

# Complementary N- and P-Channel 20 V (D-S) MOSFET

## PRODUCT SUMMARY

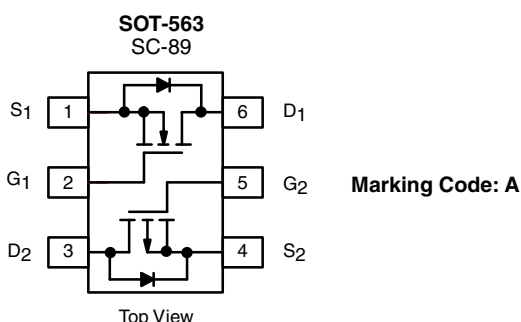
|           | $V_{DS}$ (V) | $R_{DS(on)}$ ( $\Omega$ ) | $I_D$ (mA) |
|-----------|--------------|---------------------------|------------|
| N-Channel | 20           | 0.70 at $V_{GS} = 4.5$ V  | 600        |
|           |              | 0.85 at $V_{GS} = 2.5$ V  | 500        |
|           |              | 1.25 at $V_{GS} = 1.8$ V  | 350        |
| P-Channel | - 20         | 1.2 at $V_{GS} = - 4.5$ V | - 400      |
|           |              | 1.6 at $V_{GS} = - 2.5$ V | - 300      |
|           |              | 2.7 at $V_{GS} = - 1.8$ V | - 150      |

## FEATURES

- **Halogen-free According to IEC 61249-2-21 Definition**
- TrenchFET® Power MOSFETs
- 2000 V ESD Protection
- Very Small Footprint
- High-Side Switching
- Low On-Resistance:  
N-Channel, 0.7  $\Omega$   
P-Channel, 1.2  $\Omega$
- Low Threshold:  $\pm 0.8$  V (Typ.)
- Fast Switching Speed: 14 ns
- 1.8 V Operation
- Compliant to RoHS Directive 2002/95/EC



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**



## BENEFITS

- Ease in Driving Switches
- Low Offset (Error) Voltage
- Low-Voltage Operation
- High-Speed Circuits
- Low Battery Voltage Operation

## APPLICATIONS

- Replace Digital Transistor, Level-Shifter
- Battery Operated Systems
- Power Supply Converter Circuits

**Ordering Information:** Si1016X-T1-GE3 (Lead (Pb)-free and Halogen-free)

## ABSOLUTE MAXIMUM RATINGS ( $T_A = 25$ °C, unless otherwise noted)

| Parameter                                                       |                        | Symbol                            | N-Channel   |              | P-Channel |              | Unit |
|-----------------------------------------------------------------|------------------------|-----------------------------------|-------------|--------------|-----------|--------------|------|
|                                                                 |                        |                                   | 5 s         | Steady State | 5 s       | Steady State |      |
| Drain-Source Voltage                                            |                        | V <sub>DS</sub>                   | 20          |              | - 20      |              | V    |
| Gate-Source Voltage                                             |                        | V <sub>GS</sub>                   | ± 6         |              |           |              |      |
| Continuous Drain Current (T <sub>J</sub> = 150 °C) <sup>a</sup> | T <sub>A</sub> = 25 °C | I <sub>D</sub>                    | 515         | 485          | - 390     | - 370        | mA   |
|                                                                 | T <sub>A</sub> = 85 °C |                                   | 370         | 350          | - 280     | - 265        |      |
| Pulsed Drain Current <sup>b</sup>                               |                        | I <sub>DM</sub>                   | 650         |              | - 650     |              |      |
| Continuous Source Current (Diode Conduction) <sup>a</sup>       |                        | I <sub>S</sub>                    | 450         | 380          | - 450     | - 380        | mW   |
| Maximum Power Dissipation <sup>a</sup>                          | T <sub>A</sub> = 25 °C | P <sub>D</sub>                    | 280         | 250          | 280       | 250          |      |
|                                                                 | T <sub>A</sub> = 85 °C |                                   | 145         | 130          | 145       | 130          |      |
| Operating Junction and Storage Temperature Range                |                        | T <sub>J</sub> , T <sub>stg</sub> | - 55 to 150 |              |           |              | °C   |
| Gate-Source ESD Rating (HBM, Method 3015)                       |                        | ESD                               | 2000        |              |           |              | V    |

Notes:

a. Surface mounted on FR4 board.

b. Pulse width limited by maximum junction temperature.

| SPECIFICATIONS (T <sub>J</sub> = 25 °C, unless otherwise noted) |                     |                                                                                                                                                                                                                                                                                        |              |        |                |                |      |
|-----------------------------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------|----------------|----------------|------|
| Parameter                                                       | Symbol              | Test Conditions                                                                                                                                                                                                                                                                        |              | Min.   | Typ.           | Max.           | Unit |
| Static                                                          |                     |                                                                                                                                                                                                                                                                                        |              |        |                |                |      |
| Gate Threshold Voltage                                          | V <sub>GS(th)</sub> | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                                                                                                                                                                                                                            | N-Ch         | 0.45   |                | 1              | V    |
|                                                                 |                     | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = - 250 μA                                                                                                                                                                                                                          | P-Ch         | - 0.45 |                | - 1            |      |
| Gate Body Leakage                                               | I <sub>GSS</sub>    | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 4.5 V                                                                                                                                                                                                                                       | N-Ch<br>P-Ch |        | ± 0.5<br>± 1.0 | ± 1.0<br>± 2.0 | μA   |
| Zero Gate Voltage Drain Current                                 | I <sub>DSS</sub>    | V <sub>DS</sub> = 16 V, V <sub>GS</sub> = 0 V                                                                                                                                                                                                                                          | N-Ch         |        | 0.3            | 100            | nA   |
|                                                                 |                     | V <sub>DS</sub> = - 16 V, V <sub>GS</sub> = 0 V                                                                                                                                                                                                                                        | P-Ch         |        | - 0.3          | - 100          |      |
|                                                                 |                     | V <sub>DS</sub> = 16 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 85 °C                                                                                                                                                                                                                  | N-Ch         |        |                | 5              | μA   |
|                                                                 |                     | V <sub>DS</sub> = - 16 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 85 °C                                                                                                                                                                                                                | P-Ch         |        |                | - 5            |      |
| On State Drain Current <sup>a</sup>                             | I <sub>D(on)</sub>  | V <sub>DS</sub> = 5 V, V <sub>GS</sub> = 4.5 V                                                                                                                                                                                                                                         | N-Ch         | 700    |                |                | mA   |
|                                                                 |                     | V <sub>DS</sub> = - 5 V, V <sub>GS</sub> = - 4.5 V                                                                                                                                                                                                                                     | P-Ch         | - 700  |                |                |      |
| Drain-Source On-State Resistance <sup>a</sup>                   | R <sub>DS(on)</sub> | V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 600 mA                                                                                                                                                                                                                                       | N-Ch         |        | 0.41           | 0.70           | Ω    |
|                                                                 |                     | V <sub>GS</sub> = - 4.5 V, I <sub>D</sub> = - 350 mA                                                                                                                                                                                                                                   | P-Ch         |        | 0.80           | 1.2            |      |
|                                                                 |                     | V <sub>GS</sub> = 2.5 V, I <sub>D</sub> = 500 mA                                                                                                                                                                                                                                       | N-Ch         |        | 0.53           | 0.85           |      |
|                                                                 |                     | V <sub>GS</sub> = - 2.5 V, I <sub>D</sub> = - 300 mA                                                                                                                                                                                                                                   | P-Ch         |        | 1.20           | 1.6            |      |
|                                                                 |                     | V <sub>GS</sub> = 1.8 V, I <sub>D</sub> = 350 mA                                                                                                                                                                                                                                       | N-Ch         |        | 0.70           | 1.25           |      |
|                                                                 |                     | V <sub>GS</sub> = - 1.8 V, I <sub>D</sub> = - 150 mA                                                                                                                                                                                                                                   | P-Ch         |        | 1.80           | 2.7            |      |
| Forward Transconductance <sup>a</sup>                           | g <sub>fs</sub>     | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 400 mA                                                                                                                                                                                                                                        | N-Ch         |        | 1.0            |                | S    |
|                                                                 |                     | V <sub>DS</sub> = - 10 V, I <sub>D</sub> = - 250 mA                                                                                                                                                                                                                                    | P-Ch         |        | 0.4            |                |      |
| Diode Forward Voltage <sup>a</sup>                              | V <sub>SD</sub>     | I <sub>S</sub> = 150 mA, V <sub>GS</sub> = 0 V                                                                                                                                                                                                                                         | N-Ch         |        | 0.8            | 1.2            | V    |
|                                                                 |                     | I <sub>S</sub> = - 150 mA, V <sub>GS</sub> = 0 V                                                                                                                                                                                                                                       | P-Ch         |        | - 0.8          | - 1.2          |      |
| Dynamic <sup>b</sup>                                            |                     |                                                                                                                                                                                                                                                                                        |              |        |                |                |      |
| Total Gate Charge                                               | Q <sub>g</sub>      | N-Channel<br>V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 250 mA<br>P-Channel<br>V <sub>DS</sub> = - 10 V, V <sub>GS</sub> = - 4.5 V, I <sub>D</sub> = - 250 mA                                                                                                   | N-Ch<br>P-Ch |        | 750<br>1500    |                | pC   |
| Gate-Source Charge                                              | Q <sub>gs</sub>     |                                                                                                                                                                                                                                                                                        | N-Ch<br>P-Ch |        | 75<br>150      |                |      |
| Gate-Drain Charge                                               | Q <sub>gd</sub>     |                                                                                                                                                                                                                                                                                        | N-Ch<br>P-Ch |        | 225<br>450     |                |      |
| Turn-On Time                                                    | t <sub>ON</sub>     | N-Channel<br>V <sub>DD</sub> = 10 V, R <sub>L</sub> = 47 Ω<br>I <sub>D</sub> ≅ 200 mA, V <sub>GEN</sub> = 4.5 V, R <sub>g</sub> = 10 Ω<br>P-Channel<br>V <sub>DD</sub> = - 10 V, R <sub>L</sub> = 47 Ω<br>I <sub>D</sub> ≅ - 200 mA, V <sub>GEN</sub> = - 4.5 V, R <sub>g</sub> = 10 Ω | N-Ch<br>P-Ch |        | 5<br>5         |                | ns   |
| Turn-Off Time                                                   | t <sub>OFF</sub>    |                                                                                                                                                                                                                                                                                        | N-Ch         |        | 25             |                |      |
|                                                                 |                     |                                                                                                                                                                                                                                                                                        | P-Ch         |        | 35             |                |      |
|                                                                 |                     |                                                                                                                                                                                                                                                                                        |              |        |                |                |      |

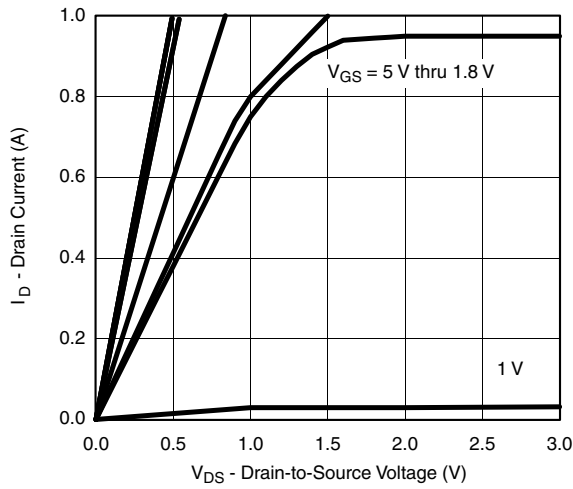
Notes:

a. Pulse test; pulse width  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$ .

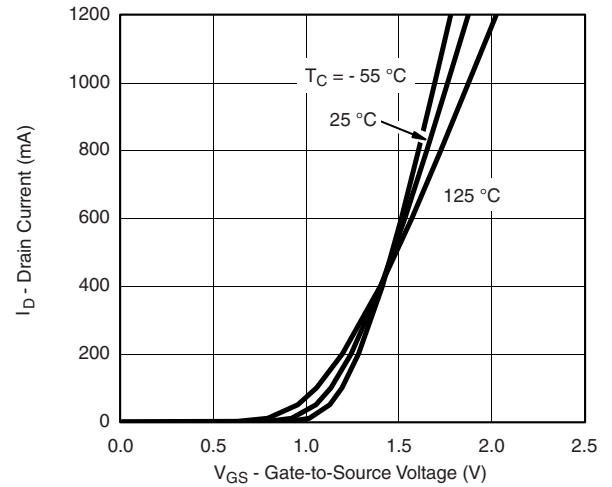
b. Guaranteed by design, not subject to production testing.

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.

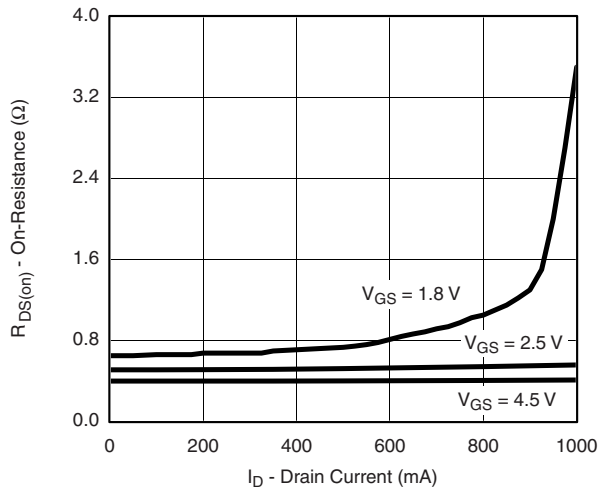
## N-CHANNEL TYPICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , unless otherwise noted)



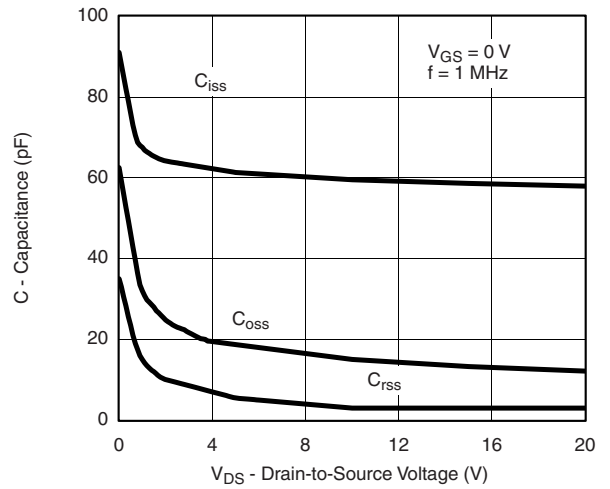
Output Characteristics



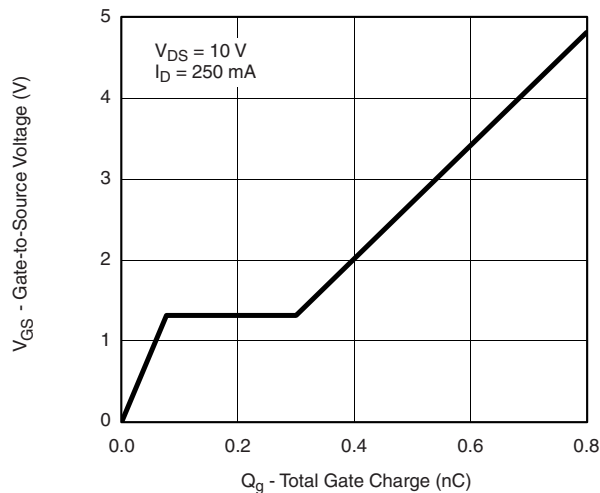
Transfer Characteristics



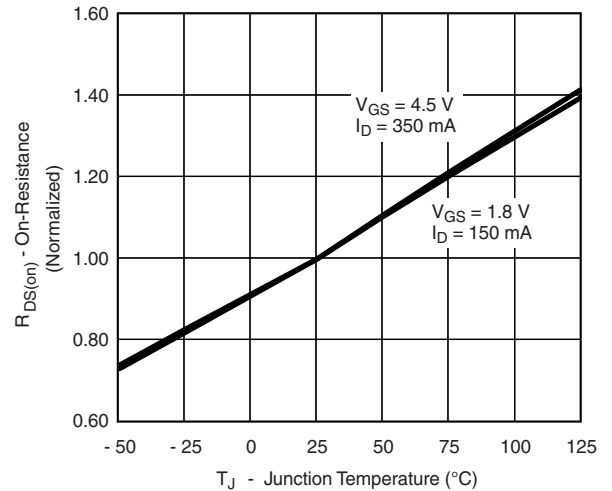
On-Resistance vs. Drain Current



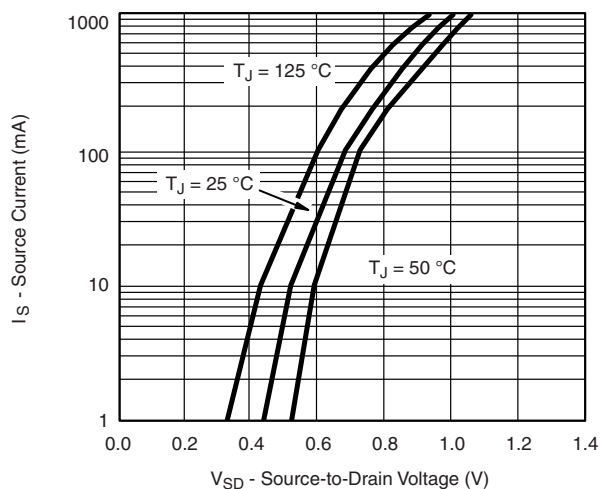
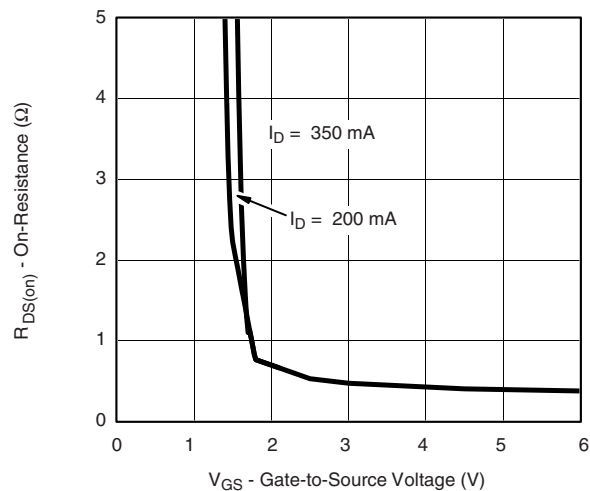
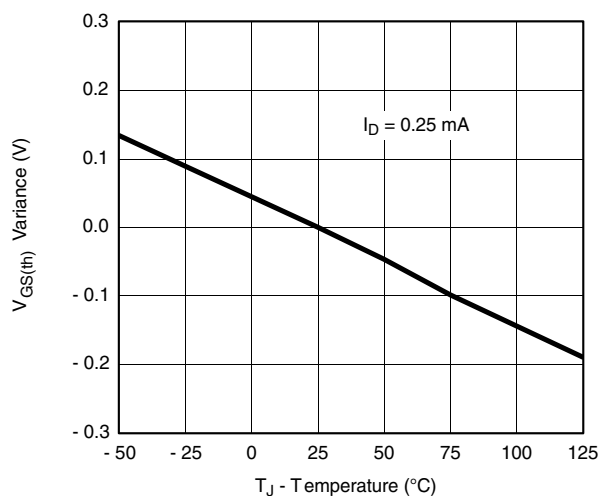
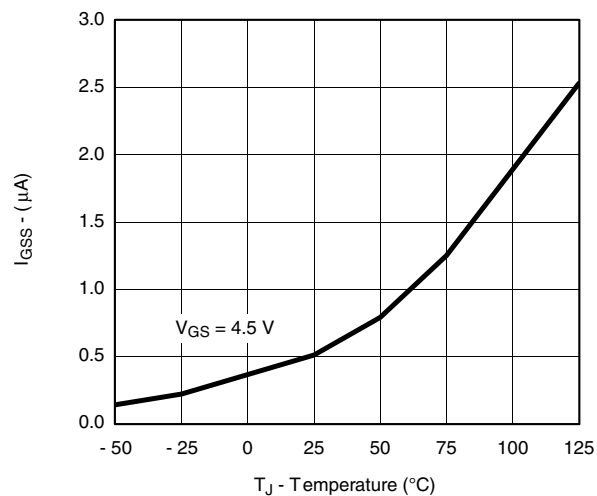
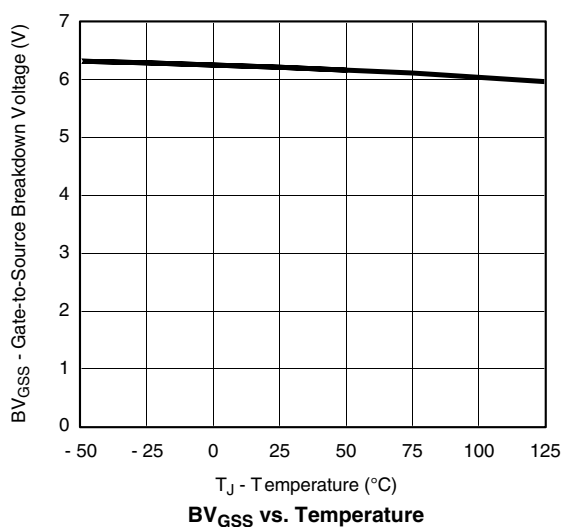
Capacitance



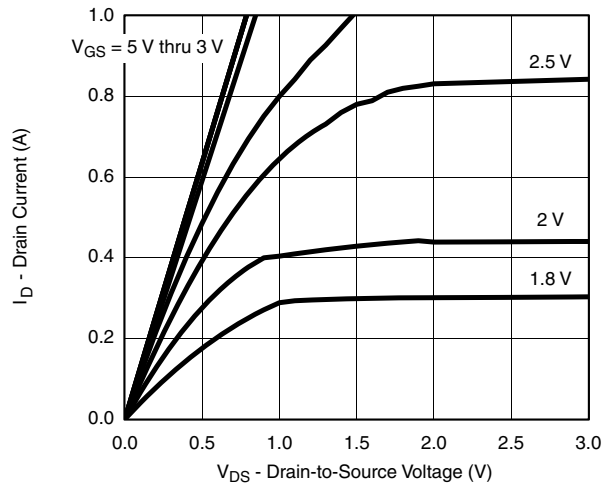
Gate Charge



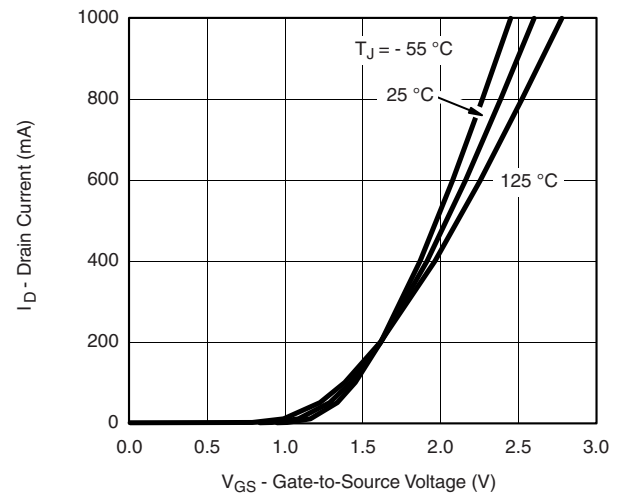
On-Resistance vs. Junction Temperature

**N-CHANNEL TYPICAL CHARACTERISTICS** ( $T_A = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

**Source-Drain Diode Forward Voltage**

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

**Threshold Voltage Variance vs. Temperature**

 **$I_{GSS}$  vs. Temperature**

 **$BV_{GSS}$  vs. Temperature**

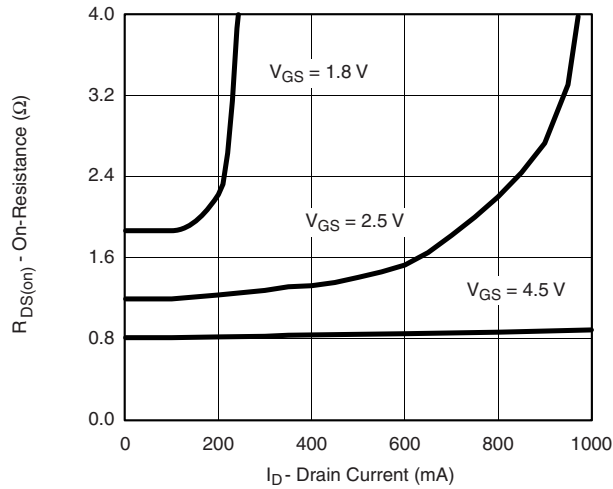
## P-CHANNEL TYPICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , unless otherwise noted)



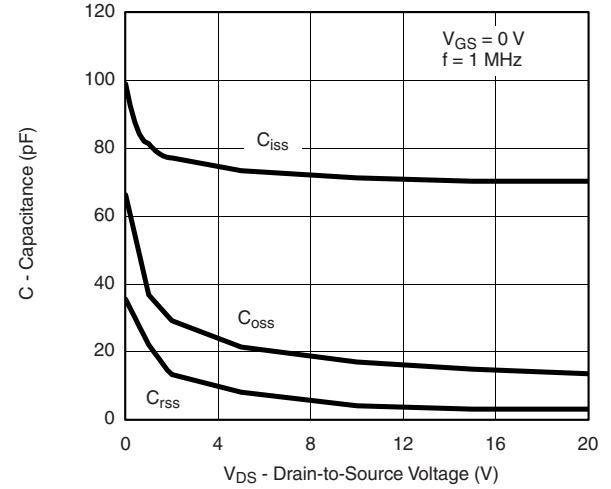
Output Characteristics



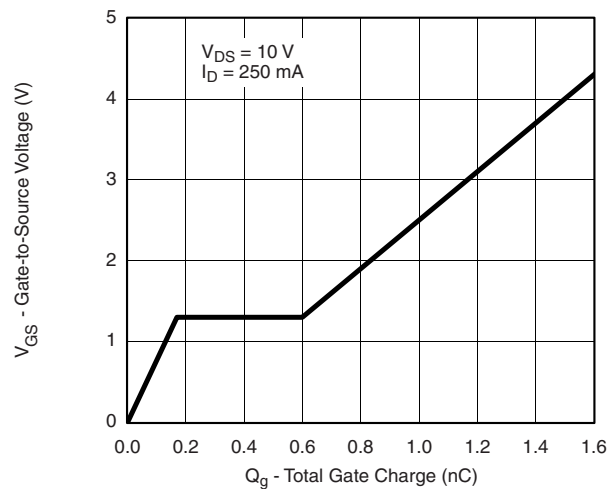
Transfer Characteristics



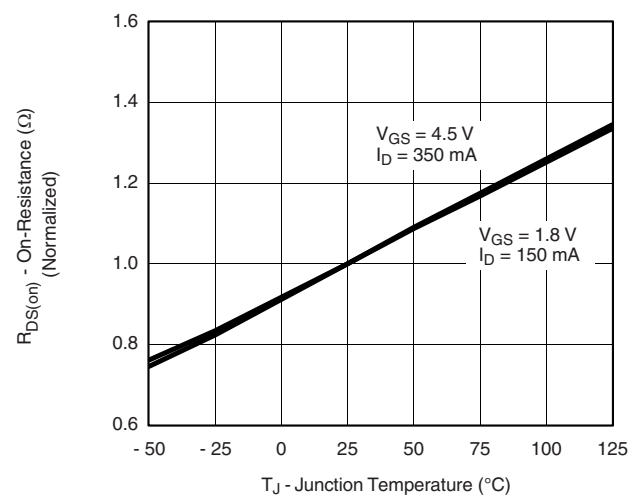
On-Resistance vs. Drain Current



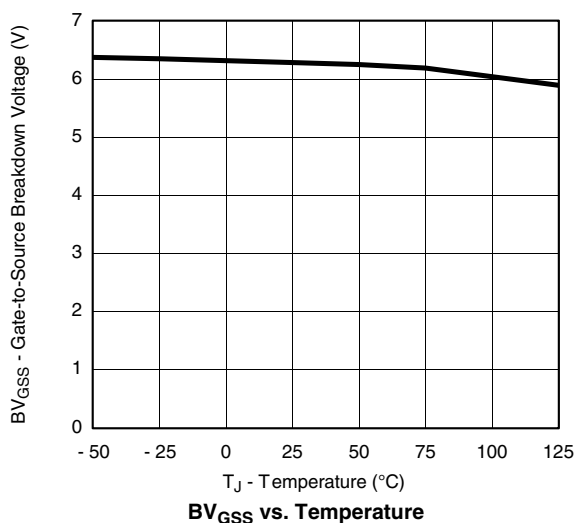
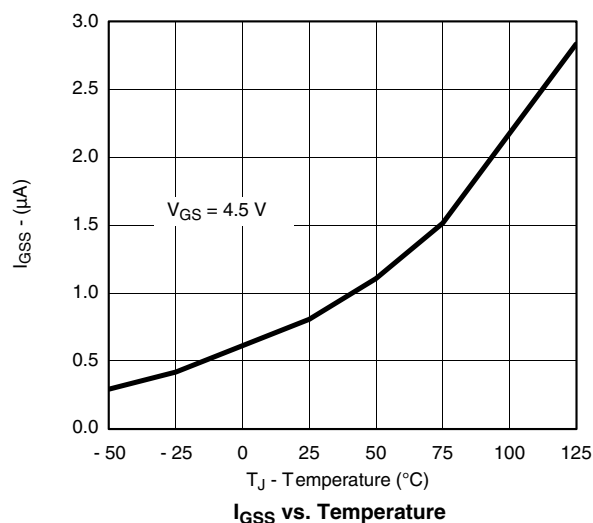
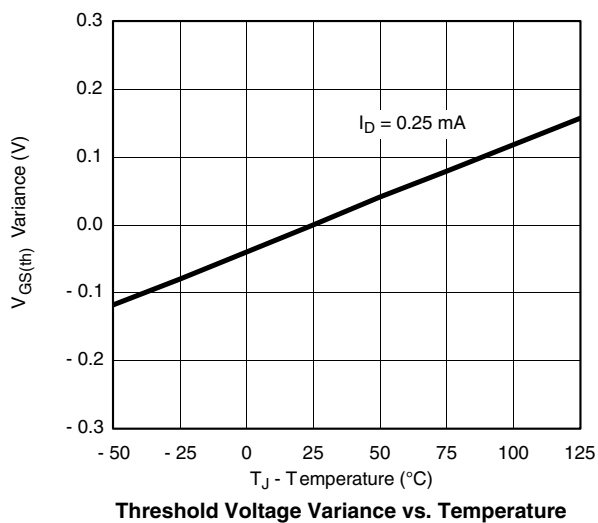
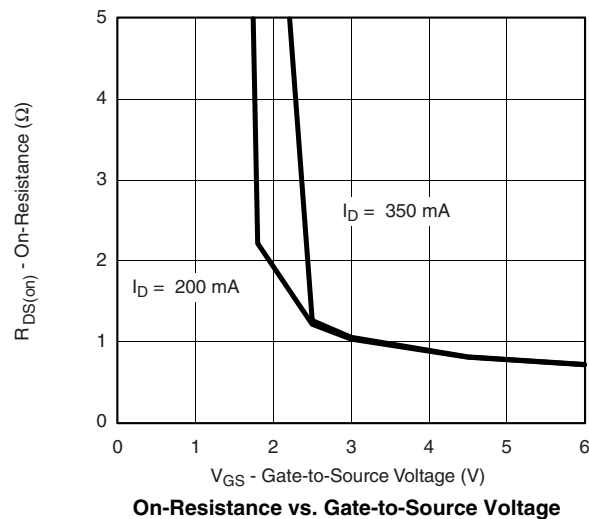
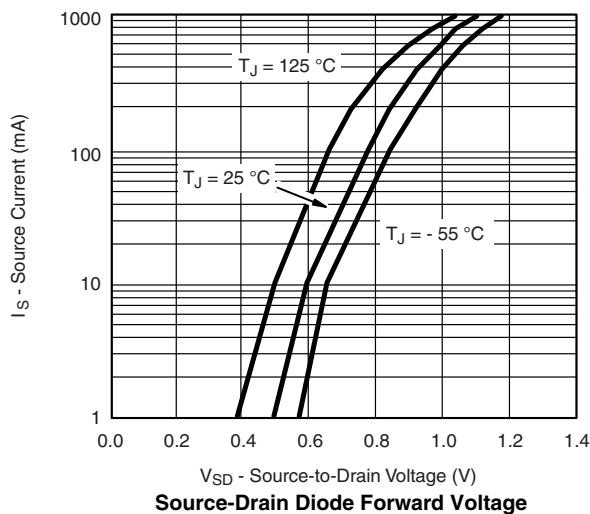
Capacitance



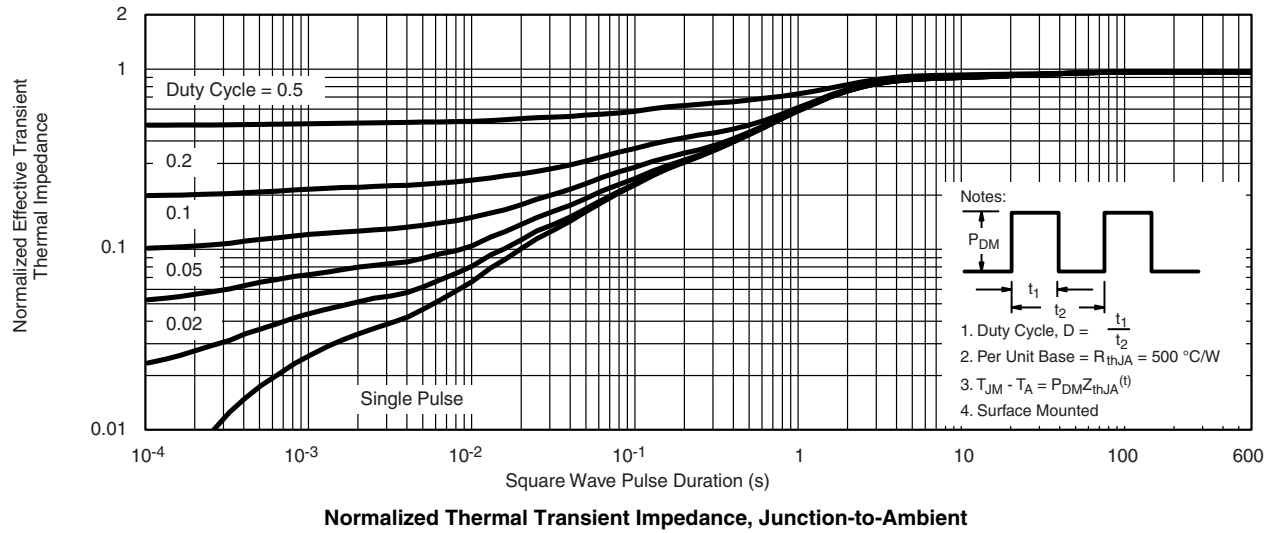
Gate Charge



On-Resistance vs. Junction Temperature

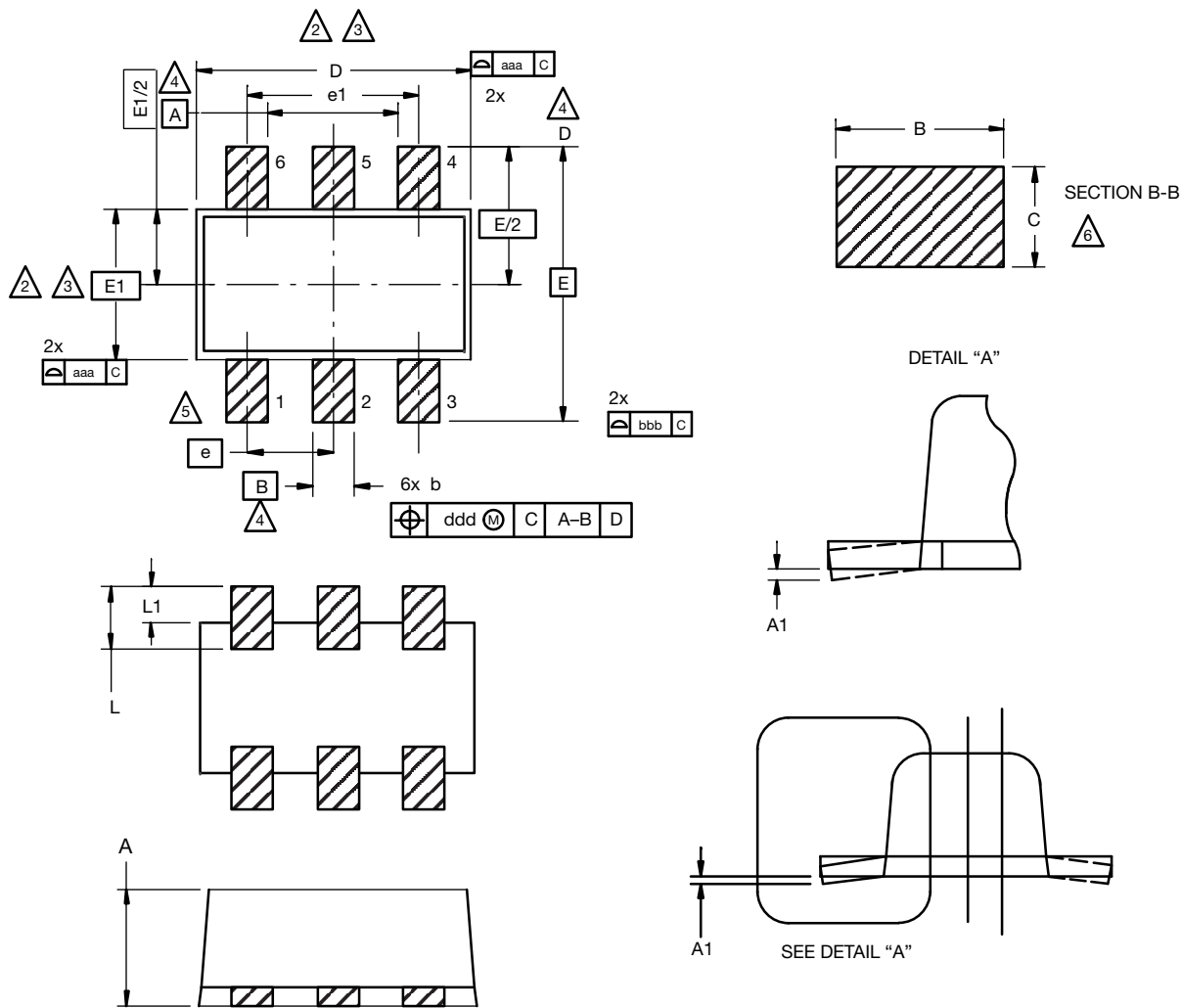
**P-CHANNEL TYPICAL CHARACTERISTICS** ( $T_A = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

## N- OR P-CHANNEL TYPICAL CHARACTERISTICS ( $T_A = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)



Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see [www.vishay.com/ppg?71168](http://www.vishay.com/ppg?71168).

## SC-89 6-Leads (SOT-563F)



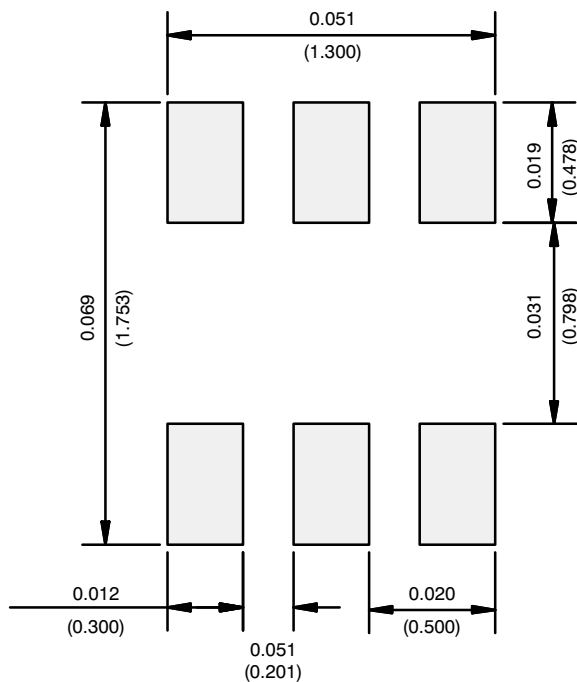
## Notes

1. Dimensions in millimeters.
2. Dimension D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm per dimension E1 does not include interlead flash or protrusion, interlead flash or protrusion shall not exceed 0.15 mm per side.
3. Dimensions D and E1 are determined at the outmost extremes of the plastic body exclusive of mold flash, the bar burrs, gate burrs and interlead flash, but including any mismatch between the top and the bottom of the plastic body.
4. Datums A, B and D to be determined 0.10 mm from the lead tip.
5. Terminal numbers are shown for reference only.
6. These dimensions apply to the flat section of the lead between 0.08 mm and 0.15 mm from the lead tip.

| DIM. | MILLIMETERS |      |      |
|------|-------------|------|------|
|      | MIN.        | NOM. | MAX. |
| A    | 0.56        | 0.58 | 0.60 |
| A1   | 0           | 0.02 | 0.10 |
| b    | 0.15        | 0.22 | 0.30 |
| c    | 0.10        | 0.14 | 0.18 |
| D    | 1.50        | 1.60 | 1.70 |
| E    | 1.50        | 1.60 | 1.70 |
| E1   | 1.15        | 1.20 | 1.25 |
| e    | 0.45        | 0.50 | 0.55 |
| e1   | 0.95        | 1.00 | 1.05 |
| L    | 0.25        | 0.35 | 0.50 |
| L1   | 0.10        | 0.20 | 0.30 |

C14-0439-Rev. C, 11-Aug-14  
DWG: 5880

## RECOMMENDED MINIMUM PADS FOR SC-89: 6-Lead



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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