

## Dual, 200mA Output, Low Noise, High PSRR Low-Dropout Linear Regulators

### FEATURES

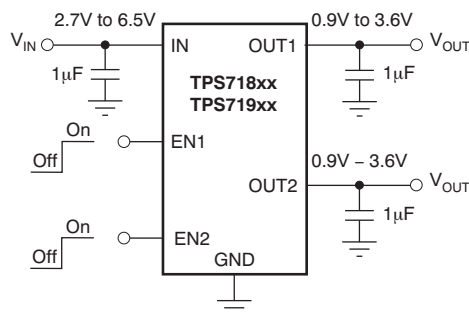
- Dual, 200mA High-Performance LDOs
- Low Total Quiescent Current: 90µA with Both LDOs Enabled
- Low Noise: 70µV<sub>RMS</sub>/V
- Active Output Pulldown (TPS719xx)
- Independent Enables for Each LDO
- PSRR: 65dB at 1kHz, 45dB at 1MHz
- Available in Multiple Fixed-Output Voltage Combinations from 0.9V to 3.6V Using Innovative Factory EEPROM Programming
- Fast Start-Up Time: 160µs
- Over-Current, Over-Temperature and Under-Voltage Protection
- Low Dropout: 230mV at 200mA
- Stable with 1µF Ceramic Output Capacitor
- Available in 2mm × 2mm SON-6 and 6-Ball WCSP Packages

### DESCRIPTION

The TPS718xx and TPS719xx families of low-dropout (LDO) regulators offer a high power-supply rejection ratio (PSRR), low noise, fast start-up, and excellent line and load transient responses while consuming a very low 90µA (typical) at no load ground current with both LDOs enabled. The TPS719xx also provides an active pulldown circuit to quickly discharge output loads. The TPS718xx and TPS719xx are stable with ceramic capacitors and use an advanced BiCMOS fabrication process to yield a typical dropout voltage of 230mV at 200mA output loads. The TPS718xx and TPS719xx also use a precision voltage reference and feedback loop to achieve 3% overall accuracy over all load, line, process, and temperature variations. Both families of devices are fully specified from  $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  and are offered in 2mm × 2mm SON-6 and 6-ball Wafer Chip-Scale (WCSP) packages that are ideal for applications such as mobile handsets and WLAN that require good thermal dissipation while maintaining a very small footprint.

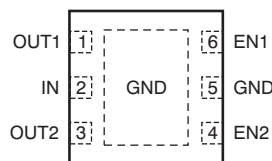
### APPLICATIONS

- Digital Cameras and Camera Modules
- Cellular Camera and TV Phones
- Wireless LAN, Bluetooth®
- Handheld Products

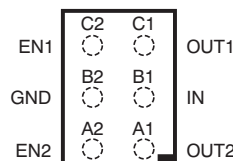


Typical Application Circuit

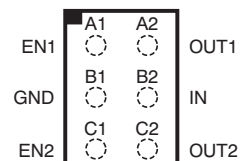
TPS718xx, TPS719xx  
DRV Package  
2mm x 2mm SON-6  
(Top View)



TPS718xx, TPS719xx  
YZC Package  
6-BALL WCSP  
(Top View)



TPS718Axx, TPS719Axx  
YZC Package  
6-BALL WCSP  
(Top View)



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This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## ORDERING INFORMATION<sup>(1)</sup>

| PRODUCT                                                                    | V <sub>OUT</sub> <sup>(2)(3)</sup>                                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TPS718xx-yywwwz<br>TPS718Axx-yywwwz<br>TPS719xx-yywwwz<br>TPS719Axx-yywwwz | <b>A</b> denotes device with rotated pin 1 orientation of wafer-chipscale package.<br><b>XX</b> is nominal output voltage for LDO1 (for example, 28 = 2.8V).<br><b>YY</b> is nominal output voltage for LDO2.<br><b>WWW</b> is package designator.<br><b>Z</b> is tape and reel quantity (R = 3000, T = 250). |
| <b>Examples:</b> TPS71918–285DRV<br>TPS719185–33DRV                        | <b>XX</b> = 18 = 1.8V, <b>YYY</b> = 285 = 2.85V<br><b>XXX</b> = 185 = 1.85V, <b>YY</b> = 33 = 3.3V<br><b>DRV</b> = 2mm x 2mm SON package<br><b>Z</b> = R = 3000 piece reel                                                                                                                                    |

- (1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).
- (2) Both outputs are programmable from 0.9V to 3.6V in 50mV increments.
- (3) Output voltages from 0.9V to 3.6V in 50mV increments are available through the use of innovative factory EEPROM programming; minimum order quantities may apply. Contact factory for details and availability.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Over operating temperature range (unless otherwise noted). All voltages are with respect to GND.

| PARAMETER                                                   | TPS718xx, TPS719xx                            | UNIT |
|-------------------------------------------------------------|-----------------------------------------------|------|
| Input voltage range, V <sub>IN</sub>                        | –0.3 to +7.0                                  | V    |
| Enable voltage range, V <sub>EN1</sub> and V <sub>EN2</sub> | –0.3 to V <sub>IN</sub> + 0.3V                | V    |
| Output voltage range, V <sub>OUT</sub>                      | –0.3 to +7.0                                  | V    |
| Peak output current                                         | Internally limited                            |      |
| Output short-circuit duration                               | Indefinite                                    |      |
| Junction temperature range, T <sub>J</sub>                  | –55 to +150                                   | °C   |
| Storage temperature range, T <sub>STG</sub>                 | –55 to +150                                   | °C   |
| Total continuous power dissipation, P <sub>DISS</sub>       | See <a href="#">Dissipation Ratings</a> Table |      |
| ESD rating, HBM                                             | 2                                             | kV   |
| ESD rating, CDM                                             | 500                                           | V    |

- (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

## DISSIPATION RATINGS

| BOARD                 | PACKAGE | R <sub>θJC</sub> | R <sub>θJA</sub> | DERATING FACTOR<br>ABOVE T <sub>A</sub> = +25°C | T <sub>A</sub> < +25°C | T <sub>A</sub> = +70°C | T <sub>A</sub> = +85°C |
|-----------------------|---------|------------------|------------------|-------------------------------------------------|------------------------|------------------------|------------------------|
| High-K <sup>(1)</sup> | DRV     | 20°C/W           | 95°C/W           | 10.53mW/°C                                      | 1053mW                 | 579mW                  | 421mW                  |
| High-K <sup>(1)</sup> | YZC     | 27°C/W           | 190°C/W          | 5.3mW/°C                                        | 530mW                  | 295mW                  | 215mW                  |

- (1) The JEDEC high-K (2s2p) board used to derive this data was a 3in × 3in, multilayer board with 1-ounce internal power and ground planes and 2-ounce copper traces on top and bottom of the board.

## ELECTRICAL CHARACTERISTICS

Over operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ),  $V_{IN} = V_{OUT(TYP)} + 0.5\text{V}$  or  $2.7\text{V}$ , whichever is greater;  
 $I_{OUT} = 0.5\text{mA}$ ,  $V_{EN1} = V_{EN2} = V_{IN}$ ,  $C_{OUT} = 1.0\mu\text{F}$ , unless otherwise noted. Typical values are at  $T_J = +25^{\circ}\text{C}$ .

| PARAMETER                         |                                                                                                                | TEST CONDITIONS                                                                                                                            | MIN  | TYP                 | MAX  | UNIT                |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------|---------------------|------|---------------------|
| $V_{IN}$                          | Input voltage range <sup>(1)</sup>                                                                             |                                                                                                                                            | 2.7  |                     | 6.5  | V                   |
| $V_{OUT1}$ , $V_{OUT2}$           | Output voltage range                                                                                           |                                                                                                                                            | 0.9  |                     | 3.6  | V                   |
| $V_{OUT1}$ , $V_{OUT2}$           | Output accuracy                                                                                                | Nominal<br>$T_J = +25^{\circ}\text{C}$                                                                                                     |      | $\pm 2.5$           |      | mV                  |
|                                   |                                                                                                                | Over $V_{IN}$ , $I_{OUT}$ ,<br>Temp<br>$V_{OUT} + 0.5\text{V} \leq V_{IN} \leq 6.5\text{V}$<br>$0\text{mA} \leq I_{OUT} \leq 200\text{mA}$ | -3.0 |                     | +3.0 | %                   |
| $\Delta V_{OUT} / \Delta V_{IN}$  | Line regulation                                                                                                | $V_{OUT(NOM)} + 0.5\text{V} \leq V_{IN} \leq 6.5\text{V}$ ,<br>$I_{OUT} = 5\text{mA}$                                                      |      | 130                 |      | $\mu\text{V/V}$     |
| $\Delta V_{OUT} / \Delta I_{OUT}$ | Load regulation                                                                                                | $0\text{mA} \leq I_{OUT} \leq 200\text{mA}$                                                                                                |      | 75                  |      | $\mu\text{V/mA}$    |
| $V_{DO}$                          | Dropout voltage <sup>(2)</sup><br>( $V_{IN} = V_{OUT(NOM)} - 0.1\text{V}$ )                                    | $I_{OUT} = 200\text{mA}$                                                                                                                   |      | 230                 | 400  | mV                  |
| $I_{CL}$                          | Output current limit (per output)                                                                              | $V_{OUT} = 0.9 \times V_{OUT(NOM)}$                                                                                                        | 240  | 340                 | 575  | mA                  |
| $I_{GND}$                         | Ground pin current                                                                                             | $I_{OUT1} = I_{OUT2} = 0.1\text{mA}$                                                                                                       |      | 90                  | 160  | $\mu\text{A}$       |
|                                   |                                                                                                                | $I_{OUT1} = I_{OUT2} = 200\text{mA}$                                                                                                       |      | 250                 |      | $\mu\text{A}$       |
| $I_{SHDN}$                        | Shutdown current ( $I_{GND}$ )                                                                                 | $V_{EN1,2} \leq 0.4\text{V}$ , $2.7\text{V} \leq V_{IN} < 4.5\text{V}$ ,<br>$T_J = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$           |      | 0.3                 | 3.0  | $\mu\text{A}$       |
|                                   |                                                                                                                | $V_{EN1,2} \leq 0.4\text{V}$ , $4.5\text{V} \leq V_{IN} \leq 6.5\text{V}$ ,<br>$T_J = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$        |      | 1.8                 |      | $\mu\text{A}$       |
| PSRR                              | Power-supply rejection ratio<br>$V_{IN} = 3.8\text{V}$ , $V_{OUT} = 2.8\text{V}$ ,<br>$I_{OUT} = 200\text{mA}$ | $f = 100\text{Hz}$                                                                                                                         |      | 63                  |      | dB                  |
|                                   |                                                                                                                | $f = 1\text{kHz}$                                                                                                                          |      | 63                  |      | dB                  |
|                                   |                                                                                                                | $f = 10\text{kHz}$                                                                                                                         |      | 72                  |      | dB                  |
|                                   |                                                                                                                | $f = 100\text{kHz}$                                                                                                                        |      | 58                  |      | dB                  |
|                                   |                                                                                                                | $f = 1\text{MHz}$                                                                                                                          |      | 44                  |      | dB                  |
| $V_N$                             | Output noise voltage<br>BW = 100Hz to 100kHz                                                                   |                                                                                                                                            |      | $70 \times V_{OUT}$ |      | $\mu\text{V}_{RMS}$ |
| $T_{STR}$                         | Startup time <sup>(3)</sup>                                                                                    | $R_L = 14\Omega$ , $V_{OUT} = 2.8\text{V}$ ,<br>$C_{OUT} = 1.0\mu\text{F}$                                                                 |      | 160                 |      | $\mu\text{s}$       |
| $T_{SHUT}$                        | Shutdown time <sup>(4), (5)</sup><br>(TPS719xx only)                                                           | $R_L = \infty$ , $C_{OUT} = 1.0\mu\text{F}$ ,<br>$V_{OUT} = 2.8\text{V}$                                                                   |      | 180                 |      | $\mu\text{s}$       |
| $V_{EN(HI)}$                      | Enable high (enabled)<br>(EN1 and EN2)                                                                         | $V_{IN} \leq 5.5\text{V}$                                                                                                                  | 1.2  |                     | 6.5  | V                   |
|                                   |                                                                                                                | $5.5\text{V} < V_{IN} \leq 6.5\text{V}$                                                                                                    | 1.25 |                     | 6.5  | V                   |
| $V_{EN(LO)}$                      | Enable low (shutdown)<br>(EN1 and EN2)                                                                         |                                                                                                                                            | 0    |                     | 0.4  | V                   |
| $I_{EN}$                          | Enable pin current, enabled<br>(EN1 and EN2)                                                                   | $EN1 = EN2 = 6.5\text{V}$                                                                                                                  |      | 0.04                | 1.0  | $\mu\text{A}$       |
| UVLO                              | Undervoltage lockout                                                                                           | $V_{IN}$ rising                                                                                                                            | 2.38 | 2.45                | 2.52 | V                   |
|                                   | Hysteresis                                                                                                     | $V_{IN}$ falling                                                                                                                           |      | 150                 |      | mV                  |
| $T_{SD}$                          | Thermal shutdown temperature                                                                                   | Shutdown, temperature increasing                                                                                                           |      | +160                |      | $^{\circ}\text{C}$  |
|                                   |                                                                                                                | Reset, temperature decreasing                                                                                                              |      | +140                |      | $^{\circ}\text{C}$  |
| $T_J$                             | Operating junction temperature                                                                                 |                                                                                                                                            | -40  |                     | +125 | $^{\circ}\text{C}$  |

(1) Minimum  $V_{IN} = V_{OUT} + V_{DO}$  or  $2.7\text{V}$ , whichever is greater.

(2)  $V_{DO}$  is not measured for devices with  $V_{OUT(NOM)} < 2.8\text{V}$  because minimum  $V_{IN} = 2.7\text{V}$ .

(3) Time from  $V_{EN} = 1.25\text{V}$  to  $V_{OUT} = 95\%$  ( $V_{OUT(NOM)}$ ).

(4) Time from  $V_{EN} = 0.4\text{V}$  to  $V_{OUT} = 5\%$  ( $V_{OUT(NOM)}$ ).

(5) See [Shutdown](#) section in the Applications Information for more details.

## DEVICE INFORMATION

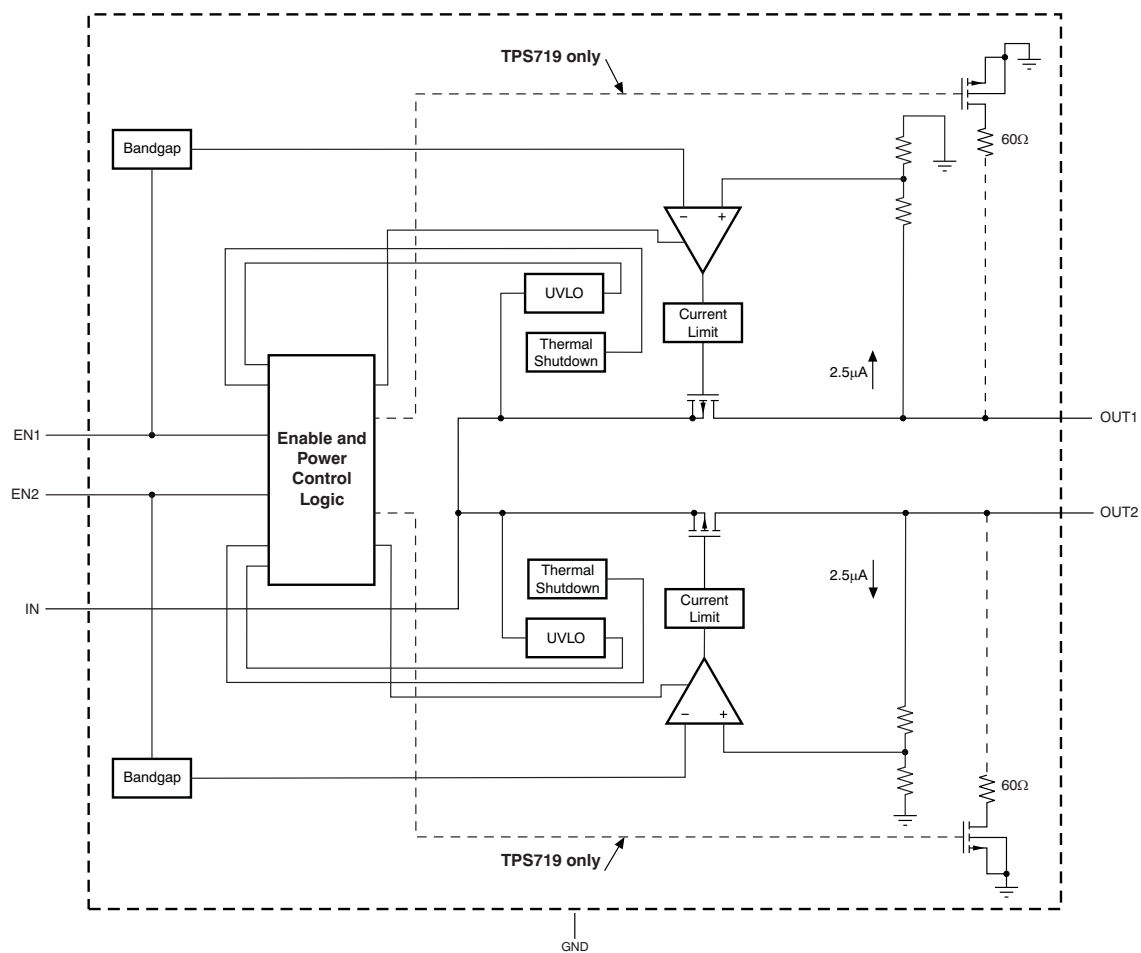
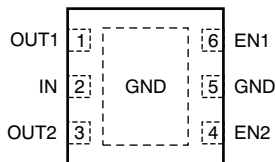
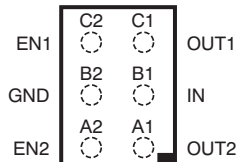
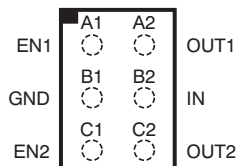


Figure 1. Functional Block Diagram

**DRV PACKAGE  
SON-6  
(TOP VIEW)**

**YZC PACKAGE  
6-BALL WCSP  
(TOP VIEW)**


TPS718xx  
TPS719xx

**YZC PACKAGE  
6-BALL WCSP  
(TOP VIEW)**


TPS718Axx  
TPS719Axx

**PIN DESCRIPTIONS**

| TPS718xx<br>TPS719xx |     |     | TPS718Axx <sup>(1)</sup><br>TPS719Axx <sup>(1)</sup> | DESCRIPTION                                                                                                                                                               |
|----------------------|-----|-----|------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME                 | DRV | YZC | YZC                                                  |                                                                                                                                                                           |
| OUT1                 | 1   | C1  | A2                                                   | Output of Regulator 1. A small ceramic capacitor (typically $\geq 1\mu\text{F}$ ) is needed from this pin to ground to assure stability.                                  |
| IN                   | 2   | B1  | B2                                                   | Input supply to both regulators.                                                                                                                                          |
| OUT2                 | 3   | A1  | C2                                                   | Output of Regulator 2. A small ceramic capacitor (typically $\geq 1\mu\text{F}$ ) is needed from this pin to ground to assure stability.                                  |
| EN2                  | 4   | A2  | C1                                                   | Enable pin for Regulator 2. Driving the Enable pin (EN2) high turns on Regulator 2. Driving this pin low puts Regulator 2 into shutdown mode, reducing operating current. |
| GND                  | 5   | B2  | B1                                                   | Ground. DRV thermal pad should also be connected to ground.                                                                                                               |
| EN1                  | 6   | C2  | A1                                                   | Enable pin for Regulator 1. Driving the Enable pin (EN1) high turns on Regulator 1. Driving this pin low puts Regulator 1 into shutdown mode, reducing operating current. |

(1) **A** option denotes devices with rotated Pin 1 orientation on Wafer Chipscale packages.

## TYPICAL CHARACTERISTICS

Over operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ),  $V_{IN} = V_{OUT(TYP)} + 0.5\text{V}$  or  $2.7\text{V}$ , whichever is greater;  
 $I_{OUT} = 0.5\text{mA}$ ,  $V_{EN1} = V_{EN2} = V_{IN}$ ,  $C_{OUT} = 1.0\mu\text{F}$ , unless otherwise noted. Typical values are at  $T_J = +25^{\circ}\text{C}$ .

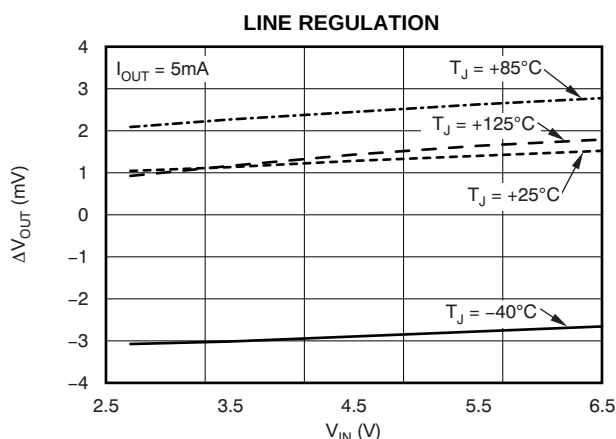


Figure 2.

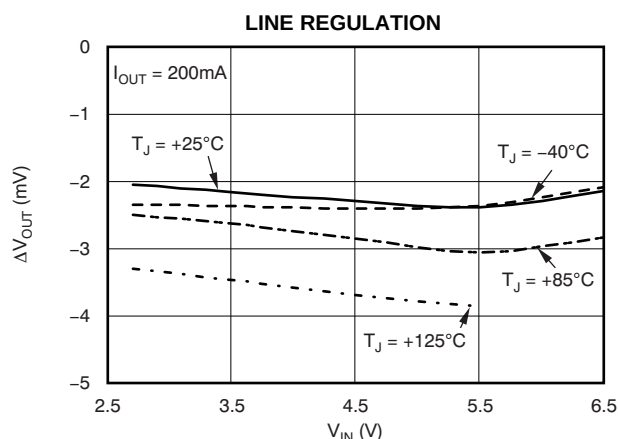


Figure 3.

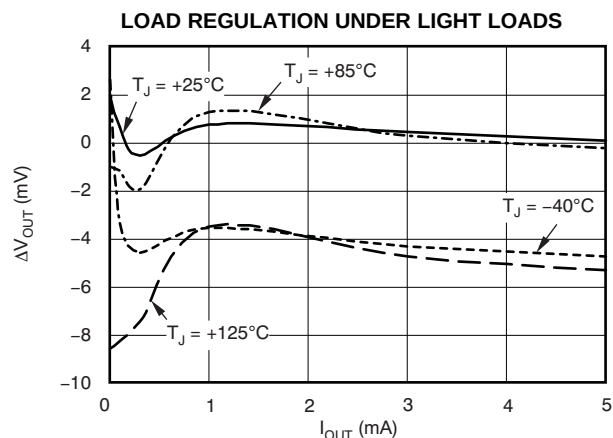


Figure 4.

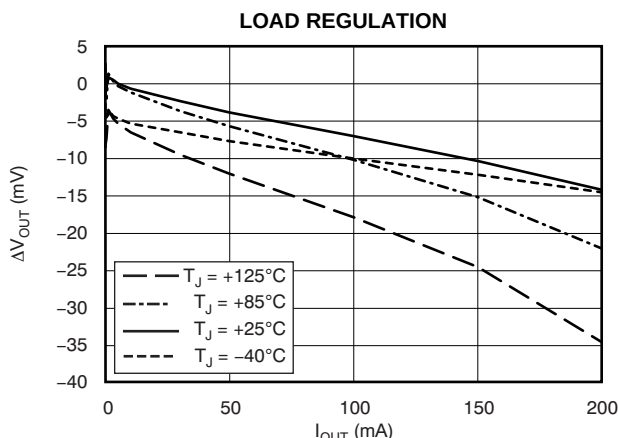


Figure 5.

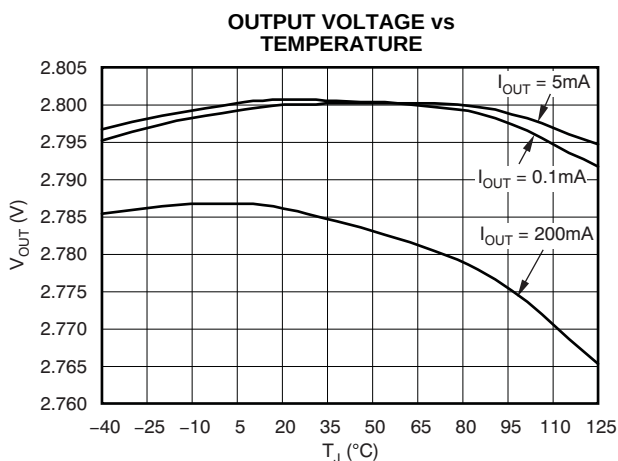


Figure 6.

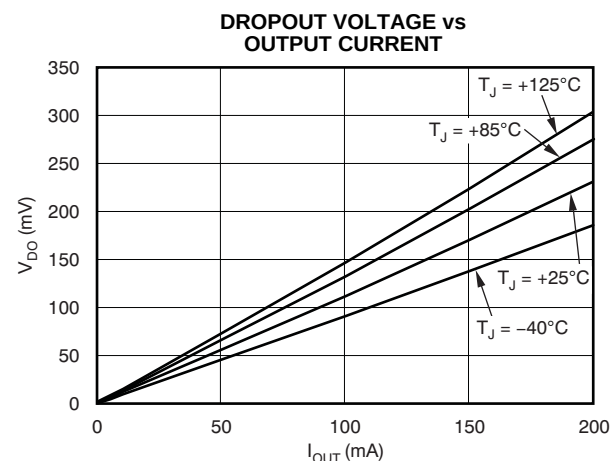


Figure 7.

## TYPICAL CHARACTERISTICS (continued)

Over operating temperature range ( $T_J = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ ),  $V_{IN} = V_{OUT(TYP)} + 0.5\text{V}$  or  $2.7\text{V}$ , whichever is greater;  $I_{OUT} = 0.5\text{mA}$ ,  $V_{EN1} = V_{EN2} = V_{IN}$ ,  $C_{OUT} = 1.0\mu\text{F}$ , unless otherwise noted. Typical values are at  $T_J = +25^\circ\text{C}$ .

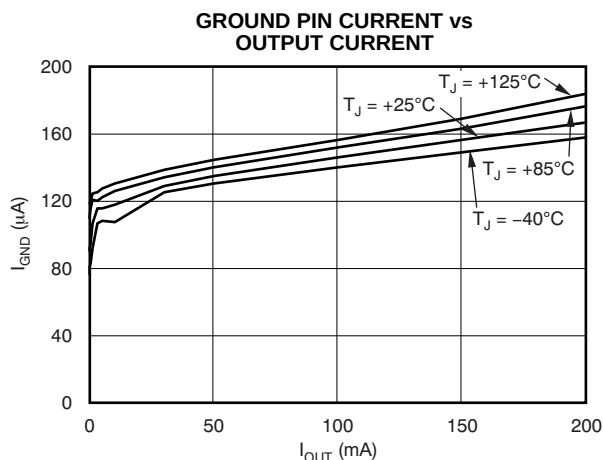


Figure 8.

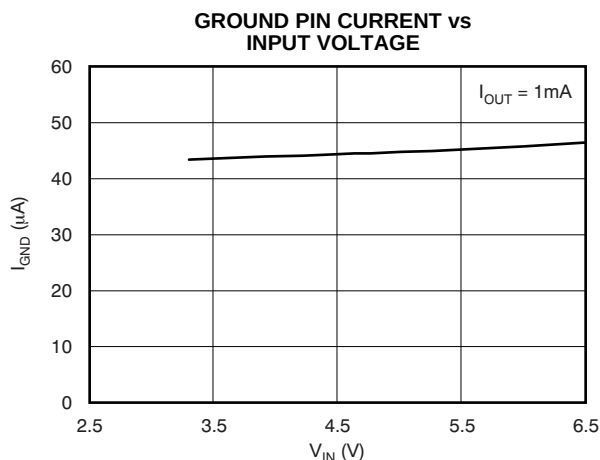


Figure 9.

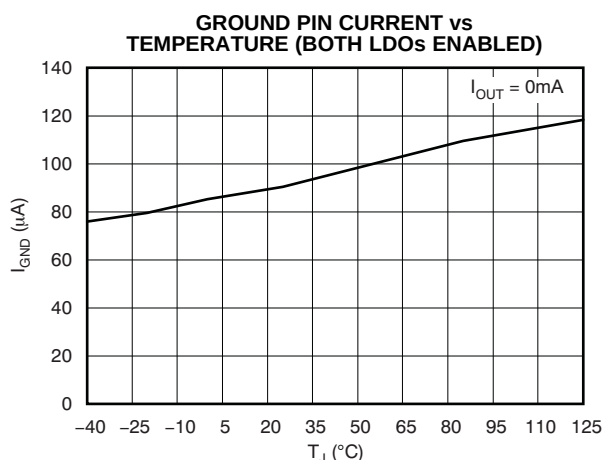


Figure 10.

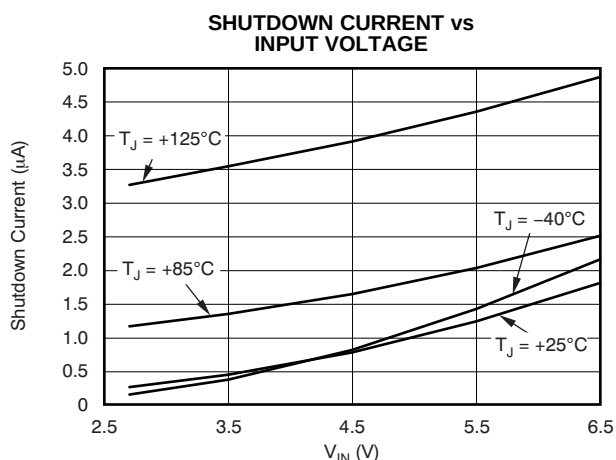


Figure 11.

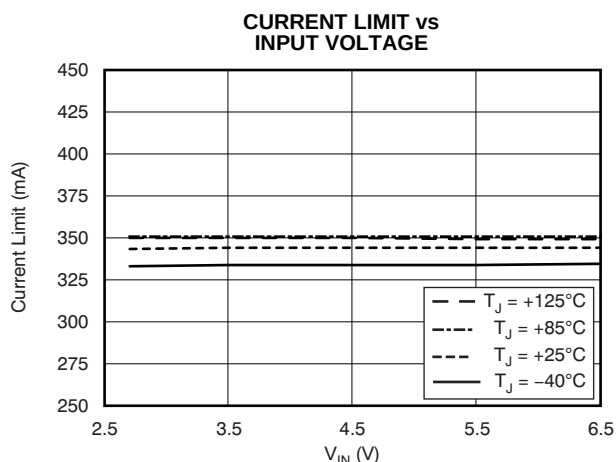


Figure 12.

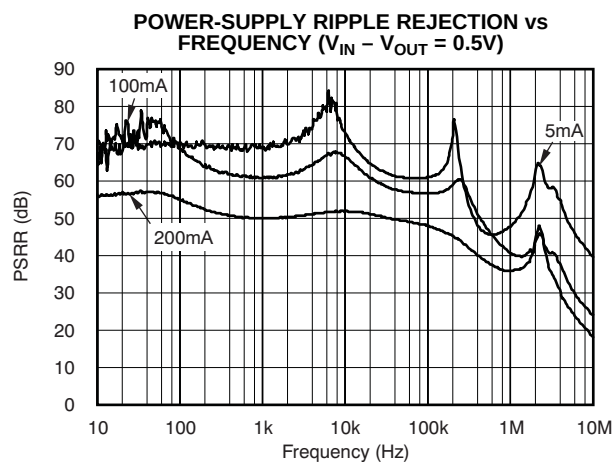


Figure 13.

## TYPICAL CHARACTERISTICS (continued)

Over operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ),  $V_{IN} = V_{OUT(TYP)} + 0.5\text{V}$  or  $2.7\text{V}$ , whichever is greater;  $I_{OUT} = 0.5\text{mA}$ ,  $V_{EN1} = V_{EN2} = V_{IN}$ ,  $C_{OUT} = 1.0\mu\text{F}$ , unless otherwise noted. Typical values are at  $T_J = +25^{\circ}\text{C}$ .

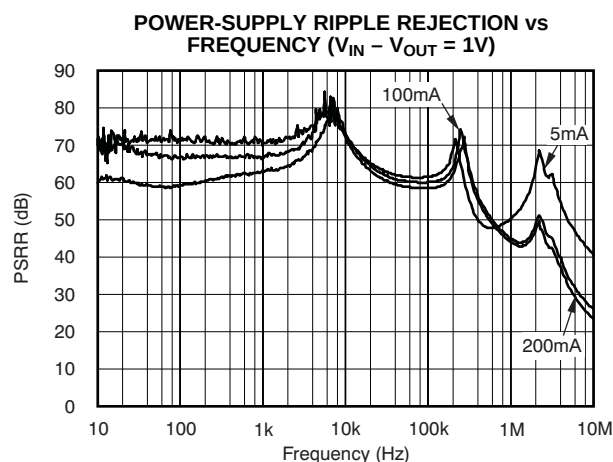


Figure 14.

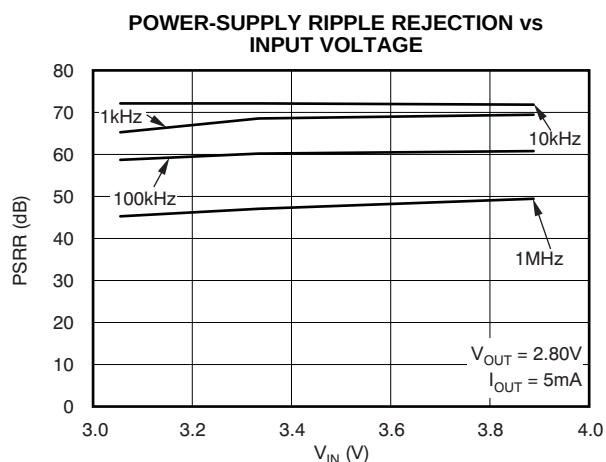


Figure 15.

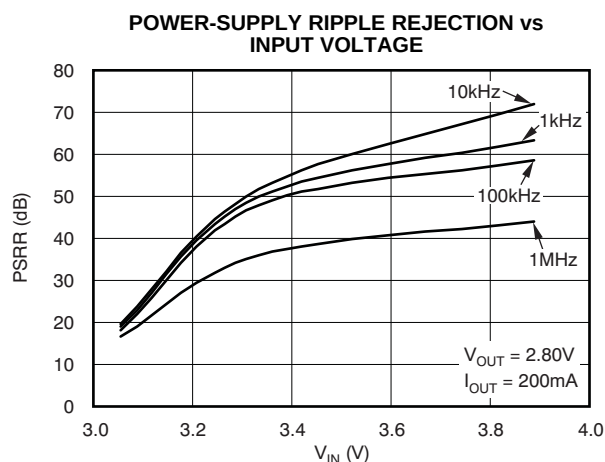


Figure 16.

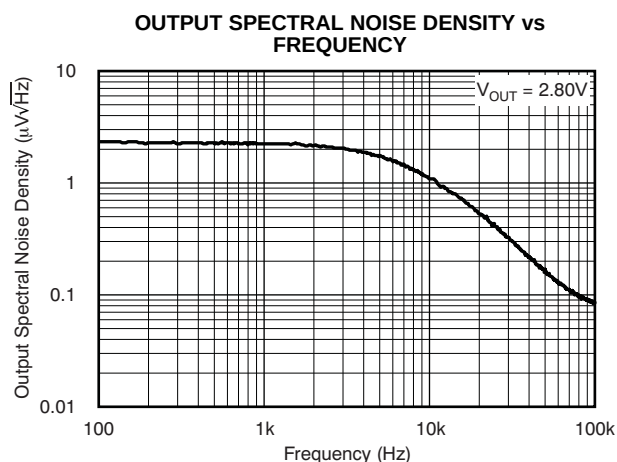


Figure 17.

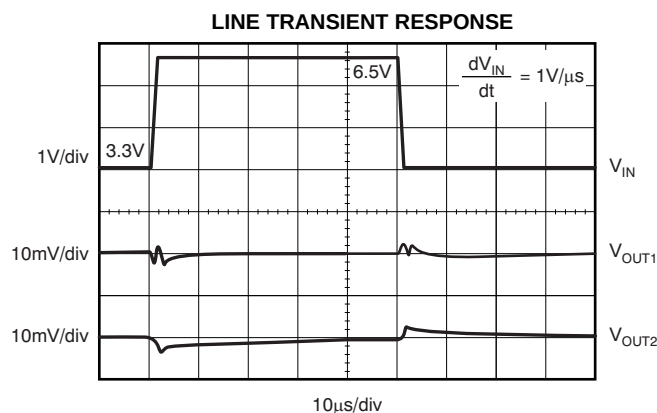


Figure 18.

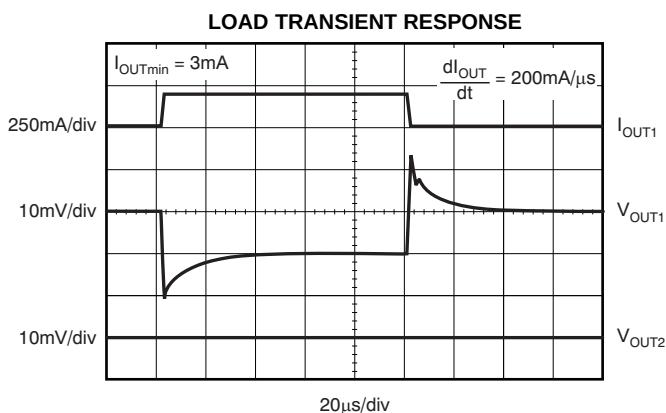
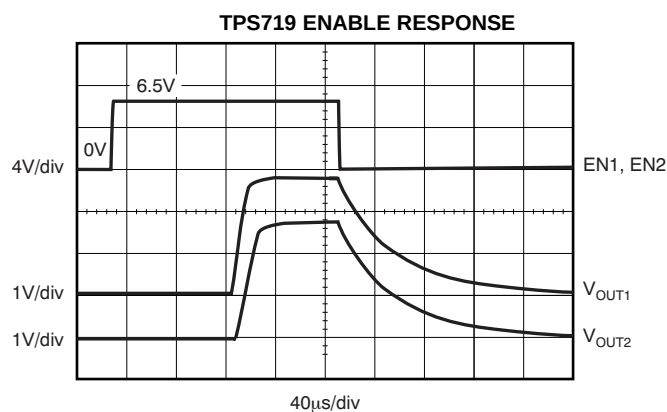


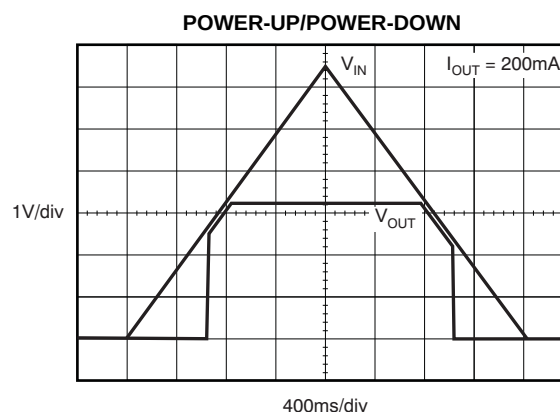
Figure 19.

## TYPICAL CHARACTERISTICS (continued)

Over operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ),  $V_{IN} = V_{OUT(TYP)} + 0.5\text{V}$  or  $2.7\text{V}$ , whichever is greater;  
 $I_{OUT} = 0.5\text{mA}$ ,  $V_{EN1} = V_{EN2} = V_{IN}$ ,  $C_{OUT} = 1.0\mu\text{F}$ , unless otherwise noted. Typical values are at  $T_J = +25^{\circ}\text{C}$ .



**Figure 20.**



**Figure 21.**

## APPLICATION INFORMATION

The TPS718xx/TPS719xx belong to a family of new generation LDO regulators that use innovative circuitry to achieve ultra-wide bandwidth and high loop gain, resulting in extremely high PSRR (up to 1MHz) at very low headroom ( $V_{IN} - V_{OUT}$ ). These features, combined with low noise, two independent enables, low ground pin current and ultra-small packaging, make this part ideal for portable applications. This family of regulators offer sub-bandgap output voltages, current limit and thermal protection, and is fully specified from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

Figure 22 shows the basic circuit connections.

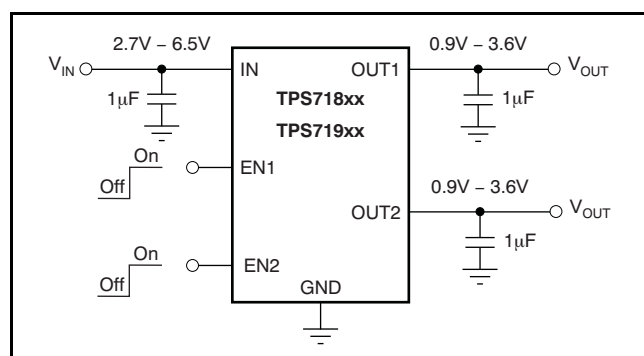


Figure 22. Typical Application Circuit

### Input and Output Capacitor Requirements

Although an input capacitor is not required for stability, it is good analog design practice to connect a 0.1µF to 1.0µF low equivalent series resistance (ESR) capacitor across the input supply near the regulator. This capacitor counteracts reactive input sources and improves transient response, noise rejection, and ripple rejection. A higher-value capacitor may be necessary if large, fast rise-time load transients are anticipated or if the device is located close to the power source. If source impedance is not sufficiently low, a 0.1µF input capacitor may be necessary to ensure stability.

The TPS718xx/TPS719xx are designed to be stable with standard ceramic capacitors of values 1.0µF or larger at the output. X5R- and X7R-type capacitors are best because they have minimal variation in value and ESR over temperature. Maximum ESR should be  $<1.0\Omega$ .

### Board Layout Recommendations to Improve PSRR and Noise Performance

To improve ac performance such as PSRR, output noise, and transient response, it is recommended that the board be designed with separate ground planes for  $V_{IN}$  and  $V_{OUT}$ , with each ground plane connected only at the GND pin of the device. In addition, the ground connection for the output capacitor should connect directly to the GND pin of the device. High ESR capacitors may degrade PSRR.

### Internal Current Limit

The TPS718xx/TPS719xx internal current limits help protect the regulator during fault conditions. During current limit, the output sources a fixed amount of current that is largely independent of output voltage. For reliable operation, the device should not be operated in a current limit state for extended periods of time.

The PMOS pass element in the TPS718xx/TPS719xx has a built-in body diode that conducts current when the voltage at OUT exceeds the voltage at IN. This current is not limited, so if extended reverse voltage operation is anticipated, external limiting to 5% of rated output current may be appropriate.

### Shutdown

The enable pin (EN) is active high and is compatible with standard and low voltage, TTL-CMOS levels. When shutdown capability is not required, EN can be connected to IN. The TPS719 with internal active output pulldown circuitry discharges the output with a time constant ( $t$ ) of:

$$t = 3 \left[ \frac{60 \times R_L}{60 + R_L} \right] \times C_{OUT}$$

with:

$R_L$  = output load resistance

$C_{OUT}$  = output capacitance

### Dropout Voltage

The TPS718xx/TPS719xx use a PMOS pass transistor to achieve low dropout. When  $(V_{IN} - V_{OUT})$  is less than the dropout voltage ( $V_{DO}$ ), the PMOS pass device is in its linear region of operation and the input-to-output resistance is the  $R_{DS(ON)}$  of the PMOS pass element.  $V_{DO}$  approximately scales with output current because the PMOS device behaves like a resistor in dropout.

As with any linear regulator, PSRR and transient response are degraded as  $(V_{IN} - V_{OUT})$  approaches dropout. This effect is shown in [Figure 13](#) and [Figure 14](#) in the [Typical Characteristics](#) section.

## Transient Response

As with any regulator, increasing the size of the output capacitor will reduce over/undershoot magnitude but increase duration of the transient response.

## Undervoltage Lock-Out (UVLO)

The TPS718xx/TPS719xx utilize an undervoltage lock-out circuit to keep the output shut off until internal circuitry is operating properly. The UVLO circuit has a de-glitch feature so that it typically ignores undershoot transients on the input if they are less than 50μs duration. On the TPS719xx, the active pulldown discharges  $V_{OUT}$  when the device is in UVLO off condition. However, the input voltage needs to be greater than 0.8V for active pulldown to work.

## Minimum Load

The TPS718xx/TPS719xx are stable with no output load. Traditional PMOS LDO regulators suffer from lower loop gain at very light output loads. The TPS718xx/TPS719xx employ an innovative, low-current mode circuit under very light or no-load conditions, resulting in improved output voltage regulation performance down to zero output current.

## THERMAL INFORMATION

### Thermal Protection

Thermal protection disables the output when the junction temperature rises to approximately +160°C, allowing the device to cool. When the junction temperature cools to approximately +140°C the output circuitry is again enabled. Depending on power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may cycle on and off. This cycling limits the dissipation of the regulator, protecting it from damage due to overheating.

Any tendency to activate the thermal protection circuit indicates excessive power dissipation or an inadequate heatsink. For reliable operation, junction temperature should be limited to +125°C maximum. To estimate the margin of safety in a complete design (including heatsink), increase the ambient temperature until the thermal protection is triggered; use worst-case loads and signal conditions. For good reliability, thermal protection should trigger at least +35°C above the maximum expected ambient condition of your particular application. This configuration produces a worst-case junction temperature of +125°C at the highest expected ambient temperature and worst-case load.

The internal protection circuitry of the TPS718xx/TPS719xx has been designed to protect against overload conditions. It was not intended to replace proper heatsinking. Continuously running the TPS718xx/TPS719xx into thermal shutdown degrades device reliability.

### Power Dissipation

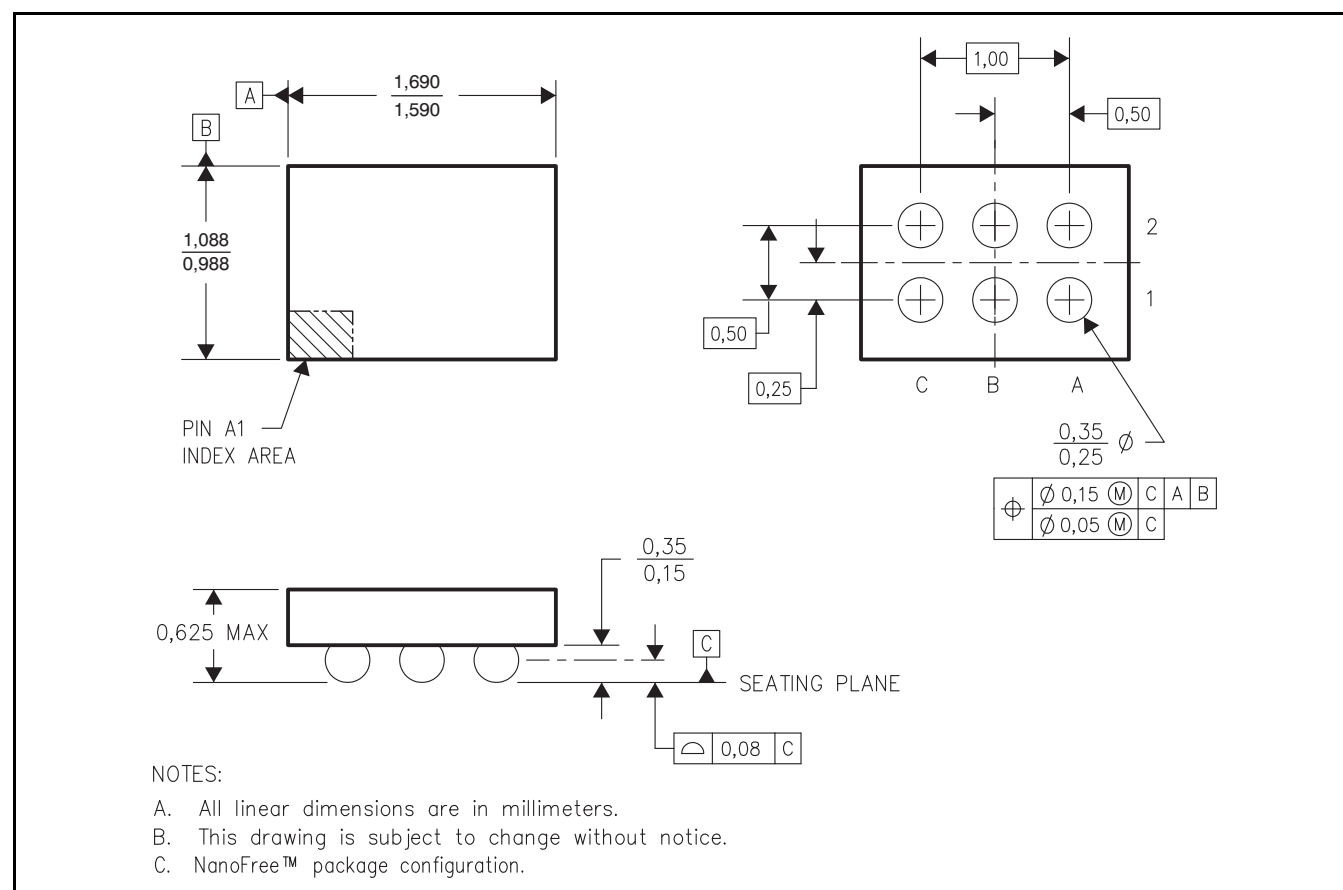
The ability to remove heat from the die is different for each package type, presenting different considerations in the printed circuit board (PCB) layout. The PCB area around the device that is free of other components moves the heat from the device to the ambient air. Performance data for JEDEC low- and high-K boards are given in the [Dissipation Ratings](#) table. Using heavier copper increases the effectiveness in removing heat from the device. The addition of plated through-holes to heat-dissipating layers also improves the heatsink effectiveness.

Power dissipation depends on input voltage and load conditions. Power dissipation ( $P_D$ ) is equal to the product of the output current times the voltage drop across the output pass element ( $V_{IN}$  to  $V_{OUT}$ ), as shown in [Equation 1](#):

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} \quad (1)$$

### Package Mounting

Solder pad footprint recommendations for the TPS718xx/TPS719xxx are available from the Texas Instruments web site at [www.ti.com](http://www.ti.com).



**Figure 23. YZC Wafer Chip-Scale Package Dimensions (in mm)**

**PACKAGING INFORMATION**

| Orderable Device  | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|-------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| TPS71812-33DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BVC                     | <a href="#">Samples</a> |
| TPS71812-33DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BVC                     | <a href="#">Samples</a> |
| TPS71818-33DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAU   NIPDAUAG                    | Level-1-260C-UNLIM   | -40 to 125   | OEI                     | <a href="#">Samples</a> |
| TPS71818-33DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAU   NIPDAUAG                    | Level-1-260C-UNLIM   | -40 to 125   | OEI                     | <a href="#">Samples</a> |
| TPS71825-12DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BVO                     | <a href="#">Samples</a> |
| TPS71825-12DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BVO                     | <a href="#">Samples</a> |
| TPS71828-30DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BVX                     | <a href="#">Samples</a> |
| TPS71828-30DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BVX                     | <a href="#">Samples</a> |
| TPS71913-28DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BWP                     | <a href="#">Samples</a> |
| TPS71913-28DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BWP                     | <a href="#">Samples</a> |
| TPS71918-12DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BWW                     | <a href="#">Samples</a> |
| TPS71918-12DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BWW                     | <a href="#">Samples</a> |
| TPS71918-28DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | ODQ                     | <a href="#">Samples</a> |
| TPS71918-28DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | ODQ                     | <a href="#">Samples</a> |
| TPS71921-22DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | OBW                     | <a href="#">Samples</a> |
| TPS71921-22DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | OBW                     | <a href="#">Samples</a> |
| TPS71928-28DRVR   | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | CAK                     | <a href="#">Samples</a> |
| TPS71928-28DRVT   | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | CAK                     | <a href="#">Samples</a> |
| TPS71928-28DRVTG4 | ACTIVE        | WSON         | DRV                | 6    | 250            | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | CAK                     | <a href="#">Samples</a> |
| TPS719285-285DRVR | ACTIVE        | WSON         | DRV                | 6    | 3000           | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | OAU                     | <a href="#">Samples</a> |

| Orderable Device  | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|-------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| TPS71933-28DRVR   | ACTIVE        | WSON         | DRV             | 6    | 3000        | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | CAH                     | <a href="#">Samples</a> |
| TPS71933-28DRVT   | ACTIVE        | WSON         | DRV             | 6    | 250         | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | CAH                     | <a href="#">Samples</a> |
| TPS71933-28DRVTG4 | ACTIVE        | WSON         | DRV             | 6    | 250         | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | CAH                     | <a href="#">Samples</a> |
| TPS71933-33DRVR   | ACTIVE        | WSON         | DRV             | 6    | 3000        | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BWL                     | <a href="#">Samples</a> |
| TPS71933-33DRVT   | ACTIVE        | WSON         | DRV             | 6    | 250         | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | BWL                     | <a href="#">Samples</a> |
| TPS71936-315DRVR  | ACTIVE        | WSON         | DRV             | 6    | 3000        | RoHS & Green    | NIPDAUAG                             | Level-1-260C-UNLIM   | -40 to 125   | CVZ                     | <a href="#">Samples</a> |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

<sup>(2)</sup> **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

<sup>(3)</sup> MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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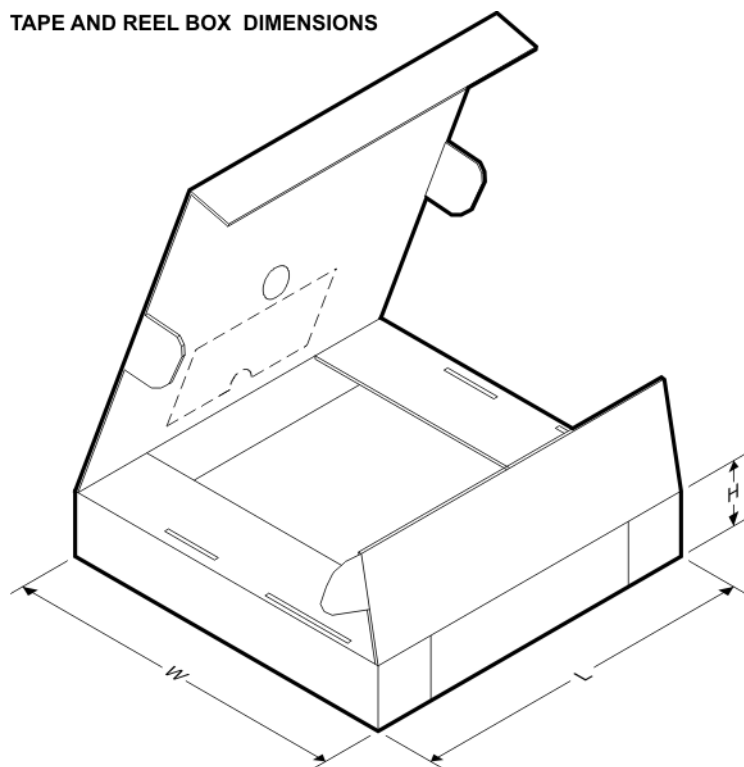
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**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

| Device          | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS71812-33DRVR | WSO          | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71812-33DRVT | WSO          | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71818-33DRVR | WSO          | DRV             | 6    | 3000 | 178.0              | 8.4                | 2.25    | 2.25    | 1.0     | 4.0     | 8.0    | Q2            |
| TPS71818-33DRVT | WSO          | DRV             | 6    | 250  | 178.0              | 8.4                | 2.25    | 2.25    | 1.0     | 4.0     | 8.0    | Q2            |
| TPS71825-12DRVR | WSO          | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71825-12DRVT | WSO          | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71828-30DRVR | WSO          | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71828-30DRVT | WSO          | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71913-28DRVR | WSO          | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71913-28DRVT | WSO          | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71918-12DRVR | WSO          | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71918-12DRVT | WSO          | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71918-28DRVR | WSO          | DRV             | 6    | 3000 | 178.0              | 8.4                | 2.25    | 2.25    | 1.0     | 4.0     | 8.0    | Q2            |
| TPS71918-28DRVT | WSO          | DRV             | 6    | 250  | 178.0              | 8.4                | 2.25    | 2.25    | 1.0     | 4.0     | 8.0    | Q2            |
| TPS71921-22DRVR | WSO          | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71921-22DRVT | WSO          | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71928-28DRVR | WSO          | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71928-28DRVT | WSO          | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |

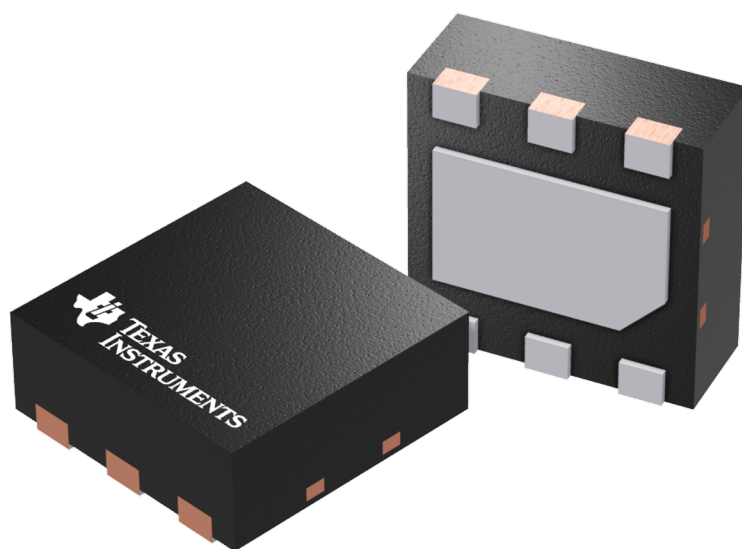
| Device            | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS719285-285DRVR | WSON         | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71933-28DRVR   | WSON         | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71933-28DRVT   | WSON         | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71933-33DRVR   | WSON         | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71933-33DRVT   | WSON         | DRV             | 6    | 250  | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |
| TPS71936-315DRVR  | WSON         | DRV             | 6    | 3000 | 179.0              | 8.4                | 2.2     | 2.2     | 1.2     | 4.0     | 8.0    | Q2            |

**TAPE AND REEL BOX DIMENSIONS**


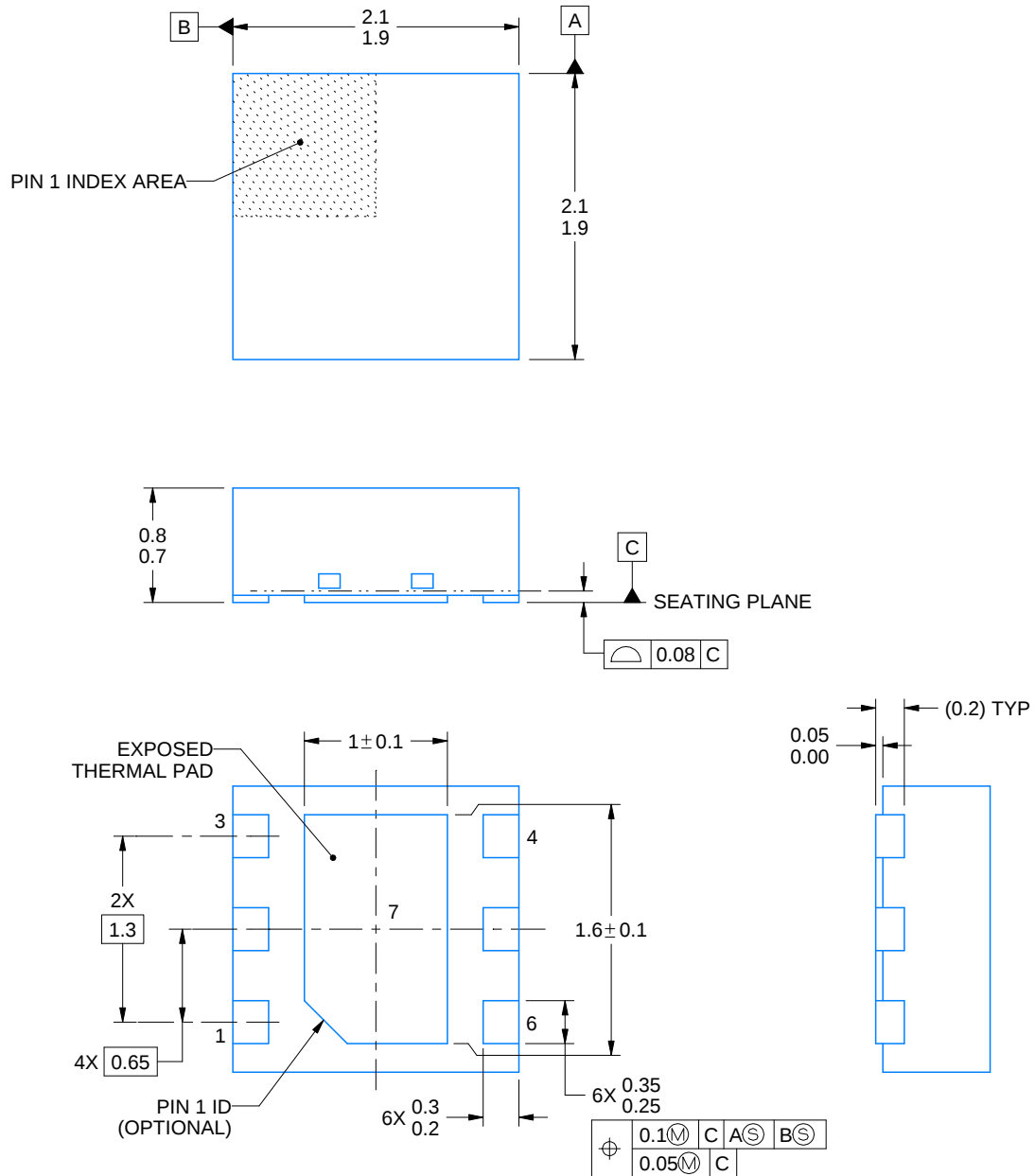
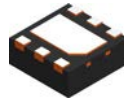
\*All dimensions are nominal

| Device          | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS71812-33DRVR | WSON         | DRV             | 6    | 3000 | 200.0       | 183.0      | 25.0        |
| TPS71812-33DRVT | WSON         | DRV             | 6    | 250  | 200.0       | 183.0      | 25.0        |
| TPS71818-33DRVR | WSON         | DRV             | 6    | 3000 | 205.0       | 200.0      | 33.0        |
| TPS71818-33DRVT | WSON         | DRV             | 6    | 250  | 205.0       | 200.0      | 33.0        |
| TPS71825-12DRVR | WSON         | DRV             | 6    | 3000 | 200.0       | 183.0      | 25.0        |
| TPS71825-12DRVT | WSON         | DRV             | 6    | 250  | 200.0       | 183.0      | 25.0        |
| TPS71828-30DRVR | WSON         | DRV             | 6    | 3000 | 200.0       | 183.0      | 25.0        |
| TPS71828-30DRVT | WSON         | DRV             | 6    | 250  | 203.0       | 203.0      | 35.0        |
| TPS71913-28DRVR | WSON         | DRV             | 6    | 3000 | 203.0       | 203.0      | 35.0        |
| TPS71913-28DRVT | WSON         | DRV             | 6    | 250  | 200.0       | 183.0      | 25.0        |
| TPS71918-12DRVR | WSON         | DRV             | 6    | 3000 | 203.0       | 203.0      | 35.0        |

| Device            | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS71918-12DRVT   | WSON         | DRV             | 6    | 250  | 203.0       | 203.0      | 35.0        |
| TPS71918-28DRVR   | WSON         | DRV             | 6    | 3000 | 205.0       | 200.0      | 33.0        |
| TPS71918-28DRVT   | WSON         | DRV             | 6    | 250  | 205.0       | 200.0      | 33.0        |
| TPS71921-22DRVR   | WSON         | DRV             | 6    | 3000 | 203.0       | 203.0      | 35.0        |
| TPS71921-22DRVT   | WSON         | DRV             | 6    | 250  | 200.0       | 183.0      | 25.0        |
| TPS71928-28DRVR   | WSON         | DRV             | 6    | 3000 | 203.0       | 203.0      | 35.0        |
| TPS71928-28DRVT   | WSON         | DRV             | 6    | 250  | 203.0       | 203.0      | 35.0        |
| TPS719285-285DRVR | WSON         | DRV             | 6    | 3000 | 203.0       | 203.0      | 35.0        |
| TPS71933-28DRVR   | WSON         | DRV             | 6    | 3000 | 200.0       | 183.0      | 25.0        |
| TPS71933-28DRVT   | WSON         | DRV             | 6    | 250  | 203.0       | 203.0      | 35.0        |
| TPS71933-33DRVR   | WSON         | DRV             | 6    | 3000 | 200.0       | 183.0      | 25.0        |
| TPS71933-33DRVT   | WSON         | DRV             | 6    | 250  | 203.0       | 203.0      | 35.0        |
| TPS71936-315DRVR  | WSON         | DRV             | 6    | 3000 | 203.0       | 203.0      | 35.0        |



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4222173/B 04/2018

**NOTES:**

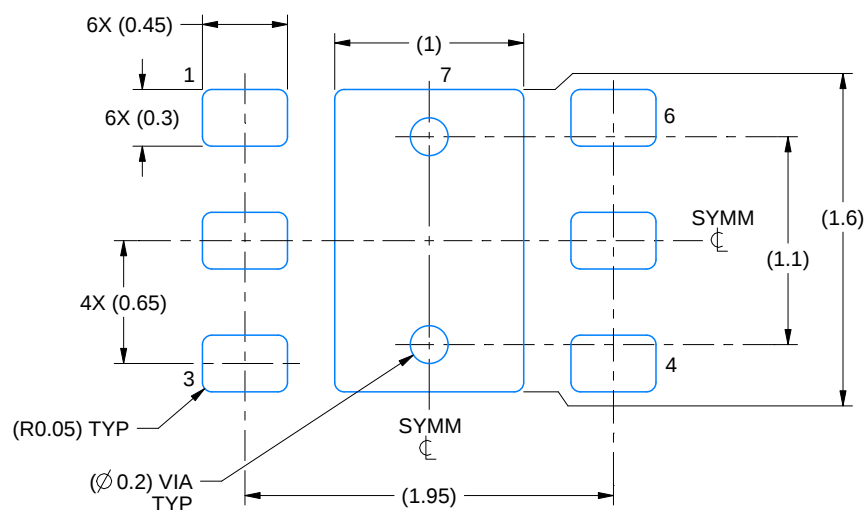
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

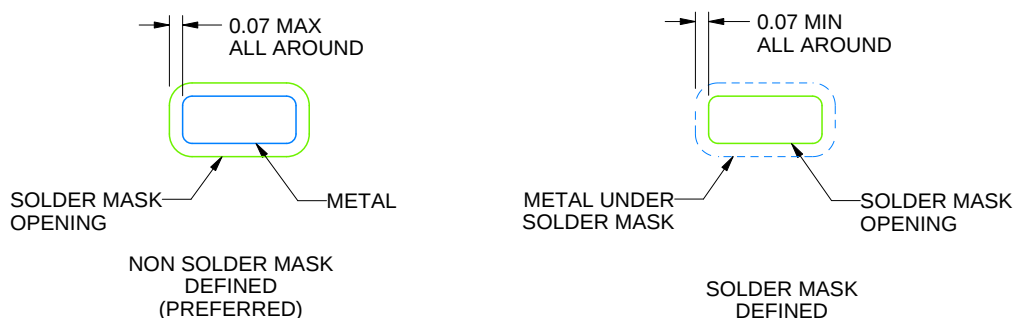
DRV0006A

WSN - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:25X



SOLDER MASK DETAILS

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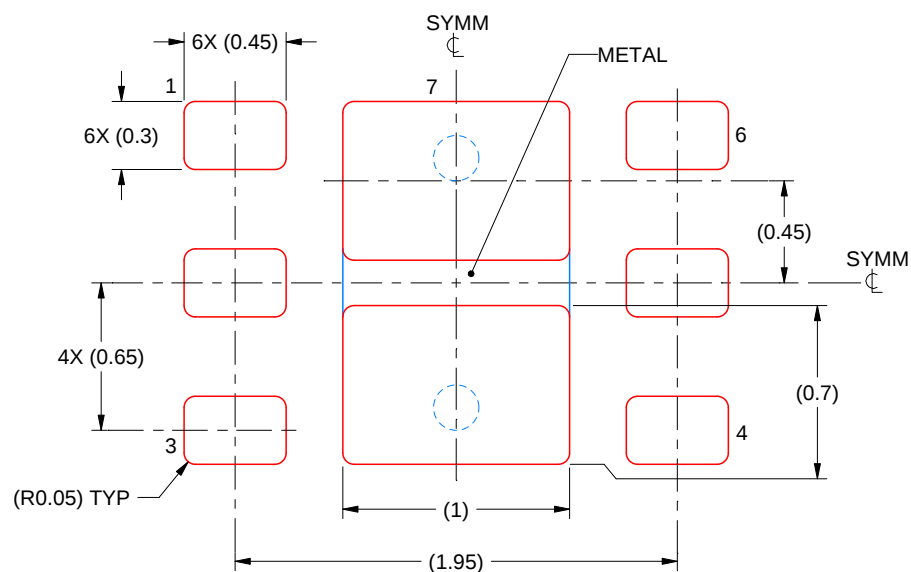
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.

**DRV0006A**

**WSON - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



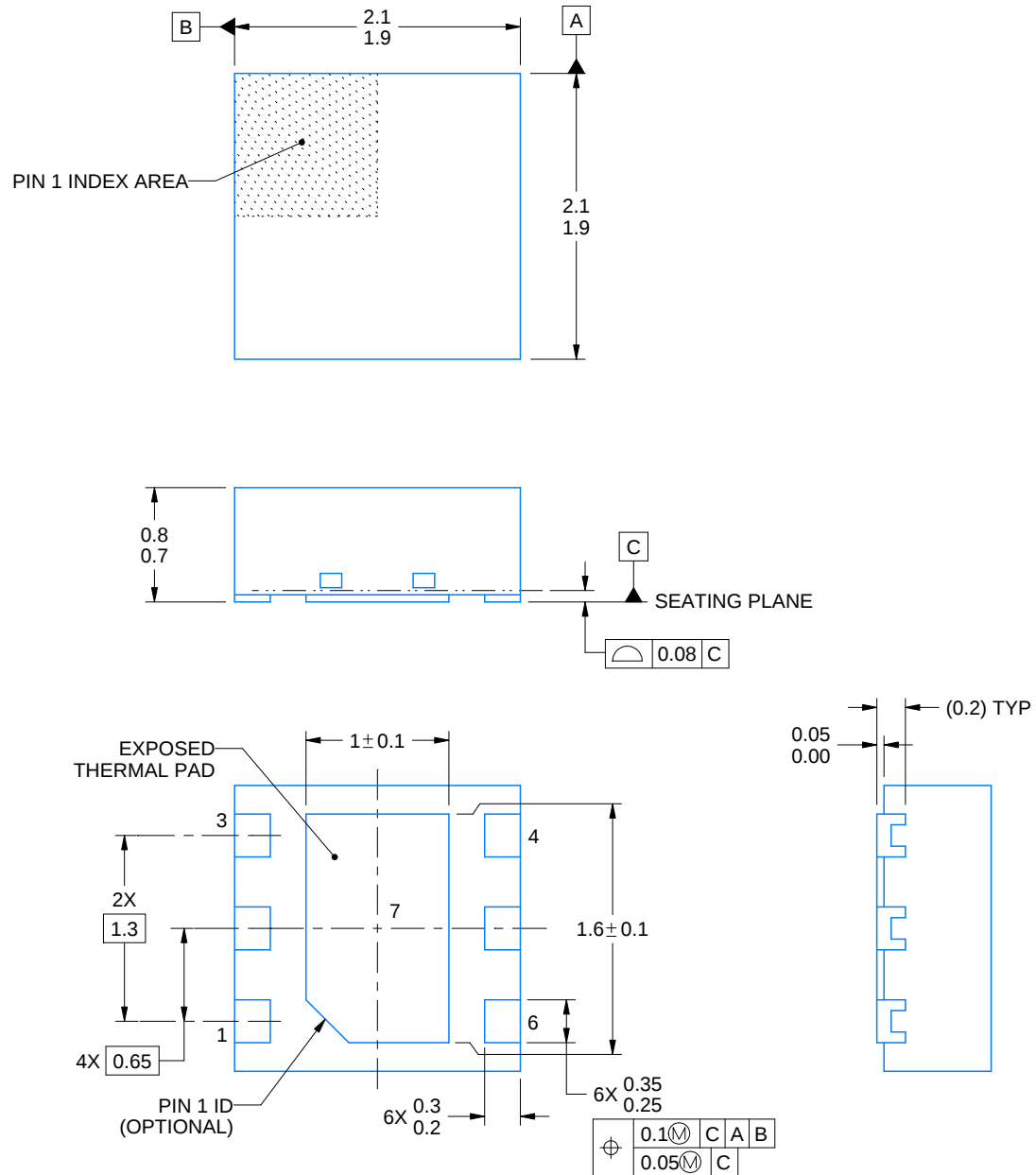
## SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD #7  
88% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:30X

4222173/B 04/2018

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.



4225563/A 12/2019

**NOTES:**

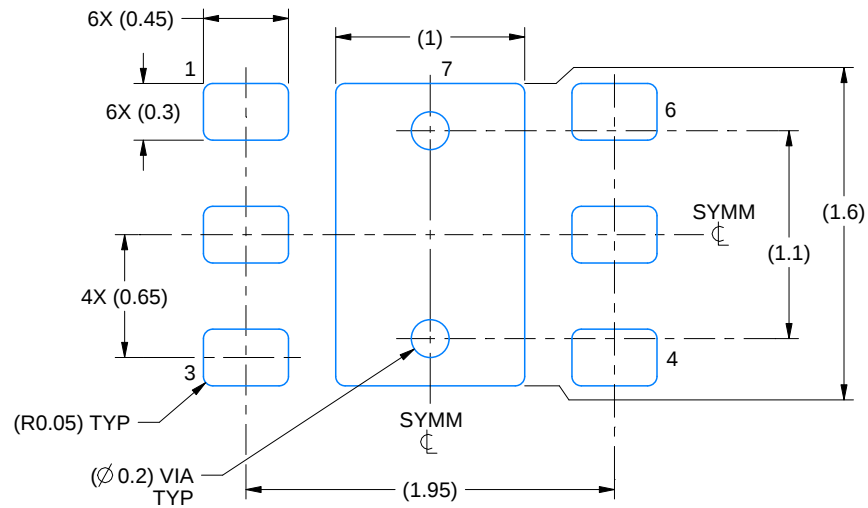
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

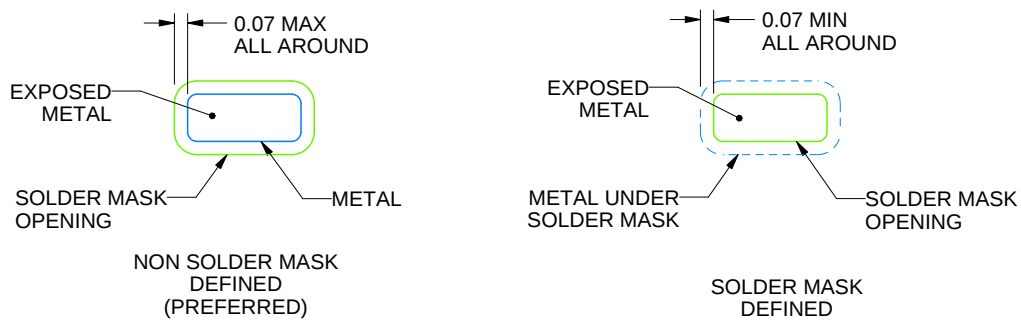
DRV0006D

WSN - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



**LAND PATTERN EXAMPLE**  
EXPOSED METAL SHOWN  
SCALE:25X



**SOLDER MASK DETAILS**

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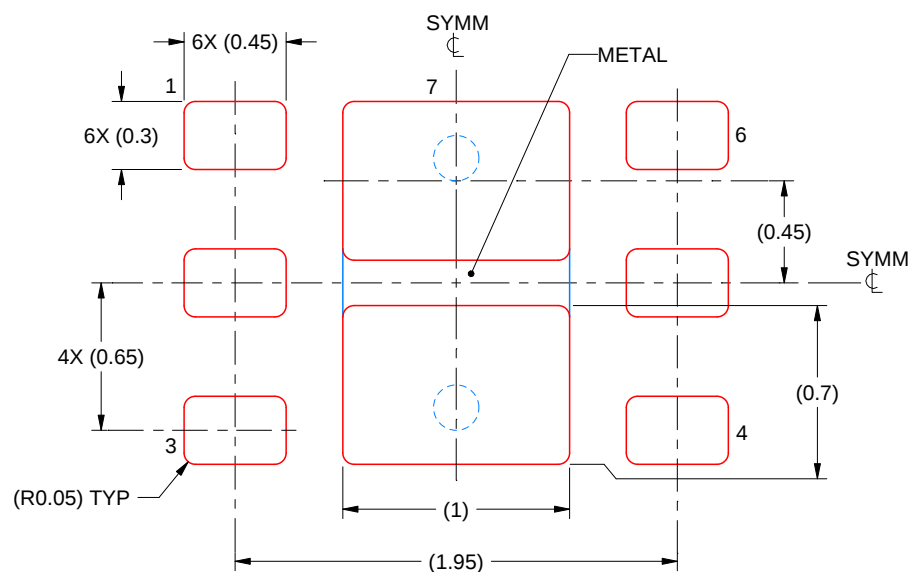
NOTES: (continued)

- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
- Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.

**DRV0006D**

**WSN - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



## SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD #7  
88% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:30X

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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