

# IGBT for Automotive Application

1200 V, 40 A



ON Semiconductor®

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## 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.

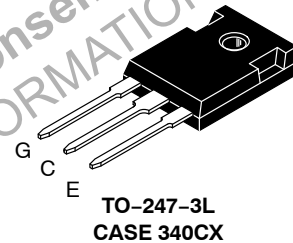
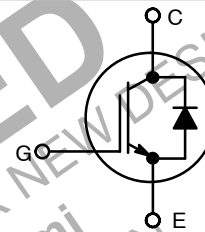
### Features

- Extremely Efficient Trench with Field Stop Technology
- Maximum Junction Temperature:  $T_J = 175^{\circ}\text{C}$
- Short Circuit Withstand Time 9  $\mu\text{s}$
- Low Saturation Voltage:  $V_{CE(\text{Sat})} = 1.75 \text{ V (Typ.) @ } I_C = 40 \text{ A}$
- 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

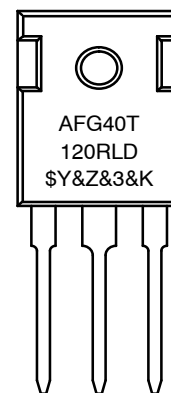
### Typical Applications

- Automotive HEV-EV E-Compressor
- Automotive HEV-EV PTC Heater
- Automotive HEV-EV Onboard Chargers
- Automotive HEV-EV DC-DC Converters

| $V_{CES}$ | $I_C$ | $V_{CE(\text{Sat})}$ |
|-----------|-------|----------------------|
| 1200 V    | 40 A  | 1.75 V (Typ.)        |



### MARKING DIAGRAM



|              |                                 |
|--------------|---------------------------------|
| AFG40T120RLD | = Specific Device Code          |
| \$Y          | = ON Semiconductor Logo         |
| &Z           | = Assembly Plant Code           |
| &3           | = 3-Digit Date Code             |
| &K           | = 2-Digit Lot Traceability Code |

### ORDERING INFORMATION

| Device         | Package   | Shipping        |
|----------------|-----------|-----------------|
| AFGHL40T120RLD | TO-247-3L | 30 Units / Rail |

# AFGHL40T120RLD

## MAXIMUM RATINGS

| Description                                                                                                  | Symbol         | Value           | Units            |
|--------------------------------------------------------------------------------------------------------------|----------------|-----------------|------------------|
| Collector to Emitter Voltage                                                                                 | $V_{CES}$      | 1200            | V                |
| Gate to Emitter Voltage                                                                                      | $V_{GES}$      | $\pm 20$        | V                |
| Transient Gate to Emitter Voltage                                                                            |                | $\pm 30$        |                  |
| Collector Current @ $T_C = 25^\circ\text{C}$ (Note 1)                                                        | $I_C$          | 48              | A                |
| Collector Current @ $T_C = 100^\circ\text{C}$                                                                |                | 40              |                  |
| Pulsed Collector Current (Note 2)                                                                            | $I_{LM}$       | 160             | A                |
| Pulsed Collector Current (Note 3)                                                                            | $I_{CM}$       | 160             | A                |
| Diode Forward Current @ $T_C = 25^\circ\text{C}$ (Note 1)                                                    | $I_F$          | 48              | A                |
| Diode Forward Current @ $T_C = 100^\circ\text{C}$                                                            |                | 40              |                  |
| Pulsed Diode Maximum Forward Current                                                                         | $I_{FM}$       | 160             | A                |
| Maximum Power Dissipation @ $T_C = 25^\circ\text{C}$                                                         | $P_D$          | 529             | W                |
| Maximum Power Dissipation @ $T_C = 100^\circ\text{C}$                                                        |                | 264             |                  |
| Short Circuit Withstand Time<br>$V_{GE} = 15\text{ V}$ , $V_{CE} = 600\text{ V}$ , $T_J = 150^\circ\text{C}$ | SCWT           | 9               | $\mu\text{s}$    |
| Operating Junction Temperature / Storage Temperature Range                                                   | $T_J, T_{STG}$ | $-55$ to $+175$ | $^\circ\text{C}$ |
| Maximum Lead Temp. For Soldering Purposes, $\frac{1}{8}$ " from case for 5 seconds                           | $T_L$          | 260             | $^\circ\text{C}$ |

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. Value limited by bond wire.
2.  $V_{CC} = 600\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 160\text{ A}$ ,  $R_G = 15\ \Omega$ , Inductive Load, 100% Tested
3. Repetitive rating: pulse width limited by max. Junction temperature.

## THERMAL CHARACTERISTICS

| Rating                                              | Symbol          | Max. | Units              |
|-----------------------------------------------------|-----------------|------|--------------------|
| Thermal Resistance, Junction to Case, for IGBT      | $R_{\theta JC}$ | 0.28 | $^\circ\text{C/W}$ |
| Thermal Resistance, Junction to Case, Max for Diode | $R_{\theta JC}$ | 0.47 | $^\circ\text{C/W}$ |
| Thermal Resistance, Junction to Ambient, Max        | $R_{\theta JA}$ | 40   | $^\circ\text{C/W}$ |

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

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

### OFF CHARACTERISTICS

|                                                                      |                                             |                                |      |     |           |                           |
|----------------------------------------------------------------------|---------------------------------------------|--------------------------------|------|-----|-----------|---------------------------|
| Collector-emitter Breakdown Voltage,<br>Gate-emitter Short-circuited | $V_{GE} = 0\text{ V}$ , $I_C = 1\text{ mA}$ | $BV_{CES}$                     | 1250 | –   | –         | V                         |
| Temperature Coefficient of Breakdown Voltage                         | $V_{GE} = 0\text{ V}$ , $I_C = 1\text{ mA}$ | $\Delta BV_{CES} / \Delta T_J$ | –    | 1.4 | –         | $\text{V}/^\circ\text{C}$ |
| Collector-emitter Cut-off Current,<br>Gate-emitter Short-circuited   | $V_{GE} = 0\text{ V}$ , $V_{CE} = V_{CES}$  | $I_{CES}$                      | –    | –   | 40        | $\mu\text{A}$             |
| Gate Leakage Current,<br>Collector-emitter Short-circuited           | $V_{GE} = V_{GES}$ , $V_{CE} = 0\text{ V}$  | $I_{GES}$                      | –    | –   | $\pm 400$ | nA                        |

### ON CHARACTERISTICS

|                                      |                                                                                                                          |               |     |              |          |   |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------|-----|--------------|----------|---|
| Gate-emitter Threshold Voltage       | $V_{GE} = V_{CE}$ , $I_C = 40\text{ mA}$                                                                                 | $V_{GE(th)}$  | 5.3 | 6.3          | 7.3      | V |
| Collector-emitter Saturation Voltage | $V_{GE} = 15\text{ V}$ , $I_C = 40\text{ A}$<br>$V_{GE} = 15\text{ V}$ , $I_C = 40\text{ A}$ , $T_J = 175^\circ\text{C}$ | $V_{CE(sat)}$ | –   | 1.75<br>2.09 | 2.1<br>– | V |

# AFGHL40T120RLD

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

| Parameter                      | Test Conditions                                                     | Symbol    | Min. | Typ. | Max. | Unit |
|--------------------------------|---------------------------------------------------------------------|-----------|------|------|------|------|
| <b>DYNAMIC CHARACTERISTICS</b> |                                                                     |           |      |      |      |      |
| Input Capacitance              | $V_{CE} = 30\text{ V}$ , $V_{GE} = 0\text{ V}$ , $f = 1\text{ MHz}$ | $C_{ies}$ | –    | 8755 | –    | pF   |
| Output Capacitance             |                                                                     | $C_{oes}$ | –    | 302  | –    |      |
| Reverse Transfer Capacitance   |                                                                     | $C_{res}$ | –    | 162  | –    |      |

## SWITCHING CHARACTERISTICS, INDUCTIVE LOAD

|                          |                                                                                                                                             |              |   |      |   |    |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|--------------|---|------|---|----|
| Turn-on Delay Time       | $T_J = 25^\circ\text{C}$<br>$V_{CC} = 600\text{ V}$ , $I_C = 20\text{ A}$<br>$R_g = 5\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load  | $t_{d(on)}$  | – | 43   | – | ns |
| Rise Time                |                                                                                                                                             | $t_r$        | – | 18   | – |    |
| Turn-off Delay Time      |                                                                                                                                             | $t_{d(off)}$ | – | 222  | – |    |
| Fall Time                |                                                                                                                                             | $t_f$        | – | 53   | – |    |
| Turn-on Switching Loss   |                                                                                                                                             | $E_{on}$     | – | 1.6  | – | mJ |
| Turn-off Switching Loss  |                                                                                                                                             | $E_{off}$    | – | 0.45 | – |    |
| Total Switching Loss     |                                                                                                                                             | $E_{ts}$     | – | 2.05 | – |    |
| Turn-on Delay Time       | $T_J = 25^\circ\text{C}$<br>$V_{CC} = 600\text{ V}$ , $I_C = 40\text{ A}$<br>$R_g = 5\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load  | $t_{d(on)}$  | – | 48   | – | ns |
| Rise Time                |                                                                                                                                             | $t_r$        | – | 32   | – |    |
| Turn-off Delay Time      |                                                                                                                                             | $t_{d(off)}$ | – | 208  | – |    |
| Fall Time                |                                                                                                                                             | $t_f$        | – | 68   | – |    |
| Turn-on Switching Loss   |                                                                                                                                             | $E_{on}$     | – | 3.4  | – | mJ |
| Turn-off Switching Loss  |                                                                                                                                             | $E_{off}$    | – | 1.2  | – |    |
| Total Switching Loss     |                                                                                                                                             | $E_{ts}$     | – | 4.6  | – |    |
| Turn-on Delay Time       | $T_J = 175^\circ\text{C}$<br>$V_{CC} = 600\text{ V}$ , $I_C = 20\text{ A}$<br>$R_g = 5\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load | $t_{d(on)}$  | – | 40   | – | ns |
| Rise Time                |                                                                                                                                             | $t_r$        | – | 20   | – |    |
| Turn-off Delay Time      |                                                                                                                                             | $t_{d(off)}$ | – | 252  | – |    |
| Fall Time                |                                                                                                                                             | $t_f$        | – | 156  | – |    |
| Turn-on Switching Loss   |                                                                                                                                             | $E_{on}$     | – | 2.5  | – | mJ |
| Turn-off Switching Loss  |                                                                                                                                             | $E_{off}$    | – | 1.08 | – |    |
| Total Switching Loss     |                                                                                                                                             | $E_{ts}$     | – | 3.58 | – |    |
| Turn-on Delay Time       | $T_J = 175^\circ\text{C}$<br>$V_{CC} = 600\text{ V}$ , $I_C = 40\text{ A}$<br>$R_g = 5\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load | $t_{d(on)}$  | – | 44   | – | ns |
| Rise Time                |                                                                                                                                             | $t_r$        | – | 32   | – |    |
| Turn-off Delay Time      |                                                                                                                                             | $t_{d(off)}$ | – | 236  | – |    |
| Fall Time                |                                                                                                                                             | $t_f$        | – | 164  | – |    |
| Turn-on Switching Loss   |                                                                                                                                             | $E_{on}$     | – | 4.9  | – | mJ |
| Turn-off Switching Loss  |                                                                                                                                             | $E_{off}$    | – | 2.5  | – |    |
| Total Switching Loss     |                                                                                                                                             | $E_{ts}$     | – | 7.4  | – |    |
| Total Gate Charge        | $V_{CE} = 600\text{ V}$ , $I_C = 40\text{ A}$ , $V_{GE} = 15\text{ V}$                                                                      | $Q_g$        | – | 395  | – | nC |
| Gate to Emitter Charge   |                                                                                                                                             | $Q_{ge}$     | – | 72   | – |    |
| Gate to collector Charge |                                                                                                                                             | $Q_{gc}$     | – | 198  | – |    |

## DIODE CHARACTERISTICS

|                               |                                                                                                                 |           |        |              |     |    |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|--------|--------------|-----|----|
| Forward Voltage               | $I_F = 40\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$I_F = 40\text{ A}$ , $T_J = 175^\circ\text{C}$               | $V_F$     | –<br>– | 1.51<br>1.54 | 2.0 | V  |
| Reverse Recovery Energy       | $T_J = 25^\circ\text{C}$<br>$V_R = 600\text{ V}$ , $I_F = 20\text{ A}$<br>$di_F/dt = 1000\text{ A}/\mu\text{s}$ | $E_{rec}$ | –      | 0.74         | –   | mJ |
| Diode Reverse Recovery Time   |                                                                                                                 | $T_{rr}$  | –      | 143          | –   | ns |
| Diode Reverse Recovery Charge |                                                                                                                 | $Q_{rr}$  | –      | 2546         | –   | nC |

# AFGHL40T120RLD

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

| Parameter                     | Test Conditions                                                                                                  | Symbol           | Min. | Typ.  | Max. | Unit |
|-------------------------------|------------------------------------------------------------------------------------------------------------------|------------------|------|-------|------|------|
| <b>DIODE CHARACTERISTICS</b>  |                                                                                                                  |                  |      |       |      |      |
| Reverse Recovery Energy       | $T_J = 25^\circ\text{C}$<br>$V_R = 600\text{ V}$ , $I_F = 40\text{ A}$<br>$dI_F/dt = 1000\text{ A}/\mu\text{s}$  | $E_{\text{rec}}$ | –    | 1.14  | –    | mJ   |
| Diode Reverse Recovery Time   |                                                                                                                  | $T_{\text{rr}}$  | –    | 195   | –    | ns   |
| Diode Reverse Recovery Charge |                                                                                                                  | $Q_{\text{rr}}$  | –    | 3761  | –    | nC   |
| Reverse Recovery Energy       | $T_J = 175^\circ\text{C}$<br>$V_R = 600\text{ V}$ , $I_F = 20\text{ A}$<br>$dI_F/dt = 1000\text{ A}/\mu\text{s}$ | $E_{\text{rec}}$ | –    | 1.92  | –    | mJ   |
| Diode Reverse Recovery Time   |                                                                                                                  | $T_{\text{rr}}$  | –    | 212   | –    | ns   |
| Diode Reverse Recovery Charge |                                                                                                                  | $Q_{\text{rr}}$  | –    | 5242  | –    | nC   |
| Reverse Recovery Energy       | $T_J = 175^\circ\text{C}$<br>$V_R = 600\text{ V}$ , $I_F = 40\text{ A}$<br>$dI_F/dt = 1000\text{ A}/\mu\text{s}$ | $E_{\text{rec}}$ | –    | 2.768 | –    | mJ   |
| Diode Reverse Recovery Time   |                                                                                                                  | $T_{\text{rr}}$  | –    | 286   | –    | ns   |
| Diode Reverse Recovery Charge |                                                                                                                  | $Q_{\text{rr}}$  | –    | 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.

**DISCONTINUED**  
THIS DEVICE IS NOT RECOMMENDED FOR NEW DESIGN  
PLEASE CONTACT YOUR onsemi  
REPRESENTATIVE FOR INFORMATION

TYPICAL CHARACTERISTICS

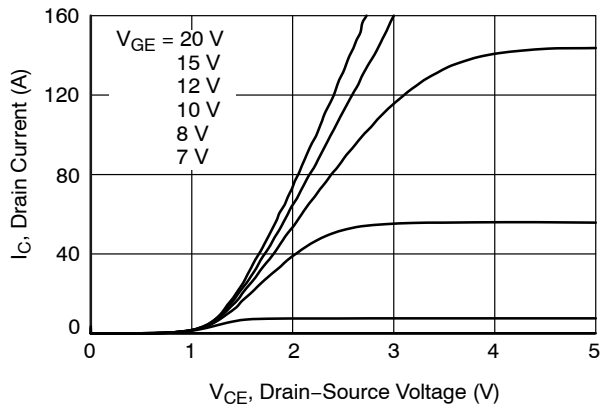


Figure 1. Typical Output Characteristics (25°C)

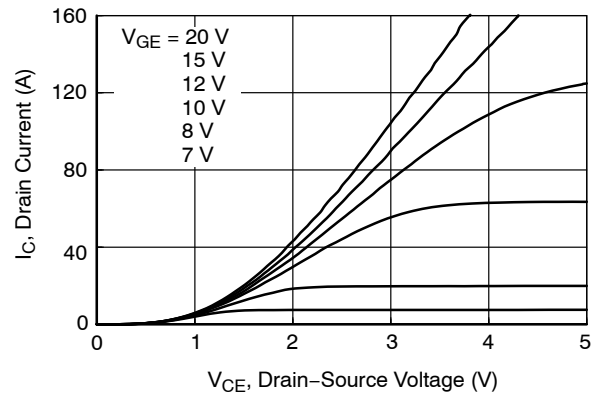


Figure 2. Typical Output Characteristics (175°C)

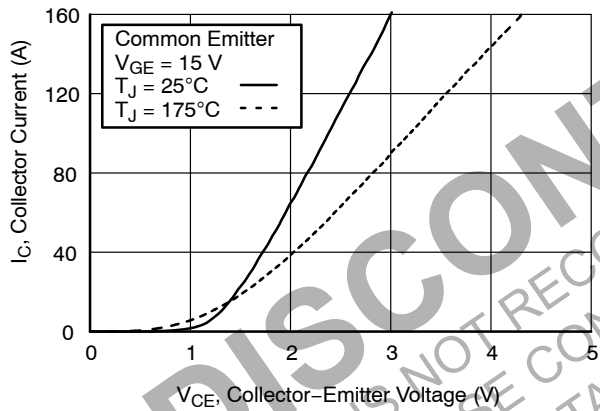


Figure 3. Typical Saturation Voltage Characteristics

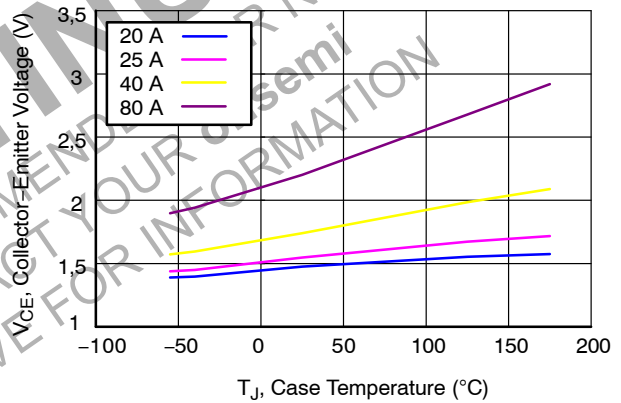


Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level

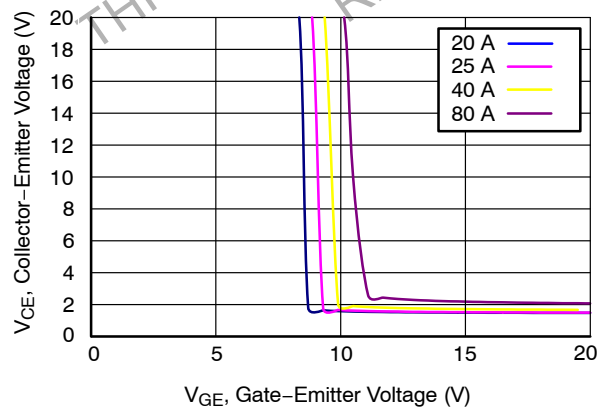


Figure 5. Saturation Voltage vs.  $V_{GE}$  (25°C)

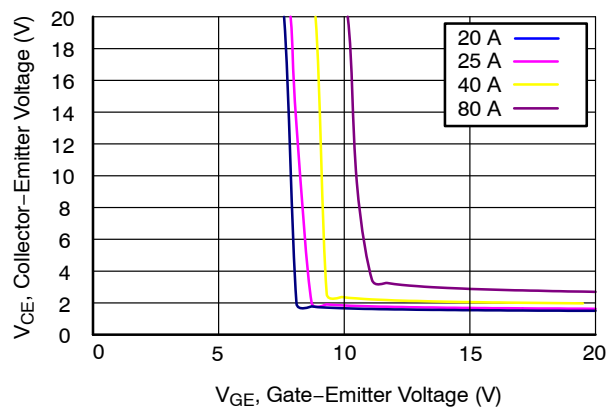


Figure 6. Saturation Voltage vs.  $V_{GE}$  (175°C)

TYPICAL CHARACTERISTICS (continued)

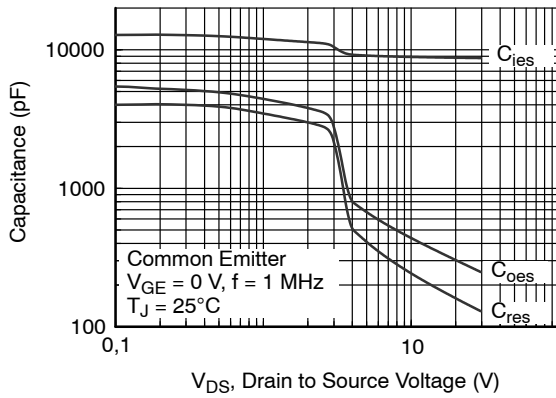


Figure 7. Capacitance Characteristics

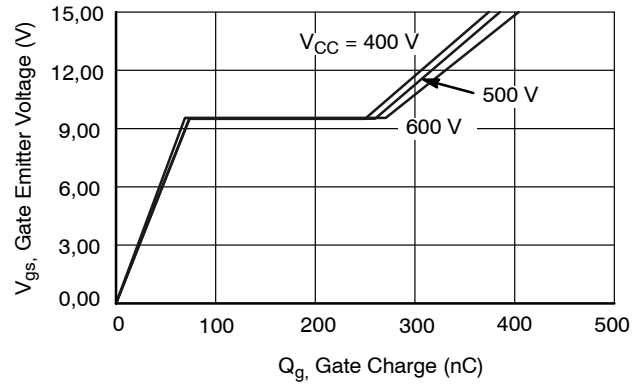


Figure 8. Gate Charge Characteristics

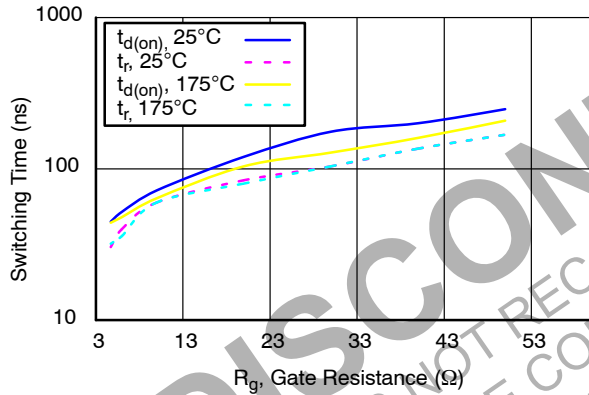


Figure 9. Turn-on Characteristics vs. Gate Resistance

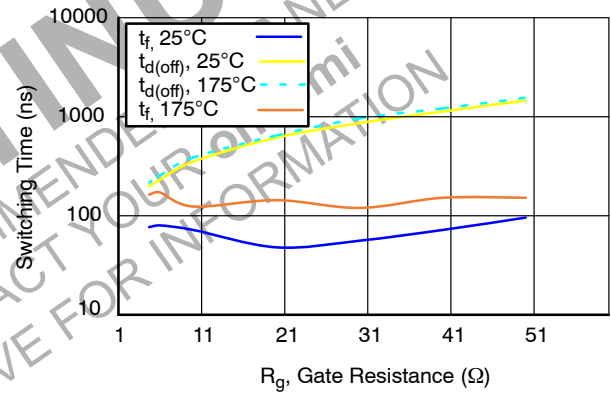


Figure 10. Turn-off Characteristics vs. Gate Resistance

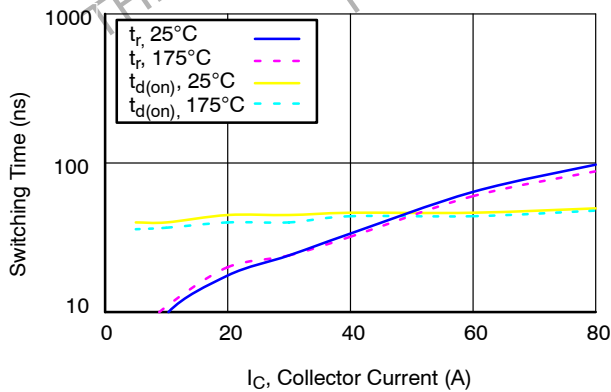


Figure 11. Turn-on Characteristics vs. Collector Current

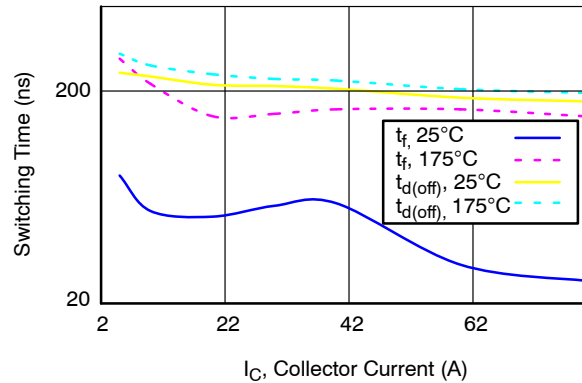


Figure 12. Turn-off Characteristics vs. Collector Current

TYPICAL CHARACTERISTICS (continued)

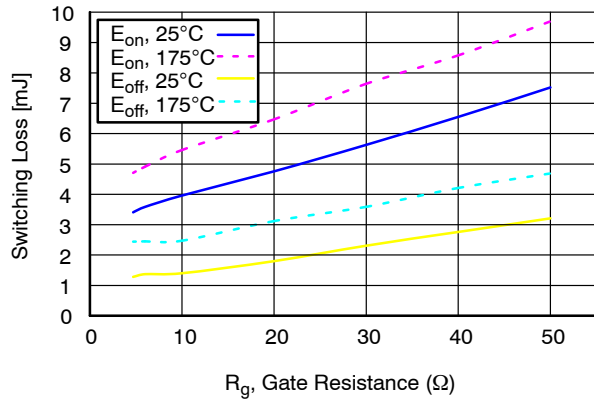


Figure 13. Switching Loss vs. Gate Resistance

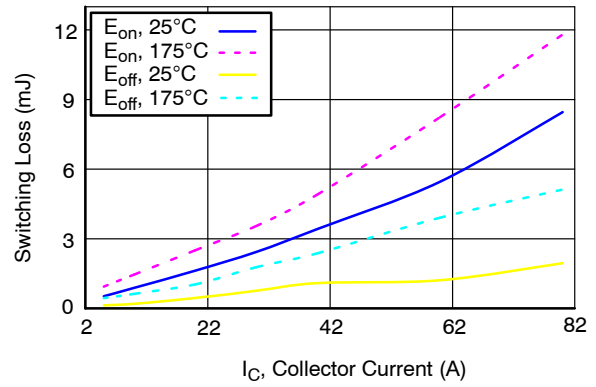


Figure 14. Switching Loss vs. Collector Current

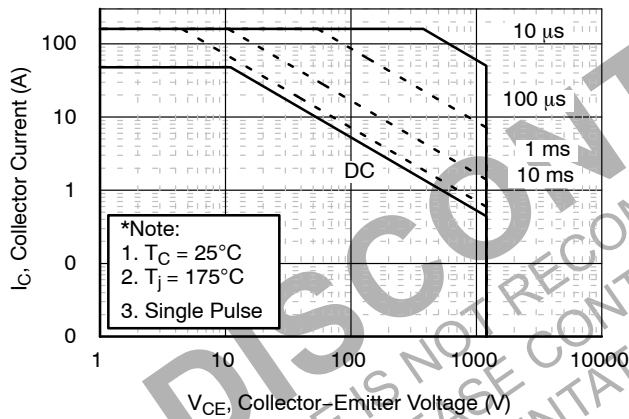


Figure 15. SOA Characteristics

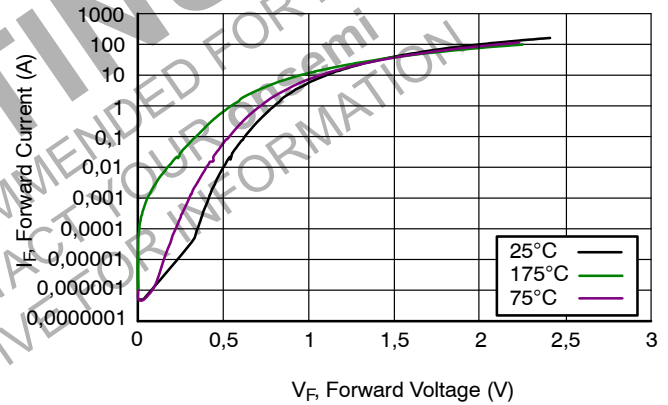


Figure 16. Forward Characteristics

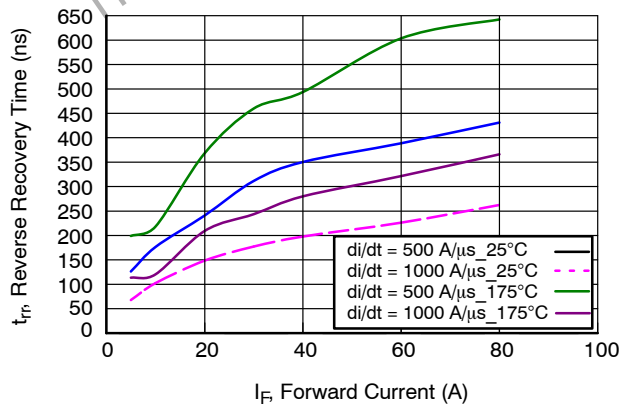


Figure 17. Reverse Recovery Time

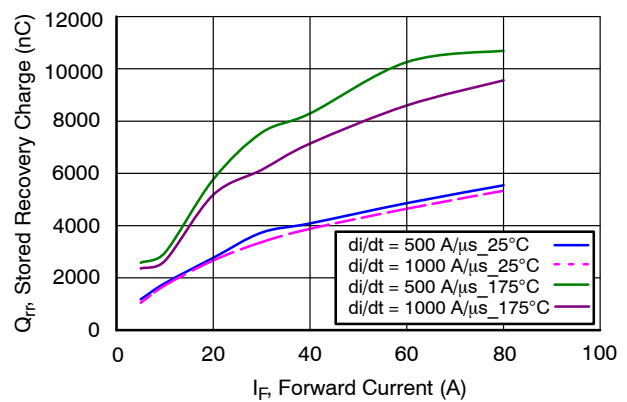


Figure 18. Stored Charge

TYPICAL CHARACTERISTICS (continued)

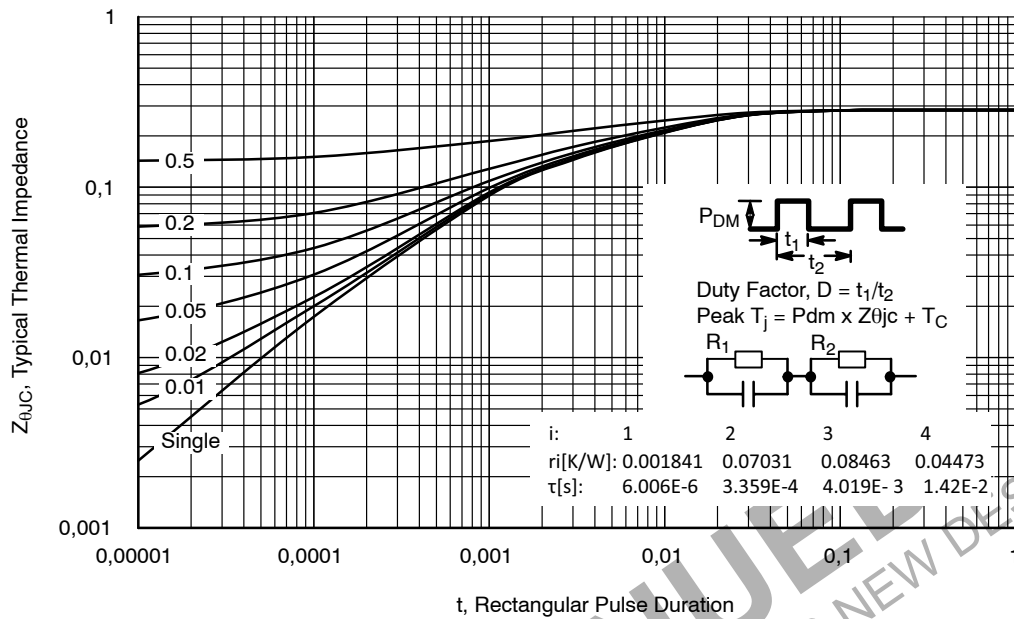


Figure 19. Transient Thermal Impedance of IGBT

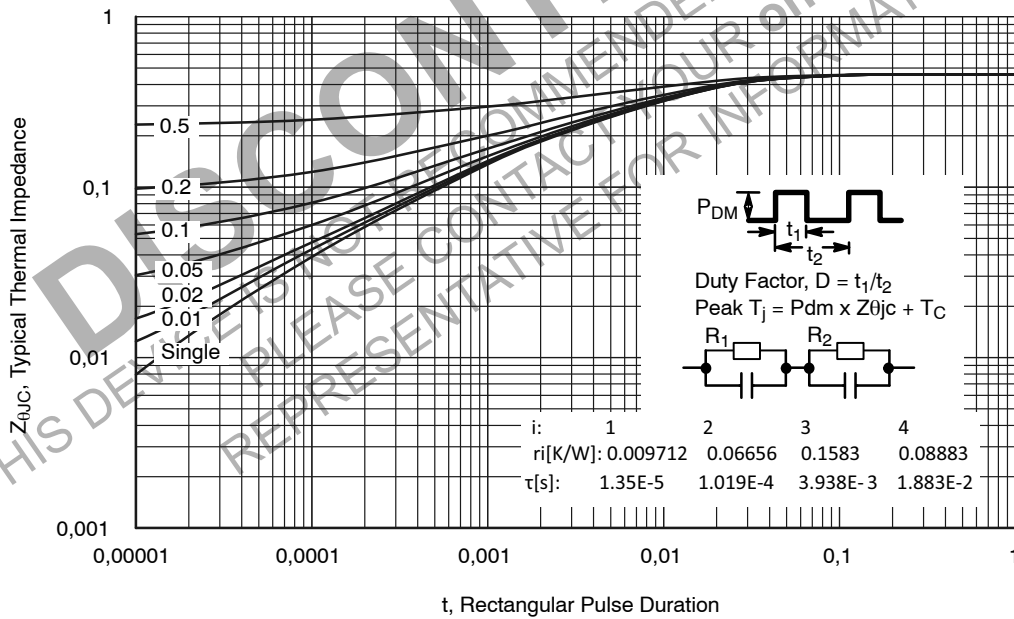


Figure 20. Transient Thermal Impedance of Diode

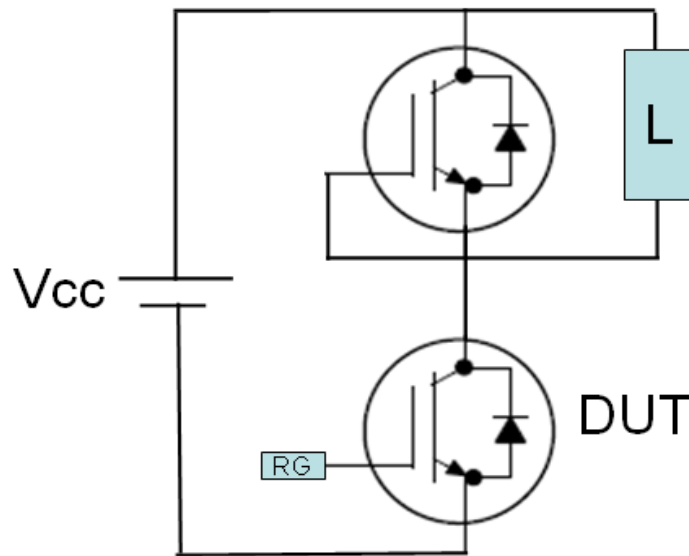


Figure 21. Test Circuit for Switching Characteristics

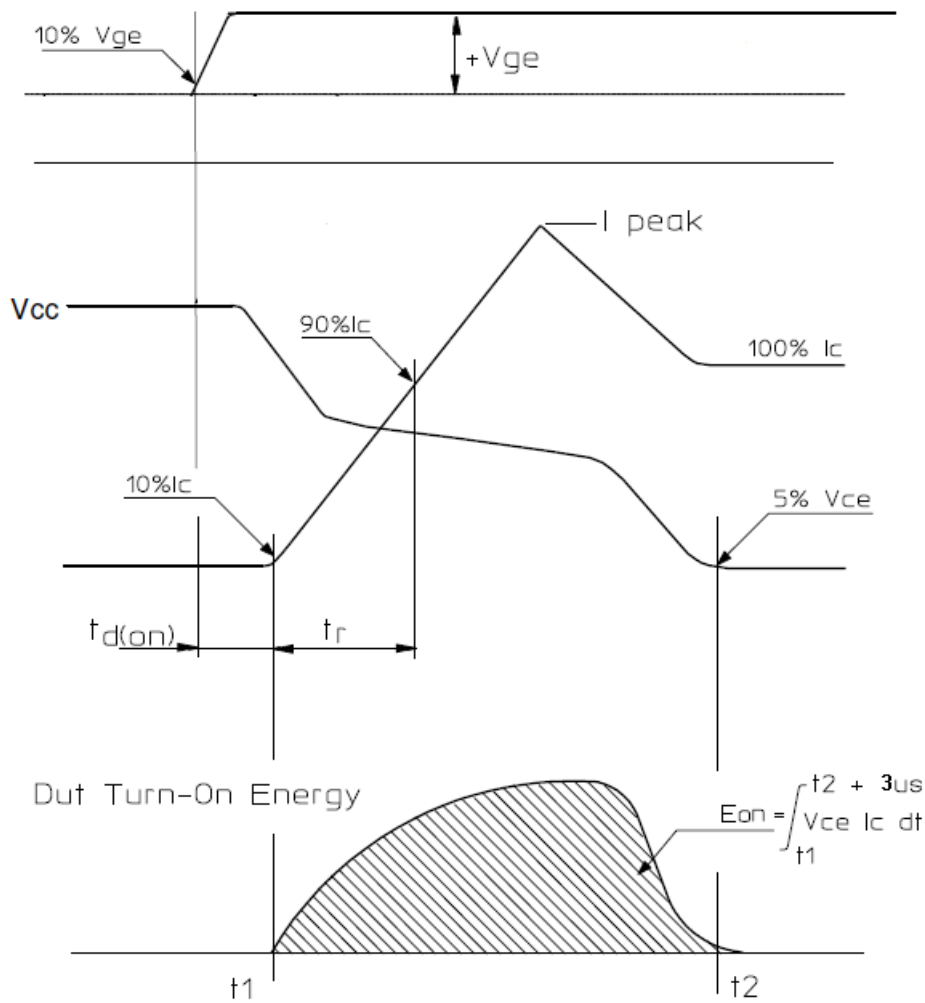


Figure 22. Definition of Turn On Waveform

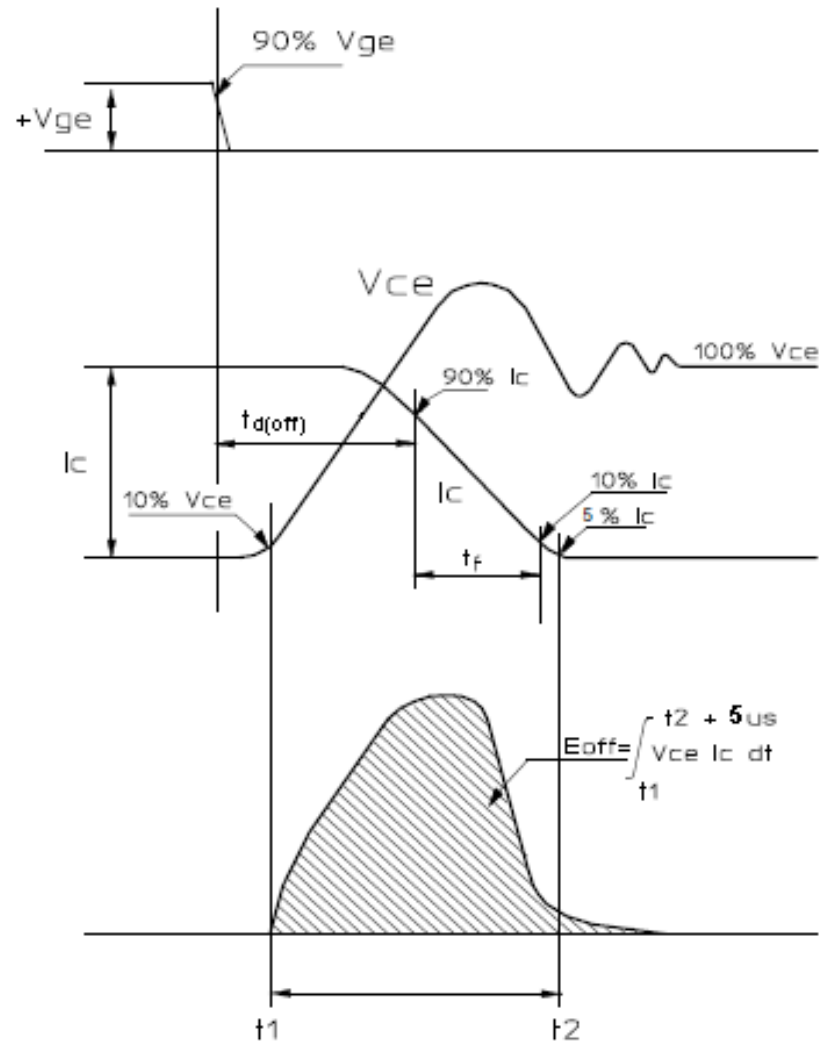
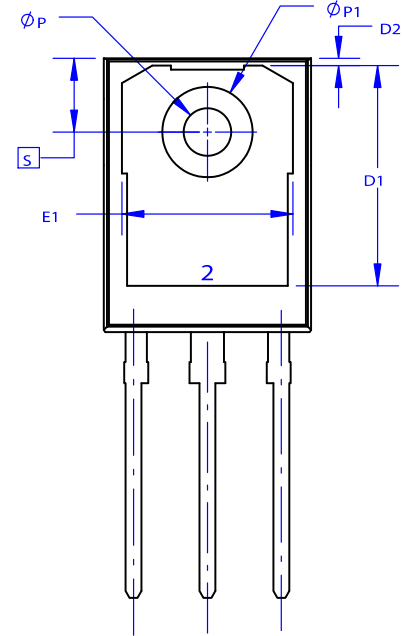
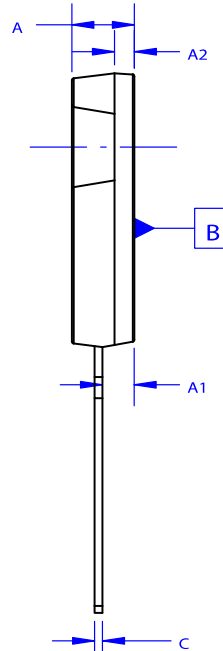
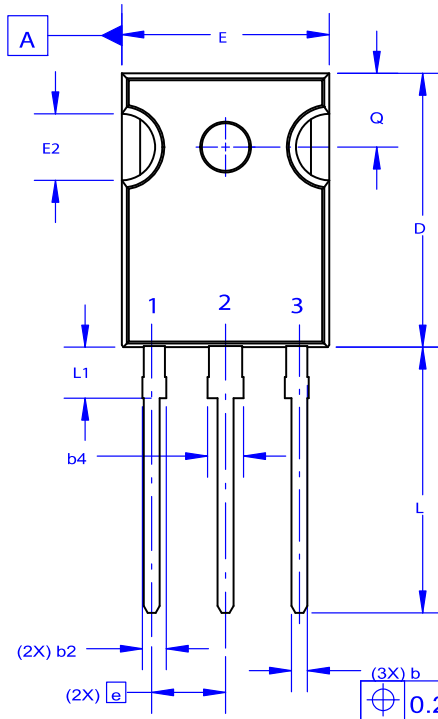
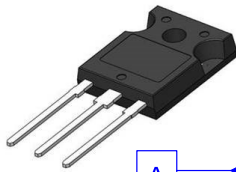


Figure 23. Definition of Turn Off Waveform

**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.

| 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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| <b>DESCRIPTION:</b>     | <b>TO-247-3LD</b>  | <b>PAGE 1 OF 1</b>                                                                                                                                                                  |

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