

# IGBT - Ultra Field Stop

## FGH40T120SQDNL4

This Insulated Gate Bipolar Transistor (IGBT) features a robust and cost effective Ultra Field Stop Trench construction, and provides superior performance in demanding switching applications, offering both low on-state voltage and minimal switching loss. The IGBT is well suited for UPS and solar applications. Incorporated into the device is a soft and fast co-packaged free wheeling diode with a low forward voltage.

### Features

- Extremely Efficient Trench with Field Stop Technology
- $T_{Jmax} = 175^{\circ}C$
- Soft Fast Reverse Recovery Diode
- Optimized for High Speed Switching
- These are Pb-Free Devices

### Typical Applications

- Solar Inverter
- Uninterruptible Power Inverter Supplies (UPS)
- Welding

### ABSOLUTE MAXIMUM RATINGS

| Rating                                                                                        | Symbol    | Value                | Unit        |
|-----------------------------------------------------------------------------------------------|-----------|----------------------|-------------|
| Collector-emitter voltage                                                                     | $V_{CES}$ | 1200                 | V           |
| Collector current<br>@ $T_c = 25^{\circ}C$<br>@ $T_c = 100^{\circ}C$                          | $I_C$     | 160<br>40            | A           |
| Pulsed collector current, $T_{pulse}$ limited by $T_{Jmax}$                                   | $I_{CM}$  | 160                  | A           |
| Diode forward current<br>@ $T_c = 25^{\circ}C$<br>@ $T_c = 100^{\circ}C$                      | $I_F$     | 160<br>40            | A           |
| Diode pulsed current, $T_{pulse}$ limited by $T_{Jmax}$                                       | $I_{FM}$  | 160                  | A           |
| Gate-emitter voltage<br>Transient gate-emitter voltage<br>( $T_{pulse} = 5 \mu s, D < 0.10$ ) | $V_{GE}$  | $\pm 20$<br>$\pm 30$ | V           |
| Power Dissipation<br>@ $T_c = 25^{\circ}C$<br>@ $T_c = 100^{\circ}C$                          | $P_D$     | 454<br>227           | W           |
| Operating junction temperature range                                                          | $T_J$     | -55 to +175          | $^{\circ}C$ |
| Storage temperature range                                                                     | $T_{stg}$ | -55 to +175          | $^{\circ}C$ |
| Lead temperature for soldering, 1/8" from case for 5 seconds                                  | $T_{SLD}$ | 260                  | $^{\circ}C$ |

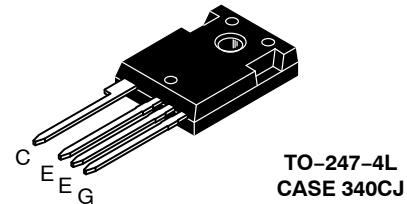
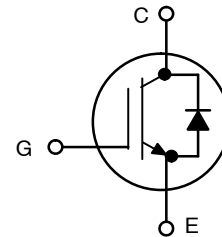
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.



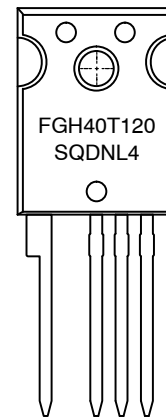
**ON Semiconductor**<sup>®</sup>

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

**40 A, 1200 V**  
 **$V_{CEsat} = 1.7 V$**   
 **$E_{off} = 1.1 mJ$**



### MARKING DIAGRAM



### ORDERING INFORMATION

| Device          | Package          | Shipping        |
|-----------------|------------------|-----------------|
| FGH40T120SQDNL4 | TO-247 (Pb-Free) | 30 Units / Rail |

# FGH40T120SQDNL4

## THERMAL CHARACTERISTICS

| Rating                                         | Symbol          | Value | Unit                        |
|------------------------------------------------|-----------------|-------|-----------------------------|
| Thermal resistance junction-to-case, for IGBT  | $R_{\theta JC}$ | 0.33  | $^{\circ}\text{C}/\text{W}$ |
| Thermal resistance junction-to-case, for Diode | $R_{\theta JC}$ | 0.61  | $^{\circ}\text{C}/\text{W}$ |
| Thermal resistance junction-to-ambient         | $R_{\theta JA}$ | 40    | $^{\circ}\text{C}/\text{W}$ |

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

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

### STATIC CHARACTERISTIC

|                                                                   |                                                                                                                           |               |               |             |           |    |
|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------|---------------|-------------|-----------|----|
| Collector-emitter breakdown voltage, gate-emitter short-circuited | $V_{GE} = 0\text{ V}, I_C = 500\ \mu\text{A}$                                                                             | $V_{(BR)CES}$ | 1200<br>1250* | -           | -         | V  |
| Collector-emitter saturation voltage                              | $V_{GE} = 15\text{ V}, I_C = 40\text{ A}$<br>$V_{GE} = 15\text{ V}, I_C = 40\text{ A}, T_J = 175^{\circ}\text{C}$         | $V_{CEsat}$   | -<br>-        | 1.78<br>2.3 | 1.95<br>- | V  |
| Gate-emitter threshold voltage                                    | $V_{GE} = V_{CE}, I_C = 400\ \mu\text{A}$                                                                                 | $V_{GE(th)}$  | 4.5           | 5.5         | 6.5       | V  |
| Collector-emitter cut-off current, gate-emitter short-circuited   | $V_{GE} = 0\text{ V}, V_{CE} = 1200\text{ V}$<br>$V_{GE} = 0\text{ V}, V_{CE} = 1200\text{ V}, T_J = 175^{\circ}\text{C}$ | $I_{CES}$     | -<br>-        | -<br>0.6    | 0.4<br>-  | mA |
| Gate leakage current, collector-emitter short-circuited           | $V_{GE} = 20\text{ V}, V_{CE} = 0\text{ V}$                                                                               | $I_{GES}$     | -             | -           | 200       | nA |

\* Guaranteed by design.

|                              |                                                                  |           |   |      |   |    |
|------------------------------|------------------------------------------------------------------|-----------|---|------|---|----|
| Input capacitance            | $V_{CE} = 20\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$    | $C_{ies}$ | - | 5000 | - | pF |
| Output capacitance           |                                                                  | $C_{oes}$ | - | 140  | - |    |
| Reverse transfer capacitance |                                                                  | $C_{res}$ | - | 80   | - |    |
| Gate charge total            | $V_{CE} = 600\text{ V}, I_C = 40\text{ A}, V_{GE} = 15\text{ V}$ | $Q_g$     | - | 221  | - | nC |
| Gate to emitter charge       |                                                                  | $Q_{ge}$  | - | 52   | - |    |
| Gate to collector charge     |                                                                  | $Q_{gc}$  | - | 100  | - |    |

### SWITCHING CHARACTERISTIC, INDUCTIVE LOAD

|                         |                                                                                                                                       |              |       |     |     |    |    |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------|-------|-----|-----|----|----|
| Turn-on delay time      | $T_J = 25^{\circ}\text{C}$<br>$V_{CC} = 600\text{ V}, I_C = 40\text{ A}$<br>$R_g = 10\ \Omega$<br>$V_{GE} = 0\text{ to }15\text{ V}$  | $t_{d(on)}$  | -     | 46  | -   | ns |    |
| Rise time               |                                                                                                                                       | $t_r$        | -     | 33  | -   |    |    |
| Turn-off delay time     |                                                                                                                                       | $t_{d(off)}$ | -     | 220 | -   |    |    |
| Fall time               |                                                                                                                                       |              | $t_f$ | -   | 56  | -  | mJ |
| Turn-on switching loss  |                                                                                                                                       | $E_{on}$     | -     | 1.4 | -   |    |    |
| Turn-off switching loss |                                                                                                                                       | $E_{off}$    | -     | 1.1 | -   |    |    |
| Total switching loss    |                                                                                                                                       | $E_{ts}$     | -     | 2.5 | -   |    |    |
| Turn-on delay time      | $T_J = 175^{\circ}\text{C}$<br>$V_{CC} = 600\text{ V}, I_C = 40\text{ A}$<br>$R_g = 10\ \Omega$<br>$V_{GE} = 0\text{ to }15\text{ V}$ | $t_{d(on)}$  | -     | 47  | -   | ns |    |
| Rise time               |                                                                                                                                       | $t_r$        | -     | 33  | -   |    |    |
| Turn-off delay time     |                                                                                                                                       | $t_{d(off)}$ | -     | 240 | -   |    |    |
| Fall time               |                                                                                                                                       |              | $t_f$ | -   | 132 | -  | mJ |
| Turn-on switching loss  |                                                                                                                                       | $E_{on}$     | -     | 2.7 | -   |    |    |
| Turn-off switching loss |                                                                                                                                       | $E_{off}$    | -     | 1.8 | -   |    |    |
| Total switching loss    |                                                                                                                                       | $E_{ts}$     | -     | 4.5 | -   |    |    |

### DIODE CHARACTERISTIC

|                          |                                                                                                                 |           |        |            |          |               |
|--------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|--------|------------|----------|---------------|
| Forward voltage          | $V_{GE} = 0\text{ V}, I_F = 40\text{ A}$<br>$V_{GE} = 0\text{ V}, I_F = 40\text{ A}, T_J = 175^{\circ}\text{C}$ | $V_F$     | -<br>- | 3.4<br>3.1 | 3.8<br>- | V             |
| Reverse recovery time    | $T_J = 25^{\circ}\text{C}$<br>$I_F = 40\text{ A}, V_R = 400\text{ V}$<br>$di_F/dt = 500\text{ A}/\mu\text{s}$   | $t_{rr}$  | -      | 166        | -        | ns            |
| Reverse recovery charge  |                                                                                                                 | $Q_{rr}$  | -      | 0.78       | -        | $\mu\text{C}$ |
| Reverse recovery current |                                                                                                                 | $I_{rrm}$ | -      | 9.0        | -        | A             |
| Reverse recovery time    | $T_J = 125^{\circ}\text{C}$<br>$I_F = 40\text{ A}, V_R = 400\text{ V}$<br>$di_F/dt = 500\text{ A}/\mu\text{s}$  | $t_{rr}$  | -      | 390        | -        | ns            |
| Reverse recovery charge  |                                                                                                                 | $Q_{rr}$  | -      | 4.0        | -        | $\mu\text{C}$ |
| Reverse recovery current |                                                                                                                 | $I_{rrm}$ | -      | 20         | -        | 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.

# FGH40T120SQDNL4

## TYPICAL CHARACTERISTICS

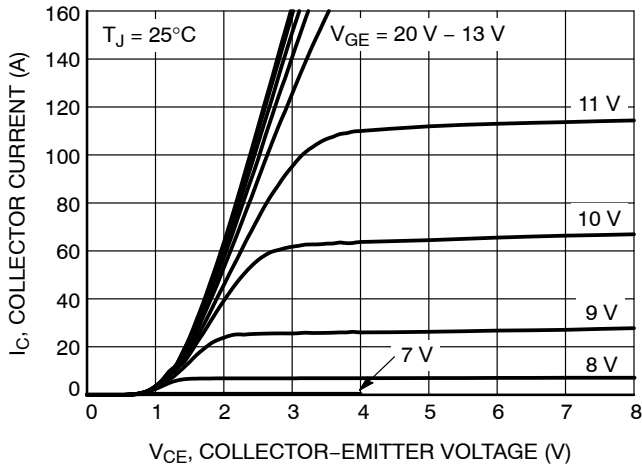


Figure 1. Output Characteristics

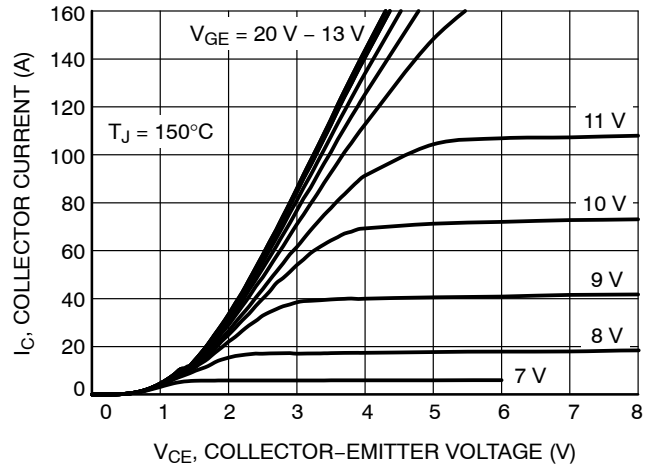


Figure 2. Output Characteristics

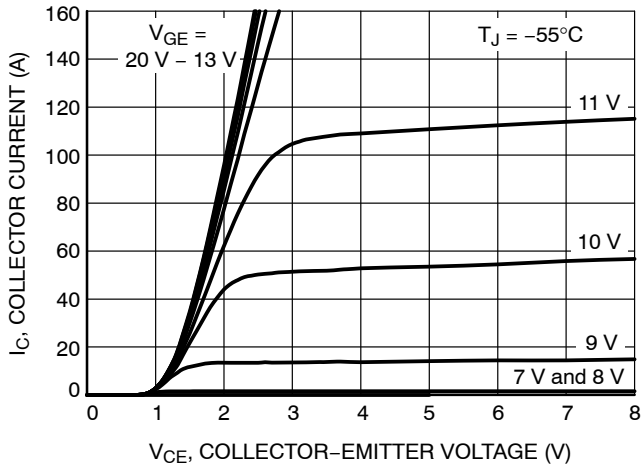


Figure 3. Output Characteristics

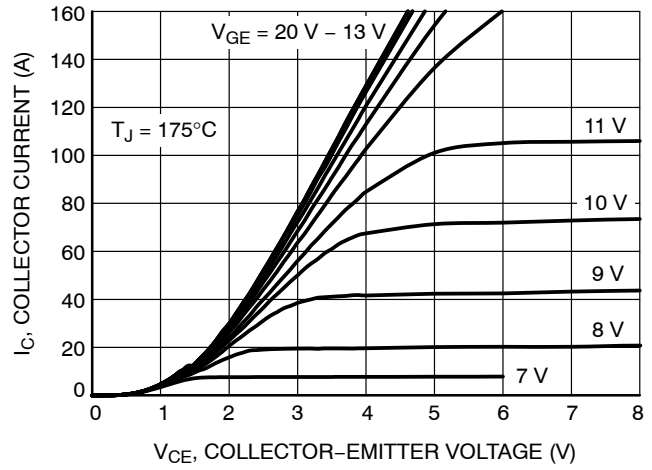


Figure 4. Output Characteristics

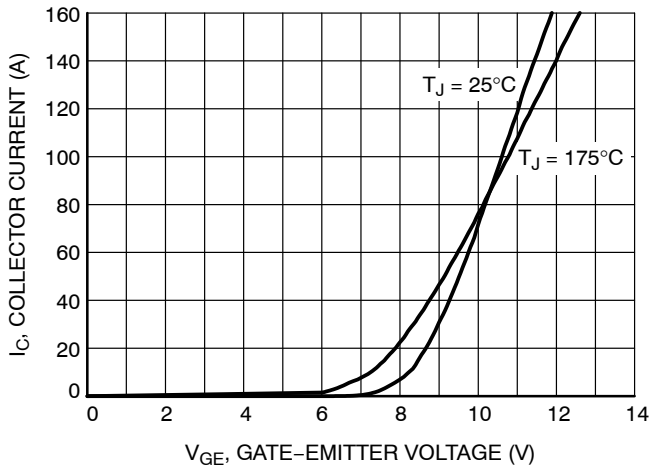


Figure 5. Typical Transfer Characteristics

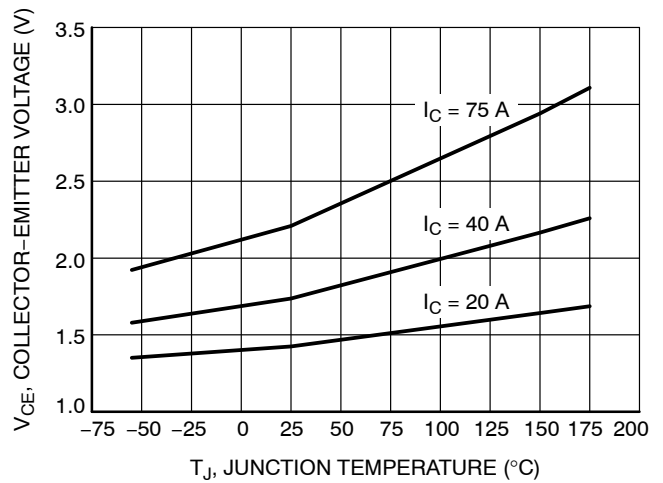


Figure 6.  $V_{CE(sat)}$  vs.  $T_J$

# FGH40T120SQDNL4

## TYPICAL CHARACTERISTICS

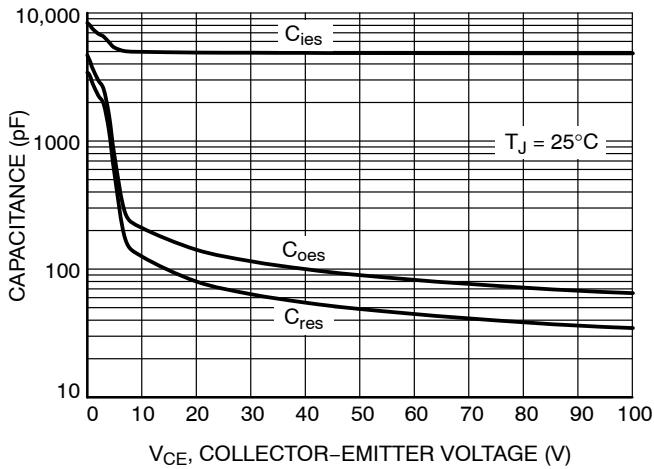


Figure 7. Typical Capacitance

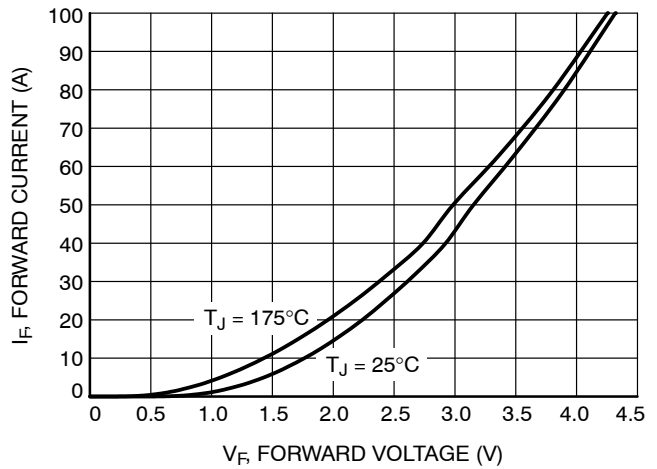


Figure 8. Diode Forward Characteristics

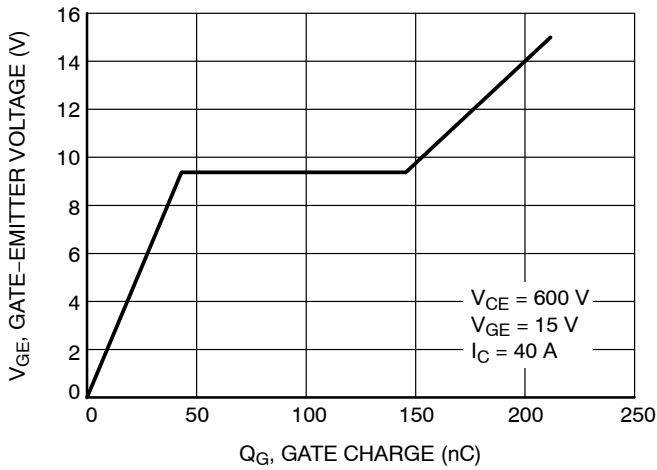


Figure 9. Typical Gate Charge

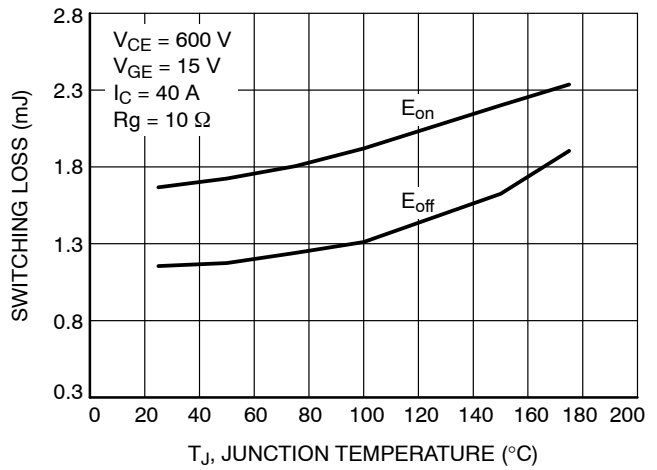


Figure 10. Switching Loss vs. Temperature

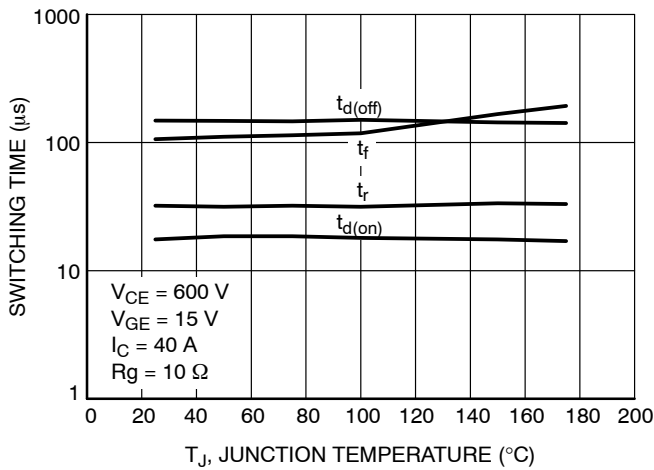


Figure 11. Switching Time vs. Temperature

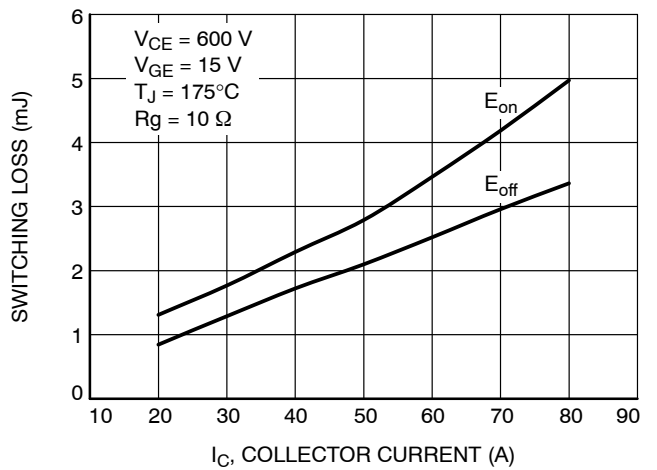


Figure 12. Switching Loss vs. IC

# FGH40T120SQDNL4

## TYPICAL CHARACTERISTICS

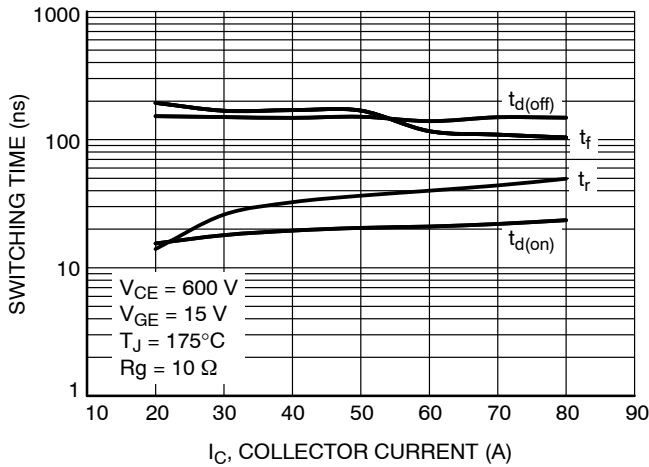


Figure 13. Switching Time vs.  $I_C$

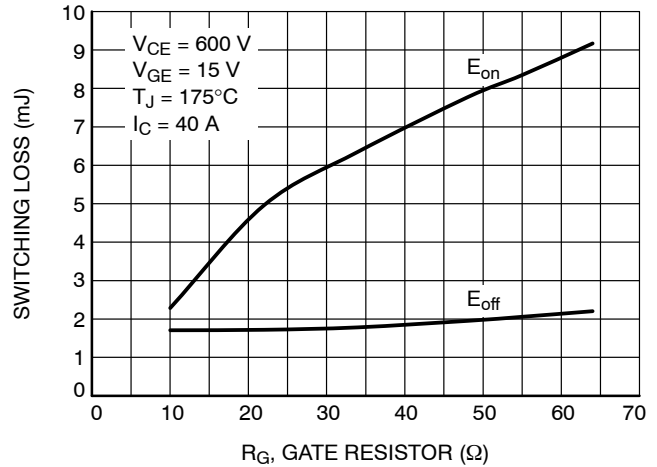


Figure 14. Switching Loss vs.  $R_G$

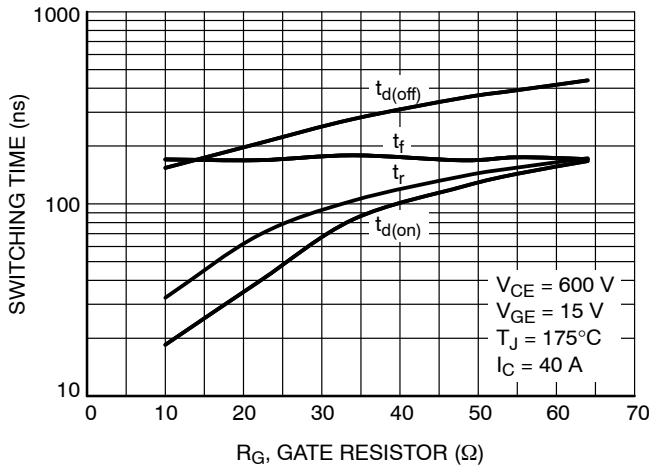


Figure 15. Switching Time vs.  $R_G$

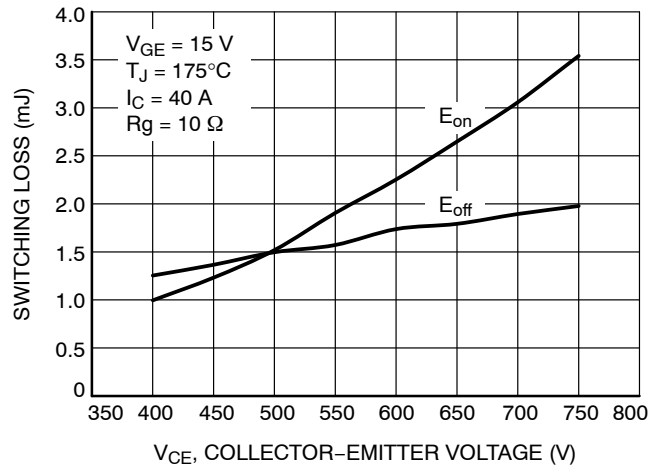


Figure 16. Switching Loss vs.  $V_{CE}$

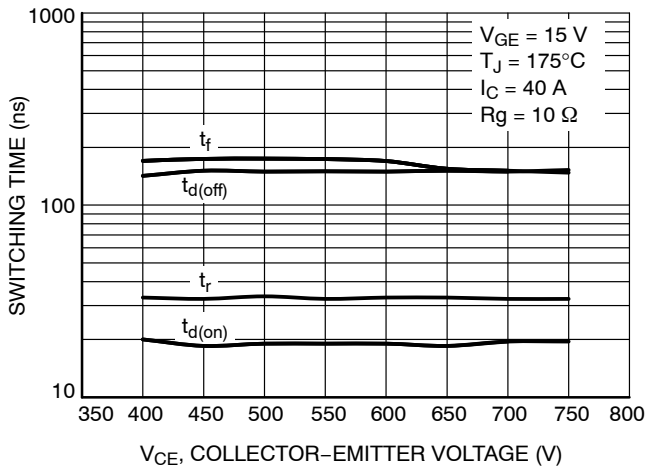


Figure 17. Switching Time vs.  $V_{CE}$

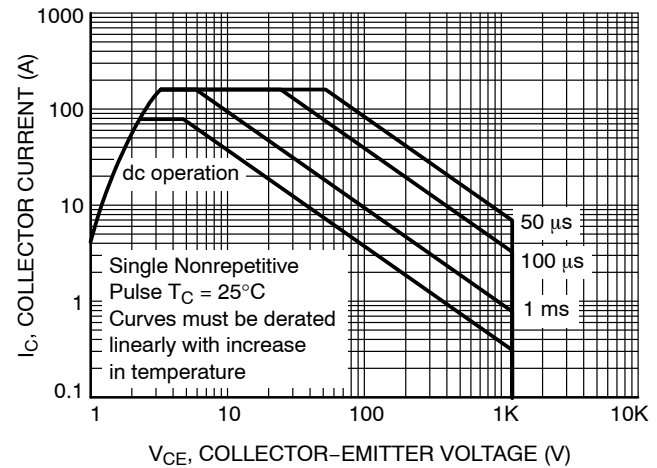


Figure 18. Safe Operating Area

# FGH40T120SQDNL4

## TYPICAL CHARACTERISTICS

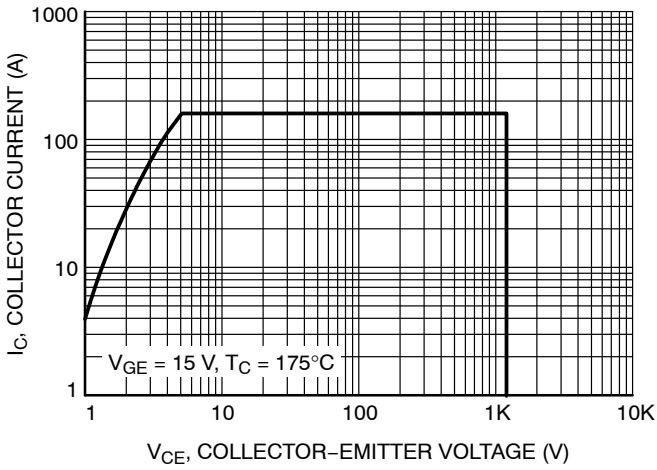


Figure 19. Reverse Bias Safe Operating Area

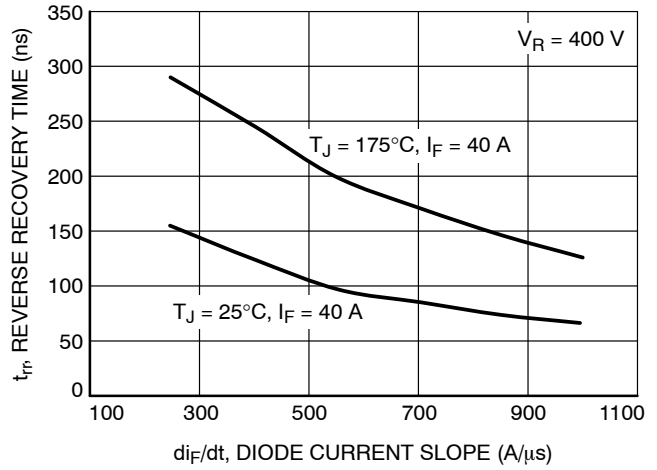


Figure 20.  $t_{rr}$  vs.  $di_F/dt$

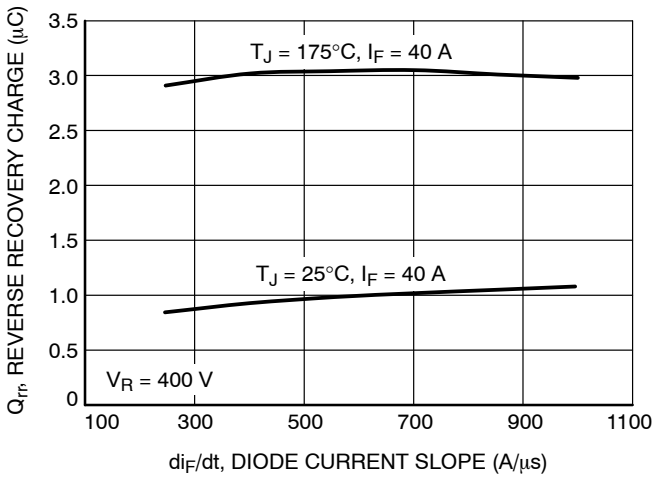


Figure 21.  $Q_{rr}$  vs.  $di_F/dt$

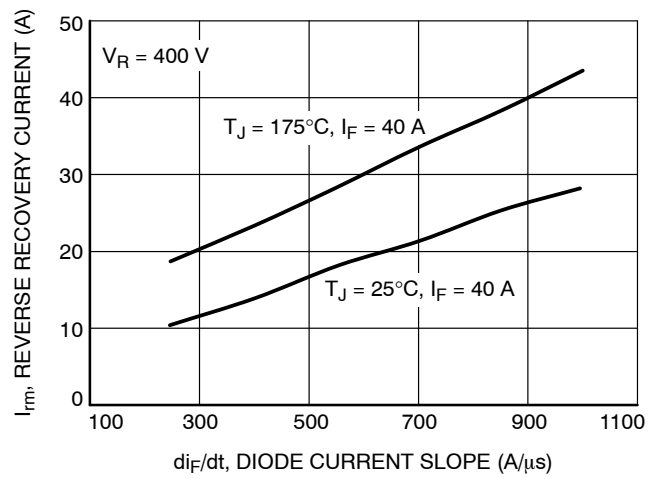


Figure 22.  $I_{rrm}$  vs.  $di_F/dt$

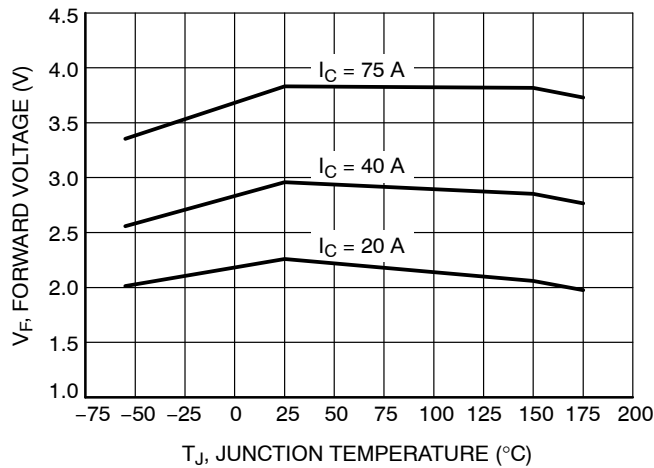


Figure 23.  $V_F$  vs.  $T_J$

# FGH40T120SQDNL4

## TYPICAL CHARACTERISTICS

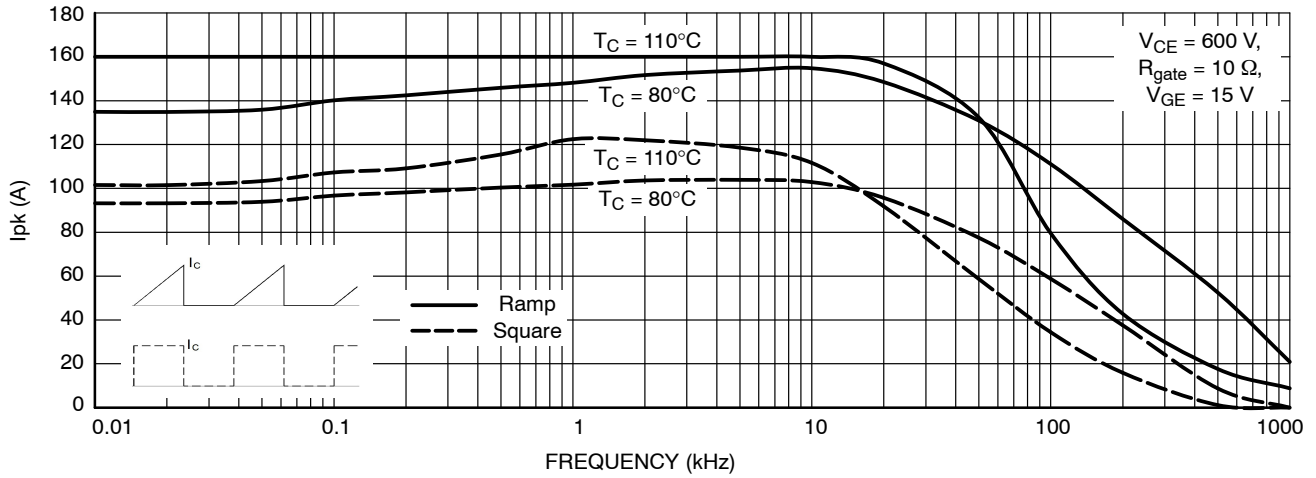


Figure 24. Collector Current vs. Switching Frequency

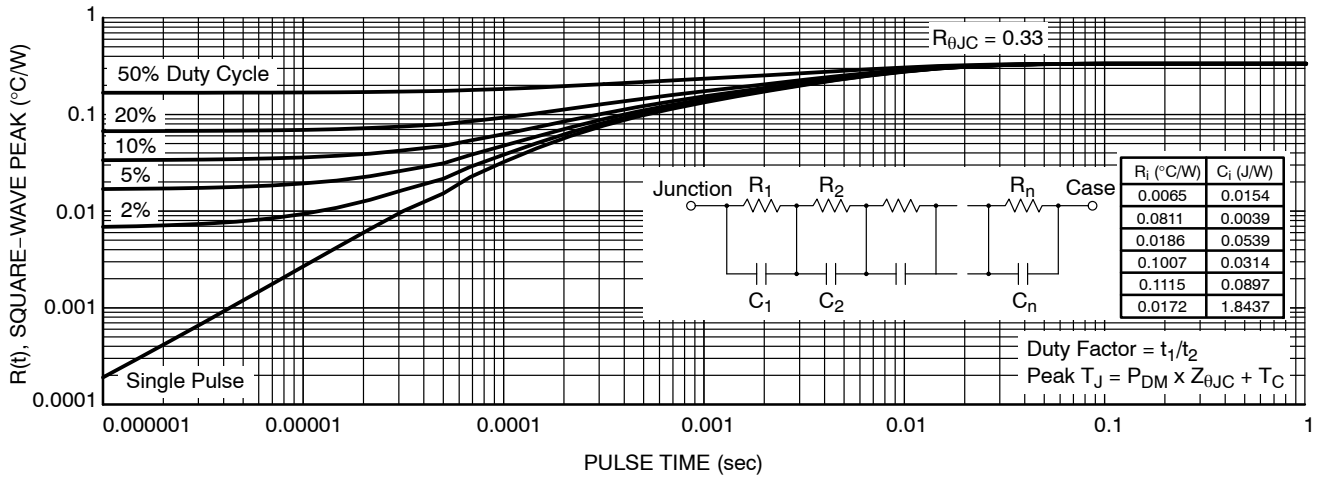


Figure 25. IGBT Transient Thermal Impedance

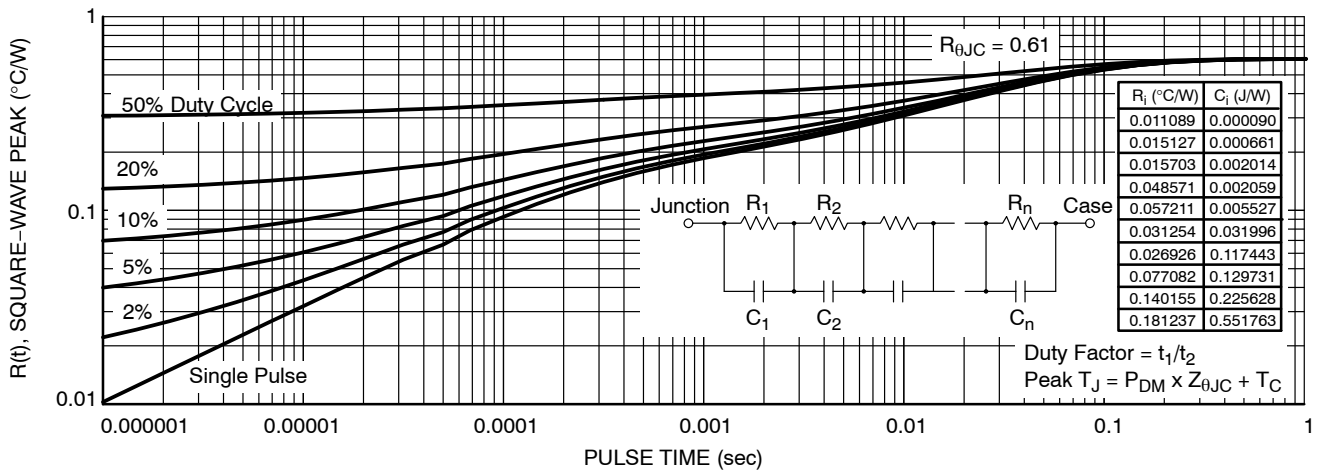


Figure 26. Diode Transient Thermal Impedance

# FGH40T120SQDNL4



Figure 27. Test Circuit for Switching Characteristics

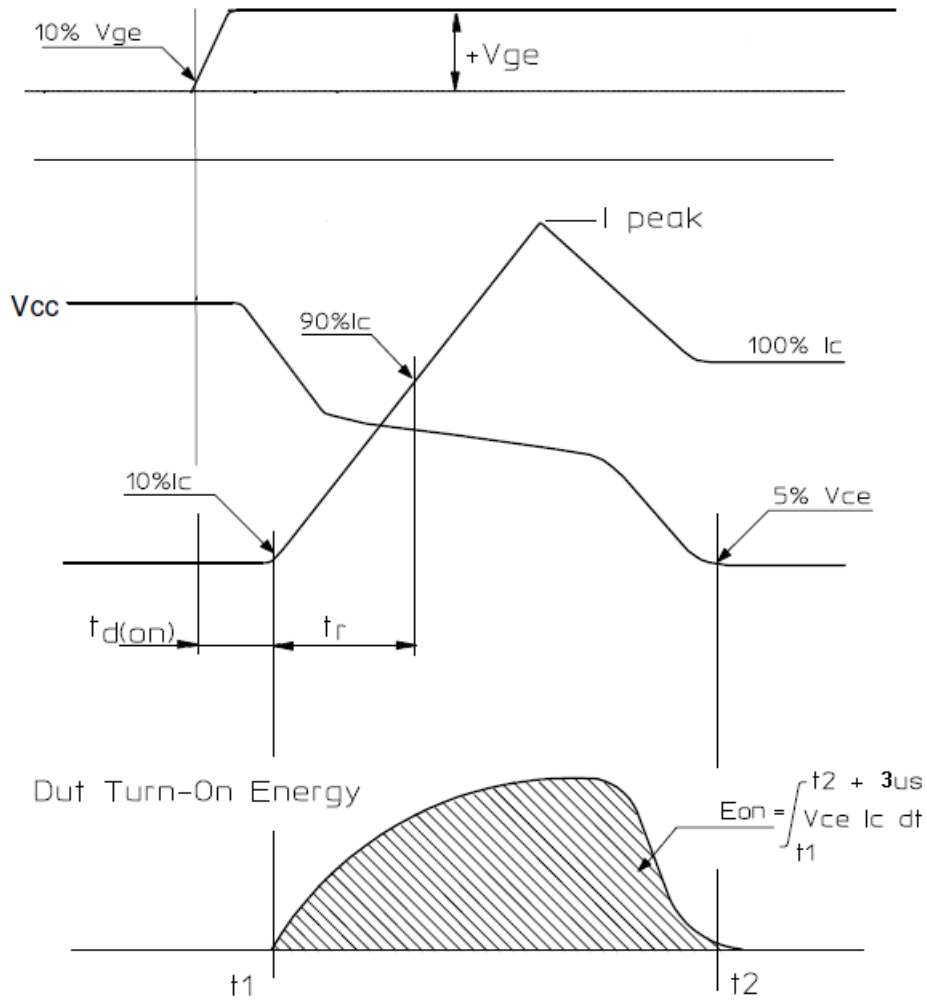


Figure 28. Definition of Turn On Waveform





Figure 29. Definition of Turn Off Waveform

# MECHANICAL CASE OUTLINE

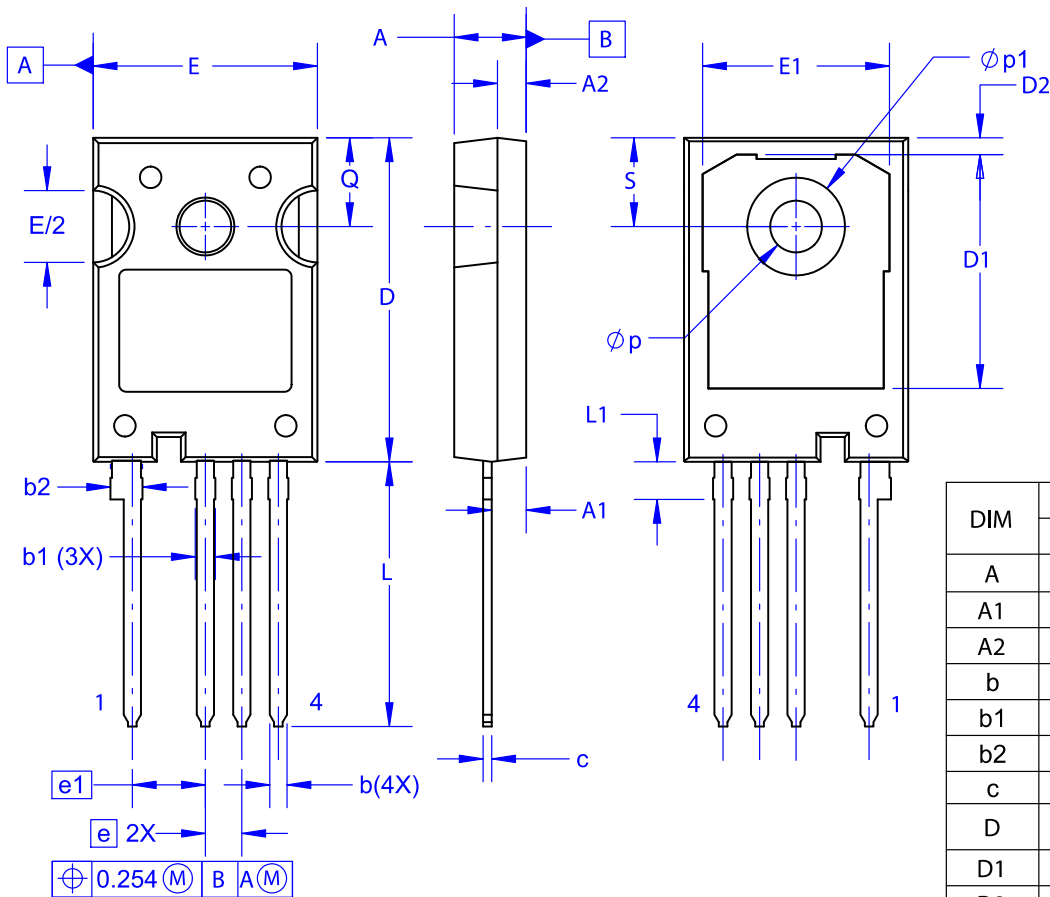
## PACKAGE DIMENSIONS

ON Semiconductor®



TO-247-4LD  
CASE 340CJ  
ISSUE A

DATE 16 SEP 2019



| 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  |

**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.

|                         |                    |                                                                                                                                                                                  |
|-------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NUMBER:</b> | <b>98AON13852G</b> | Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| <b>DESCRIPTION:</b>     | <b>TO-247-4LD</b>  | <b>PAGE 1 OF 1</b>                                                                                                                                                               |

ON Semiconductor and are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. ON Semiconductor does not convey any license under its patent rights nor the rights of others.

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Email Requests to: [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

ON Semiconductor Website: [www.onsemi.com](http://www.onsemi.com)

### TECHNICAL SUPPORT

North American Technical Support:  
Voice Mail: 1 800-282-9855 Toll Free USA/Canada  
Phone: 011 421 33 790 2910

### Europe, Middle East and Africa Technical Support:

Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative