

FW356-TL-E-VB Datasheet

N- and P-Channel 60-V (D-S) MOSFET

| PRODUCT SUMMARY | | | | |
|-----------------|---------------------|------------------------------------|---------------------------------|-----------------------|
| | V _{DS} (V) | R _{DS(on)} (Ω) | I _D (A) ^a | Q _g (Typ.) |
| N-Channel | 60 | 0.026 at V _{GS} = 10 V | 5.3 | 6 nC |
| | | 0.029 at V _{GS} = 4.5 V | 4.7 | |
| P-Channel | - 60 | 0.055 at V _{GS} = - 10 V | - 4.9 | 8 nC |
| | | 0.060 at V _{GS} = - 4.5 V | - 4.5 | |

FEATURES

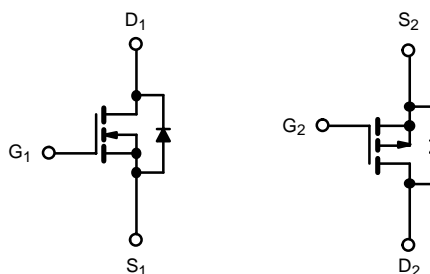
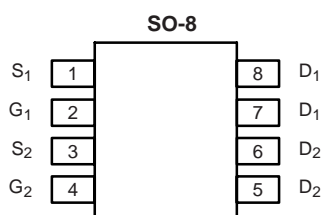
- Halogen-free According to IEC 61249-2-21 Available
- TrenchFET[®] Power MOSFET
- 100 % R_g and UIS Tested

APPLICATIONS

- CCFL Inverter



RoHS
COMPLIANT
HALOGEN
FREE
Available



N-Channel MOSFET

P-Channel MOSFET

| ABSOLUTE MAXIMUM RATINGS T _A = 25 °C, unless otherwise noted | | | | |
|---|-----------------------------------|---------------------|-----------------------|------|
| Parameter | Symbol | N-Channel | P-Channel | Unit |
| Drain-Source Voltage | V _{DS} | 60 | - 60 | V |
| Gate-Source Voltage | V _{GS} | ± 20 | | |
| Continuous Drain Current (T _J = 150 °C) | T _C = 25 °C | 5.3 | - 4.9 | A |
| | T _C = 70 °C | 4.3 | - 4.2 | |
| | T _A = 25 °C | 4.3 ^{b, c} | - 4.0 ^{b, c} | |
| | T _A = 70 °C | 3.4 ^{b, c} | - 3.4 ^{b, c} | |
| Pulsed Drain Current (10 μs Pulse Width) | I _{DM} | 20 | - 25 | A |
| Source Drain Current Diode Current | T _C = 25 °C | 2.6 | - 2.8 | |
| | T _A = 25 °C | 1.7 ^{b, c} | - 1.7 ^{b, c} | |
| Pulsed Source-Drain Current | I _{SM} | 20 | - 25 | A |
| Single Pulse Avalanche Current | I _{AS} | 11 | 15 | |
| Single Pulse Avalanche Energy | E _{AS} | 6.1 | 11 | mJ |
| Maximum Power Dissipation | T _C = 25 °C | 3.1 | 3.4 | W |
| | T _C = 70 °C | 2 | 2.2 | |
| | T _A = 25 °C | 2 ^{b, c} | 2 ^{b, c} | |
| | T _A = 70 °C | 1.3 ^{b, c} | 1.3 ^{b, c} | |
| Operating Junction and Storage Temperature Range | T _J , T _{stg} | - 55 to 150 | | °C |

| THERMAL RESISTANCE RATINGS | | | | | | | |
|---|--------------|-------------------|------|-----------|------|------|------|
| Parameter | Symbol | N-Channel | | P-Channel | | Unit | |
| | | Typ. | Max. | Typ. | Max. | | |
| Maximum Junction-to-Ambient ^{b, d} | t ≤ 10 s | R _{thJA} | 55 | 62.5 | 53 | 62.5 | °C/W |
| Maximum Junction-to-Foot (Drain) | Steady State | R _{thJF} | 33 | 40 | 30 | 37 | |

Notes:

a. Based on T_C = 25 °C.

b. Surface Mounted on 1" x 1" FR4 board.

c. t = 10 s.

d. Maximum under Steady State conditions is 110 °C/W for N-Channel and P-Channel.

| SPECIFICATIONS $T_J = 25\text{ }^\circ\text{C}$, unless otherwise noted | | | | | | | | |
|---|-------------------------|---|---|------|-------------------|------|---------------|----------|
| Parameter | Symbol | Test Conditions | | Min. | Typ. ^a | Max. | Unit | |
| Static | | | | | | | | |
| Drain-Source Breakdown Voltage | V_{DS} | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$ | N-Ch | 60 | | | V | |
| | | $V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$ | P-Ch | -60 | | | | |
| V_{DS} Temperature Coefficient | $\Delta V_{DS}/T_J$ | $I_D = 250\text{ }\mu\text{A}$ | N-Ch | | 55 | | mV | |
| | | $I_D = -250\text{ }\mu\text{A}$ | P-Ch | | -50 | | | |
| $V_{GS(th)}$ Temperature Coefficient | $\Delta V_{GS(th)}/T_J$ | $I_D = 250\text{ }\mu\text{A}$ | N-Ch | | -6 | | mV | |
| | | $I_D = -250\text{ }\mu\text{A}$ | P-Ch | | 4 | | | |
| Gate Threshold Voltage | $V_{GS(th)}$ | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$ | N-Ch | 1 | | 3 | V | |
| | | $V_{DS} = V_{GS}, I_D = -250\text{ }\mu\text{A}$ | P-Ch | -1 | | -3 | | |
| Gate-Body Leakage | I_{GSS} | $V_{DS} = 0\text{ V}, V_{GS} = \pm 20\text{ V}$ | N-Ch | | | 100 | nA | |
| | | | P-Ch | | | -100 | | |
| Zero Gate Voltage Drain Current | I_{DSS} | $V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}$ | N-Ch | | | 1 | μA | |
| | | | P-Ch | | | -1 | | |
| | | $V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}, T_J = 55\text{ }^\circ\text{C}$ | N-Ch | | | 10 | | |
| | | | P-Ch | | | -10 | | |
| On-State Drain Current ^b | $I_{D(on)}$ | $V_{DS} \geq 5\text{ V}, V_{GS} = 10\text{ V}$ | N-Ch | 20 | | | A | |
| | | $V_{DS} \leq -5\text{ V}, V_{GS} = -10\text{ V}$ | P-Ch | -25 | | | | |
| Drain-Source On-State Resistance ^b | $R_{DS(on)}$ | $V_{GS} = 10\text{ V}, I_D = 4.3\text{ A}$ | N-Ch | | 0.026 | | Ω | |
| | | $V_{GS} = -10\text{ V}, I_D = -3.1\text{ A}$ | P-Ch | | 0.055 | | | |
| | | $V_{GS} = 4.5\text{ V}, I_D = 3.9\text{ A}$ | N-Ch | | 0.029 | | | |
| | | $V_{GS} = -4.5\text{ V}, I_D = -0.2\text{ A}$ | P-Ch | | 0.060 | | | |
| Forward Transconductance ^b | g_{fs} | $V_{DS} = 15\text{ V}, I_D = 4.3\text{ A}$ | N-Ch | | 15 | | S | |
| | | $V_{DS} = -15\text{ V}, I_D = -3.1\text{ A}$ | P-Ch | | 8.5 | | | |
| Dynamic^a | | | | | | | | |
| Input Capacitance | C_{iss} | N-Channel $V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$ | N-Ch | | 665 | | μF | |
| | | | P-Ch | | 650 | | | |
| Output Capacitance | C_{oss} | | P-Channel $V_{DS} = -15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$ | N-Ch | | 75 | | |
| | | | | P-Ch | | 95 | | |
| Reverse Transfer Capacitance | C_{rss} | | | N-Ch | | 40 | | |
| | | | | P-Ch | | 60 | | |
| Total Gate Charge | Q_g | | $V_{DS} = 30\text{ V}, V_{GS} = 10\text{ V}, I_D = 4.3\text{ A}$ | N-Ch | | 13 | 20 | nC |
| | | | | P-Ch | | 14.5 | 22 | |
| | | $V_{DS} = 30\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 4.3\text{ A}$ | N-Ch | | 6 | 9 | | |
| | | | P-Ch | | 8 | 12 | | |
| Gate-Source Charge | Q_{gs} | $V_{DS} = 30\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 4.3\text{ A}$ | N-Ch | | 2.3 | | | |
| P-Ch | | | 2.2 | | | | | |
| Gate-Drain Charge | Q_{gd} | $V_{DS} = -30\text{ V}, V_{GS} = -4.5\text{ V}, I_D = -3.1\text{ A}$ | N-Ch | | 2.6 | | | |
| | | | P-Ch | | 3.7 | | | |
| Gate Resistance | R_g | | $f = 1\text{ MHz}$ | N-Ch | | 2 | 3 | Ω |
| | | | | P-Ch | | 14 | 20 | |

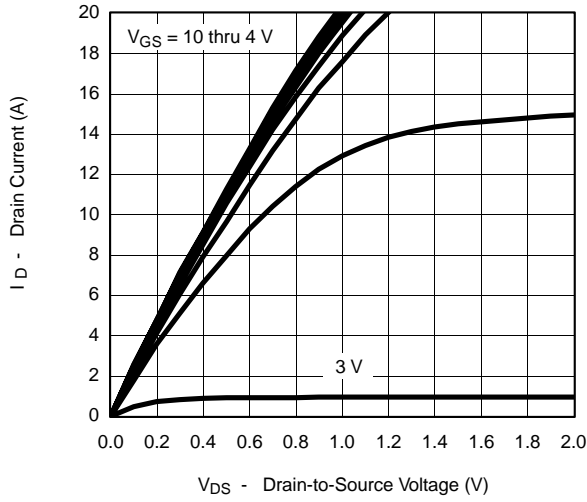
| SPECIFICATIONS $T_J = 25\text{ }^\circ\text{C}$, unless otherwise noted | | | | | | | | |
|---|--------------|--|---|------|-------------------|------|------|----|
| Parameter | Symbol | Test Conditions | | Min. | Typ. ^a | Max. | Unit | |
| Dynamic^a | | | | | | | | |
| Turn-On Delay Time | $t_{d(on)}$ | N-Channel $V_{DD} = 30\text{ V}$, $R_L = 8.8\ \Omega$ $I_D \cong 3.4\text{ A}$, $V_{GEN} = 4.5\text{ V}$, $R_g = 1\ \Omega$ | N-Ch | | 15 | 25 | ns | |
| Rise Time | t_r | | P-Ch | | 30 | 45 | | |
| Turn-Off Delay Time | $t_{d(off)}$ | P-Channel $V_{DD} = -30\text{ V}$, $R_L = 12.5\ \Omega$ $I_D \cong -2.4\text{ A}$, $V_{GEN} = -4.5\text{ V}$, $R_g = 1\ \Omega$ | N-Ch | | 65 | 100 | | |
| | | | P-Ch | | 70 | 105 | | |
| Fall Time | t_f | | N-Ch | | 15 | 25 | | |
| | | | P-Ch | | 40 | 60 | | |
| Turn-On Delay Time | $t_{d(on)}$ | | N-Channel $V_{DD} = 30\text{ V}$, $R_L = 8.8\ \Omega$ $I_D \cong 3.4\text{ A}$, $V_{GEN} = 10\text{ V}$, $R_g = 1\ \Omega$ | N-Ch | | 10 | | 15 |
| | | | | P-Ch | | 10 | | 15 |
| Rise Time | t_r | | | N-Ch | | 15 | | 25 |
| | | | | P-Ch | | 13 | | 20 |
| Turn-Off Delay Time | $t_{d(off)}$ | N-Ch | | | 20 | 30 | | |
| | | P-Ch | | | 35 | 55 | | |
| Fall Time | t_f | N-Ch | | | 10 | 15 | | |
| | | P-Ch | | | 30 | 45 | | |
| Drain-Source Body Diode Characteristics | | | | | | | | |
| Continuous Source-Drain Diode Current | I_S | $T_C = 25\text{ }^\circ\text{C}$ | N-Ch | | | 2.6 | A | |
| | | | P-Ch | | | -2.8 | | |
| Pulse Diode Forward Current ^a | I_{SM} | | N-Ch | | | 20 | A | |
| | | | P-Ch | | | -25 | | |
| Body Diode Voltage | V_{SD} | $I_S = 1.7\text{ A}$ | N-Ch | | 0.8 | 1.2 | V | |
| | | $I_S = -2\text{ A}$ | P-Ch | | -0.8 | -1.2 | | |
| Body Diode Reverse Recovery Time | t_{rr} | N-Channel $I_F = 1.7\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$, $T_J = 25\text{ }^\circ\text{C}$ | N-Ch | | 30 | 60 | ns | |
| | | | P-Ch | | 30 | 50 | | |
| Body Diode Reverse Recovery Charge | Q_{rr} | P-Channel $I_F = -2\text{ A}$, $di/dt = -100\text{ A}/\mu\text{s}$, $T_J = 25\text{ }^\circ\text{C}$ | N-Ch | | 32 | 50 | nC | |
| | | | P-Ch | | 35 | 60 | | |
| Reverse Recovery Fall Time | t_a | | N-Ch | | 25 | | ns | |
| | | | P-Ch | | 16 | | | |
| Reverse Recovery Rise Time | t_b | N-Ch | | 5 | | ns | | |
| | | P-Ch | | 14 | | | | |

Notes:

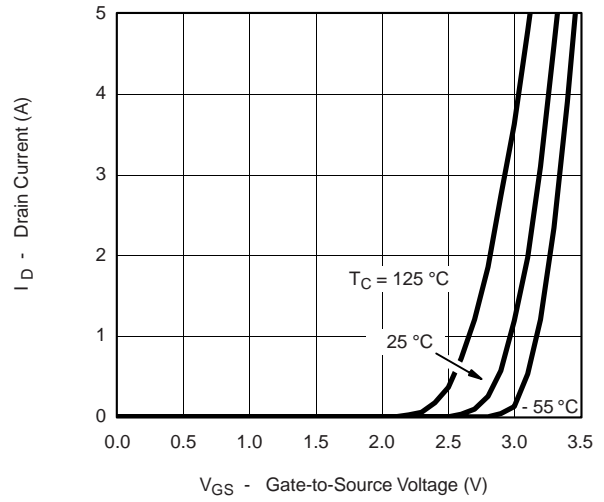
- a. Guaranteed by design, not subject to production testing.
 b. Pulse test; pulse width $\leq 300\ \mu\text{s}$, duty cycle $\leq 2\%$.

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 25 °C, unless otherwise noted



Output Characteristics



Transfer Characteristics



On-Resistance vs. Drain Current and Gate Voltage



Capacitance

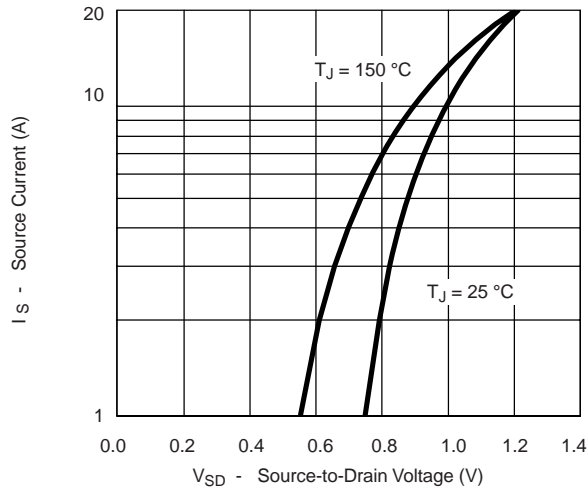


Gate Charge

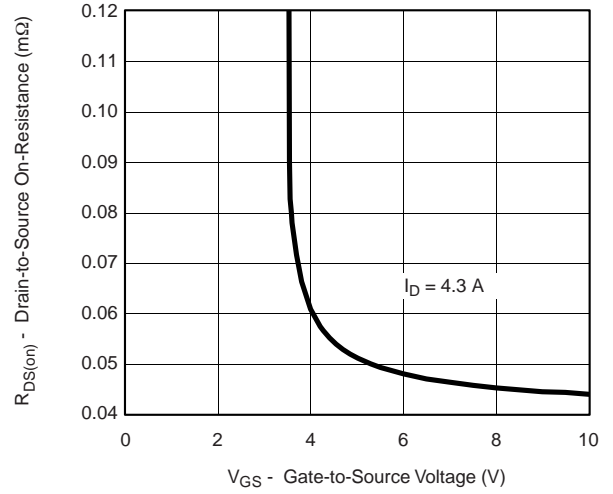


On-Resistance vs. Junction Temperature

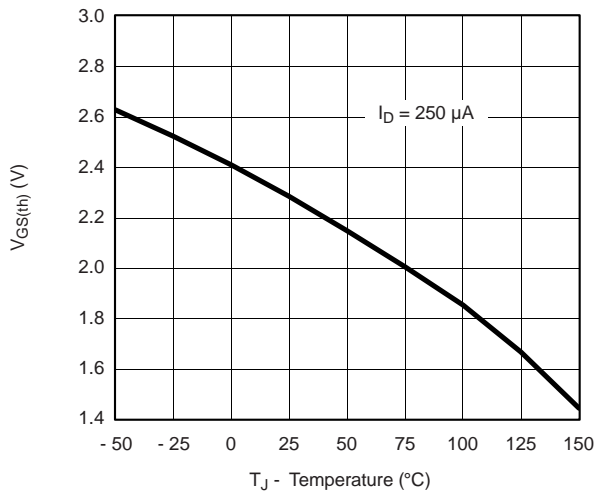
N-CHANNEL TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



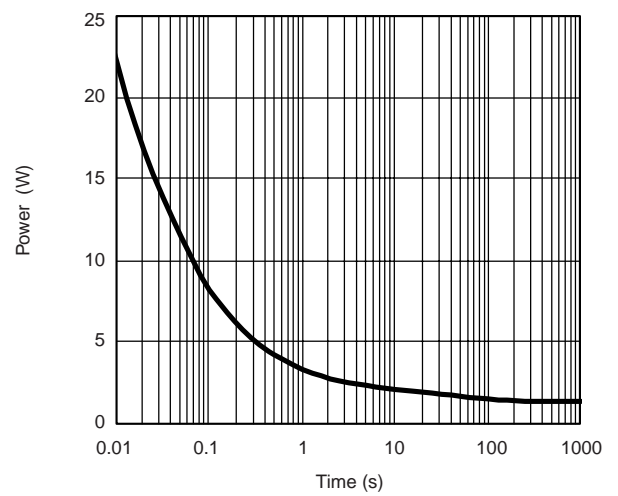
Source-Drain Diode Forward Voltage



On-Resistance vs. Gate-to-Source Voltage



Threshold Voltage



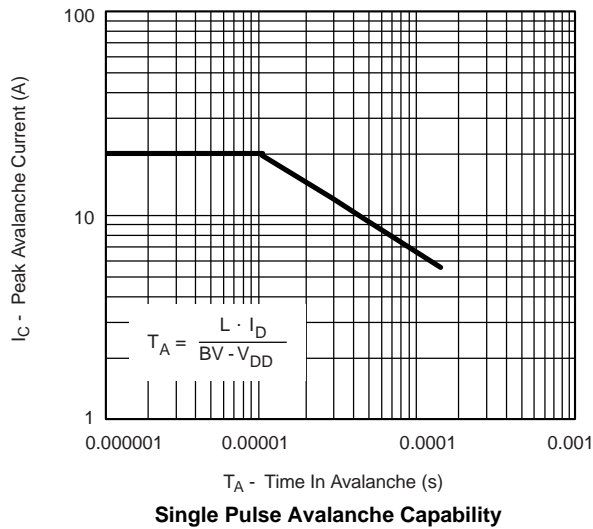
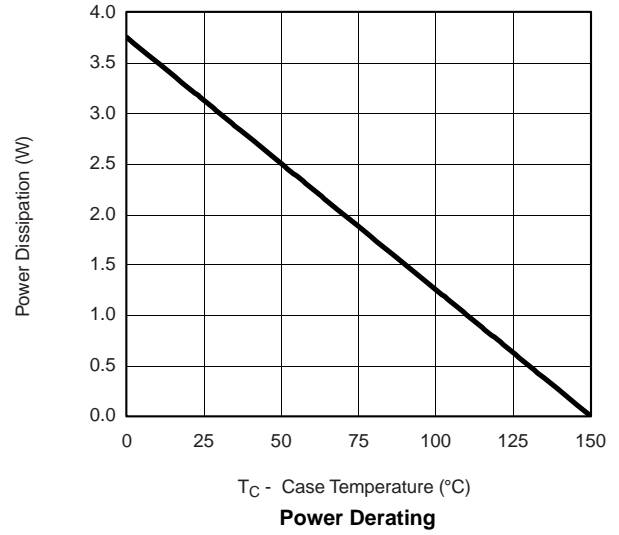
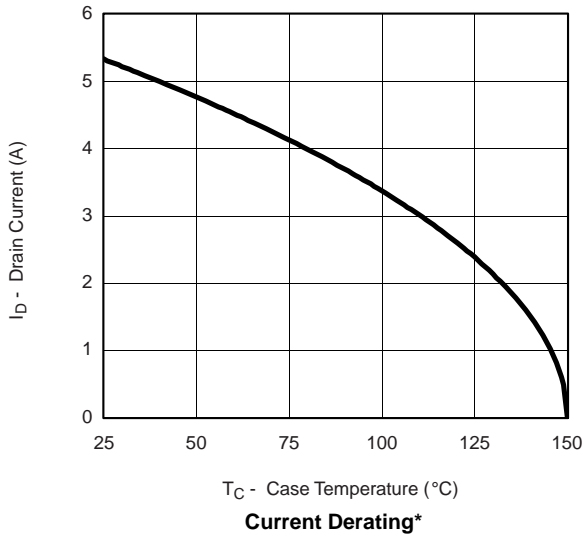
Single Pulse Power, Junction-to-Ambient



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

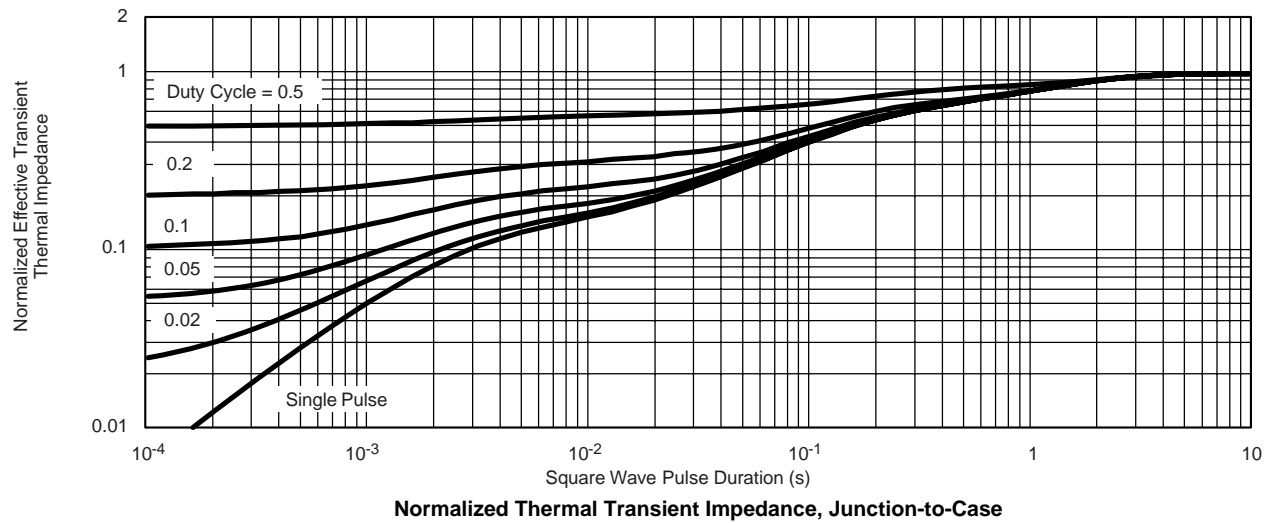
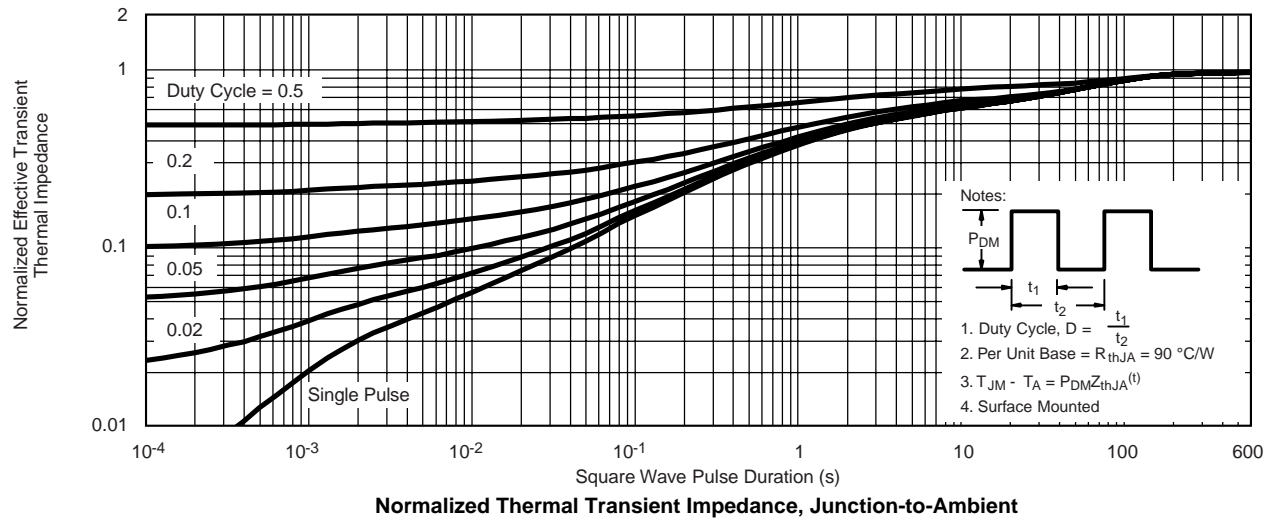
Safe Operating Area

N-CHANNEL TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



* The power dissipation P_D is based on $T_{J(max)} = 150$ °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below the package limit.

N-CHANNEL TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



P-CHANNEL TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



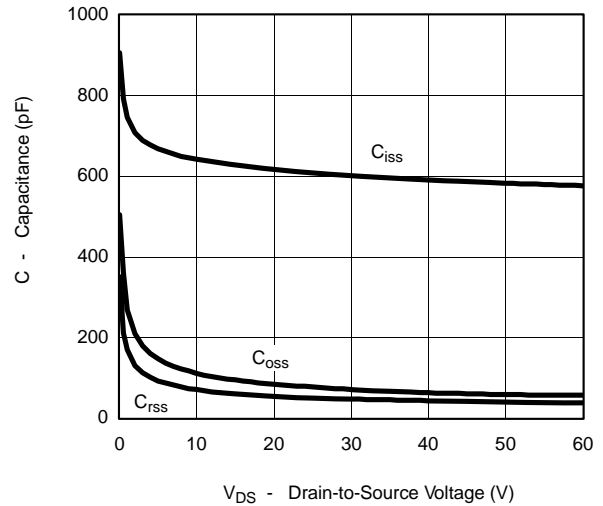
Output Characteristics



Transfer Characteristics



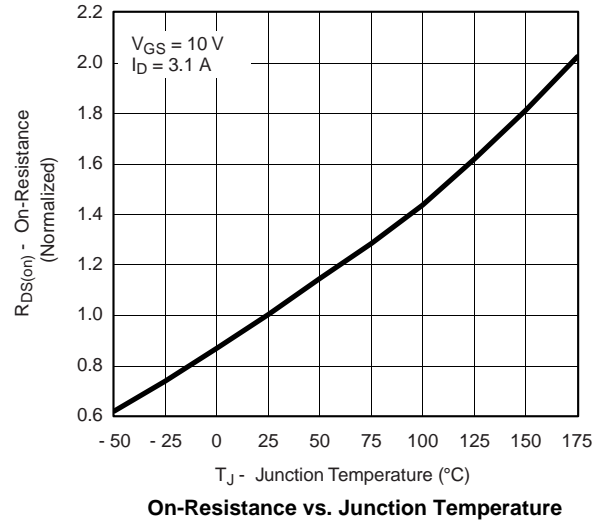
On-Resistance vs. Drain Current



Capacitance

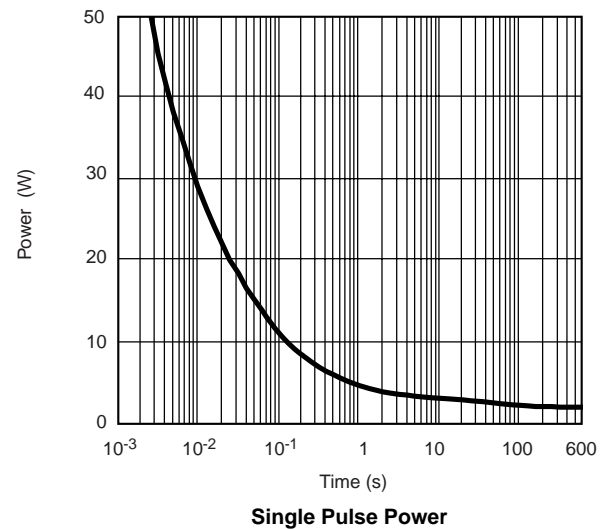
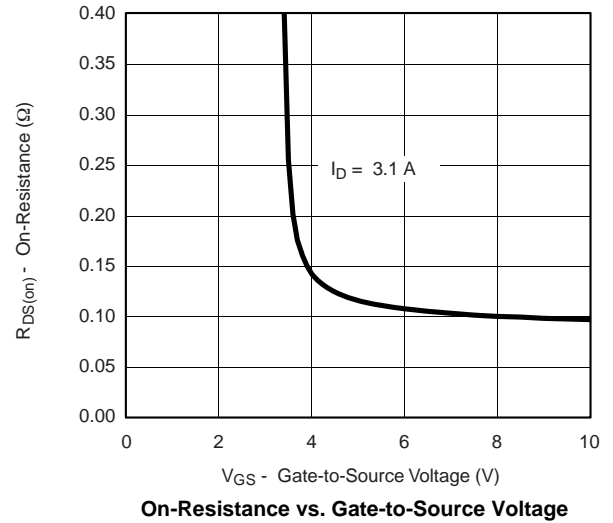


Gate Charge



On-Resistance vs. Junction Temperature

P-CHANNEL TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



P-CHANNEL TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



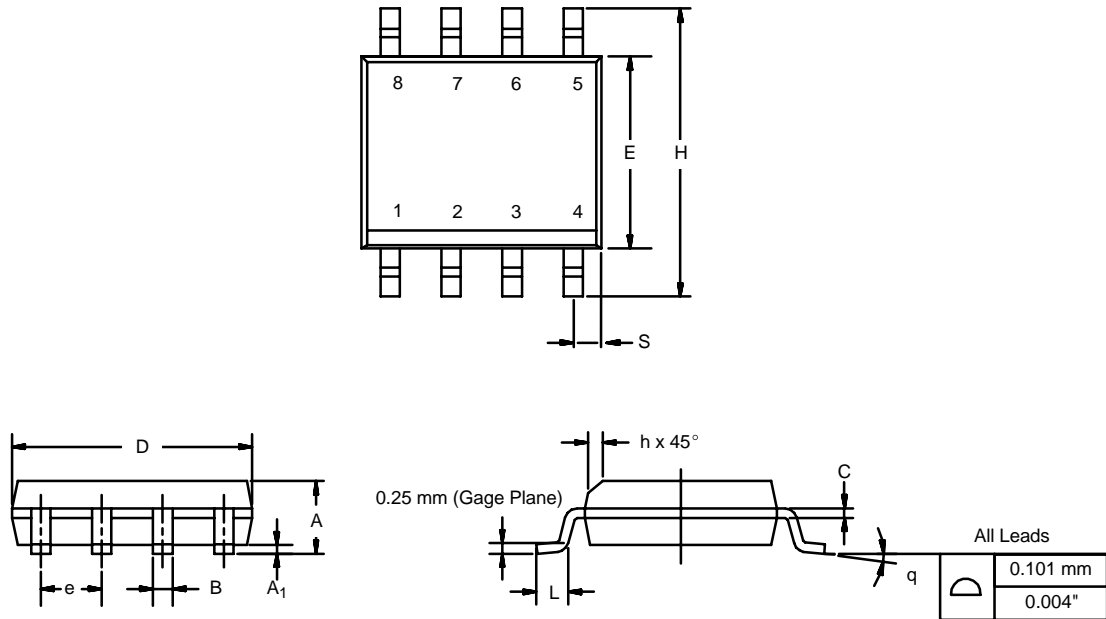
* The power dissipation P_D is based on $T_{J(max)} = 150$ °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below the package limit.

P-CHANNEL TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



SOIC (NARROW): 8-LEAD

JEDEC Part Number: MS-012



| DIM | MILLIMETERS | | INCHES | |
|--------------------------------|-------------|------|-----------|-------|
| | Min | Max | Min | Max |
| A | 1.35 | 1.75 | 0.053 | 0.069 |
| A ₁ | 0.10 | 0.20 | 0.004 | 0.008 |
| B | 0.35 | 0.51 | 0.014 | 0.020 |
| C | 0.19 | 0.25 | 0.0075 | 0.010 |
| D | 4.80 | 5.00 | 0.189 | 0.196 |
| E | 3.80 | 4.00 | 0.150 | 0.157 |
| e | 1.27 BSC | | 0.050 BSC | |
| H | 5.80 | 6.20 | 0.228 | 0.244 |
| h | 0.25 | 0.50 | 0.010 | 0.020 |
| L | 0.50 | 0.93 | 0.020 | 0.037 |
| q | 0° | 8° | 0° | 8° |
| S | 0.44 | 0.64 | 0.018 | 0.026 |
| ECN: C-06527-Rev. I, 11-Sep-06 | | | | |
| DWG: 5498 | | | | |

RECOMMENDED MINIMUM PADS FOR SO-8



Recommended Minimum Pads
Dimensions in Inches/(mm)

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