# Automotive N-Channel 40 V (D-S) 175 °C MOSFET

| PRODUCT SUMMARY | |
|---|---|
| $V_{DS}$ (V) | 40 |
| $R_{DS(on)}$ (Ω) at $V_{GS}$ = 10 V | 0.032 |
| $R_{DS(on)}$ (Ω) at $V_{GS}$ = 4.5 V | 0.042 |
| $I_D$ (A) | 8 |
| Configuration | Single |
| Package | TSOP-6 |

## FEATURES

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

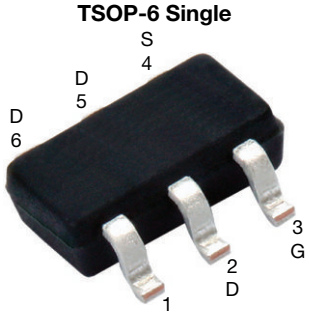
AUTOMOTIVE GRADE

Pb-free

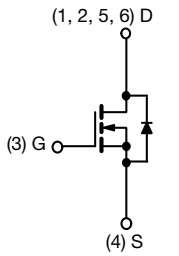
RoHS COMPLIANT

HALOGEN FREE

**TSOP-6 Single**




Top View




N-Channel MOSFET

**Marking Code**: 8P

| ABSOLUTE MAXIMUM RATINGS ($T_C$ = 25 °C, unless otherwise noted) | | | | |
|---|---|---|---|---|
| **PARAMETER** | | **SYMBOL** | **LIMIT** | **UNIT** |
| Drain-Source Voltage | | $V_{DS}$ | 40 | V |
| Gate-Source Voltage | | $V_{GS}$ | ± 20 | |
| Continuous Drain Current | $T_C$ = 25 °C [a] | $I_D$ | 8 | A |
| | $T_C$ = 125 °C | | 5 | |
| Continuous Source Current (Diode Conduction) | | $I_S$ | 6 | |
| Pulsed Drain Current [b] | | $I_{DM}$ | 32 | |
| Single Pulse Avalanche Current | L = 0.1 mH | $I_{AS}$ | 13.5 | |
| Single Pulse Avalanche Energy | | $E_{AS}$ | 9.1 | mJ |
| Maximum Power Dissipation [b] | $T_C$ = 25 °C | $P_D$ | 5 | W |
| | $T_C$ = 125 °C | | 1.6 | |
| Operating Junction and Storage Temperature Range | | $T_J$, $T_{stg}$ | -55 to +175 | °C |

| THERMAL RESISTANCE RATINGS | | | | |
|---|---|---|---|---|
| **PARAMETER** | | **SYMBOL** | **LIMIT** | **UNIT** |
| Junction-to-Ambient | PCB Mount [c] | $R_{thJA}$ | 110 | °C/W |
| Junction-to-Foot (Drain) | | $R_{thJF}$ | 30 | |

**Notes**

a. Package limited.
b. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %.
c. When mounted on 1" square PCB (FR4 material).
d. Parametric verification ongoing.



For technical questions, contact: automos.techsupport@vishay.com

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| **SPECIFICATIONS** ($T_C$ = 25 °C, unless otherwise noted) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **Static** | | | | | | | |
| Drain-Source Breakdown Voltage | $V_{DS}$ | $V_{GS}$ = 0, $I_D$ = 250 µA | | 40 | - | - | V |
| Gate-Source Threshold Voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | | 1.5 | 2.0 | 2.5 | |
| Gate-Source Leakage | $I_{GSS}$ | $V_{DS}$ = 0 V, $V_{GS}$ = ± 20 V | | - | - | ± 100 | nA |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{GS}$ = 0 V | $V_{DS}$ = 40 V | - | - | 1 | µA |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = 40 V, $T_J$ = 125 °C | - | - | 50 | |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = 40 V, $T_J$ = 175 °C | - | - | 150 | |
| On-State Drain Current [a] | $I_{D(on)}$ | $V_{GS}$ = 10 V | $V_{DS}$ ≥ 5 V | 10 | - | - | A |
| Drain-Source On-State Resistance [a] | $R_{DS(on)}$ | $V_{GS}$ = 10 V | $I_D$ = 5 A | - | 0.026 | 0.032 | Ω |
| | | $V_{GS}$ = 10 V | $I_D$ = 5 A, $T_J$ = 125 °C | - | - | 0.050 | |
| | | $V_{GS}$ = 10 V | $I_D$ = 5 A, $T_J$ = 175 °C | - | - | 0.061 | |
| | | $V_{GS}$ = 4.5 V | $I_D$ = 4 A | - | 0.032 | 0.042 | |
| Forward Transconductance [b] | $g_{fs}$ | $V_{DS}$ = 15 V, $I_D$ = 4 A | | - | 21 | - | S |
| **Dynamic [b]** | | | | | | | |
| Input Capacitance | $C_{iss}$ | $V_{GS}$ = 0 V | $V_{DS}$ = 20 V, f = 1 MHz | - | 452 | 678 | pF |
| Output Capacitance | $C_{oss}$ | | | - | 81 | 121 | |
| Reverse Transfer Capacitance | $C_{rss}$ | | | - | 36 | 53 | |
| Total Gate Charge [c] | $Q_g$ | $V_{GS}$ = 10 V | $V_{DS}$ = 20 V, $I_D$ = 4 A | - | 8.5 | 12.7 | nC |
| Gate-Source Charge [c] | $Q_{gs}$ | | | - | 1.1 | - | |
| Gate-Drain Charge [c] | $Q_{gd}$ | | | - | 2.0 | - | |
| Gate Resistance | $R_g$ | f = 1 MHz | | 1.0 | 2.0 | 3.0 | Ω |
| Turn-On Delay Time [c] | $t_{d(on)}$ | $V_{DD}$ = 20 V, $R_L$ = 4 Ω<br>$I_D$ ≅ 5 A, $V_{GEN}$ = 10 V, $R_g$ = 1 Ω | | - | 6 | 8 | ns |
| Rise Time [c] | $t_r$ | | | - | 28 | 37 | |
| Turn-Off Delay Time [c] | $t_{d(off)}$ | | | - | 12 | 16 | |
| Fall Time [c] | $t_f$ | | | - | 37 | 50 | |
| **Source-Drain Diode Ratings and Characteristics [b]** ($T_C$ = 25 °C) | | | | | | | |
| Pulsed Current [a] | $I_{SM}$ | | | - | - | 32 | A |
| Forward Voltage | $V_{SD}$ | $I_F$ = 3 A, $V_{GS}$ = 0 | | - | 0.8 | 1.2 | V |

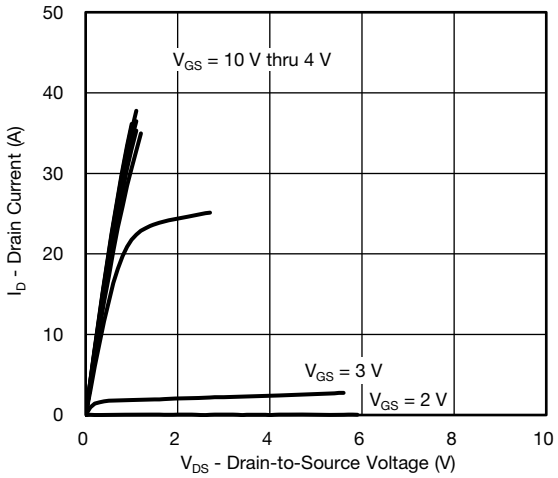
**Notes**

a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %.
b. Guaranteed by design, not subject to production testing.
c. Independent of operating temperature.

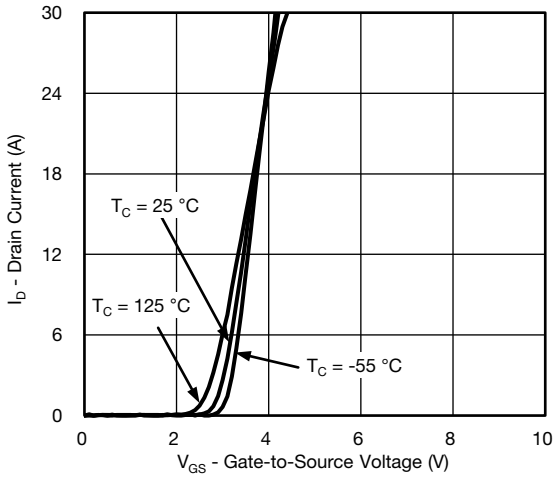
*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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


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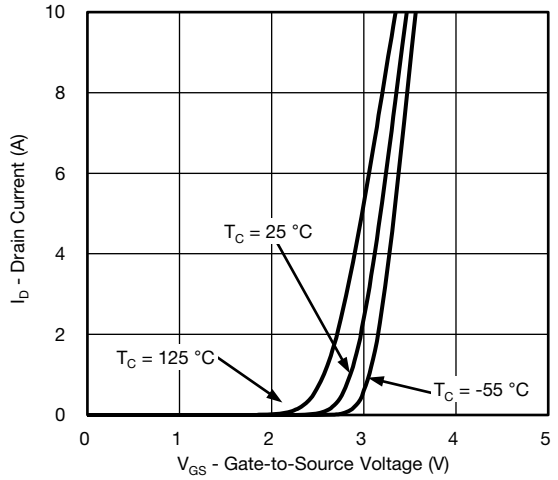
## TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



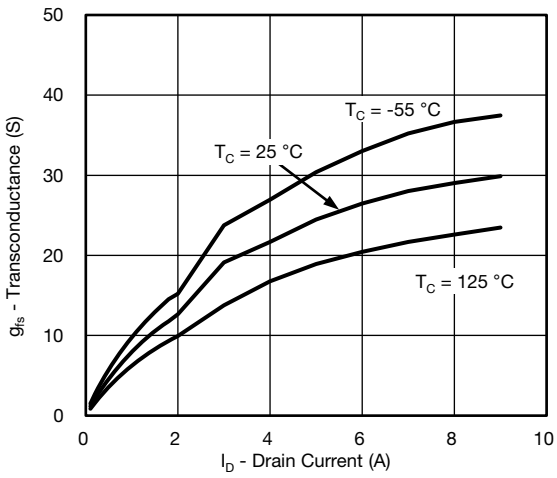

**Output Characteristics**



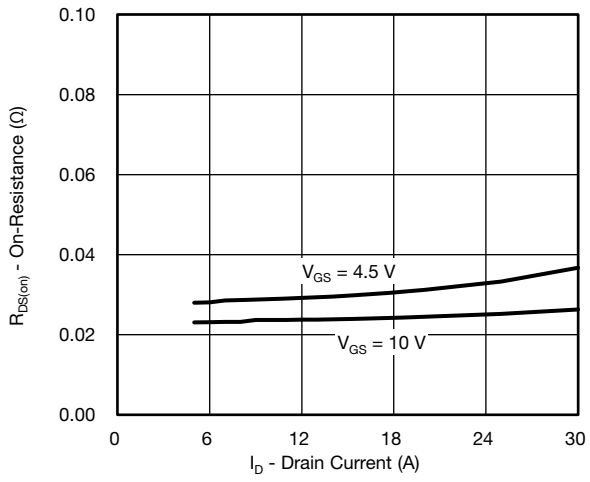

**Transfer Characteristics**



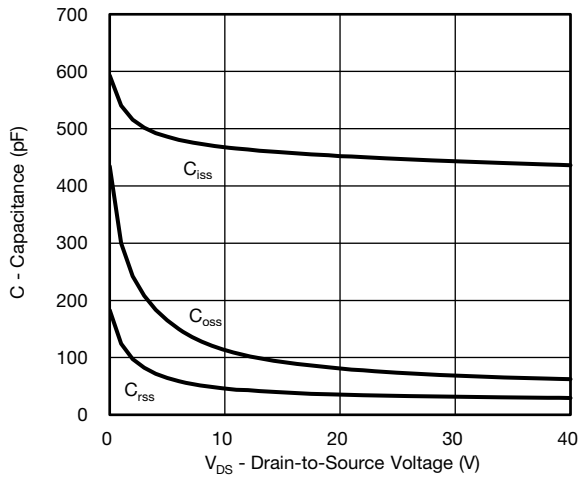

**Transfer Characteristics**




**Transconductance**



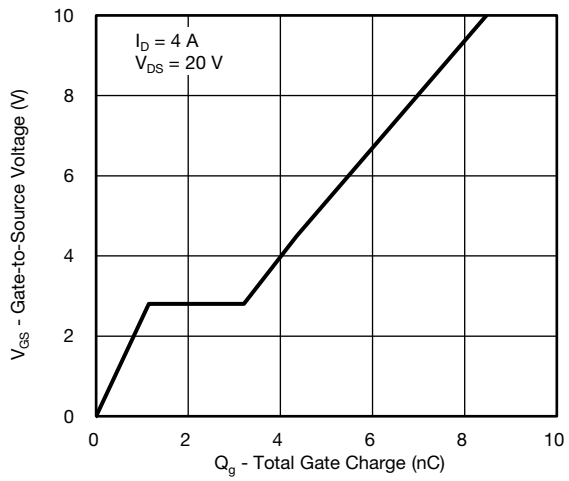

**On-Resistance vs. Drain Current**



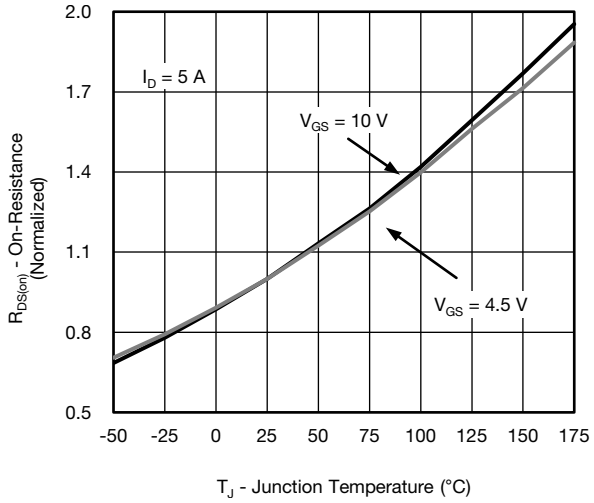

**Capacitance**


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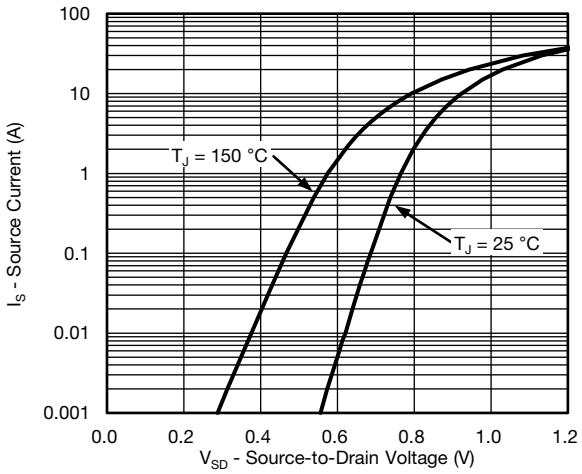
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



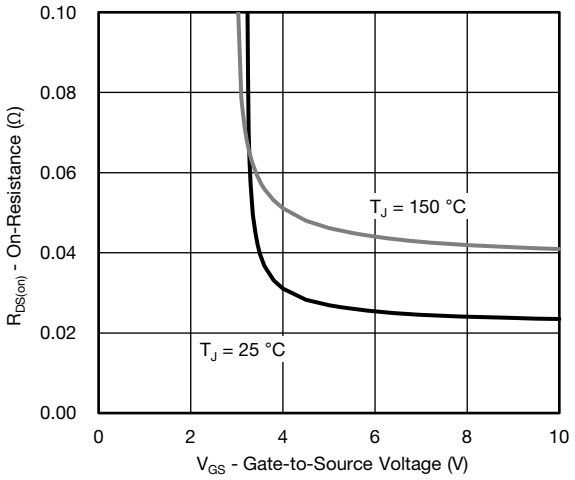

**Gate Charge**



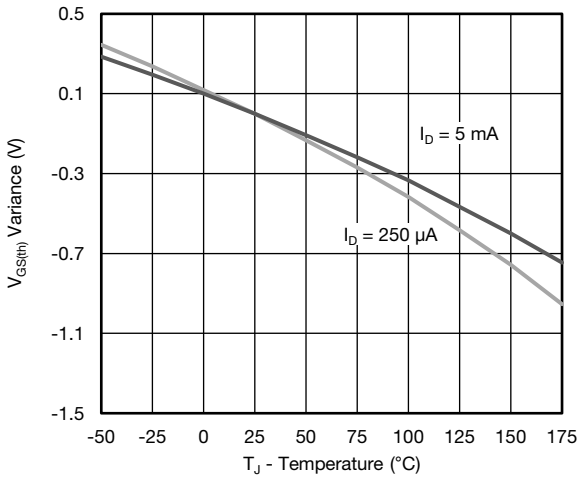

**On-Resistance vs. Junction Temperature**



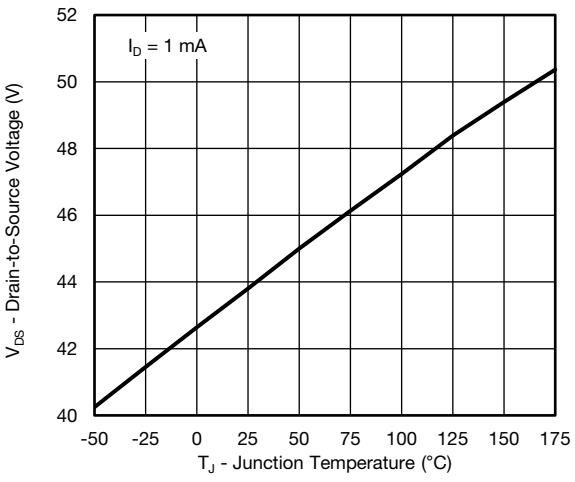

**Source Drain Diode Forward Voltage**




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



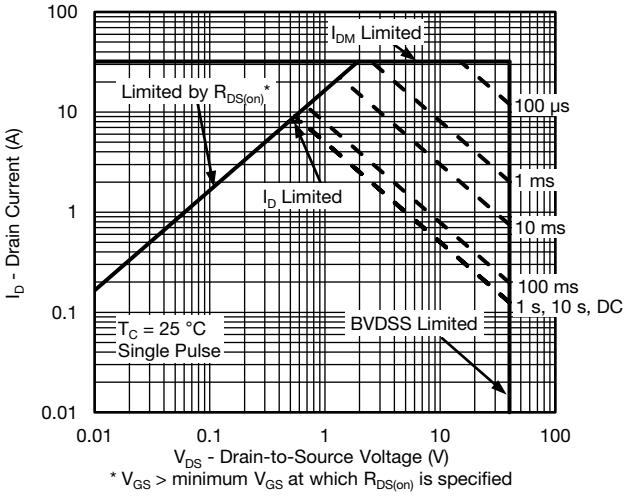

**Threshold Voltage**



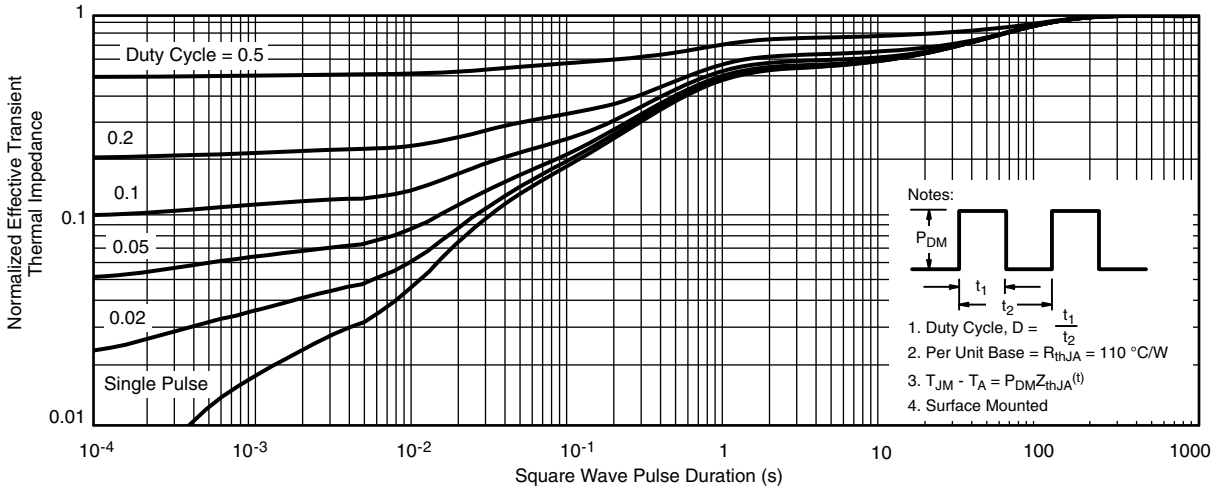

**Drain Source Breakdown vs. Junction Temperature**


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**THERMAL RATINGS** ($T_A$ = 25 °C, unless otherwise noted)



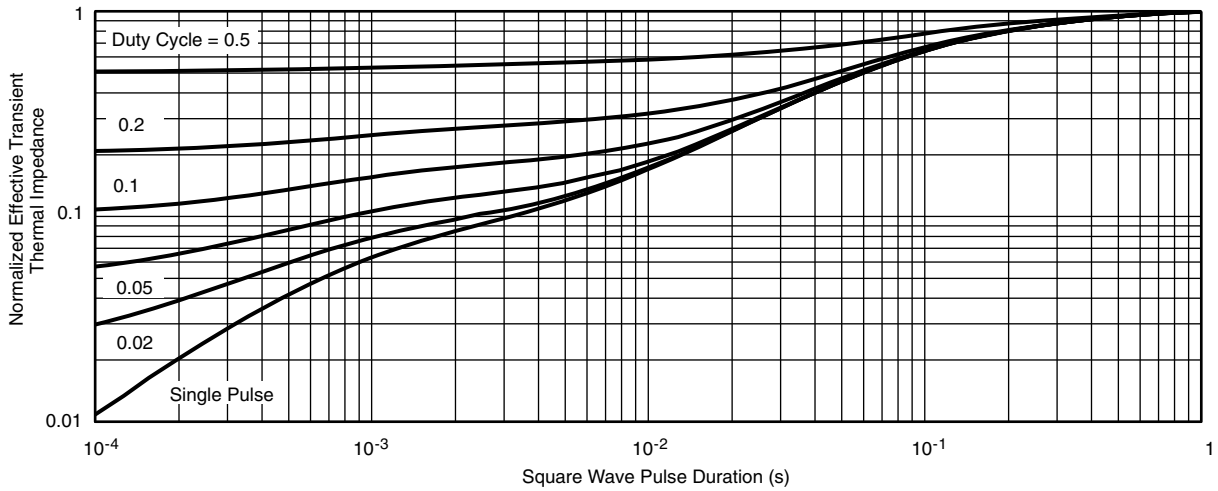

**Safe Operating Area**




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


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**THERMAL RATINGS** ($T_A$ = 25 °C, unless otherwise noted)




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

**Note**

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

*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?63412.*


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# TSOP-6

Ordering codes for the SQ rugged series power MOSFETs in the TSOP-6 package:

| DATASHEET PART NUMBER | OLD ORDERING CODE [a] | NEW ORDERING CODE |
|---|---|---|
| SQ3410EV | SQ3410EV-T1-GE3 | **SQ3410EV-T1_GE3** |
| SQ3418EV | - | **SQ3418EV-T1_GE3** |
| SQ3419AEEV | - | **SQ3419AEEV-T1_GE3** |
| SQ3419EV | - | **SQ3419EV-T1_GE3** |
| SQ3426AEEV | - | **SQ3426AEEV-T1_GE3** |
| SQ3426EV | - | **SQ3426EV-T1_GE3** |
| SQ3427AEEV | - | **SQ3427AEEV-T1_GE3** |
| SQ3427EV | - | **SQ3427EV-T1_GE3** |
| SQ3456BEV | SQ3456BEV-T1-GE3 | **SQ3456BEV-T1_GE3** |
| SQ3457EV | SQ3457EV-T1-GE3 | **SQ3457EV-T1_GE3** |
| SQ3460EV | SQ3460EV-T1-GE3 | **SQ3460EV-T1_GE3** |
| SQ3461EV | - | **SQ3461EV-T1_GE3** |
| SQ3469EV | SQ3469EV-T1-GE3 | **SQ3469EV-T1_GE3** |
| SQ3481EV | SQ3481EV-T1-GE3 | **SQ3481EV-T1_GE3** |
| SQ3985EV | - | **SQ3985EV-T1_GE3** |

**Note**

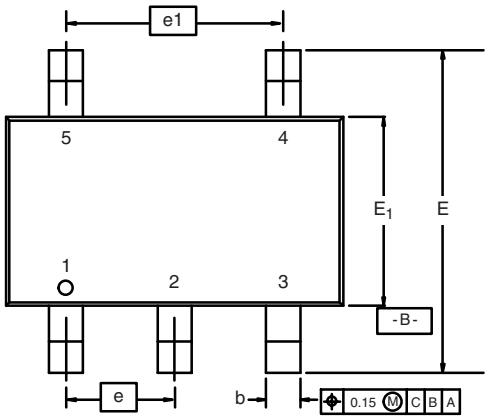
a. Old ordering code is obsolete and no longer valid for new orders



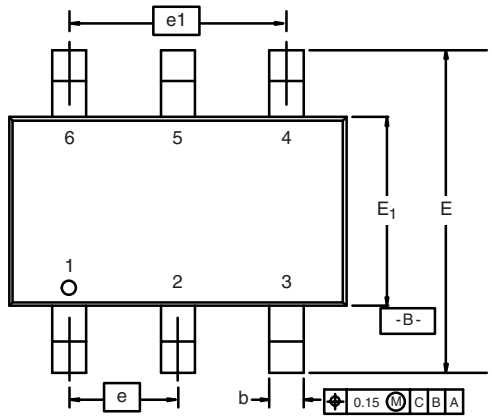
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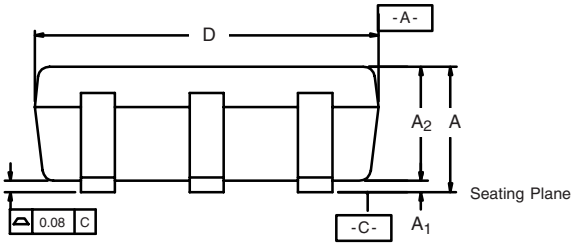
**TSOP: 5/6–LEAD**
**JEDEC Part Number: MO-193C**

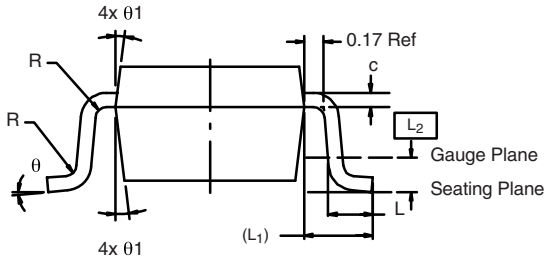



**5-LEAD TSOP**




**6-LEAD TSOP**




| Dim | MILLIMETERS | | | INCHES | | |
|---|---|---|---|---|---|---|
| | Min | Nom | Max | Min | Nom | Max |
| **A** | 0.91 | - | 1.10 | 0.036 | - | 0.043 |
| **$A_1$** | 0.01 | - | 0.10 | 0.0004 | - | 0.004 |
| **$A_2$** | 0.90 | - | 1.00 | 0.035 | 0.038 | 0.039 |
| **b** | 0.30 | 0.32 | 0.45 | 0.012 | 0.013 | 0.018 |
| **c** | 0.10 | 0.15 | 0.20 | 0.004 | 0.006 | 0.008 |
| **D** | 2.95 | 3.05 | 3.10 | 0.116 | 0.120 | 0.122 |
| **E** | 2.70 | 2.85 | 2.98 | 0.106 | 0.112 | 0.117 |
| **$E_1$** | 1.55 | 1.65 | 1.70 | 0.061 | 0.065 | 0.067 |
| **e** | 0.95 BSC | | | 0.0374 BSC | | |
| **$e_1$** | 1.80 | 1.90 | 2.00 | 0.071 | 0.075 | 0.079 |
| **L** | 0.32 | - | 0.50 | 0.012 | - | 0.020 |
| **$L_1$** | 0.60 Ref | | | 0.024 Ref | | |
| **$L_2$** | 0.25 BSC | | | 0.010 BSC | | |
| **R** | 0.10 | - | - | 0.004 | - | - |
| **θ** | 0° | 4° | 8° | 0° | 4° | 8° |
| **$\theta_1$** | 7° Nom | | | 7° Nom | | |
| ECN: C-06593-Rev. I, 18-Dec-06<br>DWG: 5540 | | | | | | |

# Mounting LITTLE FOOT® TSOP-6 Power MOSFETs

Surface mounted power MOSFET packaging has been based on integrated circuit and small signal packages. Those packages have been modified to provide the improvements in heat transfer required by power MOSFETs. Leadframe materials and design, molding compounds, and die attach materials have been changed. What has remained the same is the footprint of the packages.

The basis of the pad design for surface mounted power MOSFET is the basic footprint for the package. For the TSOP-6 package outline drawing see http://www.vishay.com/doc?71200 and see http://www.vishay.com/doc?72610 for the minimum pad footprint. In converting the footprint to the pad set for a power MOSFET, you must remember that not only do you want to make electrical connection to the package, but you must made thermal connection and provide a means to draw heat from the package, and move it away from the package.

In the case of the TSOP-6 package, the electrical connections are very simple. Pins 1, 2, 5, and 6 are the drain of the MOSFET and are connected together. For a small signal device or integrated circuit, typical connections would be made with traces that are 0.020 inches wide. Since the drain pins serve the additional function of providing the thermal connection to the package, this level of connection is inadequate. The total cross section of the copper may be adequate to carry the current required for the application, but it presents a large thermal impedance. Also, heat spreads in a circular fashion from the heat source. In this case the drain pins are the heat sources when looking at heat spread on the PC board.

Figure 1 shows the copper spreading recommended footprint for the TSOP-6 package. This pattern shows the starting point for utilizing the board area available for the heat spreading copper. To create this pattern, a plane of copper overlays the basic pattern on pins 1,2,5, and 6. The copper plane connects the drain pins electrically, but more importantly provides planar copper to draw heat from the drain leads and start the process of spreading the heat so it can be dissipated into the ambient air. Notice that the planar copper is shaped like a “T” to move heat away from the drain leads in all directions. This pattern uses all the available area underneath the body for this purpose.

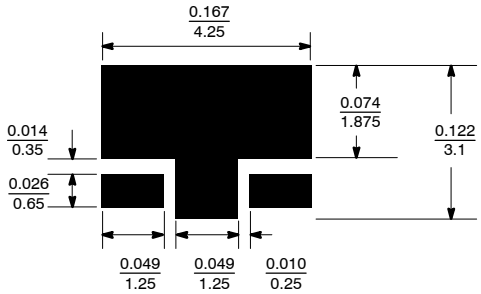


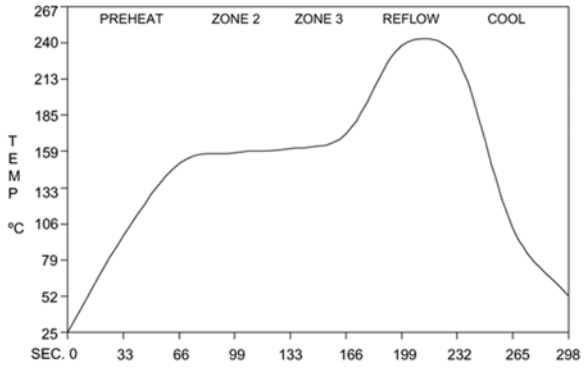

**FIGURE 1.** Recommended Copper Spreading Footprint

Since surface mounted packages are small, and reflow soldering is the most common form of soldering for surface mount components, “thermal” connections from the planar copper to the pads have not been used. Even if additional planar copper area is used, there should be no problems in the soldering process. The actual solder connections are defined by the solder mask openings. By combining the basic footprint with the copper plane on the drain pins, the solder mask generation occurs automatically.

A final item to keep in mind is the width of the power traces. The absolute minimum power trace width must be determined by the amount of current it has to carry. For thermal reasons, this minimum width should be at least 0.020 inches. The use of wide traces connected to the drain plane provides a low impedance path for heat to move away from the device.

## REFLOW SOLDERING

Vishay Siliconix surface-mount packages meet solder reflow reliability requirements. Devices are subjected to solder reflow as a test preconditioning and are then reliability-tested using temperature cycle, bias humidity, HAST, or pressure pot. The solder reflow temperature profile used, and the temperatures and time duration, are shown in Figures 2 and 3.




| | |
|---|---|
| Ramp-Up Rate | +6°C/Second Maximum |
| Temperature @ 155 ± 15°C | 120 Seconds Maximum |
| Temperature Above 180°C | 70 – 180 Seconds |
| Maximum Temperature | 240 +5/–0°C |
| Time at Maximum Temperature | 20 – 40 Seconds |
| Ramp-Down Rate | +6°C/Second Maximum |

**FIGURE 2.** Solder Reflow Temperature Profile

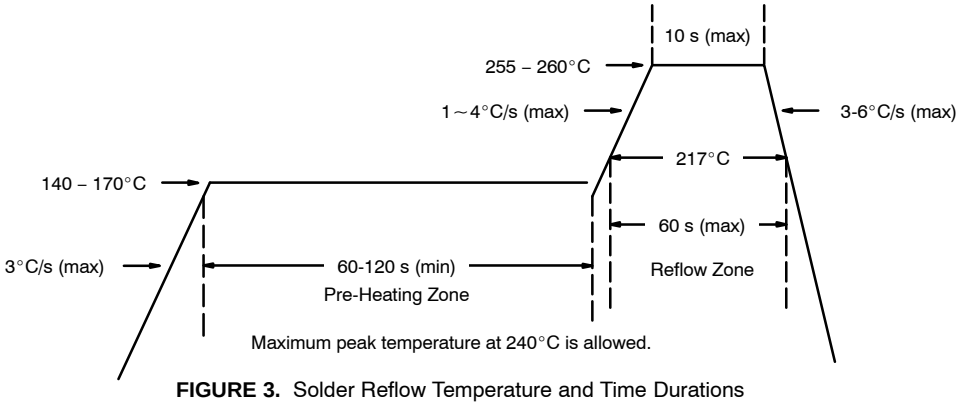



**FIGURE 3.** Solder Reflow Temperature and Time Durations

## THERMAL PERFORMANCE

A basic measure of a device's thermal performance is the junction-to-case thermal resistance, $R\theta_{jc}$, or the junction-to-foot thermal resistance, $R\theta_{jf}$. This parameter is measured for the device mounted to an infinite heat sink and is therefore a characterization of the device only, in other words, independent of the properties of the object to which the device is mounted. Table 1 shows the thermal performance of the TSOP-6.

**TABLE 1.**

| Equivalent Steady State Performance—TSOP-6 | |
|---|---|
| Thermal Resistance $R\theta_{jf}$ | 30°C/W |

## SYSTEM AND ELECTRICAL IMPACT OF TSOP-6

In any design, one must take into account the change in MOSFET $r_{DS(on)}$ with temperature (Figure 4).

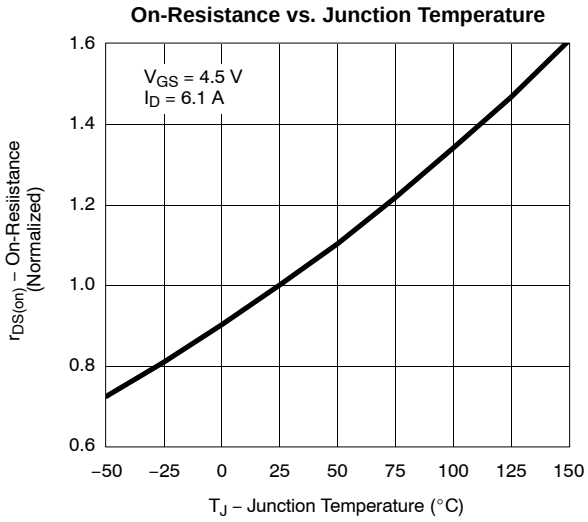
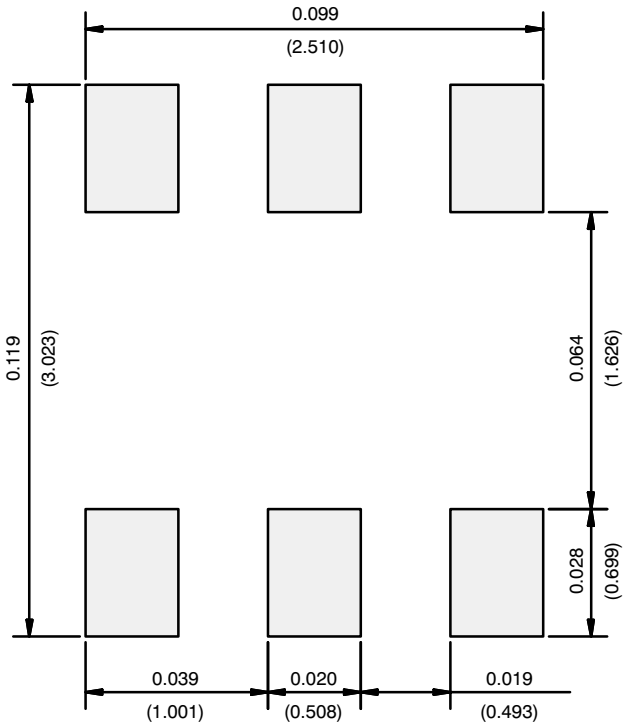



**FIGURE 4.** Si3434DV

## RECOMMENDED MINIMUM PADS FOR TSOP-6




Recommended Minimum Pads
Dimensions in Inches/(mm)

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