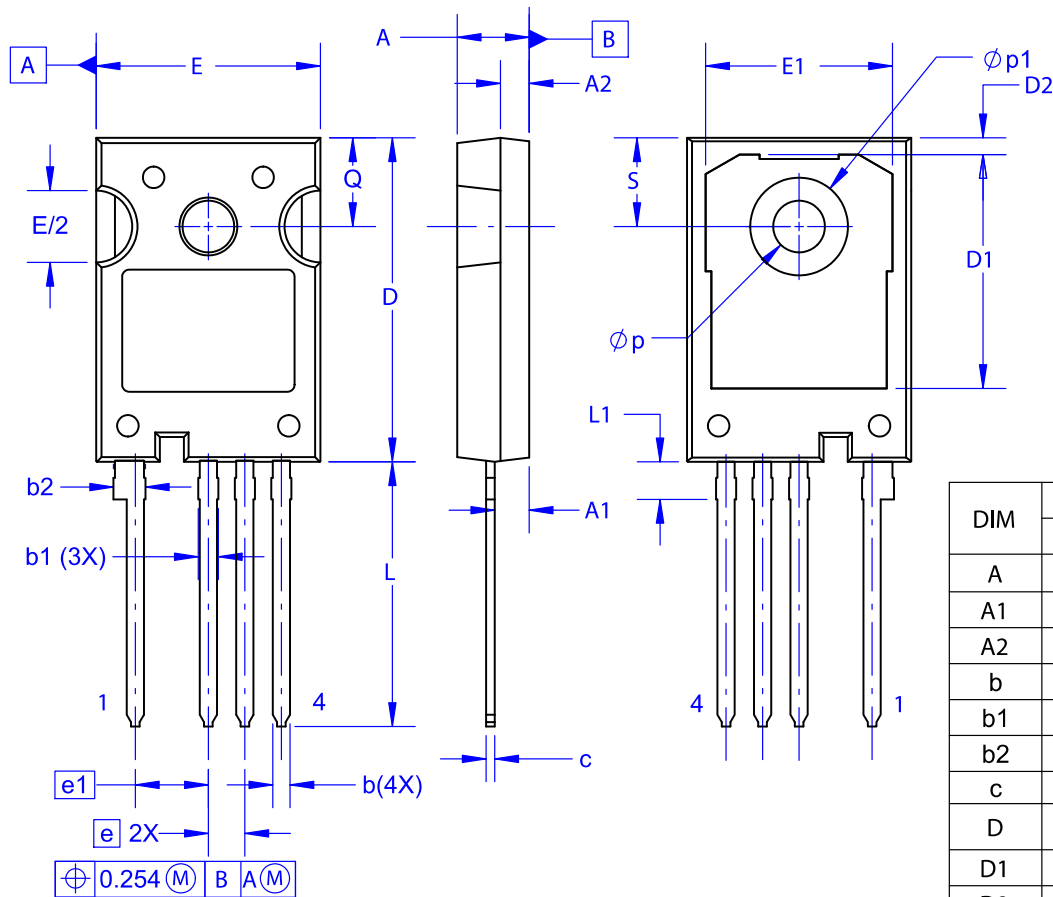


Figure 22. Transient Thermal Impedance of Diode

**TO-247-4LD**  
**CASE 340CJ**  
**ISSUE A**

DATE 16 SEP 2019


**NOTES:**

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

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN         | NOM   | MAX   |
| A   | 4.80        | 5.00  | 5.20  |
| A1  | 2.10        | 2.40  | 2.70  |
| A2  | 1.80        | 2.00  | 2.20  |
| b   | 1.07        | 1.20  | 1.33  |
| b1  | 1.20        | 1.40  | 1.60  |
| b2  | 2.02        | 2.22  | 2.42  |
| c   | 0.50        | 0.60  | 0.70  |
| D   | 22.34       | 22.54 | 22.74 |
| D1  | 16.00       | 16.25 | 16.50 |
| D2  | 0.97        | 1.17  | 1.37  |
| e   | 2.54 BSC    |       |       |
| e1  | 5.08 BSC    |       |       |
| E   | 15.40       | 15.60 | 15.80 |
| E1  | 12.80       | 13.00 | 13.20 |
| E/2 | 4.80        | 5.00  | 5.20  |
| L   | 18.22       | 18.42 | 18.62 |
| L1  | 2.42        | 2.62  | 2.82  |
| p   | 3.40        | 3.60  | 3.80  |
| p1  | 6.60        | 6.80  | 7.00  |
| Q   | 5.97        | 6.17  | 6.37  |
| S   | 5.97        | 6.17  | 6.37  |

|                         |                    |                                                                                                                                                                                     |
|-------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| <b>DESCRIPTION:</b>     | <b>TO-247-4LD</b>  | <b>PAGE 1 OF 1</b>                                                                                                                                                                  |

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