

## AP4578GM-VB Datasheet

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

#### PRODUCT SUMMARY

|           | V <sub>DS</sub> (V) | R <sub>DS(on)</sub> (Ω)            | I <sub>D</sub> (A) <sup>a</sup> | Q <sub>g</sub> (Typ.) |
|-----------|---------------------|------------------------------------|---------------------------------|-----------------------|
| N-Channel | 60                  | 0.026 at V <sub>GS</sub> = 10 V    | 5.3                             | 6 nC                  |
|           |                     | 0.029 at V <sub>GS</sub> = 4.5 V   | 4.7                             |                       |
| P-Channel | - 60                | 0.055 at V <sub>GS</sub> = - 10 V  | - 4.9                           | 8 nC                  |
|           |                     | 0.060 at V <sub>GS</sub> = - 4.5 V | - 4.5                           |                       |

#### FEATURES

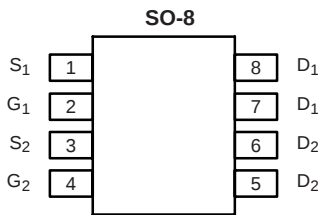
- Halogen-free According to IEC 61249-2-21 Available
- Trench Power MOSFET
- 100 % R<sub>g</sub> and UIS Tested

#### APPLICATIONS

- CCFL Inverter



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



#### ABSOLUTE MAXIMUM RATINGS T<sub>A</sub> = 25 °C, unless otherwise noted

| Parameter                                          |                        | Symbol                            | N-Channel           | P-Channel             | Unit |
|----------------------------------------------------|------------------------|-----------------------------------|---------------------|-----------------------|------|
| Drain-Source Voltage                               |                        | V <sub>DS</sub>                   | 60                  | - 60                  | V    |
| Gate-Source Voltage                                |                        | V <sub>GS</sub>                   | ± 20                |                       |      |
| Continuous Drain Current (T <sub>J</sub> = 150 °C) | T <sub>C</sub> = 25 °C | I <sub>D</sub>                    | 5.3                 | - 4.9                 | A    |
|                                                    | T <sub>C</sub> = 70 °C |                                   | 4.3                 | - 4.2                 |      |
|                                                    | T <sub>A</sub> = 25 °C |                                   | 4.3 <sup>b, c</sup> | - 4.0 <sup>b, c</sup> |      |
|                                                    | T <sub>A</sub> = 70 °C |                                   | 3.4 <sup>b, c</sup> | - 3.4 <sup>b, c</sup> |      |
| Pulsed Drain Current (10 μs Pulse Width)           |                        | I <sub>DM</sub>                   | 20                  | - 25                  |      |
| Source Drain Current Diode Current                 | T <sub>C</sub> = 25 °C | I <sub>S</sub>                    | 2.6                 | - 2.8                 |      |
|                                                    | T <sub>A</sub> = 25 °C |                                   | 1.7 <sup>b, c</sup> | - 1.7 <sup>b, c</sup> |      |
| Pulsed Source-Drain Current                        |                        | I <sub>SM</sub>                   | 20                  | - 25                  |      |
| Single Pulse Avalanche Current                     | L = 0.1 mH             | I <sub>AS</sub>                   | 11                  | 15                    | mJ   |
| Single Pulse Avalanche Energy                      |                        | E <sub>AS</sub>                   | 6.1                 | 11                    |      |
| Maximum Power Dissipation                          | T <sub>C</sub> = 25 °C | P <sub>D</sub>                    | 3.1                 | 3.4                   | W    |
|                                                    | T <sub>C</sub> = 70 °C |                                   | 2                   | 2.2                   |      |
|                                                    | T <sub>A</sub> = 25 °C |                                   | 2 <sup>b, c</sup>   | 2 <sup>b, c</sup>     |      |
|                                                    | T <sub>A</sub> = 70 °C |                                   | 1.3 <sup>b, c</sup> | 1.3 <sup>b, c</sup>   |      |
| Operating Junction and Storage Temperature Range   |                        | T <sub>J</sub> , T <sub>stg</sub> | - 55 to 150         |                       | °C   |

#### THERMAL RESISTANCE RATINGS

| Parameter                                   | Symbol                            | N-Channel |      | P-Channel |      | Unit |
|---------------------------------------------|-----------------------------------|-----------|------|-----------|------|------|
|                                             |                                   | Typ.      | Max. | Typ.      | Max. |      |
| Maximum Junction-to-Ambient <sup>b, d</sup> | t ≤ 10 s<br>R <sub>thJA</sub>     | 55        | 62.5 | 53        | 62.5 | °C/W |
| Maximum Junction-to-Foot (Drain)            | Steady State<br>R <sub>thJF</sub> | 33        | 40   | 30        | 37   |      |

Notes:

a. Based on T<sub>C</sub> = 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 <sub>J</sub> = 25 °C, unless otherwise noted |                                      |                                                                                      |                                                                                            |                 |                   |              |      |   |            |
|---------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------|-------------------|--------------|------|---|------------|
| Parameter                                                     | Symbol                               | Test Conditions                                                                      |                                                                                            | Min.            | Typ. <sup>a</sup> | Max.         | Unit |   |            |
| Static                                                        |                                      |                                                                                      |                                                                                            |                 |                   |              |      |   |            |
| Drain-Source Breakdown Voltage                                | V <sub>DS</sub>                      | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA                                       | N-Ch                                                                                       | 60              |                   |              | V    |   |            |
|                                                               |                                      | V <sub>GS</sub> = 0 V, I <sub>D</sub> = - 250 μA                                     | P-Ch                                                                                       | - 60            |                   |              |      |   |            |
| V <sub>DS</sub> Temperature Coefficient                       | ΔV <sub>DS</sub> /T <sub>J</sub>     | I <sub>D</sub> = 250 μA                                                              | N-Ch                                                                                       |                 | 55                |              | mV   |   |            |
|                                                               |                                      | I <sub>D</sub> = - 250 μA                                                            | P-Ch                                                                                       |                 | - 50              |              |      |   |            |
| V <sub>GS(th)</sub> Temperature Coefficient                   | ΔV <sub>GS(th)</sub> /T <sub>J</sub> | I <sub>D</sub> = 250 μA                                                              | N-Ch                                                                                       |                 | - 6               |              |      |   |            |
|                                                               |                                      | I <sub>D</sub> = - 250 μA                                                            | P-Ch                                                                                       |                 | 4                 |              |      |   |            |
| Gate Threshold Voltage                                        | V <sub>GS(th)</sub>                  | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                          | N-Ch                                                                                       | 1               |                   | 3            | V    |   |            |
|                                                               |                                      | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = - 250 μA                        | P-Ch                                                                                       | - 1             |                   | - 3          |      |   |            |
| Gate-Body Leakage                                             | I <sub>GSS</sub>                     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 20 V                                      | N-Ch<br>P-Ch                                                                               |                 |                   | 100<br>- 100 | nA   |   |            |
| Zero Gate Voltage Drain Current                               | I <sub>DSS</sub>                     | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V                                        | N-Ch                                                                                       |                 |                   | 1            | μA   |   |            |
|                                                               |                                      | V <sub>DS</sub> = - 60 V, V <sub>GS</sub> = 0 V                                      | P-Ch                                                                                       |                 |                   | - 1          |      |   |            |
|                                                               |                                      | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 55 °C                | N-Ch                                                                                       |                 |                   | 10           |      |   |            |
|                                                               |                                      | V <sub>DS</sub> = - 60 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 55 °C              | P-Ch                                                                                       |                 |                   | - 10         |      |   |            |
| On-State Drain Current <sup>b</sup>                           | I <sub>D(on)</sub>                   | V <sub>DS</sub> ≥ 5 V, V <sub>GS</sub> = 10 V                                        | N-Ch                                                                                       | 20              |                   |              | A    |   |            |
|                                                               |                                      | V <sub>DS</sub> ≤ - 5 V, V <sub>GS</sub> = - 10 V                                    | P-Ch                                                                                       | - 25            |                   |              |      |   |            |
| Drain-Source On-State Resistance <sup>b</sup>                 | R <sub>DS(on)</sub>                  | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4.3 A                                       | N-Ch                                                                                       |                 | 0.026             |              | Ω    |   |            |
|                                                               |                                      | V <sub>GS</sub> = - 10 V, I <sub>D</sub> = - 3.1 A                                   | P-Ch                                                                                       |                 | 0.055             |              |      |   |            |
|                                                               |                                      | V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 3.9 A                                      | N-Ch                                                                                       |                 | 0.029             |              |      |   |            |
|                                                               |                                      | V <sub>GS</sub> = - 4.5 V, I <sub>D</sub> = - 0.2 A                                  | P-Ch                                                                                       |                 | 0.060             |              |      |   |            |
| Forward Transconductance <sup>b</sup>                         | g <sub>fs</sub>                      | V <sub>DS</sub> = 15 V, I <sub>D</sub> = 4.3 A                                       | N-Ch                                                                                       |                 | 15                |              | S    |   |            |
|                                                               |                                      | V <sub>DS</sub> = - 15 V, I <sub>D</sub> = - 3.1 A                                   | P-Ch                                                                                       |                 | 8.5               |              |      |   |            |
| Dynamic <sup>a</sup>                                          |                                      |                                                                                      |                                                                                            |                 |                   |              |      |   |            |
| Input Capacitance                                             | C <sub>iss</sub>                     | N-Channel<br>V <sub>DS</sub> = 15 V, V <sub>GS</sub> = 0 V, f = 1 MHz                | N-Ch<br>P-Ch                                                                               |                 | 665<br>650        |              | pF   |   |            |
| Output Capacitance                                            | C <sub>oss</sub>                     |                                                                                      | N-Ch<br>P-Ch                                                                               |                 | 75<br>95          |              |      |   |            |
| Reverse Transfer Capacitance                                  | C <sub>rss</sub>                     | P-Channel<br>V <sub>DS</sub> = - 15 V, V <sub>GS</sub> = 0 V, f = 1 MHz              | N-Ch<br>P-Ch                                                                               |                 | 40<br>60          |              |      |   |            |
|                                                               |                                      |                                                                                      |                                                                                            |                 |                   |              |      |   |            |
| Total Gate Charge                                             | Q <sub>g</sub>                       | V <sub>DS</sub> = 30 V, V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4.3 A               | N-Ch                                                                                       |                 | 13                | 20           | nC   |   |            |
|                                                               |                                      | V <sub>DS</sub> = - 30 V, V <sub>GS</sub> = - 10 V, I <sub>D</sub> = - 3.1 A         | P-Ch                                                                                       |                 | 14.5              | 22           |      |   |            |
| Gate-Source Charge                                            | Q <sub>gs</sub>                      | N-Channel<br>V <sub>DS</sub> = 30 V, V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 4.3 A | N-Ch<br>P-Ch                                                                               |                 | 6<br>8            | 9<br>12      |      |   |            |
|                                                               |                                      |                                                                                      | P-Channel<br>V <sub>DS</sub> = - 30 V, V <sub>GS</sub> = - 4.5 V, I <sub>D</sub> = - 3.1 A | N-Ch<br>P-Ch    |                   | 2.3<br>2.2   |      |   |            |
|                                                               |                                      | Gate-Drain Charge                                                                    |                                                                                            | Q <sub>gd</sub> |                   | N-Ch<br>P-Ch |      |   | 2.6<br>3.7 |
|                                                               |                                      |                                                                                      |                                                                                            |                 |                   |              |      |   |            |
| Gate Resistance                                               | R <sub>g</sub>                       | f = 1 MHz                                                                            | N-Ch<br>P-Ch                                                                               |                 | 2<br>14           | 3<br>20      |      | Ω |            |

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

Notes:

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

b. Pulse test; pulse width  $\leq 300\text{ }\mu\text{s}$ , 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



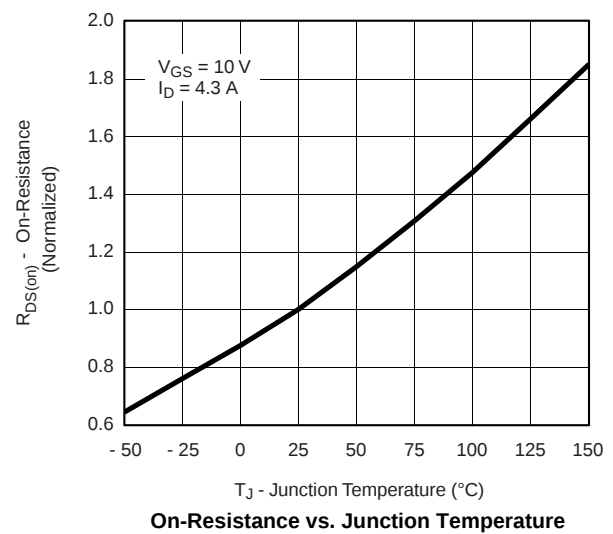
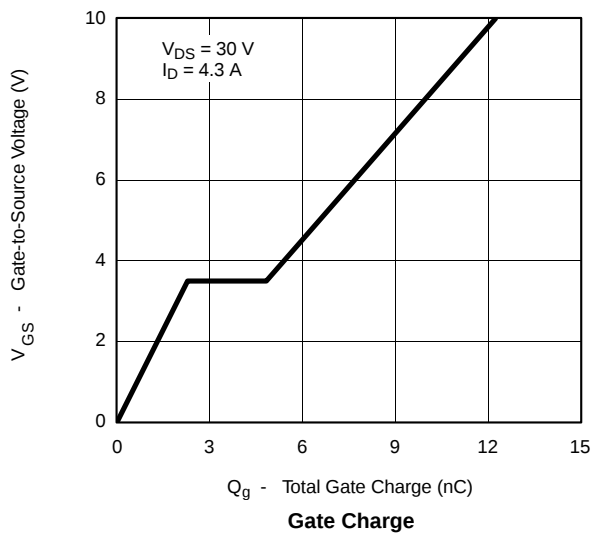
Transfer Characteristics



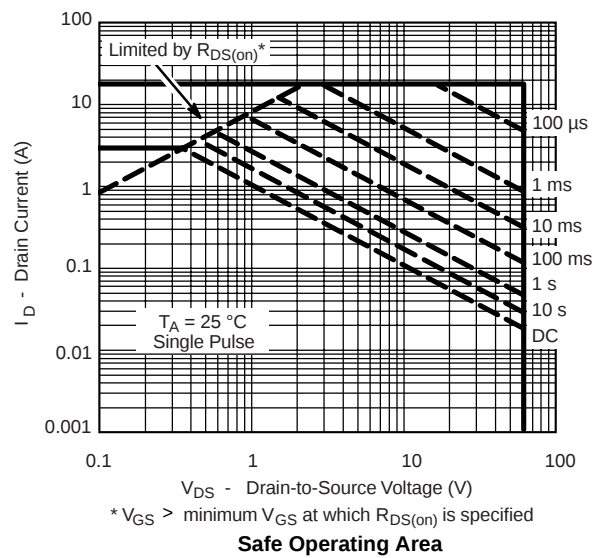
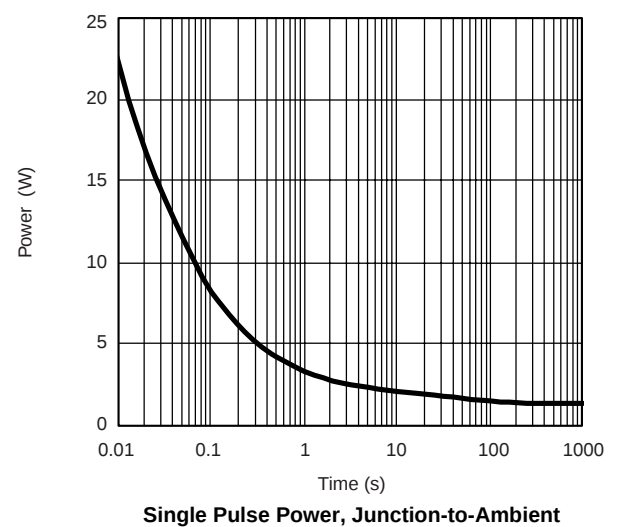
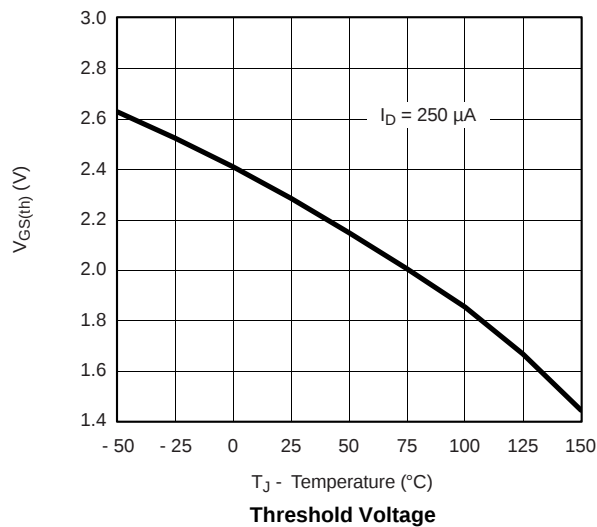
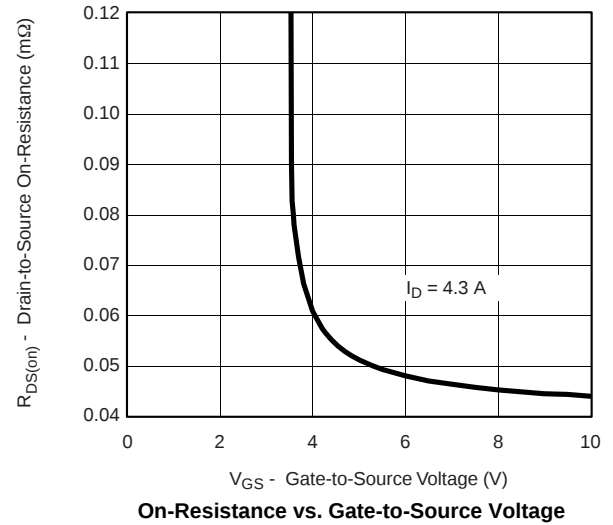
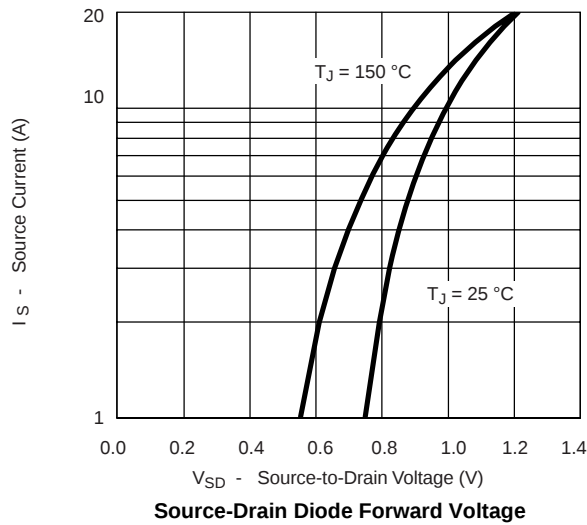
On-Resistance vs. Drain Current and Gate Voltage



Capacitance



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



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

 $T_C$  - Case Temperature (°C)

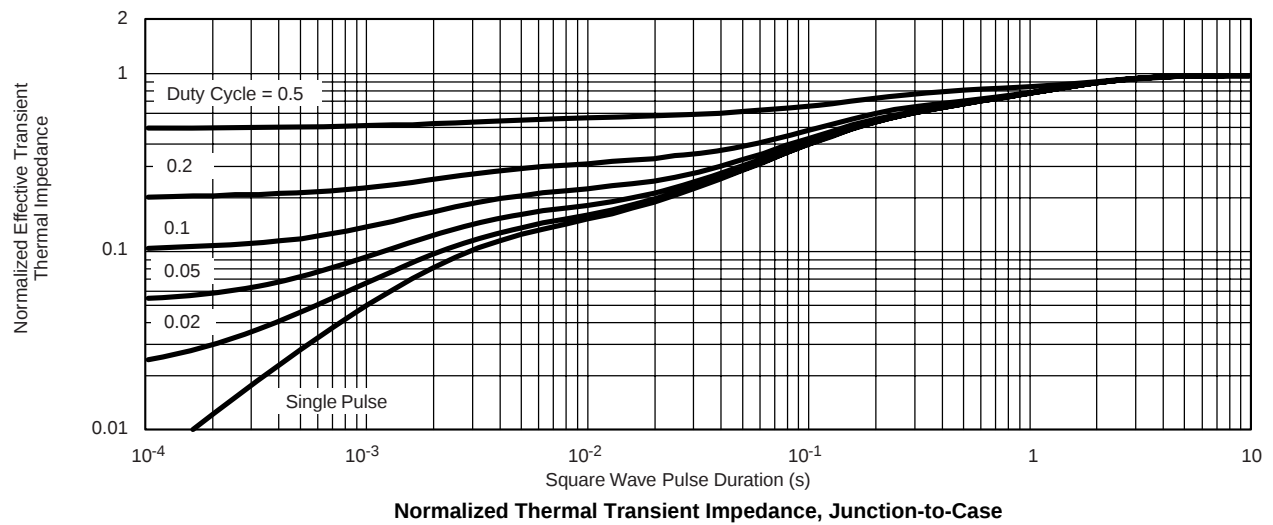
**Current Derating\***

 $T_C$  - Case Temperature (°C)

**Power Derating**

**Single Pulse Avalanche Capability**

\* 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**

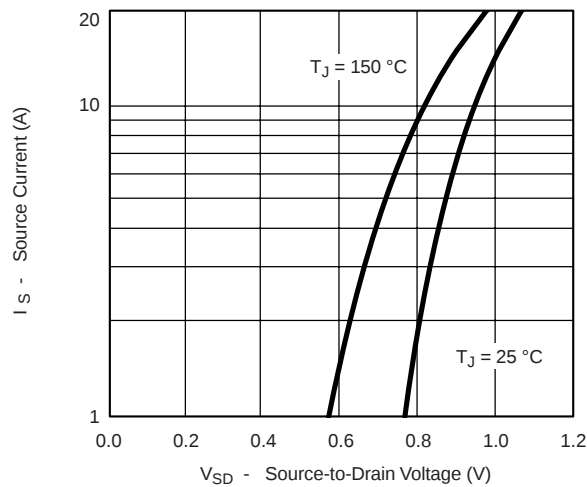


**Gate Charge**

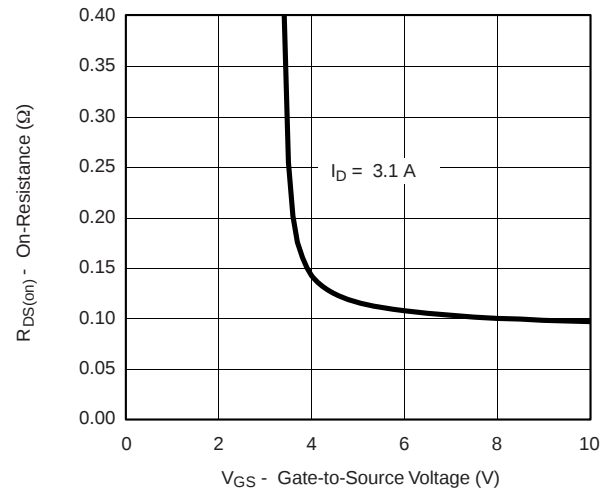


**On-Resistance vs. Junction Temperature**

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



Source-Drain Diode Forward Voltage



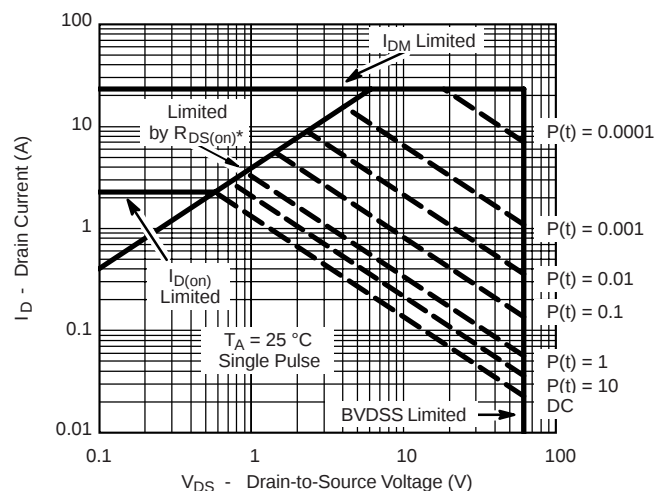
On-Resistance vs. Gate-to-Source Voltage



Threshold Voltage

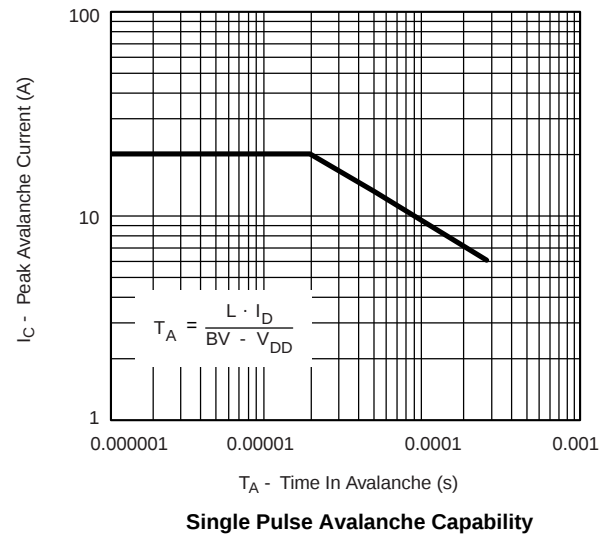
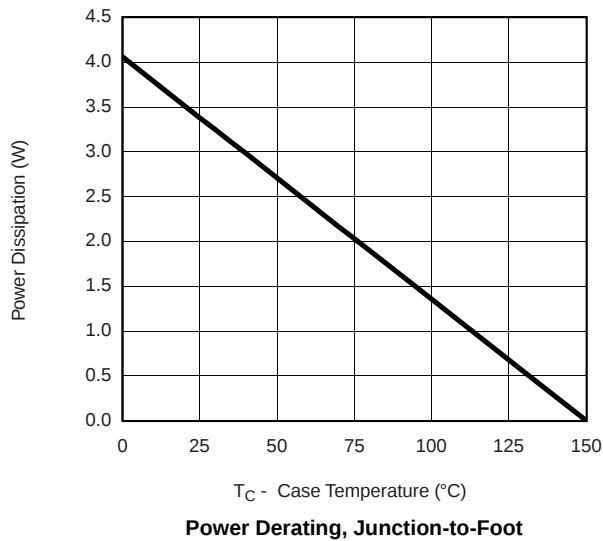
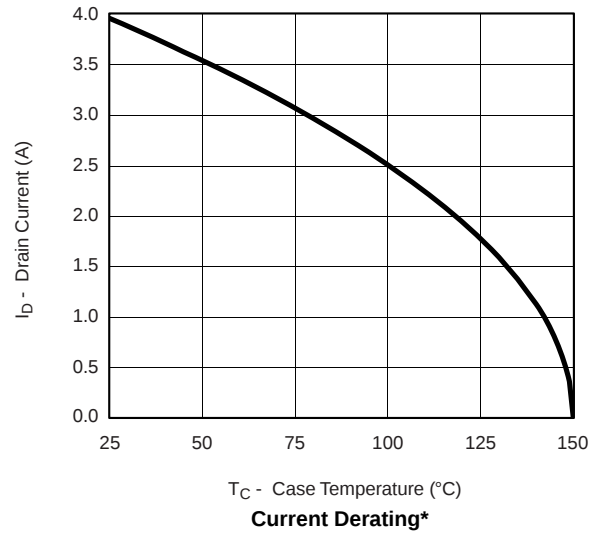


Single Pulse Power

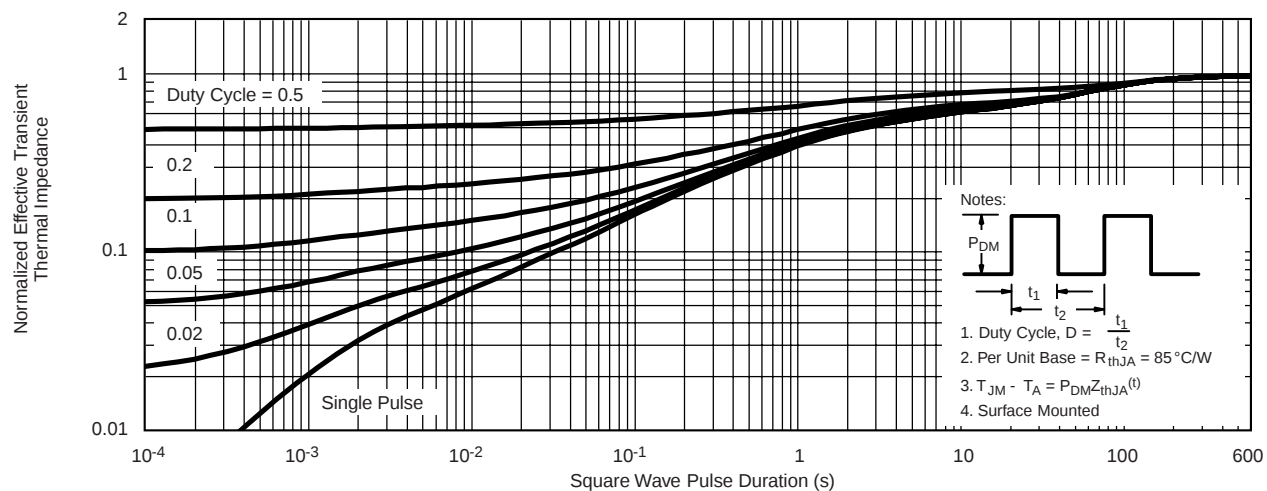
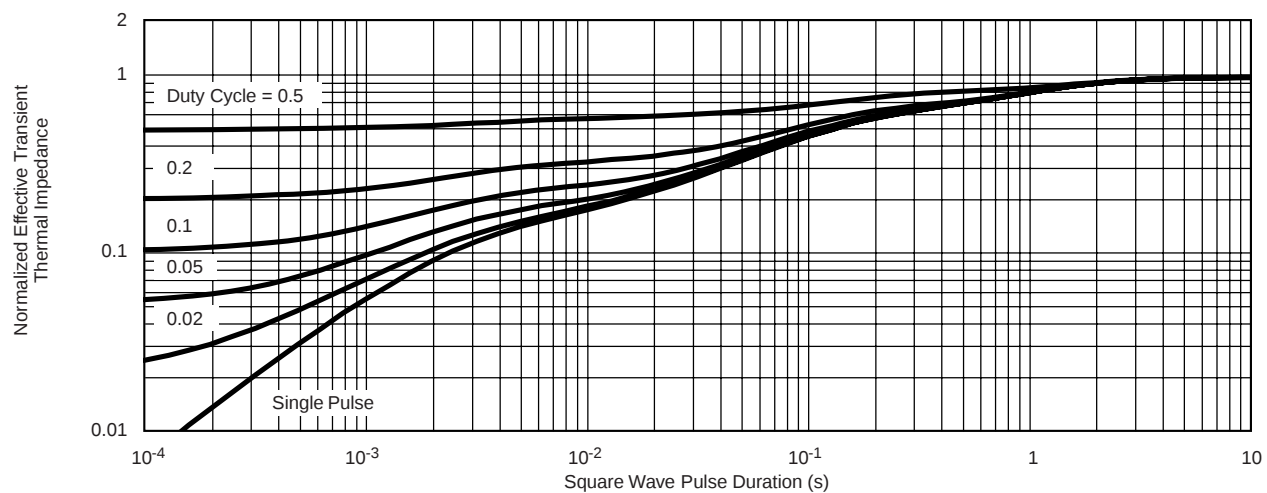


\*  $V_{GS} > \text{minimum } V_{GS} \text{ at which } R_{DS(on)} \text{ is specified}$

Safe Operating Area, Junction-to-Case

**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

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

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

**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 <sub>1</sub>                 | 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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