Dual Enhancement Mode MOSFET (N- and P-Channel)

## Features

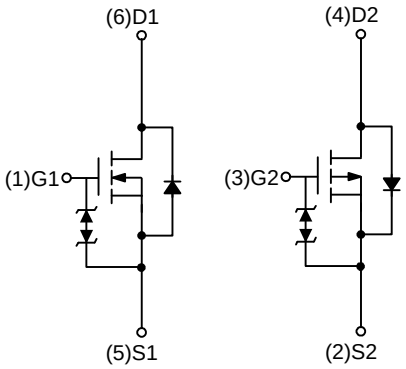
- N-Channel
  20V/4A,
  $R_{DS(ON)}$=30mΩ (typ.) @ $V_{GS}$=4.5V
  $R_{DS(ON)}$=40mΩ (typ.) @ $V_{GS}$=2.5V
  $R_{DS(ON)}$=67mΩ (typ.) @ $V_{GS}$=1.8V
- P-Channel
  -20V/-3A,
  $R_{DS(ON)}$=56mΩ (typ.) @ $V_{GS}$=-4.5V
  $R_{DS(ON)}$=85mΩ (typ.) @ $V_{GS}$=-2.5V
  $R_{DS(ON)}$=135mΩ (typ.) @ $V_{GS}$=-1.8V
- Super High Dense Cell Design
- Reliable and Rugged
- Lead Free and Green Devices Available (RoHS Compliant)

## Applications

- Power Management in Notebook Computer, Portable Equipment and Battery Powered Systems

## Pin Description


Top View of JSOT-6




N-Channel MOSFET P-Channel MOSFET

## Ordering and Marking Information

APM2704 □□□-□□ □

- Assembly Material
- Handling Code
- Temperature Range
- Package Code

Package Code
CG : JSOT-6
Operating Junction Temperature Range
C : -55 to 150 °C
Handling Code
TR : Tape & Reel
Assembly Material
G : Halogen and Lead Free Device

APM2704 CG : M2704 XXXXX

XXXXX - Date Code

Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020C for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

## Absolute Maximum Ratings ($T_A$ = 25°C unless otherwise noted)

| Symbol | Parameter | | Rating | | Unit |
|---|---|---|---|---|---|
| | | | N Channel | P Channel | |
| $V_{DSS}$ | Drain-Source Voltage | | 20 | -20 | V |
| $V_{GSS}$ | Gate-Source Voltage | | ±10 | ±10 | |
| $I_D$* | Continuous Drain Current | $V_{GS}$=4.5V (N)<br>$V_{GS}$=-4.5V (P) | 4 | -3 | A |
| $I_{DM}$* | Pulsed Drain Current | | 15 | -10 | |
| $I_S$* | Diode Continuous Forward Current | | 1 | -0.6 | A |
| $T_J$ | Maximum Junction Temperature | | 150 | | °C |
| $T_{STG}$ | Storage Temperature Range | | -55 to 150 | | |
| $P_D$* | Power Dissipation | $T_A$=25°C | 1 | | W |
| | | $T_A$=100°C | 0.4 | | |
| $R_{\theta JA}$* | Thermal Resistance-Junction to Ambient | | 125 | | °C/W |

Note : *Surface Mounted on 1in$^2$ pad area, t ≤ 10sec.

## Electrical Characteristics ($T_A$ = 25°C unless otherwise noted)

| Symbol | Parameter | Test Conditions | | APM2704CG | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| **Static Characteristics** | | | | | | | |
| $BV_{DSS}$ | Drain-Source Breakdown Voltage | $V_{GS}$=0V, $I_{DS}$=250µA | N-Ch | 20 | - | - | V |
| | | $V_{GS}$=0V, $I_{DS}$=-250µA | P-Ch | -20 | - | - | |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$=16V, $V_{GS}$=0V | N-Ch | - | - | 1 | µA |
| | | $T_J$=85°C | | - | - | 30 | |
| | | $V_{DS}$=-16V, $V_{GS}$=0V | P-Ch | - | - | -1 | |
| | | $T_J$=85°C | | - | - | -30 | |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{DS}$=$V_{GS}$, $I_{DS}$=250µA | N-Ch | 0.5 | 0.75 | 1 | V |
| | | $V_{DS}$=$V_{GS}$, $I_{DS}$=-250µA | P-Ch | -0.5 | -0.75 | -1 | |
| $I_{GSS}$ | Gate Leakage Current | $V_{GS}$=±10V, $V_{DS}$=0V | N-Ch | - | - | ±10 | µA |
| | | $V_{GS}$=±10V, $V_{DS}$=0V | P-Ch | - | - | ±10 | |
| $V_{SD}$[a] | Diode Forward Voltage | $I_{SD}$=1A, $V_{GS}$=0V | N-Ch | - | 0.6 | 1.3 | V |
| | | $I_{SD}$=-0.6A, $V_{GS}$=0V | P-Ch | - | -0.6 | -1.3 | |

## Electrical Characteristics (Cont.) ($T_A$ = 25°C unless otherwise noted)

| Symbol | Parameter | Test Conditions | | APM2704CG | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| **Static Characteristics (Cont.)** | | | | | | | |
| $R_{DS(ON)}$ [a] | Drain-Source On-State Resistance | $V_{GS}$=4.5V, $I_{DS}$=4A | N-Ch | - | 30 | 38 | mΩ |
| | | $V_{GS}$=-4.5V, $I_{DS}$=-3A | P-Ch | - | 56 | 70 | |
| | | $V_{GS}$=2.5V, $I_{DS}$=2.5A | N-Ch | - | 40 | 55 | |
| | | $V_{GS}$=-2.5V, $I_{DS}$=-1.5A | P-Ch | - | 85 | 115 | |
| | | $V_{GS}$=1.8V, $I_{DS}$=1.5A | N-Ch | - | 67 | 105 | |
| | | $V_{GS}$=-1.8V, $I_{DS}$=-1A | P-Ch | - | 135 | 200 | |
| **Dynamic Characteristics** [b] | | | | | | | |
| $R_G$ | Gate Resistance | $V_{GS}$=0V,$V_{DS}$=0V,F=1MHz | N-Ch | - | 5 | - | Ω |
| | | | P-Ch | - | 10 | - | |
| $C_{iss}$ | Input Capacitance | N-Channel $V_{GS}$=0V, $V_{DS}$=10V, Frequency=1.0MHz P-Channel $V_{GS}$=0V, $V_{DS}$=-10V, Frequency=1.0MHz | N-Ch | - | 600 | - | pF |
| | | | P-Ch | - | 790 | - | |
| $C_{oss}$ | Output Capacitance | | N-Ch | - | 110 | - | |
| | | | P-Ch | - | 110 | - | |
| $C_{rss}$ | Reverse Transfer Capacitance | | N-Ch | - | 80 | - | |
| | | | P-Ch | - | 80 | - | |
| $t_{d(ON)}$ | Turn-on Delay Time | N-Channel $V_{DD}$=10V, $R_L$=10Ω, $I_{DS}$=1A, $V_{GEN}$=4.5V, $R_G$=6Ω P-Channel $V_{DD}$=-10V, $R_L$=10Ω, $I_{DS}$=-1A, $V_{GEN}$=-4.5V, $R_G$=6Ω | N-Ch | - | 12 | 23 | ns |
| | | | P-Ch | - | 10 | 19 | |
| $t_r$ | Turn-on Rise Time | | N-Ch | - | 30 | 55 | |
| | | | P-Ch | - | 26 | 48 | |
| $t_{d(OFF)}$ | Turn-off Delay Time | | N-Ch | - | 38 | 69 | |
| | | | P-Ch | - | 50 | 91 | |
| $t_f$ | Turn-off Fall Time | | N-Ch | - | 6 | 12 | |
| | | | P-Ch | - | 45 | 82 | |
| $t_{rr}$ | Reverse Recovery Time | N-Channel $I_{DS}$=4A,$dI_{SD}$/dt =100A/μs P-Channel $I_{DS}$=-3A,$dI_{SD}$/dt =100A/μs | N-Ch | - | 21 | - | ns |
| | | | P-Ch | - | 25 | - | |
| $Q_{rr}$ | Reverse Recovery Charge | | N-Ch | - | 10 | - | nc |
| | | | P-Ch | - | 7 | - | |

## Electrical Characteristics (Cont.) ($T_A$ = 25°C unless otherwise noted)

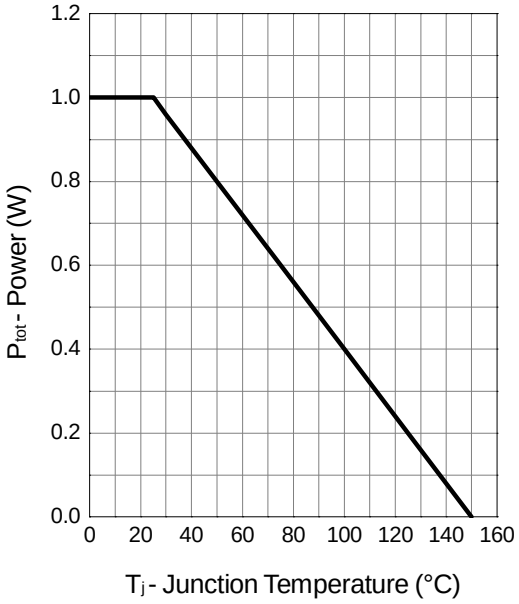
| Symbol | Parameter | Test Conditions | | APM2704CG | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| **Gate Charge Characteristics** [b] | | | | | | | |
| $Q_g$ | Total Gate Charge | N-Channel $V_{DS}$=10V, $V_{GS}$=4.5V, $I_{DS}$=4A<br>P-Channel $V_{DS}$=-10V, $V_{GS}$=-4.5V, $I_{DS}$=-3A | N-Ch | - | 10 | 14 | nC |
| | | | P-Ch | - | 8 | 11 | |
| $Q_{gs}$ | Gate-Source Charge | | N-Ch | - | 1.2 | - | |
| | | | P-Ch | - | 1.3 | - | |
| $Q_{gd}$ | Gate-Drain Charge | | N-Ch | - | 3 | - | |
| | | | P-Ch | - | 2.7 | - | |

Note a : Pulse test ; pulse width≤300μs, duty cycle≤2%.
Note b : Guaranteed by design, not subject to production testing.

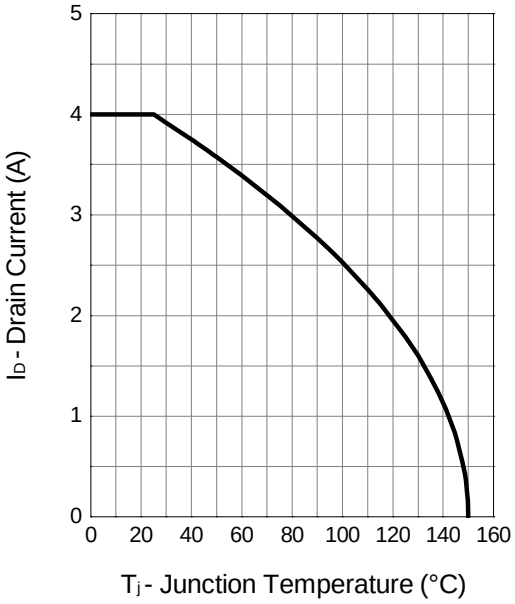
## Typical Operating Characteristics

**N-Channel**

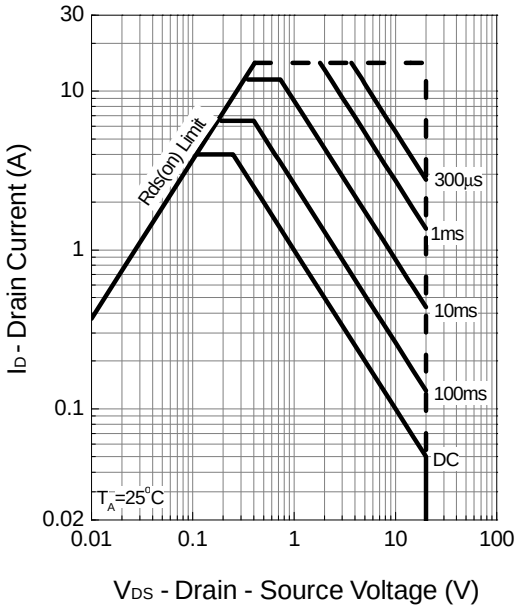
**Power Dissipation**



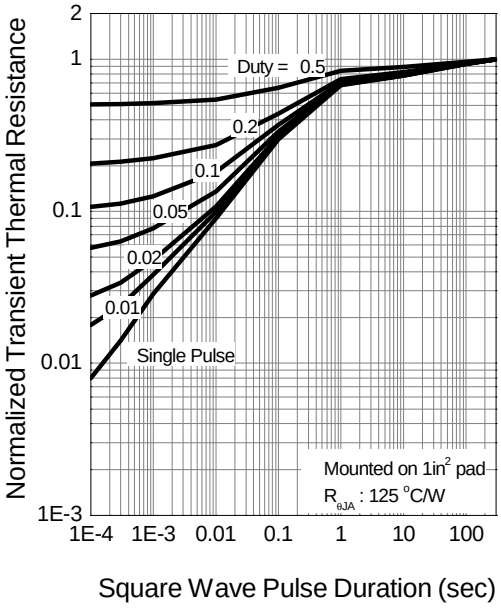

**Drain Current**




**Safe Operation Area**



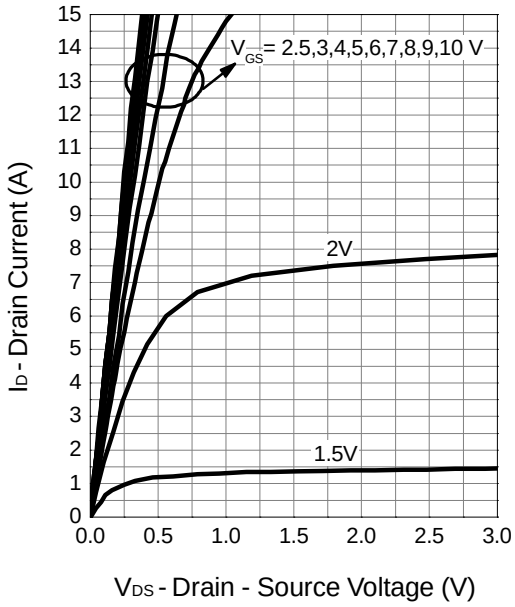

**Thermal Transient Impedance**



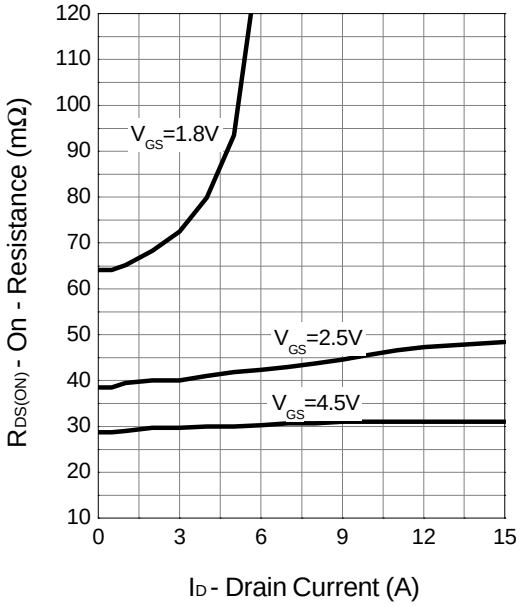
## Typical Operating Characteristics (Cont.)

**N-Channel**

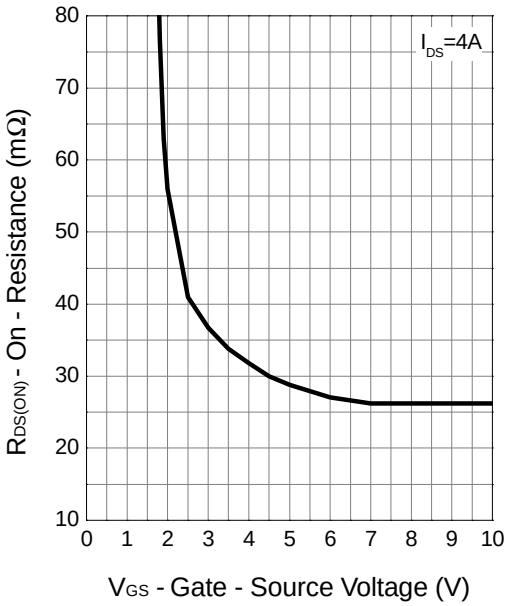
**Output Characteristics**



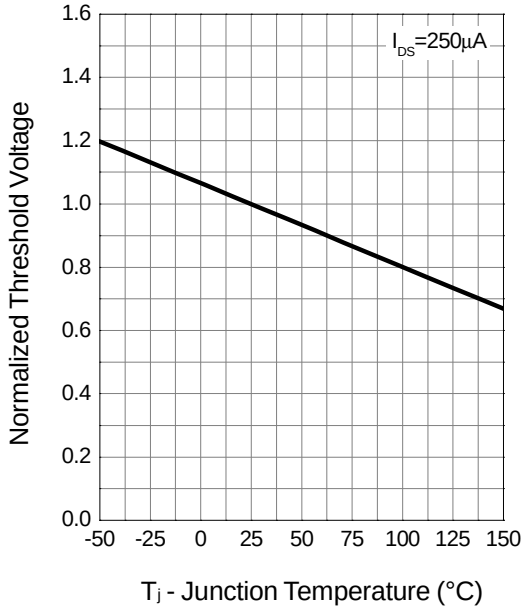

**Drain-Source On Resistance**




**Drain-Source On Resistance**



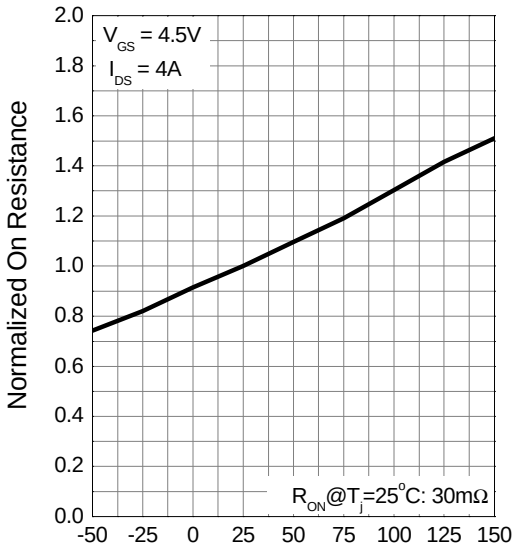

**Gate Threshold Voltage**



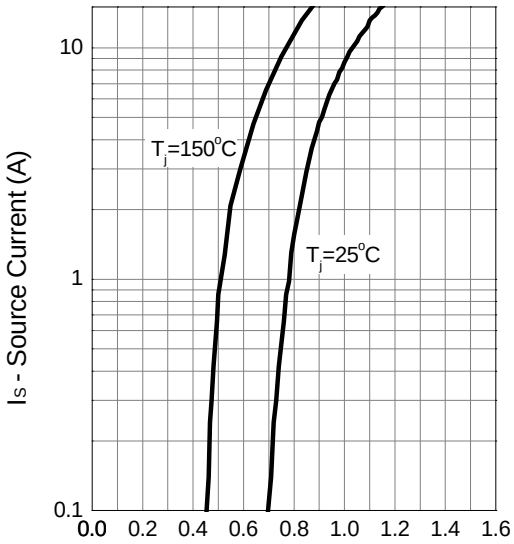
## Typical Operating Characteristics (Cont.)

**N-Channel**

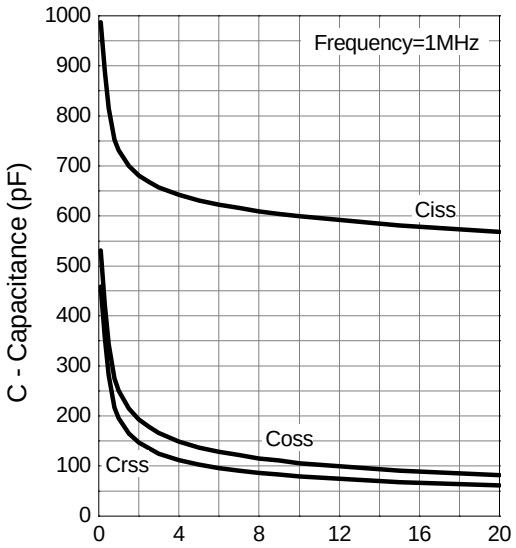
**Drain-Source On Resistance**



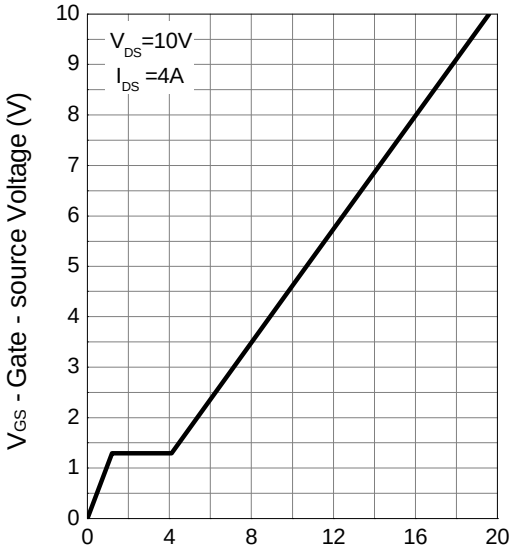

**Source-Drain Diode Forward**




**Capacitance**



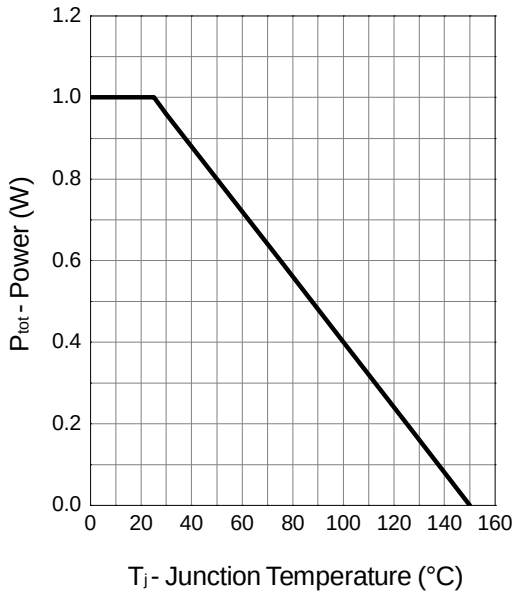

**Gate Charge**



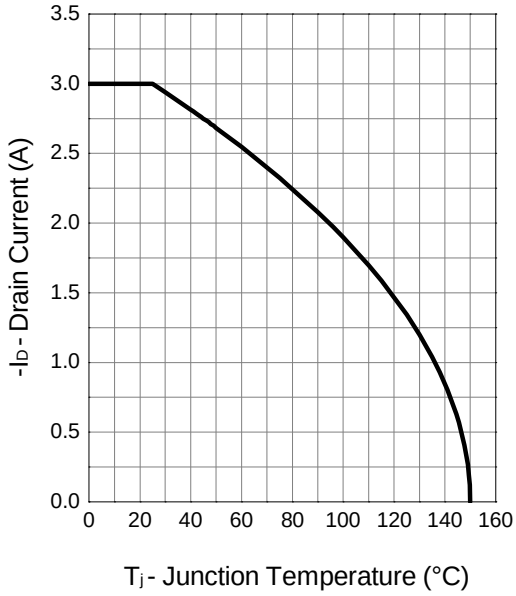
## Typical Operating Characteristics (Cont.)

**P-Channel**

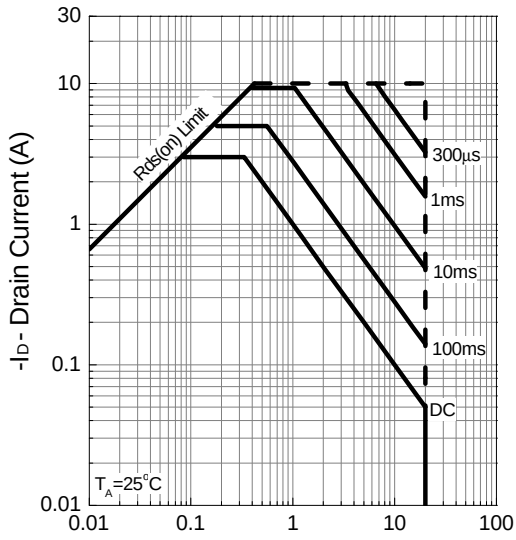
**Power Dissipation**



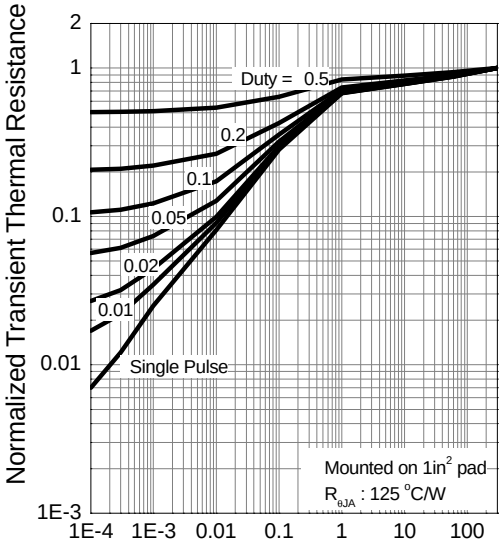

**Drain Current**




**Safe Operation Area**



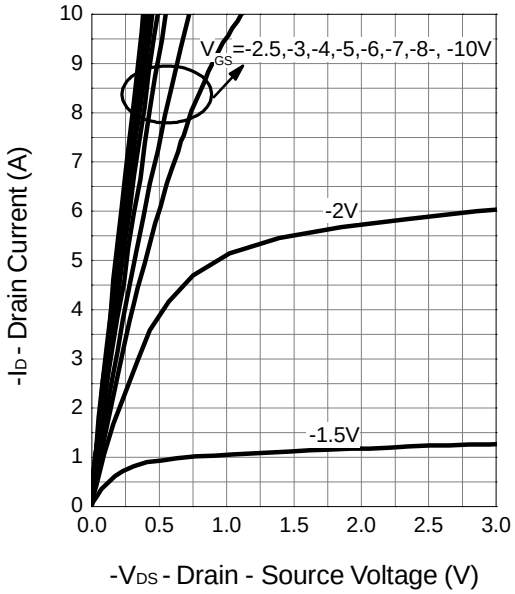

**Thermal Transient Impedance**



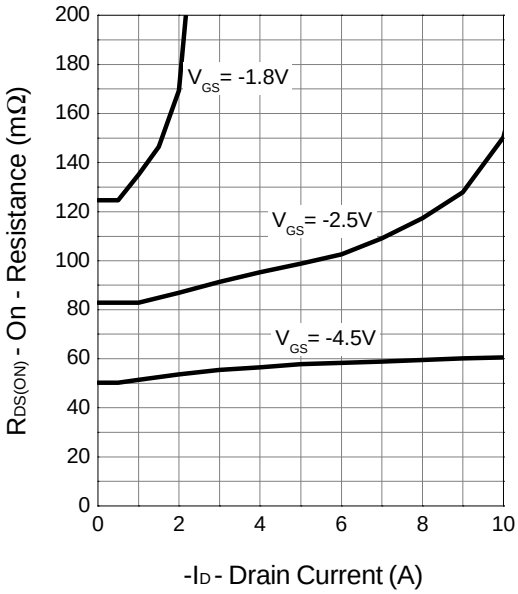
## Typical Operating Characteristics (Cont.)

**P-Channel**

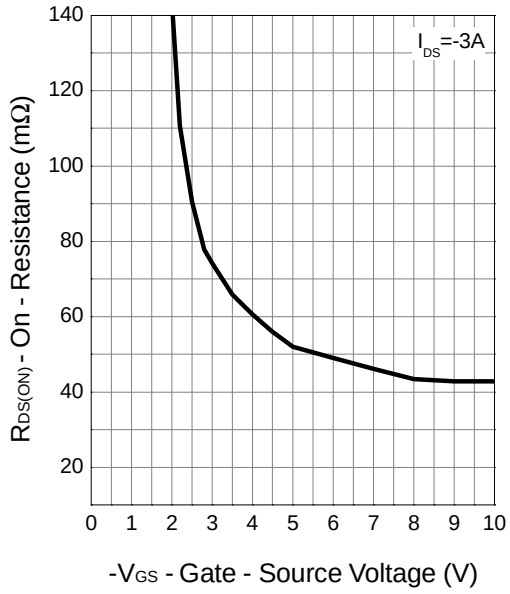
**Output Characteristics**



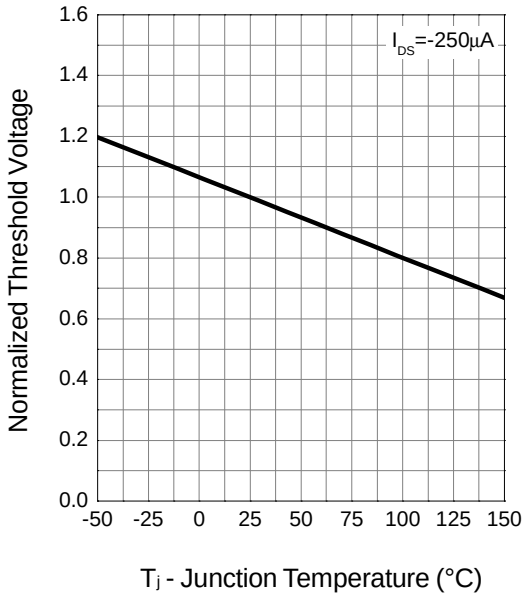

**Drain-Source On Resistance**




**Drain-Source On Resistance**



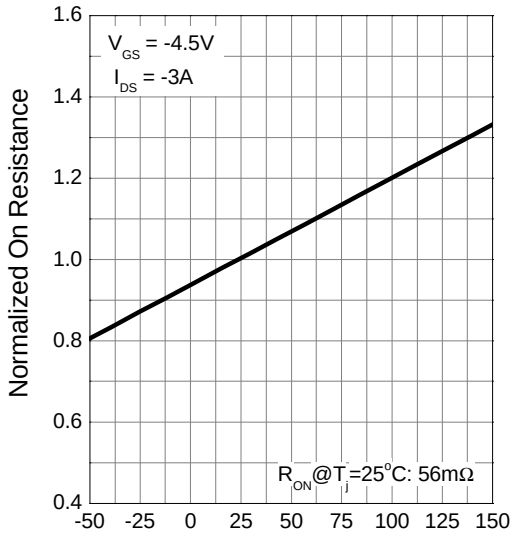

**Gate Threshold Voltage**



## Typical Operating Characteristics (Cont.)

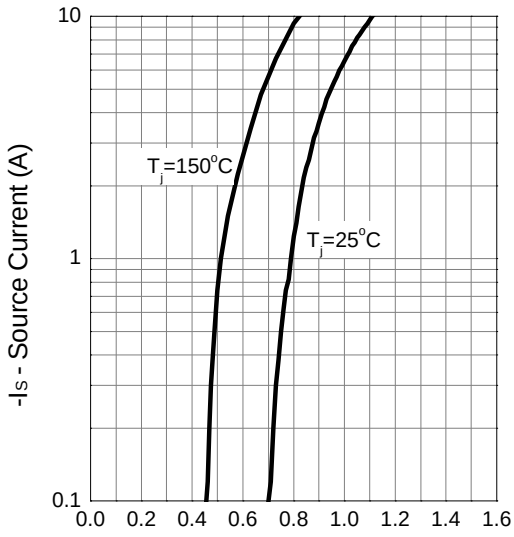
**P-Channel**

**Drain-Source On Resistance**



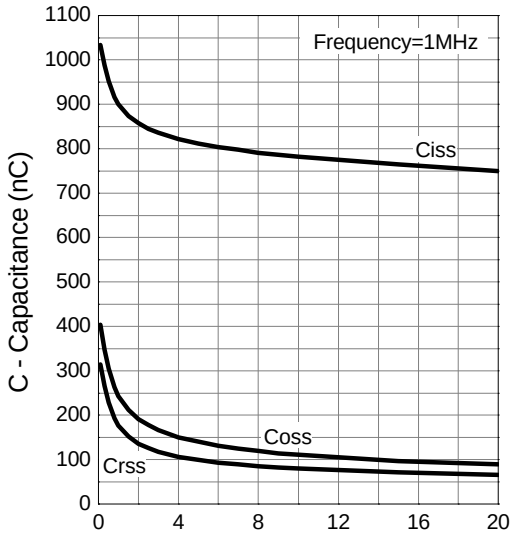

$T_j$ - Junction Temperature (°C)

**Source-Drain Diode Forward**



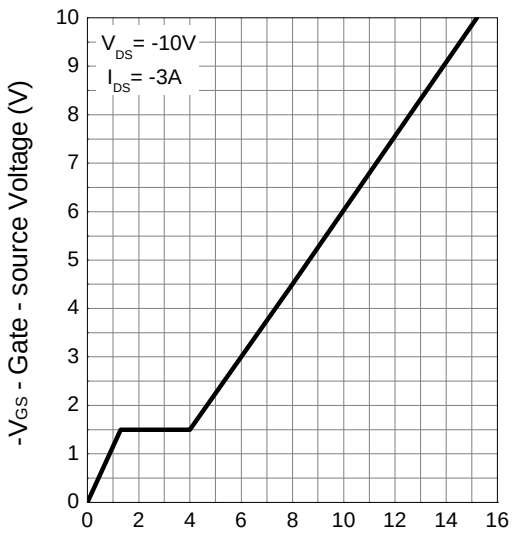

$-V_{SD}$ - Source - Drain Voltage (V)

**Capacitance**




$-V_{DS}$ - Drain - Source Voltage (V)

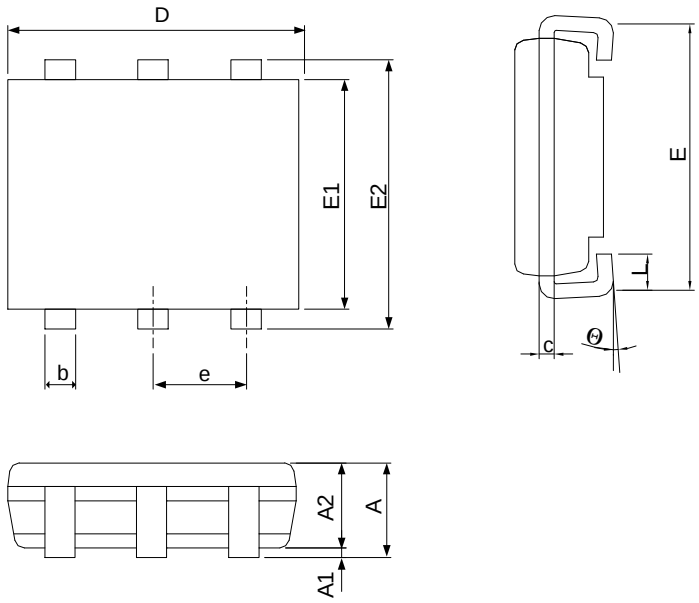
**Gate Charge**




$Q_G$ - Gate Charge (nC)

## Package Information

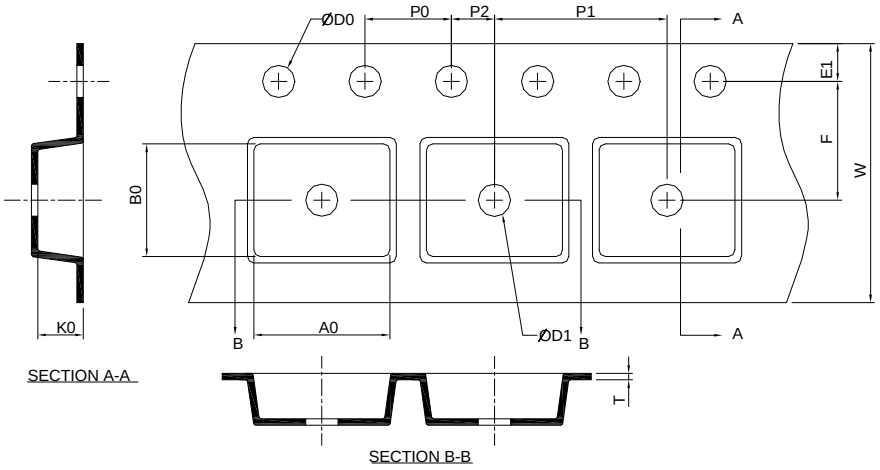
**JSOT-6**

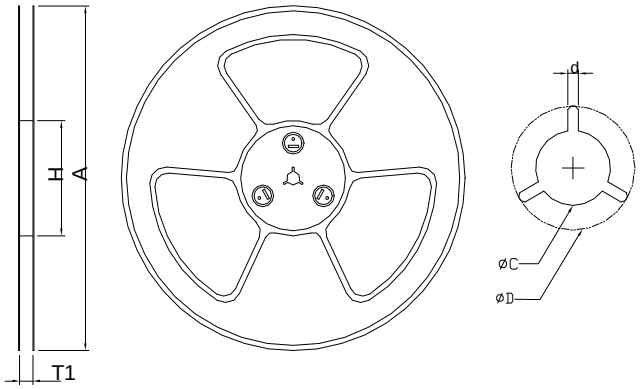



| SYMBOL | JSOT-6 | | | |
|---|---|---|---|---|
| | MILLIMETERS | | INCHES | |
| | MIN. | MAX. | MIN. | MAX. |
| A | 0.93 | 1.10 | 0.037 | 0.043 |
| A1 | 0.01 | 0.10 | 0.000 | 0.004 |
| A2 | 0.92 | 1.00 | 0.036 | 0.039 |
| b | 0.25 | 0.40 | 0.010 | 0.016 |
| c | 0.10 | 0.20 | 0.004 | 0.008 |
| D | 2.95 | 3.10 | 0.116 | 0.122 |
| E | 2.50 | 3.00 | 0.098 | 0.118 |
| E1 | 2.30 | 2.50 | 0.091 | 0.098 |
| E2 | 2.65 | 3.05 | 0.104 | 0.120 |
| e | 0.95 BSC | | 0.037 BSC | |
| θ | 0° | 8° | 0° | 8° |
| L | 0.30 | 0.60 | 0.012 | 0.024 |

Note : 1. Follow GEM 2928 6J.
2. Dimension D, D1, and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 10 mil.

## Carrier Tape & Reel Dimensions




| Application | A | H | T1 | C | d | D | W | E1 | F |
|---|---|---|---|---|---|---|---|---|---|
| JSOT-6 | 178.0±2.00 | 50 MIN. | 8.4+2.00 -0.00 | 13.0+0.50 -0.20 | 1.5 MIN. | 20.2 MIN. | 8.0±0.30 | 1.75±0.10 | 3.5±0.05 |
| | **P0** | **P1** | **P2** | **D0** | **D1** | **T** | **A0** | **B0** | **K0** |
| | 4.0±0.10 | 4.0±0.10 | 2.0±0.05 | 1.5+0.10 -0.00 | 1.0 MIN. | 0.6+0.00 -0.40 | 3.20±0.20 | 3.10±0.20 | 1.50±0.20 |

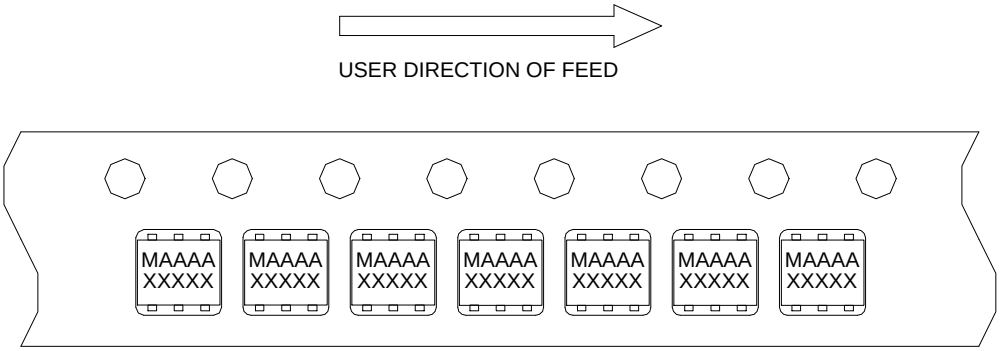
(mm)

## Devices Per Unit

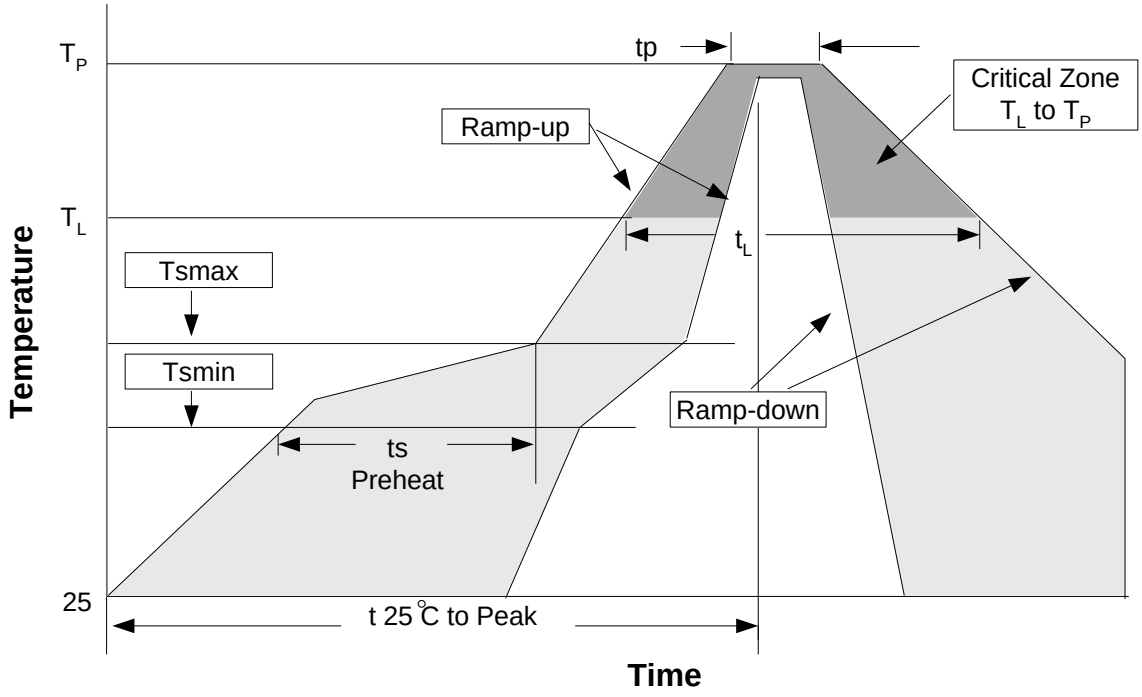
| Package Type | Unit | Quantity |
|---|---|---|
| **JSOT-6** | Tape & Reel | 3000 |

## Taping Direction Information

**JSOT-6**




## Reflow Condition (IR/Convection or VPR Reflow)




## Reliability Test Program

| Test item | Method | Description |
|---|---|---|
| SOLDERABILITY | MIL-STD-883D-2003 | 245°C, 5 sec |
| HOLT | MIL-STD-883D-1005.7 | 1000 Hrs Bias @125°C |
| PCT | JESD-22-B, A102 | 168 Hrs, 100%RH, 121°C |
| TST | MIL-STD-883D-1011.9 | -65°C~150°C, 200 Cycles |

## Classification Reflow Profiles

| Profile Feature | Sn-Pb Eutectic Assembly | Pb-Free Assembly |
|---|---|---|
| Average ramp-up rate ($T_L$ to $T_P$) | 3°C/second max. | 3°C/second max. |
| Preheat<br>- Temperature Min (Tsmin)<br>- Temperature Max (Tsmax)<br>- Time (min to max) (ts) | 100°C<br>150°C<br>60-120 seconds | 150°C<br>200°C<br>60-180 seconds |
| Time maintained above:<br>- Temperature ($T_L$)<br>- Time ($t_L$) | 183°C<br>60-150 seconds | 217°C<br>60-150 seconds |
| Peak/Classification Temperature (Tp) | See table 1 | See table 2 |
| Time within 5°C of actual Peak Temperature (tp) | 10-30 seconds | 20-40 seconds |
| Ramp-down Rate | 6°C/second max. | 6°C/second max. |
| Time 25°C to Peak Temperature | 6 minutes max. | 8 minutes max. |

Note: All temperatures refer to topside of the package. Measured on the body surface.

Table 1. SnPb Eutectic Process – Package Peak Reflow Temperatures

| Package Thickness | Volume $mm^3$ <350 | Volume $mm^3$ ≥350 |
|---|---|---|
| <2.5 mm | 240 +0/-5°C | 225 +0/-5°C |
| ≥2.5 mm | 225 +0/-5°C | 225 +0/-5°C |

Table 2. Pb-free Process – Package Classification Reflow Temperatures

| Package Thickness | Volume $mm^3$ <350 | Volume $mm^3$ 350-2000 | Volume $mm^3$ >2000 |
|---|---|---|---|
| <1.6 mm | 260 +0°C* | 260 +0°C* | 260 +0°C* |
| 1.6 mm – 2.5 mm | 260 +0°C* | 250 +0°C* | 245 +0°C* |
| ≥2.5 mm | 250 +0°C* | 245 +0°C* | 245 +0°C* |

*Tolerance: The device manufacturer/supplier **shall** assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.

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