

## ULTRALOW-NOISE HIGH-PSRR FAST-RF 200-mA LOW-DROPOUT LINEAR REGULATORS

### FEATURES

- Qualified For Automotive Applications
- ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)
- 200-mA Low-Dropout Regulator With Enable (EN)
- Available in 1.8-V, 2.5-V, 2.8-V, 2.85-V, 3-V, 3.3-V, 4.75-V, and Adjustable Options
- High Power-Supply Rejection Ratio (PSRR) (70 dB at 10 kHz)
- Ultralow Noise (32  $\mu$ V)
- Fast Start-Up Time (50  $\mu$ s)
- Stable With a 2.2- $\mu$ F Ceramic Capacitor
- Excellent Load/Line Transient
- Very Low Dropout Voltage (112 mV at Full Load, TPS79330)
- 5-Pin SOT23 (DBV) Package

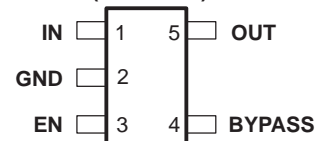
### APPLICATIONS

- VCOs
- RF
- Bluetooth™, Wireless LAN

### DESCRIPTION

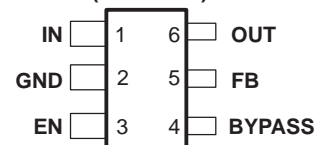
The TPS793xx family of low-dropout (LDO) low-power linear voltage regulators features high power-supply rejection ratio (PSRR), ultralow noise, fast start-up, and excellent line and load transient responses in a small-outline SOT23 package. Each device in the family is stable, with a small 2.2- $\mu$ F ceramic capacitor on the output. The TPS793xx family uses an advanced, proprietary BiCMOS fabrication process to yield extremely low dropout voltages (e.g., 112 mV at 200 mA, TPS79330). Each device achieves fast start-up times (approximately 50  $\mu$ s with a 0.001- $\mu$ F bypass capacitor) while consuming very low quiescent current (170  $\mu$ A typical). Moreover, when the device is placed in standby mode, the supply current is reduced to less than 1  $\mu$ A. The TPS79328 exhibits approximately 32  $\mu$ V<sub>RMS</sub> of output voltage noise with a 0.1- $\mu$ 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.

DBV PACKAGE  
(TOP VIEW)



Fixed Option

DBV PACKAGE  
(TOP VIEW)

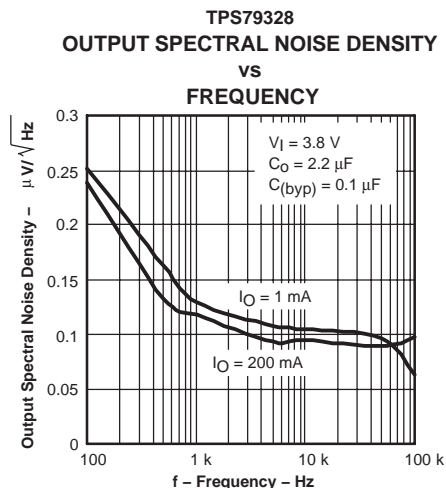
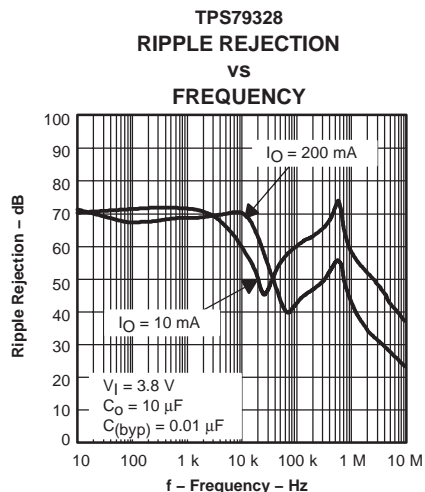


Adjustable Option



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

Bluetooth is a trademark of Bluetooth SIG, Inc.



**ORDERING INFORMATION†**

| <b>T<sub>J</sub></b> | <b>VOLTAGE</b> | <b>PACKAGE‡</b> | <b>PART NUMBER§</b> | <b>SYMBOL</b> |
|----------------------|----------------|-----------------|---------------------|---------------|
| -40°C to 125°C       | 1.2 to 5.5 V   | SOT23<br>(DBV)  | TPS79301DBVRQ1      | PGV1          |
|                      | 1.8 V          |                 | TPS79318DBVRQ1      | PHH1          |
|                      | 2.5 V          |                 | TPS79325DBVRQ1      | PGW1          |
|                      | 2.8 V          |                 | TPS79328DBVRQ1¶     | PGX1          |
|                      | 2.85 V         |                 | TPS793285QDBVRQ1    | PHI1          |
|                      | 3 V            |                 | TPS79330DBVRQ1¶     | PGY1          |
|                      | 3.3 V          |                 | TPS79333DBVRQ1      | PHU1          |
|                      | 4.75 V         |                 | TPS793475DBVRQ1¶    | PHJ1          |

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).

‡ Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

§ The DBVR indicates tape and reel of 3000 parts.

¶ Product preview

**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

|  |                                    |
|--|------------------------------------|
| Input voltage range (see Note 1)                             | –0.3 V to 6 V                      |
| Voltage range at EN  | –0.3 V to (V <sub>I</sub> + 0.3 V) |
| Voltage range on OUT   | –0.3 V to 6 V                      |
| Peak output current  | internally limited                 |
| ESD rating, Human-Body Model (HBM)                           | 2 kV                               |
| ESD rating, Charged-Device Model (CDM)                       | 500 V                              |
| Continuous total power dissipation                           | See Dissipation Rating Table       |
| Operating virtual junction temperature range, T <sub>J</sub> | –40°C to 150°C                     |
| Operating ambient temperature range, T <sub>A</sub>          | –40°C to 125°C                     |
| Storage temperature range, T <sub>stg</sub>                  | –65°C to 150°C                     |

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(1) All voltage values are with respect to network ground terminal.

**DISSIPATION RATING TABLE**

| 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<br>POWER RATING | T <sub>A</sub> = 70°C<br>POWER RATING | T <sub>A</sub> = 85°C<br>POWER RATING |
|---------|---------|------------------|------------------|--|---------------------------------------|---------------------------------------|---------------------------------------|
| Low K‡  | DBV     | 63.75°C/W        | 256°C/W          | 3.906 mW/°C                                    | 391 mW                                | 215 mW                                | 156 mW                                |
| High K§ | DBV     | 63.75°C/W        | 178.3°C/W        | 5.609 mW/°C                                    | 561 mW                                | 308 mW                                | 224 mW                                |

‡ The JEDEC low K (1s) board design used to derive this data was a 3-in × 3-in, two-layer board with 2-oz copper traces on top of the board.

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

electrical characteristics over recommended operating free-air temperature range  $EN = V_I$ ,  
 $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ,  $V_I = V_O(\text{typ}) + 1\text{ V}$ ,  $I_O = 1\text{ mA}$ ,  $C_O = 10\ \mu\text{F}$ ,  $C(\text{byp}) = 0.01\ \mu\text{F}$  (unless otherwise noted)

| PARAMETER   |  | TEST CONDITIONS   |  | MIN        | TYP   | MAX        | UNIT             |               |
|---|--|---|--|------------|-------|------------|------------------|---------------|
| $V_I$   | Input voltage (see Note 1)   |   |  | 2.7        |       | 5.5        | V                |               |
| $I_O$   | Continuous output current (see Note 2)                                       |   |  | 0          |       | 200        | mA               |               |
| $T_J$   | Operating junction temperature   |   |  | -40        |       | 125        | $^\circ\text{C}$ |               |
| Output voltage  | TPS79301   | $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,<br>(see Note 4) | $1.22\ \text{V} \leq V_O \leq 5.2\ \text{V}$ | $0.98 V_O$ |       | $1.02 V_O$ | V                |               |
|   | TPS79318   | $T_J = 25^\circ\text{C}$                                  |  |            | 1.8   |            |                  |               |
|   |  | $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,                 | $2.8\ \text{V} < V_I < 5.5\ \text{V}$        | 1.764      |       | 1.836      |                  |               |
|   | TPS79325   | $T_J = 25^\circ\text{C}$                                  |  |            | 2.5   |            |                  |               |
|   |  | $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,                 | $3.5\ \text{V} < V_I < 5.5\ \text{V}$        | 2.45       |       | 2.55       |                  |               |
|   | TPS79328   | $T_J = 25^\circ\text{C}$                                  |  |            | 2.8   |            |                  |               |
|   |  | $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,                 | $3.8\ \text{V} < V_I < 5.5\ \text{V}$        | 2.744      |       | 2.856      |                  |               |
|   | TPS793285  | $T_J = 25^\circ\text{C}$                                  |  |            | 2.85  |            |                  |               |
|   |  | $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,                 | $3.85\ \text{V} < V_I < 5.5\ \text{V}$       | 2.793      |       | 2.907      |                  |               |
|   | TPS79330   | $T_J = 25^\circ\text{C}$                                  |  |            | 3     |            |                  |               |
| $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,                           |  | $4\ \text{V} < V_I < 5.5\ \text{V}$                       | 2.94   |            | 3.06  |            |                  |               |
| TPS79333  | $T_J = 25^\circ\text{C}$   |   |  | 3.3        |       |            |                  |               |
|   | $0\ \mu\text{A} \leq I_O < 200\ \text{mA}$ ,                                 | $4.3\ \text{V} < V_I < 5.5\ \text{V}$                     | 3.234  |            | 3.366 |            |                  |               |
| TPS793475   | $T_J = 25^\circ\text{C}$   |   |  | 4.75       |       |            |                  |               |
|   | $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,                                    | $5.25\ \text{V} < V_I < 5.5\ \text{V}$                    | 4.655  |            | 4.845 |            |                  |               |
| Quiescent current (GND current)                                     | $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,                                    |   | $T_J = 25^\circ\text{C}$                     |            | 170   |            | $\mu\text{A}$    |               |
|   | $0\ \mu\text{A} < I_O < 200\ \text{mA}$                                      |   |  |            | 220   |            |                  |               |
| Load regulation   | $0\ \mu\text{A} < I_O < 200\ \text{mA}$ ,                                    |   | $T_J = 25^\circ\text{C}$                     |            | 5     |            | mV               |               |
| Output voltage line regulation ( $\Delta V_O/V_O$ )<br>(see Note 4) | $V_O + 1\ \text{V} < V_I \leq 5.5\ \text{V}$ ,                               |   | $T_J = 25^\circ\text{C}$                     |            | 0.05  |            | %V               |               |
|   | $V_O + 1\ \text{V} < V_I \leq 5.5\ \text{V}$                                 |   |  |            | 0.12  |            |                  |               |
| Output noise voltage (TPS79328)                                     | BW = 200 Hz to 100 kHz,<br>$I_O = 200\ \text{mA}$ , $T_J = 25^\circ\text{C}$ | $C(\text{byp}) = 0.001\ \mu\text{F}$                      |  |            | 55    |            | $\mu\text{VRMS}$ |               |
|   |  | $C(\text{byp}) = 0.0047\ \mu\text{F}$                     |  |            | 36    |            |                  |               |
|   |  | $C(\text{byp}) = 0.01\ \mu\text{F}$                       |  |            | 33    |            |                  |               |
|   |  | $C(\text{byp}) = 0.1\ \mu\text{F}$                        |  |            | 32    |            |                  |               |
| Start-up time (TPS79328)  | $R_L = 14\ \Omega$ ,<br>$C_O = 1\ \mu\text{F}$ , $T_J = 25^\circ\text{C}$    | $C(\text{byp}) = 0.001\ \mu\text{F}$                      |  |            | 50    |            | $\mu\text{s}$    |               |
|   |  | $C(\text{byp}) = 0.0047\ \mu\text{F}$                     |  |            | 70    |            |                  |               |
|   |  | $C(\text{byp}) = 0.01\ \mu\text{F}$                       |  |            | 100   |            |                  |               |
| Output current limit  | $V_O = 0\ \text{V}$ ,  |   | See Note 3                                   |            | 285   |            | 600              | mA            |
| Standby current   | $EN = 0\ \text{V}$ , $2.7\ \text{V} < V_I < 5.5\ \text{V}$                   |   |  |            | 0.07  |            | 1                | $\mu\text{A}$ |
| High-level enable input voltage                                     | $2.7\ \text{V} < V_I < 5.5\ \text{V}$  |   |  |            | 2     |            |                  | V             |
| Low-level enable input voltage                                      | $2.7\ \text{V} < V_I < 5.5\ \text{V}$  |   |  |            |       |            | 0.7              | V             |
| Input current (EN)  | $EN = 0$   |   |  |            | -1    |            | 1                | $\mu\text{A}$ |
| Input current (FB) (TPS79301)                                       | $FB = 1.8\ \text{V}$   |   |  |            |       |            | 1                | $\mu\text{A}$ |

(1) To calculate the minimum input voltage for your maximum output current, use the following formula:

$$V_{I(\text{min})} = V_O(\text{max}) + V_{\text{DO}}(\text{max load})$$

(2) Continuous output current and operating junction temperature are limited by internal protection circuitry, but it is not recommended that the device operate under conditions beyond those specified in this table for extended periods of time.

(3) The minimum  $I_N$  operating voltage is  $2.7\ \text{V}$  or  $V_O(\text{typ}) + 1\ \text{V}$ , whichever is greater. The maximum  $I_N$  voltage is  $5.5\ \text{V}$ . The maximum output current is  $200\ \text{mA}$ .

(4) If  $V_O \leq 2.5\ \text{V}$ , then  $V_{I(\text{min})} = 2.7\ \text{V}$ ,  $V_{I(\text{max})} = 5.5\ \text{V}$ :

$$\text{Line Regulation (mV)} = (\%/\text{V}) \times \frac{V_O(V_{I(\text{max})} - 2.7\ \text{V})}{100} \times 1000$$

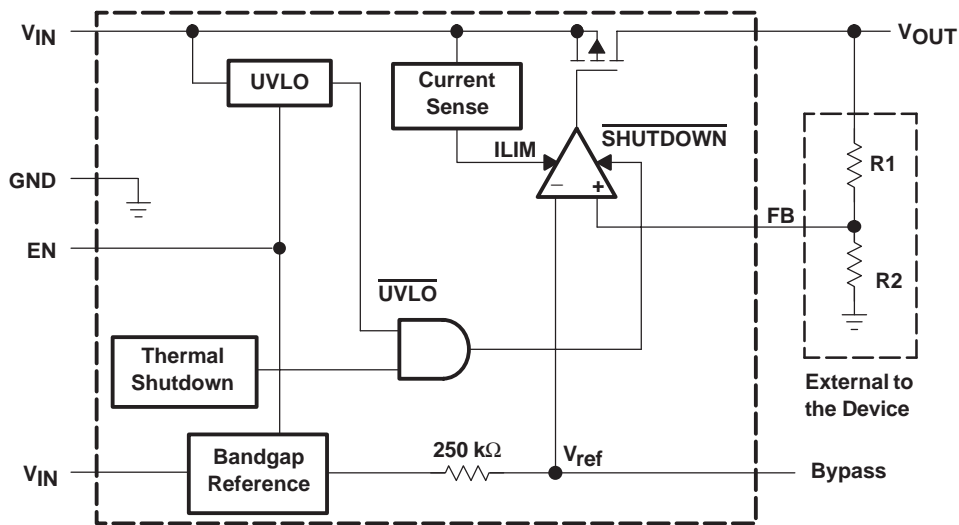
If  $V_O \geq 2.5\ \text{V}$ , then  $V_{I(\text{min})} = V_O + 1\ \text{V}$ ,  $V_{I(\text{max})} = 5.5\ \text{V}$ .

electrical characteristics over recommended operating free-air temperature range  $EN = V_I$ ,  $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ,  $V_I = V_{O(\text{typ})} + 1\text{ V}$ ,  $I_O = 1\text{ mA}$ ,  $C_O = 10\text{ }\mu\text{F}$ ,  $C_{(\text{byp})} = 0.01\text{ }\mu\text{F}$  (unless otherwise noted)  
(continued)

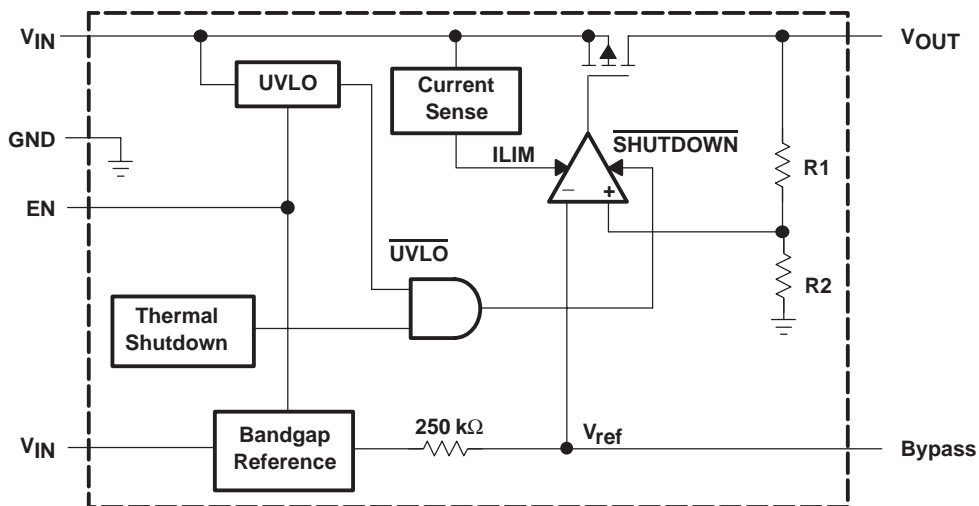
| PARAMETER                     |                 | TEST CONDITIONS   | MIN | TYP  | MAX | UNIT |      |    |
|-------------------------------|-----------------|---|-----|------|-----|------|------|----|
| Power-supply ripple rejection | TPS79328        | $f = 100\text{ Hz}$ , $T_J = 25^\circ\text{C}$ , $I_O = 10\text{ mA}$   |     | 70   |     | dB   |      |    |
|                               |                 | $f = 100\text{ Hz}$ , $T_J = 25^\circ\text{C}$ , $I_O = 200\text{ mA}$  |     | 68   |     |      |      |    |
|                               |                 | $f = 10\text{ kHz}$ , $T_J = 25^\circ\text{C}$ , $I_O = 200\text{ mA}$  |     | 70   |     |      |      |    |
|                               |                 | $f = 100\text{ kHz}$ , $T_J = 25^\circ\text{C}$ , $I_O = 200\text{ mA}$ |     | 43   |     |      |      |    |
| Dropout voltage (see Note 1)  | TPS79328        | $I_O = 200\text{ mA}$ , $T_J = 25^\circ\text{C}$                        |     | 120  |     | mV   |      |    |
|                               |                 | $I_O = 200\text{ mA}$   |     |      | 200 |      |      |    |
|                               | TPS793285       | $I_O = 200\text{ mA}$ , $T_J = 25^\circ\text{C}$                        |     | 120  |     |      |      |    |
|                               |                 | $I_O = 200\text{ mA}$   |     |      | 200 |      |      |    |
|                               | TPS79330        | $I_O = 200\text{ mA}$ , $T_J = 25^\circ\text{C}$                        |     | 112  |     |      |      |    |
|                               |                 | $I_O = 200\text{ mA}$   |     |      | 200 |      |      |    |
|                               | TPS79333        | $I_O = 200\text{ mA}$ , $T_J = 25^\circ\text{C}$                        |     | 102  |     |      |      |    |
|                               |                 | $I_O = 200\text{ mA}$   |     |      | 180 |      |      |    |
|                               | TPS793475       | $I_O = 200\text{ mA}$ , $T_J = 25^\circ\text{C}$                        |     | 77   |     |      |      |    |
|                               |                 | $I_O = 200\text{ mA}$   |     |      | 125 |      |      |    |
|                               | UVLO threshold  | $V_{CC}$ rising   |     | 2.25 |     |      | 2.65 | V  |
|                               | UVLO hysteresis | $T_J = 25^\circ\text{C}$ , $V_{CC}$ rising                              |     |      | 100 |      |      | mV |

(1)  $I_N$  voltage equals  $V_{O(\text{typ})} - 100\text{ mV}$ . The TPS79325 dropout voltage is limited by the input voltage range limitations.

**FUNCTIONAL BLOCK DIAGRAM—ADJUSTABLE VERSION**



**FUNCTIONAL BLOCK DIAGRAM—FIXED VERSION**



**Terminal Functions**

| NAME   | TERMINAL NO. |       | I/O | DESCRIPTION  |
|--------|--------------|-------|-----|--|
|        | ADJ          | FIXED |     |  |
| BYPASS | 4            | 4     |     | An external bypass capacitor connected to this terminal, in conjunction with an internal resistor, creates a low-pass filter to further reduce regulator noise.                      |
| EN     | 3            | 3     | I   | EN is an input that enables or shuts down the device. When EN goes to a logic high, the device will be enabled. When the device goes to a logic low, the device is in shutdown mode. |
| FB     | 5            | N/A   | I   | Feedback input voltage for the adjustable device.  |
| GND    | 2            | 2     |     | Regulator ground   |
| IN     | 1            | 1     | I   | Input to the device.   |
| OUT    | 6            | 5     | O   | Regulated output of the device.  |

TYPICAL CHARACTERISTICS

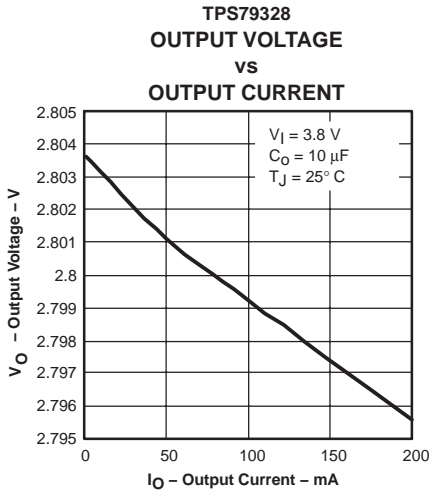


Figure 1

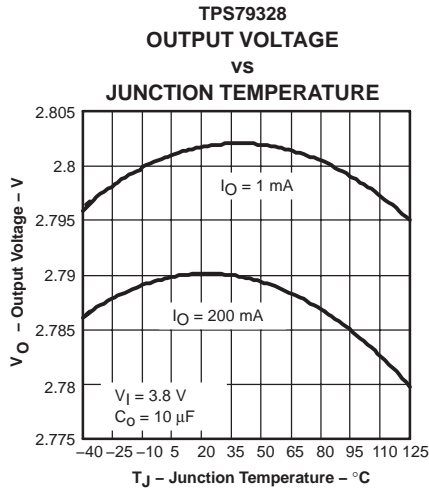


Figure 2

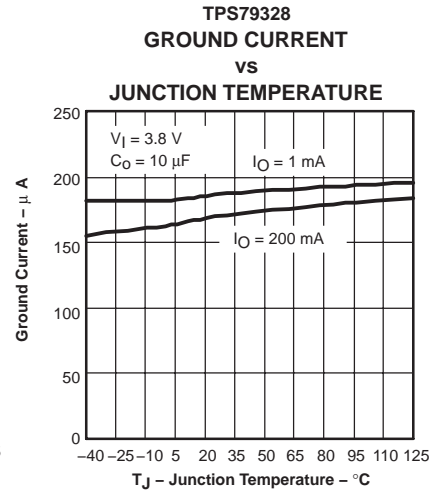


Figure 3

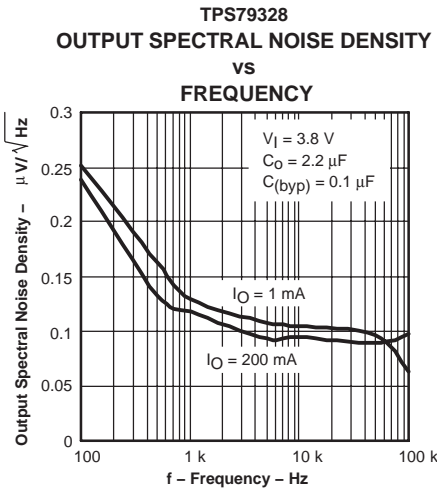


Figure 4

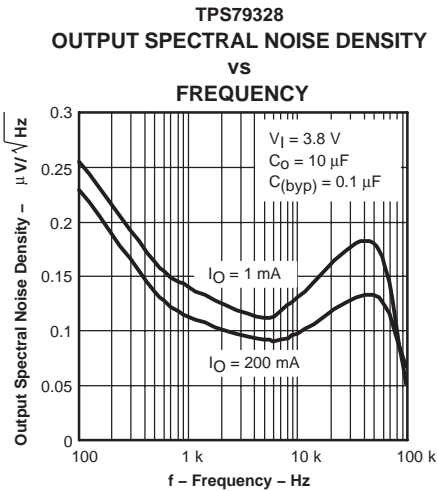


Figure 5

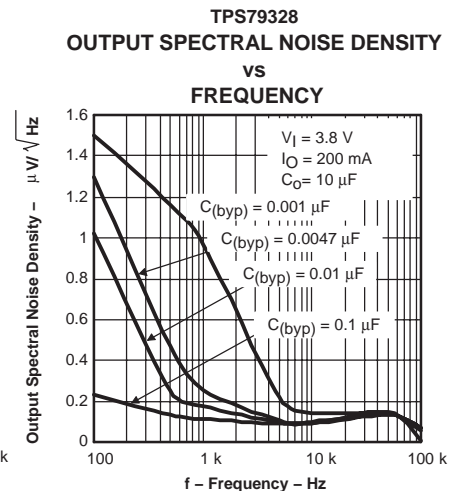


Figure 6

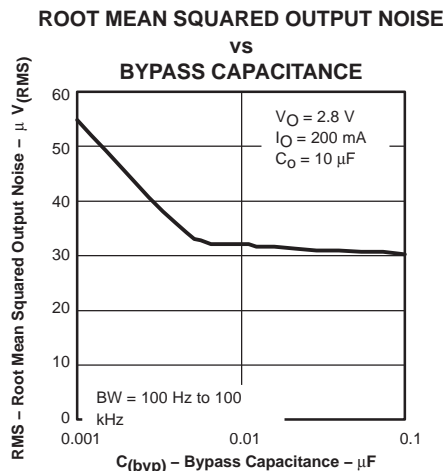


Figure 7

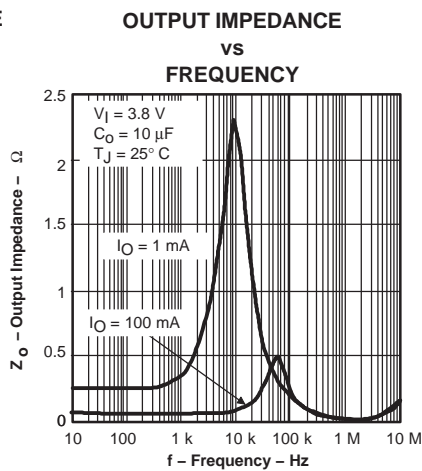


Figure 8

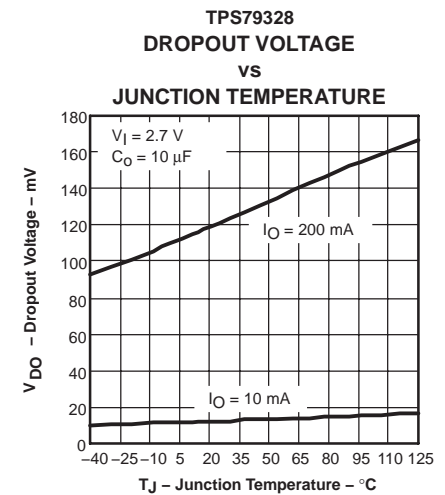


Figure 9

TYPICAL CHARACTERISTICS

TPS79328  
 RIPPLE REJECTION  
 VS  
 FREQUENCY

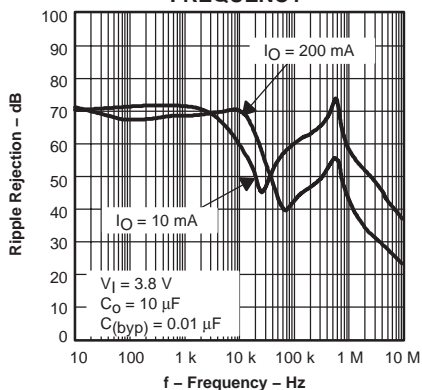


Figure 10

TPS79328  
 RIPPLE REJECTION  
 VS  
 FREQUENCY

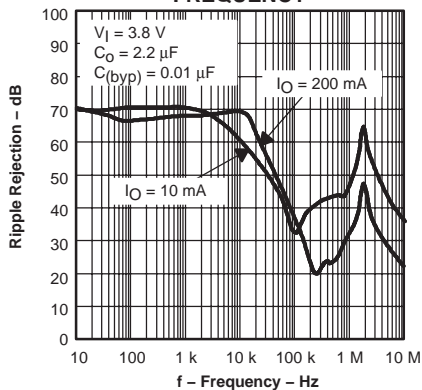


Figure 11

TPS79328  
 RIPPLE REJECTION  
 VS  
 FREQUENCY

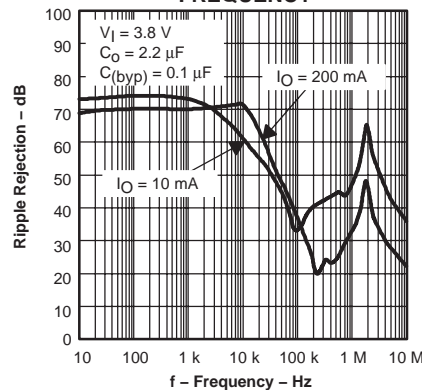


Figure 12

TPS79328  
 OUTPUT VOLTAGE, ENABLE VOLTAGE  
 VS  
 TIME (START-UP)

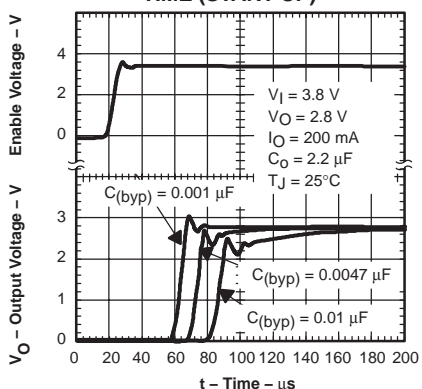


Figure 13

TPS79328  
 LINE TRANSIENT RESPONSE

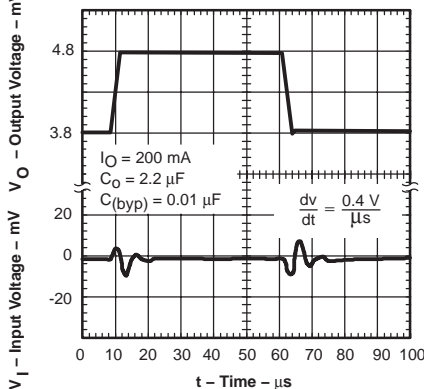


Figure 14

TPS79328  
 LOAD TRANSIENT RESPONSE

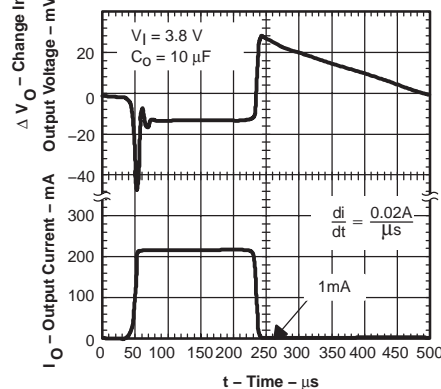


Figure 15

POWER UP / POWER DOWN

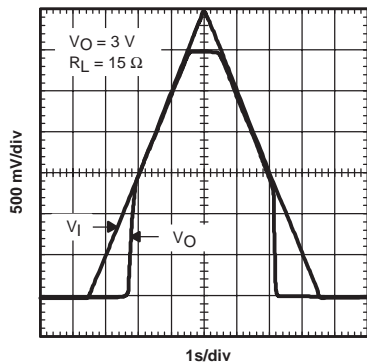


Figure 16

DC DROPOUT VOLTAGE  
 VS  
 OUTPUT CURRENT

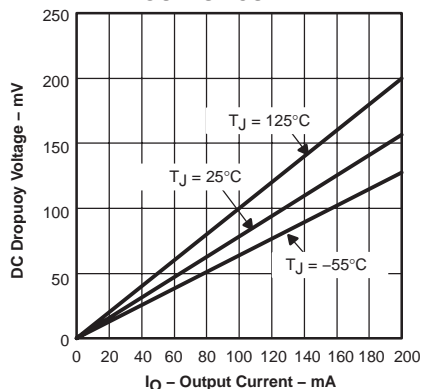


Figure 17

TPS79301  
 DROPOUT VOLTAGE  
 VS  
 INPUT VOLTAGE

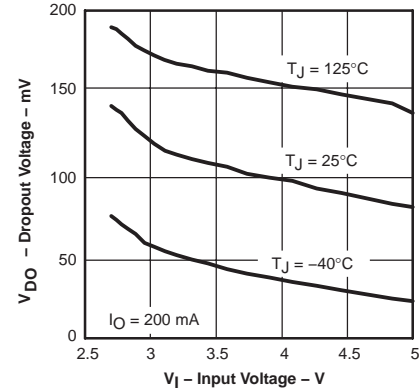


Figure 18



**TYPICAL CHARACTERISTICS**

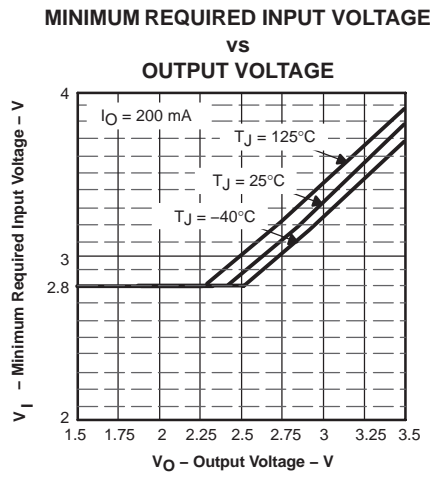


Figure 19

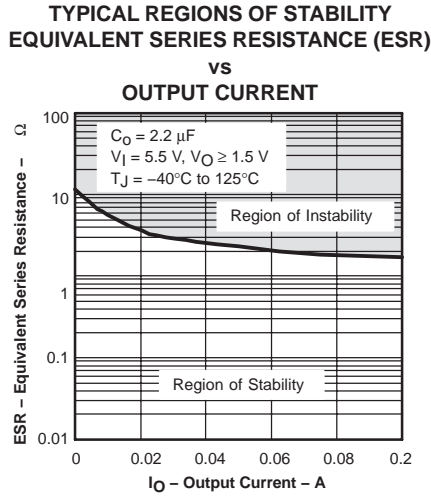


Figure 20

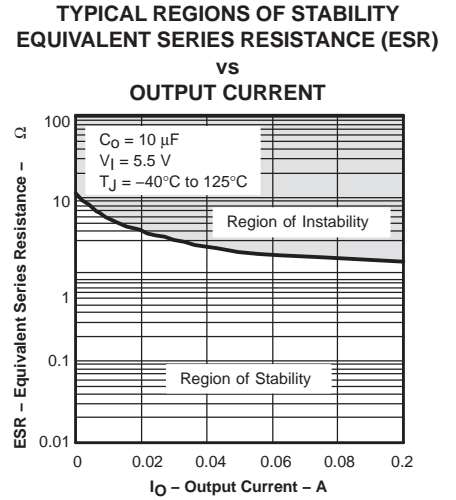


Figure 21

## APPLICATION INFORMATION

The TPS793xx family of low-dropout (LDO) regulators has been optimized for use in noise-sensitive battery-operated equipment. The device features low dropout voltages, high PSRR, ultralow output noise, low quiescent current (170  $\mu\text{A}$  typical), and enable input to reduce supply currents to less than 1  $\mu\text{A}$  when the regulator is turned off.

A typical application circuit is shown in Figure 22.

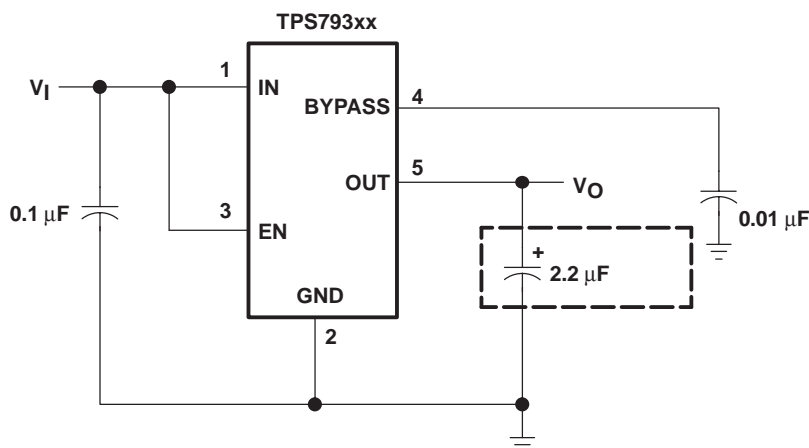


Figure 22. Typical Application Circuit

## EXTERNAL CAPACITOR REQUIREMENTS

A 0.1- $\mu\text{F}$  or larger ceramic input bypass capacitor, connected between IN and GND and located close to the TPS793xx, is required for stability and improves transient response, noise rejection, and ripple rejection. A higher-value electrolytic input capacitor may be necessary if large, fast rise time, load transients are anticipated and the device is located several inches from the power source.

Like all low dropout regulators, the TPS793xx 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.

The internal voltage reference is a key source of noise in an LDO regulator. The TPS793xx has a BYPASS pin that is connected to the voltage reference through a 250-k $\Omega$  internal resistor. The 250-k $\Omega$  internal resistor, in conjunction with an external bypass capacitor connected to the BYPASS 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 BYPASS 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.

For example, the TPS79328 exhibits only 32  $\mu\text{V}_{\text{RMS}}$  of output voltage noise using a 0.1- $\mu\text{F}$  ceramic bypass capacitor and a 2.2- $\mu\text{F}$  ceramic output capacitor. Note that the output starts up slower as the bypass capacitance increases due to the RC time constant at BYPASS that is created by the internal 250-k $\Omega$  resistor and external capacitor.

## BOARD LAYOUT RECOMMENDATION TO IMPROVE PSRR AND NOISE PERFORMANCE

To improve ac measurements such as PSRR, output noise, and transient response, it is recommended that the board be designed with separate ground planes for  $V_{\text{IN}}$  and  $V_{\text{OUT}}$ , 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.

## APPLICATION INFORMATION

### POWER DISSIPATION AND JUNCTION TEMPERATURE

Specified regulator operation is assured to a junction temperature of 125°C; the maximum junction temperature should be restricted to 125°C under normal operating conditions. This restriction limits the power dissipation the regulator can handle in any given application. To ensure the junction temperature is within acceptable limits, calculate the maximum allowable dissipation,  $P_{D(max)}$ , and the actual dissipation,  $P_D$ , which must be less than or equal to  $P_{D(max)}$ .

The maximum power dissipation limit is determined using the following equation:

$$P_{D(max)} = \frac{T_{Jmax} - T_A}{R_{\theta JA}} \quad (1)$$

Where:

$T_{Jmax}$  = Maximum allowable junction temperature

$R_{\theta JA}$  = Thermal resistance, junction-to-ambient, for the package (see the dissipation rating table)

$T_A$  = Ambient temperature.

The regulator dissipation is calculated using:

$$P_D = (V_I - V_O) \times I_O \quad (2)$$

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

### PROGRAMMING THE TPS79301 ADJUSTABLE LDO REGULATOR

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:

$$V_O = V_{ref} \times \left(1 + \frac{R1}{R2}\right) \quad (3)$$

Where:

$V_{ref}$  = 1.2246 V typ (internal reference voltage)

Resistors R1 and R2 should be chosen for approximately 50- $\mu$ A divider current. Lower-value resistors can be used for improved noise performance, but the solution consumes more power. Higher resistor values should be avoided, as leakage current into/out of FB across R1/R2 creates an offset voltage that artificially increases/decreases the feedback voltage and, thus, erroneously decreases/increases  $V_O$ . The recommended design procedure is to choose  $R2 = 30.1 \text{ k}\Omega$  to set the divider current at 50  $\mu$ A,  $C1 = 15 \text{ pF}$  for stability, and then calculate R1 using:

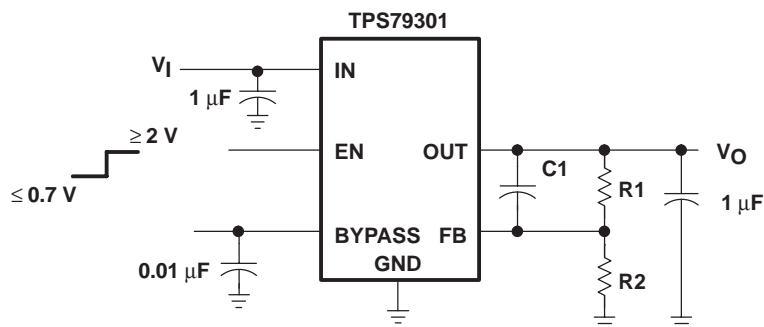
$$R1 = \left(\frac{V_O}{V_{ref}} - 1\right) \times R2 \quad (4)$$

In order to improve the stability of the adjustable version, it is suggested that a small compensation capacitor be placed between OUT and FB. For voltages <1.8 V, the value of this capacitor should be 100 pF. For voltages >1.8 V, the approximate value of this capacitor can be calculated as:

$$C1 = \frac{(3 \times 10^{-7}) \times (R1 + R2)}{(R1 \times R2)} \quad (5)$$

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

## APPLICATION INFORMATION



### OUTPUT VOLTAGE PROGRAMMING GUIDE

| OUTPUT VOLTAGE | R1      | R2      | C1    |
|----------------|---------|---------|-------|
| 2.5 V          | 31.6 kΩ | 30.1 kΩ | 22 pF |
| 3.3 V          | 51 kΩ   | 30.1 kΩ | 15 pF |
| 3.6 V          | 59 kΩ   | 30.1 kΩ | 15 pF |

Figure 23. TPS79301 Adjustable LDO Regulator Programming

## REGULATOR PROTECTION

The TPS793xx PMOS-pass transistor has a built-in back diode that conducts reverse current when the input voltage drops below the output voltage (e.g., 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 might be appropriate.

The TPS793xx features internal current limiting and thermal protection. During normal operation, the TPS793xx 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. If the temperature of the device exceeds approximately 165°C, thermal-protection circuitry shuts it down. Once the device has cooled down to below approximately 140°C, regulator operation resumes.

**PACKAGING INFORMATION**

| Orderable Device  | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|-------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TPS79301DBVRG4Q1  | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS79301DBVRQ1    | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | TBD                     | CU NIPDAU        | Level-1-220C-UNLIM           |
| TPS79318DBVRG4Q1  | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS79318DBVRQ1    | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | TBD                     | CU NIPDAU        | Level-1-220C-UNLIM           |
| TPS79325DBVRG4Q1  | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS79325DBVRQ1    | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | TBD                     | CU NIPDAU        | Level-1-220C-UNLIM           |
| TPS793285QDBVRQ1  | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS79333DBVRG4Q1  | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS79333DBVRQ1    | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | TBD                     | CU NIPDAU        | Level-1-220C-UNLIM           |
| TPS793475DBVRG4Q1 | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS793475DBVRQ1   | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | TBD                     | CU NIPDAU        | Level-1-220C-UNLIM           |

<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.

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

<sup>(2)</sup> 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.

**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 TPS79301-Q1, TPS79318-Q1, TPS79325-Q1, TPS793285-Q1, TPS79333-Q1, TPS793475-Q1 :**

● Catalog: [TPS79301](#), [TPS79318](#), [TPS79325](#), [TPS793285](#), [TPS79333](#), [TPS793475](#)

- Enhanced Product: [TPS79301-EP](#), [TPS79318-EP](#), [TPS79325-EP](#), [TPS79333-EP](#), [TPS793475-EP](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

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-G6)

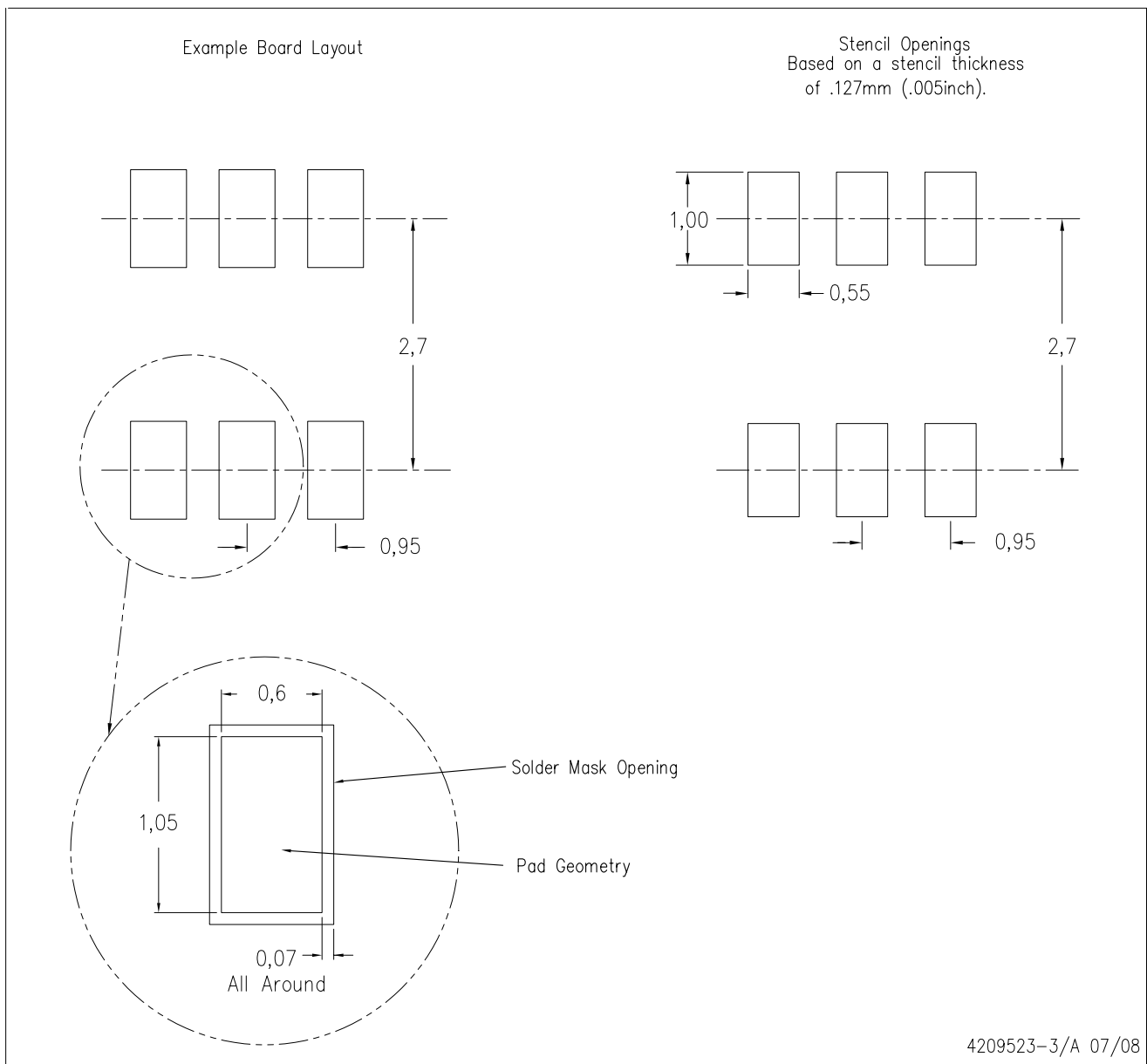
PLASTIC SMALL-OUTLINE PACKAGE



- 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. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- $\triangle$  Falls within JEDEC MO-178 Variation AB, except minimum lead width.

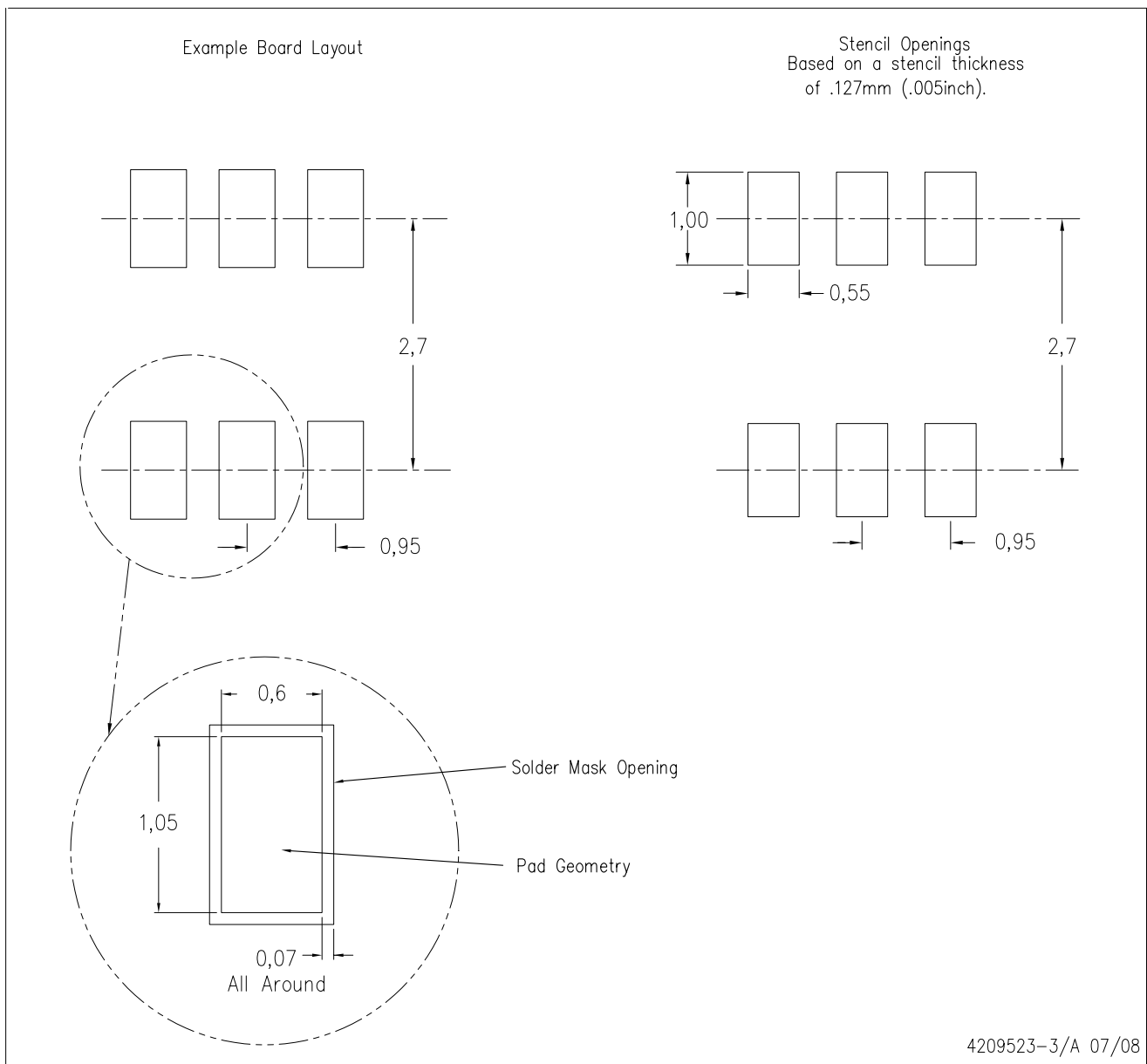


DBV (R-PDSO-G6)



- 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.

DBV (R-PDSO-G6)



- 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.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information 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.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered 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.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

|                             |  |
|-----------------------------|--|
| Amplifiers                  | <a href="http://amplifier.ti.com">amplifier.ti.com</a>             |
| Data Converters             | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>     |
| DSP                         | <a href="http://dsp.ti.com">dsp.ti.com</a>                         |
| Clocks and Timers           | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>           |
| Interface                   | <a href="http://interface.ti.com">interface.ti.com</a>             |
| Logic                       | <a href="http://logic.ti.com">logic.ti.com</a>                     |
| Power Mgmt                  | <a href="http://power.ti.com">power.ti.com</a>                     |
| Microcontrollers            | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a> |
| RFID                        | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>               |
| RF/IF and ZigBee® Solutions | <a href="http://www.ti.com/lprf">www.ti.com/lprf</a>               |

### Applications

|                    |  |
|--------------------|--|
| Audio              | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                   |
| Automotive         | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>         |
| Broadband          | <a href="http://www.ti.com/broadband">www.ti.com/broadband</a>           |
| Digital Control    | <a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a> |
| Medical            | <a href="http://www.ti.com/medical">www.ti.com/medical</a>               |
| Military           | <a href="http://www.ti.com/military">www.ti.com/military</a>             |
| Optical Networking | <a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a> |
| Security           | <a href="http://www.ti.com/security">www.ti.com/security</a>             |
| Telephony          | <a href="http://www.ti.com/telephony">www.ti.com/telephony</a>           |
| Video & Imaging    | <a href="http://www.ti.com/video">www.ti.com/video</a>                   |
| Wireless           | <a href="http://www.ti.com/wireless">www.ti.com/wireless</a>             |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2008, Texas Instruments Incorporated