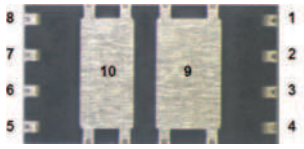
# Automotive 40 V N- and P-Channel Common Drain MOSFET Pair and 200 V N-Channel MOSFET




Package Top View




Package Bottom View

## FEATURES

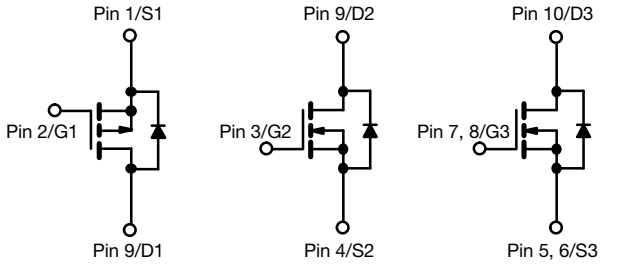
- Optimized triple die package
- TrenchFET® power MOSFET
- 100 % $R_g$ and UIS tested
- AEC-Q101 qualified
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

AUTOMOTIVE GRADE

RoHS COMPLIANT

HALOGEN FREE

| PRODUCT SUMMARY | | | |
|---|---|---|---|
| | N-CH 2 | P-CH 1 | N-CH 3 |
| $V_{DS}$ (V) | 40 | -40 | 200 |
| $R_{DS(on)}$ (Ω) at $V_{GS}$ = 10 V | 0.0092 | 0.030 | 0.075 |
| $R_{DS(on)}$ (Ω) at $V_{GS}$ = 4.5 V | 0.0135 | 0.048 | - |
| $I_D$ (A) | 30 | -30 | 16 |
| $Q_g$ typ. (nC) | 25.5 | 30.2 | 11 |
| Configuration | N- and p-pair | | |
| Package | Triple die | | |




| ABSOLUTE MAXIMUM RATINGS ($T_A$ = 25 °C, unless otherwise noted) | | | | | | |
|---|---|---|---|---|---|---|
| PARAMETER | | SYMBOL | N-CH 2 | P-CH 1 | N-CH 3 | UNIT |
| Drain-source voltage | | $V_{DS}$ | 40 | -40 | 200 | V |
| Gate-source voltage | | $V_{GS}$ | 20 | 20 | 20 | |
| Continuous drain current ($T_J$ = 175 °C) | $T_C$ = 25 °C | $I_D$ | 30 | -30 | 16 | A |
| | $T_C$ = 125 °C | | 30 | -30 | 9.1 | |
| Pulsed drain current (t = 300 µs) | | $I_{DM}$ | 120 | -120 | 50 | |
| Continuous source drain current | $T_C$ = 25 °C | $I_S$ | 30 | -30 | 16 | |
| | $T_C$ = 125 °C | | 30 | -30 | 10 | |
| Single pulse avalanche current | L = 0.1 mH | $I_{AS}$ | 26.5 | -25 | 16 | |
| Single pulse avalanche energy | | $E_{AS}$ | 35 | 31 | 12.8 | mJ |
| Maximum power dissipation | $T_C$ = 25 °C | $P_D$ | 48 | 48 | 50 | W |
| | $T_C$ = 125 °C | | 16 | 16 | 16 | |
| Operating junction and storage temperature range | | $T_J$, $T_{stg}$ | -55 to +175 | | | °C |

| THERMAL RESISTANCE RATINGS | | | | | |
|---|---|---|---|---|---|
| PARAMETER | SYMBOL | N-CH 2 | P-CH 1 | N-CH 3 | UNIT |
| Junction-to-case (drain) | $R_{thJC}$ | 2.6 | 2.6 | 3.0 | °C/W |

**Notes**

a. Package limited, $T_C$ = 25 °C
b. Surface mounted on 1" x 1" FR4 board
c. t = 10 s
d. See solder profile (www.vishay.com/doc?73257). The end of the lead terminal is exposed copper (not plated) as a result of the singulation process in manufacturing
e. Rework conditions: manual soldering with a soldering iron is not recommended for leadless components



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| **SPECIFICATIONS** ($T_J$ = 25 °C, unless otherwise noted) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **Static** | | | | | | | |
| Drain-source breakdown voltage | $V_{DS}$ | $V_{GS}$ = 0 V, $I_D$ = 250 µA | N-Ch 2 | 40 | - | - | V |
| | | $V_{GS}$ = 0 V, $I_D$ = -250 µA | P-Ch 1 | -40 | - | - | |
| | | $V_{GS}$ = 0 V, $I_D$ = 250 µA | N-Ch 3 | 200 | - | - | |
| Gate-source threshold voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | N-Ch 2 | 1.5 | 2.0 | 2.5 | |
| | | $V_{DS}$ = $V_{GS}$, $I_D$ = -250 µA | P-Ch 1 | 1.5 | 2.0 | 2.5 | |
| | | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | N-Ch 3 | 2.5 | 3.0 | 3.5 | |
| Gate-source leakage | $I_{GSS}$ | $V_{DS}$ = 0 V, $V_{GS}$ = ± 20 V | N-Ch 2 | - | - | ± 100 | nA |
| | | | P-Ch 1 | - | - | ± 100 | |
| | | | N-Ch 3 | - | - | ± 100 | |
| Zero gate voltage drain current | $I_{DSS}$ | $V_{DS}$ = 40 V, $V_{GS}$ = 0 V | N-Ch 2 | - | - | 1 | mA |
| | | $V_{DS}$ = -40 V, $V_{GS}$ = 0 V | P-Ch 1 | - | - | -1 | |
| | | $V_{DS}$ = 200 V, $V_{GS}$ = 0 V | N-Ch 3 | - | - | 1 | |
| | | $V_{DS}$ = 40 V, $V_{GS}$ = 0 V, $T_J$ = 125 °C | N-Ch 2 | - | - | 50 | |
| | | $V_{DS}$ = -40 V, $V_{GS}$ = 0 V, $T_J$ = 125 °C | P-Ch 1 | - | - | -50 | |
| | | $V_{DS}$ = 200 V, $V_{GS}$ = 0 V, $T_J$ = 125 °C | N-Ch 3 | - | - | 50 | |
| On-state drain current [a] | $I_{D(on)}$ | $V_{DS}$ ≥ 5 V, $V_{GS}$ = 10 V | N-Ch 2 | 25 | - | - | A |
| | | $V_{DS}$ ≤ 5 V, $V_{GS}$ = -10 V | P-Ch 1 | -25 | - | - | |
| | | $V_{DS}$ ≥ 5 V, $V_{GS}$ = 10 V | N-Ch 3 | 20 | - | - | |
| Drain-source on-state resistance [a] | $R_{DS(on)}$ | $V_{GS}$ = 10 V, $I_D$ = 9.8 A | N-Ch 2 | - | 0.0077 | 0.0092 | Ω |
| | | $V_{GS}$ = -10 V, $I_D$ = -6 A | P-Ch 1 | - | 0.0220 | 0.0300 | |
| | | $V_{GS}$ = 10 V, $I_D$ = 5 A | N-Ch 3 | - | 0.0710 | 0.0750 | |
| | | $V_{GS}$ = 4.5 V, $I_D$ = 8.9 A | N-Ch 2 | - | 0.0940 | 0.0135 | |
| | | $V_{GS}$ = 4.5 V, $I_D$ = -4.7 A | P-Ch 1 | - | 0.0360 | 0.0480 | |
| Forward transconductance [a] | $g_{fs}$ | $V_{DS}$ = 15 V, $I_D$ = 9.8 A | N-Ch 2 | - | 65 | - | S |
| | | $V_{DS}$ = -15 V, $I_D$ = 6 A | P-Ch 1 | - | 16 | - | |
| | | $V_{DS}$ = 15 V, $I_D$ = 19 A | N-Ch 3 | - | 19 | - | |
| **Dynamic [b]** | | | | | | | |
| Input capacitance | $C_{iss}$ | $V_{DS}$ = 20 V, $V_{GS}$ = 0 V, f = 1 MHz | N-Ch 2 | - | 1474 | - | pF |
| | | $V_{DS}$ = -20 V, $V_{GS}$ = 0 V, f = 1 MHz | P-Ch 1 | - | 1302 | - | |
| | | $V_{DS}$ = 100 V, $V_{GS}$ = 0 V, f = 1 MHz | N-Ch 3 | - | 600 | - | |
| Output capacitance | $C_{oss}$ | $V_{DS}$ = 20 V, $V_{GS}$ = 0 V, f = 1 MHz | N-Ch 2 | - | 218 | - | |
| | | $V_{DS}$ = -20 V, $V_{GS}$ = 0 V, f = 1 MHz | P-Ch 1 | - | 222 | - | |
| | | $V_{DS}$ = 100 V, $V_{GS}$ = 0 V, f = 1 MHz | N-Ch 3 | - | 70 | - | |
| Reverse transfer capacitance | $C_{rss}$ | $V_{DS}$ = 20 V, $V_{GS}$ = 0 V, f = 1 MHz | N-Ch 2 | - | 89 | - | |
| | | $V_{DS}$ = -20 V, $V_{GS}$ = 0 V, f = 1 MHz | P-Ch 1 | - | 154 | - | |
| | | $V_{DS}$ = 100 V, $V_{GS}$ = 0 V, f = 1 MHz | N-Ch 3 | - | 5 | - | |
| Total gate charge | $Q_g$ | $V_{DS}$ = 20 V, $V_{GS}$ = 10 V, $I_D$ = 10 A | N-Ch 2 | - | 23 | - | nC |
| | | $V_{DS}$ = -20 V, $V_{GS}$ = -10 V, $I_D$ = -10 A | P-Ch 1 | - | 30.2 | - | |
| | | $V_{DS}$ = 100 V, $V_{GS}$ = 10 V, $I_D$ = 10 A | N-Ch 3 | - | 11 | - | |
| Gate-source charge | $Q_{gs}$ | $V_{DS}$ = 20 V, $V_{GS}$ = 10 V, $I_D$ = 10 A | N-Ch 2 | - | 4.4 | - | |
| | | $V_{DS}$ = -20 V, $V_{GS}$ = -10 V, $I_D$ = -10 A | P-Ch 1 | - | 4.1 | - | |
| | | $V_{DS}$ = 100 V, $V_{GS}$ = 10 V, $I_D$ = 10 A | N-Ch 3 | - | 3.2 | - | |
| Gate-drain charge | $Q_{gd}$ | $V_{DS}$ = 20 V, $V_{GS}$ = 10 V, $I_D$ = 10 A | N-Ch 2 | - | 4.3 | - | |
| | | $V_{DS}$ = -20 V, $V_{GS}$ = -10 V, $I_D$ = -10 A | P-Ch 1 | - | 7.4 | - | |
| | | $V_{DS}$ = 100 V, $V_{GS}$ = 10 V, $I_D$ = 10 A | N-Ch 3 | - | 3 | - | |
| Gate resistance | $R_g$ | f = 1 MHz | N-Ch 2 | - | - | 2.1 | Ω |
| | | | P-Ch 1 | - | - | 9.5 | |
| | | | N-Ch 3 | - | - | 2.4 | |


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| **SPECIFICATIONS** ($T_J$ = 25 °C, unless otherwise noted) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **Dynamic** [b] | | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD}$ = 20 V, $R_L$ = 2 Ω, $I_D$ = 10 A, $V_{GEN}$ = 10 V, $R_g$ = 1 Ω | N-Ch 2 | - | 8 | - | ns |
| | | $V_{DD}$ = -20 V, $R_L$ = 2 Ω, $I_D$ = -10 A, $V_{GEN}$ = -10 V, $R_g$ = 1 Ω | P-Ch 1 | - | 7 | - | |
| | | $V_{DD}$ = 100 V, $R_L$ = 5.2 Ω, $I_D$ = 10 A, $V_{GEN}$ = 10 V, $R_g$ = 2.5 Ω | N-Ch 3 | - | 9 | - | |
| Rise time | $t_r$ | $V_{DD}$ = 20 V, $R_L$ = 2 Ω, $I_D$ = 10 A, $V_{GEN}$ = 10 V, $R_g$ = 1 Ω | N-Ch 2 | - | 12 | - | |
| | | $V_{DD}$ = -20 V, $R_L$ = 2 Ω, $I_D$ = -10 A, $V_{GEN}$ = -10 V, $R_g$ = 1 Ω | P-Ch 1 | - | 9 | - | |
| | | $V_{DD}$ = 100 V, $R_L$ = 5.2 Ω, $I_D$ = 10 A, $V_{GEN}$ = 10 V, $R_g$ = 2.5 Ω | N-Ch 3 | - | 3 | - | |
| Turn-off delay time | $t_{d(off)}$ | $V_{DD}$ = 20 V, $R_L$ = 2 Ω, $I_D$ = 10 A, $V_{GEN}$ = 10 V, $R_g$ = 1 Ω | N-Ch 2 | - | 22 | - | |
| | | $V_{DD}$ = -20 V, $R_L$ = 2 Ω, $I_D$ = -10 A, $V_{GEN}$ = -10 V, $R_g$ = 1 Ω | P-Ch 1 | - | 43 | - | |
| | | $V_{DD}$ = 100 V, $R_L$ = 5.2 Ω, $I_D$ = 10 A, $V_{GEN}$ = 10 V, $R_g$ = 2.5 Ω | N-Ch 3 | - | 14 | - | |
| Fall time | $t_f$ | $V_{DD}$ = 20 V, $R_L$ = 2 Ω, $I_D$ = 10 A, $V_{GEN}$ = 10 V, $R_g$ = 1 Ω | N-Ch 2 | - | 10 | - | |
| | | $V_{DD}$ = -20 V, $R_L$ = 2 Ω, $I_D$ = -10 A, $V_{GEN}$ = -10 V, $R_g$ = 1 Ω | P-Ch 1 | - | 19 | - | |
| | | $V_{DD}$ = 100 V, $R_L$ = 5.2 Ω, $I_D$ = 10 A, $V_{GEN}$ = 10 V, $R_g$ = 2.5 Ω | N-Ch 3 | - | 2 | - | |
| **Source-Drain Diode Ratings and Characteristics** | | | | | | | |
| Pulsed current | $I_{SM}$ | | N-Ch 2 | - | - | 120 | A |
| | | | P-Ch 1 | - | - | -120 | |
| | | | N-Ch 3 | - | - | 50 | |
| Forward voltage | $V_{SD}$ | $I_S$ = 6.5 A, $V_{GS}$ = 0 V | N-Ch 2 | - | 0.79 | - | V |
| | | $I_S$ = -3.4 A, $V_{GS}$ = 0 V | P-Ch 1 | - | -0.78 | - | |
| | | $I_S$ = 19 A, $V_{GS}$ = 0 V | N-Ch 3 | - | 0.9 | - | |

**Notes**

a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %

b. Guaranteed by design, not subject to production testing

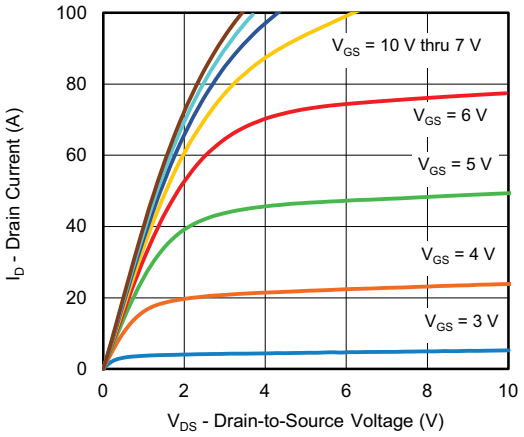
*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*



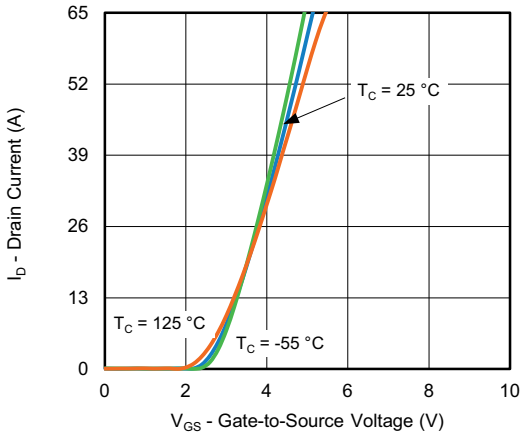
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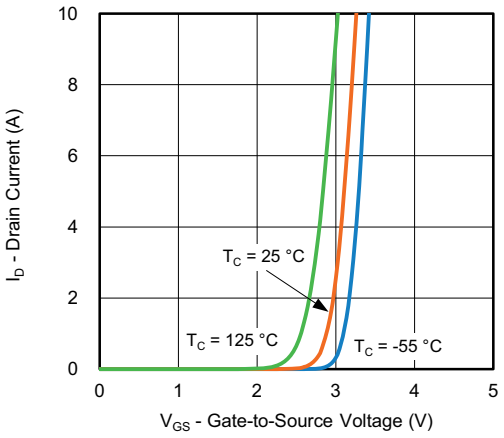
## CHANNEL-1 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



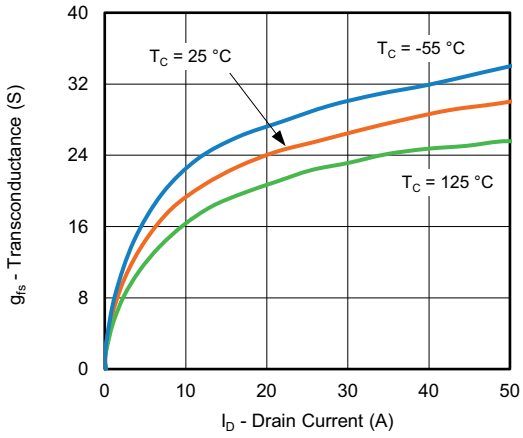

**Output Characteristics**



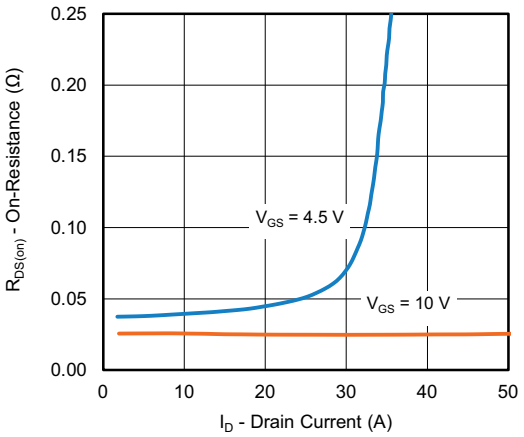

**Transfer Characteristics**



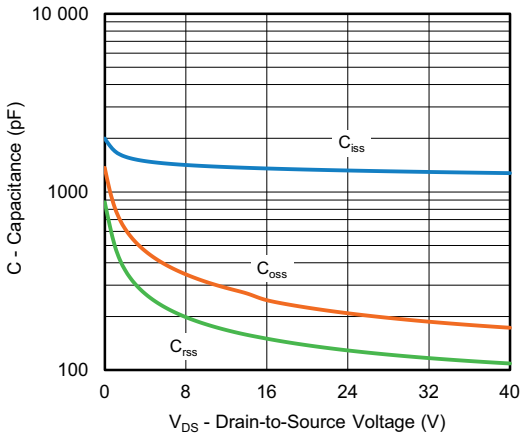

**Transfer Characteristics**




**Transconductance**



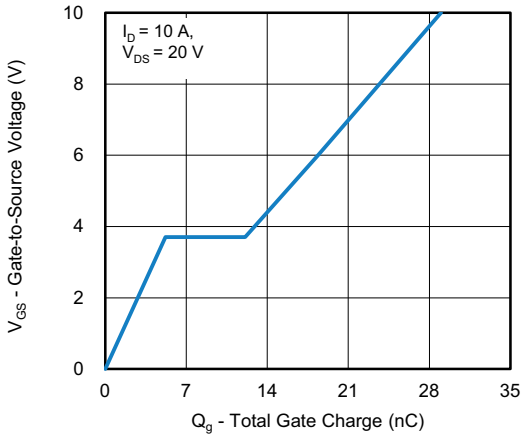

**On-Resistance vs. Drain Current**



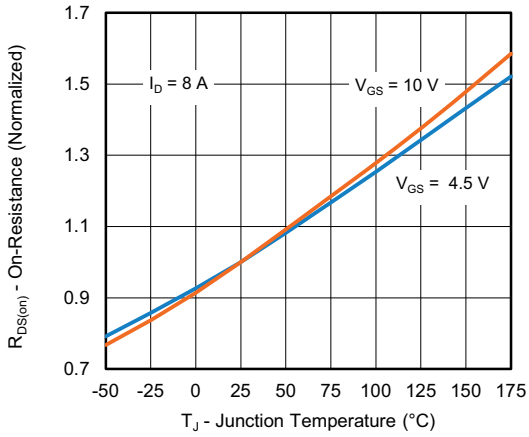

**Capacitance**


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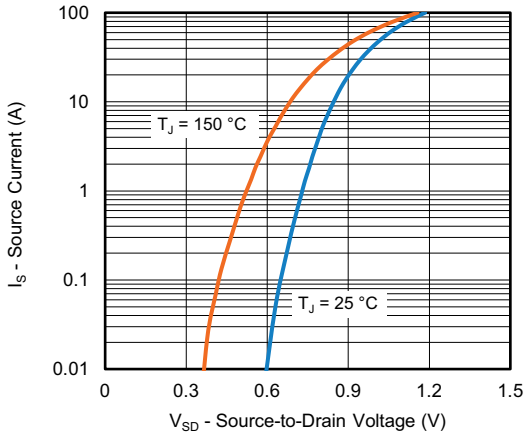
## CHANNEL-1 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



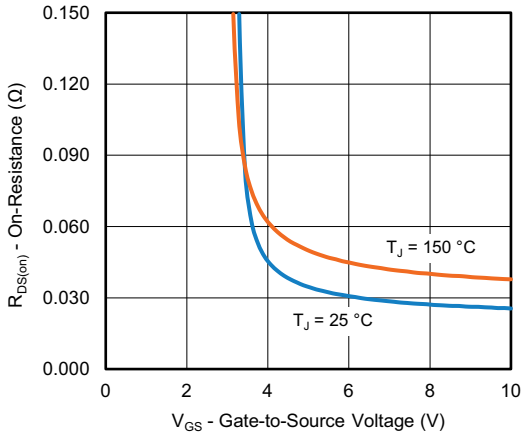

**Gate Charge**



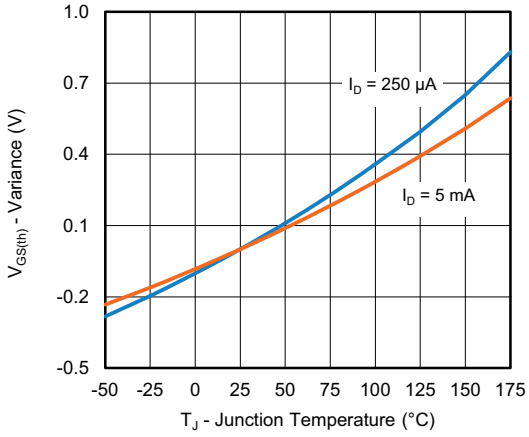

**On-Resistance vs. Junction Temperature**



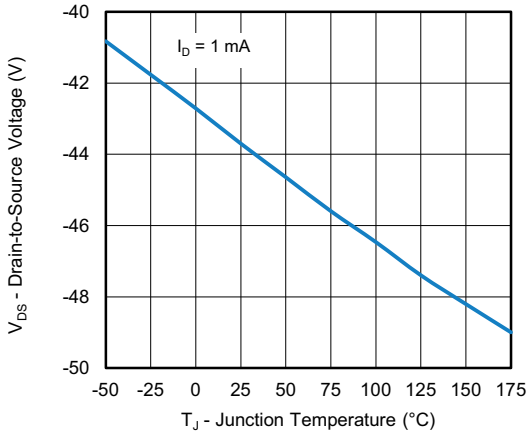

**Source Drain Diode Forward Voltage**




**On-Resistance vs. Gate-to-Source Voltage**



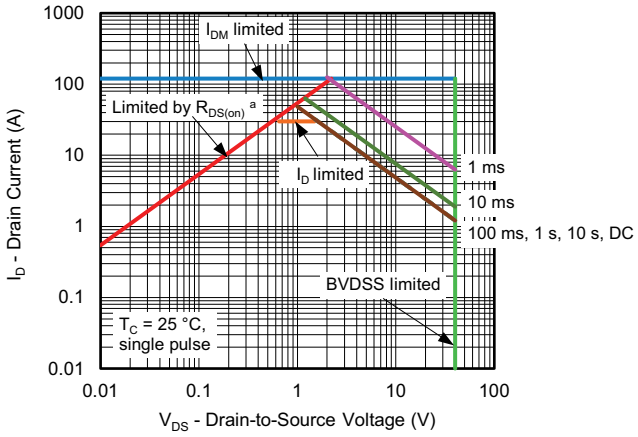

**Threshold Voltage**



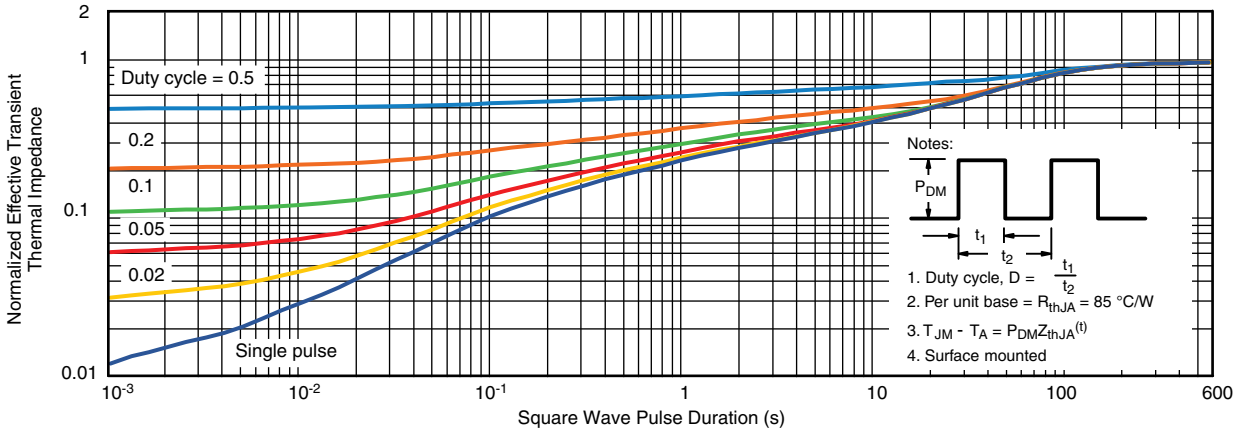

**Drain Source Breakdown vs. Junction Temperature**


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## CHANNEL-1 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)




**Safe Operating Area**




**Normalized Thermal Transient Impedance, Junction-to-Ambient**

**Note**

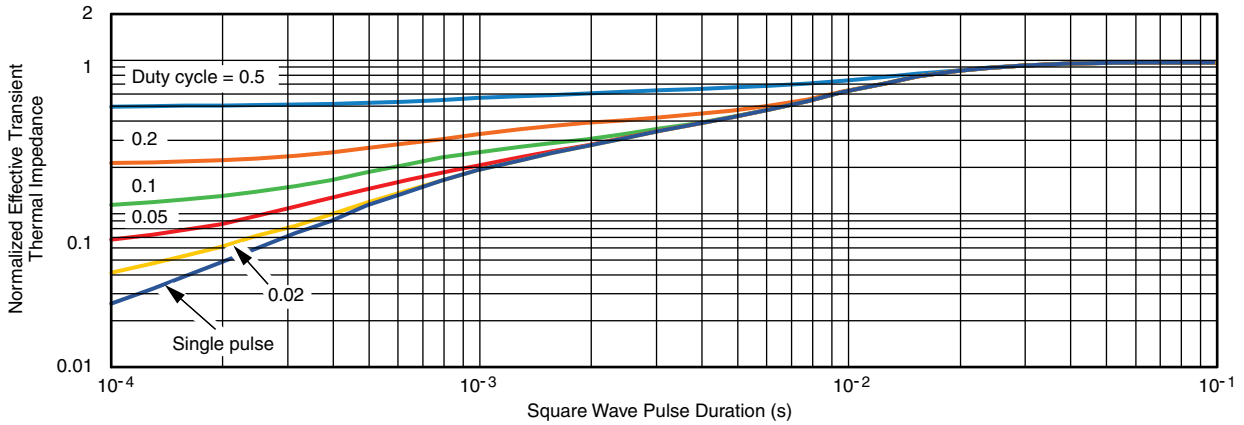
a. $V_{GS}$ > minimum $V_{GS}$ at which $R_{DS(on)}$ is specified



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## CHANNEL-1 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)




**Normalized Thermal Transient Impedance, Junction-to-Case**

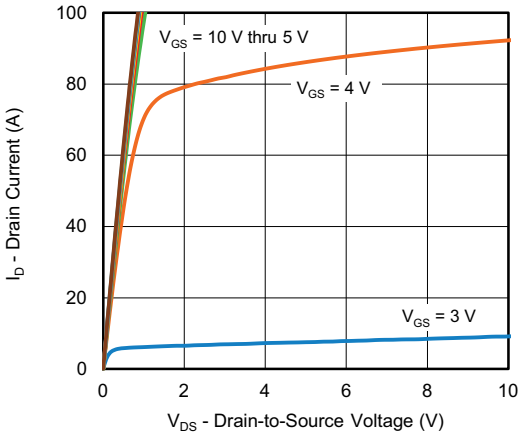
**Note**

- The characteristics shown in the two graphs
  - Normalized Transient Thermal Impedance Junction-to-Ambient (25 °C)
  - Normalized Transient Thermal Impedance Junction-to-Case (25 °C)

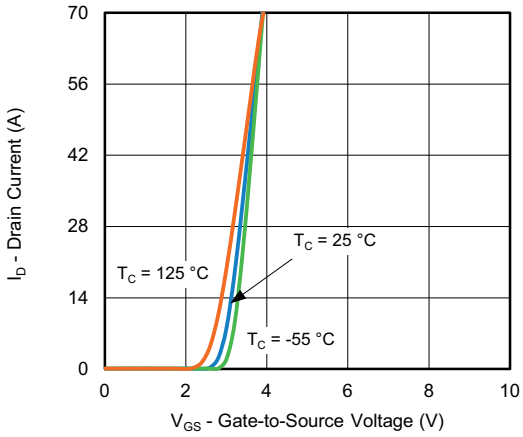
  are given for general guidelines only to enable the user to get a “ball park” indication of part capabilities. The data are extracted from single pulse transient thermal impedance characteristics which are developed from empirical measurements. The latter is valid for the part mounted on printed circuit board - FR4, size 1" x 1" x 0.062", double sided with 2 oz. copper, 100 % on both sides. The part capabilities can widely vary depending on actual application parameters and operating conditions


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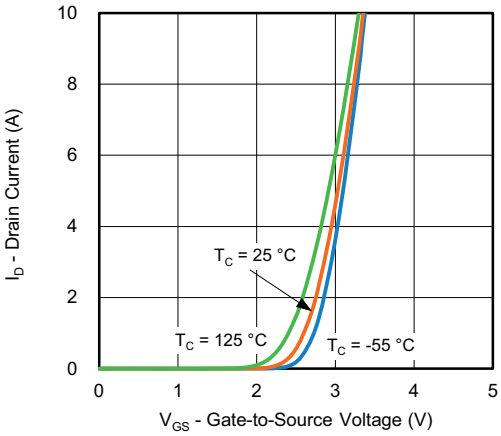
## CHANNEL-2 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



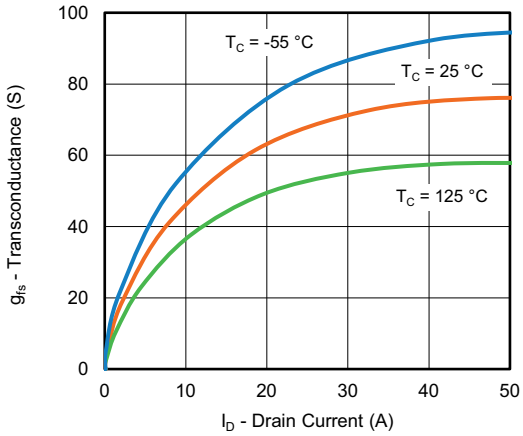

**Output Characteristics**



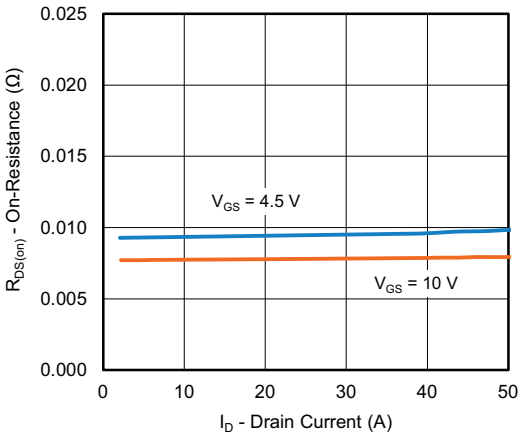

**Transfer Characteristics**



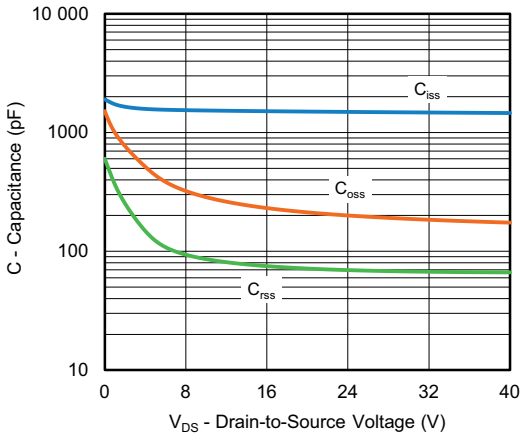

**Transfer Characteristics**




**Transconductance**



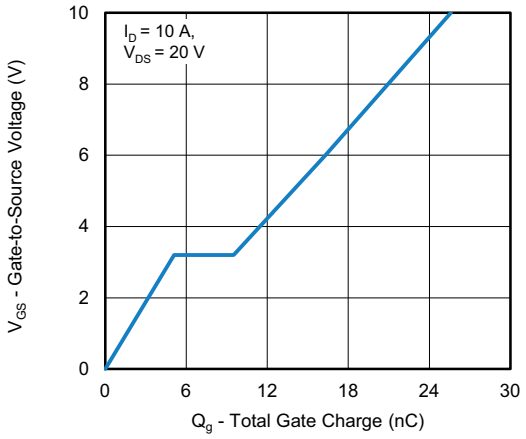

**On-Resistance vs. Drain Current**



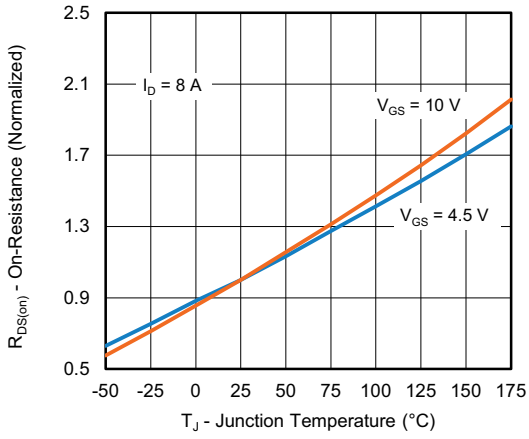

**Capacitance**


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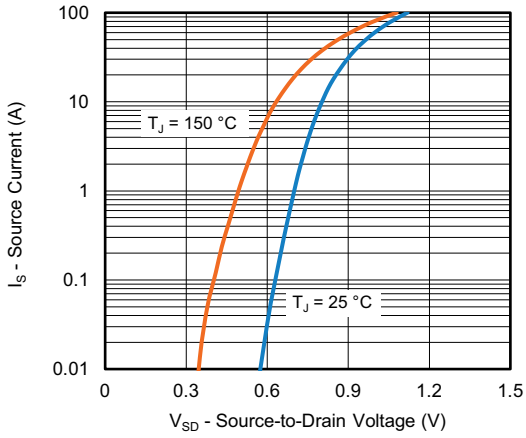
## CHANNEL-2 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



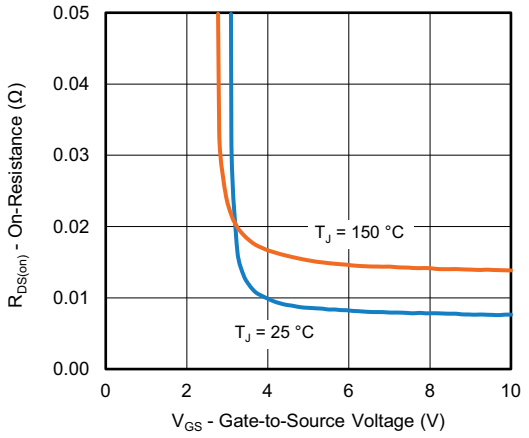

**Gate Charge**



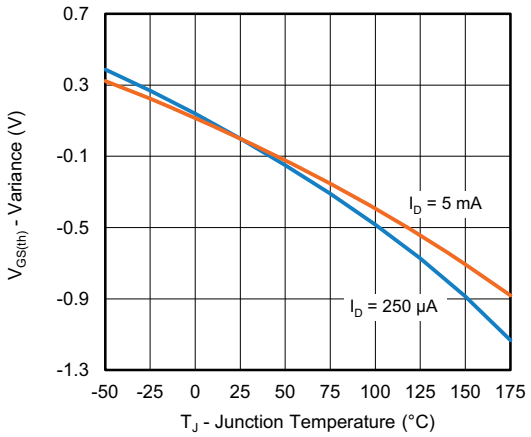

**On-Resistance vs. Junction Temperature**



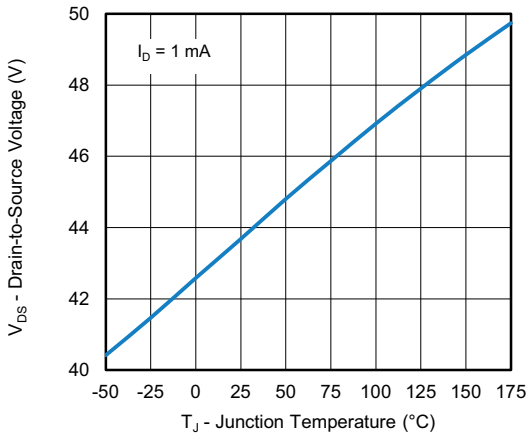

**Source Drain Diode Forward Voltage**




**On-Resistance vs. Gate-to-Source Voltage**



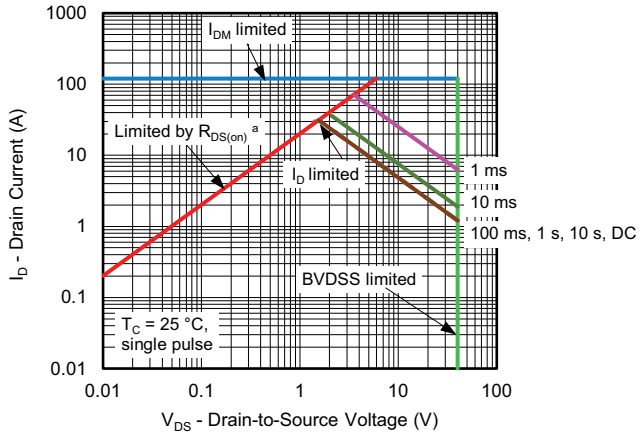

**Threshold Voltage**



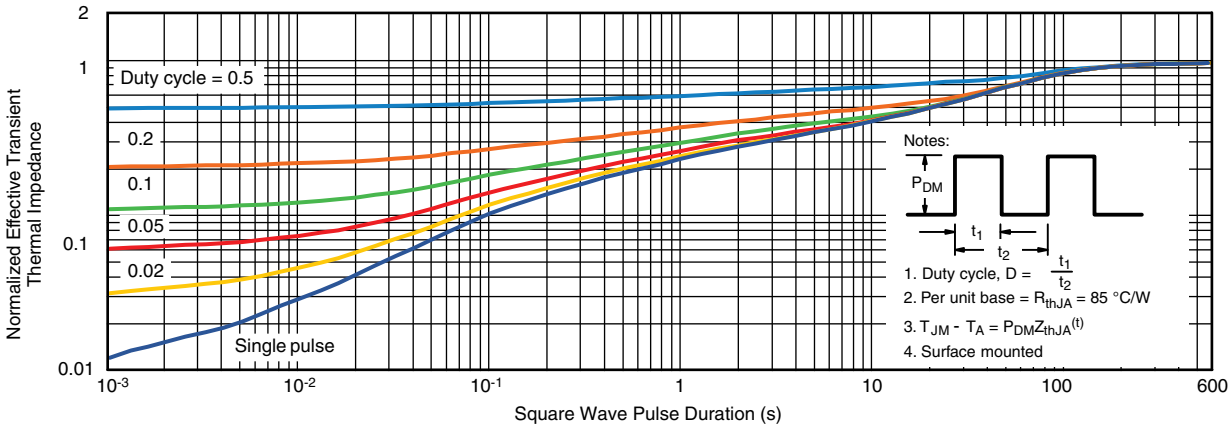

**Drain Source Breakdown vs. Junction Temperature**


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## CHANNEL-2 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)




**Safe Operating Area**



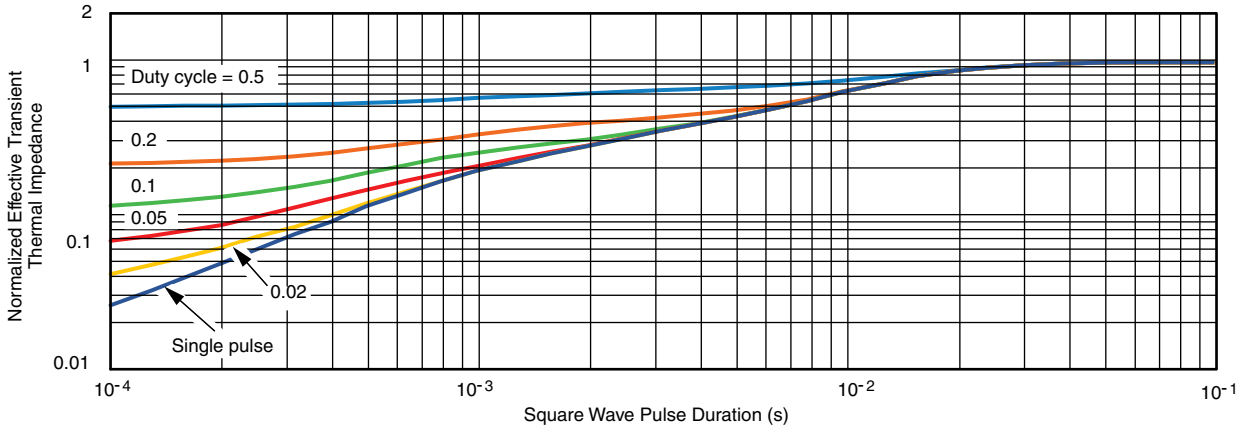

**Normalized Thermal Transient Impedance, Junction-to-Ambient**

**Note**

a. $V_{GS}$ > minimum $V_{GS}$ at which $R_{DS(on)}$ is specified


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## CHANNEL-2 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)




**Normalized Thermal Transient Impedance, Junction-to-Case**

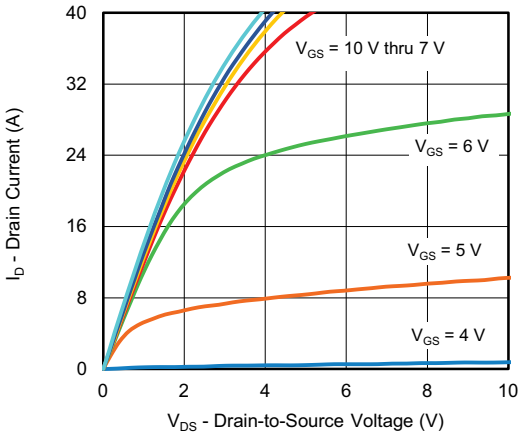
**Note**

- The characteristics shown in the two graphs
  - Normalized Transient Thermal Impedance Junction-to-Ambient (25 °C)
  - Normalized Transient Thermal Impedance Junction-to-Case (25 °C)

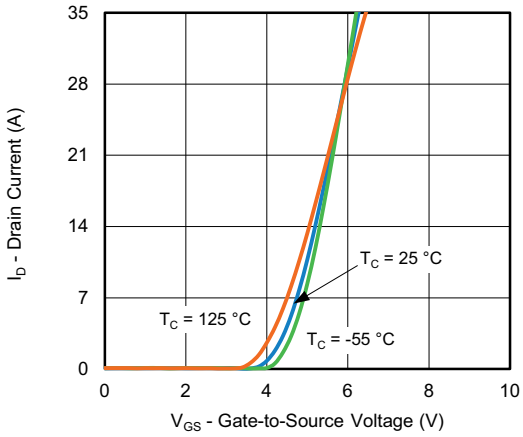
  are given for general guidelines only to enable the user to get a “ball park” indication of part capabilities. The data are extracted from single pulse transient thermal impedance characteristics which are developed from empirical measurements. The latter is valid for the part mounted on printed circuit board - FR4, size 1" x 1" x 0.062", double sided with 2 oz. copper, 100 % on both sides. The part capabilities can widely vary depending on actual application parameters and operating conditions


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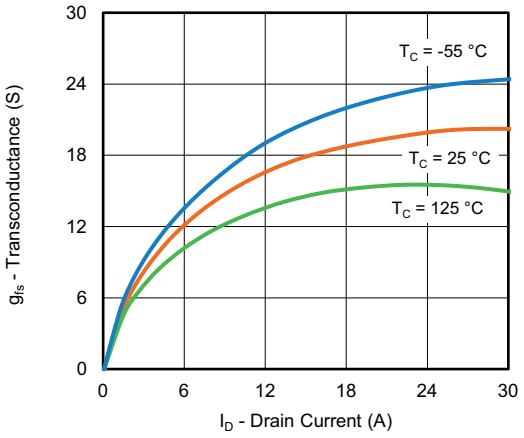
## CHANNEL-3 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



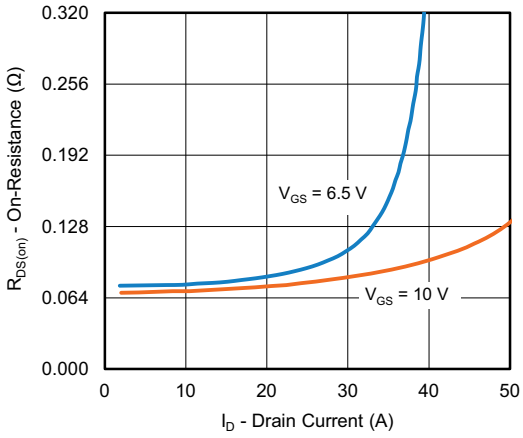

**Output Characteristics**



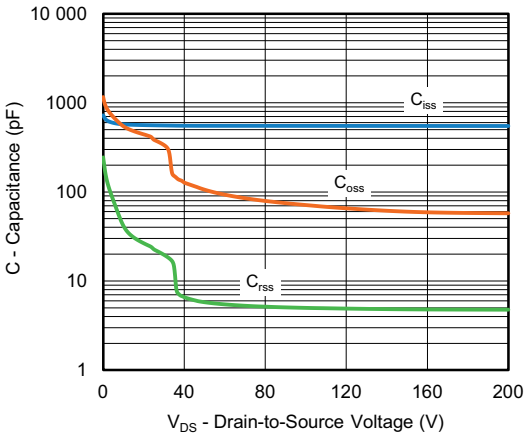

**Transfer Characteristics**



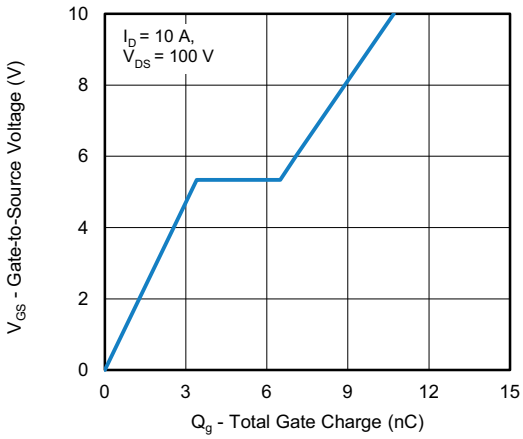

**Transconductance**




**On-Resistance vs. Drain Current**



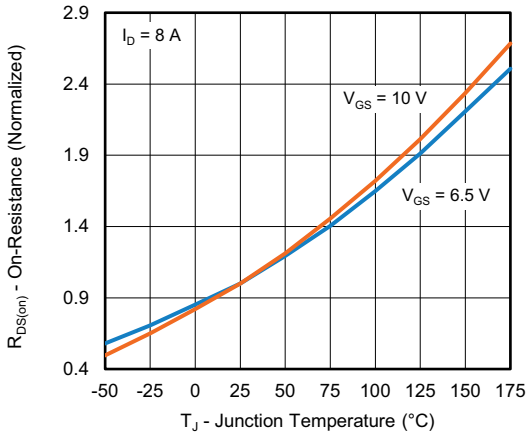

**Capacitance**



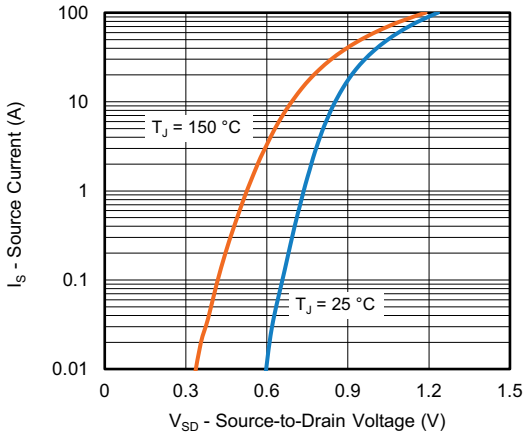

**Gate Charge**


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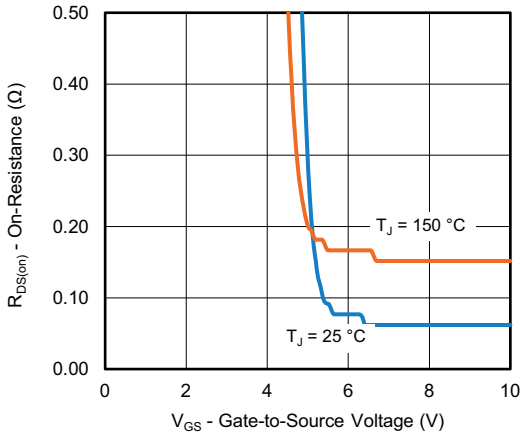
## CHANNEL-3 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



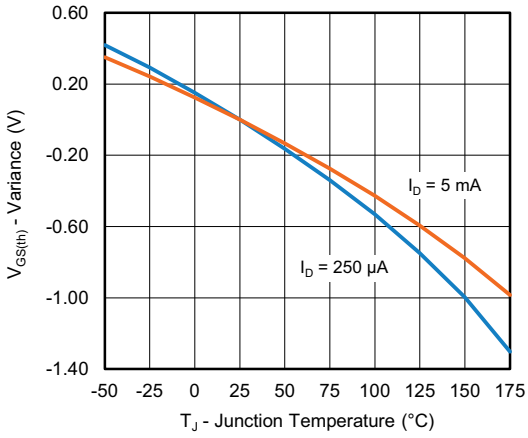

**On-Resistance vs. Junction Temperature**



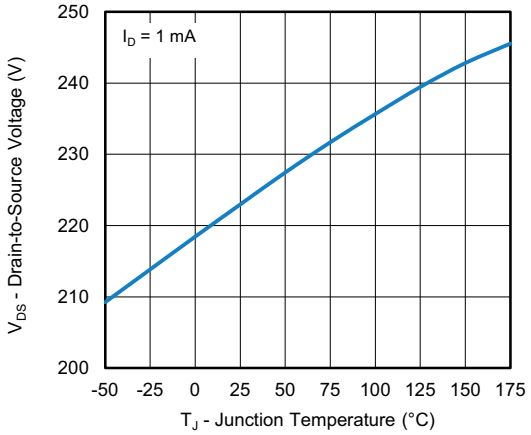

**Source Drain Diode Forward Voltage**



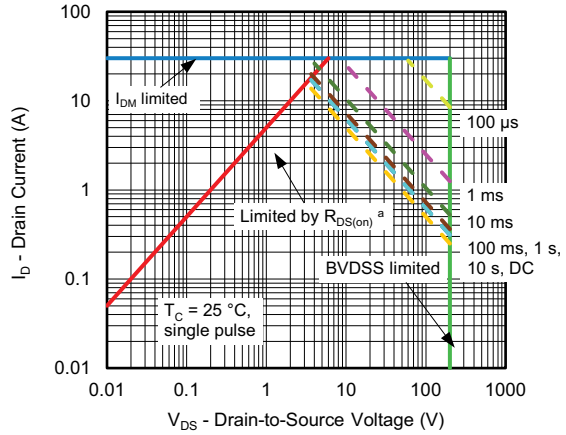

**On-Resistance vs. Gate-to-Source Voltage**




**Threshold Voltage**




**Drain Source Breakdown vs. Junction Temperature**



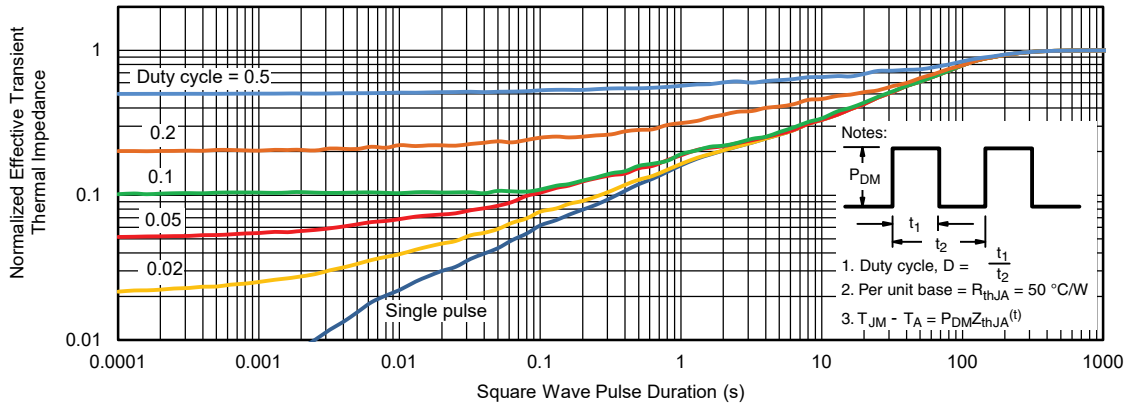

**Safe Operating Area**

**Note**

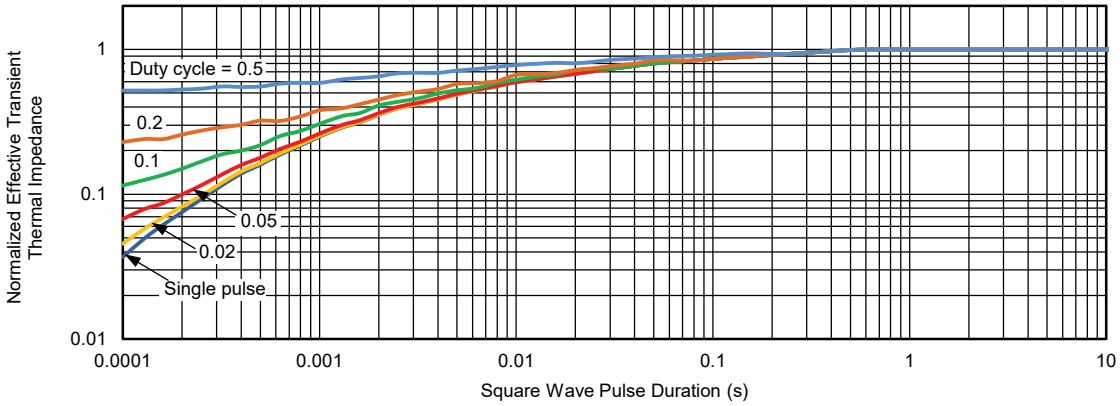
a. $V_{GS}$ > minimum $V_{GS}$ at which $R_{DS(on)}$ is specified


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## CHANNEL-3 TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)




**Normalized Thermal Transient Impedance, Junction-to-Ambient**




**Normalized Thermal Transient Impedance, Junction-to-Case**

**Note**

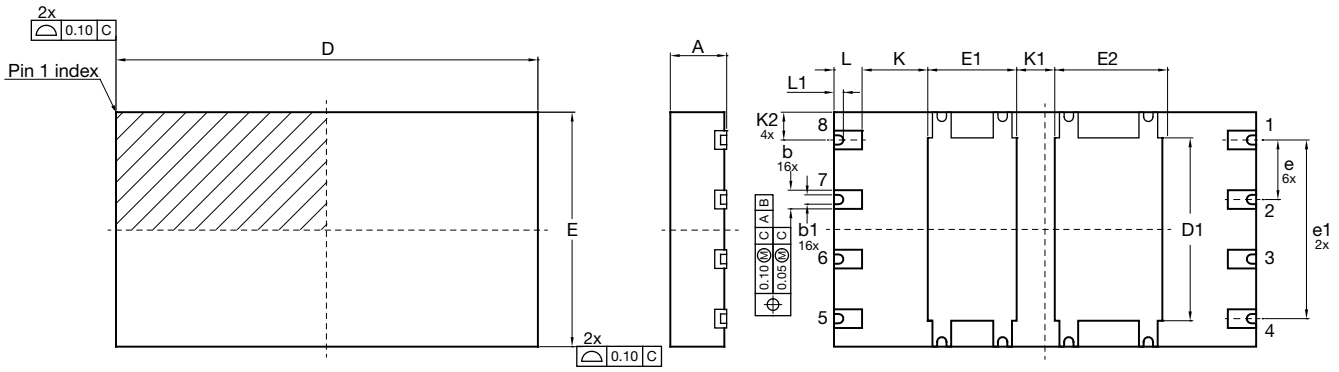
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  - Normalized Transient Thermal Impedance Junction-to-Ambient (25 °C)
  - Normalized Transient Thermal Impedance Junction-to-Case (25 °C)

  are given for general guidelines only to enable the user to get a “ball park” indication of part capabilities. The data are extracted from single pulse transient thermal impedance characteristics which are developed from empirical measurements. The latter is valid for the part mounted on printed circuit board - FR4, size 1" x 1" x 0.062", double sided with 2 oz. copper, 100 % on both sides. The part capabilities can widely vary depending on actual application parameters and operating conditions

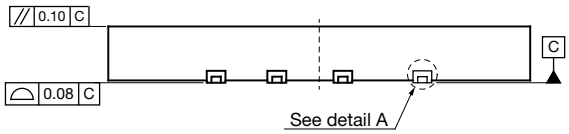
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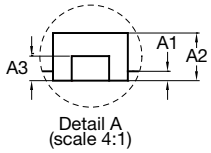

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# PowerPAK® 5 x 9 Triple Case Outline




Top view Side view Bottom view




| DIM. | MILLIMETERS | | | INCHES | | |
|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | 1.15 | 1.20 | 1.25 | 0.045 | 0.047 | 0.049 |
| A1 | 0.00 | - | 0.05 | 0.000 | - | 0.002 |
| A2 | | 0.25 ref. | | | 0.010 ref. | |
| A3 | 0.08 | - | - | 0.003 | - | - |
| b | 0.35 | 0.40 | 0.45 | 0.014 | 0.016 | 0.018 |
| b1 | 0.05 | 0.20 | 0.25 | 0.002 | 0.008 | 0.010 |
| D | 8.90 | 9.00 | 9.10 | 0.350 | 0.354 | 0.358 |
| D1 | 3.85 | 3.90 | 3.95 | 0.152 | 0.154 | 0.156 |
| E | 4.90 | 5.00 | 5.10 | 0.193 | 0.197 | 0.201 |
| E1 | 1.85 | 1.90 | 1.95 | 0.073 | 0.075 | 0.077 |
| E2 | 2.25 | 2.30 | 2.35 | 0.089 | 0.091 | 0.093 |
| e | | 1.27 BSC | | | 0.050 BSC | |
| e1 | | 3.81 BSC | | | 0.150 BSC | |
| K | | 1.40 ref. | | | 0.055 ref. | |
| K1 | 0.76 | 0.81 | 0.86 | 0.030 | 0.032 | 0.034 |
| K2 | | 0.60 ref. | | | 0.024 ref. | |
| L | 0.50 | 0.60 | 0.70 | 0.020 | 0.024 | 0.028 |
| L1 | | 0.20 ref. | | | 0.008 ref. | |
| ECN: C18-1128-Rev. A, 27-Aug-2018<br>DWG: 6070 | | | | | | |

**Notes**

(1) Use millimeters as the primary measurement
(2) Dimensioning and tolerances conform to ASME Y14.5M. - 1994
(3) N is the number of terminals
(4) Package warpage max. 0.08 mm
(5) The pin #1 identifier must be existed on the top surface of the package by using indentation mark or other feature of package body
(6) Exact shape and size of this feature is optional



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