# N-Channel 60-V (D-S) MOSFET

| PRODUCT SUMMARY | | |
|---|---|---|
| $V_{DS}$ (V) | $R_{DS(on)}$ (Ω) | $I_D$ (mA) |
| 60 | 3 at $V_{GS}$ = 10 V | 240 |

## FEATURES

- **Halogen-free According to IEC 61249-2-21 Available**
- Low On-Resistance: 3 Ω
- Low Threshold: 2 V (typ.)
- Low Input Capacitance: 25 pF
- Fast Switching Speed: 7.5 ns
- Low Input and Output Leakage

Pb-free
RoHS COMPLIANT
HALOGEN FREE Available

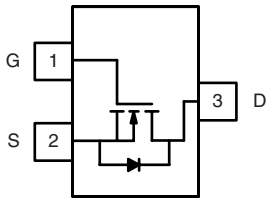
## BENEFITS

- Low Offset Voltage
- Low-Voltage Operation
- Easily Driven Without Buffer
- High-Speed Circuits
- Low Error Voltage

## APPLICATIONS

- Direct Logic-Level Interface: TTL/CMOS
- Drivers: Relays, Solenoids, Lamps, Hammers, Display, Memories, Transistors, etc.
- Battery Operated Systems
- Solid-State Relays

**TO-236**
**(SOT-23)**




Top View

Marking Code: 7Ewl
E = Part Number Code for 2N7002E
w = Week Code
l = Lot Traceability

Ordering Information: 2N7002E-T1-E3 (Lead (Pb)-free)
2N7002E-T1-GE3 (Lead (Pb)-free and Halogen-free)

**ABSOLUTE MAXIMUM RATINGS** $T_A$ = 25 °C, unless otherwise noted

| Parameter | | Symbol | Limit | Unit |
|---|---|---|---|---|
| Drain-Source Voltage | | $V_{DS}$ | 60 | V |
| Gate-Source Voltage | | $V_{GS}$ | ± 20 | |
| Continuous Drain Current ($T_J$ = 150 °C) | $T_A$ = 25 °C | $I_D$ | 240 | mA |
| | $T_A$ = 70 °C | | 190 | |
| Pulsed Drain Current[a] | | $I_{DM}$ | 1300 | |
| Power Dissipation | $T_A$ = 25 °C | $P_D$ | 0.35 | W |
| | $T_A$ = 70 °C | | 0.22 | |
| Thermal Resistance, Junction-to-Ambient | | $R_{thJA}$ | 357 | °C/W |
| Operating Junction and Storage Temperature Range | | $T_J$, $T_{stg}$ | - 55 to 150 | °C |

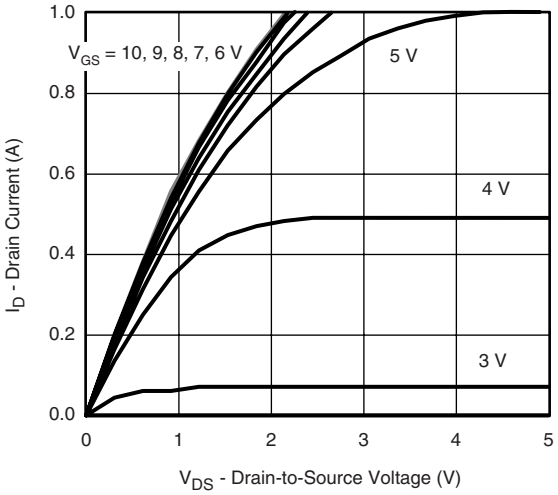
Notes:
a. Pulse width limited by maximum junction temperature.

| **SPECIFICATIONS** $T_A$ = 25 °C, unless otherwise noted | | | | | | |
|---|---|---|---|---|---|---|
| | | | Limits | | | |
| **Parameter** | **Symbol** | **Test Conditions** | **Min.** | **Typ.[a]** | **Max.** | **Unit** |
| **Static** | | | | | | |
| Drain-Source Breakdown Voltage | $V_{DS}$ | $V_{GS}$ = 0 V, $I_D$ = 10 µA | 60 | 68 | | V |
| Gate-Threshold Voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | 1 | 2 | 2.5 | |
| Gate-Body Leakage | $I_{GSS}$ | $V_{DS}$ = 0 V, $V_{GS}$ = ± 15 V | | | ± 10 | nA |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{DS}$ = 60 V, $V_{GS}$ = 0 V | | | 1 | µA |
| | | $V_{DS}$ = 60 V, $V_{GS}$ = 0 V , $T_J$ = 125 °C | | | 500 | |
| On-State Drain Current[b] | $I_{D(on)}$ | $V_{GS}$ = 10 V, $V_{DS}$ = 7.5 V | 800 | 1300 | | mA |
| | | $V_{GS}$ = 4.5 V, $V_{DS}$ = 10 V | 500 | 700 | | |
| Drain-Source On-Resistance[b] | $R_{DS(on)}$ | $V_{GS}$ = 10 V, $I_D$ = 250 mA | | 1.2 | 3 | Ω |
| | | $V_{GS}$ = 4.5 V, $I_D$ = 200 mA | | 1.8 | 4 | |
| Forward Transconductance[b] | $g_{fs}$ | $V_{DS}$ = 15 V, $I_D$ = 200 mA | | 600 | | mS |
| Diode Forward Voltage | $V_{SD}$ | $I_S$ = 200 mA, $V_{GS}$ = 0 V | | 0.85 | 1.2 | V |
| **Dynamic[a]** | | | | | | |
| Total Gate Charge | $Q_g$ | $V_{DS}$ = 10 V, $V_{GS}$ = 4.5 V<br>$I_D \cong$ 250 mA | | 0.4 | 0.6 | nC |
| Gate-Source Charge | $Q_{gs}$ | | | 0.06 | | |
| Gate-Drain Charge | $Q_{gd}$ | | | 0.06 | | |
| Input Capacitance | $C_{iss}$ | $V_{DS}$ = 5 V, $V_{GS}$ = 0 V, f = 1 MHz | | 21 | | pF |
| Output Capacitance | $C_{oss}$ | | | 7 | | |
| Reverse Transfer Capacitance | $C_{rss}$ | | | 2.5 | | |
| **Switching[a, c]** | | | | | | |
| Turn-On Time | $t_{d(on)}$ | $V_{DD}$ = 10 V, $R_L$ = 40 Ω<br>$I_D \cong$ 250 mA, $V_{GEN}$ = 10 V, $R_G$ = 10 Ω | | 13 | 20 | ns |
| Turn-Off Time | $t_{d(off)}$ | | | 18 | 25 | |

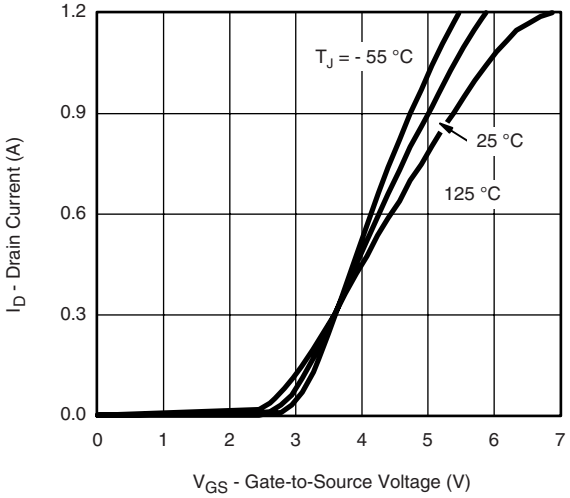
Notes:
a. For DESIGN AID ONLY, not subject to production testing.
b. Pulse test: pulse width ≤ 300 µs duty cycle ≤ 2 %.
c. Switching time is essentially independent of operating temperature.

*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.*

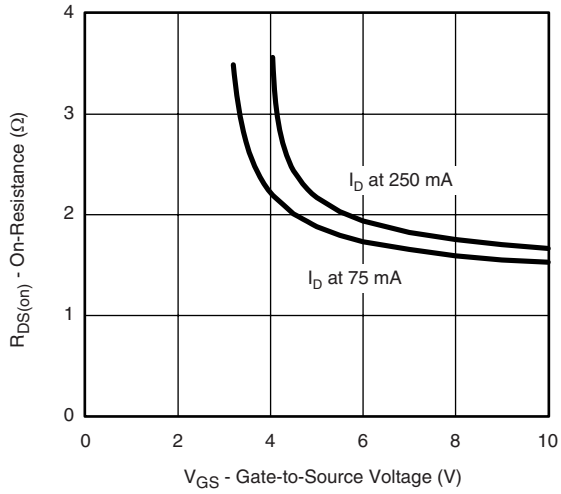
**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



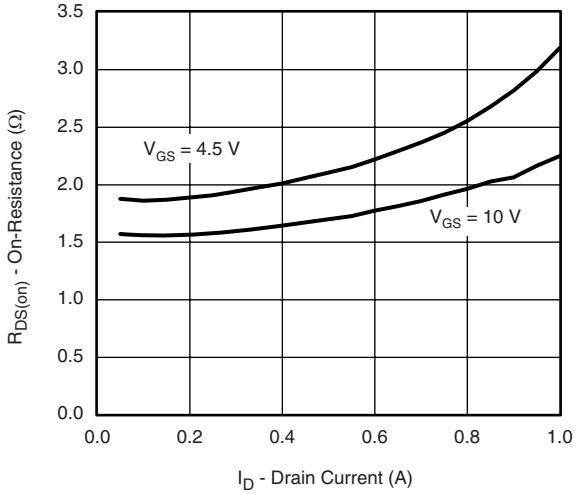

**Output Characteristics**



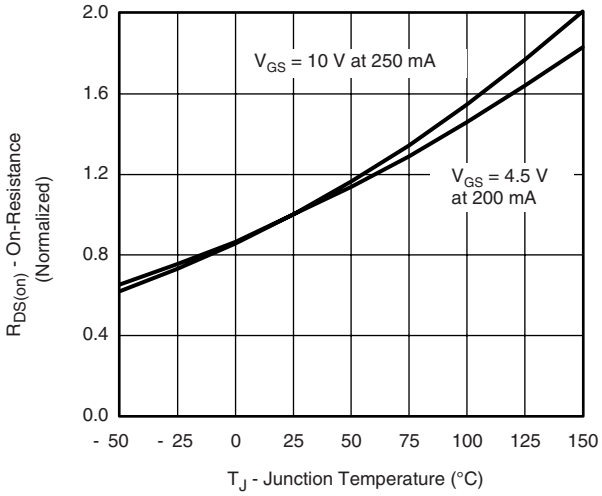

**Transfer Characteristics**



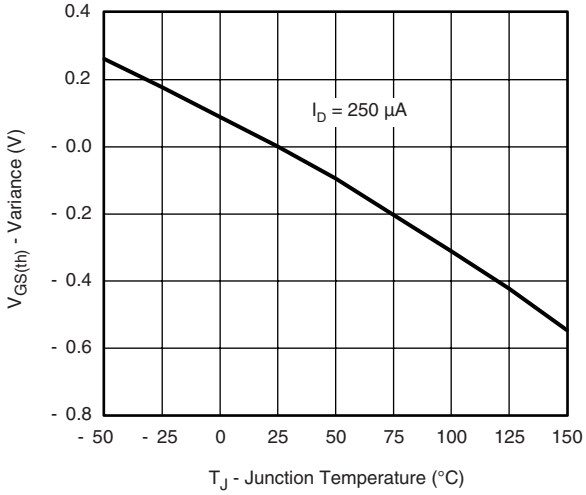

**On-Resistance vs. Gate-Source Voltage**




**On-Resistance vs. Drain Current**

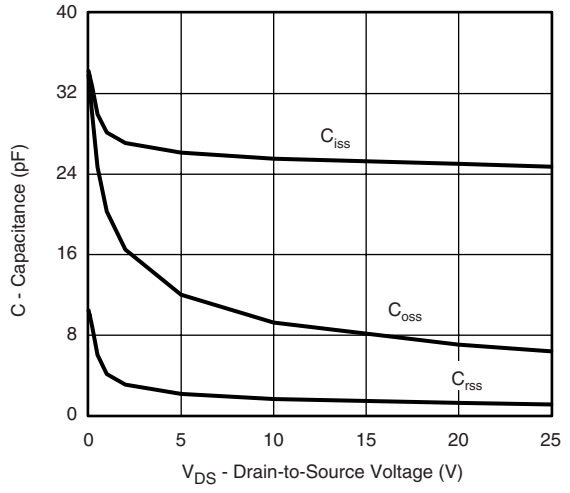



**On-Resistance vs. Junction Temperature**

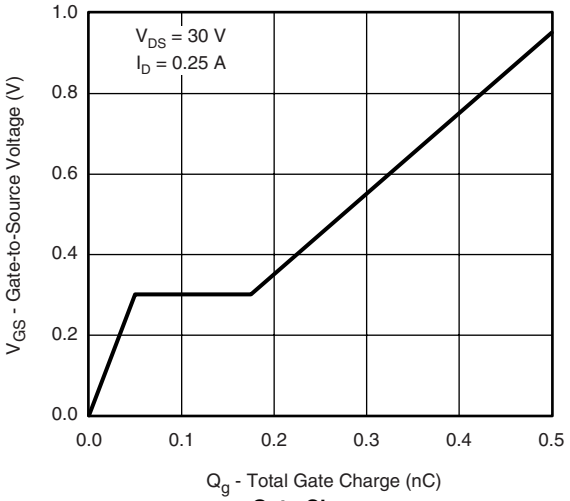



**Threshold Voltage Variance Over Temperature**

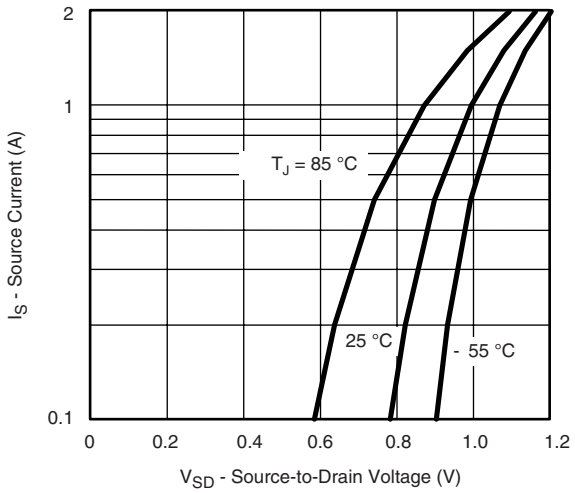
## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted




**Capacitance**




**Gate Charge**




**Source-Drain Diode Forward Voltage**

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