fast SiC semiconductor

# FF07009M2

Product Datasheet

## Silicon Carbide MOSFET

750V, 9mΩ SiC MOSFET – Falcon M2 Series

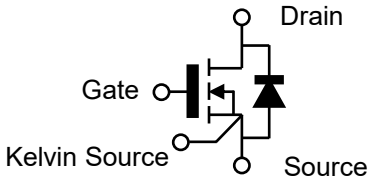
### Features

- Optimized $R_{DS(on)}$ with Rapid Switching Behavior
- Compatible with Standard Gate Drivers
- Clean Kelvin-Source Switching Pin-out
- High Avalanche Endurance Capability
- Optimized for High Power Density Applications
- RoHS Compliant and Halogen Free

### Potential Applications

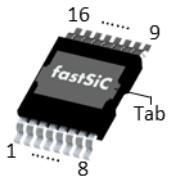
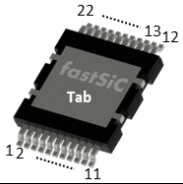
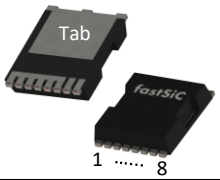
- Switching Mode Power Supply
- PFC & DC/DC Converter
- Portable Adaptor
- Renewable Energy
- Power Inverter
- Motor Driver

### Product Information:




### Benefits

- Higher System Efficiency
- Increase Parallel Device Convenience
- Enable High Temperature Application
- Allow High Frequency Operation
- Realize Compact and Lightweight Systems
- High Reliability

| Product Information | Packaging Type | | |
|---|---|---|---|
| | TOLT | QDPAK | TOLL |
| |   |   |   |
| Gate | 8 | 1 | 1 |
| Drain | 9-16, Tab | 12-22, Tab | Tab |
| Source | 1-6 | 3-11 | 3, 4, 5, 6, 7, 8 |
| Kelvin Source | 7 | 2 | 2 |
| Part Number | FF07009M2K | FF07009M2L | FF07009M2F |
| Marking | FF07009M2 | FF07009M2 | FF07009M2 |
| Continuous Drain Current | 260A | 230A | 260A |
| Power Dissipation | 1153W | 882W | 1153W |

### Key Performance Parameters

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DS}$ @$T_{j(max)}$ | 750 | V |
| Recommended Gate-Source Turn-On Voltage | $V_{GS}$ | 15~18 | |
| Drain-Source On-State Resistance | $R_{DS(on)}$ | 9 | mΩ |
| Pulse Drain Current | $I_{D, pulse}$ | 491 | A |
| Avalanche Energy | $E_{AS}$ | 3610 | mJ |
| Gate Charge | $Q_G$ | 248.5 | nC |
| Output Capacitive Charge | $Q_{oss}$ | 292.7 | |
| Junction & Storage Temperature | $T_j$, $T_{stg}$ | -55 to 175 | °C |

For further information about comparable products, please contact (www.fastsic.com).

## Maximum Ratings: (Tj = 25°C, unless otherwise specified)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions | |
|---|---|---|---|---|---|---|---|
| Drain-Source Voltage | $V_{DSS}$ | 750 | -- | -- | V | $V_{GS}$=0V, $I_D$=1mA | |
| Continuous Drain Current | $I_D$ | -- | -- | 260 | A | $V_{GS}$=18V, $T_C$=25°C | By package type[1] |
| | | | | 189 | | $V_{GS}$=18V, $T_C$=100°C | |
| Continuous Body Diode Current | $I_S$ | -- | -- | 174 | | $V_{GS}$=0V, $T_C$=25°C | |
| Pulse Drain Current | $I_{D,pulse}$ | -- | -- | 491 | | Per SOA | |
| Avalanche Energy, Single Pulse | $E_{AS}$ | -- | -- | 3610 | mJ | $L$=25mH | |
| Operate Gate Source Voltage | $V_{GS,op}$ | -8 | -- | 15~18 | V | Recommended operating values | |
| Transient Gate Source Voltage | $V_{GS,tran.}$ | -9 | -- | 19 | | Transient operating limit (AC f > 1Hz, pulse width < 100ns) | |
| Junction Temperature | $T_j$ | -55 | -- | 175 | °C | | |
| Storage Temperature | $T_{stg}$ | -55 | -- | 175 | | | |
| Soldering Temperature | $T_L$ | -- | -- | 260 | | | |

[1] *Per figure section 2~6*

## Electrical Characteristics:

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| **DC Characteristics (at $T_j$ = 25°C, unless otherwise specified)** | | | | | | |
| Drain-source Breakdown Voltage | $V_{(BR)DSS}$ | 750 | -- | -- | V | $V_{GS}$=0V, $I_D$=1mA, $T_j$=25°C |
| Drain-Source On-State Resistance | $R_{DS(on)}$ | -- | 9 | -- | mΩ | $V_{GS}$=18V, $I_D$=80A, $T_j$=25°C |
| | | -- | 14 | -- | | $V_{GS}$=18V, $I_D$=80A, $T_j$=175°C |
| | | -- | 10 | -- | | $V_{GS}$=15V, $I_D$=80A, $T_j$=25°C |
| | | -- | 15 | -- | | $V_{GS}$=15V, $I_D$=80A, $T_j$=175°C |
| Gate-Source Threshold Voltage | $V_{th}$ | -- | 2.5 | -- | V | $V_{GS}$=$V_{DS}$, $I_D$=100mA |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | -- | <1 | 1000 | μA | $V_{DS}$=750V, $V_{GS}$=0V, $T_j$=25°C |
| Gate-Source Leakage Current | $I_{GSS}$ | -- | -- | 100 | nA | $V_{GS}$=18V, $V_{DS}$=0V |
| Body Diode Forward Voltage | $V_{SD}$ | -- | 3.0 | -- | V | $V_{GS}$=0V, $I_S$=40A, $T_j$=25°C |
| | | -- | 2.6 | -- | | $V_{GS}$=0V, $I_S$=40A, $T_j$=175°C |
| **AC Characteristics (at $T_j$ = 25°C, unless otherwise specified)** | | | | | | |
| Input Capacitance | $C_{iss}$ | -- | 7921.3 | -- | pF | $V_{DS}$=400V, $V_{GS}$=0V, $f$=250kHz, $V_{AC}$=25mV |
| Output Capacitance | $C_{oss}$ | -- | 433.8 | -- | | |
| Reverse Capacitance | $C_{rss}$ | -- | 27.4 | -- | | |
| Effective Output Capacitance, energy related | $C_{o(er)}$[1] | -- | 495.8 | -- | | |
| Effective Output Capacitance, time related | $C_{o(tr)}$[2] | -- | 732.0 | -- | | |
| $C_{oss}$ Stored Energy | $E_{oss}$ | -- | 39.7 | -- | μJ | |
| Output Capacitive Charge | $Q_{oss}$ | -- | 292.7 | -- | nC | |
| Internal Gate Resistance | $R_{G,int.}$ | -- | 2.1 | -- | Ω | $f$=1MHz, $V_{AC}$=25mV |

[1] $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400V.

[2] $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400V.

## Switching Characteristics:

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| **Gate Characteristics** | | | | | | |
| Gate to Source Charge | $Q_{GS}$ | -- | 53.0 | -- | nC | $V_{DS}$=400V, $V_{GS}$=0V/+15V, $I_D$=60A |
| Gate to Drain Charge | $Q_{GD}$ | -- | 58.2 | -- | | |
| Total Gate Charge | $Q_G$ | -- | 248.5 | -- | | |
| **Inductive Load** | | | | | | |
| Turn On Delay Time | $t_{d(on)}$ | -- | 93.0 | -- | nC | $V_{DS}$=400V, $I_D$=60A, $V_{GS}$=-3/+15V, $R_{G(ext.)}$= 4.7Ω |
| Rise Time | $t_r$ | -- | 78.0 | -- | | |
| Turn Off Delay Time | $t_{d(off)}$ | -- | 91.0 | -- | | |
| Fall Time | $t_f$ | -- | 16.0 | -- | | |
| Turn On Switching Energy | $E_{on}$ | -- | 2.6 | -- | | |
| Turn Off Switching Energy | $E_{off}$ | -- | 0.3 | -- | | |
| **Body Diode Characteristics** | | | | | | |
| Forward Recovery Charge | $Q_{fr}$ | -- | 481.0 | -- | nC | $V_{GS}$=0V, $I_S$=60A, $V_{DS}$=400V, $di/dt$=2015A/μs *$Q_{fr}$ herein excluded the $Q_{oss}$ value. |
| Forward Recovery Time | $t_{fr}$ | -- | 32.0 | -- | ns | |
| Peak Foreard Recovery Current | $I_{frm}$ | -- | 35.0 | -- | A | |

[1] Test are based on TO-220-3L PKG

## Thermal Characteristics:

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| Thermal Impedance, junction-case | $R_{th\text{-}jc}$ | -- | 0.13 | -- | K/W | *TOLT* |
| | | -- | 0.17 | -- | | *QDPAK* |
| | | -- | 0.13 | -- | | *TOLL* |
| Thermal Impedance, junction-ambient | $R_{th\text{-}ja}$ | -- | 40 | -- | | *Device on PCB, with 6 cm² of cooling area* |

## 1. Electrical Characteristics Diagrams

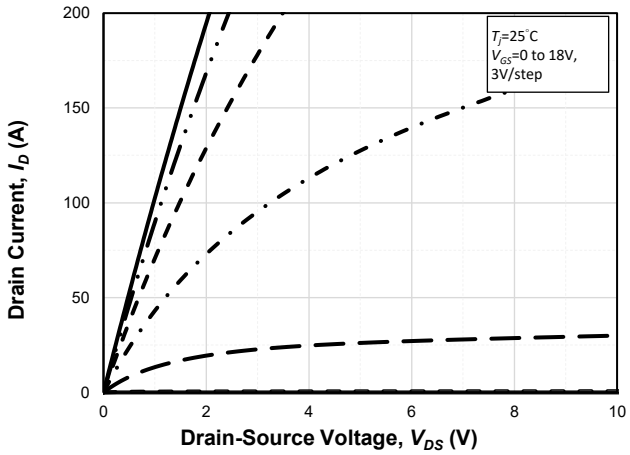



Fig. 1-1 Typical Output Characteristics at $T_j$=25˚C

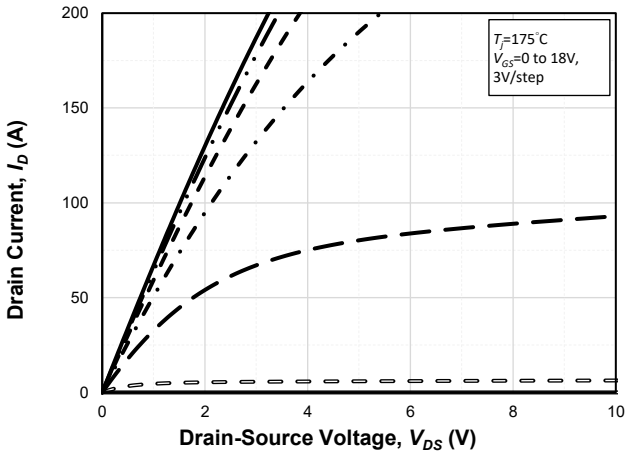



Fig. 1-2 Typical Output Characteristics at $T_j$=175˚C

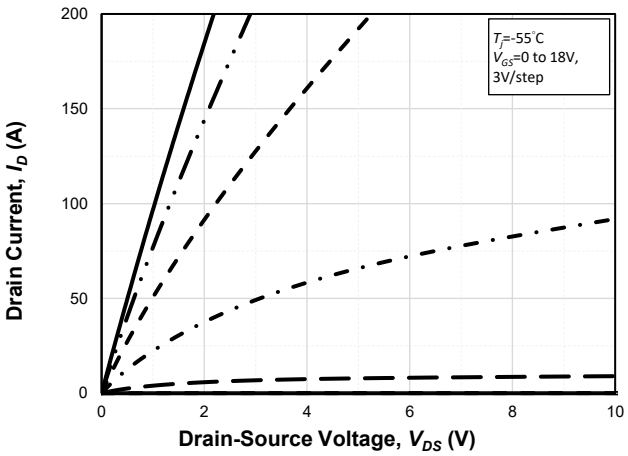



Fig. 1-3 Typical Output Characteristics at $T_j$=-55˚C

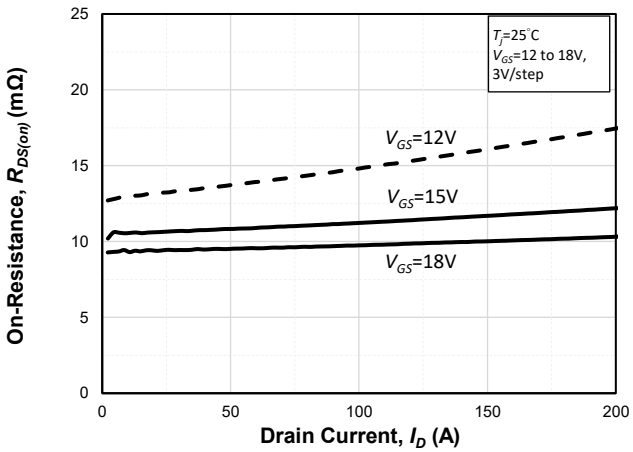



Fig. 1-4 Typ. $R_{DS(on)}$ vs. $I_D$ with Various $V_{GS}$

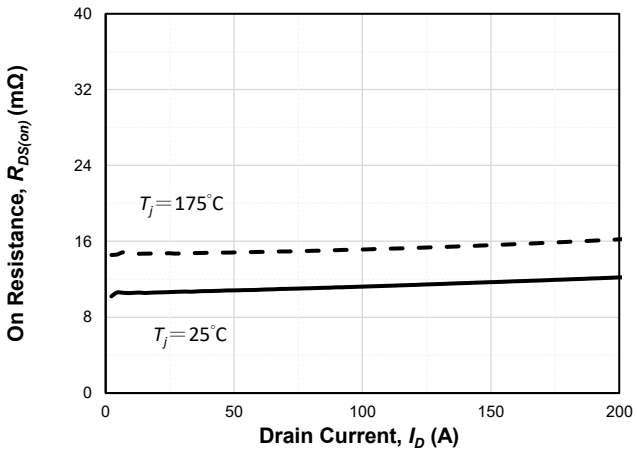



Fig. 1-5 Typ. $R_{DS(on)}$ vs. $I_D$ with Various $T_j$, $V_{GS}$=18V

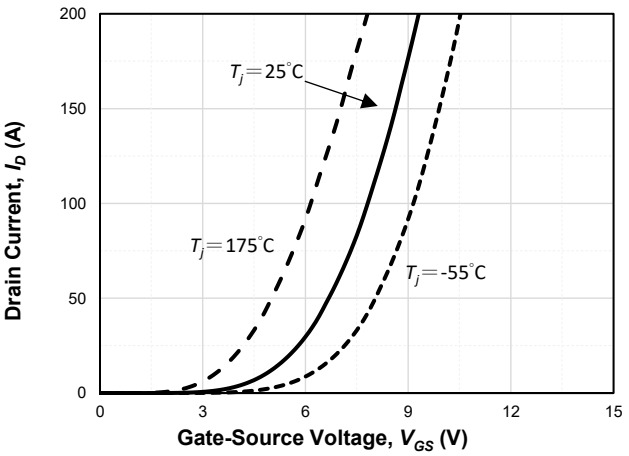



Fig. 1-6 Typ. $I_D$ vs. $V_{GS}$ with Various $T_j$, $V_{DS}$=10V

## 1. Electrical Characteristics Diagrams

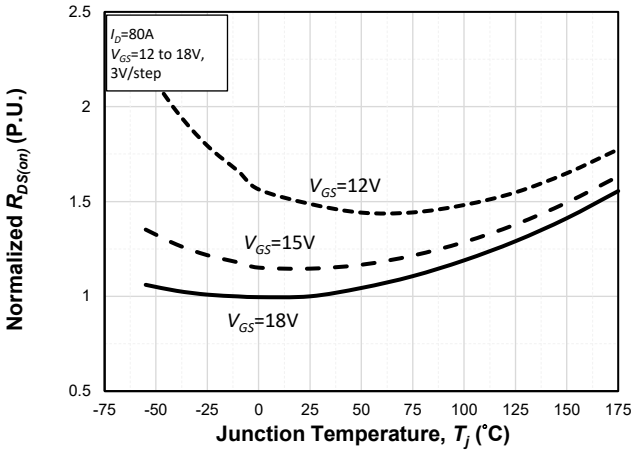



Fig. 1-7 Normalized $R_{DS(on)}$ vs. $T_j$ with Various $V_{GS}$

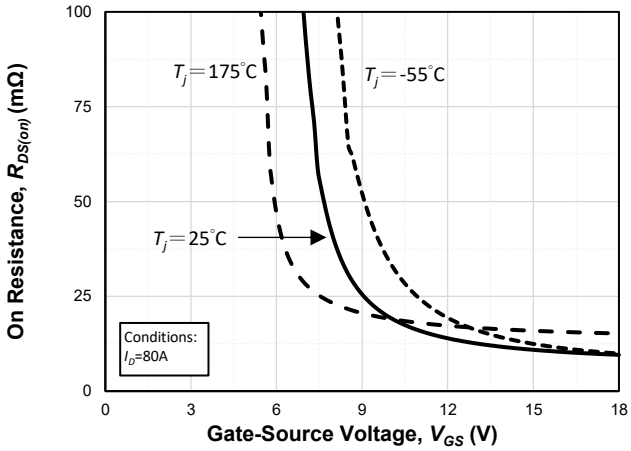



Fig. 1-8 Typ. $R_{DS(on)}$ vs. $V_{GS}$ with Various $T_j$

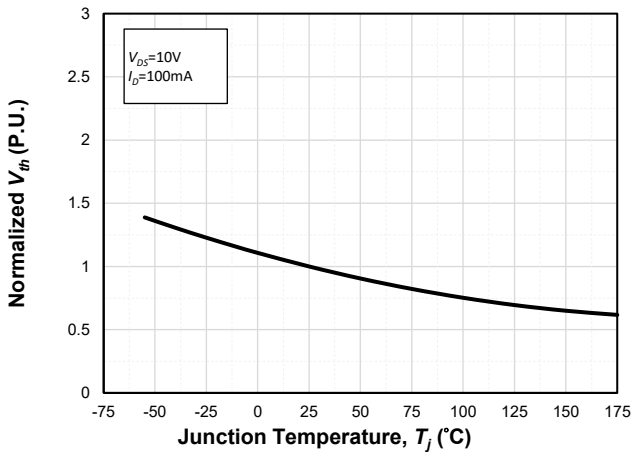



Fig. 1-9 Normalized $V_{th}$ vs. $T_j$

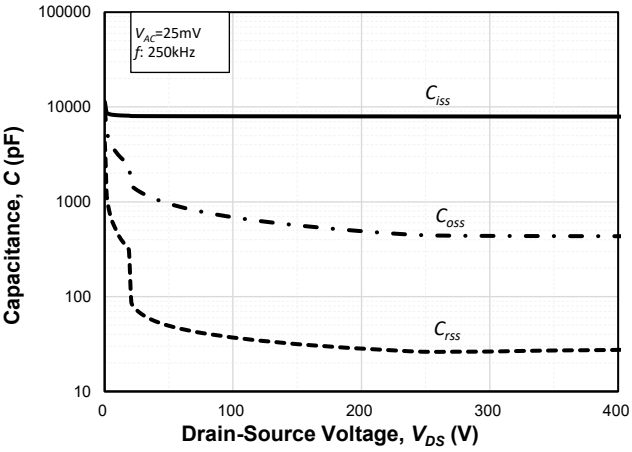



Fig. 1-10 Typ. Capacitance vs. $V_{DS}$ at $f_{sw}$=250kHz

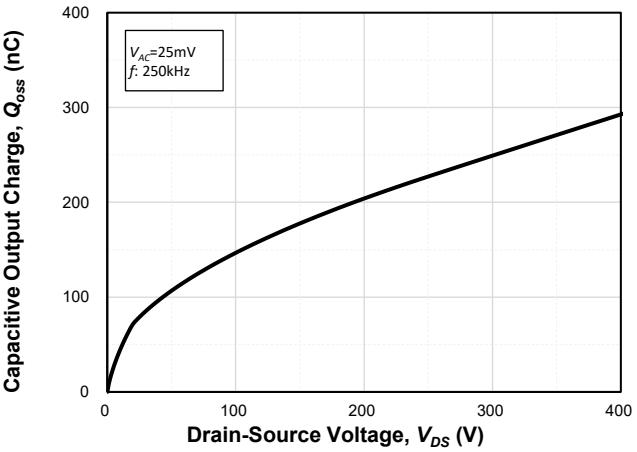



Fig. 1-11 Typ. Capacitive Output Charge at $f_{sw}$=250kHz

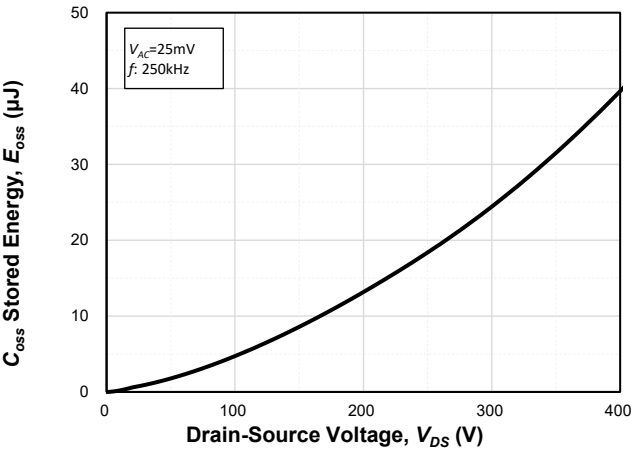



Fig. 1-12 Typ. CossStored Energy at fsw=250kHz

## 1. Electrical Characteristics Diagrams

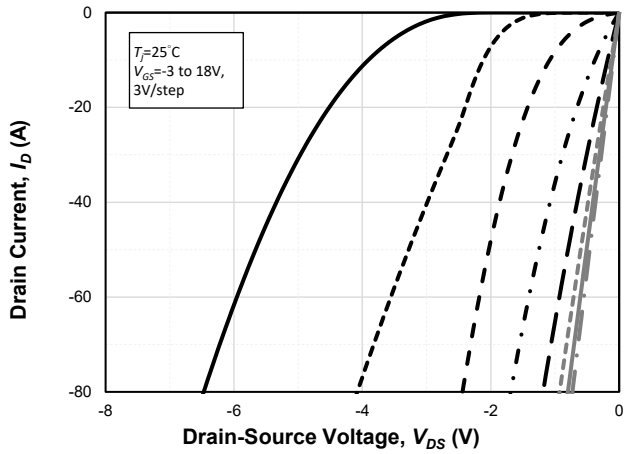



Fig. 1-13 Typical Forward Characteristics of Reverse Conduction at $T_j$=25°C

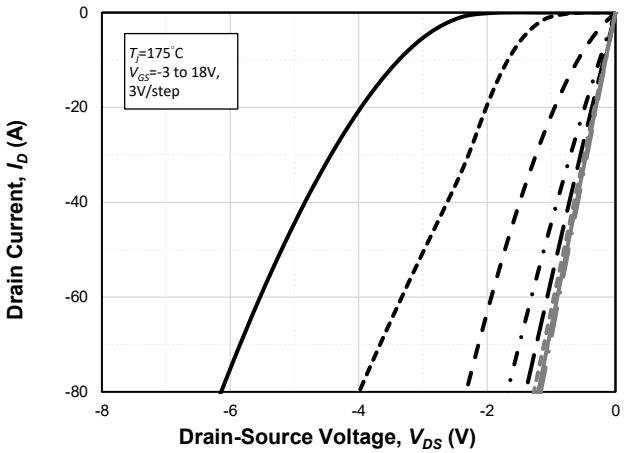



Fig. 1-14 Typical Forward Characteristics of Reverse Conduction at $T_j$=175°C

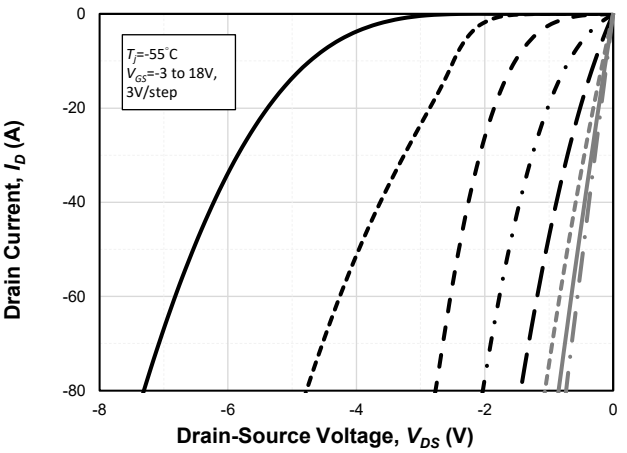



Fig. 1-15 Typical Forward Characteristics of Reverse Conduction at $T_j$=-55°C

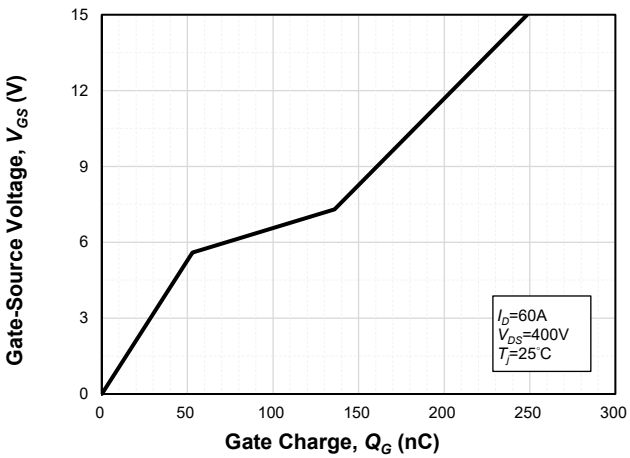



Fig. 1-16Typ. Gate Charge

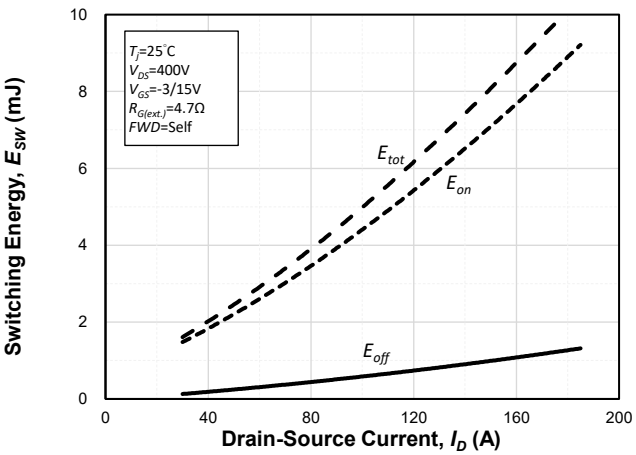



Fig. 1-17 Typ. Switching Energy vs. $I_D$

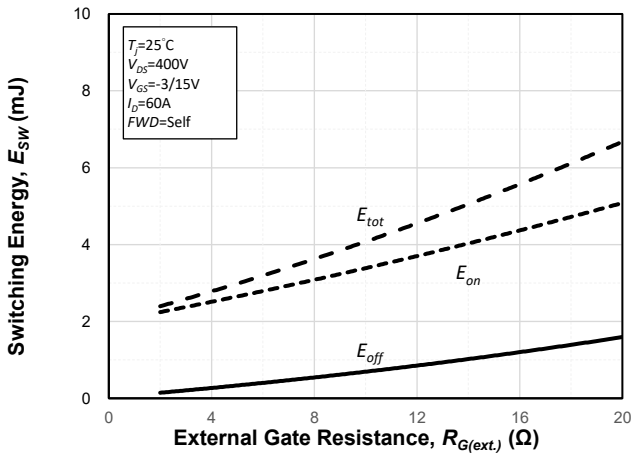



Fig. 1-18 Typ. Switching Energy vs. $R_{G(ext.)}$

## 2. Drain Power Dissipation

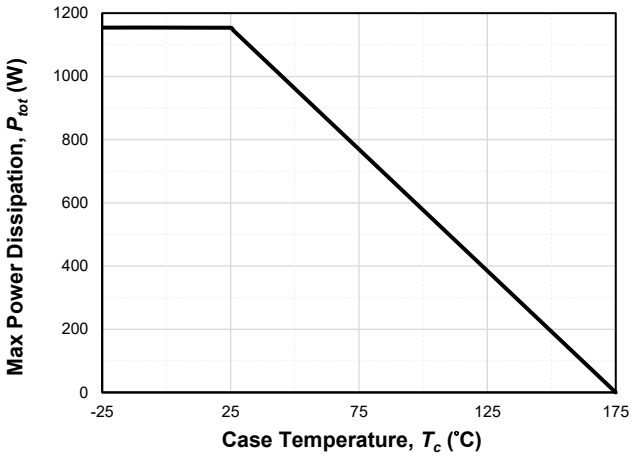



**Fig. 2-1 Power Dissipation at $V_{GS}$=18V, $T_j$≤175°C (TOLT)**

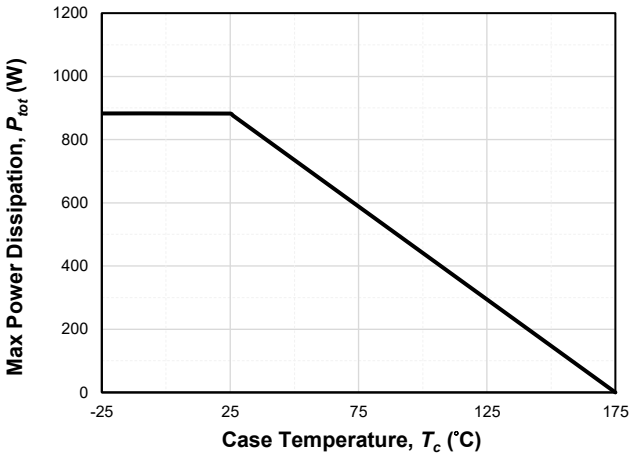



**Fig. 2-2 Power Dissipation at $V_{GS}$=18V, $T_j$≤175°C (QDPAK)**

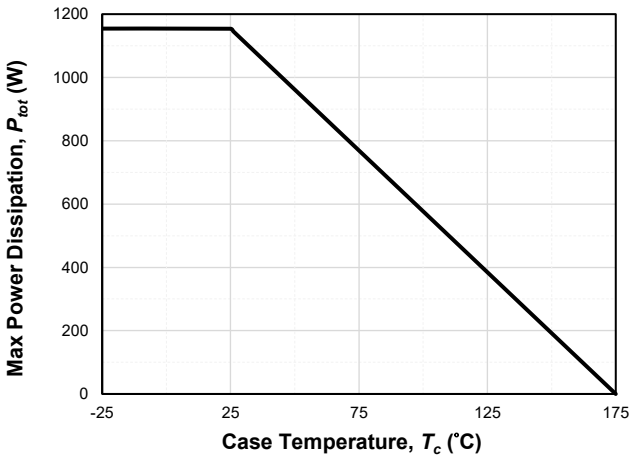



**Fig. 2-3 Power Dissipation at $V_{GS}$=18V, $T_j$≤175°C (TOLL)**

## 3. Drain Current Dissipation

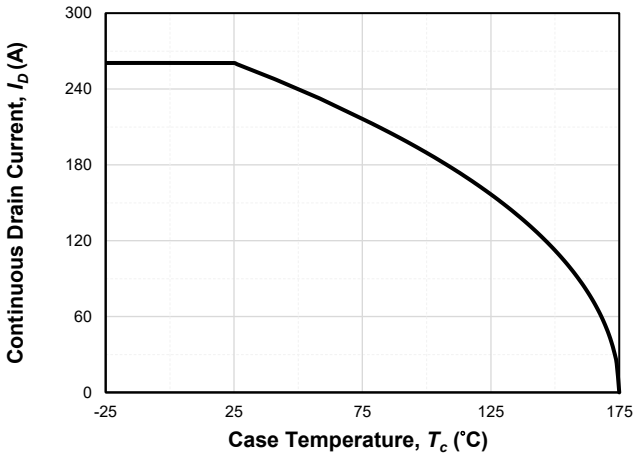



**Fig. 3-1 Current Dissipation at $V_{GS}$=18V, $T_j$≤175°C (TOLT)**

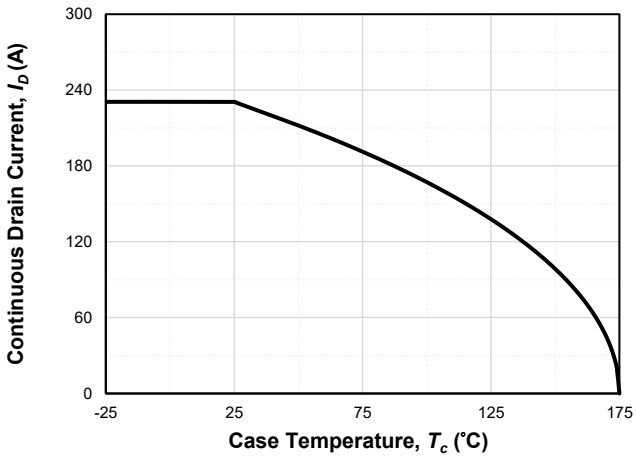



**Fig. 3-2 Current Dissipation at $V_{GS}$=18V, $T_j$≤175°C (QDPAK)**

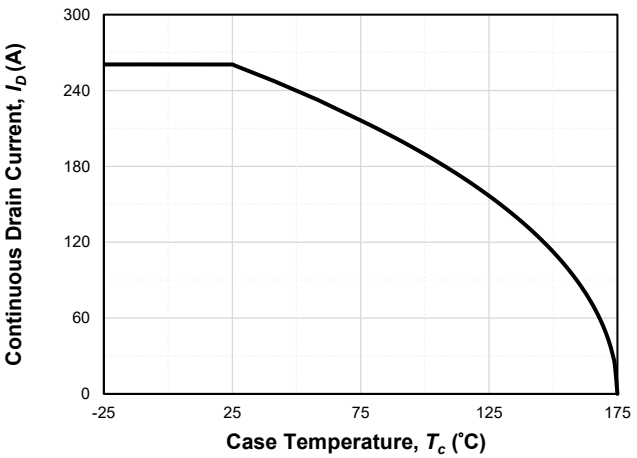



**Fig. 3-3 Current Dissipation at $V_{GS}$=18V, $T_j$≤175°C (TOLL)**

## 4. Body Diode Current Dissipation

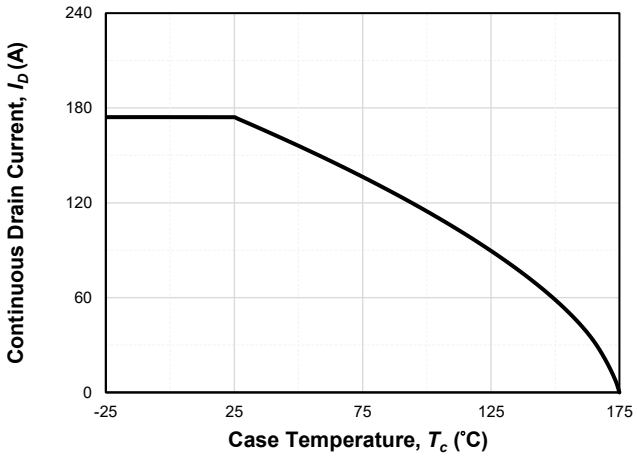



**Fig. 4-1 Body Diode Current Dissipation at $V_{GS}$=0V, $T_j$≤175˚C (TOLT)**

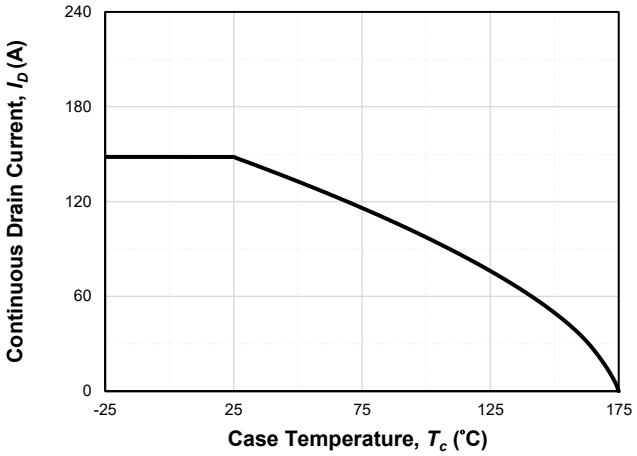



**Fig. 4-2 Body Diode Current Dissipation at $V_{GS}$=0V, $T_j$≤175˚C (QDPAK)**

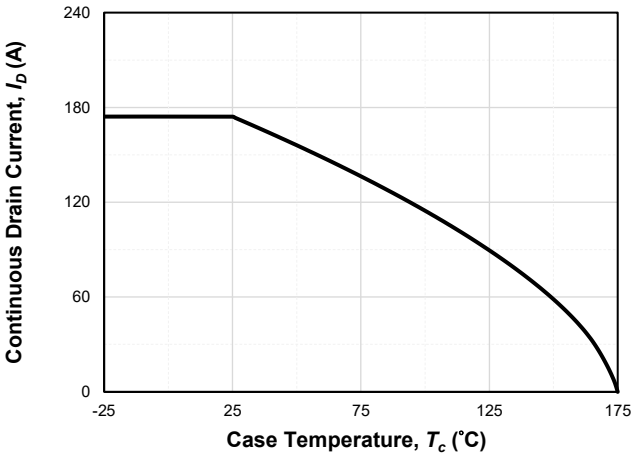



**Fig. 4-3 Body Diode Current Dissipation at $V_{GS}$=0V, $T_j$≤175˚C (TOLL)**

## 5. Thermal Impedance

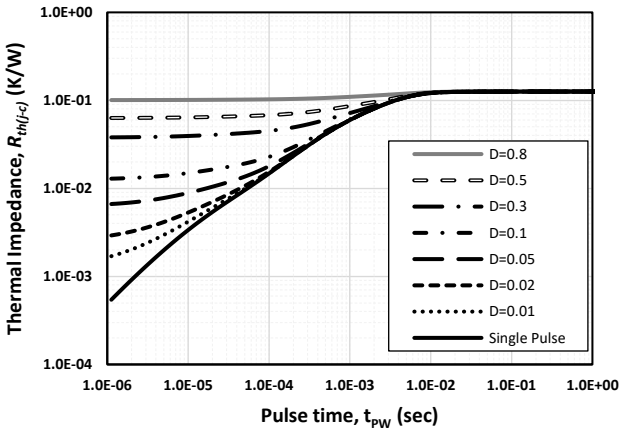



**Fig. 5-1 Typ. Transient Thermal Impedance $R_{th-jc}$ (TOLT)**

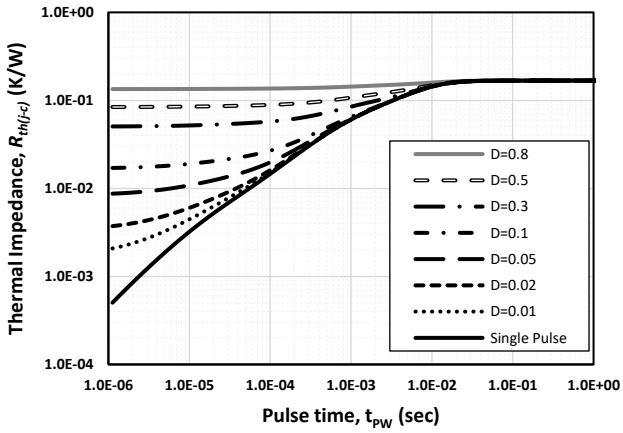



**Fig. 5-2 Typ. Transient Thermal Impedance $R_{th-jc}$ (QDPAK)**

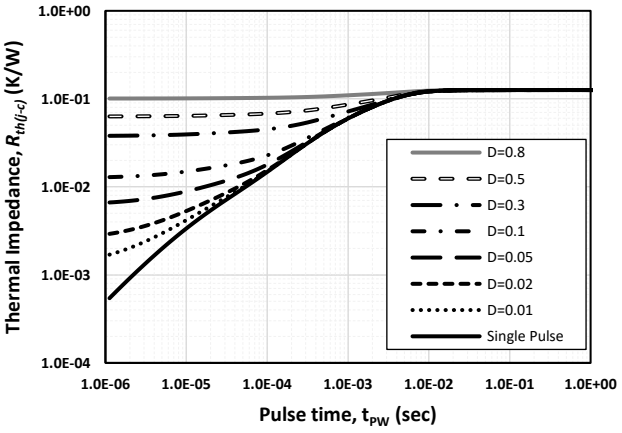



**Fig. 5-3 Typ. Transient Thermal Impedance $R_{th-jc}$ (TOLL)**

## 6. Safe Operating Area (25˚C)

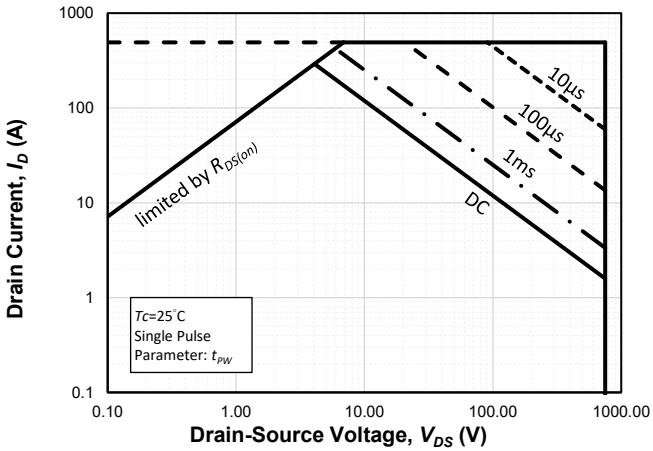



**Fig. 6-1 Safe Operating Area at $T_c$=25˚C (TOLT)**

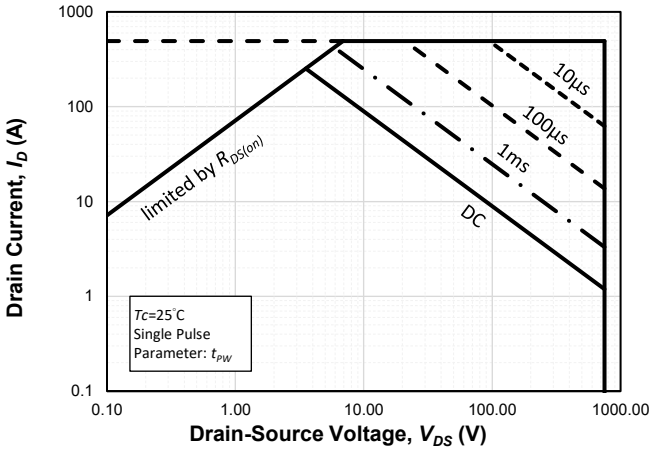



**Fig. 6-2 Safe Operating Area at $T_c$=25˚C (QDPAK)**

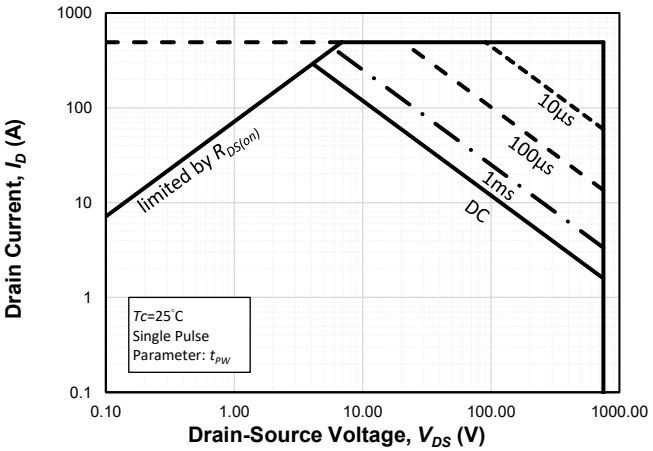



**Fig. 6-3 Safe Operating Area at $T_c$=25˚C (TOLL)**

## 7. Safe Operating Area (100˚C)

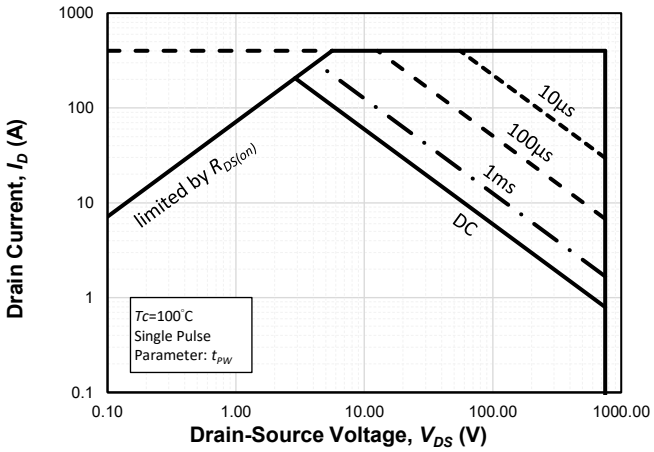



**Fig. 7-1 Safe Operating Area at $T_c$=100˚C (TOLT)**

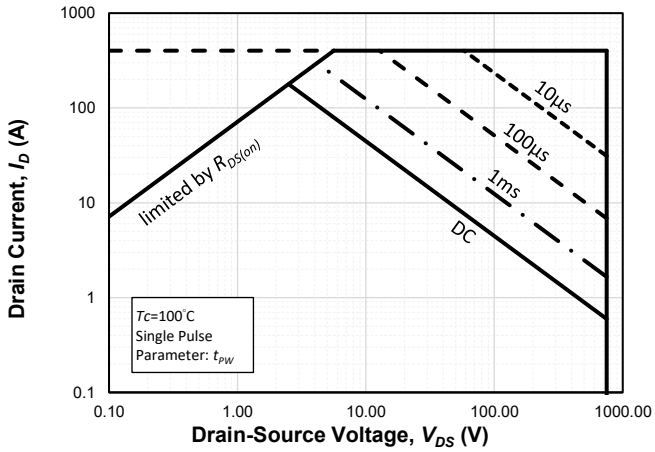



**Fig. 7-2 Safe Operating Area at $T_c$=100˚C (QDPAK)**

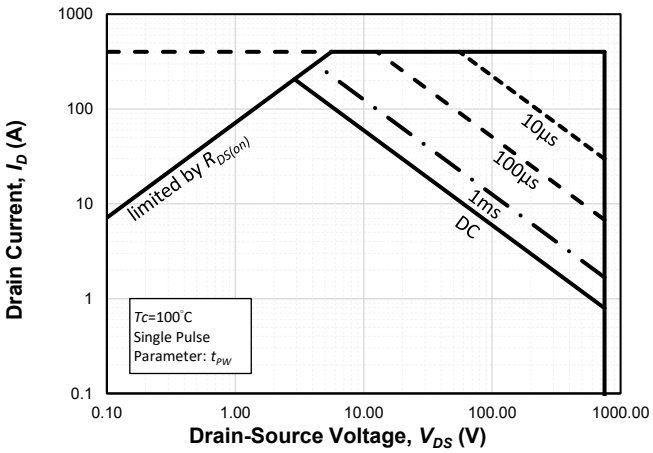
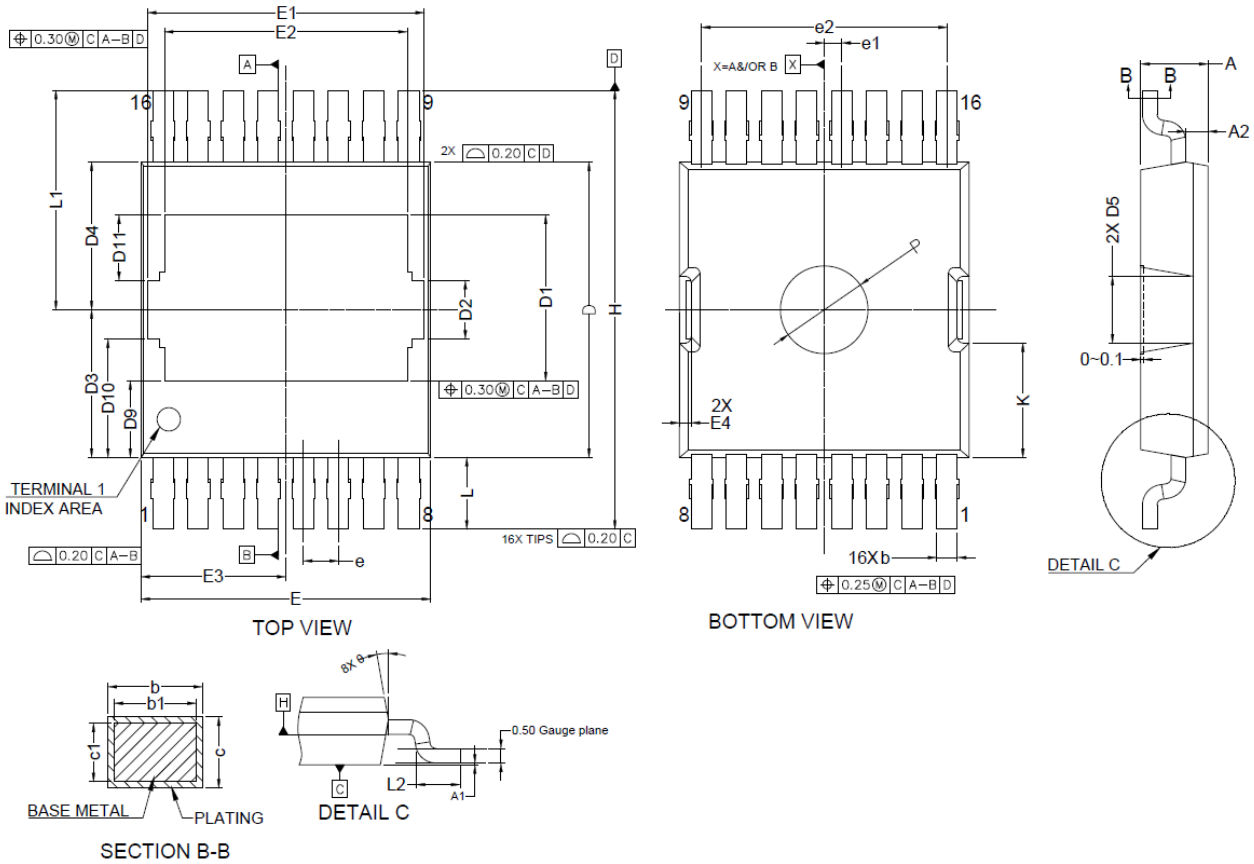


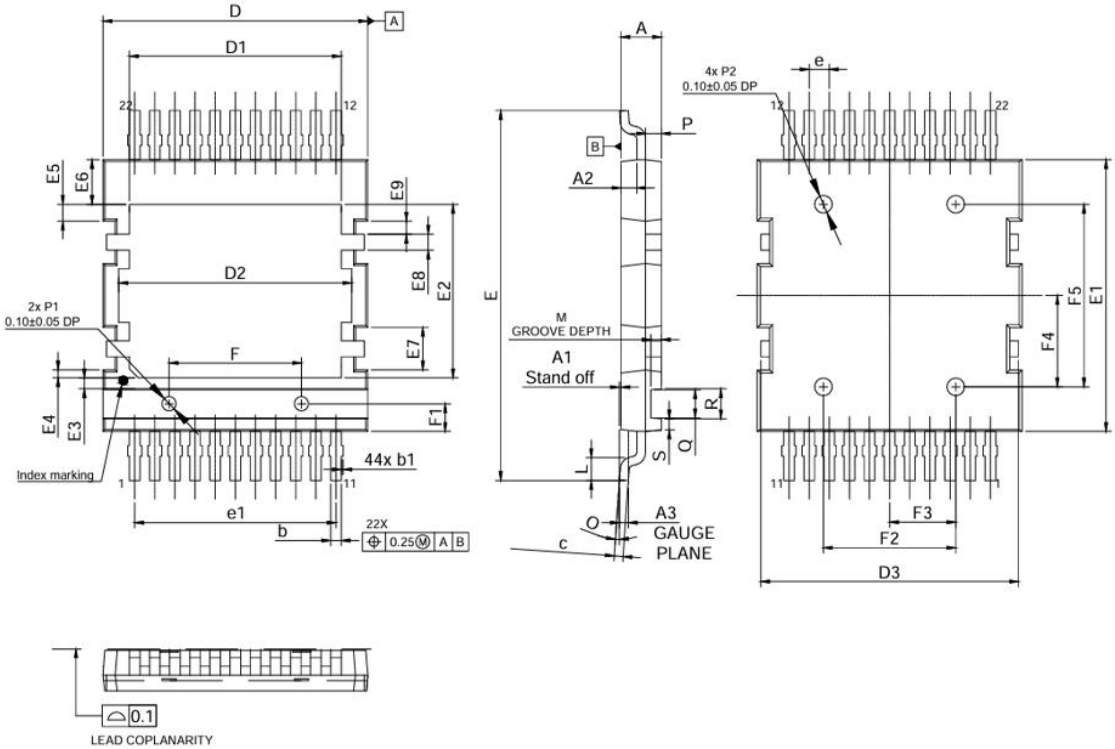

**Fig. 7-3 Safe Operating Area at $T_c$=100˚C (TOLL)**

## Package Outline (TOLT)



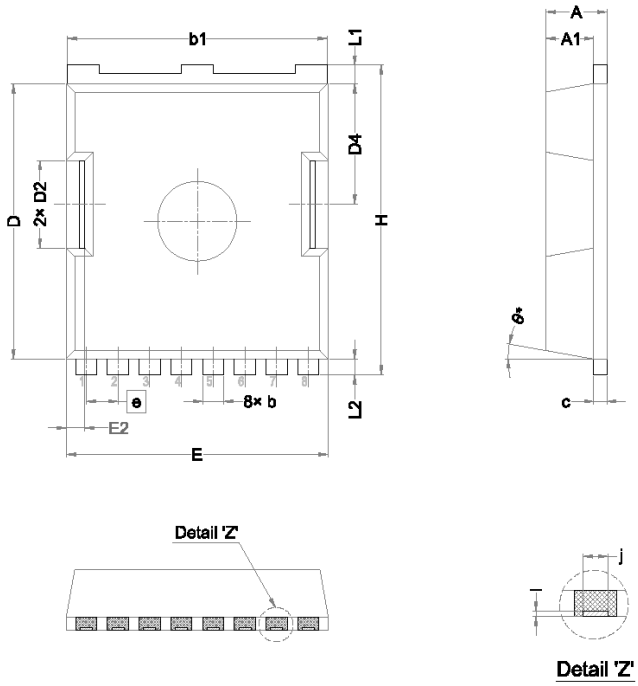

| SYMBOL | Dimension (Millimeters) | | | SYMBOL | Dimension (Millimeters) | | |
|---|---|---|---|---|---|---|---|
| | MIN | TYP | MAX | | MIN | TYP | MAX |
| A | 2.2 | 2.275 | 2.35 | E | 9.7 | 9.9 | 10.1 |
| A1 | 0.01 | 0.06 | 0.11 | E1 | 9.26 | 9.46 | 9.66 |
| A2 | 0.56 | 0.76 | 0.96 | E2 | 8.1 | 8.3 | 8.5 |
| b | 0.6 | 0.725 | 0.85 | E3 | 4.75 | 4.95 | 5.15 |
| b1 | 0.6 | 0.7 | 0.8 | E4 | 0.2 | 0.4 | 0.6 |
| c | 0.45 | 0.55 | 0.65 | e | 1.2 BSC. | | |
| c1 | 0.45 | 0.525 | 0.6 | e1 | 0.6 BSC. | | |
| D | 10 | 10.15 | 10.3 | e2 | 8.4 BSC. | | |
| D1 | 5.47 | 5.67 | 5.87 | H | 14.8 | 15 | 15.2 |
| D2 | 1.8 | 2 | 2.2 | K | 3.71 | 3.91 | 4.11 |
| D3 | 4.85 | 5.05 | 5.25 | L | 2.25 | 2.45 | 2.65 |
| D4 | 5 | 5.065 | 5.13 | L1 | 7.3 | 7.5 | 7.7 |
| D5 | 2.08 | 2.28 | 2.48 | L2 | 1.3 | 1.5 | 1.7 |
| D9 | 2.42 | 2.62 | 2.82 | R | 0.07 | | -- |
| D10 | 3.85 | 4.05 | 4.25 | P | 2.9 | 3 | 3.1 |
| D11 | 2.04 | 2.24 | 2.44 | θ | 4° | 7° | 10° |

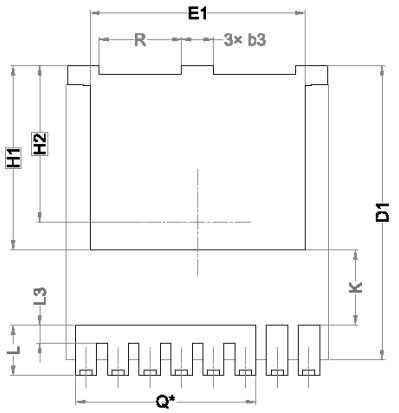
## Package Outline (QDPAK)

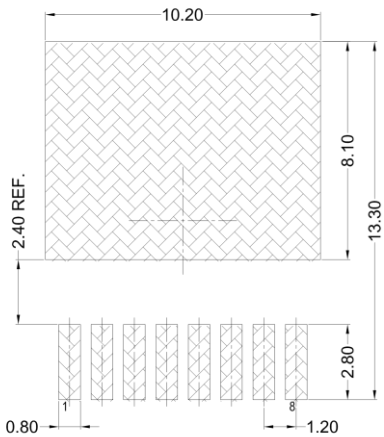



| SYMBOL | MIN | MAX | SYMBOL | MIN | MAX |
|---|---|---|---|---|---|
| A | 2.25 | 2.35 | E9 | 0.75 | |
| A1 | 0.00 | 0.15 | e | 1.14 | |
| A2 | 0.90 | | e1 | 11.4 | |
| A3 | 0.50 | | F | 7.40 | 7.60 |
| b | 0.50 | 0.70 | F1 | 1.47 | 1.67 |
| b1 | - | 0.15 | F2 | 7.40 | 7.60 |
| c | 0.46 | 0.58 | F3 | 3.65 | 3.85 |
| D | 14.90 | 15.10 | F4 | 5.07 | 5.27 |
| D1 | 12.00 | | F5 | 10.24 | 10.44 |
| D2 | 13.20 | | L | 1.30 | |
| D3 | 14.50 | 14.70 | M | 0.60 | |
| E | 20.81 | 21.11 | N | 22 | |
| E1 | 15.30 | 15.50 | O | 0° | 8° |
| E2 | 9.83 | | P | 0.90 | |
| E3 | 0.625 | | P1 | 0.70 | 0.90 |
| E4 | 0.45 | | P2 | 0.90 | 1.10 |
| E5 | 0.95 | | Q | 1.60 | |
| E6 | 2.53 | | R | 1.70 | |
| E7 | 2.40 | | S | 0.631 | |
| E8 | 0.90 | | | | |

## Package Outline (TOLL, MO-299B)




**Land Pattern (Only for reference)**

| Symbol | Dimension (Millimeters) | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 2.20 | 2.30 | 2.40 |
| A1 | 1.70 | 1.80 | 1.90 |
| b | 0.70 | 0.80 | 0.90 |
| b1 | 9.70 | 9.80 | 9.90 |
| b3 | 1.10 | 1.20 | 1.30 |
| c | 0.40 | 0.50 | 0.60 |
| D | 10.28 | 10.38 | 10.48 |
| D1 | 10.98 | 11.08 | 11.18 |
| D2 | 3.20 | 3.30 | 3.40 |
| D4 | 4.45 | 4.55 | 4.65 |
| E | 9.80 | 9.90 | 10.00 |
| E1 | 8.00 | 8.10 | 8.20 |
| E2 | 0.60 | 0.70 | 0.80 |
| e | | 1.20 BSC. | |
| H | 11.58 | 11.68 | 11.78 |
| H1 | | 6.95 BSC. | |
| H2 | | 5.89 BSC. | |
| i | | 0.10 REF. | |
| j | | 0.46REF. | |
| K | | 2.80 REF. | |
| L | 1.40 | 1.90 | 2.10 |
| L1 | 0.60 | 0.70 | 0.80 |
| L2 | 0.50 | 0.60 | 0.70 |
| L3 | 0.30 | 0.70 | 0.80 |
| N | | 8 | |
| Q | | 6.80 REF. | |
| R | 3.00 | 3.10 | 3.20 |
| θ | | 10° REF. | |

**Note:**

1. Dimensions do not inclusive burrs and mold flash.
2. "*" is for reference.

## Revision History

| Date | Revision | Changes |
|---|---|---|
| 26.04 | Preliminary | 1st issue |
| 26.04 | Preliminary | Add TOLL |
| | | |

## Important Note (Disclaimer)

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