

# 1200 V 40 mΩ SiC MOSFET

## Silicon Carbide MOSFET

### Trench-Assisted Planar Technology

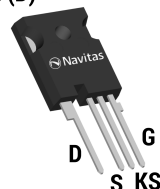
|                          |   |        |
|--------------------------|---|--------|
| $V_{DS}$                 | = | 1200 V |
| $R_{DS(ON)}(Typ.)$       | = | 40 mΩ  |
| $I_D(T_C = 100^\circ C)$ | = | 39 A   |

#### Features

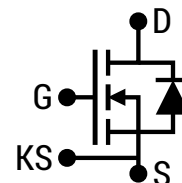
- Gen3F (3rd Generation) Technology
- Most Stable  $R_{DS(ON)}$  over Temperature
- Low  $C_{OSS}$ ,  $C_{RSS}$  and Balanced  $C_{ISS}/C_{RSS}$
- Lower  $Q_{GD}$  and Balanced  $R_{G(INT)}$
- Electromagnetically Optimized Design
- Robust Body Diode with Low  $V_F$  and Low  $Q_{RR}$
- 100% Avalanche (UIL) Tested
- AEC-Q101 Qualified

#### Package

Case (D)



TO-247-4



D = Drain  
G = Gate  
S = Source  
KS = Kelvin Source



#### Advantages

- Superior Performance and Robustness
- Lowest Conduction Losses at all Temperatures
- Lesser Switching Spikes and Lower Losses
- Faster and More Efficient Switching
- Reduced Ringing
- Ease of Paralleling without Thermal Runaway
- Excellent Power Density and System Efficiency
- Enhanced System Reliability

#### Applications

- xEV - OBC & DC-DC
- EV Fast Charging Infrastructure
- Solar / PV
- Energy Storage Systems
- Uninterruptible Power Supply
- Motor Control
- Induction Heating & Welding
- High Voltage Converters

#### Absolute Maximum Ratings (At $T_C = 25^\circ C$ Unless Otherwise Stated)

| Parameter                                  | Symbol           | Conditions                                                        | Values     | Unit       | Note    |
|--------------------------------------------|------------------|-------------------------------------------------------------------|------------|------------|---------|
| Drain-Source Voltage                       | $V_{DS(max)}$    | $V_{GS} = 0\text{ V}, I_D = 100\text{ }\mu\text{A}$               | 1200       | V          |         |
| Gate-Source Voltage (Dynamic)              | $V_{GS(max)}$    |                                                                   | -10 / +22  | V          |         |
| Gate-Source Voltage (Static)               | $V_{GS(op)-ON}$  | Recommended Operation                                             | 18         | V          | Note 1  |
|                                            | $V_{GS(op)-OFF}$ |                                                                   | -5 to -3   |            |         |
| Continuous Drain Current                   | $I_D$            | $T_C = 25^\circ C, V_{GS} = -5 / +18\text{ V}$                    | 55         | A          | Fig. 16 |
|                                            |                  | $T_C = 100^\circ C, V_{GS} = -5 / +18\text{ V}$                   | 39         |            |         |
|                                            |                  | $T_C = 135^\circ C, V_{GS} = -5 / +18\text{ V}$                   | 28         |            |         |
| Pulsed Drain Current                       | $I_{D(pulse)}$   | $t_P \leq 3\text{ }\mu\text{s}, D \leq 1\%, V_{GS} = 18\text{ V}$ | 120        | A          | Note 2  |
| Power Dissipation                          | $P_D$            | $T_C = 25^\circ C$                                                | 234        | W          | Fig. 17 |
| Non-Repetitive Avalanche Energy            | $E_{AS}$         | $L = 36\text{ mH}, I_{AV} = 5\text{ A}$                           | 450        | mJ         |         |
| Operating Junction and Storage Temperature | $T_J, T_{stg}$   |                                                                   | -55 to 175 | $^\circ C$ |         |

Note 1: This product can support 0V turn-off gate drive voltage with optimized PCB layout and gate drive circuit configuration.

Note 2: Pulse Width  $t_P$  Limited by  $T_{J(max)}$



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Electrical Characteristics (At  $T_C = 25^\circ\text{C}$  Unless Otherwise Stated)

| Parameter                                     | Symbol       | Conditions                                                                                                                                                                          | Values |      |      | Unit          | Note       |
|-----------------------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|------|---------------|------------|
|                                               |              |                                                                                                                                                                                     | Min.   | Typ. | Max. |               |            |
| Drain-Source Breakdown Voltage                | $V_{DSS}$    | $V_{GS} = 0\text{ V}, I_D = 100\text{ }\mu\text{A}$                                                                                                                                 | 1200   |      |      | V             |            |
| Zero Gate Voltage Drain Current               | $I_{DSS}$    | $V_{DS} = 1200\text{ V}, V_{GS} = 0\text{ V}$                                                                                                                                       |        | 1    | 50   | $\mu\text{A}$ |            |
| Gate Source Leakage Current                   | $I_{GSS}$    | $V_{DS} = 0\text{ V}, V_{GS} = 22\text{ V}$                                                                                                                                         |        |      | 100  | nA            |            |
|                                               |              | $V_{DS} = 0\text{ V}, V_{GS} = -10\text{ V}$                                                                                                                                        |        |      | -100 |               |            |
| Gate Threshold Voltage                        | $V_{GS(th)}$ | $V_{DS} = V_{GS}, I_D = 16\text{ mA}$                                                                                                                                               | 2.2    | 2.9  | 4.3  | V             | Note 3     |
| Transconductance                              | $g_{fs}$     | $V_{DS} = 10\text{ V}, I_D = 20\text{ A}$                                                                                                                                           |        | 10.2 |      | S             | Fig. 5     |
|                                               |              | $V_{DS} = 10\text{ V}, I_D = 20\text{ A}, T_j = 175^\circ\text{C}$                                                                                                                  |        | 11.4 |      |               |            |
| Drain-Source On-State Resistance              | $R_{DS(on)}$ | $V_{GS} = 18\text{ V}, I_D = 20\text{ A}$                                                                                                                                           |        | 40   | 53   | m $\Omega$    | Fig. 6-9   |
|                                               |              | $V_{GS} = 18\text{ V}, I_D = 20\text{ A}, T_j = 175^\circ\text{C}$                                                                                                                  |        | 71   |      |               |            |
| Input Capacitance                             | $C_{iss}$    |                                                                                                                                                                                     |        | 2023 |      | pF            | Fig. 12    |
| Output Capacitance                            | $C_{oss}$    |                                                                                                                                                                                     |        | 73   |      |               |            |
| Reverse Transfer Capacitance                  | $C_{rss}$    |                                                                                                                                                                                     |        | 5.8  |      | $\mu\text{J}$ | Fig. 13    |
| $C_{oss}$ Stored Energy                       | $E_{oss}$    | $V_{DS} = 800\text{ V}, V_{GS} = 0\text{ V}$<br>$f = 500\text{ KHz}, V_{AC} = 25\text{ mV}$                                                                                         |        | 29   |      |               |            |
| $C_{oss}$ Stored Charge                       | $Q_{oss}$    |                                                                                                                                                                                     |        | 107  |      | nC            |            |
| Effective Output Capacitance (Energy Related) | $C_{o(er)}$  |                                                                                                                                                                                     |        | 91   |      | pF            | Note 4     |
| Effective Output Capacitance (Time Related)   | $C_{o(tr)}$  |                                                                                                                                                                                     |        | 134  |      |               |            |
| Gate-Source Charge                            | $Q_{gs}$     | $V_{DS} = 800\text{ V}, V_{GS} = -5 / +18\text{ V}$                                                                                                                                 |        | 24   |      | nC            | Fig. 11    |
| Gate-Drain Charge                             | $Q_{gd}$     | $I_D = 20\text{ A}$                                                                                                                                                                 |        | 24   |      |               |            |
| Total Gate Charge                             | $Q_g$        | Per JEDEC JEP-192                                                                                                                                                                   |        | 86   |      |               |            |
| Internal Gate Resistance                      | $R_{G(int)}$ | $V_{GS} = 18\text{ V}, f = 1\text{ MHz}, V_{AC} = 25\text{ mV}$                                                                                                                     |        | 1.2  |      | $\Omega$      |            |
| Turn-On Switching Energy (Body Diode)         | $E_{on}$     | $T_j = 25^\circ\text{C}, V_{GS} = -5/+18\text{ V}, R_{G(ext)} = 5\text{ }\Omega, L = 60.0\text{ }\mu\text{H}, I_D = 20\text{ A}, V_{DD} = 800\text{ V}$                             |        | 138  |      | $\mu\text{J}$ | Fig. 24-27 |
| Turn-Off Switching Energy (Body Diode)        | $E_{off}$    |                                                                                                                                                                                     |        | 28   |      |               |            |
| Turn-On Delay Time                            | $t_{d(on)}$  | $V_{DD} = 800\text{ V}, V_{GS} = -5/+18\text{ V}$<br>$R_{G(ext)} = 5\text{ }\Omega, L = 60.0\text{ }\mu\text{H}, I_D = 20\text{ A}$<br>Timing relative to $V_{DS}$ , Inductive load |        | 41   |      | ns            | Fig. 26    |
| Rise Time                                     | $t_r$        |                                                                                                                                                                                     |        | 12   |      |               |            |
| Turn-Off Delay Time                           | $t_{d(off)}$ |                                                                                                                                                                                     |        | 22   |      |               |            |
| Fall Time                                     | $t_f$        |                                                                                                                                                                                     |        | 11   |      |               |            |

Note 3: Tested after applying 30ms pulse at  $V_{GS} = +25\text{ V}$

Note 4:  $C_{o(er)}$ , a lumped capacitance that gives same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 800V.

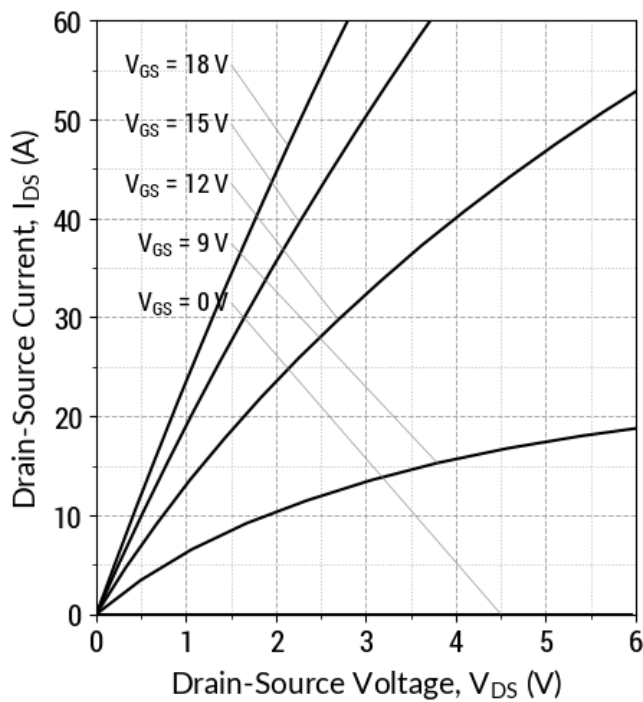
$C_{o(tr)}$ , a lumped capacitance that gives same charging times as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 800V.

## Reverse Diode Characteristics

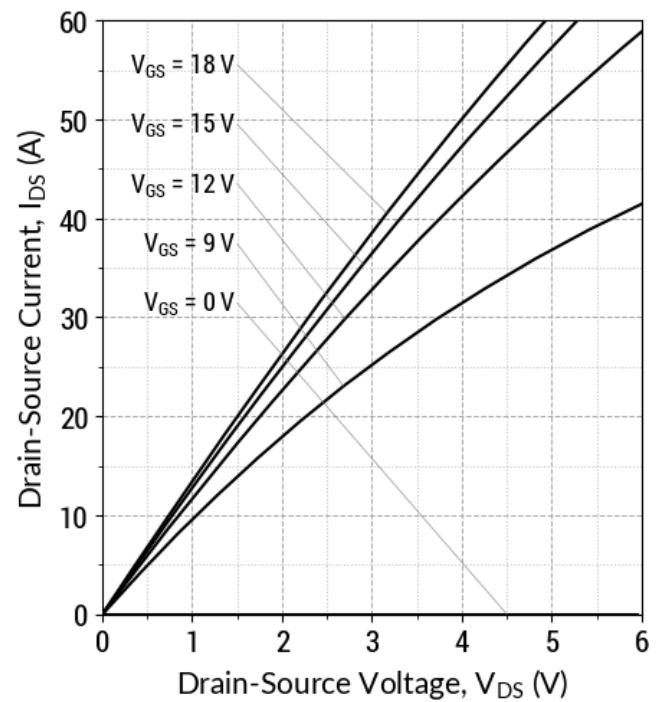
| Parameter                        | Symbol         | Conditions                                                                                                                        | Values |            |          | Unit | Note       |
|----------------------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------|--------|------------|----------|------|------------|
|                                  |                |                                                                                                                                   | Min.   | Typ.       | Max.     |      |            |
| Diode Forward Voltage            | $V_{SD}$       | $V_{GS} = -5\text{ V}, I_{SD} = 10\text{ A}$<br>$V_{GS} = -5\text{ V}, I_{SD} = 10\text{ A}, T_j = 175^\circ\text{C}$             |        | 4.3<br>3.8 |          | V    | Fig. 18-19 |
| Continuous Diode Forward Current | $I_S$          | $V_{GS} = -5\text{ V}, T_c = 25^\circ\text{C}$<br>$V_{GS} = -5\text{ V}, T_c = 100^\circ\text{C}$                                 |        |            | 37<br>22 | A    |            |
| Diode Pulse Current              | $I_{S(pulse)}$ | $V_{GS} = -5\text{ V}$                                                                                                            |        | 88         |          | A    | Note 2     |
| Reverse Recovery Time            | $t_{rr}$       | $V_{GS} = -5\text{ V}, I_{SD} = 30\text{ A}, V_R = 800\text{ V}$<br>$dif/dt = 1000\text{ A}/\mu\text{s}, T_j = 25^\circ\text{C}$  |        | 17         |          | ns   |            |
| Reverse Recovery Charge          | $Q_{rr}$       |                                                                                                                                   |        | 85         |          | nC   |            |
| Peak Reverse Recovery Current    | $I_{rm}$       |                                                                                                                                   |        | 5.5        |          | A    |            |
| Reverse Recovery Time            | $t_{rr}$       | $V_{GS} = -5\text{ V}, I_{SD} = 30\text{ A}, V_R = 800\text{ V}$<br>$dif/dt = 1000\text{ A}/\mu\text{s}, T_j = 175^\circ\text{C}$ |        | 26         |          | ns   |            |
| Reverse Recovery Charge          | $Q_{rr}$       |                                                                                                                                   |        | 220        |          | nC   |            |
| Peak Reverse Recovery Current    | $I_{rm}$       |                                                                                                                                   |        | 8          |          | A    |            |

## Package Characteristics

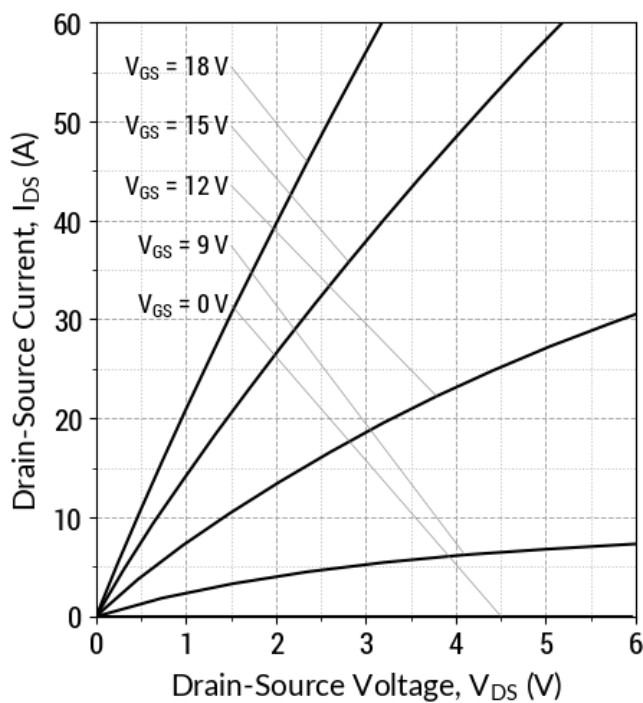
| Parameter                               | Symbol         | Conditions         | Values | Unit                      | Note    |
|-----------------------------------------|----------------|--------------------|--------|---------------------------|---------|
| Max Thermal Resistance, Junction - Case | $R_{thJC-Max}$ | Maximum            | 0.64   | $^\circ\text{C}/\text{W}$ | Fig. 14 |
| Weight                                  | $W_T$          |                    | 6.2    | g                         |         |
| Moisture Sensitivity Level              | MSL            |                    | N/A    |                           |         |
| EMC Material Group                      |                |                    | II     |                           |         |
| Max Mounting Torque                     | $T_M$          | Screws to Heatsink | 1.1    | Nm                        |         |

Fig 1: Typical Output Characteristics ( $T_J = 25^\circ\text{C}$ )

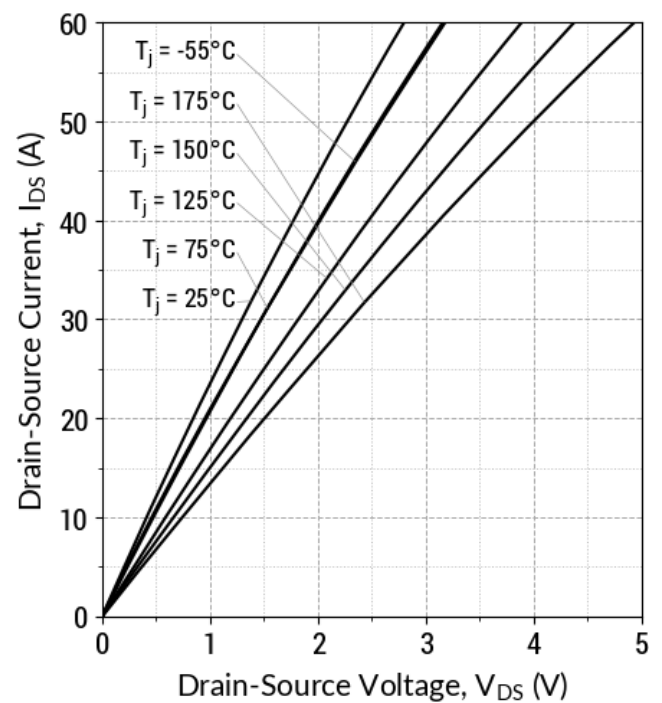
$$I_D = f(V_{DS}, V_{GS}); t_P = 50\ \mu\text{s}$$

Fig 2: Typical Output Characteristics ( $T_J = 175^\circ\text{C}$ )

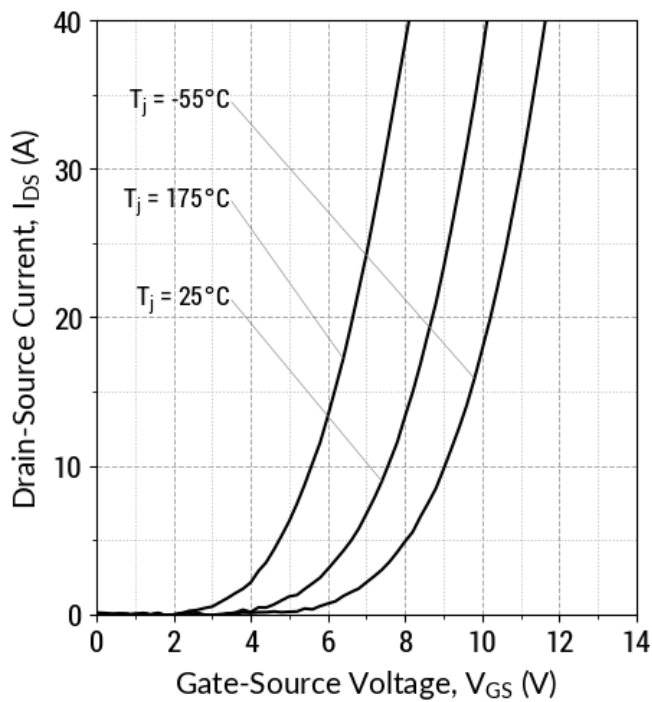
$$I_D = f(V_{DS}, V_{GS}); t_P = 50\ \mu\text{s}$$

Fig 3: Typical Output Characteristics ( $T_J = -55^\circ\text{C}$ )

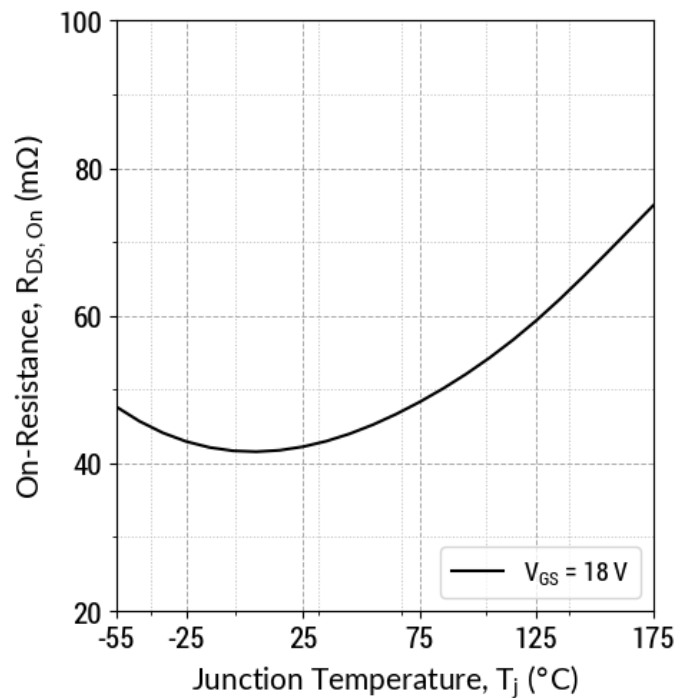
$$I_D = f(V_{DS}, V_{GS}); t_P = 50\ \mu\text{s}$$

Fig 4: Typical Output Characteristics ( $V_{GS} = 18\text{ V}$ )

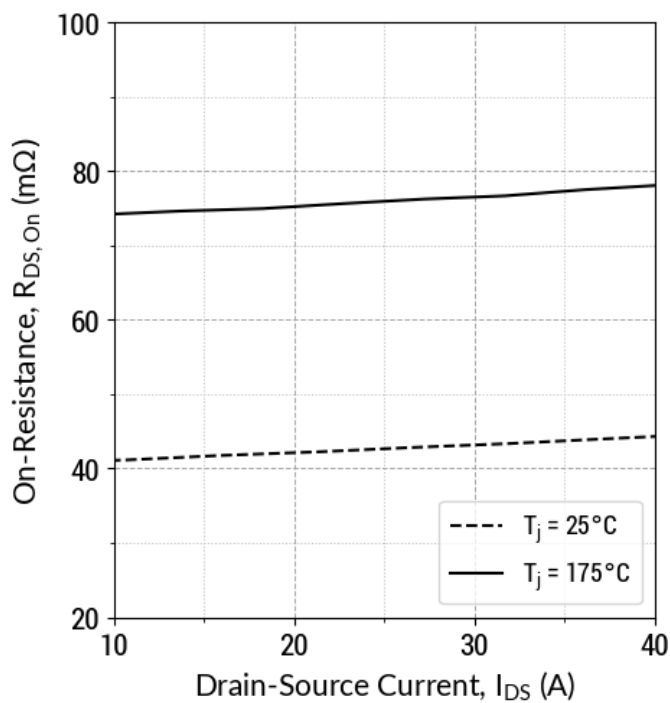
$$I_D = f(V_{DS}, T_J); t_P = 50\ \mu\text{s}$$

Fig 5: Typical Transfer Characteristics ( $V_{DS} = 10\text{ V}$ )

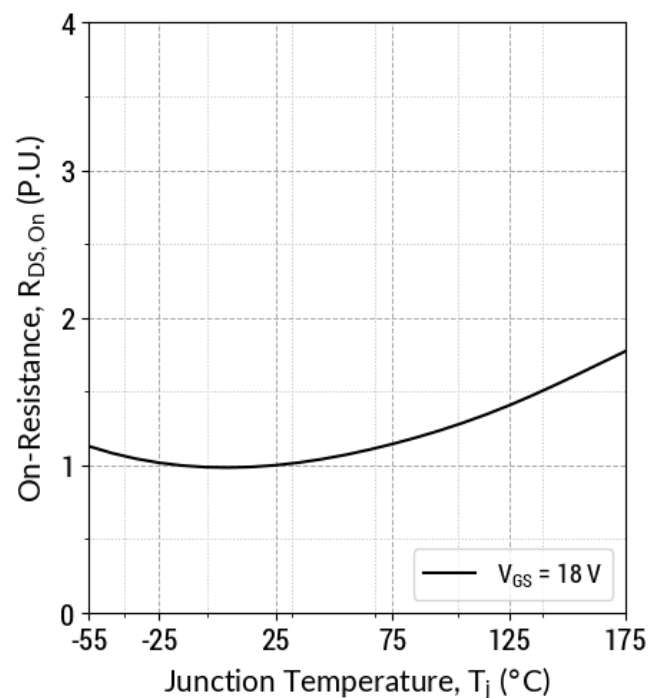
$$I_D = f(V_{GS}, T_j); t_P = 100\ \mu\text{s}$$

Fig 6: Typical  $R_{DS(ON)}$  v/s Temperature

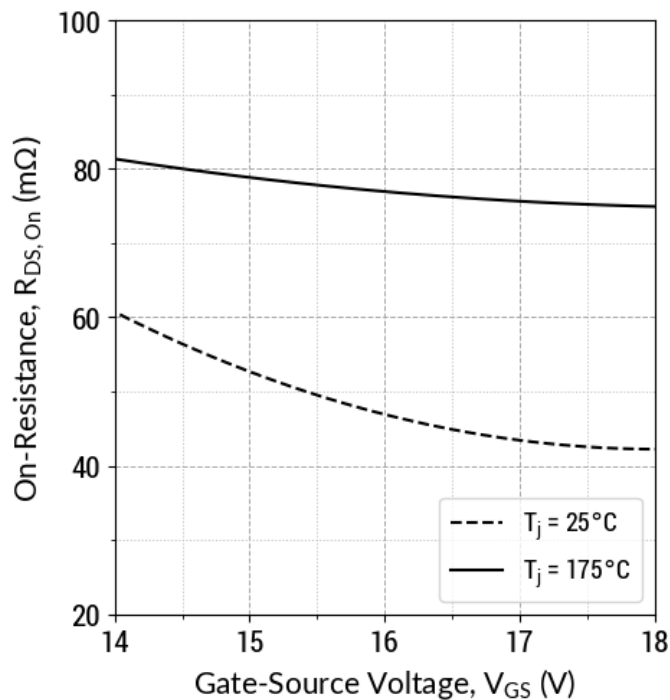
$$R_{DS(ON)} = f(T_j, V_{GS}); t_P = 50\ \mu\text{s}; I_D = 20\text{ A}$$

Fig 7: Typical  $R_{DS(ON)}$  v/s Drain Current

$$R_{DS(ON)} = f(T_j, I_D); t_P = 50\ \mu\text{s}; V_{GS} = 18\text{ V}$$

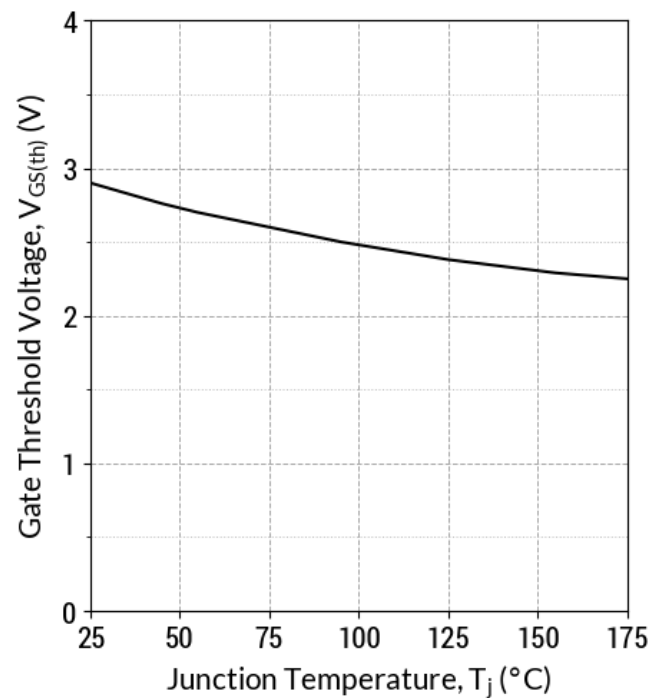
Fig 8: Typical Normalized  $R_{DS(ON)}$  v/s Temperature

$$R_{DS(ON)} = f(T_j); t_P = 50\ \mu\text{s}; I_D = 20\text{ A}$$

Fig 9: Typical  $R_{DS(ON)}$  v/s Gate Voltage

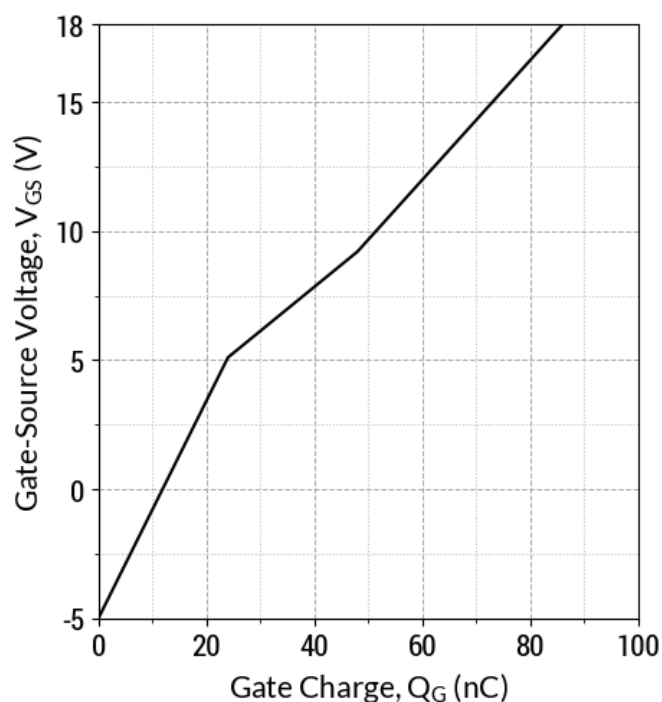
$$R_{DS(ON)} = f(T_j, V_{GS}); t_p = 50 \mu\text{s}; I_D = 20 \text{ A}$$

Fig 10: Typical Threshold Voltage Characteristics



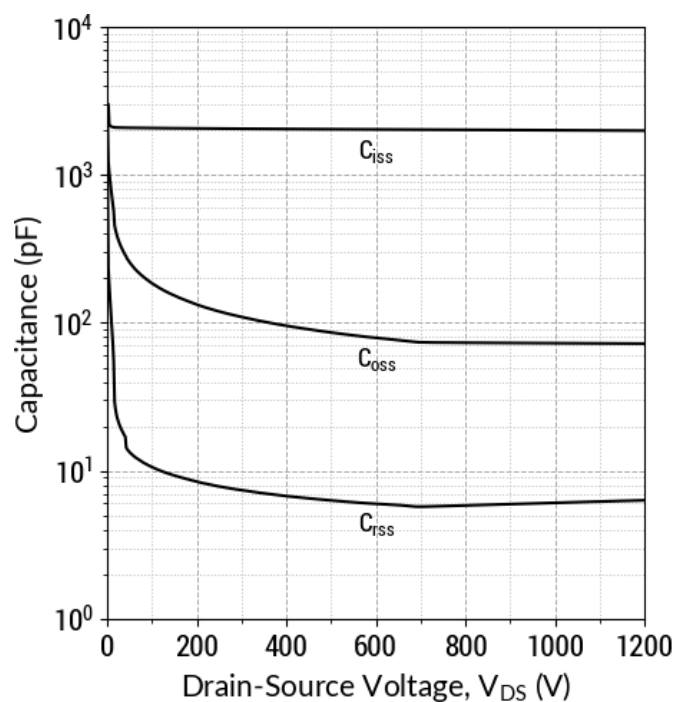
$$V_{GS(th)} = f(T_j); V_{DS} = V_{GS}; I_D = 16 \text{ mA}$$

Fig 11: Typical Gate Charge Characteristics



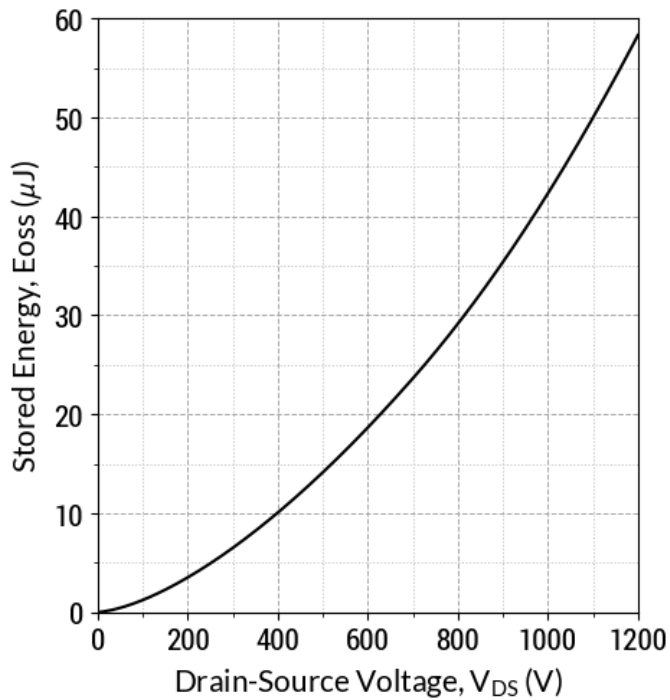
$$I_D = 20 \text{ A}; V_{DS} = 800 \text{ V}; T_c = 25^\circ\text{C}$$

Fig 12: Typical Capacitance v/s Drain-Source Voltage



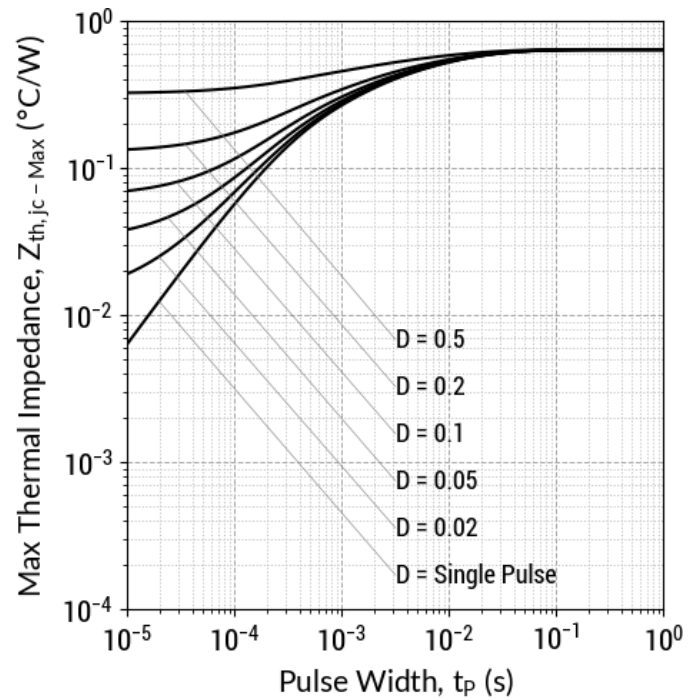
$$f = 500 \text{ KHz}; V_{AC} = 25 \text{ mV}$$

Fig 13: Output Capacitor Stored Energy

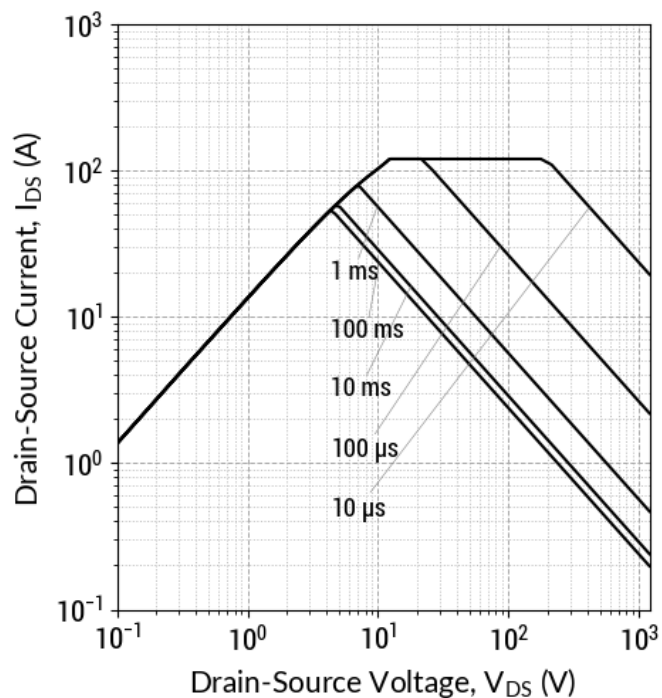


$$E_{oss} = f(V_{DS})$$

Fig 14: Max. Transient Thermal Impedance

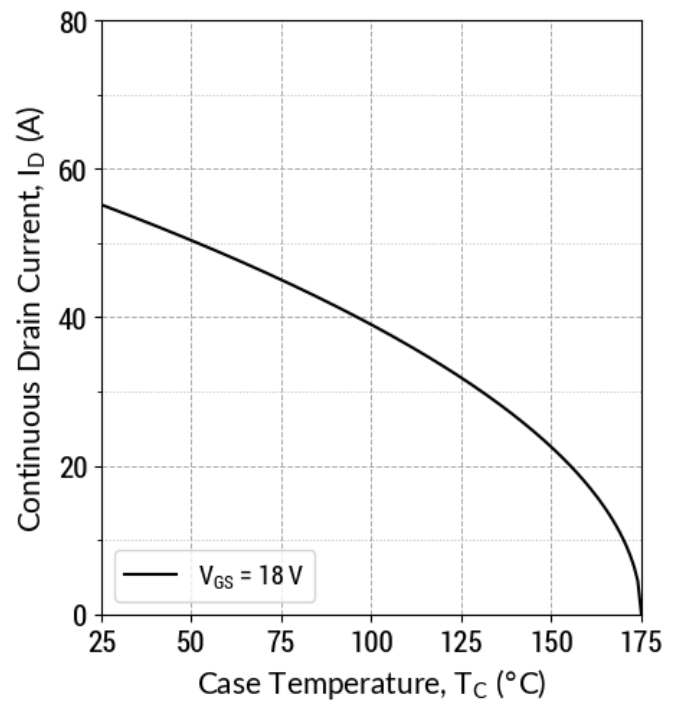


$$Z_{th,jc} = f(t_p, D); D = t_p/T$$

Fig 15: Safe Operating Area ( $T_c = 25^{\circ}C$ )

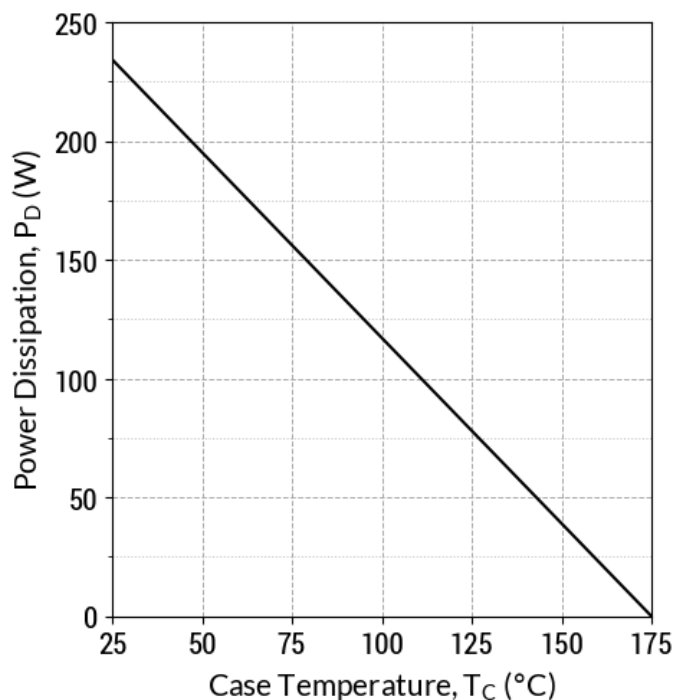
$$I_D = f(V_{DS}, t_p); T_j \leq 175^{\circ}C; D = 0$$

Fig 16: Current De-rating Curve

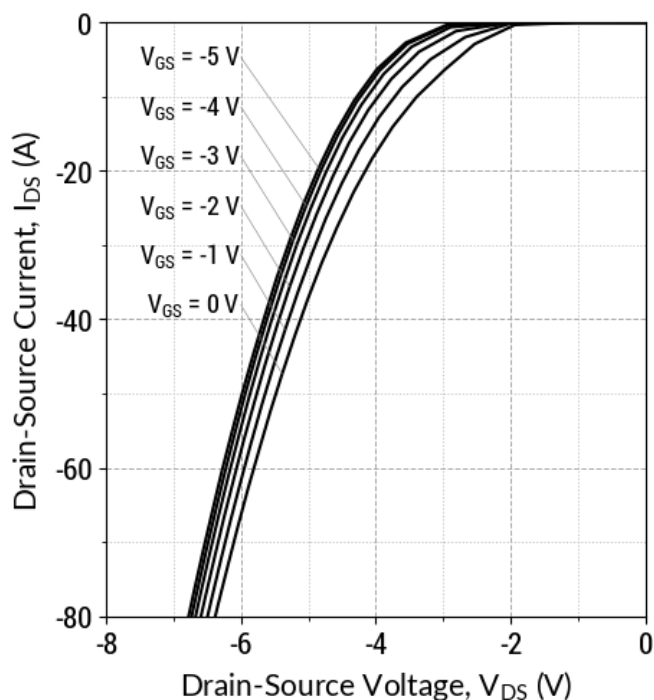


$$I_D = f(T_C); T_j \leq 175^{\circ}C$$

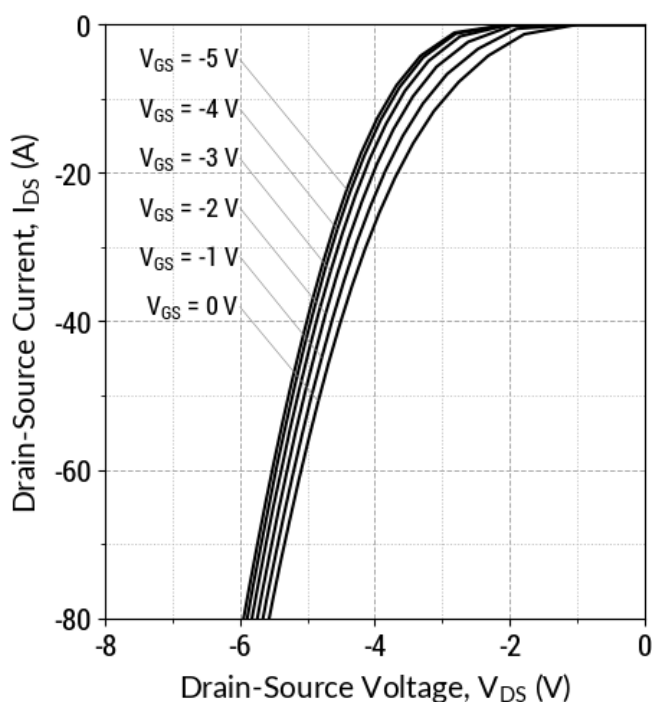
Fig 17: Power De-rating Curve



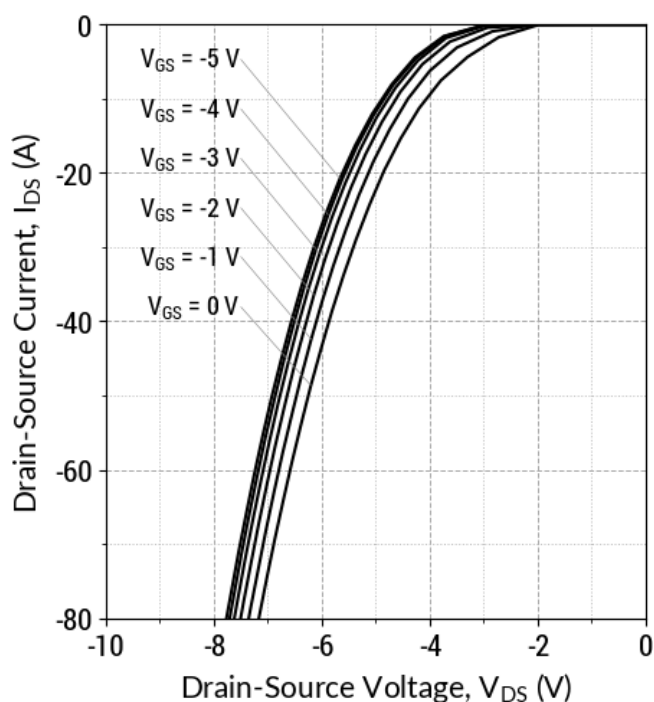
$$P_D = f(T_C); T_J \leq 175^\circ\text{C}$$

Fig 18: Typical Body Diode Characteristics ( $T_J = 25^\circ\text{C}$ )

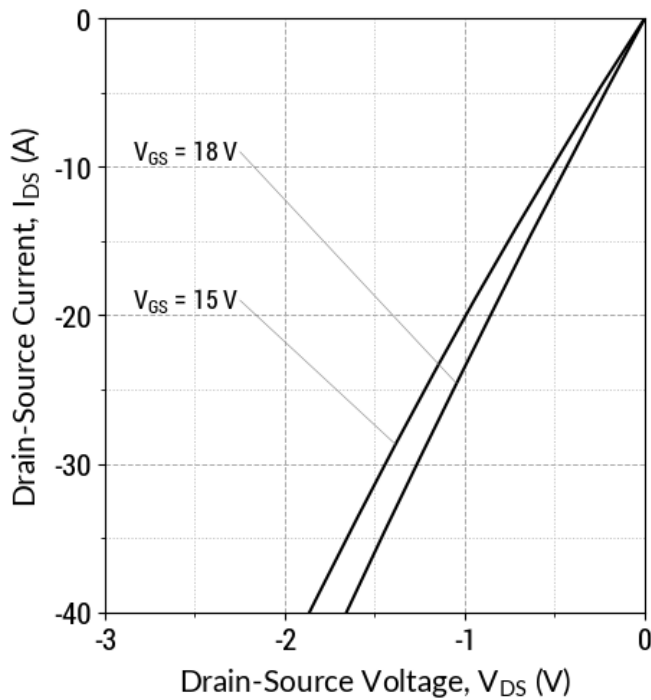
$$I_D = f(V_{DS}, V_{GS}); t_P = 50\text{ }\mu\text{s}$$

Fig 19: Typical Body Diode Characteristics ( $T_J = 175^\circ\text{C}$ )

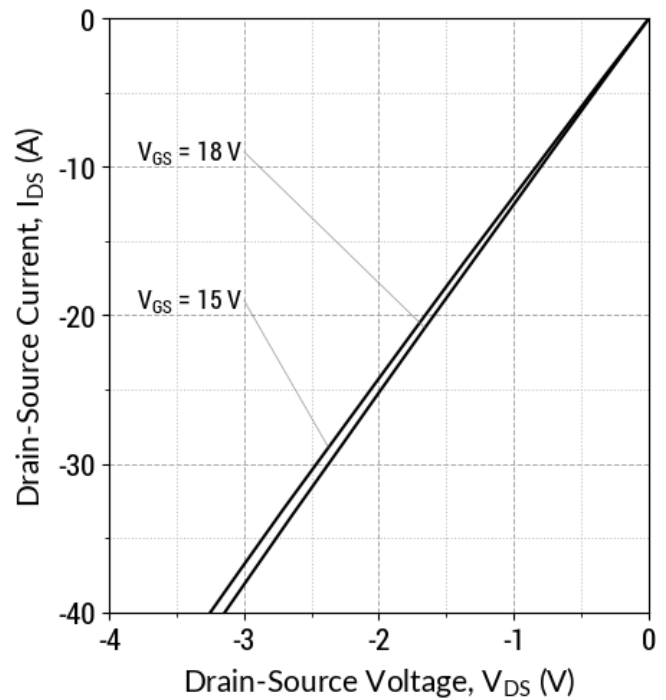
$$I_D = f(V_{DS}, V_{GS}); t_P = 50\text{ }\mu\text{s}$$

Fig 20: Typical Body Diode Characteristics ( $T_J = -55^\circ\text{C}$ )

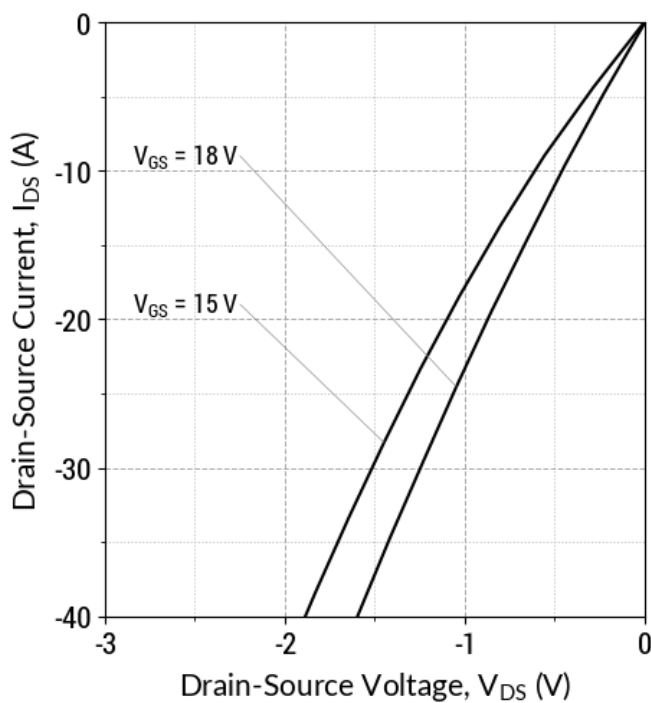
$$I_D = f(V_{DS}, V_{GS}); t_P = 50\text{ }\mu\text{s}$$

Fig 21: Typical Third Quadrant Characteristics ( $T_j = 25^\circ\text{C}$ )

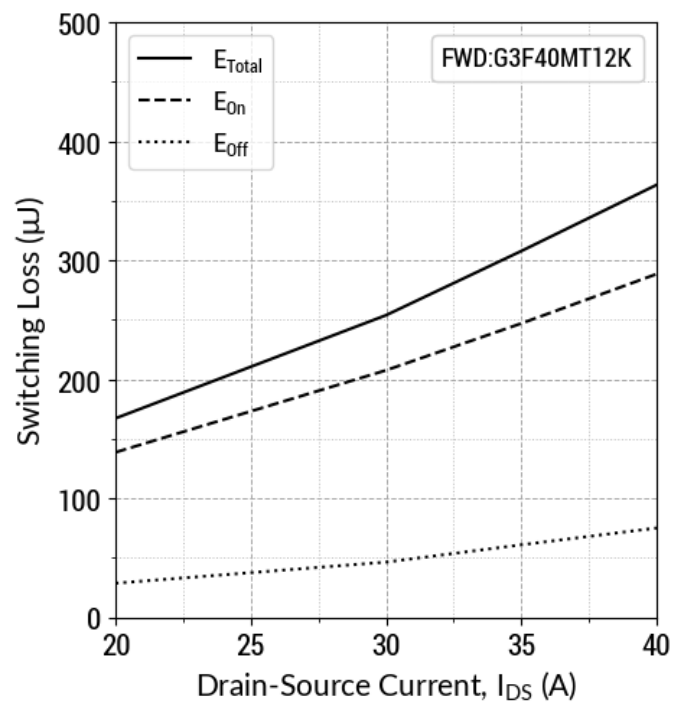
$$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$$

Fig 22: Typical Third Quadrant Characteristics ( $T_j = 175^\circ\text{C}$ )

$$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$$

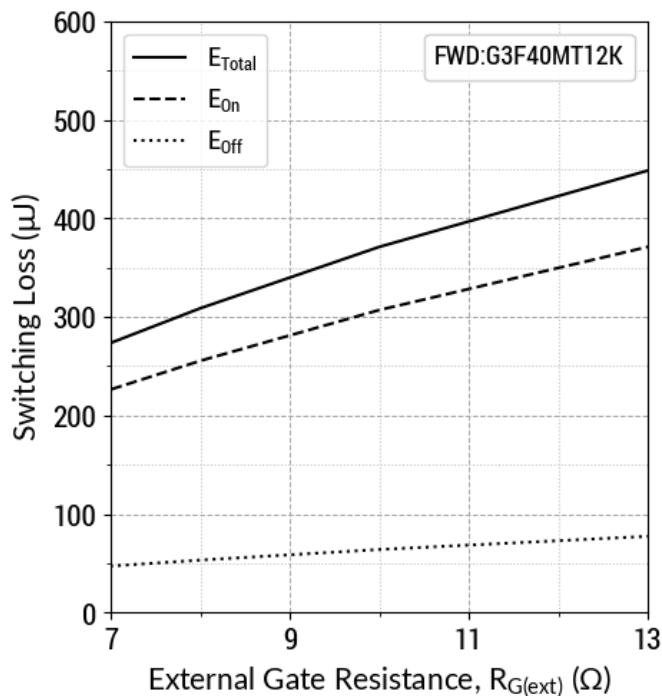
Fig 23: Typical Third Quadrant Characteristics ( $T_j = -55^\circ\text{C}$ )

$$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$$

Fig 24: Inductive Switching Energy v/s Drain Current ( $V_{DD} = 800\text{V}$ )

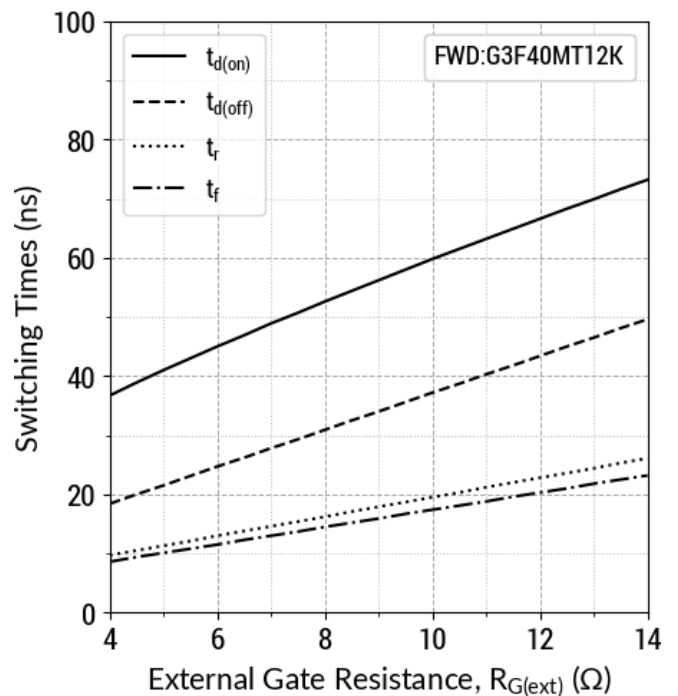
$$T_j = 25^\circ\text{C}; V_{GS} = -5/+18\text{V}; R_{G(\text{ext})} = 5 \Omega; L = 60.0 \mu\text{H}$$

Fig 25: Inductive Switching Energy v/s  $R_{G(ext)}$   
( $V_{DD} = 800V$ )



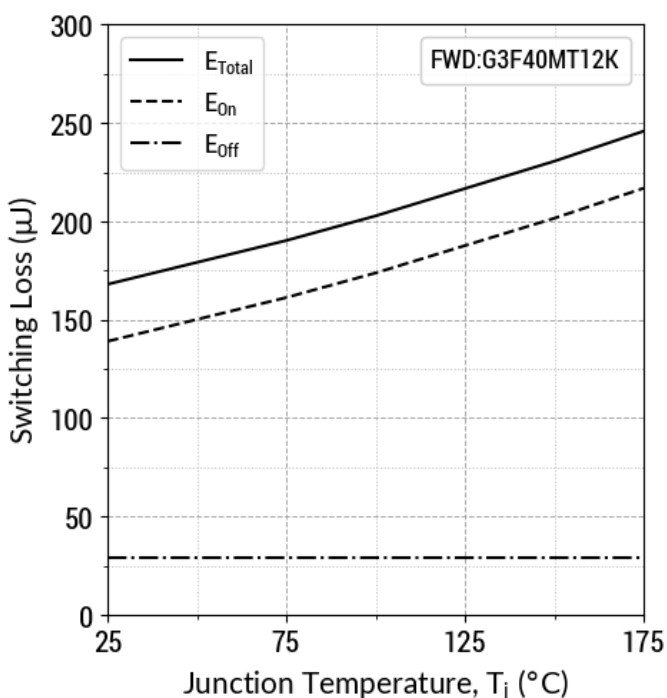
$T_j = 25^\circ C$ ;  $V_{GS} = -5/+18V$ ;  $I_{DS} = 20 A$ ;  $L = 60.0\mu H$

Fig 26: Switching Time v/s  $R_{G(ext)}$   
( $V_{DD} = 800V$ )



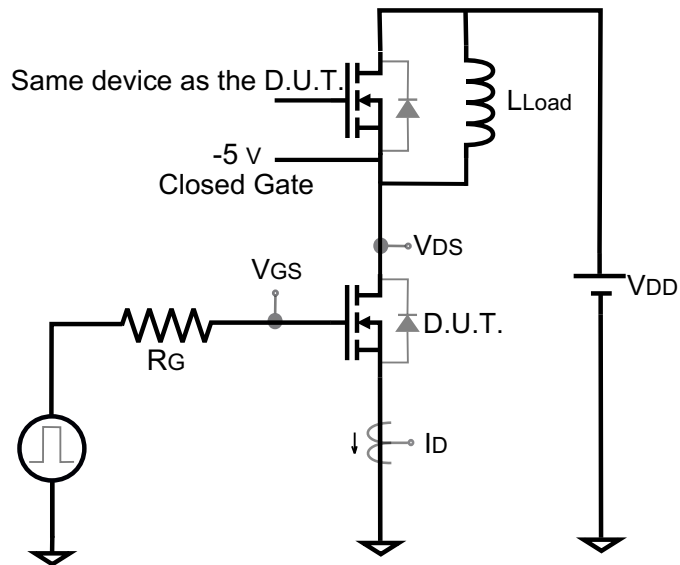
$T_j = 25^\circ C$ ;  $V_{GS} = -5/+18V$ ;  $I_{DS} = 20 A$ ;  $L = 60.0\mu H$

Fig 27: Inductive Switching Energy v/s Temperature  
( $V_{DD} = 800V$ )



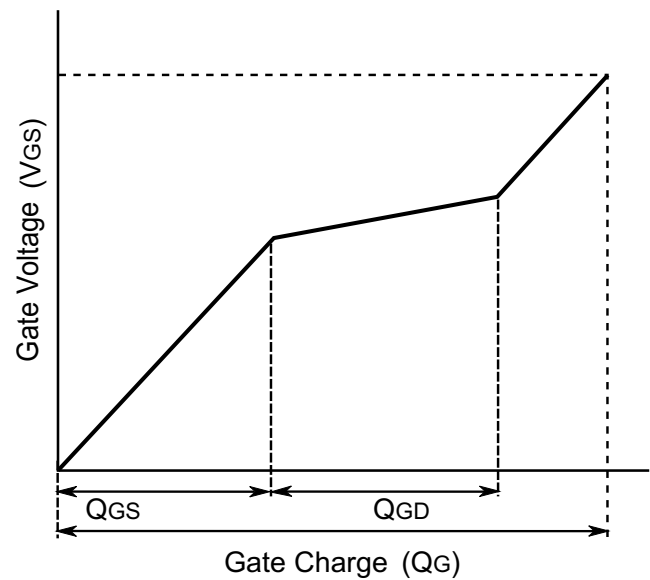
$T_j = 25^\circ C$ ;  $V_{GS} = -5/+18V$ ;  $R_{G(ext)} = 5 \Omega$ ;  $I_{DS} = 20 A$ ;  $L = 60.0\mu H$

## Dynamic Test Circuit

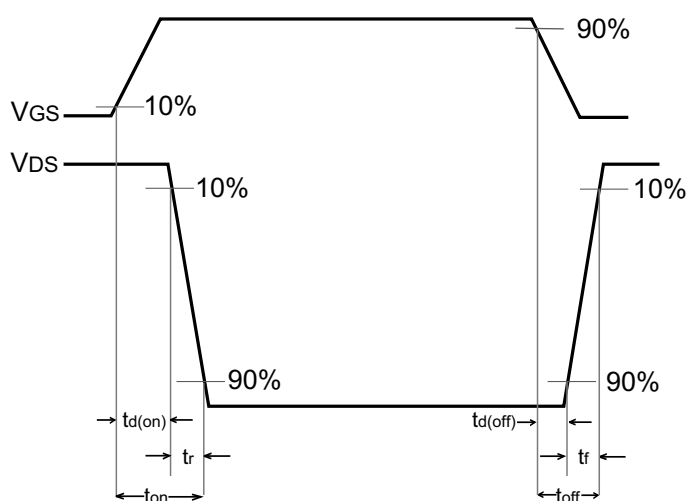


Note: Gate Charge, Switching Time and Energy Circuit

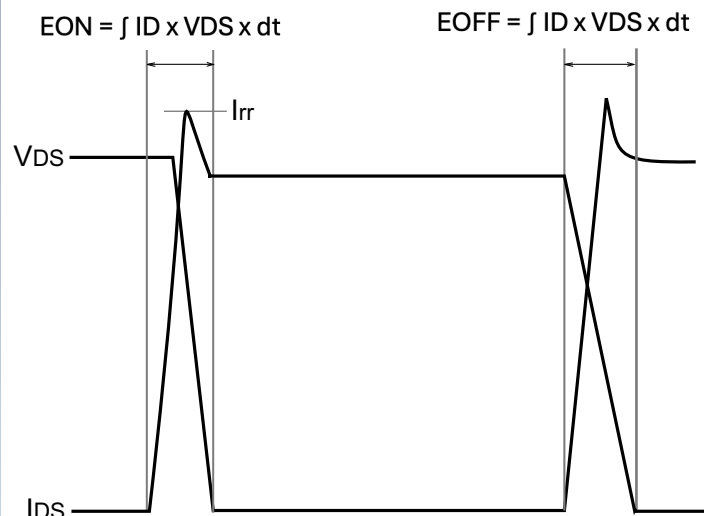
## Gate Charge Waveform



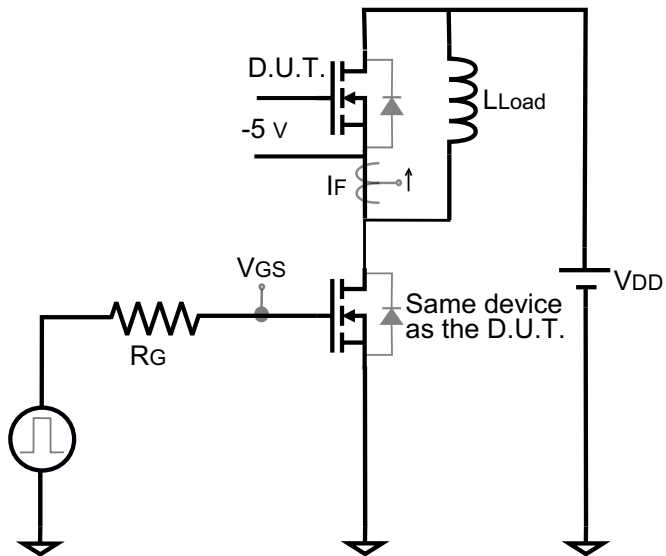
## Switching Time Waveform



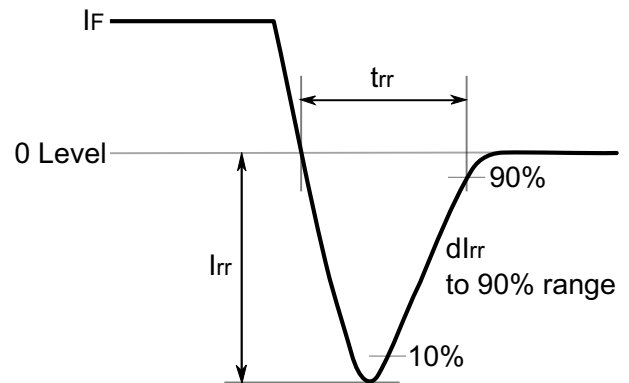
## Switching Energy Waveform



## Reverse Recovery Circuit

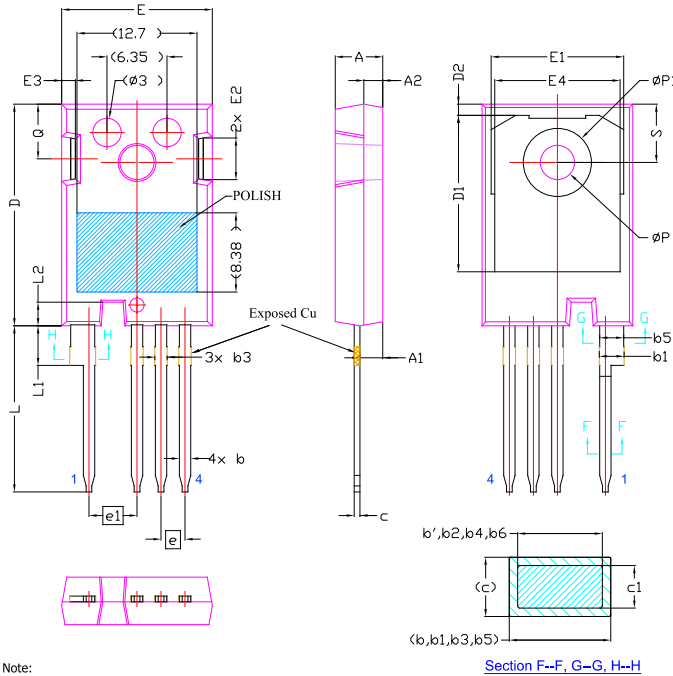


## Reverse Recovery Waveform



## Package Dimensions

## TO-247-4 Package Outline



- Note:
1. All Dimensions Are In mm.
  2. Slot Required, Notch May Be Rounded
  3. Dimension D & E Do Not Include Mold Flash. Mold Flash Shall Not Exceed 0.127mm Pre Side. These Dimensions Are Measured At The Outermost Extreme Of The Plastic Body.
  4. Thermal Pad Contour Optional Within Dimension D1 & E1.
  5. Lead Finish Uncontrolled In L1.
  6. ØP To Have A Draft Angle Of 1.5° (REF.) To The Top Of The Part With Hole Diameter Of 3.91mm (REF.).

Section F--F, G--G, H--H

| SYMBOL | DIMENSIONS |       |       |
|--------|------------|-------|-------|
|        | MIN.       | NOM.  | MAX.  |
| A      | 4.83       | 5.02  | 5.21  |
| A1     | 2.29       | 2.41  | 2.54  |
| A2     | 1.91       | 2.00  | 2.16  |
| b'     | 1.07       | 1.20  | 1.28  |
| b      | 1.07       | 1.20  | 1.33  |
| b1     | 2.39       | 2.67  | 2.94  |
| b2     | 2.39       | 2.67  | 2.84  |
| b3     | 1.07       | 1.30  | 1.60  |
| b4     | 1.07       | 1.30  | 1.50  |
| b5     | 2.39       | 2.53  | 2.69  |
| b6     | 2.39       | 2.53  | 2.64  |
| c      | 0.55       | 0.60  | 0.68  |
| c1     | 0.55       | 0.60  | 0.65  |
| D      | 23.30      | 23.45 | 23.60 |
| D1     | 16.25      | 16.55 | 17.65 |
| D2     | 0.95       | 1.19  | 1.25  |
| E      | 15.75      | 15.94 | 16.13 |
| E1     | 13.10      | 14.02 | 14.15 |
| E2     | 3.68       | 4.40  | 5.10  |
| E3     | 1.00       | 1.45  | 1.90  |
| E4     | 12.38      | 13.26 | 13.43 |
| e      | 2.54 BSC   |       |       |
| e1     | 5.08 BSC   |       |       |
| L      | 17.31      | 17.57 | 17.82 |
| L1     | 3.97       | 4.19  | 4.37  |
| L2     | 2.35       | 2.50  | 2.65  |
| ØP     | 3.51       | 3.61  | 3.65  |
| ØP1    | 7.19 REF.  |       |       |
| Q      | 5.49       | 5.79  | 6.00  |
| S      | 6.04       | 6.17  | 6.30  |

## NOTE

1. CONTROLLED DIMENSION IS MILLIMETER.
2. DIMENSIONS DO NOT INCLUDE END FLASH, MOLD FLASH, MATERIAL PROTRUSIONS.
3. THE SOURCE AND KELVIN-SOURCE PINS ARE NOT INTERCHANGABLE. THEIR EXCHANGE MIGHT LEAD TO MALFUNCTION.

## Revision History

• Rev 24/Aug: Initial Release (Rev 1.0)

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