

# TPS793 Low-Noise, High PSRR, RF, 200-mA Low-Dropout Linear Regulators in NanoStar™ Wafer Chip Scale and SOT-23

## 1 Features

- 200-mA RF Low-Dropout Regulator With Enable
- Available in Fixed-Voltage Versions from 1.8 V to 4.75 V and Adjustable (1.22 V to 5.5 V)
- High PSRR (70 dB at 10 kHz)
- Low Noise (32  $\mu\text{V}_{\text{RMS}}$ , TPS79328)
- Fast Start-Up Time (50  $\mu\text{s}$ )
- Stable With a 2.2- $\mu\text{F}$  Ceramic Capacitor
- Excellent Load and Line Transient Response
- Very Low Dropout Voltage (112 mV at 200 mA, TPS79330)
- 5- and 6-Pin SOT23 (DBV) and NanoStar Wafer Chip Scale (YZQ) Packages

## 2 Applications

- RF: VCOs, Receivers, ADCs
- Audio
- Cellular and Cordless Telephones
- *Bluetooth*®, Wireless LAN
- Handheld Organizers, PDAs

## 3 Description

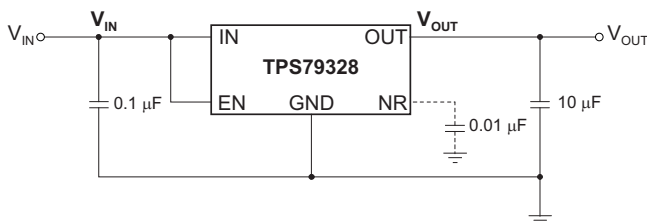
The TPS793 family of low-dropout (LDO) low-power linear voltage regulators features high power-supply rejection ratio (PSRR), ultralow-noise, fast start-up, and excellent line and load transient responses in NanoStar™ wafer chip scale and SOT23 packages. NanoStar packaging gives an ultrasmall footprint as well as an ultralow profile and package weight, making these devices ideal for portable applications such as handsets and PDAs. Each device in the family is stable, with a small, 2.2- $\mu\text{F}$  ceramic capacitor on the output. The TPS793 family uses an advanced, proprietary BiCMOS fabrication process to yield extremely low dropout voltages (for example, 112 mV at 200 mA, TPS79330). Each device achieves fast start-up times (approximately 50  $\mu\text{s}$  with a 0.001- $\mu\text{F}$  bypass capacitor) while consuming very low quiescent current (170  $\mu\text{A}$  typical). Moreover, when the device is placed in standby mode, the supply current is reduced to less than 1  $\mu\text{A}$ . The TPS79328 exhibits approximately 32  $\mu\text{V}_{\text{RMS}}$  of output voltage noise at 2.8-V output with a 0.1- $\mu\text{F}$  bypass capacitor. Applications with analog components that are noise-sensitive, such as portable RF electronics, benefit from the high PSRR and low-noise features as well as the fast response time.

### Device Information<sup>(1)</sup>

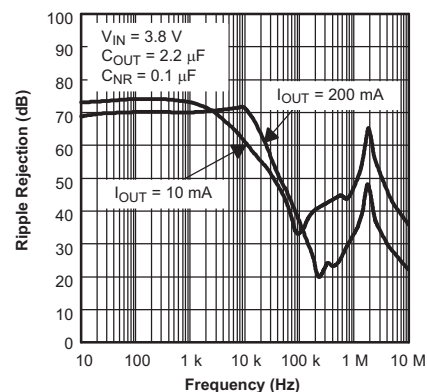
| PART NUMBER | PACKAGE    | BODY SIZE (NOM)   |
|-------------|------------|-------------------|
| TPS793      | SOT-23 (6) | 2.90 mm x 1.60 mm |
|             | SOT-23 (5) | 2.90 mm x 1.60 mm |
|             | DSBGA (5)  | 1.35 mm x 1.00 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

### Typical Application Circuit



### Ripple Rejection vs Frequency



## Table of Contents

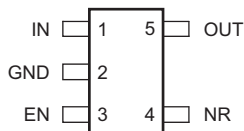
|  |           |  |           |
|--|-----------|--|-----------|
| <b>1 Features</b> .....                        | <b>1</b>  | <b>8 Application and Implementation</b> .....                    | <b>14</b> |
| <b>2 Applications</b> .....                    | <b>1</b>  | 8.1 Application Information.....                                 | 14        |
| <b>3 Description</b> .....                     | <b>1</b>  | 8.2 Typical Application .....                                    | 15        |
| <b>4 Revision History</b> .....                | <b>2</b>  | 8.3 Do's and Don'ts.....   | 17        |
| <b>5 Pin Configuration and Functions</b> ..... | <b>3</b>  | <b>9 Power Supply Recommendations</b> .....                      | <b>17</b> |
| <b>6 Specifications</b> .....                  | <b>4</b>  | <b>10 Layout</b> .....   | <b>18</b> |
| 6.1 Absolute Maximum Ratings .....             | 4         | 10.1 Layout Guidelines .....                                     | 18        |
| 6.2 ESD Ratings .....                          | 4         | 10.2 Layout Example .....  | 18        |
| 6.3 Recommended Operating Conditions.....      | 4         | 10.3 Power Dissipation .....                                     | 18        |
| 6.4 Thermal Information .....                  | 5         | <b>11 Device and Documentation Support</b> .....                 | <b>20</b> |
| 6.5 Electrical Characteristics .....           | 6         | 11.1 Device Support.....   | 20        |
| 6.6 Typical Characteristics.....               | 7         | 11.2 Documentation Support .....                                 | 20        |
| <b>7 Detailed Description</b> .....            | <b>11</b> | 11.3 Community Resource.....                                     | 20        |
| 7.1 Overview .....                             | 11        | 11.4 Trademarks .....  | 21        |
| 7.2 Functional Block Diagrams .....            | 11        | 11.5 Electrostatic Discharge Caution.....                        | 21        |
| 7.3 Feature Description.....                   | 12        | 11.6 Glossary .....  | 21        |
| 7.4 Device Functional Modes.....               | 13        | <b>12 Mechanical, Packaging, and Orderable Information</b> ..... | <b>21</b> |

## 4 Revision History

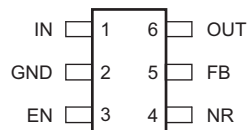
| Changes from Revision K (October 2007) to Revision L  | Page |
|---|------|
| • Changed title of data sheet .....   | 1    |
| • Deleted references to <i>YEQ</i> package throughout document (package is obsolete) .....  | 1    |
| • Changed fourth bullet of <i>Features</i> list to <i>low noise</i> .....   | 1    |
| • Changed front-page figure .....   | 1    |
| • Changed <i>Absolute Maximum Ratings</i> condition statement .....   | 4    |
| • Added <i>Pin Configurations and Functions</i> section, <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section ..... | 4    |
| • Deleted <i>Dissipation Ratings</i> table; added <i>Thermal Information</i> table .....  | 5    |
| • Deleted $T_J = 25^\circ\text{C}$ test condition from PSRR specification measurements because of redundancy .....  | 6    |
| • Added condition statement to <i>Typical Characteristics</i> .....   | 7    |
| • Changed <a href="#">Figure 23</a> ; changed capacitor notation to $C_{FF}$ in figure and related table .....  | 14   |
| • Changed <a href="#">Figure 24</a> ; changed capacitor notation to $C_{FF}$ in figure, changed 2.2 $\mu\text{F}$ capacitor value to 10 $\mu\text{F}$ , and changed device name .....   | 15   |

## 5 Pin Configuration and Functions

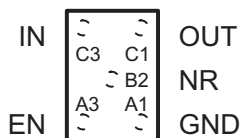
**DBV Package**  
5-Pin SOT-23 Fixed Voltage Version  
Top View



**DBV Package**  
6-Pin SOT-23 Adjustable Voltage Version  
Top View



**YZQ Package**  
5-Pin DSBGA  
Top View



### Pin Functions

| NAME | PIN |     | I/O | DESCRIPTION   |
|------|-----|-----|-----|---|
|      | DBV | YZQ |     |   |
| EN   | 3   | A3  | I   | Enable pin. Driving the enable pin (EN) high turns on the regulator. Driving this pin low puts the regulator into shutdown mode. EN can be connected to IN if not used.                         |
| FB   | 5   | —   | I   | Feedback pin. This terminal is the feedback input pin for the adjustable device. Fixed voltage versions in the DBV package do not have this pin.  |
| GND  | 2   | A1  | —   | Regulator ground.   |
| IN   | 1   | C3  | I   | Input to the device.  |
| NR   | 4   | B2  | —   | Noise Reduction pin. Connecting an external capacitor to this pin filters noise generated by the internal bandgap. This configuration improves power-supply rejection and reduces output noise. |
| OUT  | 6   | C1  | O   | Output of the regulator.  |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating junction temperature range (unless otherwise noted). All voltages are with respect to GND.<sup>(1)</sup>

|                               |                             | MIN                                     | MAX | UNIT |    |
|-------------------------------|-----------------------------|---|-----|------|----|
| Voltage                       | Input, $V_{IN}$             | −0.3                                    | 6   | V    |    |
|                               | Enable, $V_{EN}$            | −0.3                                    | 6   | V    |    |
|                               | Output, $V_{OUT}$           | −0.3                                    | 6   | V    |    |
| Current                       | Peak output, $I_{OUT(max)}$ | Internally limited                      |     | A    |    |
| Output short-circuit duration |                             | Indefinite                              |     |      |    |
| Total power dissipation       | Continuous, $P_{D(tot)}$    | See <a href="#">Thermal Information</a> |     |      |    |
| Temperature                   | Junction, $T_J$             | DBV package                             | −40 | 150  | °C |
|                               |                             | YZQ package                             | −40 | 125  | °C |
|                               | Storage, $T_{stg}$          | −65                                     | 150 | °C   |    |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 6.2 ESD Ratings

|                                     |  | VALUE | UNIT |
|-------------------------------------|--|-------|------|
| $V_{(ESD)}$ Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>              | ±2000 | V    |
|                                     | Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup> | ±500  |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.  
 (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

over operating junction temperature range (unless otherwise noted).

|           |                                | MIN                | NOM  | MAX      | UNIT |
|-----------|--------------------------------|--------------------|------|----------|------|
| $V_{IN}$  | Input supply voltage range     | 2.7                |      | 5.5      | V    |
| $V_{EN}$  | Enable supply voltage range    | 0                  |      | $V_{IN}$ | V    |
| $V_{OUT}$ | Output voltage range           | $V_{FB}$           |      | 5        | V    |
| $I_{OUT}$ | Output current                 | 0                  |      | 200      | mA   |
| $T_J$     | Operating junction temperature | −40                |      | 125      | °C   |
| $C_{IN}$  | Input capacitor                | 0.1                | 1    |          | μF   |
| $C_{OUT}$ | Output capacitor               | 2.2 <sup>(1)</sup> | 10   |          | μF   |
| $C_{NR}$  | Noise reduction capacitor      | 0                  | 10   |          | nF   |
| $C_{FF}$  | Feed-forward capacitor         |                    | 15   |          | pF   |
| $R_2$     | Lower feedback resistor        |                    | 30.1 |          | kΩ   |

- (1) If  $C_{FF}$  is not used or  $V_{OUT(nom)} < 1.8$  V, the minimum recommended  $C_{OUT} = 4.7$  μF.

## 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |  | TPS79301     |             | UNIT |
|-------------------------------|--|--------------|-------------|------|
|                               |  | DBV (SOT-23) | YZQ (DSBGA) |      |
|                               |  | 6 PINS       | 5 PINS      |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 225.1        | 178.5       | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 78.4         | 1.4         | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 54.7         | 62.1        | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 3.3          | 0.9         | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 53.8         | 62.1        | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

## 6.5 Electrical Characteristics

Over recommended operating temperature range  $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ,  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1\text{ V}^{(1)}$ ,  $I_{OUT} = 1\text{ mA}$ ,  $C_{OUT} = 10\ \mu\text{F}$ ,  $C_{NR} = 0.01\ \mu\text{F}$  (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  |                                | 5.5            | V                   |       |
| $I_{OUT}$                        | Continuous output current  |   | 0  |                                | 200            | mA                  |       |
| $V_{FB}$                         | Internal reference (TPS79301)  |   | 1.201  | 1.225                          | 1.250          | V                   |       |
| $V_{OUT}$                        | Output voltage range   | TPS79301  |  | $V_{FB}$                       | $5.5 - V_{DO}$ | V                   |       |
|                                  |  | TPS79318  | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$ , $2.8\text{ V} < V_{IN} < 5.5\text{ V}$  | 1.764                          | 1.8            |                     | 1.836 |
|                                  |  | TPS79325  | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$ , $3.5\text{ V} < V_{IN} < 5.5\text{ V}$  | 2.45                           | 2.5            |                     | 2.55  |
|                                  |  | TPS79328  | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$ , $3.8\text{ V} < V_{IN} < 5.5\text{ V}$  | 2.744                          | 2.8            |                     | 2.856 |
|                                  |  | TPS793285   | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$ , $3.85\text{ V} < V_{IN} < 5.5\text{ V}$ | 2.793                          | 2.85           |                     | 2.907 |
|                                  |  | TPS79330  | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$ , $4\text{ V} < V_{IN} < 5.5\text{ V}$    | 2.94                           | 3              |                     | 3.06  |
|                                  |  | TPS79333  | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$ , $4.3\text{ V} < V_{IN} < 5.5\text{ V}$  | 3.234                          | 3.3            |                     | 3.366 |
|                                  |  | TPS793475   | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$ , $5.25\text{ V} < V_{IN} < 5.5\text{ V}$ | 4.655                          | 4.75           |                     | 4.845 |
| $\Delta V_{OUT(\Delta V_{IN})}$  | Line regulation  | $V_{OUT} + 1\text{ V} < V_{IN} \leq 5.5\text{ V}$                       |  | 0.05                           | 0.12           | %/V                 |       |
| $\Delta V_{OUT(\Delta I_{OUT})}$ | Load regulation  | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$ , $T_J = 25^{\circ}\text{C}$ |  | 5                              |                | mV                  |       |
| $V_{DO}$                         | Dropout voltage <sup>(2)</sup><br>( $V_{IN} = V_{OUT(nom)} - 0.1\text{ V}$ ) | TPS79328  | $I_{OUT} = 200\text{ mA}$  |                                | 120            | 200                 | mV    |
|                                  |  | TPS793285   | $I_{OUT} = 200\text{ mA}$  |                                | 120            | 200                 |       |
|                                  |  | TPS79330  | $I_{OUT} = 200\text{ mA}$  |                                | 112            | 200                 |       |
|                                  |  | TPS79333  | $I_{OUT} = 200\text{ mA}$  |                                | 12             | 180                 |       |
|                                  |  | TPS793475   | $I_{OUT} = 200\text{ mA}$  |                                | 77             | 125                 |       |
| $I_{CL}$                         | Output current limit   | $V_{OUT} = 0\text{ V}$  | 285  |                                | 600            | mA                  |       |
| $I_{GND}$                        | Ground pin current   | $0\ \mu\text{A} < I_{OUT} < 200\text{ mA}$                              |  | 170                            | 220            | $\mu\text{A}$       |       |
| $I_{SHUTDOWN}$                   | Shutdown current <sup>(3)</sup>  | $V_{EN} = 0\text{ V}$ , $2.7\text{ V} < V_{IN} < 5.5\text{ V}$          |  | 0.07                           | 1              | $\mu\text{A}$       |       |
| $I_{FB}$                         | FB pin current   | $V_{FB} = 1.8\text{ V}$   |  |                                | 1              | $\mu\text{A}$       |       |
| PSRR                             | Power-supply rejection ratio   | TPS79328  | $f = 100\text{ Hz}$ , $I_{OUT} = 10\text{ mA}$                                       |                                | 70             | dB                  |       |
|                                  |  |   | $f = 100\text{ Hz}$ , $I_{OUT} = 200\text{ mA}$                                      |                                | 68             |                     |       |
|                                  |  |   | $f = 10\text{ kHz}$ , $I_{OUT} = 200\text{ mA}$                                      |                                | 70             |                     |       |
|                                  |  |   | $f = 100\text{ kHz}$ , $I_{OUT} = 200\text{ mA}$                                     |                                | 43             |                     |       |
| $V_n$                            | Output noise voltage   | TPS79328  | BW = 200 Hz to 100 kHz,<br>$I_{OUT} = 200\text{ mA}$                                 | $C_{NR} = 0.001\ \mu\text{F}$  | 55             | $\mu\text{V}_{RMS}$ |       |
|                                  |  |   |  | $C_{NR} = 0.0047\ \mu\text{F}$ | 36             |                     |       |
|                                  |  |   |  | $C_{NR} = 0.01\ \mu\text{F}$   | 33             |                     |       |
|                                  |  |   |  | $C_{NR} = 0.1\ \mu\text{F}$    | 32             |                     |       |
| $t_{STR}$                        | Startup time   | TPS79328  | $R_L = 14\ \Omega$ ,<br>$C_{OUT} = 1\ \mu\text{F}$                                   | $C_{NR} = 0.001\ \mu\text{F}$  | 50             | $\mu\text{s}$       |       |
|                                  |  |   |  | $C_{NR} = 0.0047\ \mu\text{F}$ | 70             |                     |       |
|                                  |  |   |  | $C_{NR} = 0.01\ \mu\text{F}$   | 100            |                     |       |
| $V_{EN(high)}$                   | High-level enable input voltage  | $2.7\text{ V} < V_{IN} < 5.5\text{ V}$                                  | 1.7  |                                | $V_{IN}$       | V                   |       |
| $V_{EN(low)}$                    | Low-level enable input voltage   | $2.7\text{ V} < V_{IN} < 5.5\text{ V}$                                  | 0  |                                | 0.7            | V                   |       |
| $I_{EN}$                         | EN pin current   | $V_{EN} = 0\text{ V}$   | -1   |                                | 1              | $\mu\text{A}$       |       |
| UVLO                             | UVLO   | Threshold, $V_{CC}$ rising  | 2.25   |                                | 2.65           | V                   |       |
|                                  |  | Hysteresis  |  | 100                            |                | mV                  |       |

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

(2) Dropout is not measured for the TPS79318 and TPS79325 because minimum  $V_{IN} = 2.7\text{ V}$ .

(3) For adjustable versions, this parameter applies only after  $V_{IN}$  is applied; then  $V_{EN}$  transitions high to low.

### 6.6 Typical Characteristics

Over recommended operating temperature range  $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ,  $V_{\text{EN}} = V_{\text{IN}}$ ,  $V_{\text{IN}} = V_{\text{OUT(nom)}} + 1\text{ V}$ ,  $I_{\text{OUT}} = 1\text{ mA}$ ,  $C_{\text{OUT}} = 10\text{ }\mu\text{F}$ ,  $C_{\text{NR}} = 0.01\text{ }\mu\text{F}$ ,  $V_{\text{OUT(nom)}} = 2.8\text{ V}$  (unless otherwise noted). Typical values are at  $T_J = 25^{\circ}\text{C}$ .

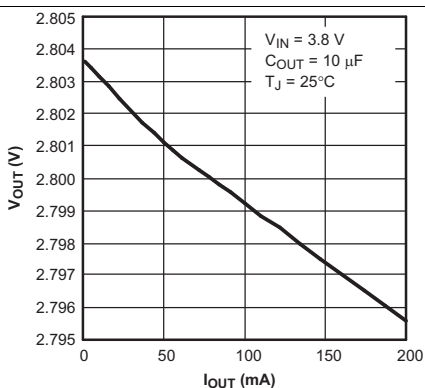


Figure 1. TPS79328 Output Voltage vs Output Current

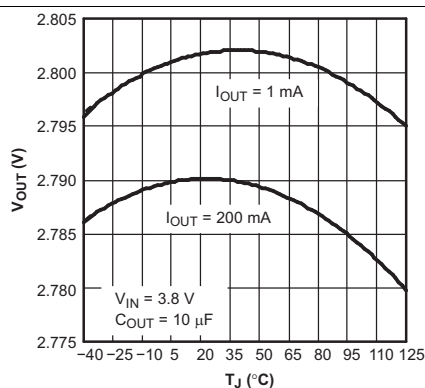


Figure 2. TPS79328 Output Voltage vs Junction Temperature

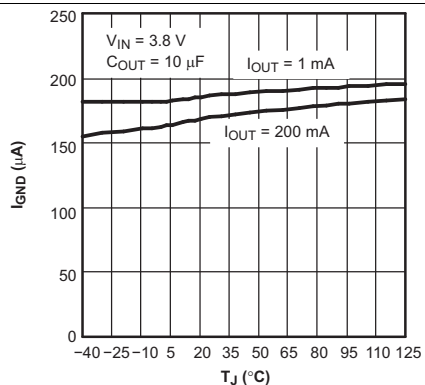


Figure 3. TPS79328 Ground Current vs Junction Temperature

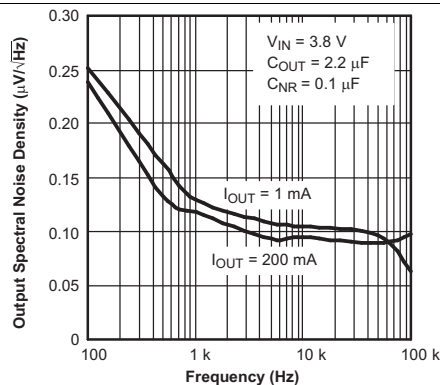


Figure 4. TPS79328 Output Spectral Noise Density vs Frequency

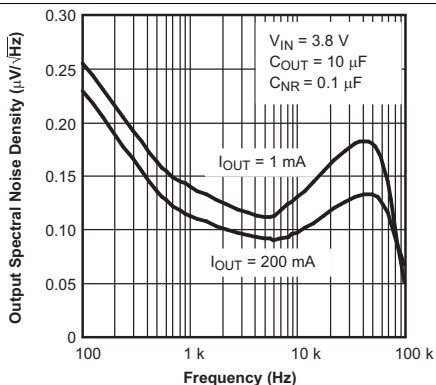


Figure 5. TPS79328 Output Spectral Noise Density vs Frequency

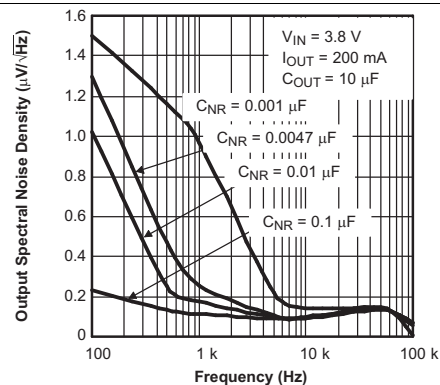


Figure 6. TPS79328 Output Spectral Noise Density vs Frequency

Typical Characteristics (continued)

Over recommended operating temperature range  $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ,  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1\text{ V}$ ,  $I_{OUT} = 1\text{ mA}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $C_{NR} = 0.01\text{ }\mu\text{F}$ ,  $V_{OUT(nom)} = 2.8\text{ V}$  (unless otherwise noted). Typical values are at  $T_J = 25^{\circ}\text{C}$ .

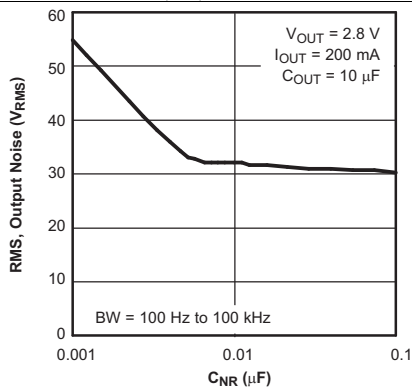


Figure 7. Root Mean Square Output Noise vs  $C_{NR}$

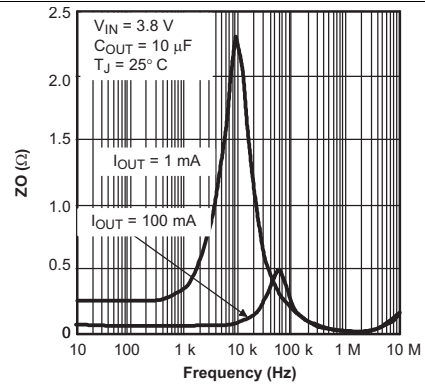


Figure 8. Output Impedance vs Frequency

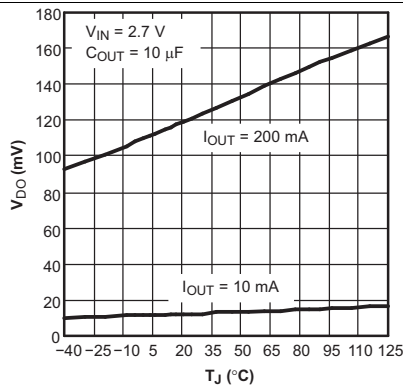


Figure 9. TPS79328 Dropout Voltage vs Junction Temperature

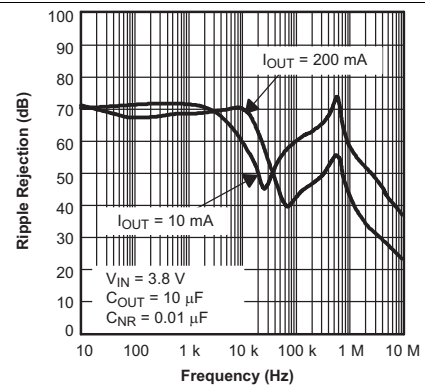


Figure 10. TPS79328 Ripple Rejection vs Frequency

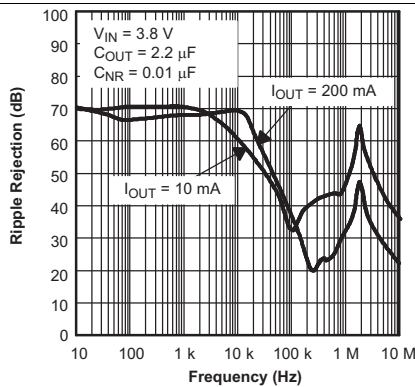


Figure 11. TPS79328 Ripple Rejection vs Frequency

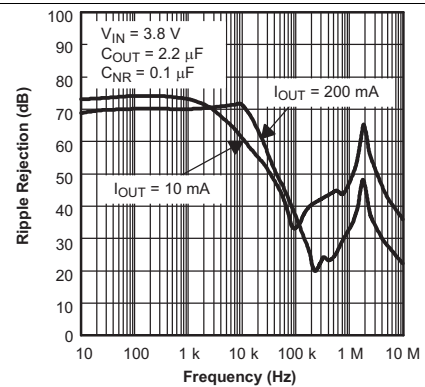


Figure 12. TPS79328 Ripple Rejection vs Frequency



Typical Characteristics (continued)

Over recommended operating temperature range  $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ,  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1\text{ V}$ ,  $I_{OUT} = 1\text{ mA}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $C_{NR} = 0.01\text{ }\mu\text{F}$ ,  $V_{OUT(nom)} = 2.8\text{ V}$  (unless otherwise noted). Typical values are at  $T_J = 25^\circ\text{C}$ .

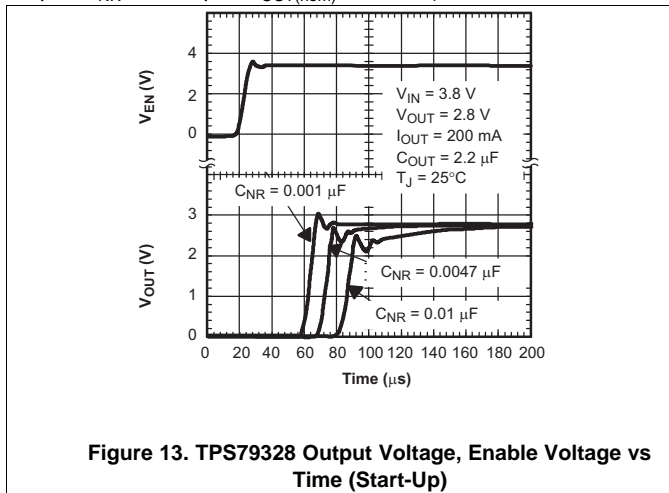


Figure 13. TPS79328 Output Voltage, Enable Voltage vs Time (Start-Up)

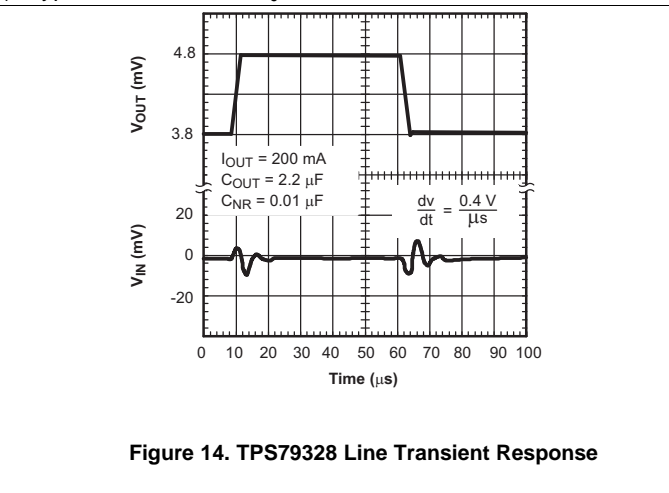


Figure 14. TPS79328 Line Transient Response

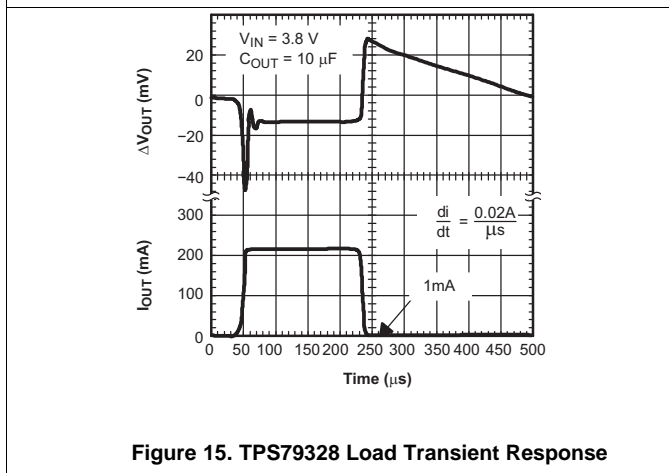


Figure 15. TPS79328 Load Transient Response

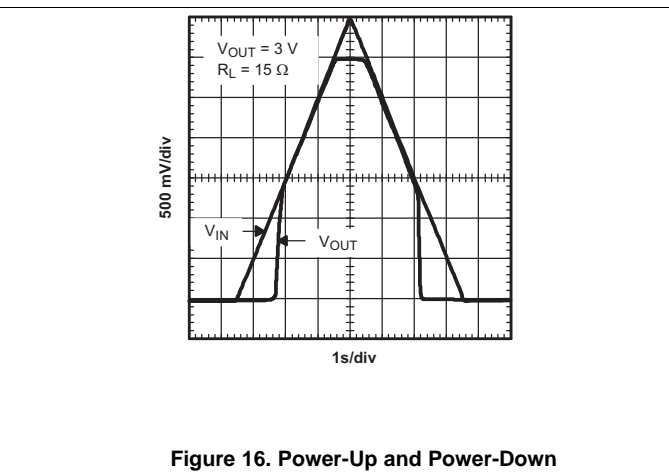


Figure 16. Power-Up and Power-Down

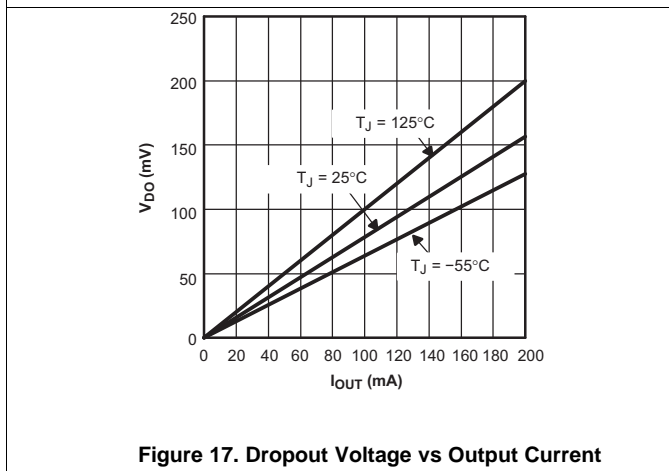


Figure 17. Dropout Voltage vs Output Current

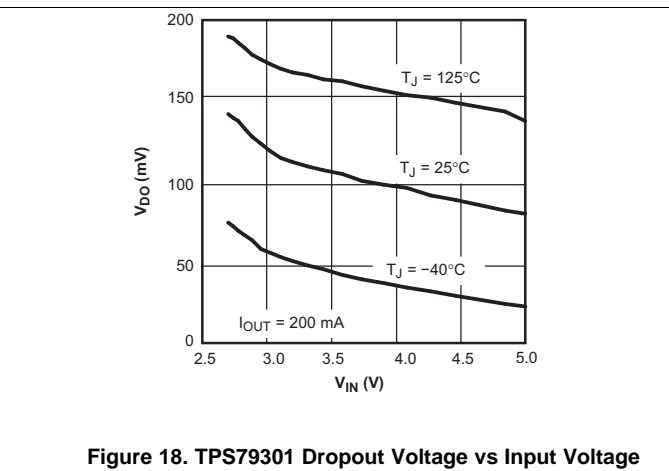


Figure 18. TPS79301 Dropout Voltage vs Input Voltage

### Typical Characteristics (continued)

Over recommended operating temperature range  $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ,  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1\text{ V}$ ,  $I_{OUT} = 1\text{ mA}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $C_{NR} = 0.01\text{ }\mu\text{F}$ ,  $V_{OUT(nom)} = 2.8\text{ V}$  (unless otherwise noted). Typical values are at  $T_J = 25^{\circ}\text{C}$ .

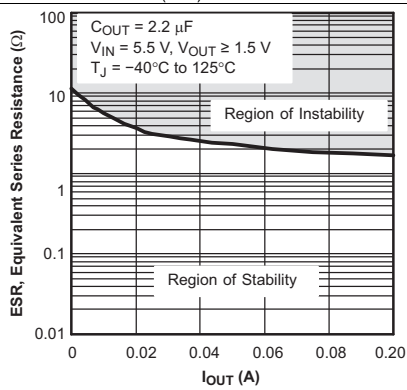


Figure 19. Typical Regions of Stability Equivalent Series Resistance (ESR) vs Output Current

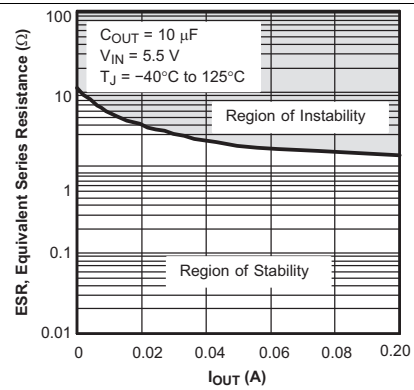


Figure 20. Typical Regions of Stability Equivalent Series Resistance (ESR) vs Output Current

## 7 Detailed Description

### 7.1 Overview

The TPS793 family of LDO regulators has been optimized for use in noise-sensitive battery-operated equipment. The device features extremely low dropout voltages, high PSRR, ultralow output noise, low quiescent current (170  $\mu\text{A}$  typically), and enable-input to reduce supply currents to less than 1  $\mu\text{A}$  when the regulator is turned off.

### 7.2 Functional Block Diagrams

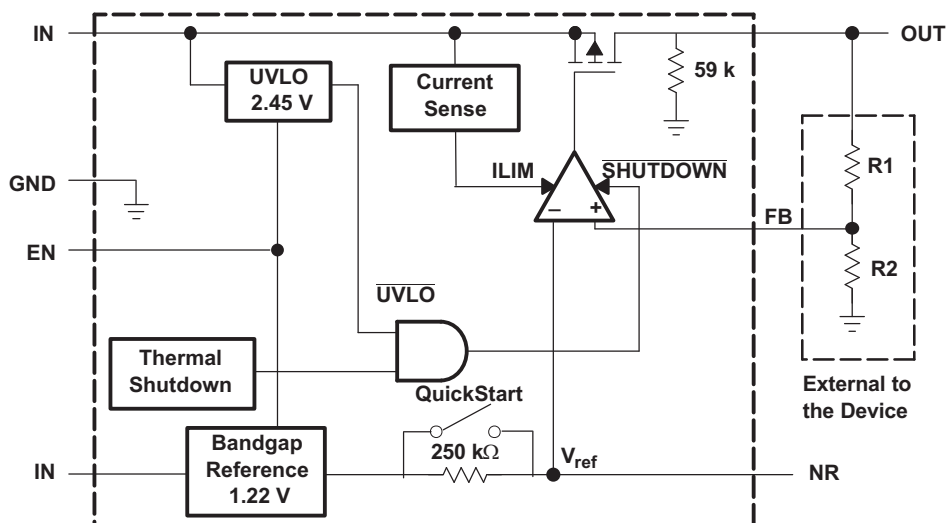


Figure 21. TPS79301 Block Diagram (Adjustable Version)

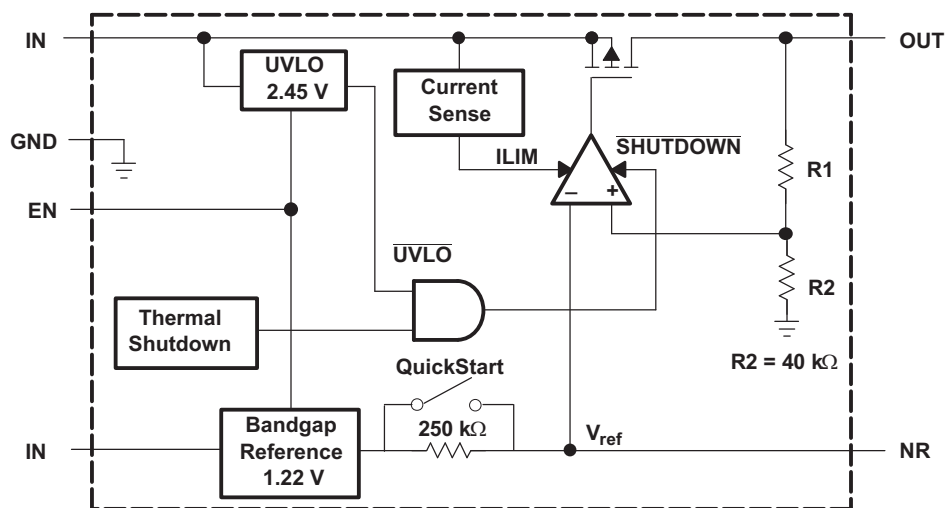


Figure 22. TPS793 Block Diagram (Fixed Version)

## 7.3 Feature Description

### 7.3.1 Undervoltage Lockout (UVLO)

The TPS793 uses an undervoltage lockout (UVLO) circuit that disables the output until the input voltage is greater than the rising UVLO voltage. This circuit ensures that the device does not exhibit any unpredictable behavior when the supply voltage is lower than the operational range of the internal circuitry,  $V_{IN(min)}$ .

### 7.3.2 Shutdown

The enable pin (EN) is active high. Enable the device by forcing the EN pin to exceed  $V_{EN(high)}$  (1.7 V, minimum). Turn off the device by forcing the EN pin to drop below 0.7 V. If shutdown capability is not required, connect EN to IN.

### 7.3.3 Foldback Current Limit

The TPS793 features internal current limiting and thermal protection. During normal operation, the TPS793 limits output current to approximately 400 mA. When current limiting engages, the output voltage scales back linearly until the overcurrent condition ends. While current limiting is designed to prevent gross device failure, care should be taken not to exceed the power dissipation ratings of the package or the absolute maximum voltage ratings of the device.

### 7.3.4 Thermal Protection

Thermal protection disables the output when the junction temperature rises to approximately 165°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 regulator dissipation, protecting the device from damage as a result of overheating.

Any tendency to activate the thermal protection circuit indicates excessive power dissipation or an inadequate heatsink. For reliable operation, junction temperature must 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.

The TPS793 internal protection circuitry is designed to protect against overload conditions. This circuitry is not intended to replace proper heatsinking. Continuously running the TPS793 into thermal shutdown degrades device reliability.

### 7.3.5 Reverse Current Operation

The TPS793 PMOS-pass transistor has a built-in back diode that conducts reverse current when the input voltage drops below the output voltage (for example, during power down). Current is conducted from the output to the input and is not internally limited. If extended reverse voltage operation is anticipated, external limiting to 5% of the rated output current is recommended.

## 7.4 Device Functional Modes

### 7.4.1 Normal Operation

The device regulates to the nominal output voltage under the following conditions:

- The input voltage is at least as high as  $V_{IN(min)}$ .
- The input voltage is greater than the nominal output voltage added to the dropout voltage.
- The enable voltage is greater than  $V_{EN(min)}$ .
- The output current is less than the current limit.
- The device junction temperature is less than the maximum specified junction temperature.

### 7.4.2 Dropout Operation

If the input voltage is lower than the nominal output voltage plus the specified dropout voltage, but all other conditions are met for normal operation, the device operates in dropout mode. In this mode of operation, the output voltage is the same as the input voltage minus the dropout voltage. The transient performance of the device is significantly degraded because the pass device is in the linear region and no longer controls the current through the LDO. Line or load transients in dropout can result in large output voltage deviations.

### 7.4.3 Disabled

The device is disabled under the following conditions:

- The enable voltage is less than the enable falling threshold voltage or has not yet exceeded the enable rising threshold.
- The device junction temperature is greater than the thermal shutdown temperature.
- The input voltage is less than  $UVLO_{falling}$ .

[Table 1](#) shows the conditions that lead to the different modes of operation.

**Table 1. Device Functional Mode Comparison**

| OPERATING MODE  | PARAMETER  |                         |                     |                            |
|---|--|-------------------------|---------------------|----------------------------|
|   | $V_{IN}$   | $V_{EN}$                | $I_{OUT}$           | $T_J$                      |
| Normal mode   | $V_{IN} > V_{OUT(nom)} + V_{DO}$ and<br>$V_{IN} > V_{IN(min)}$ | $V_{EN} > V_{EN(high)}$ | $I_{OUT} < I_{LIM}$ | $T_J < 125^{\circ}C$       |
| Dropout mode  | $V_{IN(min)} < V_{IN} < V_{OUT(nom)} + V_{DO}$                 | $V_{EN} > V_{EN(high)}$ | —                   | $T_J < 125^{\circ}C$       |
| Disabled mode<br>(any true condition disables the device) | $V_{IN} < UVLO_{falling}$                                      | $V_{EN} < V_{EN(low)}$  | —                   | $T_J > 165^{\circ}C^{(1)}$ |

(1) Approximate value for thermal shutdown.

## 8 Application and Implementation

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Information

The TPS793 family of LDO regulators has been optimized for use in noise-sensitive battery-operated equipment. The device features extremely low dropout voltages, high PSRR, ultralow output noise, low quiescent current (170  $\mu\text{A}$  typically), and enable-input to reduce supply currents to less than 1  $\mu\text{A}$  when the regulator is turned off.

#### 8.1.1 Adjustable Operation

The output voltage of the TPS79301 adjustable regulator is programmed using an external resistor divider as shown in [Figure 23](#). The output voltage is calculated using [Equation 1](#):

$$V_{\text{OUT}} = V_{\text{REF}} \times \left( 1 + \frac{R_1}{R_2} \right)$$

where:

- $V_{\text{REF}} = 1.2246 \text{ V typ}$  (the internal reference voltage) (1)

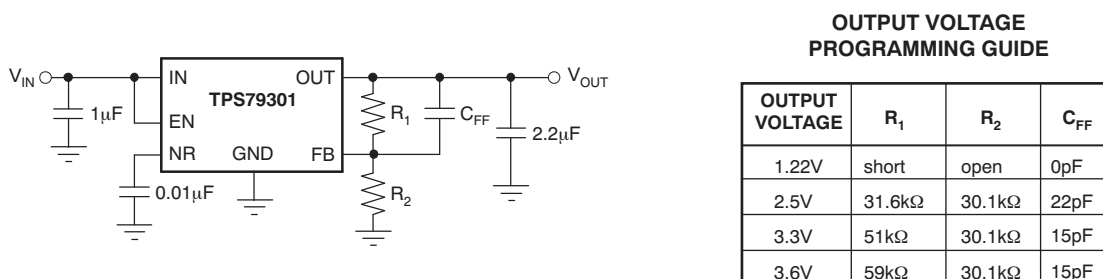
Resistors  $R_1$  and  $R_2$  should be chosen for approximately 50- $\mu\text{A}$  divider current. Lower value resistors can be used for improved noise performance, but the solution consumes more power. Higher resistors values can cause accuracy issues and other problems. The recommended design procedure is to choose  $R_2 = 30.1 \text{ k}\Omega$  to set the divider current at 50  $\mu\text{A}$ ,  $C_{\text{FF}} = 15 \text{ pF}$  for stability, and then calculate  $R_1$  using [Equation 2](#):

$$R_1 = \left( \frac{V_{\text{OUT}}}{V_{\text{REF}}} - 1 \right) \times R_2$$
 (2)

To improve the stability of the adjustable version, it is suggested that a small compensation capacitor be placed between OUT and FB. For output voltages less than 1.8 V, the value of this capacitor should be 100 pF. For output voltages greater than 1.8 V, the approximate value of this capacitor can be calculated as shown in [Equation 3](#):

$$C_{\text{FF}} = \frac{(3 \times 10^{-7}) \times (R_1 + R_2)}{(R_1 \times R_2)}$$
 (3)

The suggested value of this capacitor for several resistor ratios is shown in the table in [Figure 23](#). If this capacitor is not used (such as in a unity-gain configuration) or if an output voltage less than 1.8 V is chosen, then the minimum recommended output capacitor is 4.7  $\mu\text{F}$  instead of 2.2  $\mu\text{F}$ .



**Figure 23. TPS79301 Adjustable LDO Regulator Programming**

## 8.2 Typical Application

A typical application circuit is shown in [Figure 24](#).

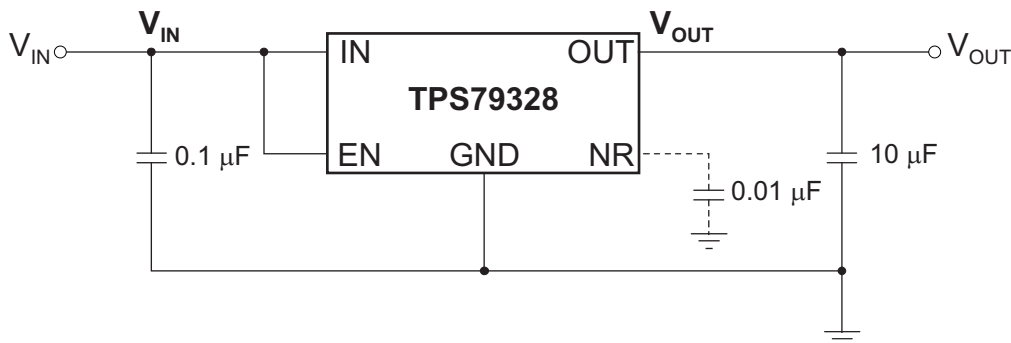


Figure 24. Typical Application Circuit

### 8.2.1 Design Requirements

[Table 2](#) lists the design requirements.

Table 2. Design Parameters

| PARAMETER                   | DESIGN REQUIREMENT                 |
|-----------------------------|------------------------------------|
| Input voltage               | 4.2 V to 3 V (Lithium Ion battery) |
| Output voltage              | 1.8 V, $\pm 1\%$                   |
| DC output current           | 10 mA                              |
| Peak output current         | 75 mA                              |
| Maximum ambient temperature | 65°C                               |

### 8.2.2 Detailed Design Procedure

Pick the desired output voltage option. An input capacitor of 0.1  $\mu\text{F}$  is used as the battery is connected to the input through a via and a short 10-mil (0.01-in) trace. An output capacitor of 10  $\mu\text{F}$  is used to provide optimal response time for the load transient. Verify that the maximum junction temperature is not exceeded by referring to [Figure 30](#).

#### 8.2.2.1 Capacitor Recommendations

Low equivalent series resistance (ESR) capacitors should be used for the input, output, noise reduction, and bypass capacitors. Ceramic capacitors with X7R and X5R dielectrics are preferred. These dielectrics offer more stable characteristics. Ceramic X7R capacitors offer improved over-temperature performance, while ceramic X5R capacitors are more cost-effective and are available in higher values.

#### 8.2.2.2 Input and Output Capacitor Requirements

A 0.1- $\mu\text{F}$  or larger ceramic input bypass capacitor, connected between IN and GND and located close to the TPS793, is required for stability and improves transient response, noise rejection, and ripple rejection. A higher-value input capacitor may be necessary if large, fast-rise-time load transients are anticipated or the device is located several inches from the power source.

Like most low-dropout regulators, the TPS793 requires an output capacitor connected between OUT and GND to stabilize the internal control loop. The minimum recommended capacitance is 2.2  $\mu\text{F}$ . Any 2.2- $\mu\text{F}$  or larger ceramic capacitor is suitable, provided the capacitance does not vary significantly over temperature. If load current is not expected to exceed 100 mA, a 1.0- $\mu\text{F}$  ceramic capacitor can be used. If a feed-forward capacitor is not used (such as in a unity-gain configuration) or if an output voltage less than 1.8 V is chosen, then the minimum recommended output capacitor is 4.7  $\mu\text{F}$  instead of 2.2  $\mu\text{F}$ . [Table 3](#) lists the recommended output capacitor sizes for several common configurations.

**Table 3. Output Capacitor Sizing**

| Condition   | C <sub>OUT</sub> (μF) |
|---|-----------------------|
| V <sub>OUT</sub> < 1.8 V or C <sub>FF</sub> = 0 nF  | 4.7                   |
| V <sub>OUT</sub> > 1.8 V, I <sub>OUT</sub> > 100 mA | 2.2                   |
| V <sub>OUT</sub> > 1.8 V, I <sub>OUT</sub> < 100 mA | 1                     |

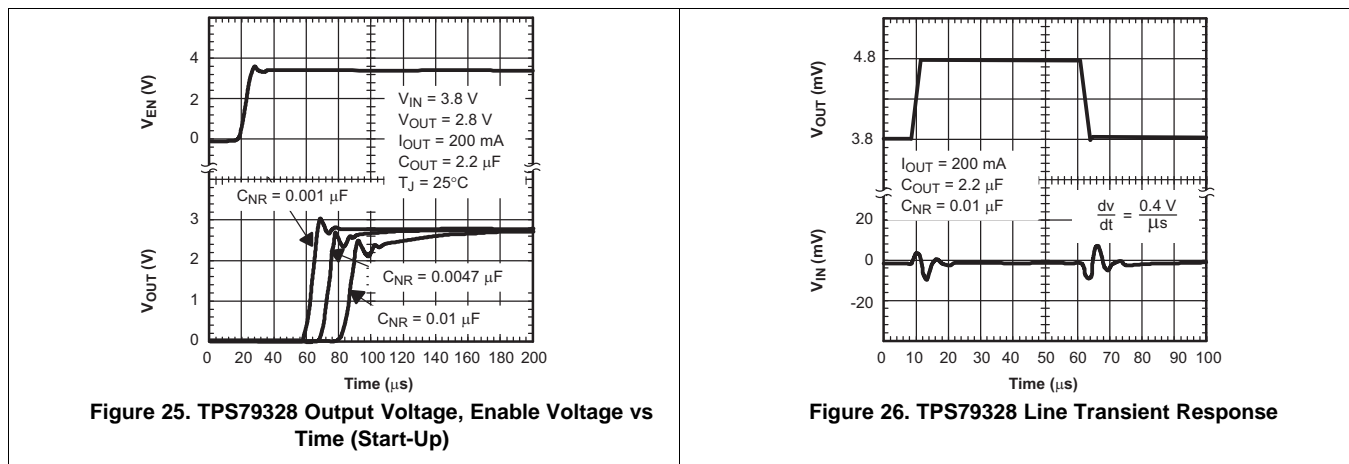
**8.2.2.3 Noise Reduction and Feed-Forward Capacitor Requirements**

The internal voltage reference is a key source of noise in an LDO regulator. The TPS793 has an NR pin which is connected to the voltage reference through a 250-kΩ internal resistor. The 250-kΩ internal resistor, in conjunction with an external bypass capacitor connected to the NR pin, creates a low-pass filter to reduce the voltage reference noise and, therefore, the noise at the regulator output. In order for the regulator to operate properly, the current flow out of the NR pin must be at a minimum, because any leakage current creates an IR drop across the internal resistor, thus creating an output error. Therefore, the bypass capacitor must have minimal leakage current. The bypass capacitor should be no more than 0.1 μF to ensure that it is fully charged during the quickstart time provided by the internal switch shown in the *Functional Block Diagrams*.

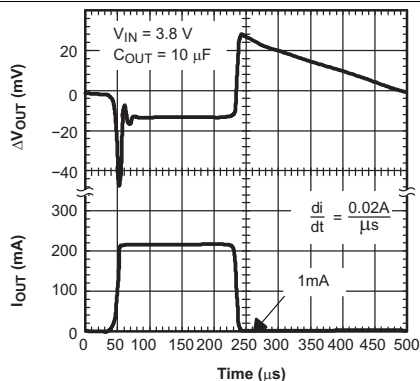
As an example, the TPS79328 exhibits only 32 μV<sub>RMS</sub> of output voltage noise using a 0.1-μF ceramic bypass capacitor and a 2.2-μF ceramic output capacitor. Note that the output starts up slower as the bypass capacitance increases due to the RC time constant at the NR pin that is created by the internal 250-kΩ resistor and external capacitor. This RC time constant is affected by the quick-start circuit, especially for values near or below 10 nF. See *Figure 13* for a comparisons of C<sub>NR</sub> capacitors and startup times.

A feed-forward capacitor is recommended to improve the stability of the device. If R<sub>2</sub> = 30.1 kΩ, set C<sub>1</sub> to 15 pF for optimal performance. For voltages less than 1.8 V, the value of this capacitor should be 100 pF. For voltages greater than 1.8 V, the approximate value of this capacitor can be calculated as shown in *Equation 3*.

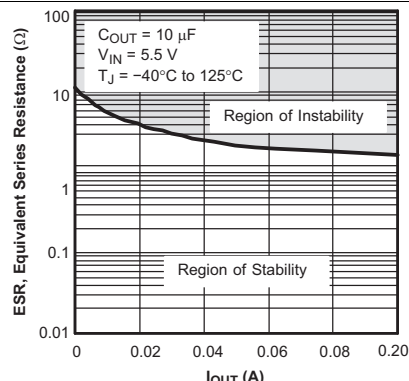
**8.2.3 Application Curves**







**Figure 27. TPS79328 Load Transient Response**



**Figure 28. Typical Regions of Stability Equivalent Series Resistance (ESR) vs Output Current**

### 8.3 Do's and Don'ts

Do place at least one, low ESR, 2.2- $\mu$ F capacitor as close as possible between the OUT pin of the regulator and the GND pin.

Do place at least one, low ESR, 0.1- $\mu$ F capacitor as close as possible between the IN pin of the regulator and the GND pin.

Do provide adequate thermal paths away from the device.

Do not place the input or output capacitor more than 10 mm away from the regulator.

Do not exceed the absolute maximum ratings.

Do not float the Enable (EN) pin.

Do not resistively or inductively load the NR pin.

Do not let the output voltage get more than 0.3 V above the input voltage.

## 9 Power Supply Recommendations

These devices are designed to operate from an input voltage supply range from 2.7 V to 5.5 V. The input voltage range must provide adequate headroom in order for the device to have a regulated output. This input supply must be well-regulated and stable. A 0.1- $\mu$ F input capacitor is required for stability; if the input supply is noisy, additional input capacitors with low ESR can help improve the output noise performance.

## 10 Layout

### 10.1 Layout Guidelines

Layout is a critical part of good power-supply design. There are several signal paths that conduct fast-changing currents or voltages that can interact with stray inductance or parasitic capacitance to generate noise or degrade the power-supply performance. To help eliminate these problems, the IN pin should be bypassed to ground with a low ESR ceramic bypass capacitor with an X5R or X7R dielectric.

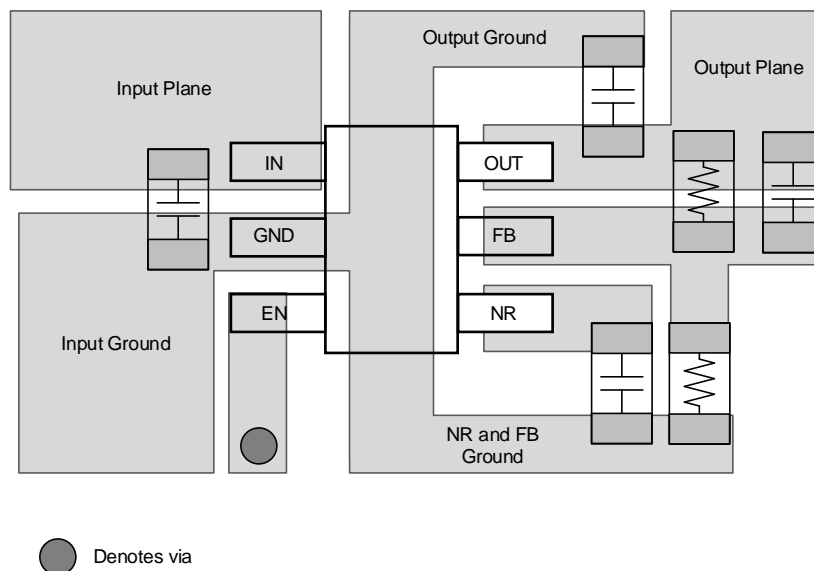
Equivalent series inductance (ESL) and equivalent series resistance (ESR) must be minimized to maximize performance and ensure stability. Every capacitor ( $C_{IN}$ ,  $C_{OUT}$ ,  $C_{NR/SS}$ ,  $C_{FF}$ ) must be placed as close as possible to the device and on the same side of the PCB as the regulator itself.

Do not place any of the capacitors on the opposite side of the PCB from where the regulator is installed. The use of vias and long traces is strongly discouraged because these circuits may impact system performance negatively, and even cause instability.

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

To improve ac measurements like 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 bypass capacitor should connect directly to the GND pin of the device.

### 10.2 Layout Example



**Figure 29. Layout Example (DBV Package)**

### 10.3 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 [Thermal Information](#). 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 ( $P_D$ ) can be approximated by the product of the output current times the voltage drop across the output pass element ( $V_{IN}$  to  $V_{OUT}$ ), as shown in [Equation 4](#).

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} \quad (4)$$

## Power Dissipation (continued)

Power dissipation resulting from quiescent current is negligible. Excessive power dissipation triggers the thermal protection circuit.

Figure 30 shows the maximum ambient temperature versus the power dissipation of the TPS730. This figure assumes the device is soldered on a JEDEC standard, high-K layout with no airflow over the board. Actual board thermal impedances vary widely. If the application requires high power dissipation, having a thorough understanding of the board temperature and thermal impedances is helpful to ensure the TPS730 does not operate above a junction temperature of 125°C.

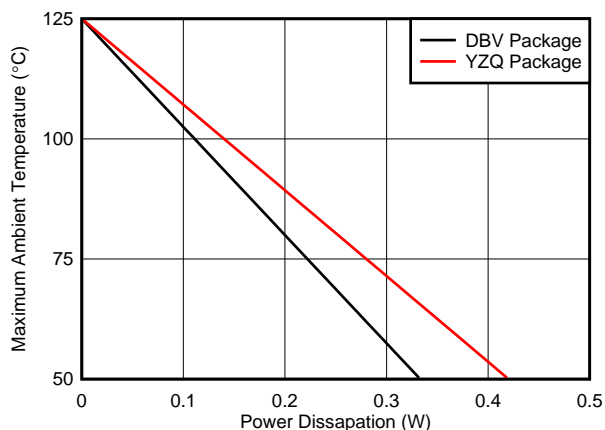


Figure 30. Maximum Ambient Temperature vs Power Dissipation

Estimating the junction temperature can be done by using the thermal metrics  $\Psi_{JT}$  and  $\Psi_{JB}$ , shown in [Thermal Information](#). These metrics are a more accurate representation of the heat transfer characteristics of the die and the package than  $R_{\theta JA}$ . The junction temperature can be estimated with [Equation 5](#).

$$\Psi_{JT}: T_J = T_T + \Psi_{JT} \cdot P_D$$

$$\Psi_{JB}: T_J = T_B + \Psi_{JB} \cdot P_D$$

where

- $P_D$  is the power dissipation shown by [Equation 4](#).
- $T_T$  is the temperature at the center-top of the IC package.
- $T_B$  is the PCB temperature measured 1 mm away from the IC package *on the PCB surface*. (5)

### NOTE

Both  $T_T$  and  $T_B$  can be measured on actual application boards using a thermo-gun (an infrared thermometer).

For more information about measuring  $T_T$  and  $T_B$ , see the application note [Using New Thermal Metrics \(SBVA025\)](#), available for download at [www.ti.com](http://www.ti.com).

## 11 Device and Documentation Support

### 11.1 Device Support

#### 11.1.1 Development Support

##### 11.1.1.1 Evaluation Modules

Seven evaluation modules (EVMs) are available to assist in the initial circuit performance evaluation using the TPS793:

- [TPS79301EVM](#)
- [TPS79318YEQEVM](#)
- [TPS79325YEQEVM](#)
- [TPS793285YEQEVM](#)
- [TPS79328EVM](#)
- [TPS79328YEQEVM](#)
- [TPS79330YEQEVM](#)

These EVMs can be requested at the Texas Instruments website through the device product folders or purchased directly from [the TI eStore](#).

##### 11.1.1.2 Spice Models

Computer simulation of circuit performance using SPICE is often useful when analyzing the performance of analog circuits and systems. A SPICE model for the TPS793 is available through the product folders under *Tools & Software*.

#### 11.1.2 Device Nomenclature

**Table 4. Ordering Information<sup>(1)(2)</sup>**

| PRODUCT      | V <sub>OUT</sub>  |
|--------------|---|
| TPS793xxyyyz | <b>XX(X)</b> is the nominal output voltage (for example, 28 = 2.8 V; 285 = 2.85 V; 01 = adjustable version).<br><b>YYY</b> is the package designator.<br><b>Z</b> is the package quantity. R is for reel (3000 pieces), T is for tape (250 pieces). |

(1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or visit the device product folder on [www.ti.com](http://www.ti.com).

(2) Output voltages from 1.2 V to 4.8 V in 50-mV increments are available. Contact the factory for details and availability.

### 11.2 Documentation Support

#### 11.2.1 Related Documentation

- Application note, *Using New Thermal Metrics*, [SBVA025](#).
- Application note, *Pros and Cons of Using a Feedforward Capacitor with a Low-Dropout Regulator*, [SBVA042](#).
- *TPS793xxYEQEVM User's Guide*, [SBVU001](#).
- *TPS79301EVM, TPS79328EVM LDO Linear Regulator Evaluation Module User's Guide*, [SLVU060A](#).

#### 11.3 Community Resource

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At [e2e.ti.com](http://e2e.ti.com), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

## 11.4 Trademarks

NanoStar, E2E are trademarks of Texas Instruments.  
*Bluetooth* is a registered trademark of Bluetooth SIG, Inc.  
All other trademarks are the property of their respective owners.

## 11.5 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## 11.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2)         | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| HPA01085DBVR     | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHJI                    | <a href="#">Samples</a> |
| HPA01085DVBR     | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHJI                    | <a href="#">Samples</a> |
| TPS79301DBVR     | ACTIVE        | SOT-23       | DBV             | 6    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PGVI                    | <a href="#">Samples</a> |
| TPS79301DBVRG4   | ACTIVE        | SOT-23       | DBV             | 6    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PGVI                    | <a href="#">Samples</a> |
| TPS79318DBVR     | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHHI                    | <a href="#">Samples</a> |
| TPS79318DBVRG4   | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHHI                    | <a href="#">Samples</a> |
| TPS79318DBVT     | ACTIVE        | SOT-23       | DBV             | 5    | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHHI                    | <a href="#">Samples</a> |
| TPS79318DBVTG4   | ACTIVE        | SOT-23       | DBV             | 5    | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHHI                    | <a href="#">Samples</a> |
| TPS79318YZQR     | ACTIVE        | DSBGA        | YZQ             | 5    | 3000        | Green (RoHS & no Sb/Br) | SNAGCU                  | Level-1-260C-UNLIM   | -40 to 125   | E3                      | <a href="#">Samples</a> |
| TPS79318YZQT     | ACTIVE        | DSBGA        | YZQ             | 5    | 250         | Green (RoHS & no Sb/Br) | SNAGCU                  | Level-1-260C-UNLIM   | -40 to 125   | E3                      | <a href="#">Samples</a> |
| TPS79325DBVR     | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PGWI                    | <a href="#">Samples</a> |
| TPS79325DBVRG4   | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PGWI                    | <a href="#">Samples</a> |
| TPS79325YZQR     | ACTIVE        | DSBGA        | YZQ             | 5    | 3000        | Green (RoHS & no Sb/Br) | SNAGCU                  | Level-1-260C-UNLIM   | -40 to 125   | E4                      | <a href="#">Samples</a> |
| TPS793285DBVR    | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHII                    | <a href="#">Samples</a> |
| TPS793285DBVRG4  | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHII                    | <a href="#">Samples</a> |
| TPS793285DBVT    | ACTIVE        | SOT-23       | DBV             | 5    | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHII                    | <a href="#">Samples</a> |
| TPS793285DBVTG4  | ACTIVE        | SOT-23       | DBV             | 5    | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHII                    | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2)         | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TPS793285YZQR    | ACTIVE        | DSBGA        | YZQ             | 5    | 3000        | Green (RoHS & no Sb/Br) | SNAGCU                  | Level-1-260C-UNLIM   | -40 to 125   | E5                      | <a href="#">Samples</a> |
| TPS79328DBVR     | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PGXI                    | <a href="#">Samples</a> |
| TPS79328DBVRG4   | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PGXI                    | <a href="#">Samples</a> |
| TPS79328YZQR     | ACTIVE        | DSBGA        | YZQ             | 5    | 3000        | Green (RoHS & no Sb/Br) | SNAGCU                  | Level-1-260C-UNLIM   | -40 to 125   | E2                      | <a href="#">Samples</a> |
| TPS79328YZQT     | ACTIVE        | DSBGA        | YZQ             | 5    | 250         | Green (RoHS & no Sb/Br) | SNAGCU                  | Level-1-260C-UNLIM   | -40 to 125   | E2                      | <a href="#">Samples</a> |
| TPS79330DBVR     | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PGYI                    | <a href="#">Samples</a> |
| TPS79330DBVRG4   | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PGYI                    | <a href="#">Samples</a> |
| TPS79330YZQR     | ACTIVE        | DSBGA        | YZQ             | 5    | 3000        | Green (RoHS & no Sb/Br) | SNAGCU                  | Level-1-260C-UNLIM   | -40 to 125   | E6                      | <a href="#">Samples</a> |
| TPS79330YZQT     | ACTIVE        | DSBGA        | YZQ             | 5    | 250         | Green (RoHS & no Sb/Br) | SNAGCU                  | Level-1-260C-UNLIM   | -40 to 125   | E6                      | <a href="#">Samples</a> |
| TPS79333DBVR     | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHUI                    | <a href="#">Samples</a> |
| TPS79333DBVRG4   | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHUI                    | <a href="#">Samples</a> |
| TPS793475DBVR    | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHJI                    | <a href="#">Samples</a> |
| TPS793475DBVRG4  | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | PHJI                    | <a href="#">Samples</a> |

(1) 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.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

#### **OTHER QUALIFIED VERSIONS OF TPS793 :**

- Automotive: [TPS793-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects



## TAPE AND REEL INFORMATION



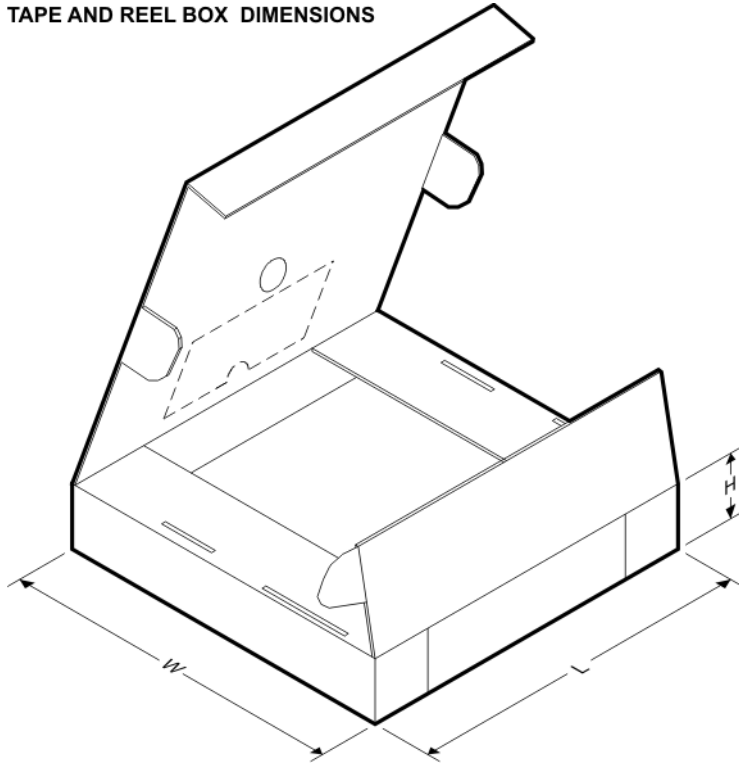
### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS79301DBVR  | SOT-23       | DBV             | 6    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS79318DBVR  | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS79318DBVT  | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS79318YZQR  | DSBGA        | YZQ             | 5    | 3000 | 178.0              | 8.4                | 0.98    | 1.46    | 0.69    | 4.0     | 8.0    | Q1            |
| TPS79318YZQT  | DSBGA        | YZQ             | 5    | 250  | 178.0              | 8.4                | 0.98    | 1.46    | 0.69    | 4.0     | 8.0    | Q1            |
| TPS79325DBVR  | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS79325YZQR  | DSBGA        | YZQ             | 5    | 3000 | 178.0              | 8.4                | 0.98    | 1.46    | 0.69    | 4.0     | 8.0    | Q1            |
| TPS793285DBVR | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS793285DBVT | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS793285YZQR | DSBGA        | YZQ             | 5    | 3000 | 178.0              | 8.4                | 0.98    | 1.46    | 0.69    | 4.0     | 8.0    | Q1            |
| TPS79328DBVR  | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS79328YZQR  | DSBGA        | YZQ             | 5    | 3000 | 178.0              | 8.4                | 0.98    | 1.46    | 0.69    | 4.0     | 8.0    | Q1            |
| TPS79328YZQT  | DSBGA        | YZQ             | 5    | 250  | 178.0              | 8.4                | 0.98    | 1.46    | 0.69    | 4.0     | 8.0    | Q1            |
| TPS79330DBVR  | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS79330YZQR  | DSBGA        | YZQ             | 5    | 3000 | 178.0              | 8.4                | 0.98    | 1.46    | 0.69    | 4.0     | 8.0    | Q1            |
| TPS79330YZQT  | DSBGA        | YZQ             | 5    | 250  | 178.0              | 8.4                | 0.98    | 1.46    | 0.69    | 4.0     | 8.0    | Q1            |
| TPS79333DBVR  | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| TPS79333DBVR  | SOT-23       | DBV             | 5    | 3000 | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

| 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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS793475DBVR | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

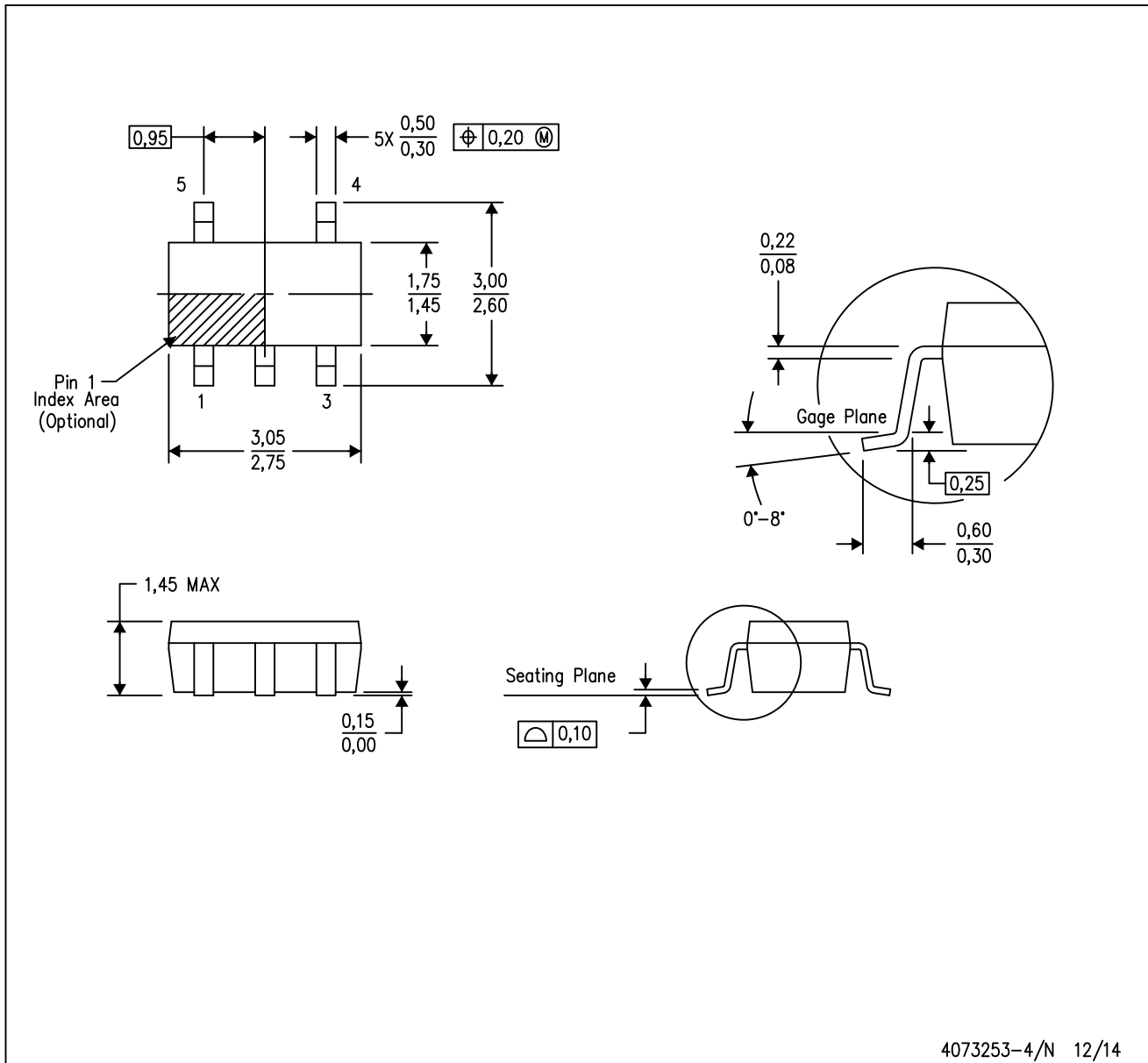
| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS79301DBVR  | SOT-23       | DBV             | 6    | 3000 | 180.0       | 180.0      | 18.0        |
| TPS79318DBVR  | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| TPS79318DBVT  | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |
| TPS79318YZQR  | DSBGA        | YZQ             | 5    | 3000 | 217.0       | 193.0      | 35.0        |
| TPS79318YZQT  | DSBGA        | YZQ             | 5    | 250  | 217.0       | 193.0      | 35.0        |
| TPS79325DBVR  | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| TPS79325YZQR  | DSBGA        | YZQ             | 5    | 3000 | 217.0       | 193.0      | 35.0        |
| TPS793285DBVR | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| TPS793285DBVT | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |
| TPS793285YZQR | DSBGA        | YZQ             | 5    | 3000 | 217.0       | 193.0      | 35.0        |
| TPS79328DBVR  | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| TPS79328YZQR  | DSBGA        | YZQ             | 5    | 3000 | 217.0       | 193.0      | 35.0        |
| TPS79328YZQT  | DSBGA        | YZQ             | 5    | 250  | 217.0       | 193.0      | 35.0        |
| TPS79330DBVR  | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| TPS79330YZQR  | DSBGA        | YZQ             | 5    | 3000 | 217.0       | 193.0      | 35.0        |
| TPS79330YZQT  | DSBGA        | YZQ             | 5    | 250  | 217.0       | 193.0      | 35.0        |

---

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS79333DBVR  | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| TPS79333DBVR  | SOT-23       | DBV             | 5    | 3000 | 210.0       | 185.0      | 35.0        |
| TPS793475DBVR | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Falls within JEDEC MO-178 Variation AA.

DBV (R-PDSO-G5)

PLASTIC SMALL OUTLINE

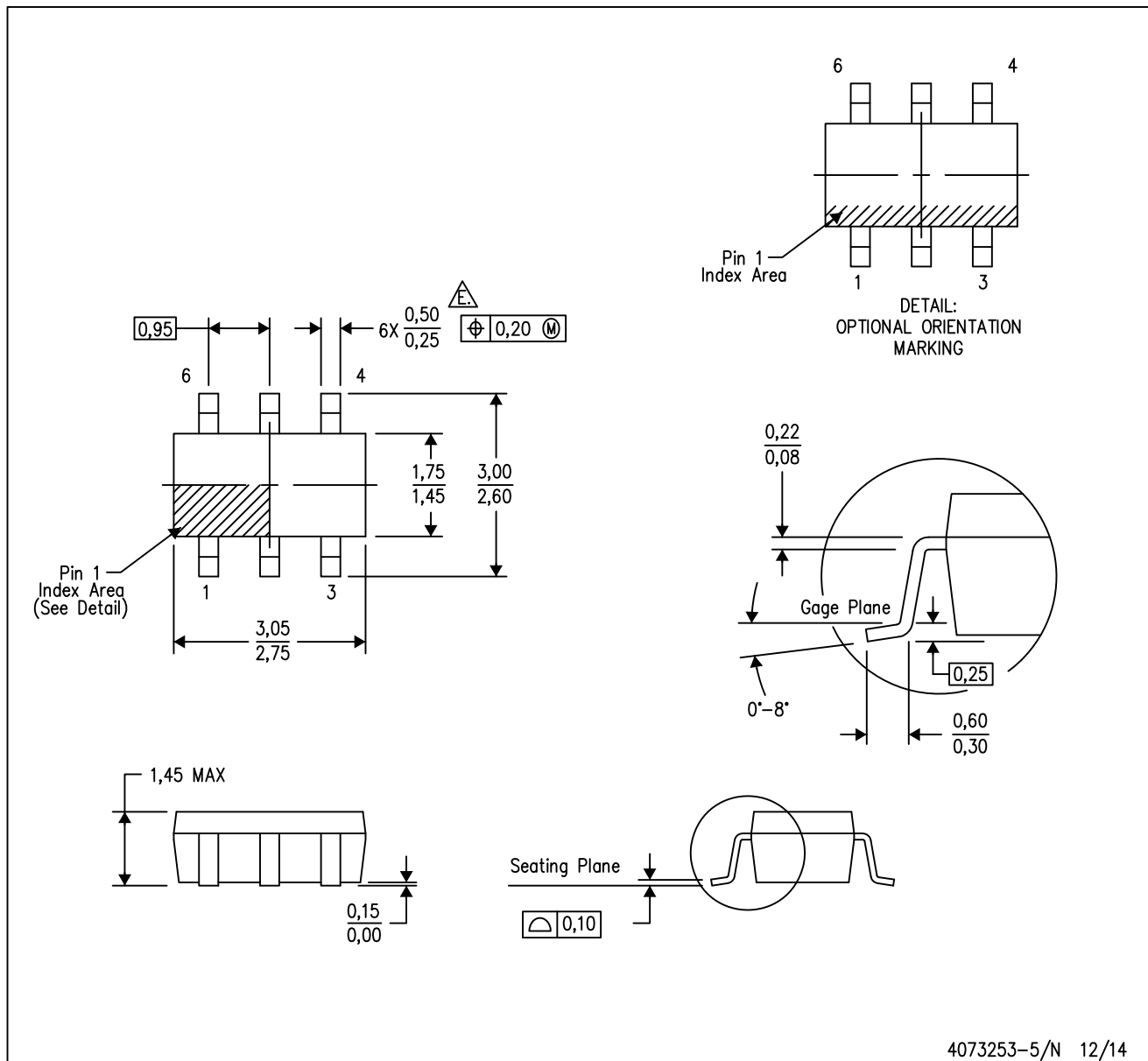


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

# MECHANICAL DATA

DBV (R-PDSO-G6)

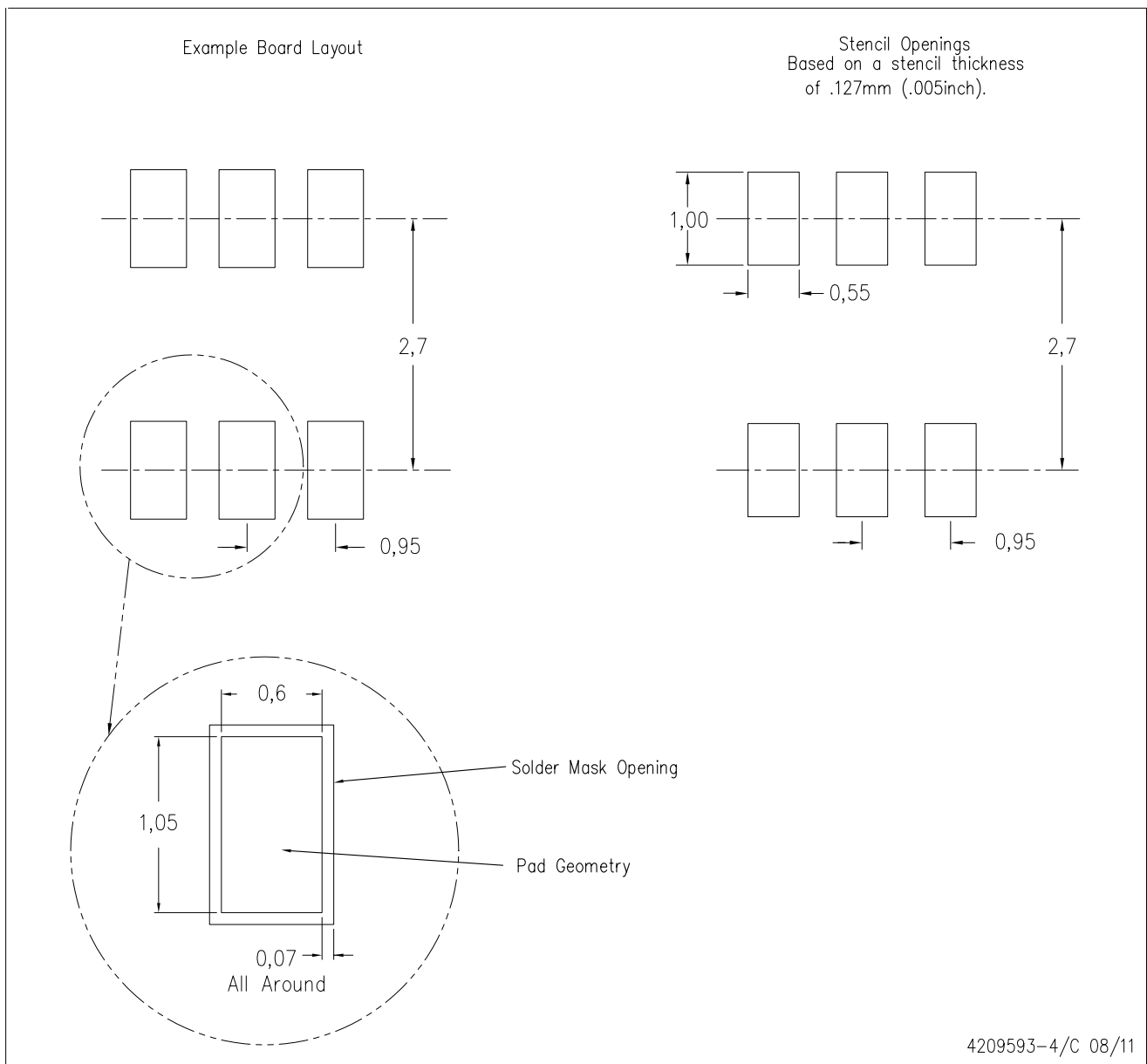
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- ⚠ Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DBV (R-PDSO-G6)

PLASTIC SMALL OUTLINE

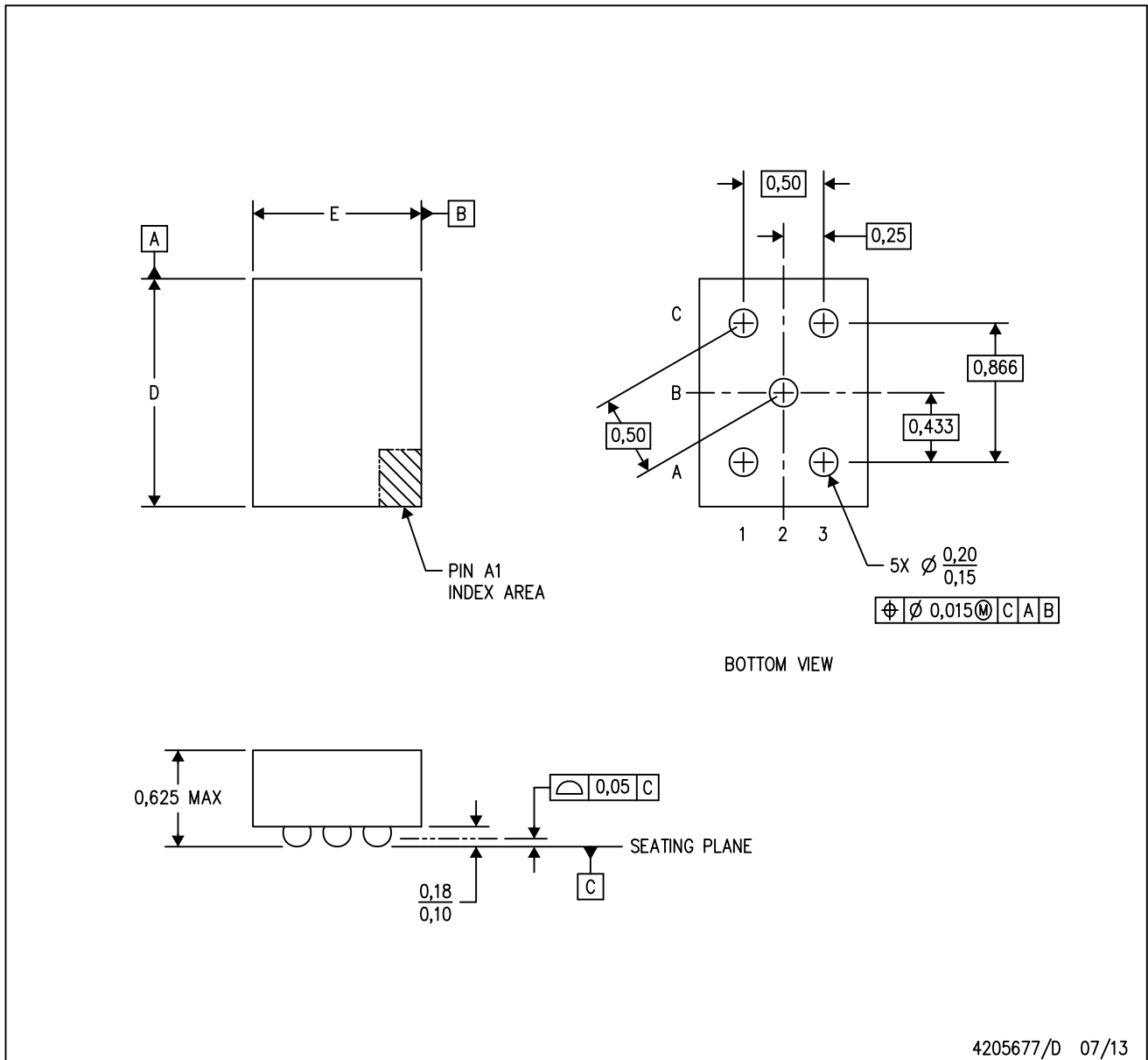


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

# MECHANICAL DATA

YZQ (R-XBGA-N5)

DIE-SIZE BALL GRID ARRAY



- Notes:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. NanoFree™ package configuration.

NanoFree is a trademark of Texas Instruments.



## IMPORTANT NOTICE

Texas Instruments Incorporated (TI) reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

TI's published terms of sale for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>) apply to the sale of packaged integrated circuit products that TI has qualified and released to market. Additional terms may apply to the use or sale of other types of TI products and services.

Reproduction of significant portions of TI information in TI data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such reproduced documentation. Information of third parties may be subject to additional restrictions. Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyers and others who are developing systems that incorporate TI products (collectively, "Designers") understand and agree that Designers remain responsible for using their independent analysis, evaluation and judgment in designing their applications and that Designers have full and exclusive responsibility to assure the safety of Designers' applications and compliance of their applications (and of all TI products used in or for Designers' applications) with all applicable regulations, laws and other applicable requirements. Designer represents that, with respect to their applications, Designer has all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. Designer agrees that prior to using or distributing any applications that include TI products, Designer will thoroughly test such applications and the functionality of such TI products as used in such applications.

TI's provision of technical, application or other design advice, quality characterization, reliability data or other services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using TI Resources in any way, Designer (individually or, if Designer is acting on behalf of a company, Designer's company) agrees to use any particular TI Resource solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

Designer is authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY DESIGNER AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Unless TI has explicitly designated an individual product as meeting the requirements of a particular industry standard (e.g., ISO/TS 16949 and ISO 26262), TI is not responsible for any failure to meet such industry standard requirements.

Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.

单击下面可查看定价，库存，交付和生命周期等信息

[>>TI\(德州仪器\)](#)