



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

| PRODUCT SUMMARY |                       |                               |                  |           |
|-----------------|-----------------------|-------------------------------|------------------|-----------|
| Part Number     | $V_{(BR)DSS}$ Min (V) | $r_{DS(on)}$ Max ( $\Omega$ ) | $V_{GS(th)}$ (V) | $I_D$ (A) |
| 2N7000          | 60                    | 5 @ $V_{GS} = 10$ V           | 0.8 to 3         | 0.2       |
| 2N7002          |                       | 7.5 @ $V_{GS} = 10$ V         | 1 to 2.5         | 0.115     |
| VQ1000J         |                       | 5.5 @ $V_{GS} = 10$ V         | 0.8 to 2.5       | 0.225     |
| VQ1000P         |                       | 5.5 @ $V_{GS} = 10$ V         | 0.8 to 2.5       | 0.225     |
| BS170           |                       | 5 @ $V_{GS} = 10$ V           | 0.8 to 3         | 0.5       |

### FEATURES

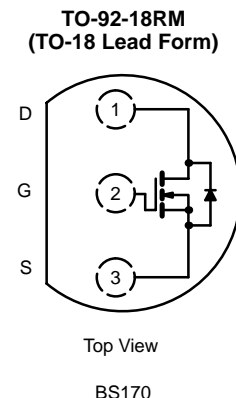
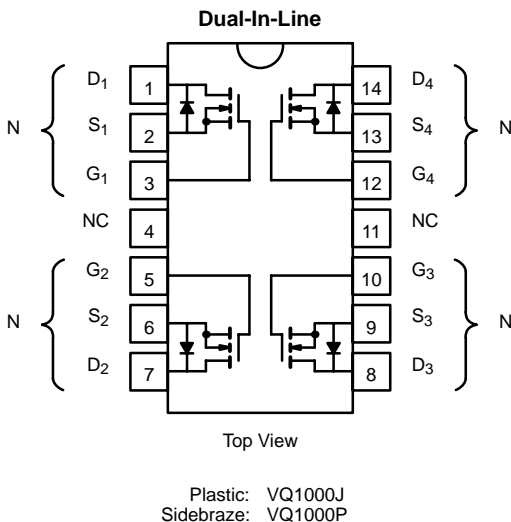
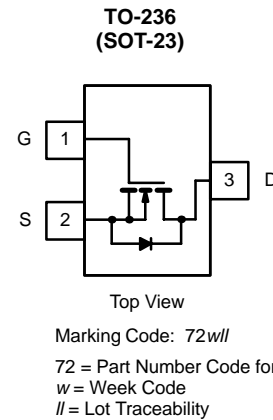
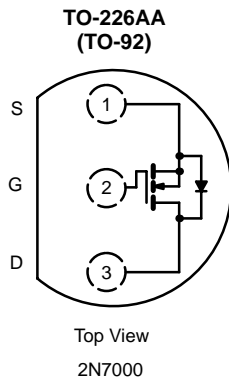
- Low On-Resistance: 2.5  $\Omega$
- Low Threshold: 2.1 V
- Low Input Capacitance: 22 pF
- Fast Switching Speed: 7 ns
- Low Input and Output Leakage

### 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, Displays, Memories, Transistors, etc.
- Battery Operated Systems
- Solid-State Relays





| ABSOLUTE MAXIMUM RATINGS (T <sub>A</sub> = 25 °C UNLESS OTHERWISE NOTED) |                                   |                |        |         |         |            |       |       |    |
|--|-----------------------------------|----------------|--------|---------|---------|------------|-------|-------|----|
| Parameter  | Symbol                            | 2N7000         | 2N7002 | Single  |         | Total Quad | BS170 | Unit  |    |
|  |                                   |                |        | VQ1000J | VQ1000P | VQ1000J/P  |       |       |    |
| Drain-Source Voltage   | V <sub>DS</sub>                   | 60             | 60     | 60      | 60      |            | 60    | V     |    |
| Gate-Source Voltage—Non-Repetitive                                       | V <sub>GSM</sub>                  | ±40            | ±40    | ±30     |         |            | ±25   |       |    |
| Gate-Source Voltage—Continuous   | V <sub>GS</sub>                   | ±20            | ±20    | ±20     | ±20     |            | ±20   |       |    |
| Continuous Drain Current (T <sub>J</sub> = 150 °C)                       | T <sub>A</sub> = 25 °C            | I <sub>D</sub> | 0.2    | 0.115   | 0.225   | 0.225      |       | 0.5   | A  |
|  | T <sub>A</sub> = 100 °C           |                | 0.13   | 0.073   | 0.14    | 0.14       |       | 0.175 |    |
| Pulsed Drain Current <sup>a</sup>  | I <sub>DM</sub>                   | 0.5            | 0.8    | 1       | 1       |            |       |       |    |
| Power Dissipation  | T <sub>A</sub> = 25 °C            | P <sub>D</sub> | 0.4    | 0.2     | 1.3     | 1.3        | 2     | 0.83  | W  |
|  | T <sub>A</sub> = 100 °C           |                | 0.16   | 0.08    | 0.52    | 0.52       | 0.8   |       |    |
| Thermal Resistance, Junction-to-Ambient                                  | R <sub>thJA</sub>                 | 312.5          | 625    | 96      | 96      | 62.5       | 156   | °C/W  |    |
| Operating Junction and Storage Temperature Range                         | T <sub>J</sub> , T <sub>stg</sub> | -55 to 150     |        |         |         |            |       |       | °C |

Notes

- a. Pulse width limited by maximum junction temperature.
- b. t<sub>p</sub> ≤ 50 μs.

| SPECIFICATIONS—2N7000 AND 2N7002 (T <sub>A</sub> = 25 °C UNLESS OTHERWISE NOTED) |                      |  |                  |        |      |        |      |      |
|--|----------------------|--|------------------|--------|------|--------|------|------|
| Parameter  | Symbol               | Test Conditions  | Typ <sup>a</sup> | Limits |      |        |      | Unit |
|  |                      |  |                  | 2N7000 |      | 2N7002 |      |      |
|  |                      |  |                  | Min    | Max  | Min    | Max  |      |
| <b>Static</b>  |                      |  |                  |        |      |        |      |      |
| Drain-Source Breakdown Voltage   | V <sub>(BR)DSS</sub> | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 10 μA                | 70               | 60     |      | 60     |      | V    |
| Gate-Threshold Voltage   | V <sub>GS(th)</sub>  | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1 mA    | 2.1              | 0.8    | 3    |        |      |      |
|  |                      | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 0.25 mA | 2.0              |        |      | 1      | 2.5  |      |
| Gate-Body Leakage  | I <sub>GSS</sub>     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ±15 V               |                  |        | ±10  |        |      | nA   |
|  |                      | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ±20 V               |                  |        |      |        | ±100 |      |
| Zero Gate Voltage Drain Current  | I <sub>DSS</sub>     | V <sub>DS</sub> = 48 V, V <sub>GS</sub> = 0 V                |                  |        | 1    |        |      | μA   |
|  |                      | T <sub>C</sub> = 125 °C                                      |                  |        | 1000 |        |      |      |
|  |                      | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V                |                  |        |      |        | 1    |      |
| On-State Drain Current <sup>b</sup>  | I <sub>D(on)</sub>   | V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 4.5 V              | 0.35             | 0.075  |      |        |      | A    |
|  |                      | V <sub>DS</sub> = 7.5 V, V <sub>GS</sub> = 10 V              | 1                |        |      | 0.5    |      |      |
|  |                      | V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 0.075 A            | 4.5              |        | 5.3  |        |      |      |
| Drain-Source On-Resistance <sup>b</sup>  | r <sub>DS(on)</sub>  | V <sub>GS</sub> = 5 V, I <sub>D</sub> = 0.05 A               | 3.2              |        |      |        | 7.5  | Ω    |
|  |                      | T <sub>C</sub> = 125 °C                                      | 5.8              |        |      |        | 13.5 |      |
|  |                      | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 0.5 A               | 2.4              |        | 5    |        | 7.5  |      |
|  |                      | T <sub>J</sub> = 125 °C                                      | 4.4              |        | 9    |        | 13.5 |      |
| Forward Transconductance <sup>b</sup>  | g <sub>fs</sub>      | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 0.2 A               |                  | 100    |      | 80     |      | mS   |
| Common Source Output Conductance <sup>b</sup>                                    | g <sub>os</sub>      | V <sub>DS</sub> = 5 V, I <sub>D</sub> = 0.05 A               | 0.5              |        |      |        |      |      |
| <b>Dynamic</b>   |                      |  |                  |        |      |        |      |      |
| Input Capacitance  | C <sub>iss</sub>     | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V<br>f = 1 MHz   | 22               |        | 60   |        | 50   | pF   |
| Output Capacitance   | C <sub>oss</sub>     |  | 11               |        | 25   |        | 25   |      |
| Reverse Transfer Capacitance   | C <sub>rss</sub>     |  | 2                |        | 5    |        | 5    |      |



| SPECIFICATIONS—2N7000 AND 2N7002 (T <sub>A</sub> = 25 °C UNLESS OTHERWISE NOTED) |                  |  |                  |        |     |        |     |      |
|--|------------------|--|------------------|--------|-----|--------|-----|------|
| Parameter  | Symbol           | Test Conditions  | Typ <sup>a</sup> | Limits |     |        |     | Unit |
|  |                  |  |                  | 2N7000 |     | 2N7002 |     |      |
|  |                  |  |                  | Min    | Max | Min    | Max |      |
| <b>Switching<sup>d</sup></b>   |                  |  |                  |        |     |        |     |      |
| Turn-On Time   | t <sub>ON</sub>  | V <sub>DD</sub> = 15 V, R <sub>L</sub> = 25 Ω<br>I <sub>D</sub> ≅ 0.5 A, V <sub>GEN</sub> = 10 V, R <sub>G</sub> = 25 Ω  | 7                |        | 10  |        |     | ns   |
| Turn-Off Time  | t <sub>OFF</sub> |  | 7                |        | 10  |        |     |      |
| Turn-On Time   | t <sub>ON</sub>  | V <sub>DD</sub> = 30 V, R <sub>L</sub> = 150 Ω<br>I <sub>D</sub> ≅ 0.2 A, V <sub>GEN</sub> = 10 V, R <sub>G</sub> = 25 Ω | 7                |        |     |        | 20  |      |
| Turn-Off Time  | t <sub>OFF</sub> |  | 11               |        |     |        | 20  |      |

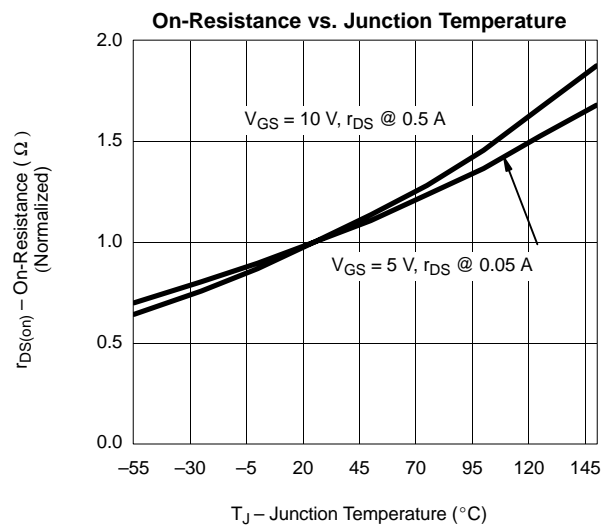
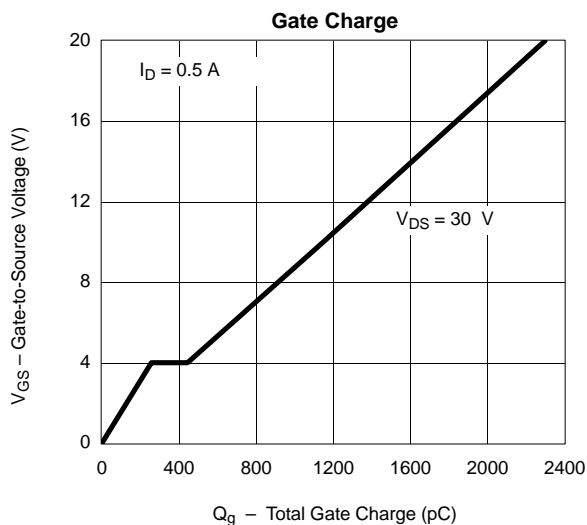
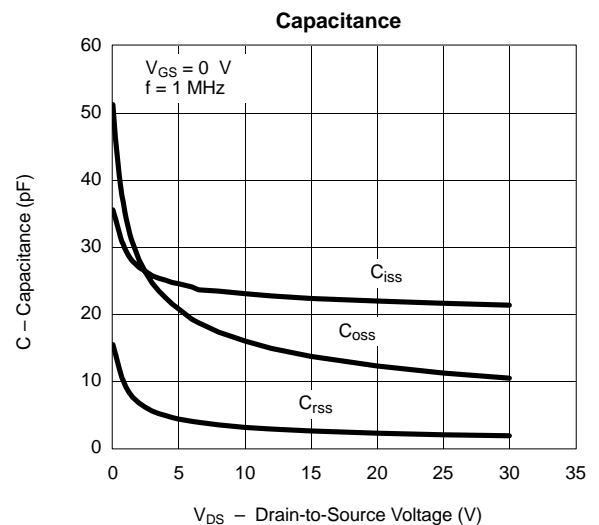
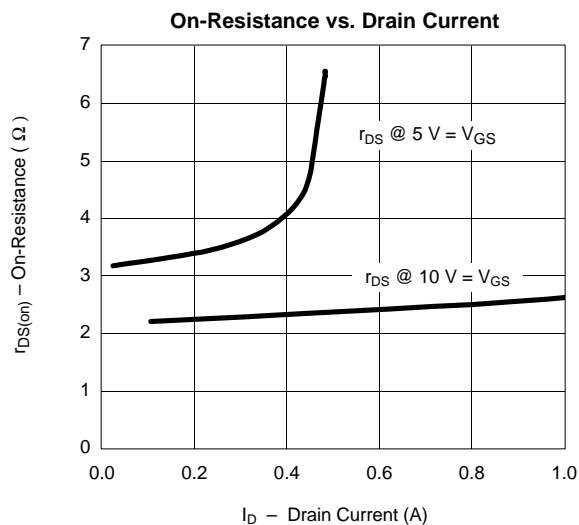
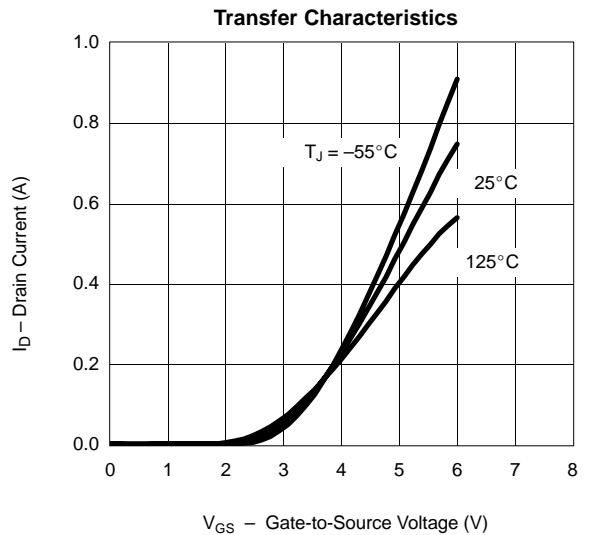
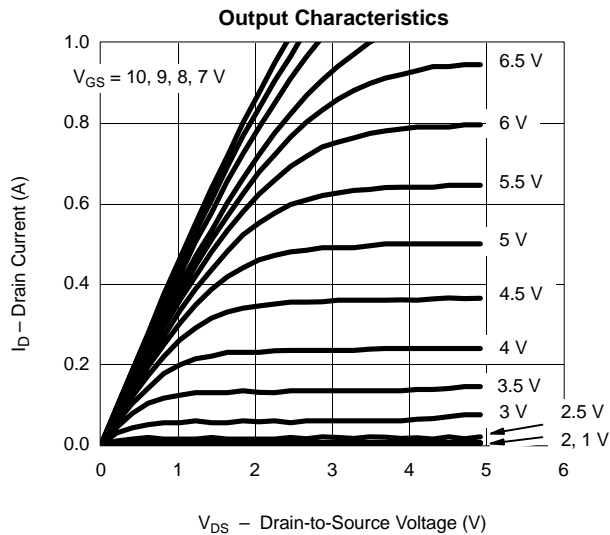
| SPECIFICATIONS—VQ1000J/P AND BS170 (T <sub>A</sub> = 25 °C UNLESS OTHERWISE NOTED) |                      |  |                  |           |      |       |     |      |
|--|----------------------|--|------------------|-----------|------|-------|-----|------|
| Parameter  | Symbol               | Test Conditions  | Typ <sup>a</sup> | Limits    |      |       |     | Unit |
|  |                      |  |                  | VQ1000J/P |      | BS170 |     |      |
|  |                      |  |                  | Min       | Max  | Min   | Max |      |
| <b>Static</b>  |                      |  |                  |           |      |       |     |      |
| Drain-Source Breakdown Voltage   | V <sub>(BR)DSS</sub> | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 100 μA   | 70               | 60        |      | 60    |     | V    |
| Gate-Threshold Voltage   | V <sub>GS(th)</sub>  | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1 mA  | 2.1              | 0.8       | 2.5  | 0.8   | 3   |      |
| Gate-Body Leakage  | I <sub>GSS</sub>     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ±10 V   |                  |           | ±100 |       |     | nA   |
|  |                      | T <sub>J</sub> = 125 °C  |                  |           | ±500 |       |     |      |
| Zero Gate Voltage Drain Current  | I <sub>DSS</sub>     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ±15 V   |                  |           |      |       | ±10 | μA   |
|  |                      | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V  |                  |           |      |       | 0.5 |      |
|  |                      | V <sub>DS</sub> = 48 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C   |                  |           | 500  |       |     |      |
| On-State Drain Current <sup>b</sup>  | I <sub>D(on)</sub>   | V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 10 V   | 1                | 0.5       |      |       |     | A    |
|  |                      | V <sub>GS</sub> = 5 V, I <sub>D</sub> = 0.2 A  | 4                |           | 7.5  |       |     | Ω    |
| Drain-Source On-Resistance <sup>b</sup>  | r <sub>DS(on)</sub>  | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 0.2 A   | 2.3              |           |      |       | 5   |      |
|  |                      | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 0.3 A   | 2.3              |           | 5.5  |       |     |      |
|  |                      | T <sub>J</sub> = 125 °C  | 4.2              |           | 7.6  |       |     |      |
|  |                      | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 0.2 A   |                  |           |      | 100   |     | mS   |
| Forward Transconductance <sup>b</sup>  | g <sub>fs</sub>      | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 0.5 A   |                  | 100       |      |       |     |      |
| Common Source Output Conductance <sup>b</sup>                                      | g <sub>os</sub>      | V <sub>DS</sub> = 5 V, I <sub>D</sub> = 0.05 A   | 0.5              |           |      |       |     |      |
| <b>Dynamic</b>   |                      |  |                  |           |      |       |     |      |
| Input Capacitance  | C <sub>iSS</sub>     | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V<br>f = 1 MHz   | 22               |           | 60   |       | 60  | pF   |
| Output Capacitance   | C <sub>oss</sub>     |  | 11               |           | 25   |       |     |      |
| Reverse Transfer Capacitance   | C <sub>rSS</sub>     |  | 2                |           | 5    |       |     |      |
| <b>Switching<sup>d</sup></b>   |                      |  |                  |           |      |       |     |      |
| Turn-On Time   | t <sub>ON</sub>      | V <sub>DD</sub> = 15 V, R <sub>L</sub> = 23 Ω<br>I <sub>D</sub> ≅ 0.6 A, V <sub>GEN</sub> = 10 V, R <sub>G</sub> = 25 Ω  | 7                |           | 10   |       |     | ns   |
| Turn-Off Time  | t <sub>OFF</sub>     |  | 7                |           | 10   |       |     |      |
| Turn-On Time   | t <sub>ON</sub>      | V <sub>DD</sub> = 25 V, R <sub>L</sub> = 125 Ω<br>I <sub>D</sub> ≅ 0.2 A, V <sub>GEN</sub> = 10 V, R <sub>G</sub> = 25 Ω | 7                |           |      |       | 10  |      |
| Turn-Off Time  | t <sub>OFF</sub>     |  | 7                |           |      |       | 10  |      |

Notes

- a. For DESIGN AID ONLY, not subject to production testing.
- b. Pulse test: PW ≤ 80 μs duty cycle ≤ 1%.
- c. This parameter not registered with JEDEC.
- d. Switching time is essentially independent of operating temperature.

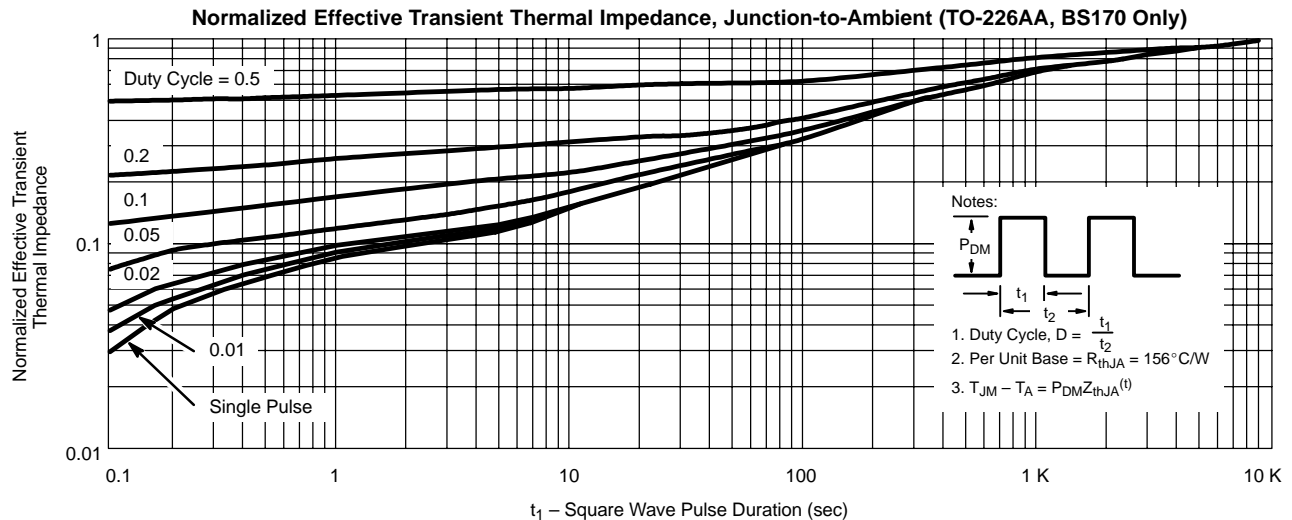
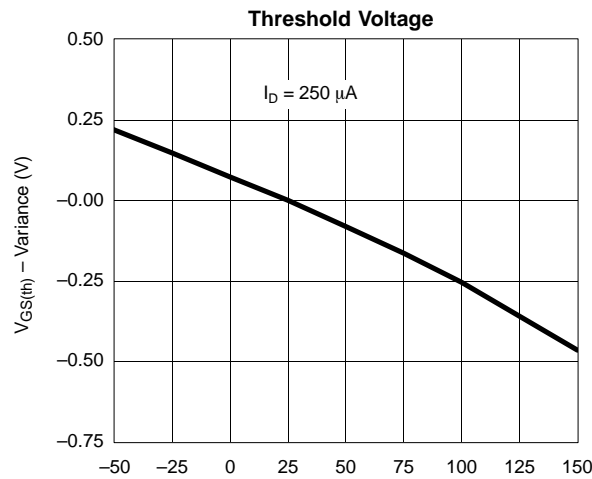
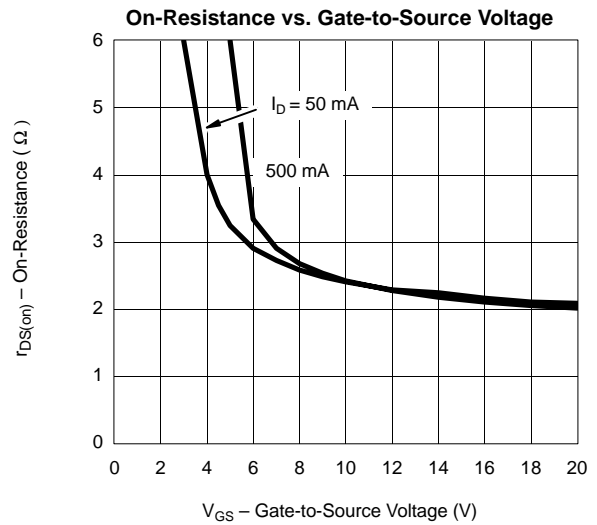
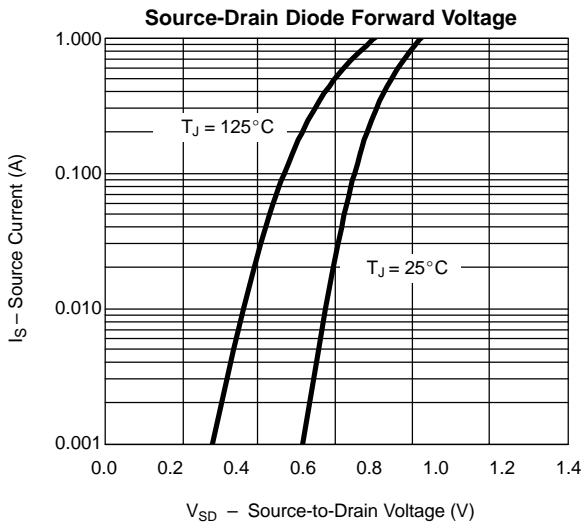
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**TYPICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$  UNLESS OTHERWISE NOTED)**





**TYPICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$  UNLESS OTHERWISE NOTED)**





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