

# FMOS2309E-Q1

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# FMOS2309E-Q1

## -1.6A -60V P-Channel Enhancement Mode Power MOSFET

### Features

- $-V_{DS}=60V$ ,  $-I_D=1.6A$ .
- $R_{DS(ON)} \leq 190m\Omega$ , @  $-V_{GS}=10V$ ,  $-I_D=1.5A$ .
- High density cell design for ultra-low on-resistance.
- Fully characterized avalanche voltage and current.
- Excellent package for good heat dissipation.
- Qualified to AEC-Q101 standards for high reliability.
- Lead-free parts meet RoHS requirements
- Suffix "-H" indicates Halogen-free part, ex.FMOS2309E-Q1-H.

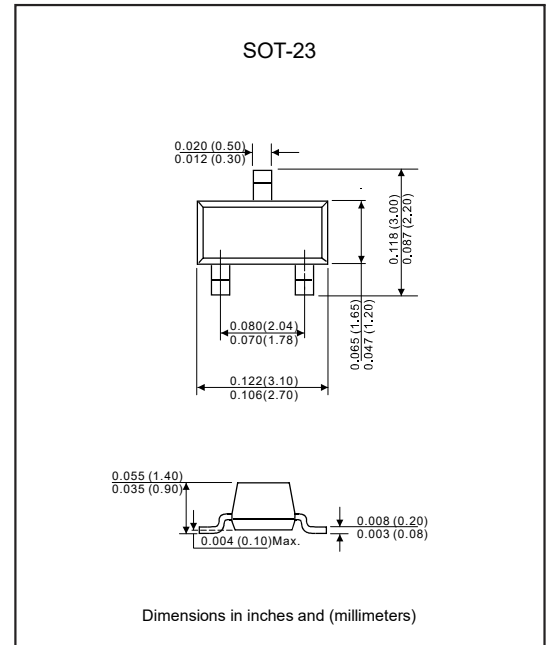
### Application

- Load switch.
- PWM application.

### Mechanical data

- Epoxy:UL94-V0 rated flame retardant.
- Case : Molded plastic, SOT-23.
- Terminals : Solder plated, solderable per MIL-STD-750, Method 2026.
- Mounting Position : Any.

### Package outline



### Maximum Ratings (At $T_A=25^\circ C$ Unless otherwise noted)

| Parameter                                                  | Symbol          | Rating      | Unit         |
|------------------------------------------------------------|-----------------|-------------|--------------|
| Drain source voltage                                       | $-V_{DS}$       | 60          | V            |
| Gate source voltage                                        | $V_{GS}$        | $\pm 20$    | V            |
| Drain current continuous                                   | $-I_D$          | 1.6         | A            |
| Pulsed drain current                                       | $-I_{DM}$       | 8           | A            |
| Power dissipation                                          | $P_D$           | 1.5         | W            |
| Thermal resistance, junction to ambient<br>( $t \leq 5s$ ) | $R_{\theta JA}$ | 83.3        | $^\circ C/W$ |
| Operating junction temperature                             | $T_J$           | +150        | $^\circ C$   |
| Storage temperature range                                  | $T_{STG}$       | -55 to +150 | $^\circ C$   |

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**Electrical characteristics** (At  $T_A=25^{\circ}\text{C}$  unless otherwise specified)

| Parameter                      | Symbol             | Conditions                                                 | Min. | Typ. | Max.      | Unit          |
|--------------------------------|--------------------|------------------------------------------------------------|------|------|-----------|---------------|
| <b>Off characteristics</b>     |                    |                                                            |      |      |           |               |
| Drain-Source breakdown voltage | $-BV_{\text{DSS}}$ | $-I_D=250\mu\text{A}$ , $V_{\text{GS}}=0\text{V}$          | 60   |      |           | V             |
| Drain-Source leakage current   | $-I_{\text{DSS}}$  | $-V_{\text{DS}}=60\text{V}$ , $V_{\text{GS}}=0\text{V}$    |      |      | 1         | $\mu\text{A}$ |
| Gate-Source leakage current    | $I_{\text{GSS}}$   | $V_{\text{GS}}=\pm 20\text{V}$ , $V_{\text{DS}}=0\text{V}$ |      |      | $\pm 100$ | nA            |

**On characteristics** (Note 3)

|                                   |                      |                                                       |     |     |     |            |
|-----------------------------------|----------------------|-------------------------------------------------------|-----|-----|-----|------------|
| Gate threshold voltage            | $-V_{\text{GS(th)}}$ | $V_{\text{DS}}=V_{\text{GS}}$ , $-I_D=250\mu\text{A}$ | 1.4 | 2   | 2.6 | V          |
| Static drain-source on-resistance | $R_{\text{DS(on)}}$  | $-V_{\text{GS}}=10\text{V}$ , $-I_D=1.5\text{A}$      |     | 140 | 190 | m $\Omega$ |
| Forward transconductance          | $g_{\text{FS}}$      | $-V_{\text{DS}}=5\text{V}$ , $-I_D=1.5\text{A}$       |     | 3   |     | S          |

**Dynamic characteristics** (Note4)

|                              |                  |                                                                             |  |      |  |    |
|------------------------------|------------------|-----------------------------------------------------------------------------|--|------|--|----|
| Input capacitance            | $C_{\text{iss}}$ | $-V_{\text{DS}}=30\text{V}$ , $V_{\text{GS}}=0\text{V}$ , $f=1.0\text{MHz}$ |  | 370  |  | pF |
| Output capacitance           | $C_{\text{oss}}$ |                                                                             |  | 31.5 |  |    |
| Reverse transfer capacitance | $C_{\text{rss}}$ |                                                                             |  | 5    |  |    |

**Switching characteristics** (Note 4)

|                     |                     |                                                                                                         |  |      |  |               |
|---------------------|---------------------|---------------------------------------------------------------------------------------------------------|--|------|--|---------------|
| Total gate charge   | $Q_g$               | $-V_{\text{GS}}=10\text{V}$ , $-V_{\text{DS}}=30\text{V}$ , $-I_D=1.5\text{A}$                          |  | 14.3 |  | nC            |
| Gate-Source charge  | $Q_{\text{gs}}$     |                                                                                                         |  | 2.2  |  |               |
| Gate-Drain Charge   | $Q_{\text{gd}}$     |                                                                                                         |  | 3.2  |  |               |
| Turn-on delay time  | $t_{\text{d(on)}}$  | $-V_{\text{DD}}=30\text{V}$ , $-V_{\text{GS}}=10\text{V}$ , $R_{\text{G}}=3\Omega$ , $-I_D=1.5\text{A}$ |  | 40   |  | ns            |
| Turn-on rise time   | $t_r$               |                                                                                                         |  | 35   |  |               |
| Turn-off delay time | $t_{\text{d(off)}}$ |                                                                                                         |  | 15   |  | $\mu\text{s}$ |
| Turn-off fall time  | $t_f$               |                                                                                                         |  | 10   |  |               |

**Drain-Source diode characteristics and maximum ratings**

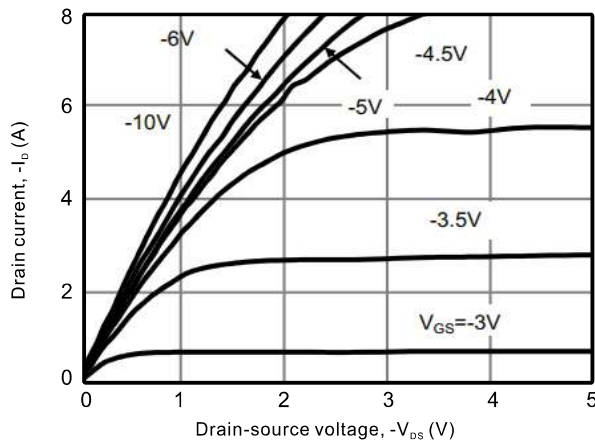
|                                                          |                  |                                                                                  |  |    |     |    |
|----------------------------------------------------------|------------------|----------------------------------------------------------------------------------|--|----|-----|----|
| Drain-Source diode forward voltage (Note 3)              | $-V_{\text{SD}}$ | $-I_S=1.5\text{A}$ , $V_{\text{GS}}=0\text{V}$                                   |  |    | 1.2 | V  |
| Maximum continuous drain-source forward current (Note 2) | $-I_S$           |                                                                                  |  |    | 1.6 | A  |
| Body diode reverse recovery time                         | $t_{\text{rr}}$  | $-I_F=1.5\text{A}$ , $di/dt=-100\text{A}/\mu\text{s}$ , $T_J=25^{\circ}\text{C}$ |  | 25 |     | ns |
| Body diode reverse recovery charge                       | $Q_{\text{rr}}$  |                                                                                  |  | 31 |     | nC |

Note: 1. Repetitive rating; pulse width limited by maximum junction temperature.  
2. Surface mounted on FR-4 board,  $t \leq 10$  seconds.  
3. Pulse test: pulse width  $\leq 300\mu\text{s}$ , duty cycle  $\leq 2\%$ .  
4. Guaranteed by design, not subject to production.

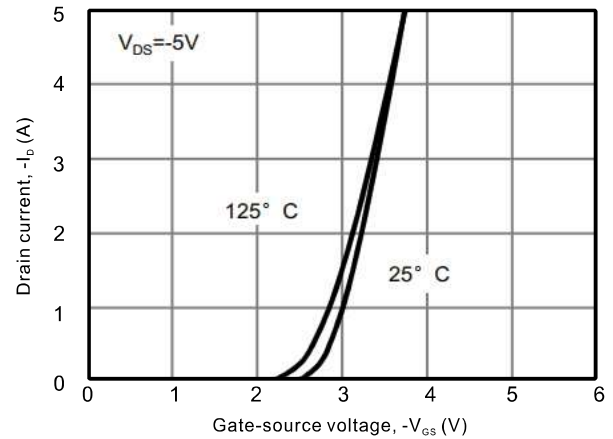
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## Rating and characteristic curves

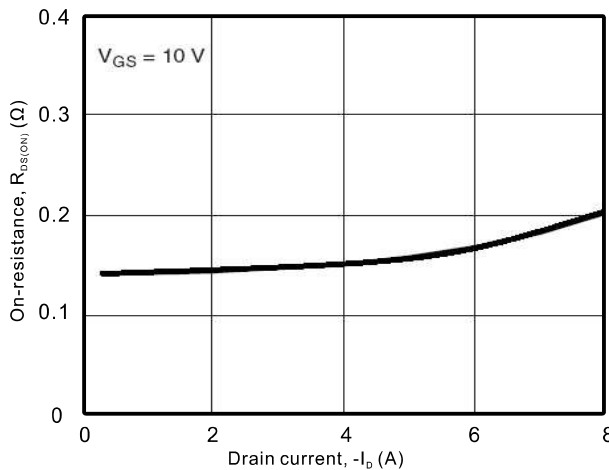
Output characteristics



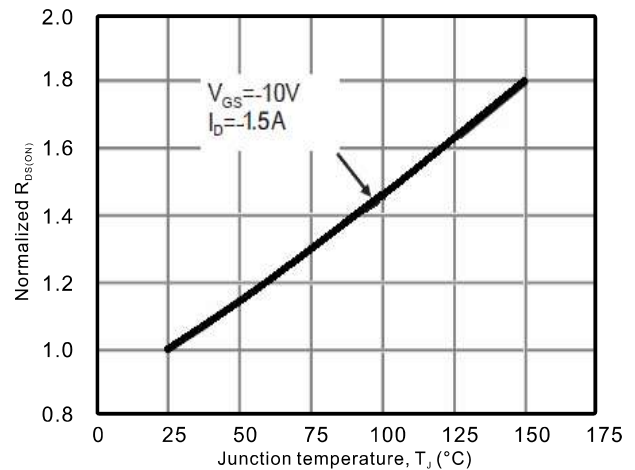
Transfer characteristics



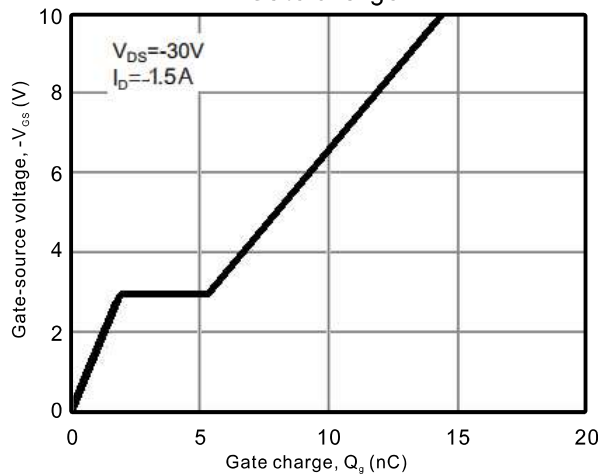
On-resistance vs. Drain current



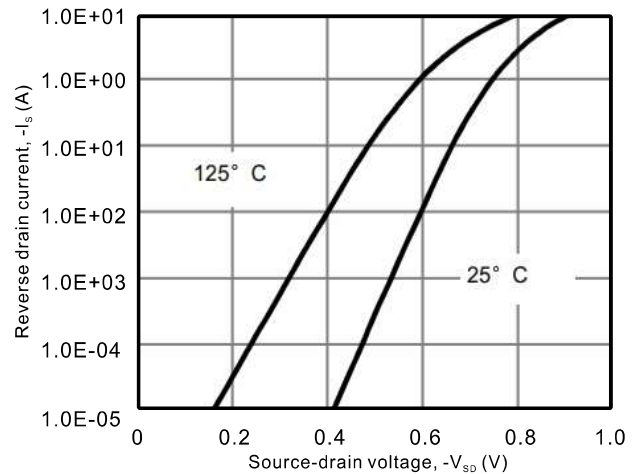
On-resistance vs. Junction temperature



Gate charge

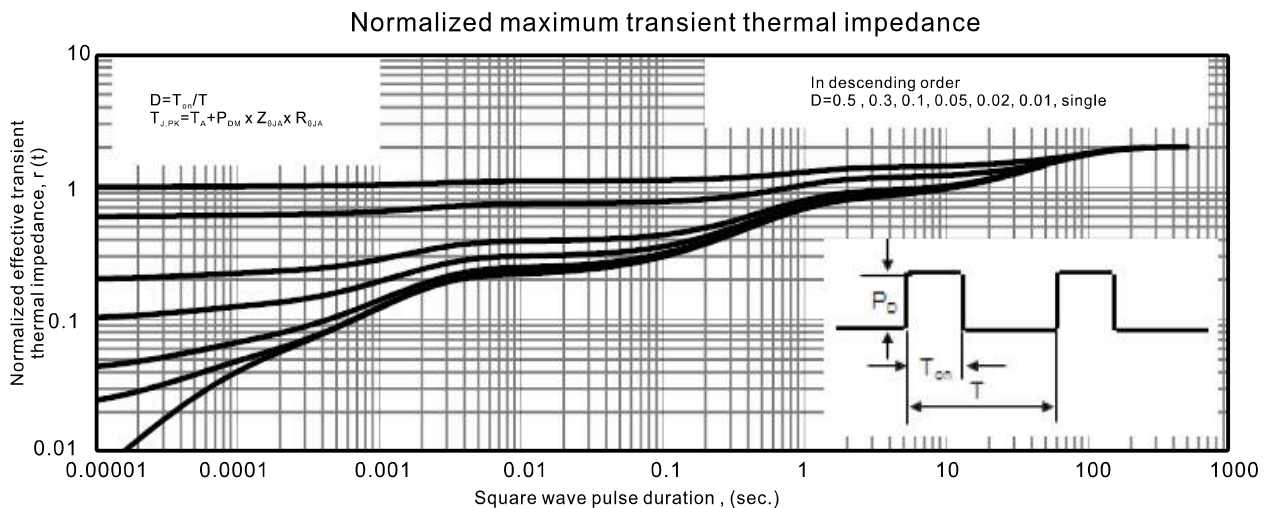
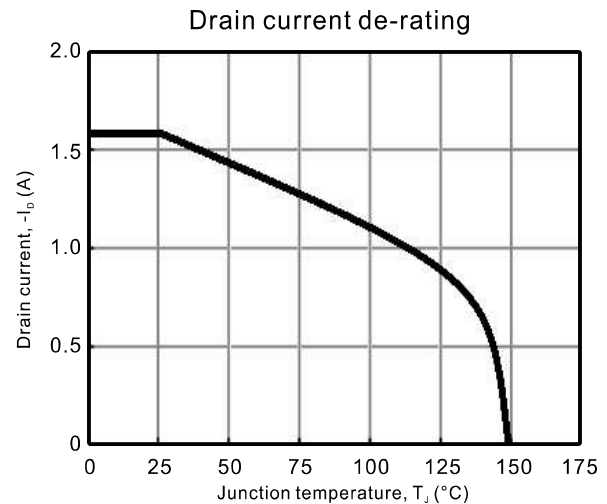
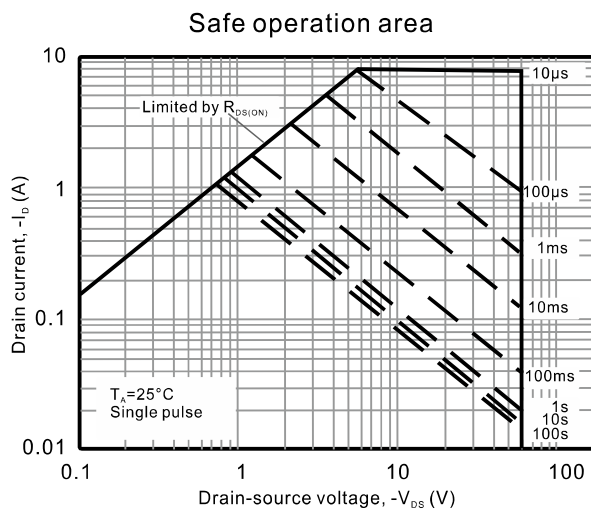
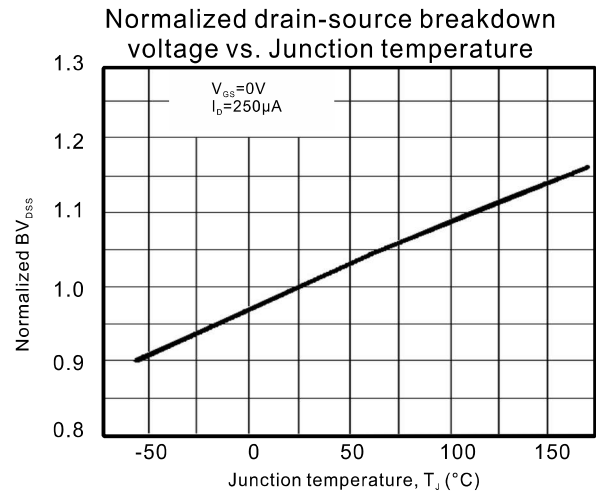
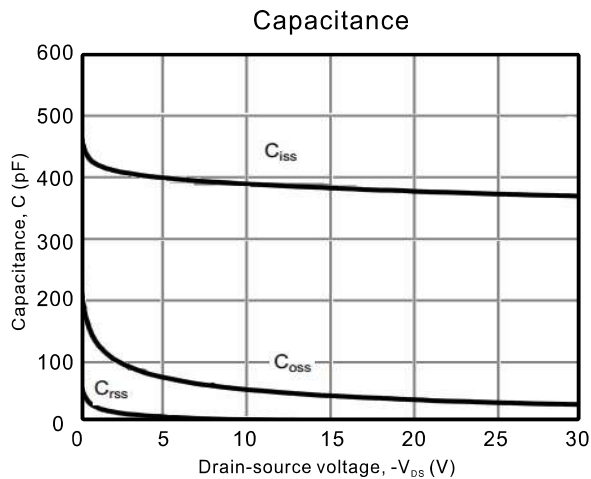


Source-drain diode forward



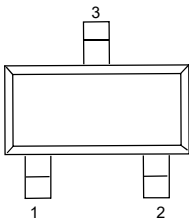
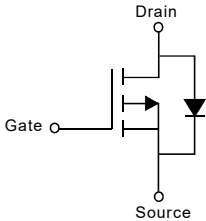
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## Rating and characteristic curves



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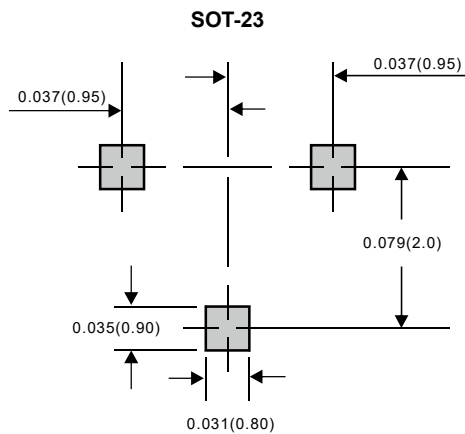
Pinning information

| Pin                                       | Simplified outline                                                                | Symbol                                                                              |
|-------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Pin 1 Gate<br>Pin 2 Source<br>Pin 3 Drain |  |  |

Marking

| Type number  | Marking code |
|--------------|--------------|
| FMOS2309E-Q1 | 2309         |

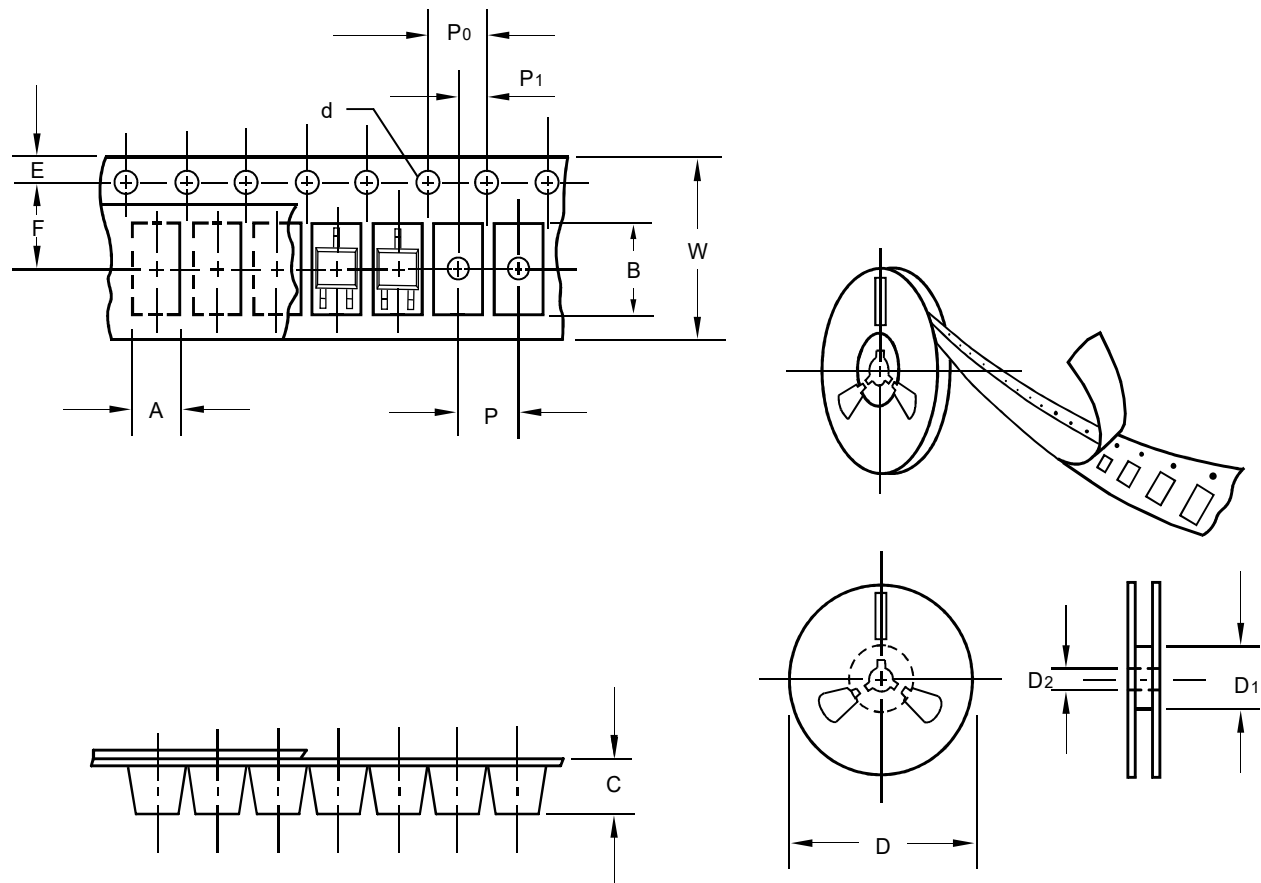
Suggested solder pad layout



Dimensions in inches and (millimeters)

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Packing information



unit:mm

| Item                      | Symbol | Tolerance | SOT-23 |
|---------------------------|--------|-----------|--------|
| Carrier width             | A      | 0.1       | 3.15   |
| Carrier length            | B      | 0.1       | 2.77   |
| Carrier depth             | C      | 0.1       | 1.22   |
| Sprocket hole             | d      | 0.1       | 1.50   |
| 13" Reel outside diameter | D      | 2.0       | -      |
| 13" Reel inner diameter   | D1     | min       | -      |
| 7" Reel outside diameter  | D      | 2.0       | 178.00 |
| 7" Reel inner diameter    | D1     | min       | 50.00  |
| Feed hole diameter        | D2     | 0.5       | 13.00  |
| Sprocket hole position    | E      | 0.1       | 1.75   |
| Punch hole position       | F      | 0.1       | 3.50   |
| Punch hole pitch          | P      | 0.1       | 4.00   |
| Sprocket hole pitch       | P0     | 0.1       | 4.00   |
| Embossment center         | P1     | 0.1       | 2.00   |

Note: Devices are packed in accordance with EIA standard RS-481-A and specifications listed above.

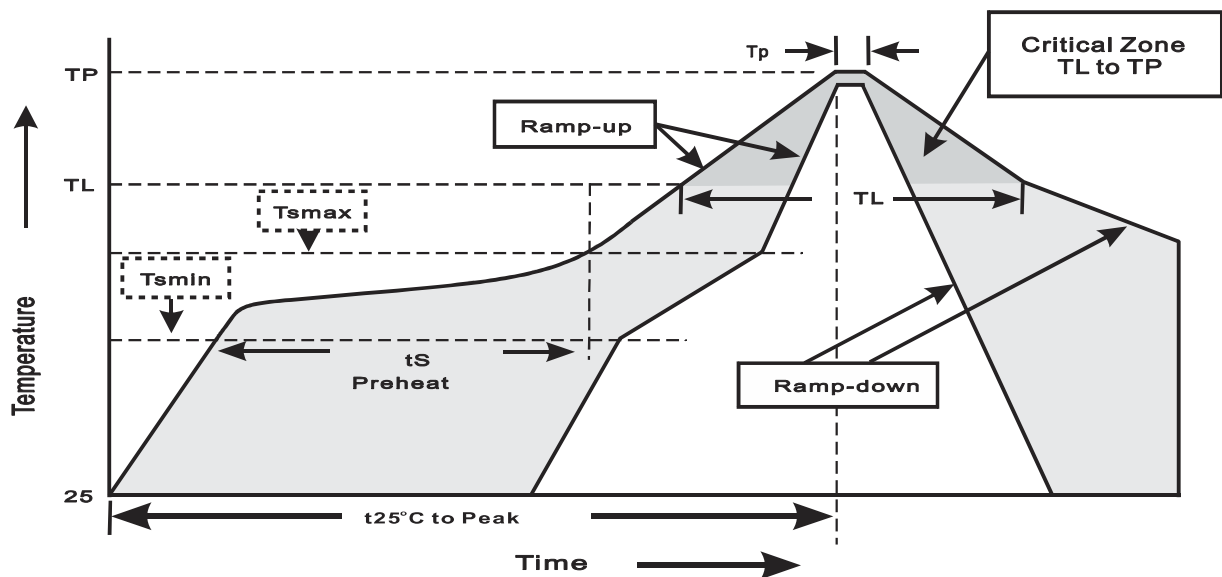
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## Reel packing

| PACKAGE | REEL SIZE | REEL (pcs) | COMPONENT SPACING (m/m) | BOX (pcs) | INNER BOX (m/m) | REEL DIA, (m/m) | CARTON SIZE (m/m) | CARTON (pcs) |
|---------|-----------|------------|-------------------------|-----------|-----------------|-----------------|-------------------|--------------|
| SOT-23  | 7"        | 3,000      | 4.0                     | 30,000    | 183*123*183     | 178             | 382*257*387       | 240,000      |

## Suggested thermal profiles for soldering processes

- 1.Storage environment: Temperature=5°C~40°C Humidity=55%±25%
- 2.Reflow soldering of surface-mount devices



## 3.Reflow soldering

| Profile Feature                                                                                           | Soldering Condition         |
|-----------------------------------------------------------------------------------------------------------|-----------------------------|
| Average ramp-up rate( $T_L$ to $T_P$ )                                                                    | $< 3^\circ\text{C/sec}$     |
| Preheat<br>-Temperature Min( $T_{smin}$ )<br>-Temperature Max( $T_{smax}$ )<br>-Time(min to max)( $t_s$ ) | 150°C<br>200°C<br>60~120sec |
| $T_{smax}$ to $T_L$<br>-Ramp-upRate                                                                       | $< 3^\circ\text{C/sec}$     |
| Time maintained above:<br>-Temperature( $T_L$ )<br>-Time( $t_L$ )                                         | 217°C<br>60~260sec          |
| Peak Temperature( $T_P$ )                                                                                 | 255°C-0/+5°C                |
| Time within 5°C of actual Peak Temperature( $t_P$ )                                                       | 10~30sec                    |
| Ramp-down Rate                                                                                            | $< 6^\circ\text{C/sec}$     |
| Time 25°C to Peak Temperature                                                                             | $< 6$ minutes               |

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## High reliability test capabilities

| Item Test                                      | Conditions                                                                               | Reference                     |
|------------------------------------------------|------------------------------------------------------------------------------------------|-------------------------------|
| 1. MSL Preconditioning                         | 24hr bake@125°C+168hrs@85°C<br>/85%RH+3xIR@260°C+1flux<br>immersion+alcohol+DI H2O rinse | JESD22-A113                   |
| 2. High Temperature Reverse Bias               | $V_{DS}=V_{DS} \times 80\%$ ( $T_J=T_J \text{ max.}$ ) Test Duration:1000hrs             | JESD22-A108                   |
| 3. High Temperature Storage Life               | $T_a=150^\circ\text{C}$ Test Duration:1000hrs                                            | JESD22 A-103                  |
| 4. Temperature Cycle                           | $-55^\circ\text{C}$ (15min) to $150^\circ\text{C}$ (15min) Test Cycles:1000cycles        | JESD22 A-104                  |
| 5. Autoclave                                   | $P=2\text{atm}$ $T_a=121^\circ\text{C}$ $\text{RH}=100\%$ Test Duration:96hrs            | JESD22 A-102                  |
| 6. Solderability                               | $245 \pm 5^\circ\text{C}$ for 5sec                                                       | J-STD-002                     |
| 7. Moisture Resistance                         | $T_a=85^\circ\text{C}$ / 85% Relative humidity Test Duration:1000hrs                     | MIL-STD-750E<br>METHOD 1021.2 |
| 8. Resistance To Solder Heat                   | $260 \pm 5^\circ\text{C}$ for 10sec                                                      | JESD22 B-106                  |
| 9. High Temperature High Humidity Reverse Bias | $T_a=85^\circ\text{C}$ , 85%RH, $V_{DS}=80\%$ rated $V_{DS}$ Test Duration: 1000hrs      | JESD22-A101                   |