IGBT for Automotive Application
1200 V, 40 A

AFGHL40T120RLD

Description
This Insulated Gate Bipolar Transistor (IGBT) features a robust and cost effective Field Stop II Trench construction. Provides superior performance in demanding switching applications, offering both low on state voltage and minimal switching loss, which is AEC Q101 qualified offer the optimum performance for both hard and soft switching topology in automotive application.

Features
• Extremely Efficient Trench with Field Stop Technology
• Maximum Junction Temperature: T_J = 175°C
• Short Circuit Withstand Time 9 µs
• Low Saturation Voltage: V_{CES} = 1.75 V (Typ.) @ I_C = 40 A
• 100% of the Parts Tested for I_{LM} (Note 2)
• Fast Switching
• Tighten Parameter Distribution
• AEC–Q101 Qualified and PPAP Capable
• This Device is Pb–Free, Halogen Free/BFR Free and is RoHS Compliant

Typical Applications
• Automotive HEV–EV E–Compressor
• Automotive HEV–EV PTC Heater
• Automotive HEV–EV Onboard Chargers
• Automotive HEV–EV DC–DC Converters

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFGHL40T120RLD</td>
<td>TO–247–3L</td>
<td>30 Units / Rail</td>
</tr>
</tbody>
</table>

MARKING DIAGRAM

VCES IC VCE(Sat)
1200 V 40 A 1.75 V (Typ.)

www.onsemi.com

© Semiconductor Components Industries, LLC, 2021
April, 2021 – Rev. 1
Publication Order Number:
AFGHL40T120RLD/D
### MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector to Emitter Voltage</td>
<td>$V_{CES}$</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>Gate to Emitter Voltage</td>
<td>$V_{GES}$</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Transient Gate to Emitter Voltage</td>
<td></td>
<td>±30</td>
<td></td>
</tr>
<tr>
<td>Collector Current @ $T_C = 25^\circ C$ (Note 1)</td>
<td>$I_C$</td>
<td>48</td>
<td>A</td>
</tr>
<tr>
<td>Collector Current @ $T_C = 100^\circ C$</td>
<td></td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Pulsed Collector Current (Note 2)</td>
<td>$I_{LM}$</td>
<td>160</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed Collector Current (Note 3)</td>
<td>$I_{CM}$</td>
<td>160</td>
<td>A</td>
</tr>
<tr>
<td>Diode Forward Current @ $T_C = 25^\circ C$ (Note 1)</td>
<td>$I_F$</td>
<td>48</td>
<td>A</td>
</tr>
<tr>
<td>Diode Forward Current @ $T_C = 100^\circ C$</td>
<td></td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Pulsed Diode Maximum Forward Current</td>
<td>$I_{FM}$</td>
<td>160</td>
<td>A</td>
</tr>
<tr>
<td>Maximum Power Dissipation @ $T_C = 25^\circ C$</td>
<td>$P_D$</td>
<td>529</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Power Dissipation @ $T_C = 100^\circ C$</td>
<td></td>
<td>264</td>
<td></td>
</tr>
<tr>
<td>Short Circuit Withstand Time</td>
<td>$SCWT$</td>
<td>9</td>
<td>$\mu$s</td>
</tr>
<tr>
<td>Operating Junction Temperature / Storage Temperature Range</td>
<td>$T_J$, $T_{STG}$</td>
<td>−55 to +175</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Lead Temp. For Soldering Purposes, ¼” from case for 5 seconds</td>
<td>$T_L$</td>
<td>260</td>
<td>°C</td>
</tr>
</tbody>
</table>

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. Value limited by bond wire.
2. $V_{CC} = 600$ V, $V_{GE} = 15$ V, $I_C = 160$ A, $R_G = 15$ $\Omega$, Inductive Load, 100% Tested

### THERMAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Resistance, Junction to Case, for IGBT</td>
<td>$R_{IJC}$</td>
<td>0.28</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Resistance, Junction to Case, Max for Diode</td>
<td>$R_{IJC}$</td>
<td>0.47</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Resistance, Junction to Ambient, Max</td>
<td>$R_{JUA}$</td>
<td>40</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

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

| Parameter                                                      | Test Conditions         | Symbol | Min. | Typ. | Max. | Unit  |
|                                                               |                        |        |      |     |      |       |
| **OFF CHARACTERISTICS**                                        |                         |        |      |     |      |       |
| Collector–emitter Breakdown Voltage, Gate–emitter Short–circuited | $V_{GE} = 0$ V, $I_C = 1$ mA | $BV_{CES}$ | 1250 | –   | –    | V     |
| Temperature Coefficient of Breakdown Voltage                  | $V_{GE} = 0$ V, $I_C = 1$ mA | $\Delta BV_{CES}/\Delta T_J$ | –     | 1.4 | –    | V/°C  |
| Collector–emitter Cut–off Current, Gate–emitter Short–circuited | $V_{GE} = 0$ V, $V_{CE} = V_{CES}$ | $I_{CES}$ | –    | –   | 40   | $\mu$A |
| Gate Leakage Current, Collector–emitter Short–circuited       | $V_{GE} = V_{GES}$, $V_{CE} = 0$ V | $I_{GES}$ | –    | –   | ±400 | nA    |

| **ON CHARACTERISTICS**                                         |                         |        |      |     |      |       |
|                                                               | $V_{GE} = V_{CE}$, $I_C = 40$ mA | $V_{GE(th)}$ | 5.3  | 6.3 | 7.3  | V     |
| Collector–emitter Saturation Voltage                          | $V_{GE} = 15$ V, $I_C = 40$ A | $V_{CE(sat)}$ | –    | 1.75| 2.1  | V     |
### ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise specified) (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Capacitance</td>
<td>V_CE = 30 V, V_GE = 0 V, f = 1 MHz</td>
<td>C_i(es)</td>
<td>–</td>
<td>8755</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td></td>
<td>C_o(es)</td>
<td>–</td>
<td>302</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Reverse Transfer Capacitance</td>
<td></td>
<td>C_r(es)</td>
<td>–</td>
<td>162</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

### DYNAMIC CHARACTERISTICS

**Input Capacitance**
- V_CE = 30 V, V_GE = 0 V, f = 1 MHz  
  C_i(es) = 8755 pF

**Output Capacitance**
- C_o(es) = 302 pF

**Reverse Transfer Capacitance**
- C_r(es) = 162 pF

### SWITCHING CHARACTERISTICS, INDUCTIVE LOAD

#### Turn-on Delay Time
- T_J = 25°C  
  V_CC = 600 V, I_C = 20 A  
  R_g = 5 Ω  
  V_GE = 15 V  
  Inductive Load  
  t_d(on) = 43 ns

#### Rise Time
- t_r = 18 ns

#### Turn-off Delay Time
- t_d(off) = 222 ns

#### Fall Time
- t_f = 53 ns

#### Turn-on Switching Loss
- E_on = 1.6 mJ

#### Turn-off Switching Loss
- E_off = 0.45 mJ

#### Total Switching Loss
- E_ts = 2.05 mJ

#### Turn-on Delay Time
- T_J = 175°C  
  V_CC = 600 V, I_C = 40 A  
  R_g = 5 Ω  
  V_GE = 15 V  
  Inductive Load  
  t_d(on) = 48 ns

#### Rise Time
- t_r = 32 ns

#### Turn-off Delay Time
- t_d(off) = 208 ns

#### Fall Time
- t_f = 68 ns

#### Turn-on Switching Loss
- E_on = 3.4 mJ

#### Turn-off Switching Loss
- E_off = 1.2 mJ

#### Total Switching Loss
- E_ts = 4.6 mJ

#### Turn-on Delay Time
- T_J = 25°C  
  V_CC = 600 V, I_C = 40 A  
  R_g = 5 Ω  
  V_GE = 15 V  
  Inductive Load  
  t_d(on) = 40 ns

#### Rise Time
- t_r = 20 ns

#### Turn-off Delay Time
- t_d(off) = 252 ns

#### Fall Time
- t_f = 156 ns

#### Turn-on Switching Loss
- E_on = 2.5 mJ

#### Turn-off Switching Loss
- E_off = 1.08 mJ

#### Total Switching Loss
- E_ts = 3.58 mJ

#### Turn-on Delay Time
- T_J = 175°C  
  V_CC = 600 V, I_C = 40 A  
  R_g = 5 Ω  
  V_GE = 15 V  
  Inductive Load  
  t_d(on) = 44 ns

#### Rise Time
- t_r = 32 ns

#### Turn-off Delay Time
- t_d(off) = 236 ns

#### Fall Time
- t_f = 164 ns

#### Turn-on Switching Loss
- E_on = 4.9 mJ

#### Turn-off Switching Loss
- E_off = 2.5 mJ

#### Total Switching Loss
- E_ts = 7.4 mJ

#### Total Gate Charge
- V_CE = 600 V, I_C = 40 A, V_GE = 15 V  
  Q_g = 395 nC

#### Gate to Emitter Charge
- Q_ge = 72 nC

#### Gate to collector Charge
- Q_gc = 198 nC

### DIODE CHARACTERISTICS

#### Forward Voltage
- I_F = 40 A, T_J = 25°C  
  V_F = 1.51 V

#### Reverse Recovery Energy
- T_R = 25°C  
  V_R = 600 V, I_F = 20 A  
  dI_F/dt = 1000 A/μs  
  E_rec = 0.74 mJ

#### Diode Reverse Recovery Time
- T_rr = 143 ns

#### Diode Reverse Recovery Charge
- Q_rr = 2546 nC

---

www.onsemi.com

3
### ELECTRICAL CHARACTERISTICS  
(T<sub>J</sub> = 25°C unless otherwise specified) (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
</table>
| Reverse Recovery Energy            | T<sub>J</sub> = 25°C  
VR = 600 V, IF = 40 A  
dI<sub>P</sub>/dt = 1000 A/μs | E<sub>rec</sub> | –    | 1.14 | –    | mJ   |
| Diode Reverse Recovery Time        |                                                                                 | T<sub>rr</sub> | –    | 195  | –    | ns   |
| Diode Reverse Recovery Charge      |                                                                                 | Q<sub>rr</sub> | –    | 3761 | –    | nC   |
| Reverse Recovery Energy            | T<sub>J</sub> = 175°C  
VR = 600 V, IF = 20 A  
dI<sub>P</sub>/dt = 1000 A/μs | E<sub>rec</sub> | –    | 1.92 | –    | mJ   |
| Diode Reverse Recovery Time        |                                                                                 | T<sub>rr</sub> | –    | 212  | –    | ns   |
| Diode Reverse Recovery Charge      |                                                                                 | Q<sub>rr</sub> | –    | 5242 | –    | nC   |
| Reverse Recovery Energy            | T<sub>J</sub> = 175°C  
VR = 600 V, IF = 40 A  
dI<sub>P</sub>/dt = 1000 A/μs | E<sub>rec</sub> | –    | 2.768 | –    | mJ   |
| Diode Reverse Recovery Time        |                                                                                 | T<sub>rr</sub> | –    | 286  | –    | ns   |
| Diode Reverse Recovery Charge      |                                                                                 | Q<sub>rr</sub> | –    | 7321 | –    | 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.
AFGHL40T120RLD

TYPICAL CHARACTERISTICS (continued)

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
AFGHL40T120RLD

TYPICAL CHARACTERISTICS (continued)

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 Time

Figure 18. Stored Charge
Figure 19. Transient Thermal Impedance of IGBT

Figure 20. Transient Thermal Impedance of Diode
Figure 21. Test Circuit for Switching Characteristics

Figure 22. Definition of Turn On Waveform
Figure 23. Definition of Turn Off Waveform
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.

**DOCUMENT NUMBER:** 98AON93302G
**DESCRIPTION:** TO-247-3LD

Electronic versions are uncontrolled except when accessed directly from the Document Repository.
Printed versions are uncontrolled except when stamped “CONTROLLED COPY” in red.