

# APM9934KC-TRL-VB Datasheet

## N- and P-Channel 30 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 | 30                  | 0.011 at V <sub>GS</sub> = 10 V    | 11                              | 13.3                  |
|           |                     | 0.013 at V <sub>GS</sub> = 4.5 V   | 10                              |                       |
| P-Channel | - 30                | 0.021 at V <sub>GS</sub> = - 10 V  | -10.5                           | 13                    |
|           |                     | 0.028 at V <sub>GS</sub> = - 4.5 V | - 9.5                           |                       |

### FEATURES

- Halogen-free According to IEC 61249-2-21 Definition
- Trench Power MOSFET
- 100 % R<sup>9</sup> and UIS Tested
- Compliant to RoHS Directive 2002/95/EC



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

### APPLICATIONS

- Motor Drive



### 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>                   | 30                   | - 30                  | V    |
| Gate-Source Voltage                                | V <sub>GS</sub>                   | ± 20                 | ± 20                  |      |
| Continuous Drain Current (T <sub>J</sub> = 150 °C) | I <sub>D</sub>                    | 11                   | - 10.5                | A    |
|                                                    |                                   | 9.8                  | - 8.8                 |      |
|                                                    |                                   | 8.8 <sup>b, c</sup>  | - 7.6 <sup>b, c</sup> |      |
|                                                    |                                   | 7.4 <sup>b, c</sup>  | - 6.3 <sup>b, c</sup> |      |
| Pulsed Drain Current (10 μs Pulse Width)           | I <sub>DM</sub>                   | 60                   | - 60                  |      |
| Source-Drain Current Diode Current                 | I <sub>S</sub>                    | 3.6                  | - 3.6                 |      |
|                                                    |                                   | 1.6 <sup>b, c</sup>  | - 1.6 <sup>b, c</sup> |      |
| Pulsed Source-Drain Current                        | I <sub>SM</sub>                   | 60                   | - 60                  | mJ   |
| Single Pulse Avalanche Current                     | I <sub>AS</sub>                   | 20                   | - 20                  |      |
| Single Pulse Avalanche Energy                      | E <sub>AS</sub>                   | 5                    | 20                    | W    |
| Maximum Power Dissipation                          | P <sub>D</sub>                    | 6.1                  | 5.2                   |      |
|                                                    |                                   | 3                    | 3.1                   |      |
|                                                    |                                   | 3 <sup>b, c</sup>    | 3 <sup>b, c</sup>     |      |
|                                                    |                                   | 2.28 <sup>b, c</sup> | 2.28 <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> | R <sub>thJA</sub> | 20        | 32.5 | 27        | 32.5 | °C/W |
| Maximum Junction-to-Foot (Drain)            | R <sub>thJF</sub> | 10        | 20   | 19        | 28   |      |

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 120 °C/W (n-channel) and 110 °C/W (p-channel).

e. Package limited.

| 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            | 30    |                   |       | V     |  |
|                                                                 |                                      | V <sub>GS</sub> = 0 V, I <sub>D</sub> = - 250 μA                                                                                                                                                                                                                                                                                                                               | P-Ch            | - 30  |                   |       |       |  |
| V <sub>DS</sub> Temperature Coefficient                         | ΔV <sub>DS</sub> /T <sub>J</sub>     | I <sub>D</sub> = 250 μA                                                                                                                                                                                                                                                                                                                                                        | N-Ch            |       | 30                |       | mV/°C |  |
|                                                                 |                                      | I <sub>D</sub> = - 250 μA                                                                                                                                                                                                                                                                                                                                                      | P-Ch            |       | - 24              |       |       |  |
| V <sub>GS(th)</sub> Temperature Coefficient                     | ΔV <sub>GS(th)</sub> /T <sub>J</sub> | I <sub>D</sub> = 250 μA                                                                                                                                                                                                                                                                                                                                                        | N-Ch            |       | - 4.1             |       |       |  |
|                                                                 |                                      | I <sub>D</sub> = - 250 μA                                                                                                                                                                                                                                                                                                                                                      | P-Ch            |       | 5                 |       |       |  |
| 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     |                   | 2.2   | V     |  |
|                                                                 |                                      | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = - 250 μA                                                                                                                                                                                                                                                                                                                  | P-Ch            | - 0.9 |                   | - 2.5 |       |  |
| Gate-Body Leakage                                               | I <sub>GSS</sub>                     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 20 V                                                                                                                                                                                                                                                                                                                                | N-Ch            |       |                   | ± 100 | nA    |  |
|                                                                 |                                      | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 20 V                                                                                                                                                                                                                                                                                                                                | P-Ch            |       |                   | ± 100 |       |  |
| Zero Gate Voltage Drain Current                                 | I <sub>DSS</sub>                     | V <sub>DS</sub> = 30 V, V <sub>GS</sub> = 0 V                                                                                                                                                                                                                                                                                                                                  | N-Ch            |       |                   | 1     | μA    |  |
|                                                                 |                                      | V <sub>DS</sub> = - 30 V, V <sub>GS</sub> = 0 V                                                                                                                                                                                                                                                                                                                                | P-Ch            |       |                   | - 1   |       |  |
|                                                                 |                                      | V <sub>DS</sub> = 30 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 55 °C                                                                                                                                                                                                                                                                                                          | N-Ch            |       |                   | 10    |       |  |
|                                                                 |                                      | V <sub>DS</sub> = - 30 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            | 40    |                   |       | A     |  |
|                                                                 |                                      | V <sub>DS</sub> = - 5 V, V <sub>GS</sub> = - 10 V                                                                                                                                                                                                                                                                                                                              | P-Ch            | - 40  |                   |       |       |  |
| Drain-Source On-State Resistance <sup>b</sup>                   | R <sub>DS(on)</sub>                  | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 6.8 A                                                                                                                                                                                                                                                                                                                                 | N-Ch            |       | 0.011             |       | Ω     |  |
|                                                                 |                                      | V <sub>GS</sub> = - 10 V, I <sub>D</sub> = - 8 A                                                                                                                                                                                                                                                                                                                               | P-Ch            |       | 0.021             |       |       |  |
|                                                                 |                                      | V <sub>GS</sub> = 8 V, I <sub>D</sub> = 6.7 A                                                                                                                                                                                                                                                                                                                                  | N-Ch            |       | 0.012             |       |       |  |
|                                                                 |                                      | V <sub>GS</sub> = - 8 V, I <sub>D</sub> = - 6.5 A                                                                                                                                                                                                                                                                                                                              | P-Ch            |       | 0.024             |       |       |  |
|                                                                 |                                      | V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 6.6 A                                                                                                                                                                                                                                                                                                                                | N-Ch            |       | 0.013             |       |       |  |
|                                                                 |                                      | V <sub>GS</sub> = - 4.5 V, I <sub>D</sub> = - 5 A                                                                                                                                                                                                                                                                                                                              | P-Ch            |       | 0.028             |       |       |  |
| Forward Transconductance <sup>b</sup>                           | g <sub>fs</sub>                      | V <sub>DS</sub> = 15 V, I <sub>D</sub> = 6.8 A                                                                                                                                                                                                                                                                                                                                 | N-Ch            |       | 37                |       | S     |  |
|                                                                 |                                      | V <sub>DS</sub> = - 15 V, I <sub>D</sub> = - 6.7 A                                                                                                                                                                                                                                                                                                                             | P-Ch            |       | 35                |       |       |  |
| Dynamic <sup>a</sup>                                            |                                      |                                                                                                                                                                                                                                                                                                                                                                                |                 |       |                   |       |       |  |
| Input Capacitance                                               | C <sub>iss</sub>                     | N-Channel<br>V <sub>DS</sub> = 20 V, V <sub>GS</sub> = 0 V, f = 1 MHz<br><br>P-Channel<br>V <sub>DS</sub> = - 20 V, V <sub>GS</sub> = 0 V, f = 1 MHz                                                                                                                                                                                                                           | N-Ch            |       | 1421              |       | pF    |  |
| Output Capacitance                                              | C <sub>oss</sub>                     |                                                                                                                                                                                                                                                                                                                                                                                | P-Ch            |       | 1515              |       |       |  |
|                                                                 |                                      |                                                                                                                                                                                                                                                                                                                                                                                | N-Ch            |       | 755               |       |       |  |
| Reverse Transfer Capacitance                                    | C <sub>rss</sub>                     |                                                                                                                                                                                                                                                                                                                                                                                | P-Ch            |       | 800               |       |       |  |
| Total Gate Charge                                               | Q <sub>g</sub>                       | N-Channel<br>V <sub>DS</sub> = 20 V, V <sub>GS</sub> = 10 V, I <sub>D</sub> = 10 A<br><br>P-Channel<br>V <sub>DS</sub> = - 20 V, V <sub>GS</sub> = - 10 V, I <sub>D</sub> = - 10 A<br><br>N-Channel<br>V <sub>DS</sub> = 20 V, V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 10 A<br><br>P-Channel<br>V <sub>DS</sub> = - 20 V, V <sub>GS</sub> = - 4.5 V, I <sub>D</sub> = - 10 A | N-Ch            |       | 13.3              | 20    | nC    |  |
|                                                                 |                                      |                                                                                                                                                                                                                                                                                                                                                                                | P-Ch            |       | 13                | 20    |       |  |
|                                                                 | N-Ch                                 |                                                                                                                                                                                                                                                                                                                                                                                |                 | 6.5   | 10                |       |       |  |
|                                                                 | P-Ch                                 |                                                                                                                                                                                                                                                                                                                                                                                |                 | 21.7  | 33                |       |       |  |
|                                                                 | Gate-Source Charge                   |                                                                                                                                                                                                                                                                                                                                                                                | Q <sub>gs</sub> | N-Ch  |                   | 2.3   |       |  |
|                                                                 |                                      |                                                                                                                                                                                                                                                                                                                                                                                |                 | P-Ch  |                   | 5.6   |       |  |
| Gate-Drain Charge                                               | Q <sub>gd</sub>                      | N-Ch                                                                                                                                                                                                                                                                                                                                                                           |                 | 1.7   |                   |       |       |  |
|                                                                 |                                      | P-Ch                                                                                                                                                                                                                                                                                                                                                                           |                 | 9.8   |                   |       |       |  |
| Gate Resistance                                                 | R <sub>g</sub>                       | f = 1 MHz                                                                                                                                                                                                                                                                                                                                                                      | N-Ch            | 0.3   | 1.3               | 2.6   | Ω     |  |
|                                                                 |                                      |                                                                                                                                                                                                                                                                                                                                                                                | P-Ch            | 1.3   | 6.4               | 12.8  |       |  |

| SPECIFICATIONS (T <sub>J</sub> = 25 °C, unless otherwise noted) |                     |                                                                                                                                          |      |                   |        |       |    |
|-----------------------------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------|--------|-------|----|
| Parameter                                                       | Symbol              | Test Conditions                                                                                                                          | Min. | Typ. <sup>a</sup> | Max.   | Unit  |    |
| Dynamic <sup>a</sup>                                            |                     |                                                                                                                                          |      |                   |        |       |    |
| Turn-On Delay Time                                              | t <sub>d(on)</sub>  | N-Channel<br>V <sub>DD</sub> = 20 V, R <sub>L</sub> = 3.7 Ω<br>I <sub>D</sub> ≅ 5.4 A, V <sub>GEN</sub> = 10 V, R <sub>g</sub> = 1 Ω     | N-Ch |                   | 5      | 10    | ns |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 10     | 20    |    |
| Rise Time                                                       | t <sub>r</sub>      |                                                                                                                                          | N-Ch |                   | 10     | 20    |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 9      | 18    |    |
| Turn-Off Delay Time                                             | t <sub>d(off)</sub> | P-Channel<br>V <sub>DD</sub> = - 20 V, R <sub>L</sub> = 2 Ω<br>I <sub>D</sub> ≅ - 10 A, V <sub>GEN</sub> = - 10 V, R <sub>g</sub> = 1 Ω  | N-Ch |                   | 16     | 25    |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 50     | 90    |    |
| Fall Time                                                       | t <sub>f</sub>      |                                                                                                                                          | N-Ch |                   | 7      | 14    |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 13     | 26    |    |
| Turn-On Delay Time                                              | t <sub>d(on)</sub>  | N-Channel<br>V <sub>DD</sub> = 20 V, R <sub>L</sub> = 3.7 Ω<br>I <sub>D</sub> ≅ 5.4 A, V <sub>GEN</sub> = 4.5 V, R <sub>g</sub> = 1 Ω    | N-Ch |                   | 11     | 22    |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 42     | 75    |    |
| Rise Time                                                       | t <sub>r</sub>      |                                                                                                                                          | N-Ch |                   | 12     | 22    |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 40     | 70    |    |
| Turn-Off Delay Time                                             | t <sub>d(off)</sub> | P-Channel<br>V <sub>DD</sub> = - 20 V, R <sub>L</sub> = 2 Ω<br>I <sub>D</sub> ≅ - 10 A, V <sub>GEN</sub> = - 4.5 V, R <sub>g</sub> = 1 Ω | N-Ch |                   | 17     | 26    |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 40     | 70    |    |
| Fall Time                                                       | t <sub>f</sub>      |                                                                                                                                          | N-Ch |                   | 7      | 14    |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 18     | 35    |    |
| Drain-Source Body Diode Characteristics                         |                     |                                                                                                                                          |      |                   |        |       |    |
| Continuous Source-Drain Diode Current                           | I <sub>S</sub>      | T <sub>C</sub> = 25 °C                                                                                                                   | N-Ch |                   |        | 5.6   | A  |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   |        | - 5.6 |    |
| Pulse Diode Forward Current <sup>a</sup>                        | I <sub>SM</sub>     |                                                                                                                                          | N-Ch |                   |        | 40    |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   |        | - 40  |    |
| Body Diode Voltage                                              | V <sub>SD</sub>     | I <sub>S</sub> = 5.4 A                                                                                                                   | N-Ch |                   | 0.81   | 1.2   | V  |
|                                                                 |                     | I <sub>S</sub> = - 2 A                                                                                                                   | P-Ch |                   | - 0.77 | - 1.2 |    |
| Body Diode Reverse Recovery Time                                | t <sub>rr</sub>     | N-Channel<br>I <sub>F</sub> = 5 A, dI/dt = 100 A/μs, T <sub>J</sub> = 25 °C                                                              | N-Ch |                   | 17     | 34    | ns |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 41     | 80    |    |
| Body Diode Reverse Recovery Charge                              | Q <sub>rr</sub>     |                                                                                                                                          | N-Ch |                   | 10     | 20    | nC |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 32     | 65    |    |
| Reverse Recovery Fall Time                                      | t <sub>a</sub>      | P-Channel<br>I <sub>F</sub> = - 5 A, dI/dt = - 100 A/μs, T <sub>J</sub> = 25 °C                                                          | N-Ch |                   | 10     |       | ns |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 15     |       |    |
| Reverse Recovery Rise Time                                      | t <sub>b</sub>      |                                                                                                                                          | N-Ch |                   | 7      |       |    |
|                                                                 |                     |                                                                                                                                          | P-Ch |                   | 26     |       |    |

Notes:

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

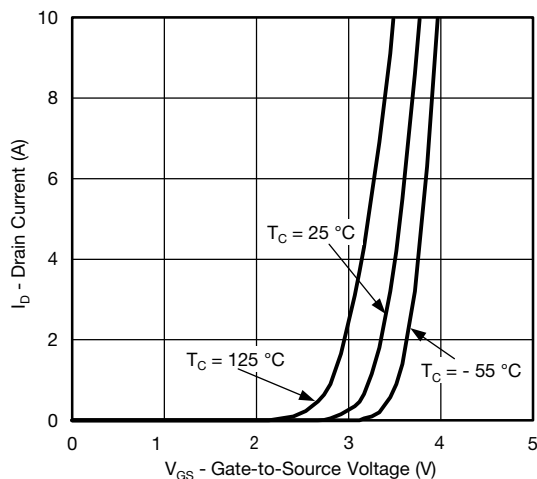
b. Pulse test; pulse width  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$ .

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.

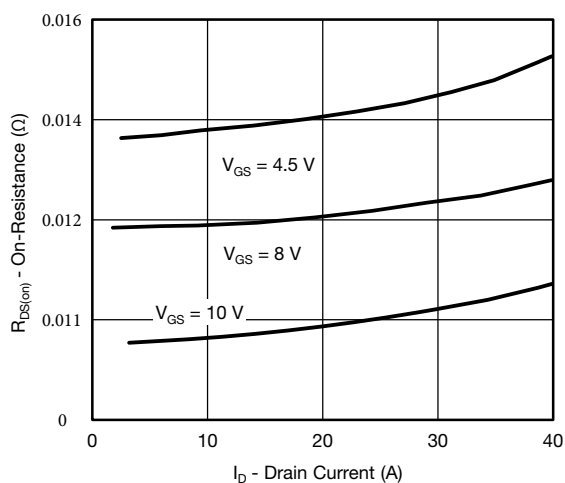
**N-CHANNEL TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



Output Characteristics



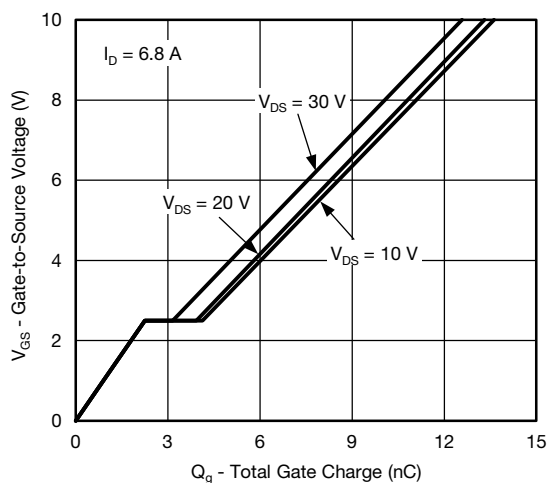
Transfer Characteristics



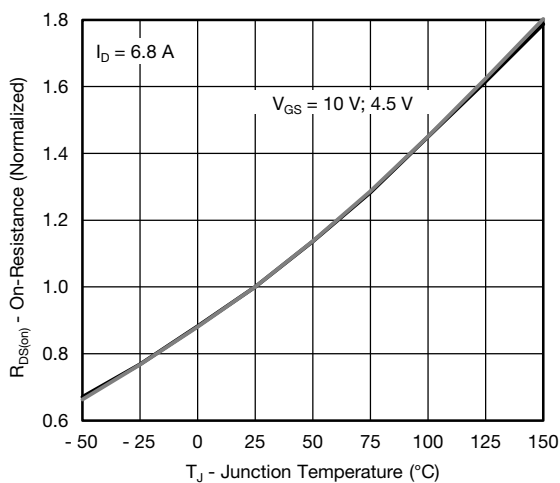
On-Resistance vs. Drain Current and Gate Voltage



Capacitance



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



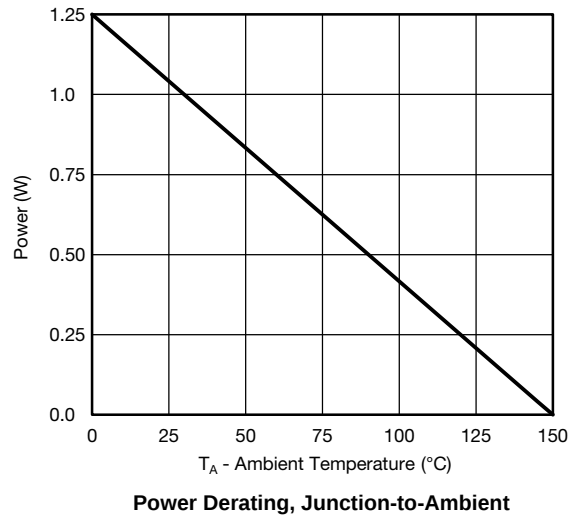
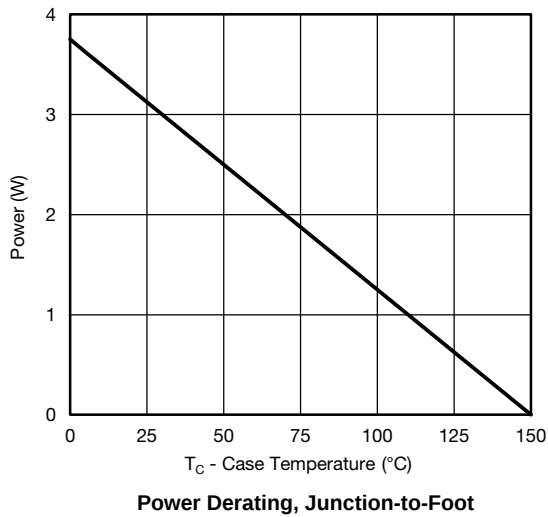
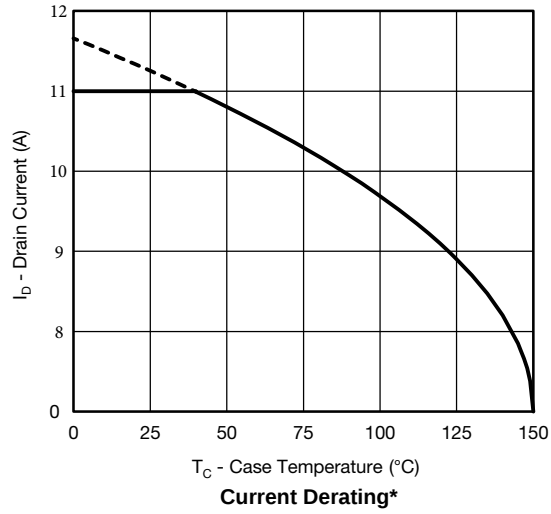
Single Pulse Power, Junction-to-Ambient



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

Safe Operating Area, Junction-to-Ambient

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

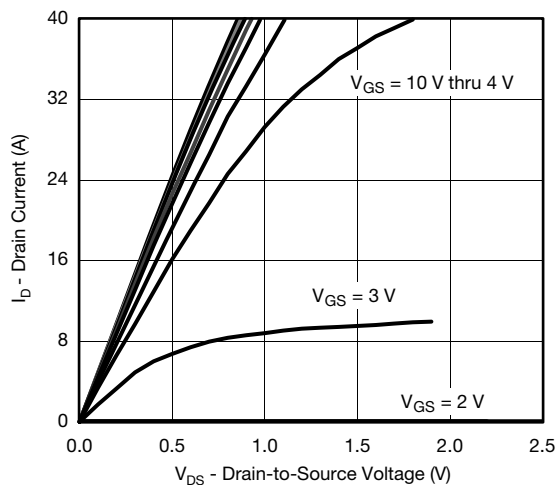
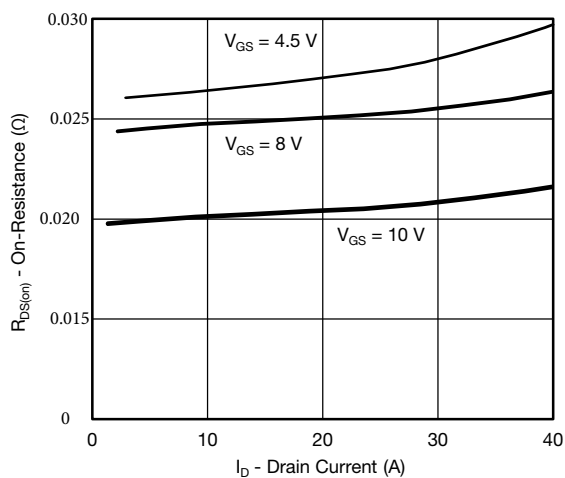
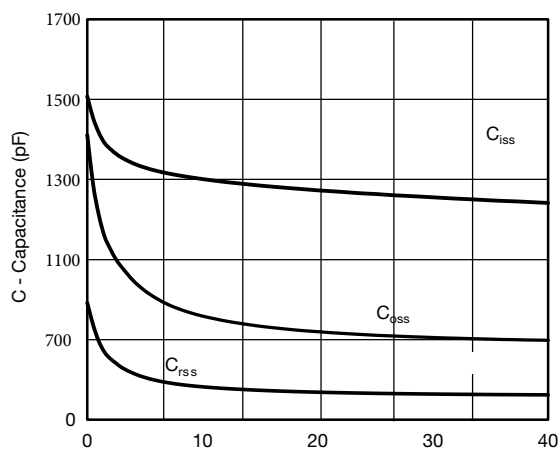
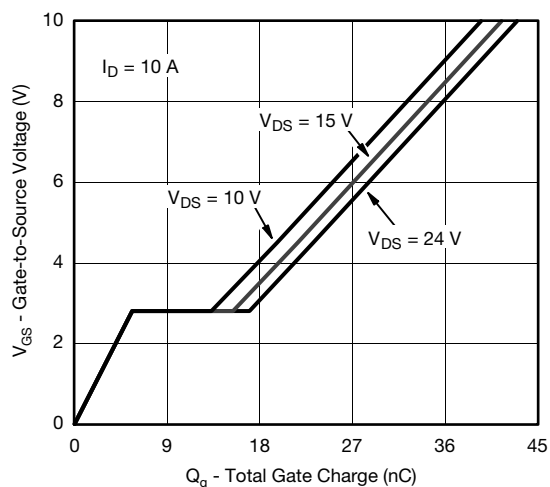


\* The power dissipation  $P_D$  is based on  $T_{J(max)} = 150$  °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below the package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

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

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

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

**P-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**

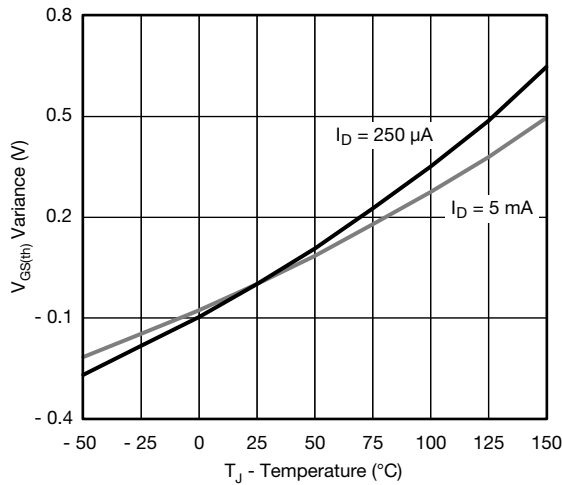
**P-CHANNEL TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



Source-Drain Diode Forward Voltage



On-Resistance vs. Gate-to-Source Voltage



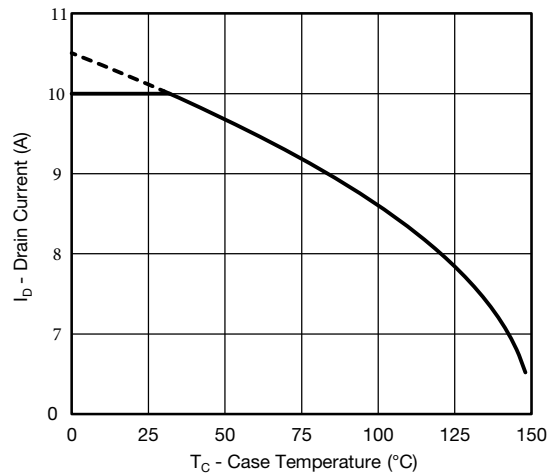
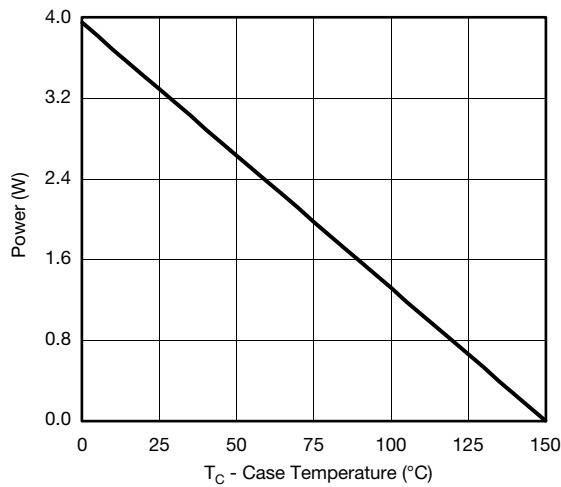
Threshold Voltage



Single Pulse Power, Junction-to-Ambient

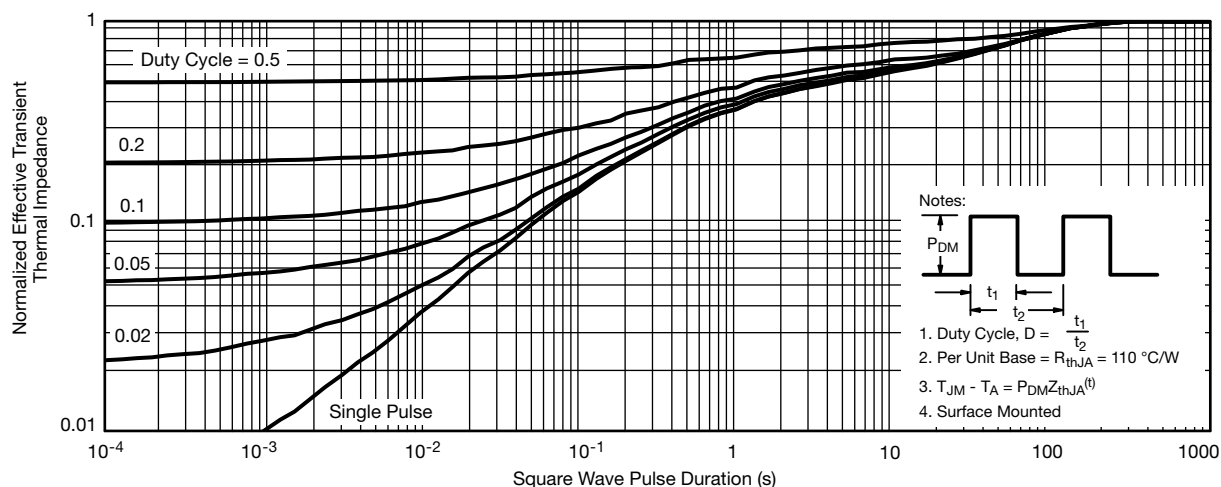


\*  $V_{GS} >$  minimum  $V_{GS}$  at which  $R_{DS(on)}$  is specified  
**Safe Operating Area, Junction-to-Ambient**

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

**Current Derating\***

**Power Derating, Junction-to-Foot**

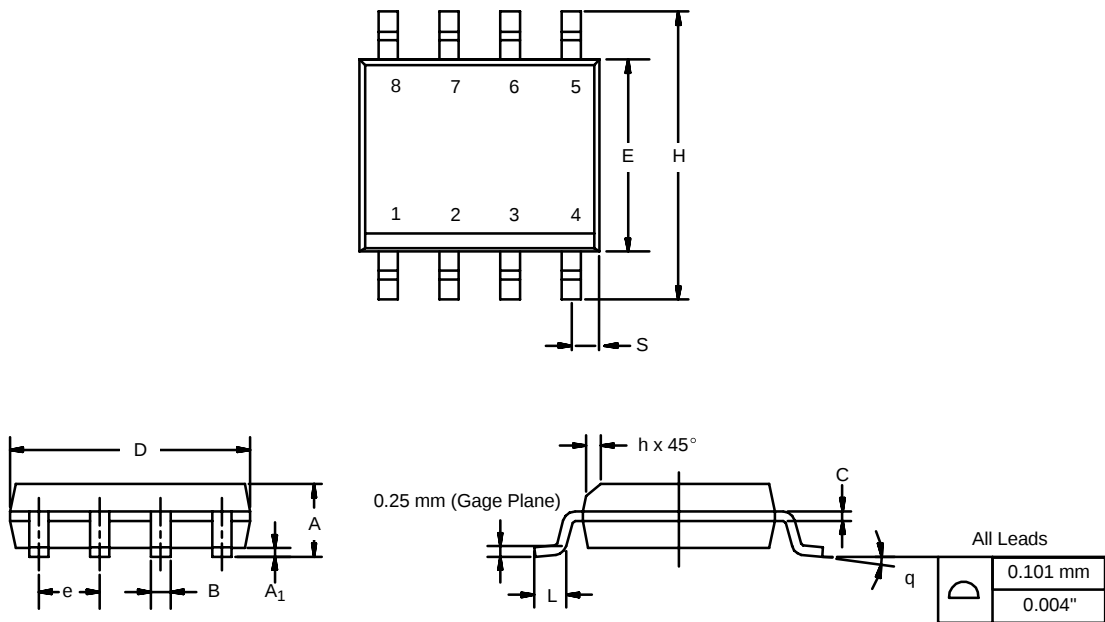
**Power Derating, Junction-to-Ambient**

\* 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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