

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

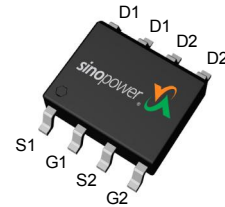
### Features

- N Channel**  
 30V/8.8A,  
 $R_{DS(ON)} = 17m\Omega$  (max.) @  $V_{GS} = 10V$   
 $R_{DS(ON)} = 23m\Omega$  (max.) @  $V_{GS} = 4.5V$
- P Channel**  
 -30V/-8.2A,  
 $R_{DS(ON)} = 20m\Omega$  (max.) @  $V_{GS} = -10V$   
 $R_{DS(ON)} = 33m\Omega$  (max.) @  $V_{GS} = -4.5V$
- 100% UIS +  $R_g$  Tested
- Reliable and Rugged
- Lead Free Available (RoHS Compliant)

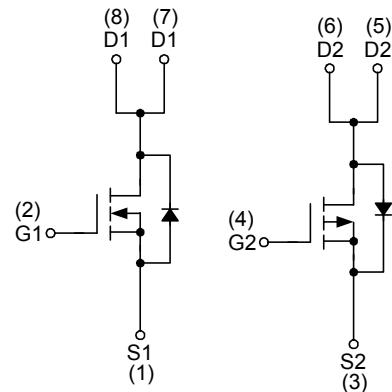
### Applications

- Synchronous Rectification.
- Motor Control
- High Current, High Speed Switching

### Pin Description



Top View of SOP-8



N-Channel MOSFET

P-Channel MOSFET

### Ordering and Marking Information

|                                                                                                                    |                                                                                                                                                                                                                             |
|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>SM4600CS □□-□□ □</p> <p>Assembly Material</p> <p>Handling Code</p> <p>Temperature Range</p> <p>Package Code</p> | <p>Package Code</p> <p>K : SOP-8</p> <p>Operating Junction Temperature Range</p> <p>C : -55 to 150 °C</p> <p>Handling Code</p> <p>TR : Tape &amp; Reel</p> <p>Assembly Material</p> <p>G : Halogen and Lead Free Device</p> |
| <p>SM4600CS K :</p> <p>4600</p> <p>XXXXX</p>                                                                       | <p>XXXXX - Lot Code</p>                                                                                                                                                                                                     |

Note : SINOPOWER lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. SINOPOWER lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature. SINOPOWER 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).

SINOPOWER reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

**Absolute Maximum Ratings** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

| Symbol                       | Parameter                                 |                                                  | N Channel            | P Channel | Unit |   |
|------------------------------|-------------------------------------------|--------------------------------------------------|----------------------|-----------|------|---|
| Common Ratings               |                                           |                                                  |                      |           |      |   |
| V <sub>DSS</sub>             | Drain-Source Voltage                      |                                                  | 30                   | -30       | V    |   |
| V <sub>GSS</sub>             | Gate-Source Voltage                       |                                                  | ±20                  | ±20       | V    |   |
| T <sub>J</sub>               | Maximum Junction Temperature              |                                                  | 150                  |           | °C   |   |
| T <sub>STG</sub>             | Storage Temperature Range                 |                                                  | -55 to 150           |           | °C   |   |
| I <sub>S</sub>               | Diode Continuous Forward Current          |                                                  | 2                    | -2        | A    |   |
| I <sub>DP</sub>              | 300µs Pulse Drain Current Tested          | V <sub>GS</sub> =10V(N),V <sub>GS</sub> =-10V(P) | 40*                  | -32*      | A    |   |
| I <sub>D</sub> <sup>a</sup>  | Continuous Drain Current                  |                                                  | T <sub>A</sub> =25°C | 8.8       | -8.2 | A |
|                              |                                           |                                                  | T <sub>A</sub> =70°C | 7         | -6.5 |   |
| P <sub>D</sub>               | Maximum Power Dissipation                 | T <sub>A</sub> =25°C                             | 2                    | 2         | W    |   |
|                              |                                           | T <sub>A</sub> =70°C                             | 1.3                  | 1.3       |      |   |
| R <sub>θJL</sub>             | Thermal Resistance-Junction to Lead       | Steady State                                     | 50                   | 50        | °C/W |   |
| R <sub>θJA</sub>             | Thermal Resistance-Junction to Ambient    | t ≤ 10s                                          | 62.5                 | 62.5      | °C/W |   |
|                              |                                           | Steady State                                     | 90                   | 90        |      |   |
| I <sub>AS</sub> <sup>b</sup> | Avalanche Current, Single pulse (L=0.5mH) |                                                  | 9                    | 16        | A    |   |
| E <sub>AS</sub> <sup>b</sup> | Avalanche Energy, Single pulse (L=0.5mH)  |                                                  | 20                   | 64        | mJ   |   |

Note a : \* Current limited by bond wire.

Note b : UIS tested and pulse width limited by maximum junction temperature  $150^\circ\text{C}$  (initial temperature  $T_J=25^\circ\text{C}$ ).

**N Channel Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

| Symbol                                   | Parameter                        | Test Conditions                                                                                           | N Channel |      |      | Unit |
|------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------|-----------|------|------|------|
|                                          |                                  |                                                                                                           | Min.      | Typ. | Max. |      |
| Static Characteristics                   |                                  |                                                                                                           |           |      |      |      |
| BV <sub>DSS</sub>                        | Drain-Source Breakdown Voltage   | V <sub>GS</sub> =0V, I <sub>DS</sub> =250μA                                                               | 30        | -    | -    | V    |
| I <sub>DSS</sub>                         | Zero Gate Voltage Drain Current  | V <sub>DS</sub> =24V, V <sub>GS</sub> =0V                                                                 | -         | -    | 1    | μA   |
|                                          |                                  | T <sub>J</sub> =85°C                                                                                      | -         | -    | 30   |      |
| V <sub>GS(th)</sub>                      | Gate Threshold Voltage           | V <sub>DS</sub> =V <sub>GS</sub> , I <sub>DS</sub> =250μA                                                 | 1.5       | 1.8  | 2.5  | V    |
| I <sub>GSS</sub>                         | Gate Leakage Current             | V <sub>GS</sub> =±20V, V <sub>DS</sub> =0V                                                                | -         | -    | ±100 | nA   |
| R <sub>DS(ON)</sub> <sup>c</sup>         | Drain-Source On-state Resistance | V <sub>GS</sub> =10V, I <sub>DS</sub> =8A                                                                 | -         | 13.5 | 17   | mΩ   |
|                                          |                                  | V <sub>GS</sub> =4.5V, I <sub>DS</sub> =8A                                                                | -         | 18   | 23   |      |
| Diode Characteristics                    |                                  |                                                                                                           |           |      |      |      |
| V <sub>SD</sub> <sup>c</sup>             | Diode Forward Voltage            | I <sub>SD</sub> =1A, V <sub>GS</sub> =0V                                                                  | -         | 0.75 | 1.1  | V    |
| t <sub>rr</sub>                          | Reverse Recovery Time            | I <sub>DS</sub> =8A, dI <sub>SD</sub> /dt=100A/μs                                                         | -         | 12   | -    | ns   |
| Q <sub>rr</sub>                          | Reverse Recovery Charge          |                                                                                                           | -         | 3.5  | -    | nC   |
| Dynamic Characteristics <sup>d</sup>     |                                  |                                                                                                           |           |      |      |      |
| R <sub>G</sub>                           | Gate Resistance                  | V <sub>GS</sub> =0V, V <sub>DS</sub> =0V, F=1MHz                                                          | -         | 1.7  | -    | Ω    |
| C <sub>iss</sub>                         | Input Capacitance                | V <sub>GS</sub> =0V, V <sub>DS</sub> =15V, Frequency=1.0MHz                                               | -         | 580  | -    | pF   |
| C <sub>oss</sub>                         | Output Capacitance               |                                                                                                           | -         | 95   | -    |      |
| C <sub>rss</sub>                         | Reverse Transfer Capacitance     |                                                                                                           | -         | 57   | -    |      |
| t <sub>d(ON)</sub>                       | Turn-on Delay Time               | V <sub>DD</sub> =15V, R <sub>L</sub> =15Ω, I <sub>DS</sub> =1A, V <sub>GEN</sub> =10V, R <sub>G</sub> =6Ω | -         | 6    | -    | ns   |
| t <sub>r</sub>                           | Turn-on Rise Time                |                                                                                                           | -         | 8.2  | -    |      |
| t <sub>d(OFF)</sub>                      | Turn-off Delay Time              |                                                                                                           | -         | 16   | -    |      |
| t <sub>f</sub>                           | Turn-off Fall Time               |                                                                                                           | -         | 4    | -    |      |
| Gate Charge Characteristics <sup>d</sup> |                                  |                                                                                                           |           |      |      |      |
| Q <sub>g</sub>                           | Total Gate Charge                | V <sub>DS</sub> =15V, V <sub>GS</sub> =10V, I <sub>DS</sub> =8A                                           | -         | 11.2 | 15   | nC   |
| Q <sub>g</sub>                           | Total Gate Charge                | V <sub>DS</sub> =15V, V <sub>GS</sub> =4.5V, I <sub>DS</sub> =8A                                          | -         | 6    | 8    |      |
| Q <sub>gth</sub>                         | Threshold Gate Charge            |                                                                                                           | -         | 0.81 | -    |      |
| Q <sub>gs</sub>                          | Gate-Source Charge               |                                                                                                           | -         | 1.5  | -    |      |
| Q <sub>gd</sub>                          | Gate-Drain Charge                |                                                                                                           | -         | 2.5  | -    |      |

Note c : Pulse test ; pulse width $\leq 300\mu s$ , duty cycle $\leq 2\%$ .

Note d : Guaranteed by design, not subject to production testing.

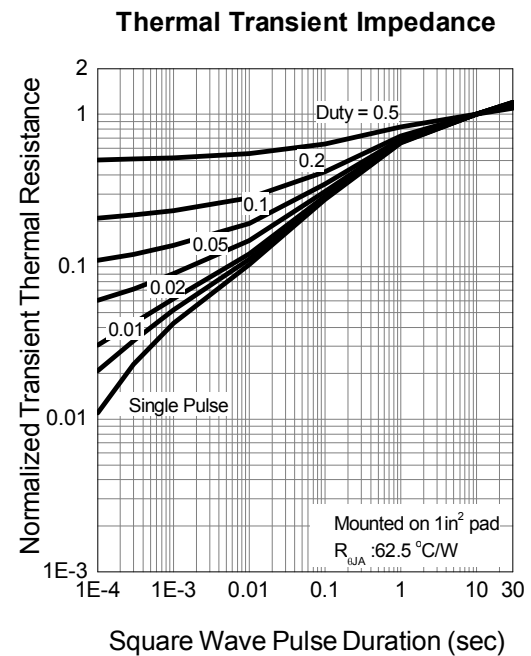
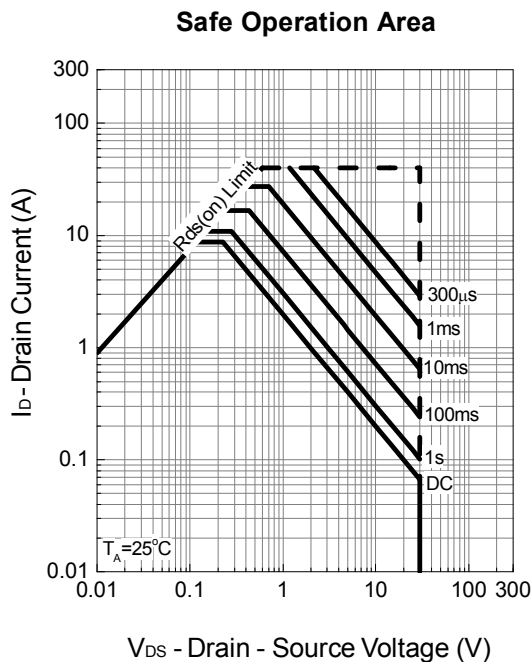
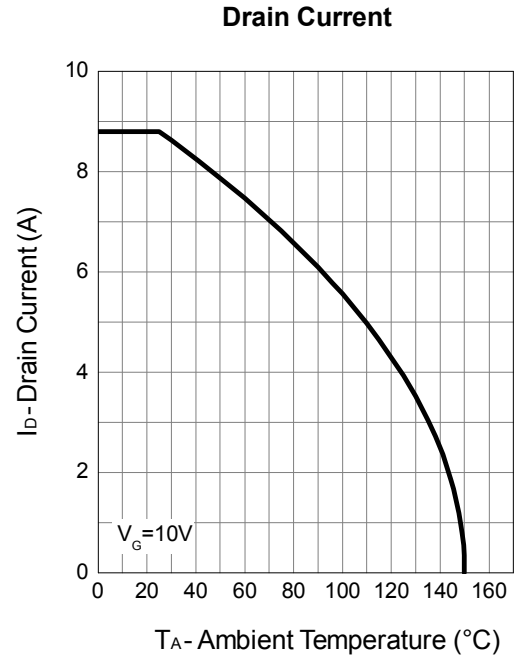
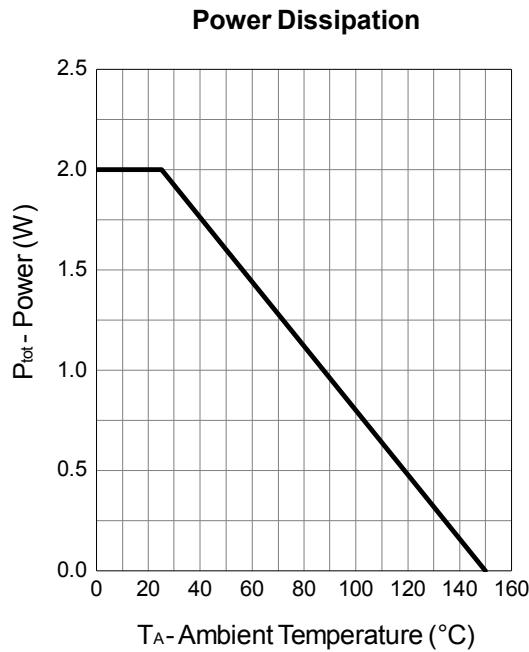
**P Channel Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

| Symbol                                   | Parameter                        | Test Conditions                                                                                                    | P Channel |      |      | Unit |
|------------------------------------------|----------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------|------|------|------|
|                                          |                                  |                                                                                                                    | Min.      | Typ. | Max. |      |
| Static Characteristics                   |                                  |                                                                                                                    |           |      |      |      |
| BV <sub>DSS</sub>                        | Drain-Source Breakdown Voltage   | V <sub>GS</sub> =0V, I <sub>DS</sub> =-250μA                                                                       | -30       | -    | -    | V    |
| I <sub>DSS</sub>                         | Zero Gate Voltage Drain Current  | V <sub>DS</sub> =-24V, V <sub>GS</sub> =0V                                                                         | -         | -    | -1   | μA   |
|                                          |                                  | T <sub>J</sub> =85°C                                                                                               | -         | -    | -30  | mA   |
| V <sub>GS(th)</sub>                      | Gate Threshold Voltage           | V <sub>DS</sub> =V <sub>GS</sub> , I <sub>DS</sub> =-250μA                                                         | -1.5      | -2   | -2.5 | V    |
| I <sub>GSS</sub>                         | Gate Leakage Current             | V <sub>GS</sub> =±20V, V <sub>DS</sub> =0V                                                                         | -         | -    | ±100 | nA   |
| R <sub>DS(ON)</sub> <sup>c</sup>         | Drain-Source On-state Resistance | V <sub>GS</sub> =-10V, I <sub>DS</sub> =-8.2A                                                                      | -         | 16   | 20   | mΩ   |
|                                          |                                  | V <sub>GS</sub> =-4.5V, I <sub>DS</sub> =-4A                                                                       | -         | 25   | 33   |      |
| Diode Characteristics                    |                                  |                                                                                                                    |           |      |      |      |
| V <sub>SD</sub> <sup>c</sup>             | Diode Forward Voltage            | I <sub>SD</sub> =-1A, V <sub>GS</sub> =0V                                                                          | -         | -0.7 | -1   | V    |
| t <sub>rr</sub>                          | Reverse Recovery Time            | I <sub>DS</sub> =-8.2A,                                                                                            | -         | 19   | -    | ns   |
| Q <sub>rr</sub>                          | Reverse Recovery Charge          | di <sub>SD</sub> /dt=100A/μs                                                                                       | -         | 10   | -    | nC   |
| Dynamic Characteristics <sup>d</sup>     |                                  |                                                                                                                    |           |      |      |      |
| R <sub>G</sub>                           | Gate Resistance                  | V <sub>GS</sub> =0V, V <sub>DS</sub> =0V, F=1MHz                                                                   | -         | 3    | -    | Ω    |
| C <sub>iss</sub>                         | Input Capacitance                | V <sub>GS</sub> =0V,<br>V <sub>DS</sub> =-15V,<br>Frequency=1.0MHz                                                 | -         | 1000 | -    | pF   |
| C <sub>oss</sub>                         | Output Capacitance               |                                                                                                                    | -         | 210  | -    |      |
| C <sub>rss</sub>                         | Reverse Transfer Capacitance     |                                                                                                                    | -         | 150  | -    |      |
| t <sub>d(ON)</sub>                       | Turn-on Delay Time               | V <sub>DD</sub> =-15V, R <sub>L</sub> =15Ω,<br>I <sub>DS</sub> =-1A, V <sub>GEN</sub> =-10V,<br>R <sub>G</sub> =6Ω | -         | 8    | -    | ns   |
| t <sub>r</sub>                           | Turn-on Rise Time                |                                                                                                                    | -         | 12   | -    |      |
| t <sub>d(OFF)</sub>                      | Turn-off Delay Time              |                                                                                                                    | -         | 32   | -    |      |
| t <sub>f</sub>                           | Turn-off Fall Time               |                                                                                                                    | -         | 16   | -    |      |
| Gate Charge Characteristics <sup>d</sup> |                                  |                                                                                                                    |           |      |      |      |
| Q <sub>g</sub>                           | Total Gate Charge                | V <sub>DS</sub> =-15V, V <sub>GS</sub> =-10V,<br>I <sub>DS</sub> =-8.2A                                            | -         | 21   | -    | nC   |
| Q <sub>gs</sub>                          | Gate-Source Charge               |                                                                                                                    | -         | 2.6  | -    |      |
| Q <sub>gd</sub>                          | Gate-Drain Charge                |                                                                                                                    | -         | 6.2  | -    |      |

Note c : Pulse test; pulse width $\leq 300\mu s$ , duty cycle $\leq 2\%$ .

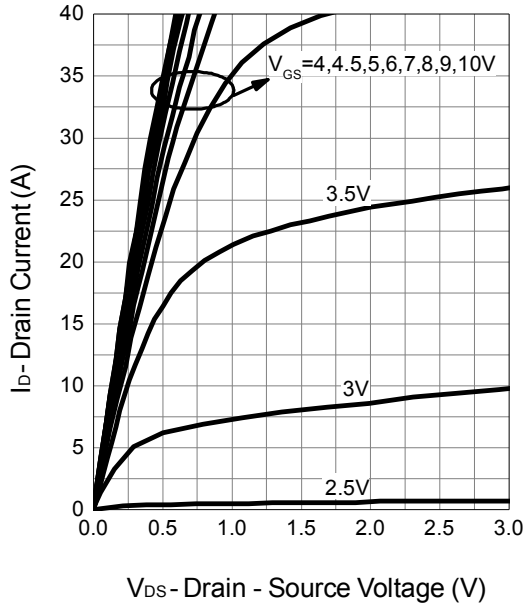
Note d : Guaranteed by design, not subject to production testing.

## N Channel Typical Operating Characteristics

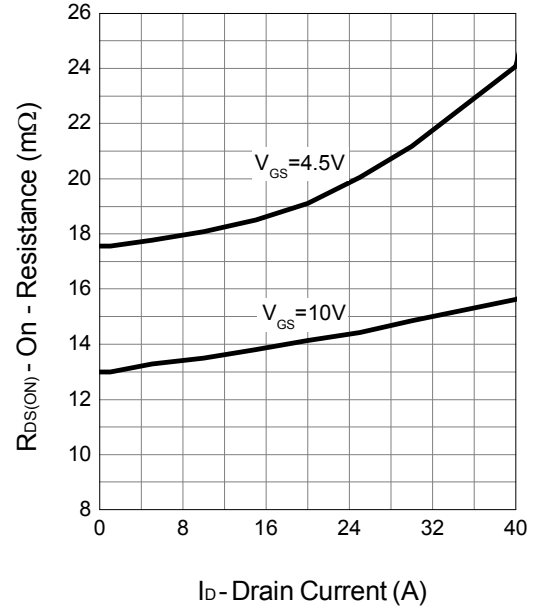


## N Channel Typical Operating Characteristics (Cont.)

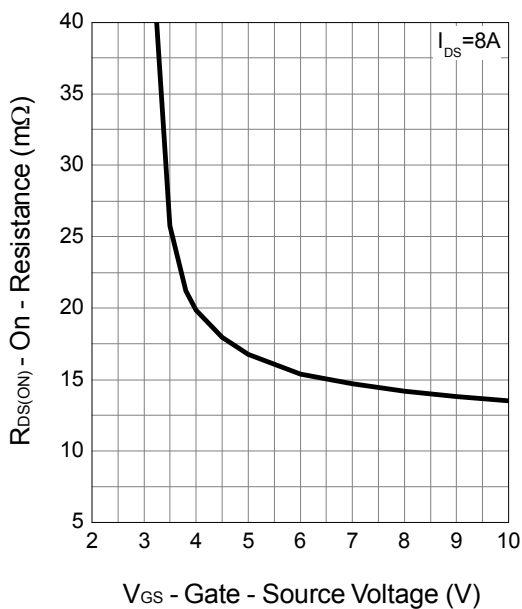
**Output Characteristics**



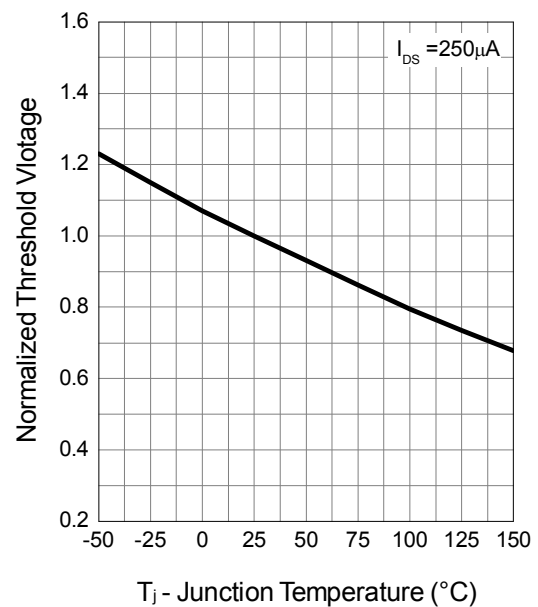
**Drain-Source On Resistance**



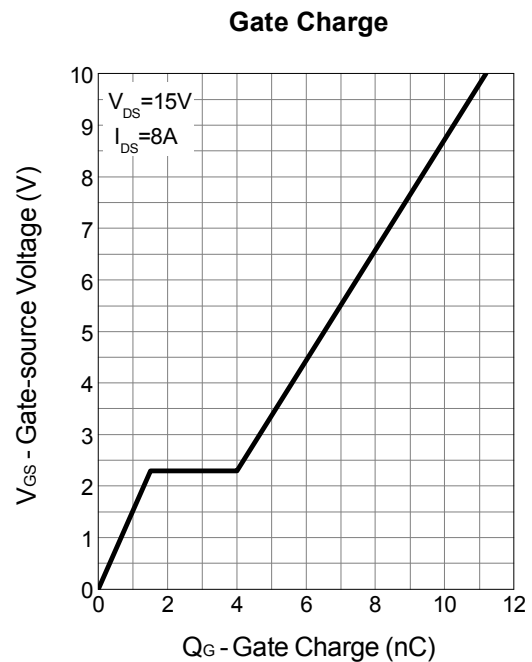
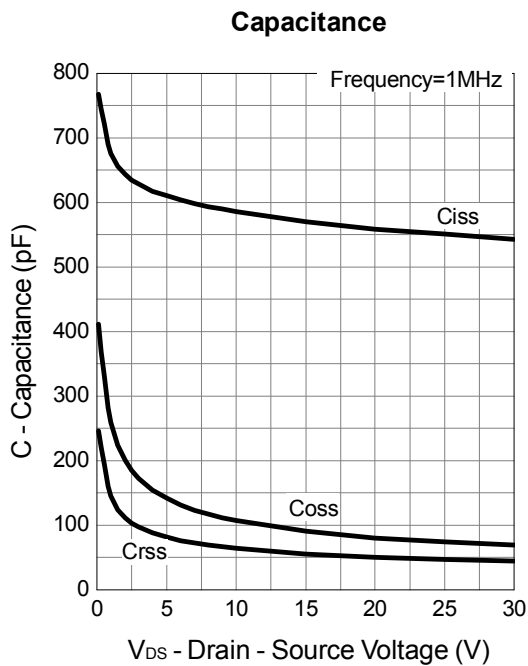
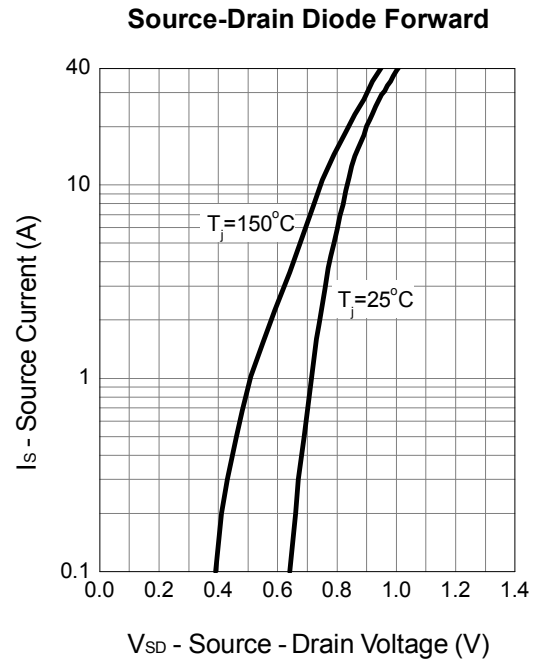
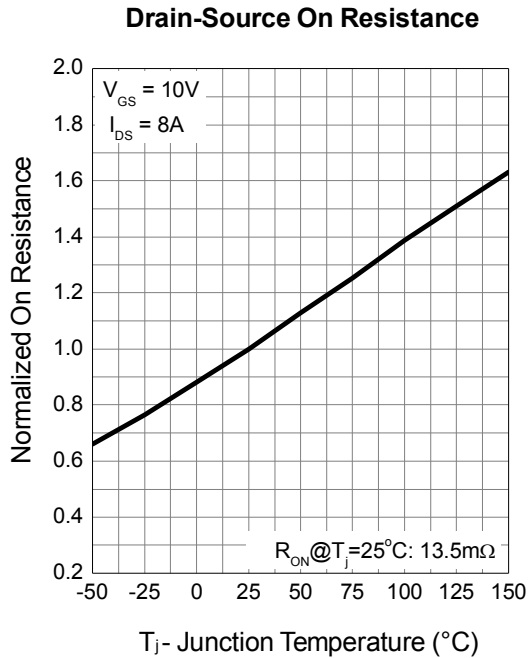
**Gate-Source On Resistance**



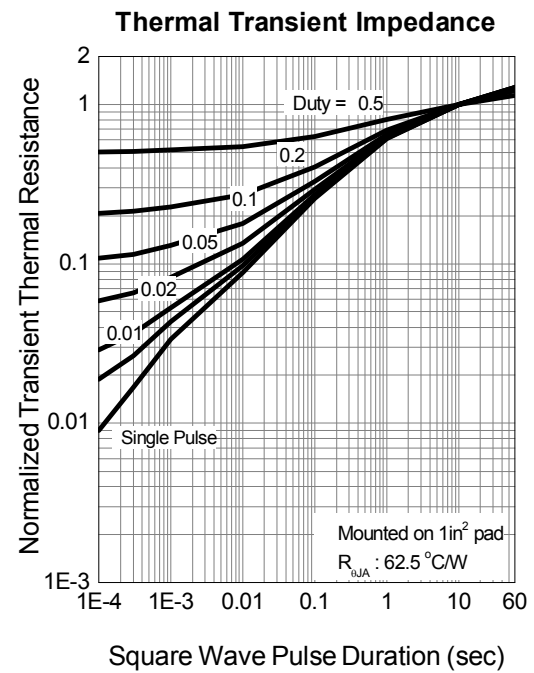
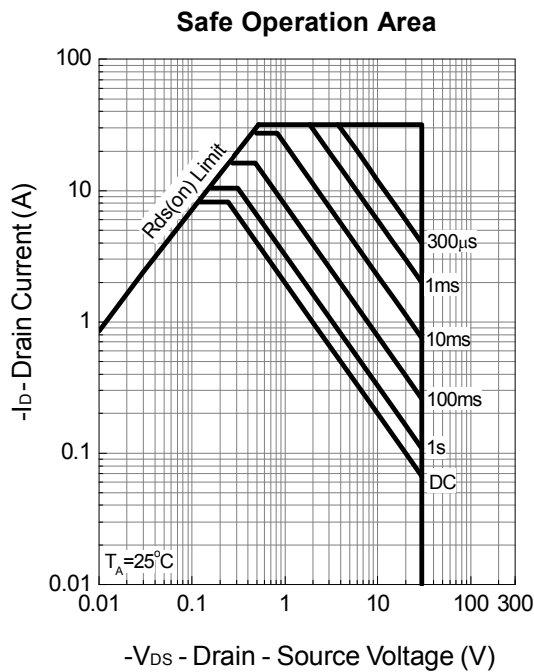
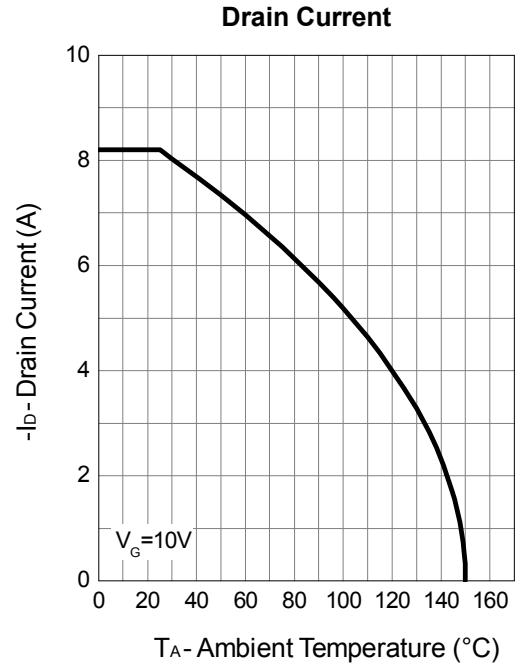
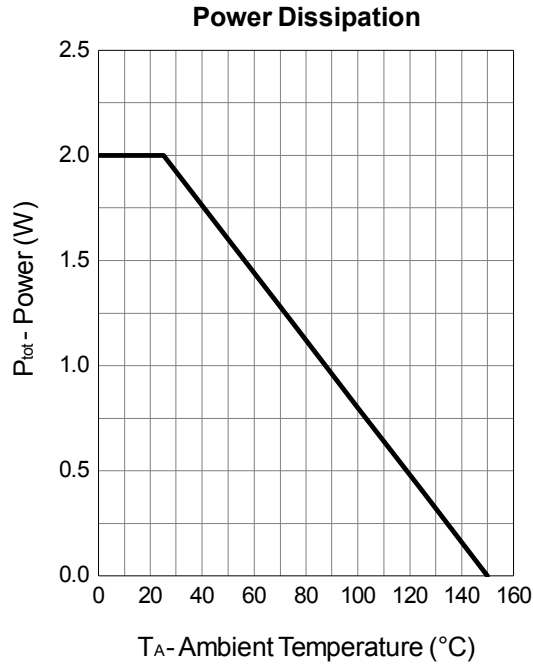
**Gate Threshold Voltage**



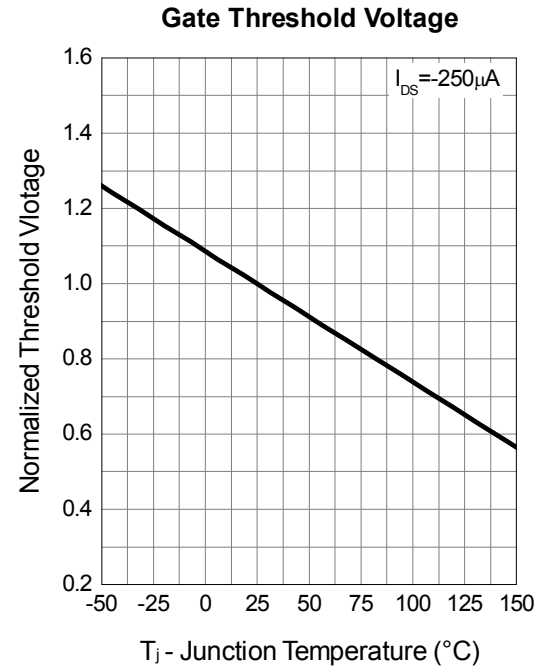
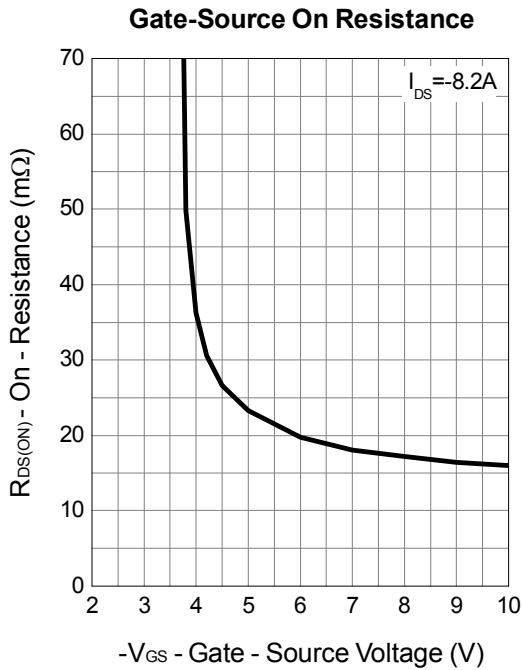
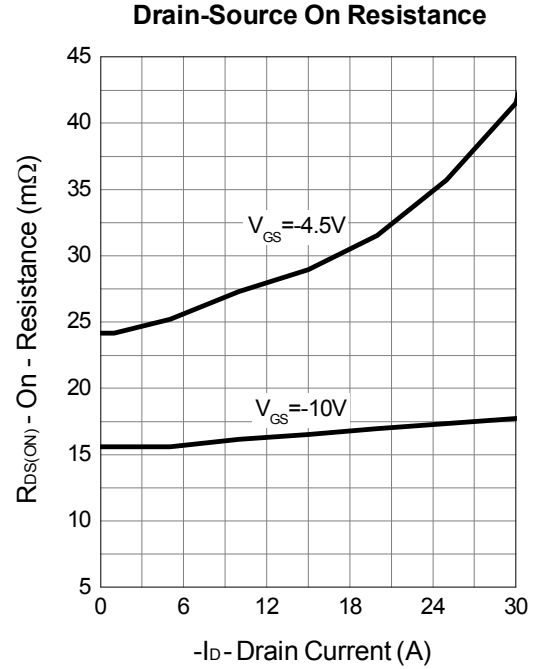
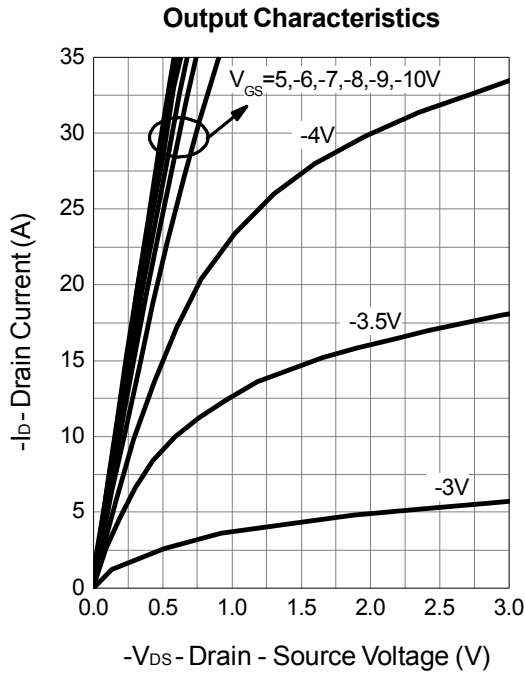
## N Channel Typical Operating Characteristics (Cont.)



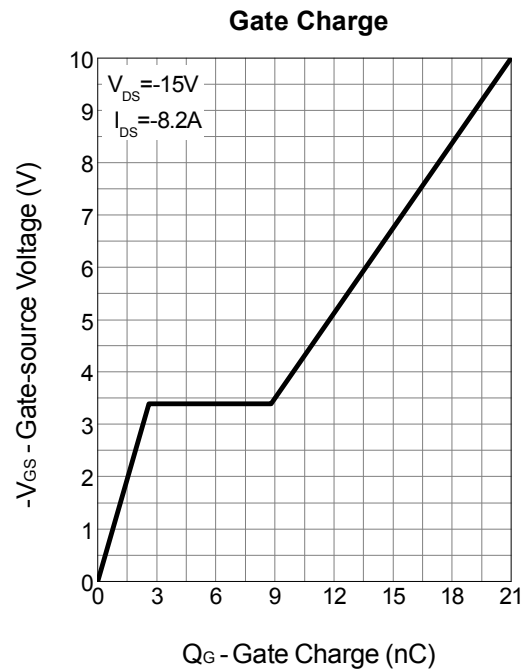
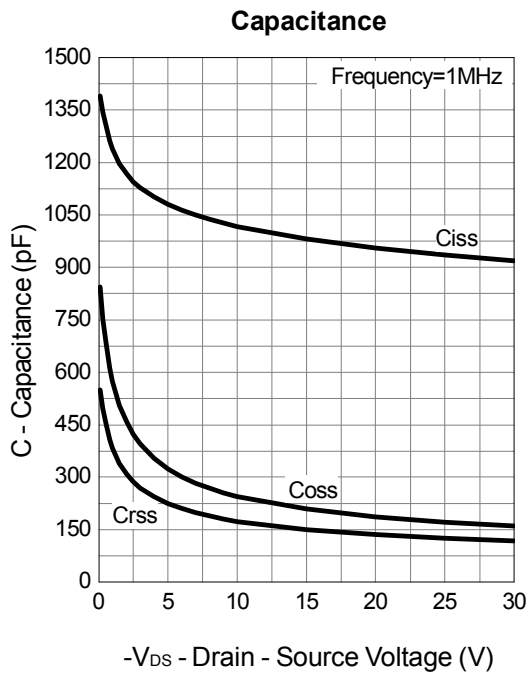
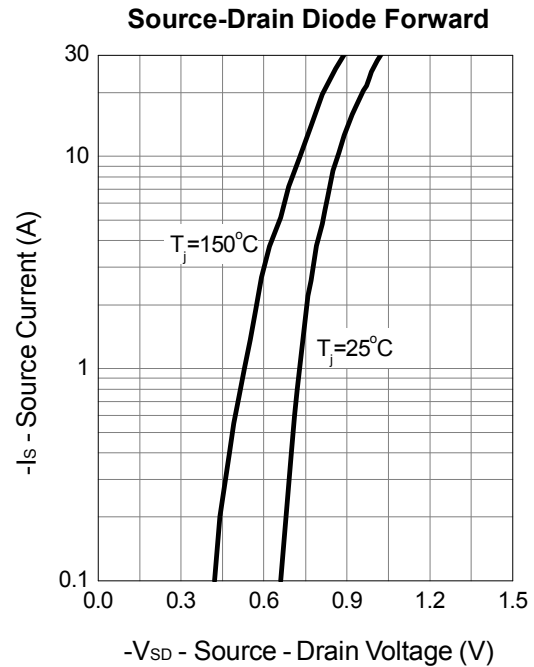
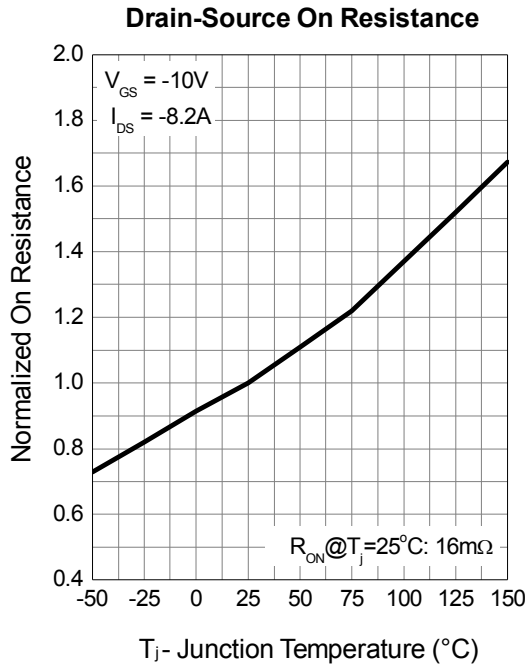
## P Channel Typical Operating Characteristics



## P Channel Typical Operating Characteristics (Cont.)

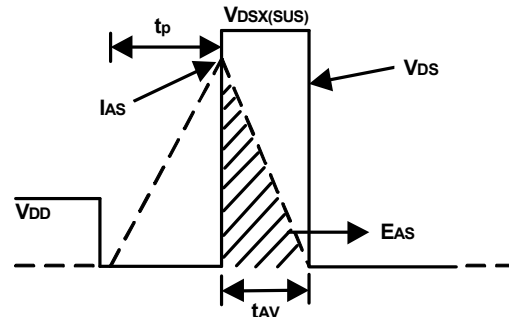
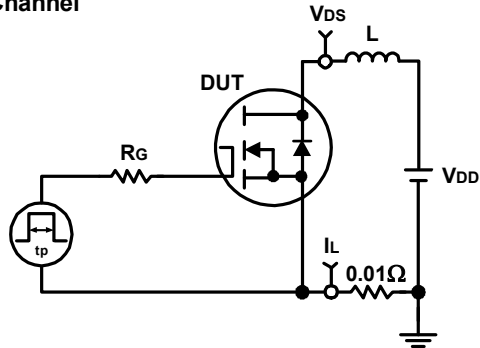


## P Channel Typical Operating Characteristics (Cont.)

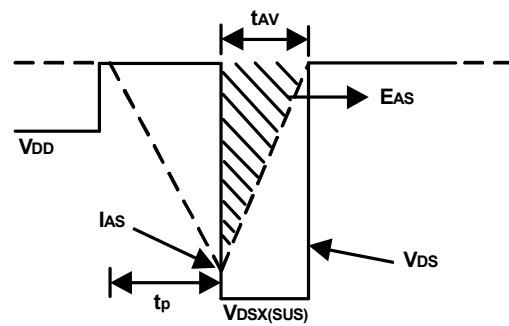
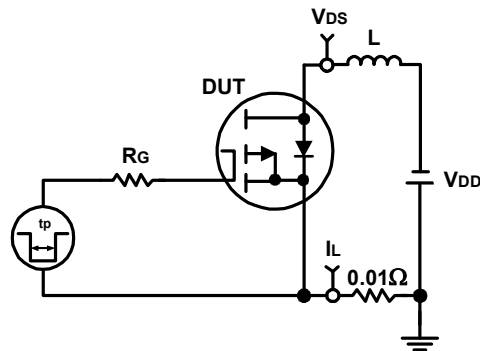


## Avalanche Test Circuit and Waveforms

N Channel

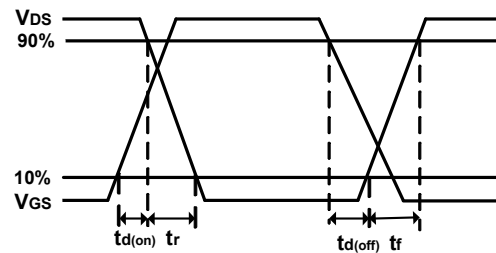
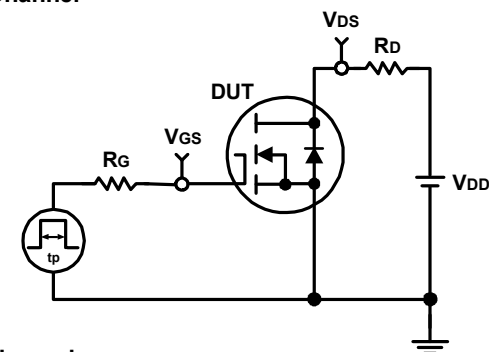


P Channel

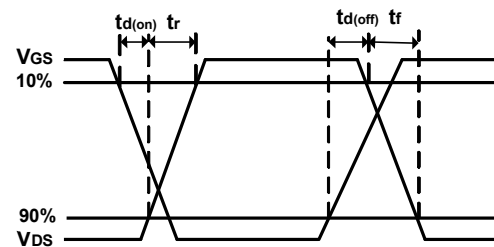
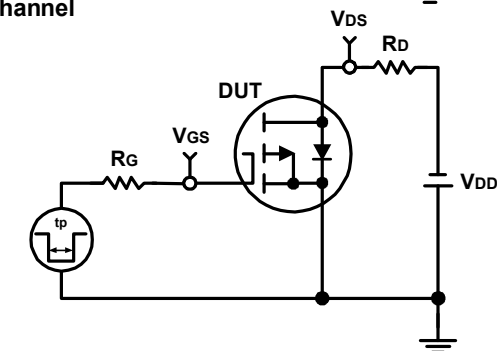


## Switching Time Test Circuit and Waveforms

N Channel



P Channel



## Disclaimer

Sinopower Semiconductor Inc. (hereinafter “Sinopower”) has been making great efforts to develop high quality and better performance products to satisfy all customers’ needs. However, a product may fail to meet customer’s expectation or malfunction for various situations.

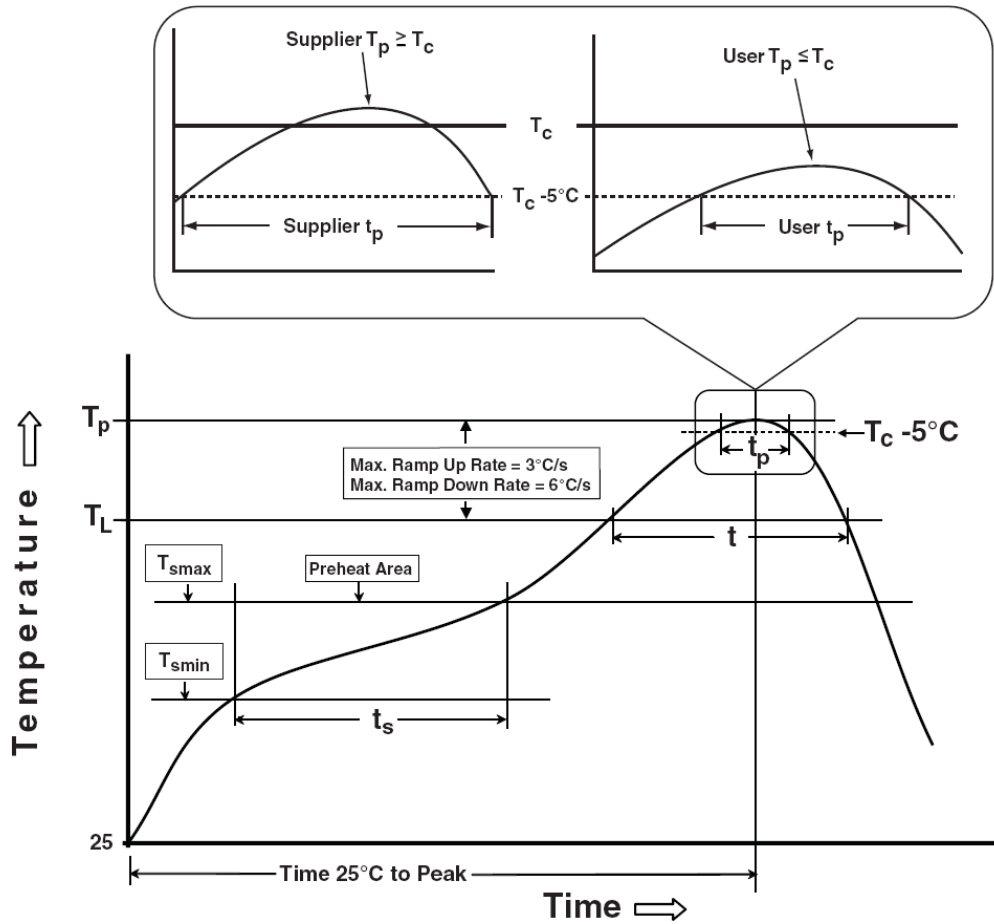
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## Classification Profile



## Classification Reflow Profiles

| Profile Feature                                                                                                  | Sn-Pb Eutectic Assembly            | Pb-Free Assembly                   |
|------------------------------------------------------------------------------------------------------------------|------------------------------------|------------------------------------|
| <b>Preheat &amp; Soak</b>                                                                                        |                                    |                                    |
| Temperature min ( $T_{smin}$ )                                                                                   | 100 °C                             | 150 °C                             |
| Temperature max ( $T_{smax}$ )                                                                                   | 150 °C                             | 200 °C                             |
| Time ( $T_{smin}$ to $T_{smax}$ ) ( $t_s$ )                                                                      | 60-120 seconds                     | 60-120 seconds                     |
| Average ramp-up rate ( $T_{smax}$ to $T_p$ )                                                                     | 3 °C/second max.                   | 3°C/second max.                    |
| Liquidous temperature ( $T_L$ )                                                                                  | 183 °C                             | 217 °C                             |
| Time at liquidous ( $t_L$ )                                                                                      | 60-150 seconds                     | 60-150 seconds                     |
| Peak package body Temperature ( $T_p$ )*                                                                         | See Classification Temp in table 1 | See Classification Temp in table 2 |
| Time ( $t_p$ )** within 5°C of the specified classification temperature ( $T_c$ )                                | 20** seconds                       | 30** seconds                       |
| Average ramp-down rate ( $T_p$ to $T_{smax}$ )                                                                   | 6 °C/second max.                   | 6 °C/second max.                   |
| Time 25°C to peak temperature                                                                                    | 6 minutes max.                     | 8 minutes max.                     |
| * Tolerance for peak profile Temperature ( $T_p$ ) is defined as a supplier minimum and a user maximum.          |                                    |                                    |
| ** Tolerance for time at peak profile temperature ( $t_p$ ) is defined as a supplier minimum and a user maximum. |                                    |                                    |

Table 1. SnPb Eutectic Process – Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>≥350 |
|-------------------|--------------------------------|--------------------------------|
| <2.5 mm           | 235 °C                         | 220 °C                         |
| ≥2.5 mm           | 220 °C                         | 220 °C                         |

Table 2. Pb-free Process – Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>350-2000 | Volume mm <sup>3</sup><br>>2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6 mm           | 260 °C                         | 260 °C                             | 260 °C                          |
| 1.6 mm – 2.5 mm   | 260 °C                         | 250 °C                             | 245 °C                          |
| ≥2.5 mm           | 250 °C                         | 245 °C                             | 245 °C                          |

## Reliability Test Program

| Test item     | Method        | Description                            |
|---------------|---------------|----------------------------------------|
| SOLDERABILITY | JESD-22, B102 | 5 Sec, 245°C                           |
| HTRB          | JESD-22, A108 | 1000 Hrs, 80% of VDS max @ $T_{jmax}$  |
| HTGB          | JESD-22, A108 | 1000 Hrs, 100% of VGS max @ $T_{jmax}$ |
| PCT           | JESD-22, A102 | 168 Hrs, 100%RH, 2atm, 121°C           |
| TCT           | JESD-22, A104 | 500 Cycles, -65°C~150°C                |

## Customer Service

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