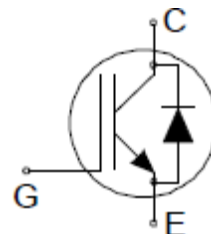




## 1. Description

STGWA40M120DF3 is obtained by advanced Trench and Field Stop (T-FS) technology which reduces the conduction loss, improves switching performance and enhances the avalanche energy.

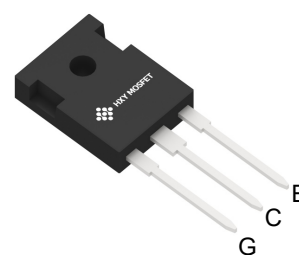


## Device Per Unit

| Package Type | Unit | Quantity |
|--------------|------|----------|
| TO-247       | Tube | 30       |

## Key Characteristics

| Parameter         | Value | Unit |
|-------------------|-------|------|
| $V_{CES}$         | 1200  | V    |
| $I_C$             | 40    | A    |
| $V_{CE(sat).typ}$ | 1.70  | V    |



TO-247

## Features

- Positive temperature coefficient
- Fast Switching
- Low  $V_{CE(sat)}$
- Reliable and Rugged
- AEC-Q101 Qualified
- 175°C operating temperature
- Halogen Free and Green Devices Available
- (RoHS Compliant)

## Applications

- PTC
- Motor drives
- OBC



## 2. Absolute ratings

| Symbol                 | Parameter                                                                                                                                                                | Values     | Units       |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------|
| $V_{CES}$              | Collector-Emitter Voltage                                                                                                                                                | 1200       | V           |
| $I_C$                  | Collector Current @ $T_C=25^{\circ}C$                                                                                                                                    | 80         | A           |
|                        | Collector Current @ $T_C=100^{\circ}C$                                                                                                                                   | 40         | A           |
| $I_{CM}$               | Pulsed Collector Current, tp limited by $T_{Jmax}$                                                                                                                       | 160        | A           |
| $I_F$                  | Diode Continuous Forward Current @ $T_C=25^{\circ}C$                                                                                                                     | 80         | A           |
|                        | Diode Continuous Forward Current @ $T_C=100^{\circ}C$                                                                                                                    | 40         | A           |
| $I_{FM}$               | Diode Maximum Forward Current, limited by $T_{Jmax}$                                                                                                                     | 160        | A           |
| $V_{GES}$              | Gate-Emitter Voltage                                                                                                                                                     | $\pm 30$   | V           |
| $t_{SC}$               | Short circuit withstand time $V_{GE}=15V$ , $V_{CC}\leq 400V$ , allowed number of short circuits<1000, times between short circuits $\geq 1.0s$ , $T_J\leq 175^{\circ}C$ | 13         | $\mu s$     |
| $P_D$                  | Power Dissipation @ $T_C=25^{\circ}C$                                                                                                                                    | 441        | W           |
| $T_{Jmax}$ , $T_{stg}$ | Operating Junction and Storage Temperature Range                                                                                                                         | -55 to 175 | $^{\circ}C$ |
| $T_L$                  | Maximum Temperature for Soldering                                                                                                                                        | 260        | $^{\circ}C$ |

## 3. Thermal characteristics

| Symbol          | Parameter                | Values | Units         |
|-----------------|--------------------------|--------|---------------|
| $R_{\theta JC}$ | Junction-to-Case (IGBT)  | 0.34   | $^{\circ}C/W$ |
| $R_{\theta JC}$ | Junction-to-Case (Diode) | 0.80   | $^{\circ}C/W$ |
| $R_{\theta JA}$ | Junction-to-Ambient      | 40     | $^{\circ}C/W$ |

## 4. Electrical Characteristics (at $T_C = 25^{\circ}C$ , unless otherwise specified)

### Static Characteristics

| Symbol        | Parameter                            | Test Conditions                                | Values |      |      | Units |
|---------------|--------------------------------------|------------------------------------------------|--------|------|------|-------|
|               |                                      |                                                | Min.   | Typ. | Max. |       |
| $V_{CES}$     | Collector-Emitter Breakdown Voltage  | $V_{GE}=0V$<br>$I_C=1mA$                       | 1200   | --   | --   | V     |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $V_{GE}=15V$<br>$I_C=40A$<br>$T_J=25^{\circ}C$ | --     | 1.70 | 2.05 | V     |
|               |                                      | $T_J=125^{\circ}C$                             | --     | 2.07 | --   |       |
|               |                                      | $T_J=175^{\circ}C$                             | --     | 2.20 | --   |       |
|               |                                      |                                                |        |      |      |       |



|                                                    |                                      |                                                                            |                |                      |                  |         |
|----------------------------------------------------|--------------------------------------|----------------------------------------------------------------------------|----------------|----------------------|------------------|---------|
| $V_{GE(TH)}$                                       | Gate Threshold Voltage               | $V_{CE}=V_{GE}, I_C=1mA$                                                   | 4.3            | 5.3                  | 6.3              | V       |
| $V_F$                                              | Diode Forward Voltage                | $I_F=40A$<br>$T_J=25^{\circ}C$<br>$T_J=125^{\circ}C$<br>$T_J=175^{\circ}C$ | --<br>--<br>-- | 1.85<br>1.70<br>1.61 | 2.25<br>--<br>-- | V       |
| $I_{CES}$                                          | Collector-Emitter Leakage Current    | $V_{CE}=1200V$<br>$V_{GE}=0V$                                              | --             | --                   | 10               | $\mu A$ |
| $I_{GES(F)}$                                       | Gate-Emitter Forward Leakage Current | $V_{GE}=+20V$                                                              | --             | --                   | 200              | nA      |
| $I_{GES(R)}$                                       | Gate-Emitter Reverse Leakage Current | $V_{GE}=-20V$                                                              | --             | --                   | -200             | nA      |
| Pulse width $tp \leq 300\mu s$ , $\delta \leq 2\%$ |                                      |                                                                            |                |                      |                  |         |

### Dynamic Characteristics

| Symbol    | Parameter                    | Test Conditions                               | Values |      |      | Units |
|-----------|------------------------------|-----------------------------------------------|--------|------|------|-------|
|           |                              |                                               | Min.   | Typ. | Max. |       |
| $C_{ies}$ | Input Capacitance            | $V_{GE}=0V$<br>$V_{CE}=25V$<br>$f=1.0MHz$     | --     | 3980 | --   | pF    |
| $C_{oes}$ | Output Capacitance           |                                               | --     | 157  | --   |       |
| $C_{res}$ | Reverse Transfer Capacitance |                                               | --     | 93   | --   |       |
| $Q_g$     | Gate charge                  | $V_{CC}=960V$<br>$I_{CE}=40A$<br>$V_{GE}=15V$ | --     | 346  | --   | nC    |
| $Q_{ge}$  | Gate-emitter charge          |                                               | --     | 2.4  | --   |       |
| $Q_{gc}$  | Gate-collector charge        |                                               | --     | 238  | --   |       |

### IGBT Switching Characteristics, at $T_J=25^{\circ}C$

| Symbol       | Parameter               | Test Conditions                                                               | Values |      |      | Units |
|--------------|-------------------------|-------------------------------------------------------------------------------|--------|------|------|-------|
|              |                         |                                                                               | Min.   | Typ. | Max. |       |
| $t_{d(on)}$  | Turn-on Delay Time      | $I_C=40A$<br>$V_{CC}=600V$<br>$V_{GE}=15V$<br>$R_g=5\Omega$<br>Inductive Load | --     | 25   | --   | ns    |
| $t_r$        | Rise Time               |                                                                               | --     | 28   | --   |       |
| $t_{d(off)}$ | Turn-Off Delay Time     |                                                                               | --     | 262  | --   |       |
| $t_f$        | Fall Time               |                                                                               | --     | 149  | --   |       |
| $E_{on}$     | Turn-On Switching Loss  |                                                                               | --     | 1.30 | --   | mJ    |
| $E_{off}$    | Turn-Off Switching Loss |                                                                               | --     | 2.30 | --   |       |
| $E_{ts}$     | Total Switching Loss    |                                                                               | --     | 3.60 | --   |       |



### IGBT Switching Characteristics, at $T_J=175^{\circ}\text{C}$

| Symbol       | Parameter               | Test Conditions                                                                                    | Values |      |      | Units |
|--------------|-------------------------|----------------------------------------------------------------------------------------------------|--------|------|------|-------|
|              |                         |                                                                                                    | Min.   | Typ. | Max. |       |
| $t_{d(on)}$  | Turn-on Delay Time      | $I_C=40\text{A}$<br>$V_{CC}=600\text{V}$<br>$V_{GE}=15\text{V}$<br>$R_g=5\Omega$<br>Inductive Load | --     | 26   | --   | ns    |
| $t_r$        | Rise Time               |                                                                                                    | --     | 35   | --   |       |
| $t_{d(off)}$ | Turn-Off Delay Time     |                                                                                                    | --     | 331  | --   |       |
| $t_f$        | Fall Time               |                                                                                                    | --     | 224  | --   |       |
| $E_{on}$     | Turn-On Switching Loss  |                                                                                                    | --     | 2.20 | --   | mJ    |
| $E_{off}$    | Turn-Off Switching Loss |                                                                                                    | --     | 3.70 | --   |       |
| $E_{ts}$     | Total Switching Loss    |                                                                                                    | --     | 5.90 | --   |       |

### Diode Characteristics, at $T_J=25^{\circ}\text{C}$

| Symbol    | Parameter                | Test Conditions                                                             | Values |      |      | Units |
|-----------|--------------------------|-----------------------------------------------------------------------------|--------|------|------|-------|
|           |                          |                                                                             | Min.   | Typ. | Max. |       |
| $T_{rr}$  | Reverse Recovery Time    | $I_F=40\text{A}$<br>$V_{CC}=600\text{V}$<br>$di/dt=200\text{A}/\mu\text{s}$ | --     | 94   | -    | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                             | --     | 225  | -    | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                             | --     | 9.7  | -    | A     |

### Diode Characteristics, at $T_J=175^{\circ}\text{C}$

| Symbol    | Parameter                | Test Conditions                                                             | Values |      |      | Units |
|-----------|--------------------------|-----------------------------------------------------------------------------|--------|------|------|-------|
|           |                          |                                                                             | Min.   | Typ. | Max. |       |
| $T_{rr}$  | Reverse Recovery Time    | $I_F=40\text{A}$<br>$V_{CC}=600\text{V}$<br>$di/dt=200\text{A}/\mu\text{s}$ | --     | 125  | -    | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                             | --     | 277  | -    | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                             | --     | 11.2 | -    | A     |



## 5. Characteristics Curves

Figure 1: Power Dissipation

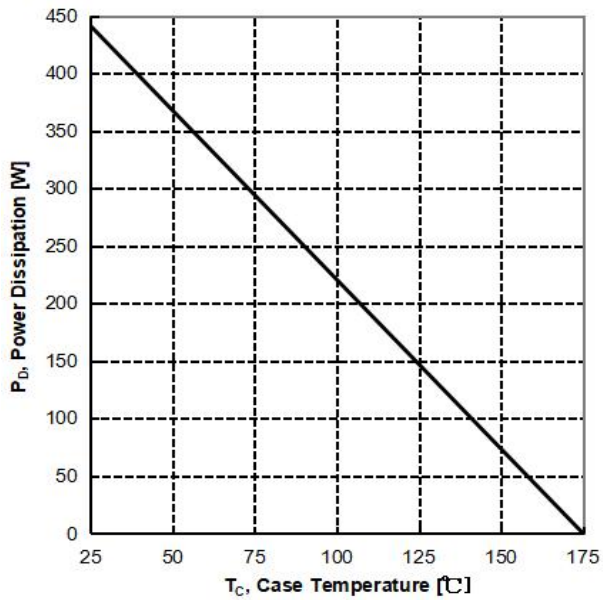


Figure 2: Collector Current vs. Case Temperature

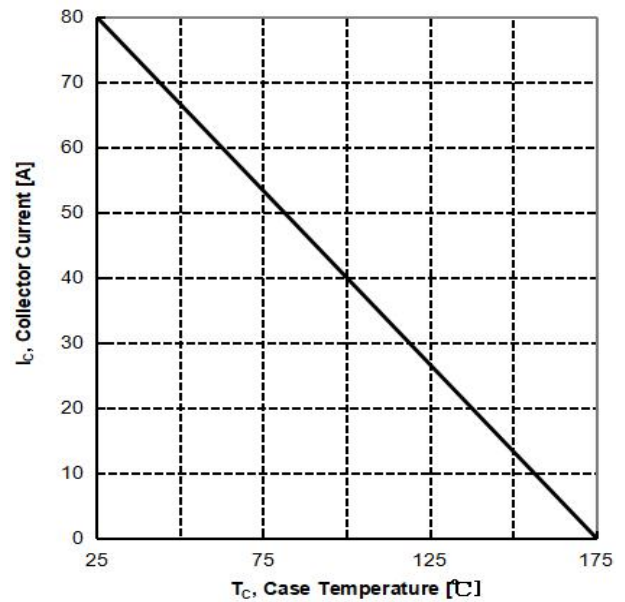


Figure 3: Safe Operation Area

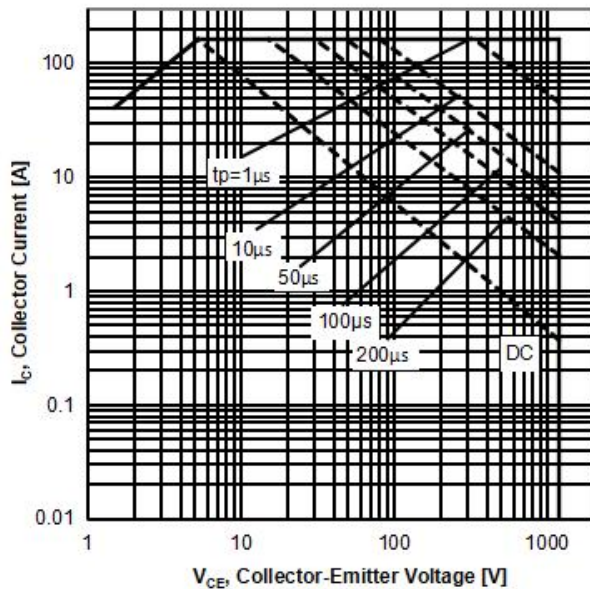


Figure 4: Typical Transfer Characteristics

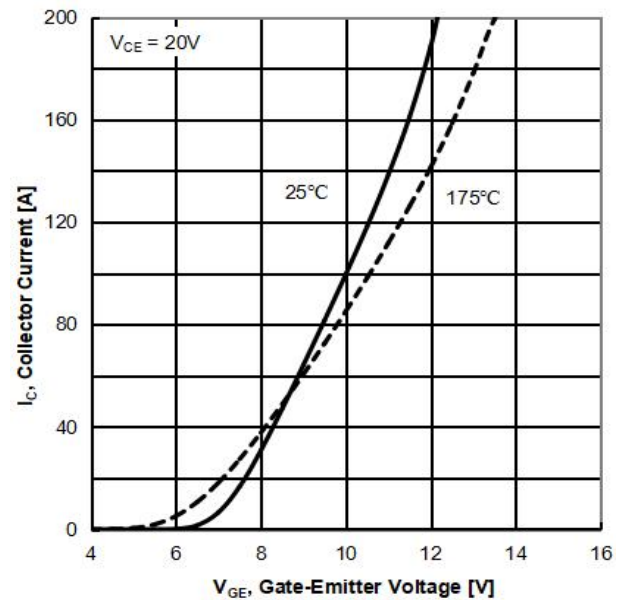




Figure 5: Typical Output Characteristics



Figure 6: Typical Output Characteristics

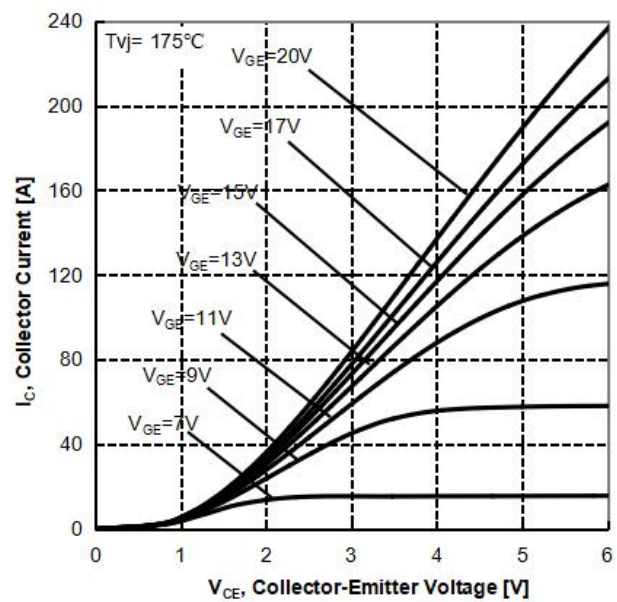


Figure 7: Typical Collector-Emitter Saturation Voltage vs. Junction Temperature



Figure 8: Typical Gate-Emitter Threshold Voltage vs. Junction Temperature

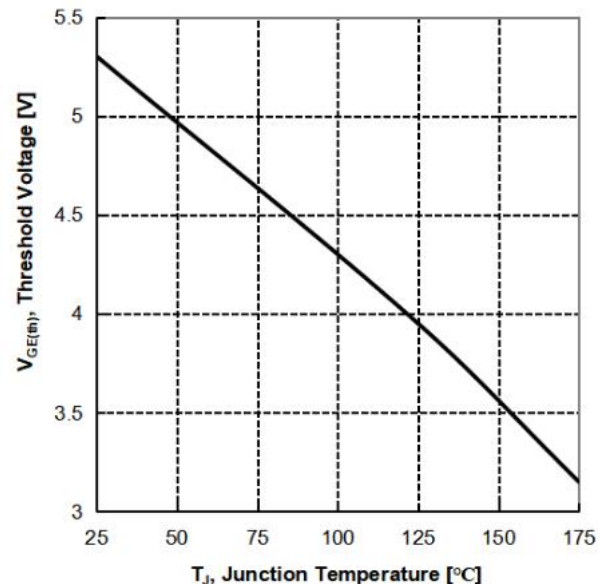




Figure 9: Typical Switching Times vs.  
Gate Resistor ( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=600\text{V}$ ,  
 $V_{GE}=15\text{V}$ ,  $I_C=40\text{A}$ )

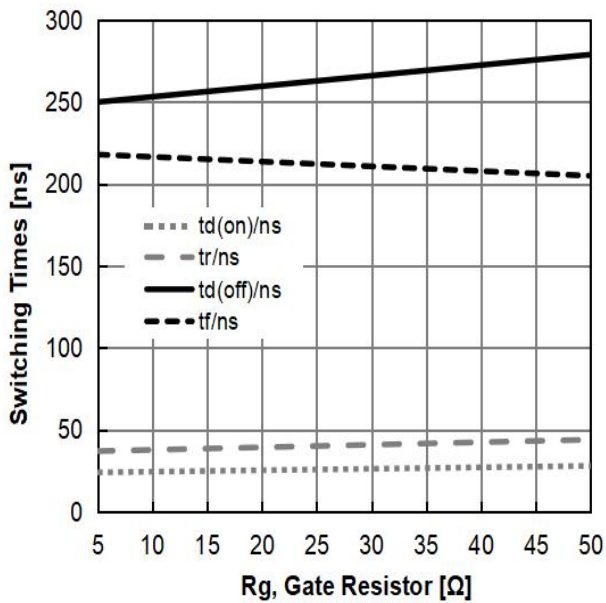


Figure 10: Typical Switching Energy vs.  
Gate Resistor ( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=600\text{V}$ ,  
 $V_{GE}=15\text{V}$ ,  $I_C=40\text{A}$ )

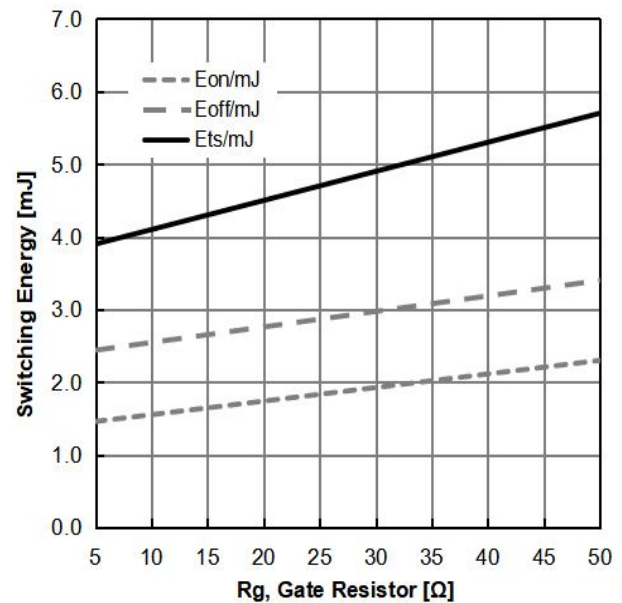


Figure 11: Typical Switching Times vs.  
Junction Temperature ( $V_{CE}=600\text{V}$ ,  
 $V_{GE}=15\text{V}$ ,  $I_C=40\text{A}$ ,  $R_g=5\Omega$ )

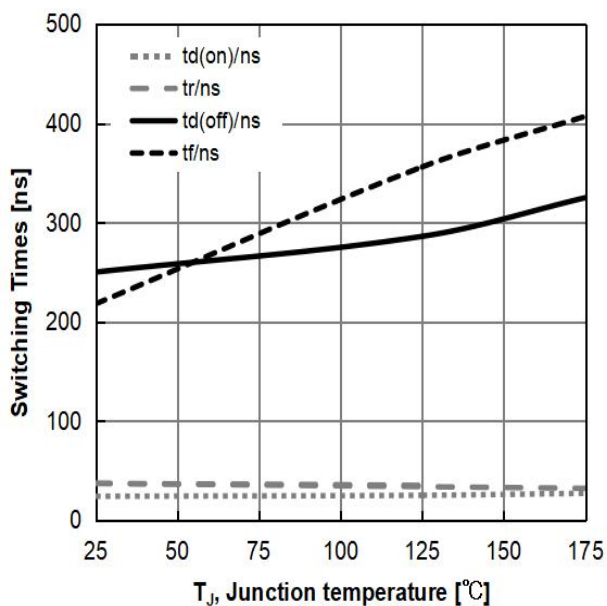


Figure 12: Typical Switching Energy vs.  
Junction Temperature ( $V_{CE}=600\text{V}$ ,  
 $V_{GE}=15\text{V}$ ,  $I_C=40\text{A}$ ,  $R_g=5\Omega$ )

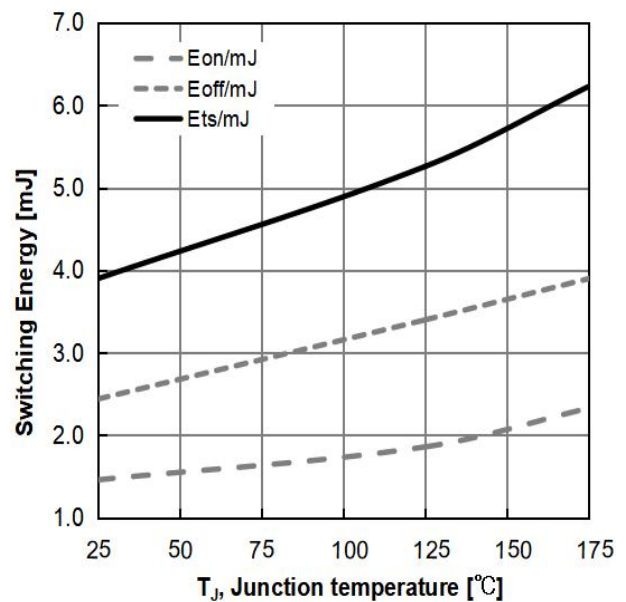




Figure 13: Typical Switching Times vs.  
Collector Current ( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=600\text{V}$ ,  
 $V_{GE}=15\text{V}$ ,  $R_g=5\Omega$ )

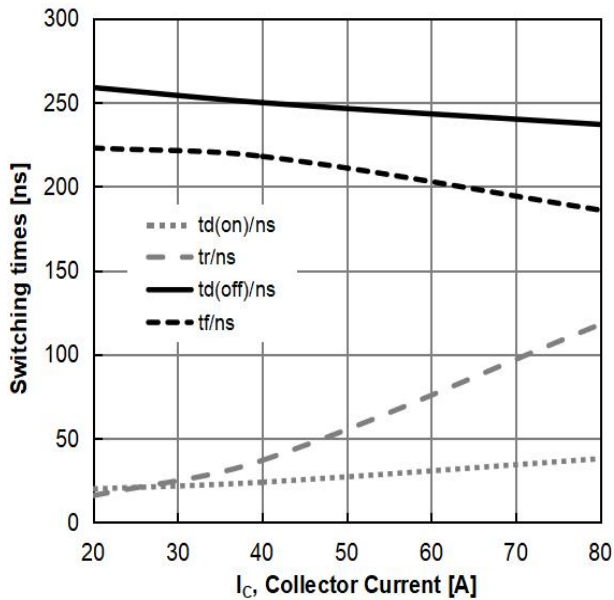


Figure 14: Typical Switching Energy vs.  
Collector Current ( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=600\text{V}$ ,  
 $V_{GE}=15\text{V}$ ,  $R_g=5\Omega$ )

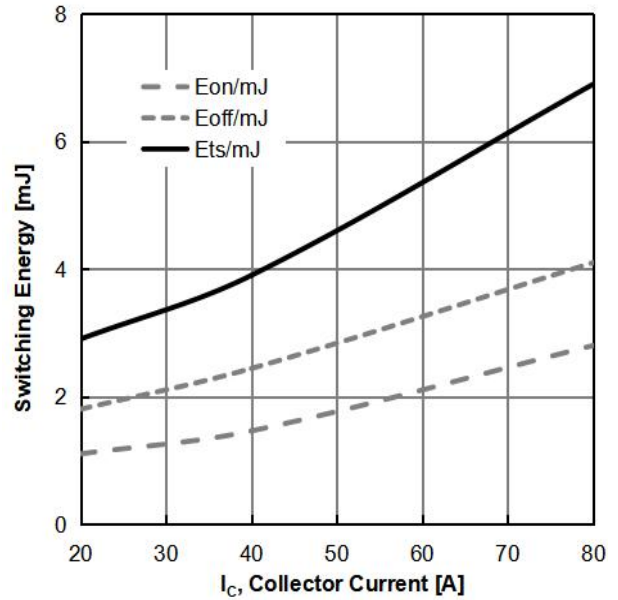


Figure 15: Typical Switching Times vs.  
 $V_{CE}$  ( $T_J=25^{\circ}\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $I_C=40\text{A}$ ,  $R_g=5\Omega$ )

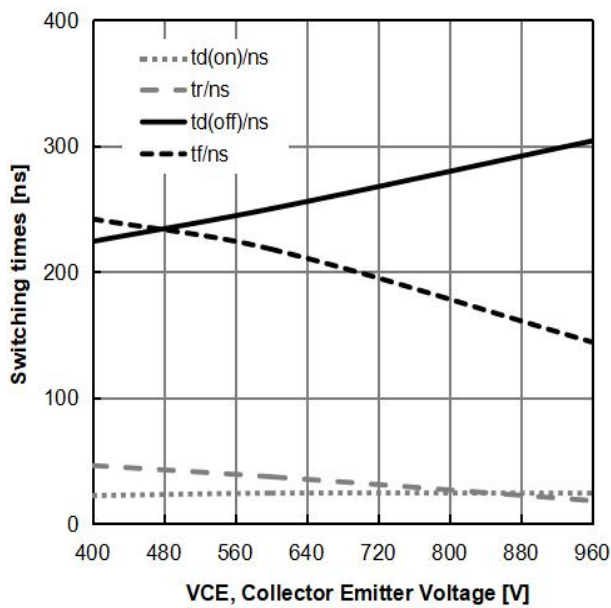


Figure 16: Typical Switching Energy vs.  
 $V_{CE}$  ( $T_J=25^{\circ}\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $I_C=40\text{A}$ ,  $R_g=5\Omega$ )

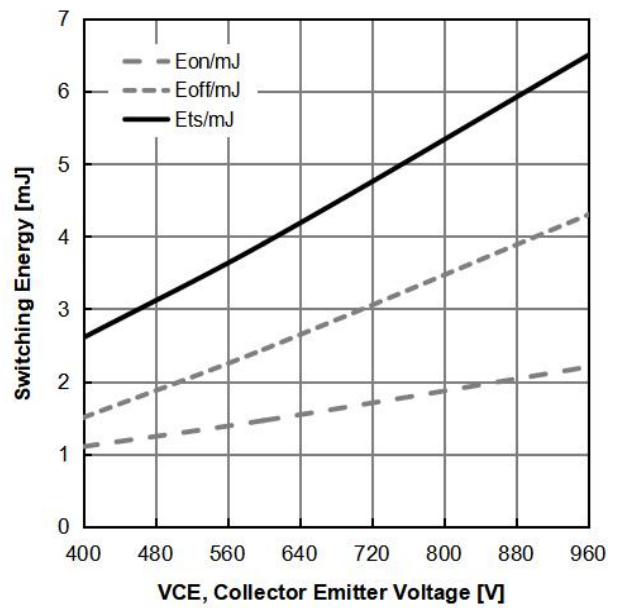




Figure 17: Typical Capacitance vs.  
Collector- Emitter Voltage

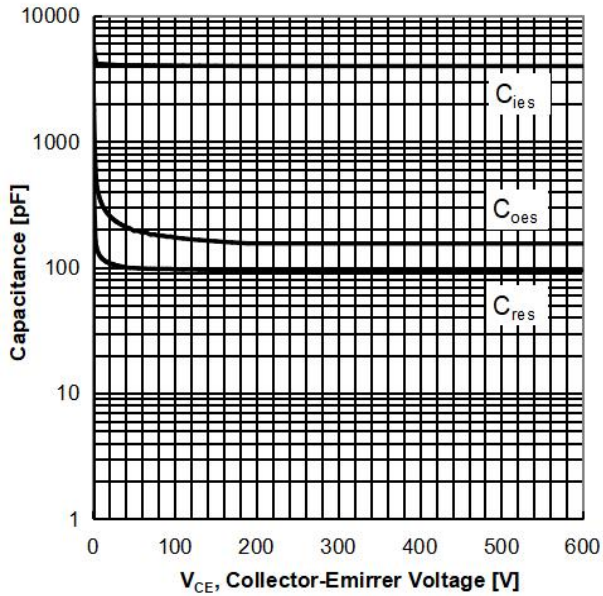


Figure 18: Typical Gate Charge

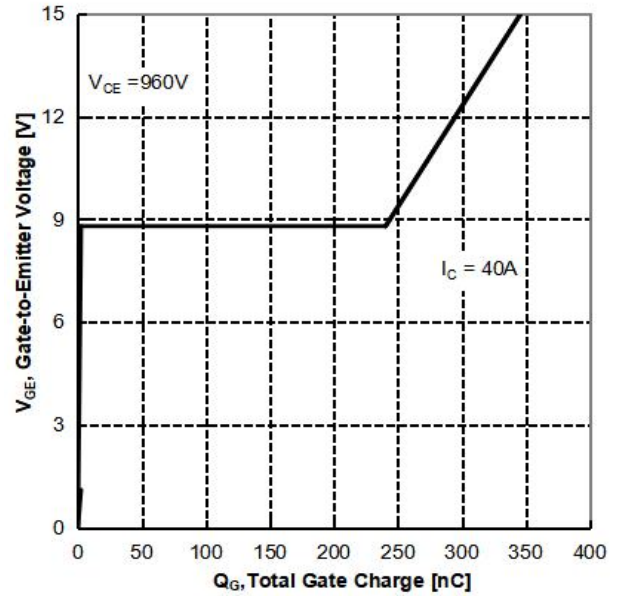


Figure 19: IGBT Transient Thermal  
Impedance vs. Pulse Width

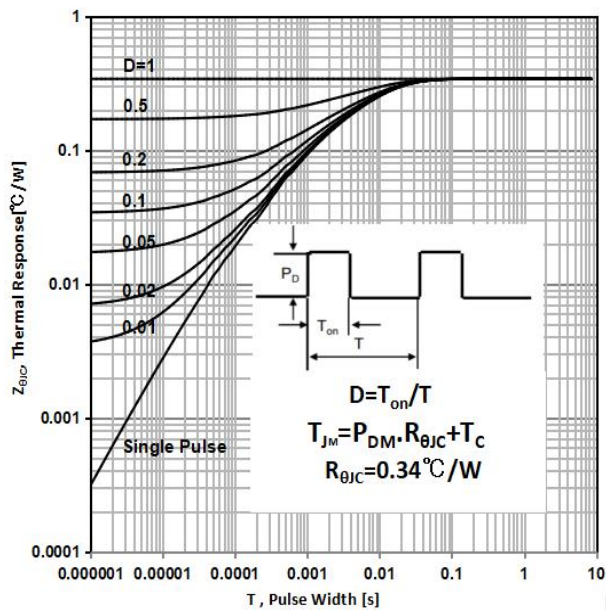


Figure 20: Diode Transient Thermal  
Impedance vs. Pulse Width

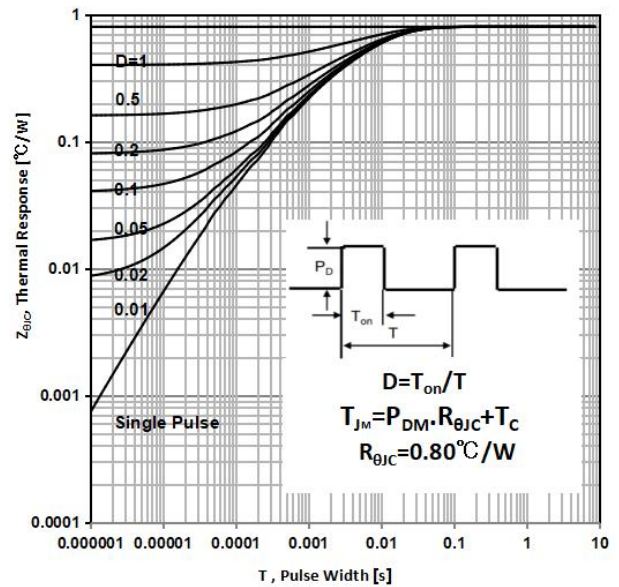
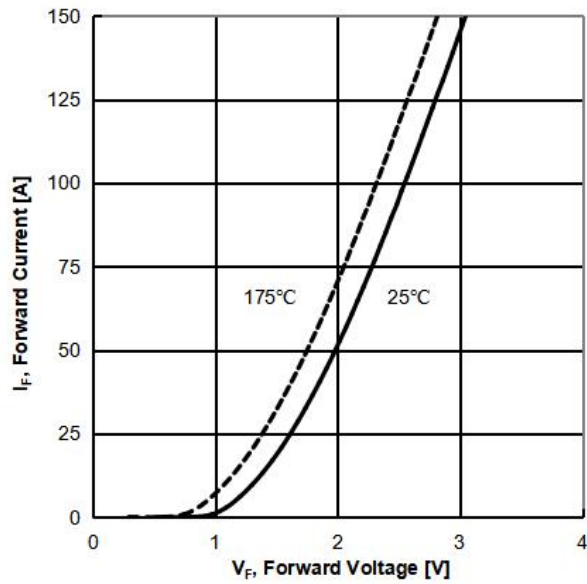




Figure 21: Typical Diode Forward Current  
vs. Forward Voltage





## 6. Test Circuit and Waveform

Figure 22. Inductive Switching Test Circuit

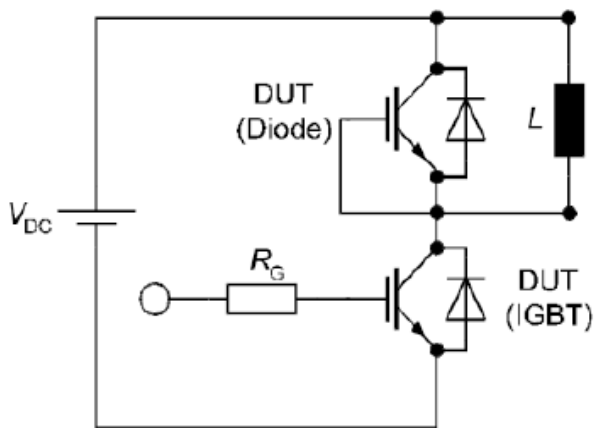


Figure 23. Definition of switching times

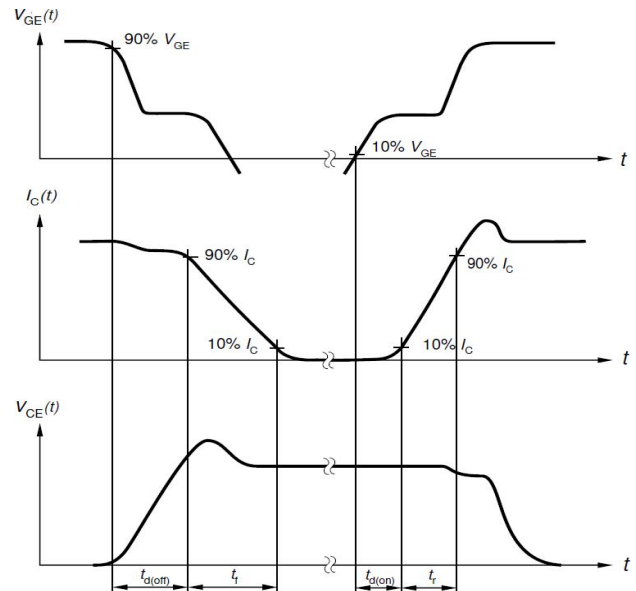


Figure 24. Definition of switching losses

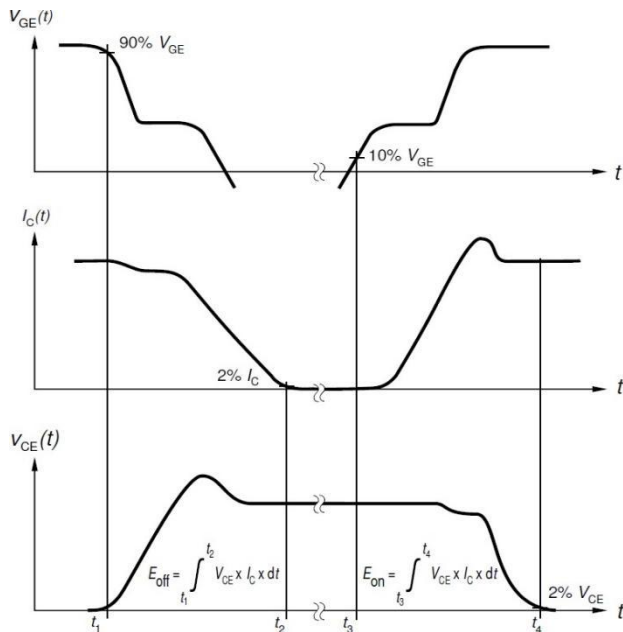
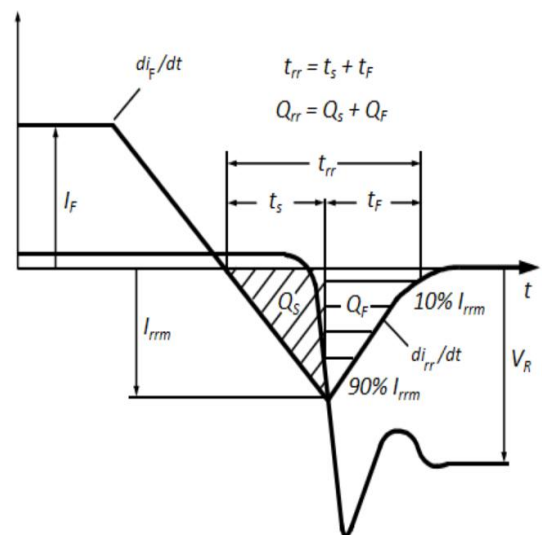


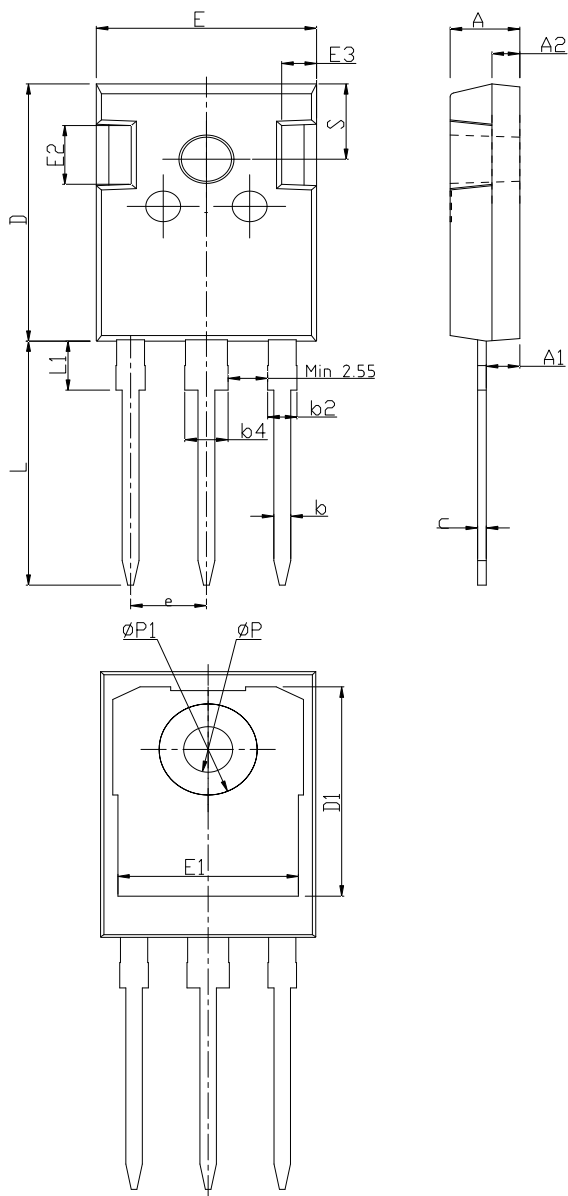
Figure 25. Definition of diode switching characteristics





## 7. Package Information

### TO-247

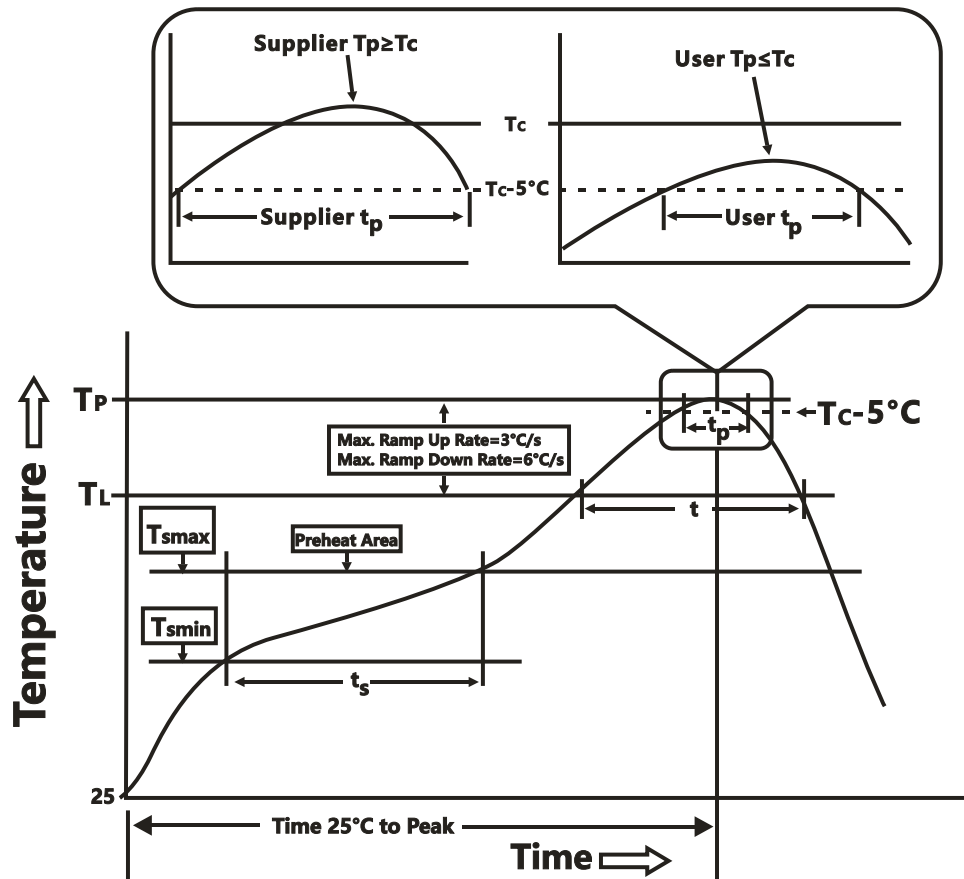


COMMON DIMENSIONS

| SYMBOL | mm      |       |       |
|--------|---------|-------|-------|
|        | MIN     | NOM   | MAX   |
| A      | 4.80    | 5.00  | 5.20  |
| A1     | 2.21    | 2.41  | 2.59  |
| A2     | 1.85    | 2.00  | 2.15  |
| b      | 1.11    | 1.21  | 1.36  |
| b2     | 1.91    | 2.01  | 2.21  |
| b4     | 2.91    | 3.01  | 3.21  |
| c      | 0.51    | 0.61  | 0.75  |
| D      | 20.70   | 21.00 | 21.30 |
| D1     | 16.25   | 16.55 | 16.85 |
| E      | 15.50   | 15.80 | 16.10 |
| E1     | 13.00   | 13.30 | 13.60 |
| E2     | 4.80    | 5.00  | 5.20  |
| E3     | 2.30    | 2.50  | 2.70  |
| e      | 5.44BSC |       |       |
| L      | 19.62   | 19.92 | 20.22 |
| L1     | -       | -     | 4.30  |
| ΦP     | 3.40    | 3.60  | 3.80  |
| ΦP1    | -       | -     | 7.30  |
| S      | 6.15BSC |       |       |



## 8. Classification Profile



## 9. Classification Reflow Profiles

| Profile Feature                                 | Sn-Pb Eutectic Assembly | Pb-Free Assembly |
|-------------------------------------------------|-------------------------|------------------|
| <b>Preheat &amp; Soak</b>                       |                         |                  |
| Temperature min ( $T_{smin}$ )                  | 100 °C                  | 150 °C           |
| Temperature max ( $T_{smax}$ )                  | 150 °C                  | 200 °C           |
| Time ( $T_{smin}$ to $T_{smax}$ ) ( $T_s$ )     | 60-120 seconds          | 60-120 seconds   |
| Average ramp-up rate<br>( $T_{smax}$ to $T_P$ ) | 3 °C/second max.        | 3°C/second max.  |
| Liquidous temperature ( $T_L$ )                 | 183 °C                  | 217 °C           |
| Time at liquidous ( $t_L$ )                     | 60-150 seconds          | 60-150 seconds   |



|                                                                                                                  |                                    |                                    |
|------------------------------------------------------------------------------------------------------------------|------------------------------------|------------------------------------|
| Peak package body temperature ( $T_p$ )*                                                                         | See Classification Temp in table 1 | See Classification Temp in table 2 |
| Time ( $t_p$ )** within 5°C of the specified classification temperature ( $T_c$ )                                | 20** seconds                       | 30** seconds                       |
| Average ramp-down rate ( $T_p$ to $T_{smax}$ )                                                                   | 6 °C/second max.                   | 6 °C/second max.                   |
| Time 25°C to peak temperature                                                                                    | 6 minutes max.                     | 8 minutes max.                     |
| *Tolerance for peak profile Temperature ( $T_p$ ) is defined as a supplier minimum and a user maximum.           |                                    |                                    |
| ** Tolerance for time at peak profile temperature ( $t_p$ ) is defined as a supplier minimum and a user maximum. |                                    |                                    |

Table 1.Sn-Pb Eutectic Process – Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>≥350 |
|-------------------|--------------------------------|--------------------------------|
| <2.5 mm           | 235 °C                         | 220 °C                         |
| ≥2.5 mm           | 220 °C                         | 220 °C                         |

Table 2.Pb-free Process – Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>350-2000 | Volume mm <sup>3</sup><br>≥2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6 mm           | 260 °C                         | 260 °C                             | 260 °C                          |
| 1.6 mm – 2.5 mm   | 260 °C                         | 250 °C                             | 245 °C                          |
| ≥2.5 mm           | 250 °C                         | 245 °C                             | 245 °C                          |

## 10. Reliability Test Program

| Test item | Method       | Description                                                                                      |
|-----------|--------------|--------------------------------------------------------------------------------------------------|
| HTRB      | JESD22-A108B | 168/500/1000 Hrs, 100% $BV_{CES}$ @ 175°C                                                        |
| HTGB      | JESD22-A108B | 168/500/1000 Hrs, 100% $V_{GE}$ @ 175°C                                                          |
| PCT       | JESD22-A102  | 121°C, 100%RH, 96 Hrs, 205kPa                                                                    |
| TCT       | JESD22-A104  | 250/500/1000 Cycles, -55°C~150°C                                                                 |
| BHAST     | JESD22-A101  | 130°C, 85%RH, 203kPa, U=42V                                                                      |
| IOL       | MIL-STD-750  | $T_a=25^\circ\text{C}$ , $\Delta T_J \geq 100^\circ\text{C}$ , $T_{on}/T_{off}$ 2min ,8600cycles |



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