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TPS76901-Q1, TPS76912-Q1, TPS76915-Q1
 TPS76918-Q1, TPS76925-Q1, TPS76927-Q1
 TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1

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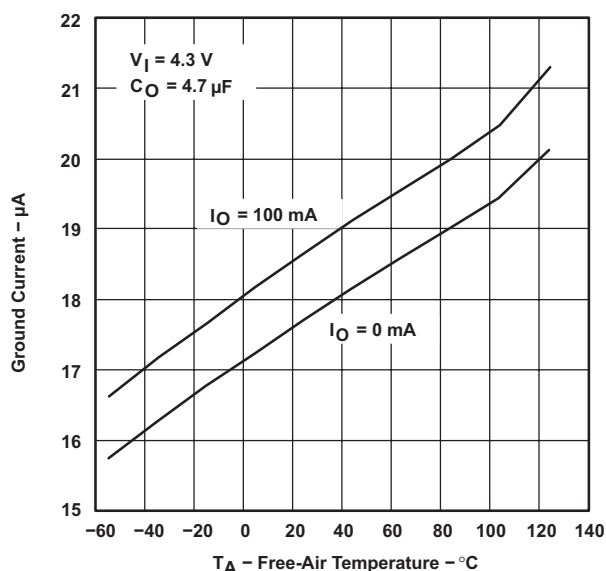
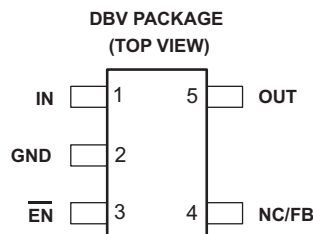
SGLS118C –DECEMBER 2001–REVISED JUNE 2012

Ultralow-Power 100-mA Low-Dropout Linear Regulators

Check for Samples: [TPS76901-Q1](#), [TPS76912-Q1](#), [TPS76915-Q1](#), [TPS76918-Q1](#), [TPS76925-Q1](#), [TPS76927-Q1](#), [TPS76928-Q1](#), [TPS76930-Q1](#), [TPS76933-Q1](#), [TPS76950-Q1](#)

FEATURES

- Qualified for Automotive Applications
- 100-mA Low-Dropout Regulator
- Available in 1.2-V, 1.5-V, 1.8-V, 2.5-V, 2.7-V, 2.8-V, 3-V, 3.3-V and 5-V Fixed-Output and Adjustable Versions
- Only 17- μ A Quiescent Current at 100 mA
- 1- μ A Quiescent Current in Standby Mode
- Dropout Voltage Typically 71 mV at 100 mA
- Over Current Limitation
- -40°C to 125°C Operating Junction Temperature Range
- 5-Pin SOT-23 (DBV) Package



DESCRIPTION

The TPS769xx-Q1 family of low-dropout (LDO) voltage regulators offers the benefits of low-dropout voltage, ultralow-power operation, and miniaturized packaging. These regulators feature low-dropout voltages and ultralow quiescent current compared to conventional LDO regulators. Offered in a 5-pin small outline integrated-circuit SOT-23 package, the TPS769xx-Q1 series devices are ideal for micropower operations and where board space is at a premium.

A combination of new circuit design and process innovation has enabled the usual PNP pass transistor to be replaced by a PMOS pass element. Because the PMOS pass element behaves as a low-value resistor, the dropout voltage is very low, typically 71 mV at 100 mA of load current (TPS76950-Q1), and is directly proportional to the load current. Since the PMOS pass element is a voltage-driven device, the quiescent current is ultralow (28 μ A maximum) and is stable over the entire range of output load current (0 mA to 100 mA). The ultralow-dropout voltage feature and ultralow-power operation result in a significant increase in system battery operating life, making this device suitable for use in automotive applications.

The TPS769xx-Q1 devices also feature a logic-enabled sleep mode to shut down the regulator, reducing quiescent current to 1 μ A typical at $T_j = 25^\circ\text{C}$. The TPS769xx-Q1 devices are offered in 1.2-V, 1.5-V, 1.8-V, 2.5-V, 2.7-V, 2.8-V, 3-V, 3.3-V, and 5-V fixed-voltage versions and in a variable version (programmable over the range of 1.2 V to 5.5 V).



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.

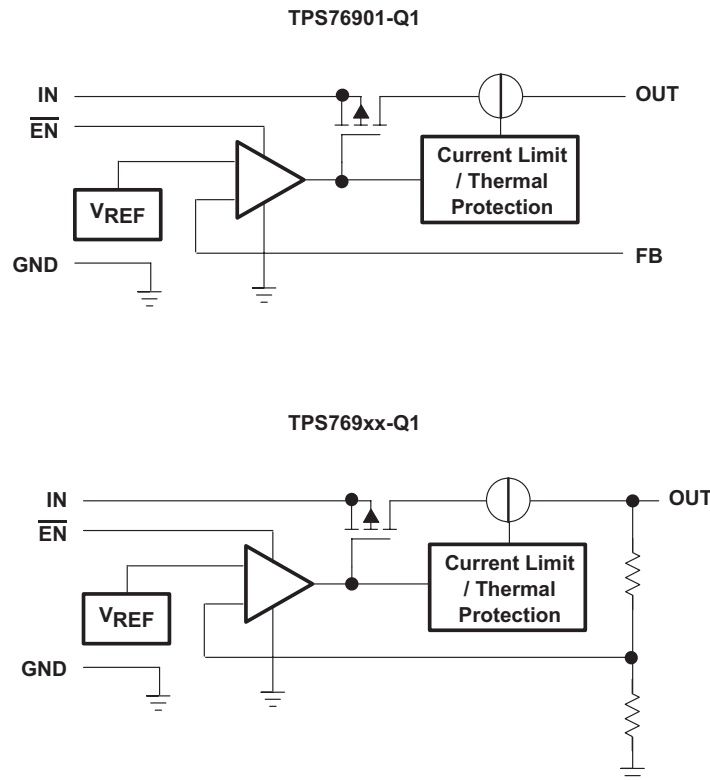
TPS76901-Q1, TPS76912-Q1, TPS76915-Q1
TPS76918-Q1, TPS76925-Q1, TPS76927-Q1
TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1

ORDERING INFORMATION⁽¹⁾

| T _J | VOLTAGE | PACKAGE ⁽²⁾ | ORDERABLE PART NUMBER | | SYMBOL |
|----------------|-------------------------|------------------------|--------------------------------|--------------------------------|--------|
| | | | | | |
| -40°C to 125°C | Variable 1.2 V to 5.5 V | SOT-23 (DBV) | TPS76901QDBVTQ1 ⁽³⁾ | TPS76901QDBVRQ1 ⁽⁴⁾ | PCFQ |
| | 1.2 V | | TPS76912QDBVTQ1 | TPS76912QDBVRQ1 | PCGQ |
| | 1.5 V | | TPS76915QDBVTQ1 | TPS76915QDBVRQ1 | PCHQ |
| | 1.8 V | | TPS76918QDBVTQ1 | TPS76918QDBVRQ1 | PCIQ |
| | 2.5 V | | TPS76925QDBVTQ1 | TPS76925QDBVRQ1 | PCJQ |
| | 2.7 V | | TPS76927QDBVTQ1 | TPS76927QDBVRQ1 | PCKQ |
| | 2.8 V | | TPS76928QDBVTQ1 | TPS76928QDBVRQ1 | PCLQ |
| | 3 V | | TPS76930QDBVTQ1 | TPS76930QDBVRQ1 | PCMQ |
| | 3.3 V | | TPS76933QDBVTQ1 | TPS76933QDBVRQ1 | PCNQ |
| | 5 V | | TPS76950QDBVTQ1 | TPS76950QDBVRQ1 | PCOQ |

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.
- (2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.
- (3) The DBVT indicates a tape and reel of 250 parts.
- (4) The DBVR indicates a tape and reel of 3000 parts.

FUNCTIONAL BLOCK DIAGRAM



PIN FUNCTIONS

| TERMINAL | | I/O | DESCRIPTION |
|------------------------|-----|-----|-------------------------------------|
| NAME | NO. | | |
| GND | 2 | | Ground |
| $\overline{\text{EN}}$ | 3 | I | Enable input |
| FB | 4 | I | Feedback voltage (TPS76901-Q1 only) |
| IN | 1 | I | Input supply voltage |
| NC | 4 | | No connection (Fixed options only) |
| OUT | 5 | O | Regulated output voltage |

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

over operating free-air temperature range (unless otherwise noted)

| | VALUE | UNIT |
|--|--|------|
| Input voltage range ⁽²⁾ | –0.3 to 13.5 | V |
| Voltage range at $\overline{\text{EN}}$ | –0.3 to $V_I + 0.3$ | V |
| Voltage on OUT, FB | 7 | V |
| Peak output current | Internally Limited | |
| ESD rating, HBM | 2 | kV |
| Continuous total power dissipation | See Dissipation Rating Table | |
| T_J Operating virtual junction temperature range | –40 to 150 | °C |
| T_{stg} Storage temperature range | –65 to 150 | °C |

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

DISSIPATION RATINGS

| BOARD | PACKAGE | $R_{\theta JC}$ | $R_{\theta JA}$ | DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$ | $T_A \leq 25^\circ\text{C}$ POWER RATING | $T_A = 70^\circ\text{C}$ POWER RATING | $T_A = 85^\circ\text{C}$ POWER RATING |
|-----------------------|---------|-----------------|-----------------|--|--|---------------------------------------|---------------------------------------|
| Low K ⁽¹⁾ | DBV | 65.8 °C/W | 259 °C/W | 3.9 mW/°C | 386 mW | 212 mW | 154 mW |
| High K ⁽²⁾ | DBV | 65.8 °C/W | 180 °C/W | 5.6 mW/°C | 555 mW | 305 mW | 222 mW |

- (1) The JEDEC Low K (1s) board design used to derive this data was a 3 inch x 3 inch, two layer board with 2 ounce copper traces on top of the board.
- (2) The JEDEC High K (2s2p) board design used to derive this data was a 3 inch x 3 inch, multilayer board with 1 ounce internal power and ground planes and 2 ounce copper traces on top and bottom of the board.

RECOMMENDED OPERATING CONDITIONS

over operating free-air temperature range (unless otherwise noted)

| | MIN | NOM | MAX | UNIT |
|---|-----|-----|-----|------|
| Input voltage, V_I ⁽¹⁾ | 2.7 | | 10 | V |
| Output voltage range, V_O | 1.2 | | 5.5 | V |
| Continuous output current, I_O ⁽²⁾ | 0 | | 100 | mA |
| Operating junction temperature, T_J | –40 | | 125 | °C |

- (1) To calculate the minimum input voltage for your maximum output current, use the following formula: $V_I(\text{min}) = V_O(\text{max}) + V_{\text{DO}}$ (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.

TPS76901-Q1, TPS76912-Q1, TPS76915-Q1
TPS76918-Q1, TPS76925-Q1, TPS76927-Q1
TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1

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ELECTRICAL CHARACTERISTICS

over recommended operating free-air temperature range, $V_I = V_O$ (typ) + 1 V, $I_O = 100$ mA, $\overline{EN} = 0$ V, $C_O = 4.7$ μ F (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT | |
|---|---|--|-------|------------|------------------------|--|
| Output voltage (10 μ A to 100 mA load) ⁽¹⁾ | TPS76901-Q1 | $1.2 \text{ V} \leq V_O \leq 5.5 \text{ V}$, $T_J = 25^\circ\text{C}$ | | V_O | | |
| | | $1.2 \text{ V} \leq V_O \leq 5.5 \text{ V}$, $T_J = -40^\circ\text{C}$ to 125°C | | 0.97 V_O | 1.03 V_O | |
| | TPS76912-Q1 | $T_J = 25^\circ\text{C}$, $2.7 \text{ V} < V_{IN} < 10 \text{ V}$ | | 1.224 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $2.7 \text{ V} < V_{IN} < 10 \text{ V}$ | | 1.187 | 1.261 | |
| | TPS76915-Q1 | $T_J = 25^\circ\text{C}$, $2.7 \text{ V} < V_{IN} < 10 \text{ V}$ | | 1.5 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $2.7 \text{ V} < V_{IN} < 10 \text{ V}$ | | 1.455 | 1.545 | |
| | TPS76918-Q1 | $T_J = 25^\circ\text{C}$, $2.8 \text{ V} < V_{IN} < 10 \text{ V}$ | | 1.8 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $2.8 \text{ V} < V_{IN} < 10 \text{ V}$ | | 1.746 | 1.854 | |
| | TPS76925-Q1 | $T_J = 25^\circ\text{C}$, $3.5 \text{ V} < V_{IN} < 10 \text{ V}$ | | 2.5 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $3.5 \text{ V} < V_{IN} < 10 \text{ V}$ | | 2.425 | 2.575 | |
| | TPS76927-Q1 | $T_J = 25^\circ\text{C}$, $3.7 \text{ V} < V_{IN} < 10 \text{ V}$ | | 2.7 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $3.7 \text{ V} < V_{IN} < 10 \text{ V}$ | | 2.619 | 2.781 | |
| | TPS76928-Q1 | $T_J = 25^\circ\text{C}$, $3.8 \text{ V} < V_{IN} < 10 \text{ V}$ | | 2.8 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $3.8 \text{ V} < V_{IN} < 10 \text{ V}$ | | 2.716 | 2.884 | |
| | TPS76930-Q1 | $T_J = 25^\circ\text{C}$, $4 \text{ V} < V_{IN} < 10 \text{ V}$ | | 3 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $4 \text{ V} < V_{IN} < 10 \text{ V}$ | | 2.910 | 3.090 | |
| TPS76933-Q1 | $T_J = 25^\circ\text{C}$, $4.3 \text{ V} < V_{IN} < 10 \text{ V}$ | | 3.3 | | | |
| | $T_J = -40^\circ\text{C}$ to 125°C , $4.3 \text{ V} < V_{IN} < 10 \text{ V}$ | | 3.201 | 3.399 | | |
| TPS76950-Q1 | $T_J = 25^\circ\text{C}$, $6 \text{ V} < V_{IN} < 10 \text{ V}$ | | 5 | | | |
| | $T_J = -40^\circ\text{C}$ to 125°C , $6 \text{ V} < V_{IN} < 10 \text{ V}$ | | 4.850 | 5.150 | | |
| Quiescent current (GND current) ⁽¹⁾⁽²⁾ | $\overline{EN} = 0$ V, $0 \text{ mA} < I_O < 100 \text{ mA}$, $T_J = 25^\circ\text{C}$ | | 17 | | μ A | |
| | $\overline{EN} = 0$ V, $I_O = 100 \text{ mA}$, $T_J = -40^\circ\text{C}$ to 125°C | | 28 | | | |
| Load regulation | $\overline{EN} = 0$ V, $I_O = 0$ to 100 mA , $T_J = 25^\circ\text{C}$ | | 12 | | mV | |
| Output voltage line regulation ($\Delta V_O/V_O$) ⁽²⁾ | $V_O + 1 \text{ V} < V_I \leq 10 \text{ V}$, $T_J = 25^\circ\text{C}$ ⁽¹⁾ | | 0.04 | | %V | |
| | $V_O + 1 \text{ V} < V_I \leq 10 \text{ V}$, $T_J = -40^\circ\text{C}$ to 125°C ⁽¹⁾ | | 0.1 | | | |
| Output noise voltage | BW = 300 Hz to 50 kHz, $C_O = 10$ μ F, $T_J = 25^\circ\text{C}$ | | 190 | | μ V _{rms} | |
| Output current limit | $V_O = 0$ V ⁽¹⁾ | | 350 | 750 | mA | |
| Standby current | $\overline{EN} = V_I$, $2.7 < V_I < 10 \text{ V}$ | | 1 | | μ A | |
| | $T_J = -40^\circ\text{C}$ to 125°C | | 2 | | μ A | |
| FB input current | FB = 1.224 V (TPS76901-Q1) | | -1 | 1 | μ A | |
| High level enable input voltage | $2.7 \text{ V} < V_I < 10 \text{ V}$ | | 1.7 | | V | |
| Low level enable input voltage | $2.7 \text{ V} < V_I < 10 \text{ V}$ | | 0.9 | | V | |
| Power supply ripple rejection | f = 1 kHz, $C_O = 10$ μ F, $T_J = 25^\circ\text{C}$ | | 60 | | dB | |
| Input current (\overline{EN}) | $\overline{EN} = 0$ V | | -1 | 0 | μ A | |
| | $\overline{EN} = V_I$ | | -1 | 1 | μ A | |

(1) Minimum IN operating voltage is 2.7 V or V_O (typ) + 1 V, whichever is greater. The maximum IN voltage is 10 V, minimum output current is 10 μ A, and maximum output current is 100 mA.

(2) If $V_O \leq 1.8$ V then $V_{Imin} = 2.7$ V, $V_{Imax} = 10$ V:

$$\text{Line Reg. (mV)} = (\% / \text{V}) \times \frac{V_O (V_{Imax} - 2.7 \text{ V})}{100} \times 1000$$

If $V_O \geq 2.5$ V then $V_{Imin} = V_O + 1$ V, $V_{Imax} = 10$ V:

$$\text{Line Reg. (mV)} = (\% / \text{V}) \times \frac{V_O (V_{Imax} - (V_O + 1 \text{ V}))}{100} \times 1000$$

ELECTRICAL CHARACTERISTICS (continued)

over recommended operating free-air temperature range, $V_I = V_O$ (typ) + 1 V, $I_O = 100$ mA, $\overline{EN} = 0$ V, $C_O = 4.7$ μ F (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT | |
|--------------------------------|-------------|--|-----|-----|-----|------|-----|
| Dropout voltage ⁽³⁾ | TPS76928-Q1 | $I_O = 50$ mA, $T_J = 25^\circ\text{C}$ | | 60 | | mV | |
| | | $I_O = 50$ mA, $T_J = -40^\circ\text{C}$ to 125°C | | | 125 | | |
| | | $I_O = 100$ mA, $T_J = 25^\circ\text{C}$ | | 122 | | | |
| | | $I_O = 100$ mA, $T_J = -40^\circ\text{C}$ to 125°C | | | 245 | | |
| | TPS76930-Q1 | $I_O = 50$ mA, $T_J = 25^\circ\text{C}$ | | | 57 | | |
| | | $I_O = 50$ mA, $T_J = -40^\circ\text{C}$ to 125°C | | | | | 115 |
| | | $I_O = 100$ mA, $T_J = 25^\circ\text{C}$ | | | 115 | | |
| | | $I_O = 100$ mA, $T_J = -40^\circ\text{C}$ to 125°C | | | | | 230 |
| | TPS76933-Q1 | $I_O = 50$ mA, $T_J = 25^\circ\text{C}$ | | | 48 | | |
| | | $I_O = 50$ mA, $T_J = -40^\circ\text{C}$ to 125°C | | | | | 100 |
| | | $I_O = 100$ mA, $T_J = 25^\circ\text{C}$ | | | 98 | | |
| | | $I_O = 100$ mA, $T_J = -40^\circ\text{C}$ to 125°C | | | | | 200 |
| | TPS76950-Q1 | $I_O = 50$ mA, $T_J = 25^\circ\text{C}$ | | | 35 | | |
| | | $I_O = 50$ mA, $T_J = -40^\circ\text{C}$ to 125°C | | | | | 85 |
| | | $I_O = 100$ mA, $T_J = 25^\circ\text{C}$ | | | 71 | | |
| | | $I_O = 100$ mA, $T_J = -40^\circ\text{C}$ to 125°C | | | | | 170 |

(3) The IN voltage equals V_O (typ) – 100 mV; the TPS76901-Q1 output voltage is set to 3.3 V nominal with an external resistor divider. TPS76912-Q1, TPS76915-Q1, TPS76918-Q1, TPS76925-Q1, and TPS76927-Q1 dropout voltage is limited by input voltage range limitations.

TPS76901-Q1, TPS76912-Q1, TPS76915-Q1
TPS76918-Q1, TPS76925-Q1, TPS76927-Q1
TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1

TYPICAL CHARACTERISTICS

TPS76925-Q1 OUTPUT VOLTAGE vs OUTPUT CURRENT

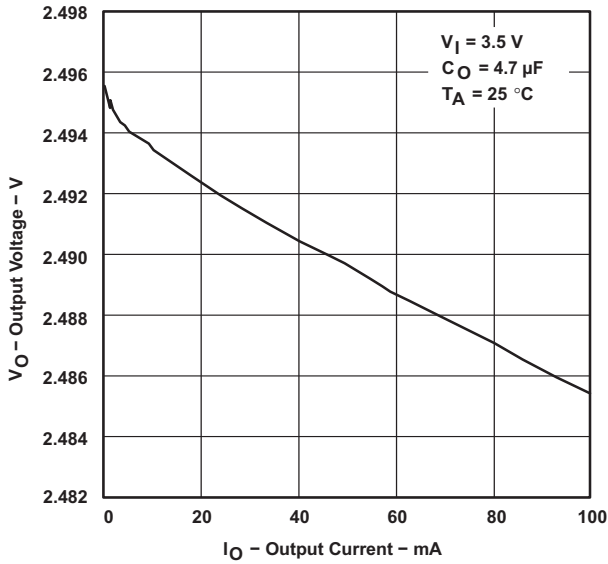


Figure 1.

TPS76915-Q1 OUTPUT VOLTAGE vs OUTPUT CURRENT

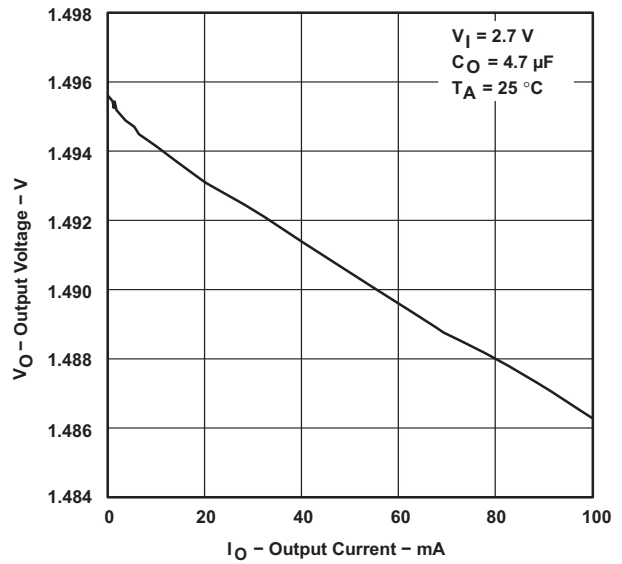


Figure 2.

TPS76933-Q1 OUTPUT VOLTAGE vs OUTPUT CURRENT

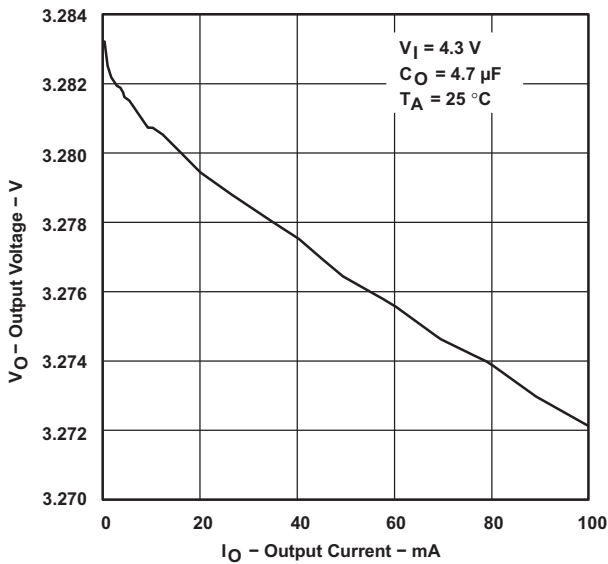


Figure 3.

TPS76915-Q1 OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

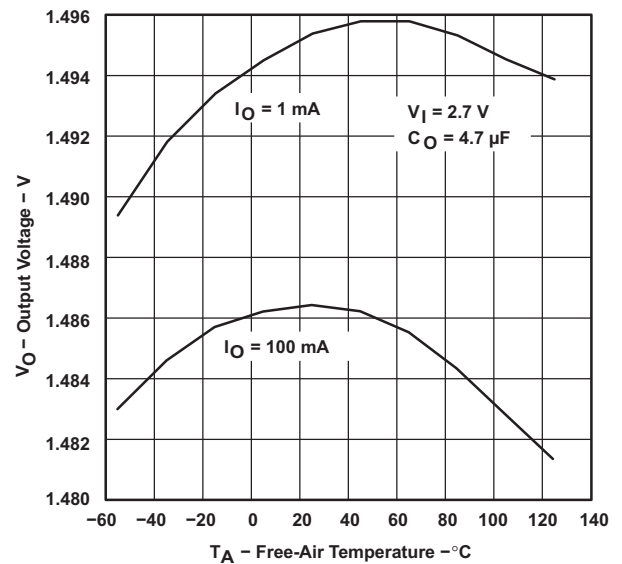


Figure 4.

TYPICAL CHARACTERISTICS (continued)

TPS76925-Q1 OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

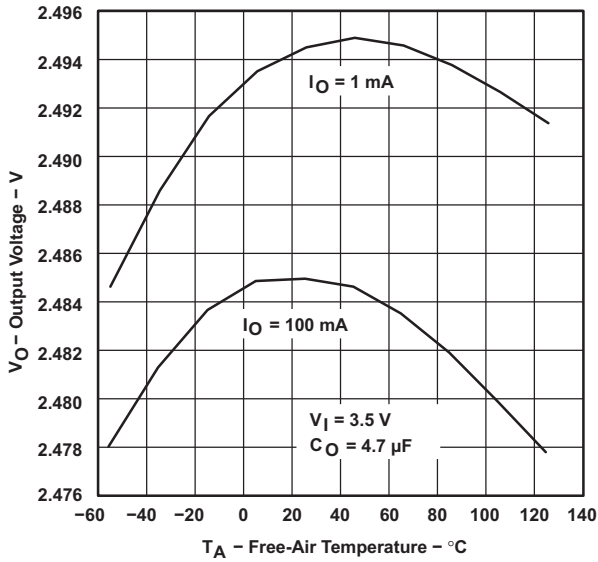


Figure 5.

TPS76933-Q1 OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

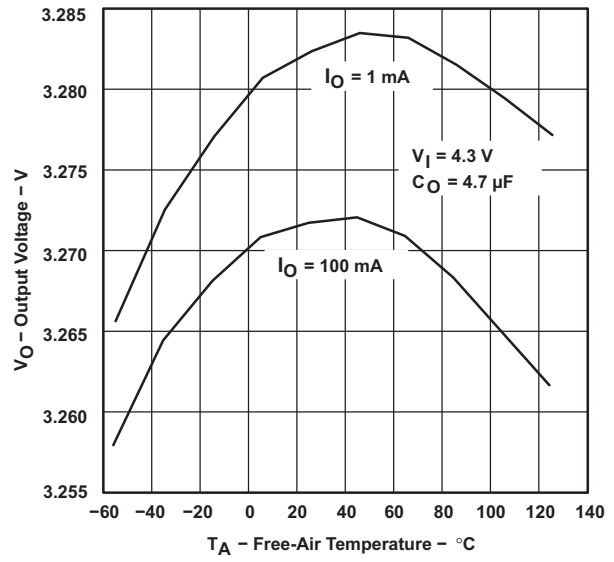


Figure 6.

TPS76933-Q1 GROUND CURRENT vs FREE-AIR TEMPERATURE

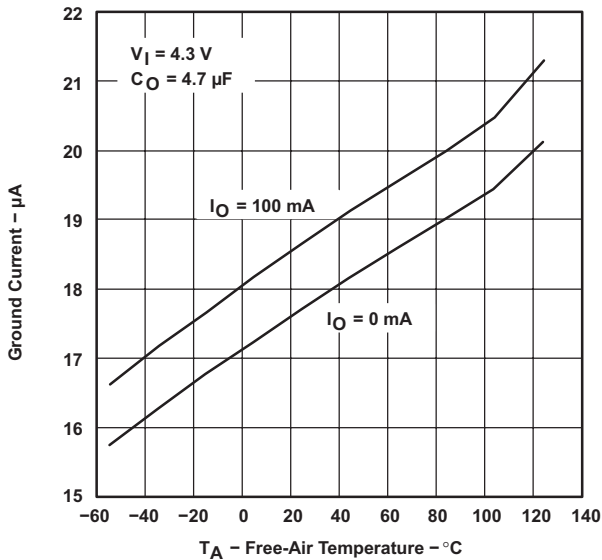


Figure 7.

TPS76933-Q1 OUTPUT SPECTRAL NOISE DENSITY vs FREQUENCY

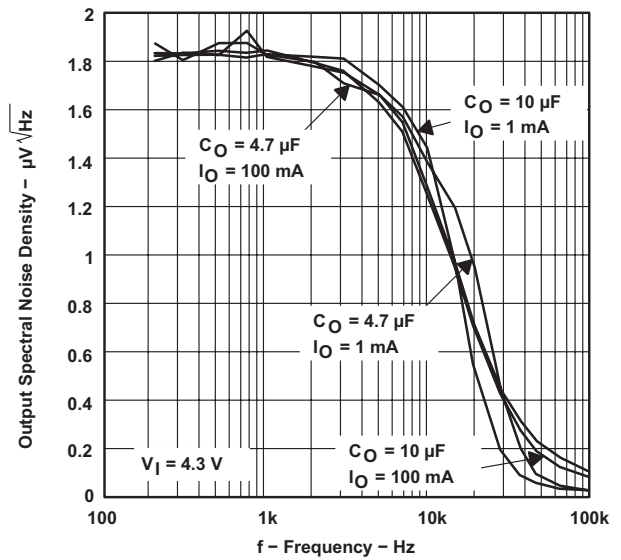


Figure 8.

TPS76901-Q1, TPS76912-Q1, TPS76915-Q1
 TPS76918-Q1, TPS76925-Q1, TPS76927-Q1
 TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1



TYPICAL CHARACTERISTICS (continued)

**OUTPUT IMPEDANCE
vs
FREQUENCY**

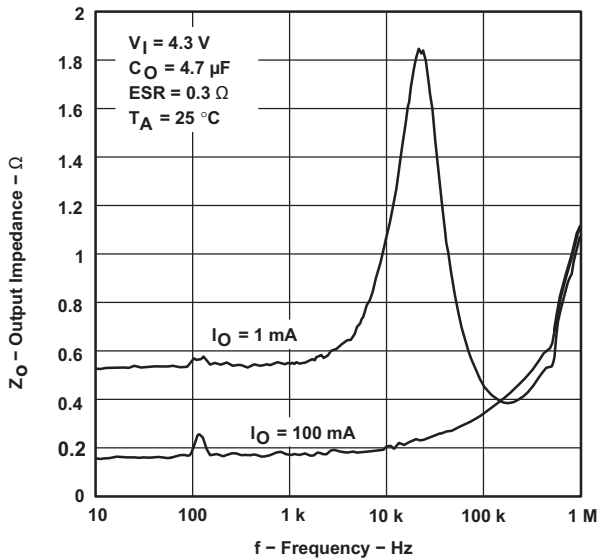


Figure 9.

**TPS76933-Q1 DROPOUT VOLTAGE
vs
FREE-AIR TEMPERATURE**

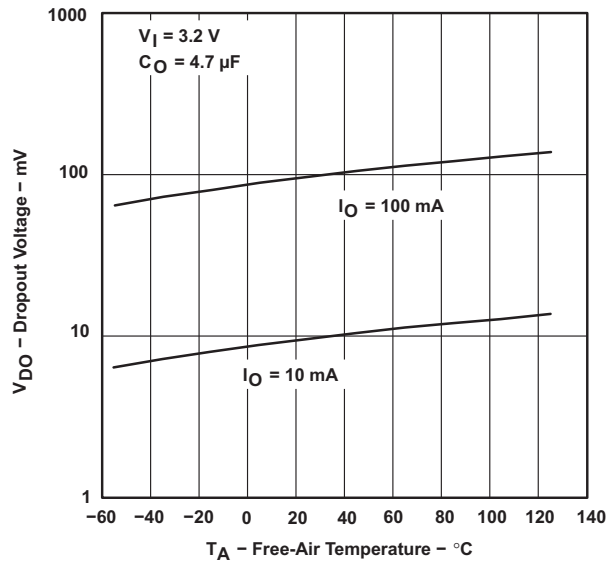


Figure 10.

**TPS76933-Q1 RIPPLE REJECTION
vs
FREQUENCY**

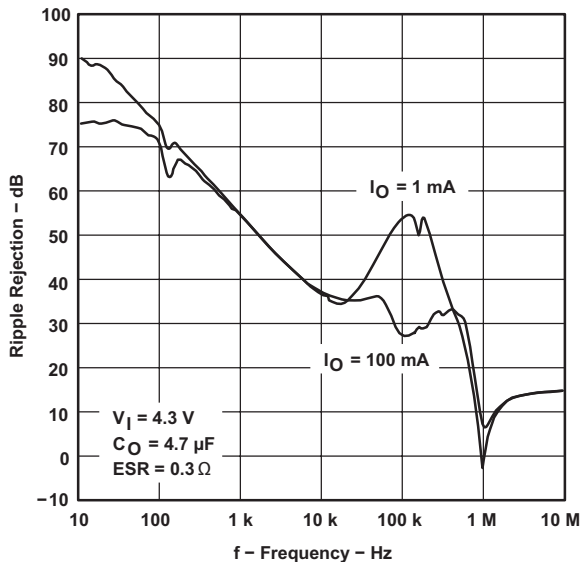


Figure 11.

LDO STARTUP TIME

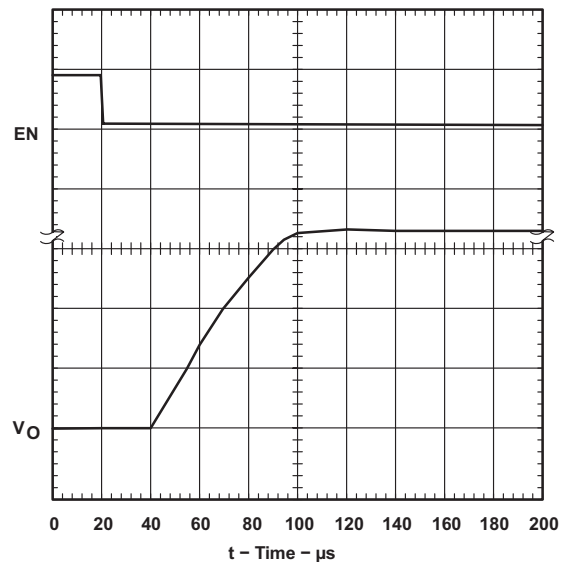


Figure 12.

TYPICAL CHARACTERISTICS (continued)

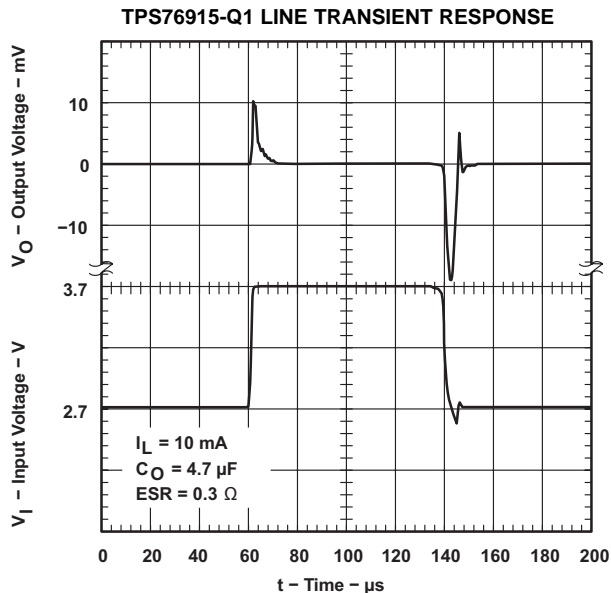


Figure 13.

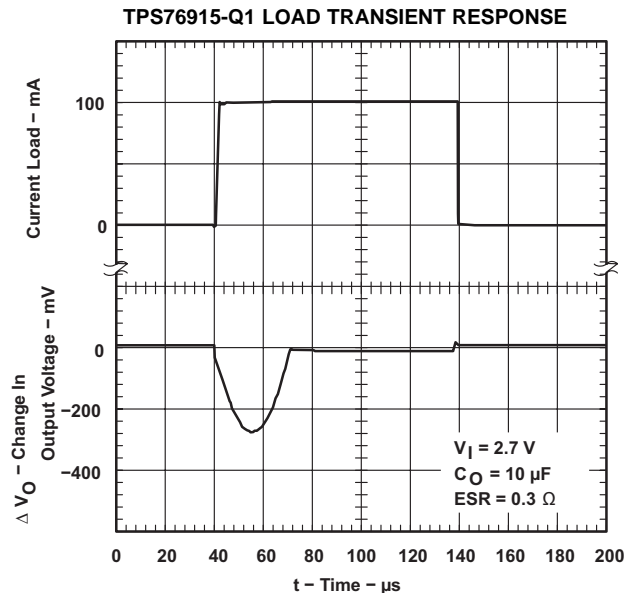


Figure 14.

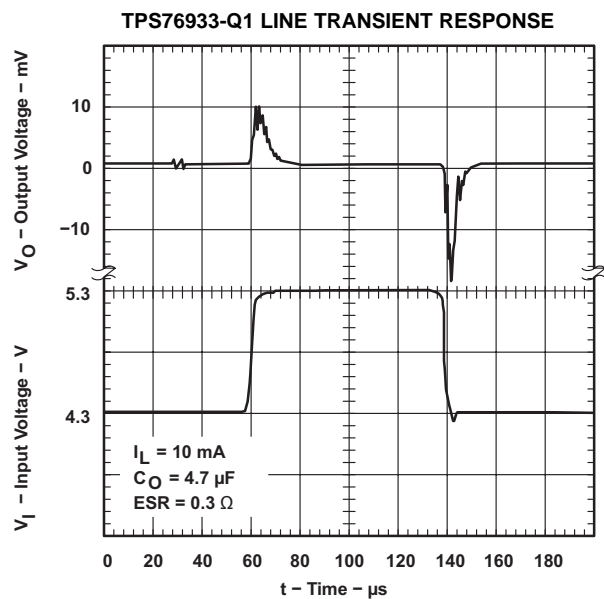


Figure 15.

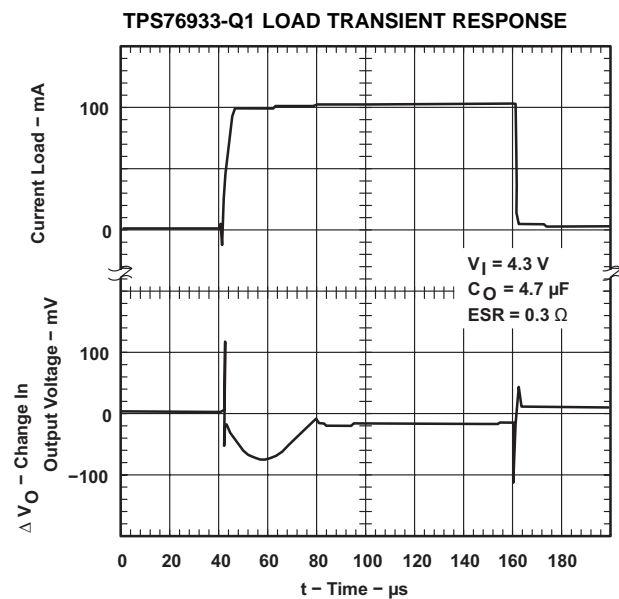


Figure 16.

TPS76901-Q1, TPS76912-Q1, TPS76915-Q1
TPS76918-Q1, TPS76925-Q1, TPS76927-Q1
TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1



TYPICAL CHARACTERISTICS (continued)

TPS76933-Q1 TYPICAL REGIONS OF STABILITY
EQUIVALENT SERIES RESISTANCE (ESR)
vs
OUTPUT CURRENT

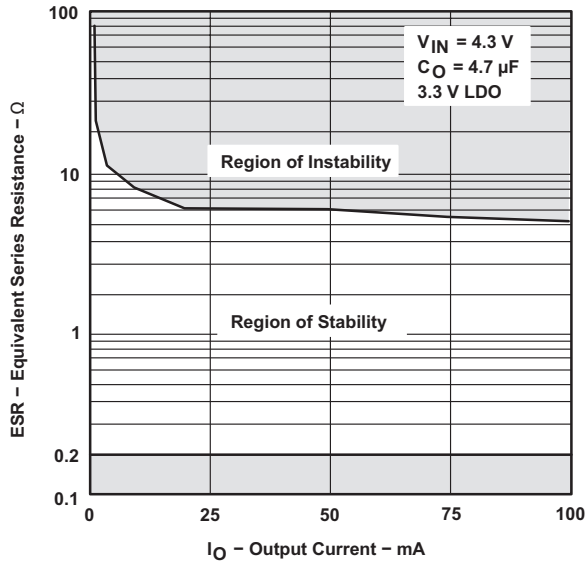


Figure 17.

TPS76933-Q1 TYPICAL REGIONS OF STABILITY
EQUIVALENT SERIES RESISTANCE (ESR)
vs
ADDED CERAMIC CAPACITANCE

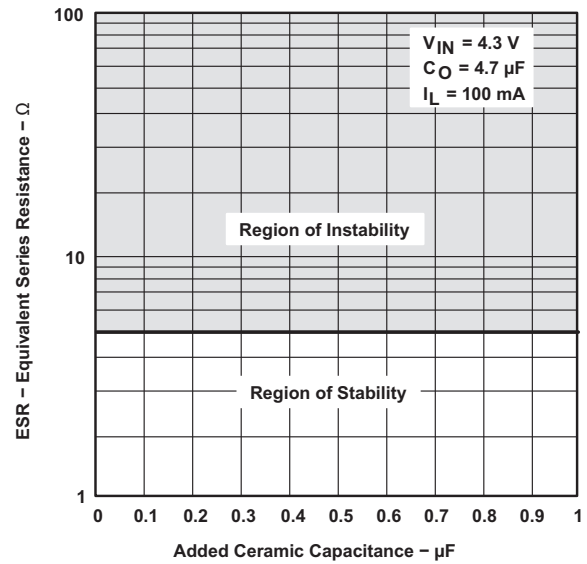


Figure 18.

TPS76933-Q1 TYPICAL REGIONS OF STABILITY
EQUIVALENT SERIES RESISTANCE (ESR)
vs
OUTPUT CURRENT

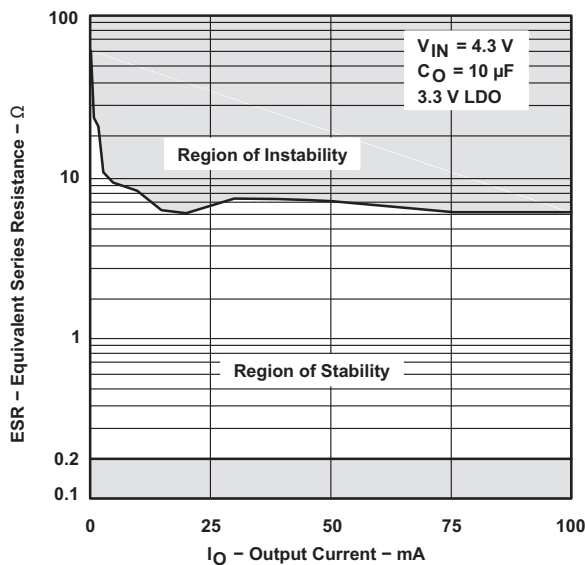


Figure 19.

TPS76933-Q1 TYPICAL REGIONS OF STABILITY
EQUIVALENT SERIES RESISTANCE (ESR)
vs
ADDED CERAMIC CAPACITANCE

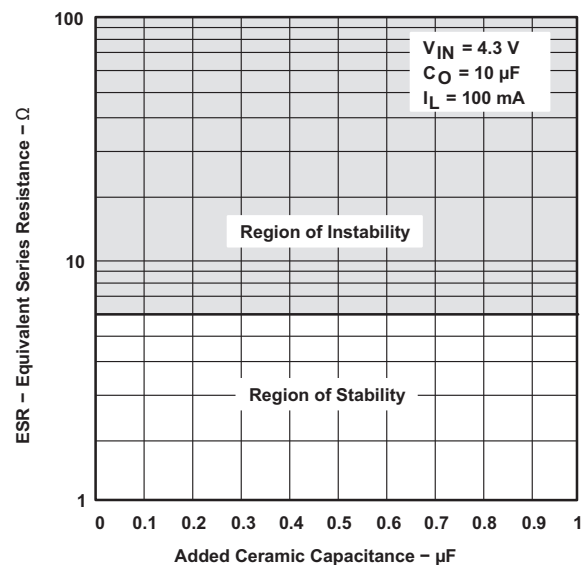


Figure 20.

APPLICATION INFORMATION

The TPS769xx-Q1 family of low-dropout (LDO) regulators are optimized for use in battery-operated equipment and automotive applications. They feature extremely low dropout voltages, low quiescent current (17 μ A nominally), and enable inputs to reduce supply currents to 1 μ A when the regulators are turned off.

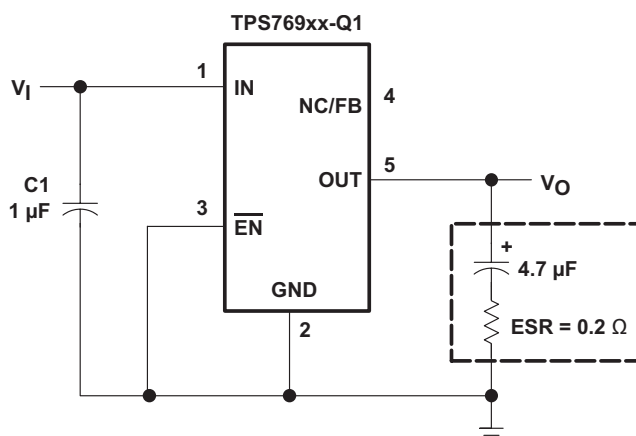
Device Operation

The TPS769xx-Q1 uses a PMOS pass element to dramatically reduce both dropout voltage and supply current over more conventional PNP-pass-element LDO designs. The PMOS pass element is a voltage-controlled device and, unlike a PNP transistor, it does not require increased drive current as output current increases. Supply current in the TPS769xx-Q1 is essentially constant from no load to maximum load.

Current limiting and thermal protection prevent damage by excessive output current and/or power dissipation. The device switches into a constant-current mode at approximately 350 mA; further load reduces the output voltage instead of increasing the output current. The thermal protection shuts the regulator off if the junction temperature rises above approximately 165°C. Recovery is automatic when the junction temperature drops approximately 25°C below the high temperature trip point. The PMOS pass element includes a back gate diode that conducts reverse current when the input voltage level drops below the output voltage level.

A voltage of 1.7 V or greater on the $\overline{\text{EN}}$ input will disable the TPS769xx-Q1 internal circuitry, reducing the supply current to 1 μ A. A voltage of less than 0.9 V on the $\overline{\text{EN}}$ input will enable the TPS769xx and will enable normal operation to resume. The $\overline{\text{EN}}$ input does not include any deliberate hysteresis, and it exhibits an actual switching threshold of approximately 1.5 V.

A typical application circuit is shown in Figure 21.



TPS76912-Q1, TPS76915-Q1, TPS76918-Q1, TPS76925-Q1, TPS76927-Q1, TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1 (fixed-voltage options).

Figure 21. Typical Application Circuit

External Capacitor Requirements

Although not required, a 0.047- μ F or larger ceramic input bypass capacitor, connected between IN and GND and located close to the TPS769xx-Q1, is recommended to improve transient response and noise 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 TPS769xx-Q1 requires an output capacitor connected between OUT and GND to stabilize the internal control loop. The minimum recommended capacitance is 4.7 μ F. The ESR (equivalent series resistance) of the capacitor should be between 0.2 Ω and 10 Ω . to ensure stability. Capacitor values larger than 4.7 μ F are acceptable, and allow the use of smaller ESR values. Capacitances less than 4.7 μ F are not recommended because they require careful selection of ESR to ensure stability. Solid tantalum

TPS76901-Q1, TPS76912-Q1, TPS76915-Q1
TPS76918-Q1, TPS76925-Q1, TPS76927-Q1
TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1

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electrolytic, aluminum electrolytic, and multilayer ceramic capacitors are all suitable, provided they meet the requirements described above. Most of the commercially available 4.7 μF surface-mount solid tantalum capacitors, including devices from Sprague, Kemet, and Nichico, meet the ESR requirements stated above. Multilayer ceramic capacitors may have very small equivalent series resistances and may therefore require the addition of a low value series resistor to ensure stability.

Table 1. Capacitor Selection

| PART NO. | MFR. | VALUE | MAX ESR | SIZE (H × L × W) ⁽¹⁾ |
|------------------|---------|--------|---------|---------------------------------|
| T494B475K016AS | KEMET | 4.7 μF | 1.5 Ω | 1.9 × 3.5 × 2.8 |
| 195D106x0016x2T | SPRAGUE | 10 μF | 1.5 Ω | 1.3 × 7 × 2.7 |
| 695D106x003562T | SPRAGUE | 10 μF | 1.3 Ω | 2.5 × 7.6 × 2.5 |
| TPSC475K035R0600 | AVX | 4.7 μF | 0.6 Ω | 2.6 × 6 × 3.2 |

(1) Size is in mm. ESR is maximum resistance in Ω at 100 kHz and T_A = 25°C. Contact manufacturer for minimum ESR values.

Output Voltage Programming

The output voltage of the TPS76901-Q1 adjustable regulator is programmed using an external resistor divider as shown in [Figure 22](#). The output voltage is calculated using:

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

Where:

V_{ref} = 1.224 V typ (the internal reference voltage)

Resistors R1 and R2 should be chosen for approximately 7-μA divider current. Lower value resistors can be used but offer no inherent advantage and waste more power. Higher values should be avoided as leakage currents at FB increase the output voltage error. The recommended design procedure is to choose R2 = 169 kΩ to set the divider current at 7 μA and then calculate R1 using:

$$R1 = \left(\frac{V_O}{V_{ref}} - 1\right) \times R2 \quad (2)$$

Table 2. Output Voltage Programming Guide

| OUTPUT VOLTAGE (V) | DIVIDER RESISTANCE (kΩ) ⁽¹⁾ | |
|--------------------|--|-----|
| | R1 | R2 |
| 2.5 | 174 | 169 |
| 3.3 | 287 | 169 |
| 3.6 | 324 | 169 |
| 4 | 383 | 169 |
| 5 | 523 | 169 |

(1) 1% values shown.

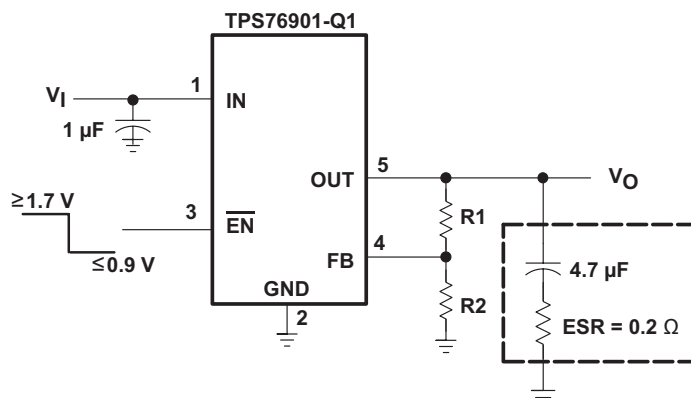


Figure 22. TPS76901-Q1 Adjustable LDO Regulator Programming

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:

$$P_{D(max)} = \frac{T_{Jmax} - T_A}{R_{\theta JA}} \quad (3)$$

Where:

T_{Jmax} is the maximum allowable junction temperature

$R_{\theta JA}$ is the thermal resistance junction-to-ambient for the package, see the dissipation rating table.

T_A is the ambient temperature.

The regulator dissipation is calculated using:

$$P_D = (V_I - V_O) \times I_O \quad (4)$$

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

Regulator Protection

The TPS769xx-Q1 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 might be appropriate.

The TPS769xx-Q1 features internal current limiting and thermal protection. During normal operation, the TPS769xx-Q1 limits output current to approximately 350 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. 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.



TPS76901-Q1, TPS76912-Q1, TPS76915-Q1
TPS76918-Q1, TPS76925-Q1, TPS76927-Q1
TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1



REVISION HISTORY

| Changes from Revision B (April, 2008) to Revision C | Page |
|--|------|
| • Changed TPS769xx part names to TPS769xx-Q1 in text and images. | 1 |
| • Updated Figures 17 and 19 to include region of Instability below 0.2 Ω. | 10 |

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|-------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TPS76901QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCFQ | Samples |
| TPS76901QDBVRQ1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCFQ | Samples |
| TPS76912QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCGQ | Samples |
| TPS76915QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCHQ | Samples |
| TPS76915QDBVRQ1 | OBSOLETE | SOT-23 | DBV | 5 | | TBD | Call TI | Call TI | -40 to 125 | | |
| TPS76918QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCIQ | Samples |
| TPS76918QDBVRQ1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCIQ | Samples |
| TPS76925QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCJQ | Samples |
| TPS76925QDBVRQ1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCJQ | Samples |
| TPS76927QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCKQ | Samples |
| TPS76927QDBVRQ1 | OBSOLETE | SOT-23 | DBV | 5 | | TBD | Call TI | Call TI | -40 to 125 | | |
| TPS76928QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCLQ | Samples |
| TPS76930QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCMQ | Samples |
| TPS76930QDBVRQ1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCMQ | Samples |
| TPS76933QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCNQ | Samples |
| TPS76933QDBVRQ1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCNQ | Samples |
| TPS76950QDBVRG4Q1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCOQ | Samples |
| TPS76950QDBVRQ1 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | PCOQ | Samples |



⁽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)

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

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

⁽⁵⁾ 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.

⁽⁶⁾ 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.

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OTHER QUALIFIED VERSIONS OF TPS76901-Q1, TPS76912-Q1, TPS76915-Q1, TPS76918-Q1, TPS76925-Q1, TPS76927-Q1, TPS76928-Q1, TPS76930-Q1, TPS76933-Q1, TPS76950-Q1 :

● Catalog: [TPS76901](#), [TPS76912](#), [TPS76915](#), [TPS76918](#), [TPS76925](#), [TPS76927](#), [TPS76928](#), [TPS76930](#), [TPS76933](#), [TPS76950](#)



Distributor of Texas Instruments: Excellent Integrated System Limited

Datasheet of TPS76933QDBVRQ1 - IC REG LDO 3.3V 0.1A SOT23-5

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PACKAGE OPTION ADDENDUM

www.ti.com

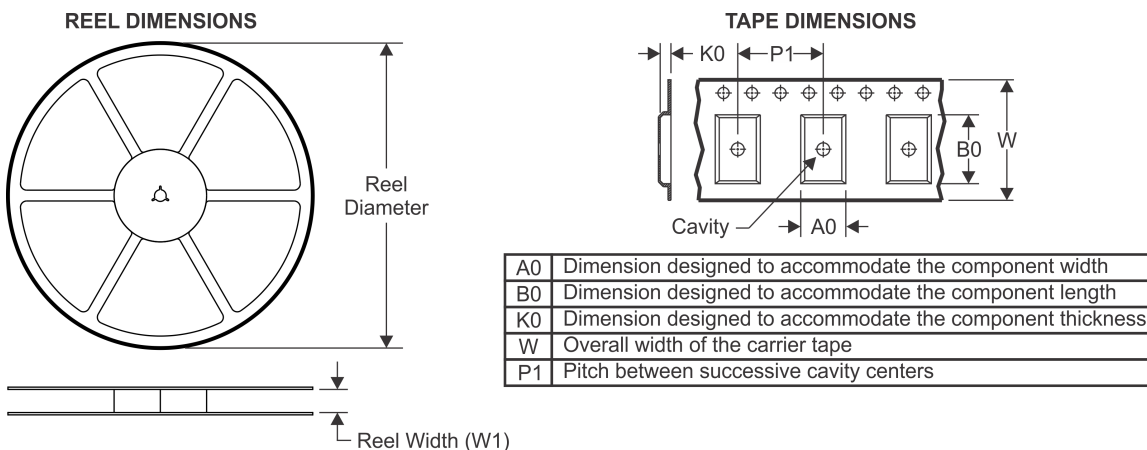
24-Aug-2014

● Enhanced Product: [TPS76901-EP](#)

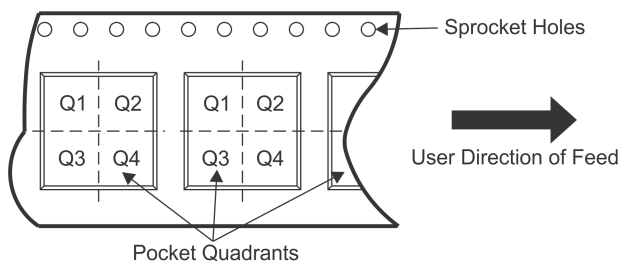
NOTE: Qualified Version Definitions:

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

TAPE AND REEL INFORMATION



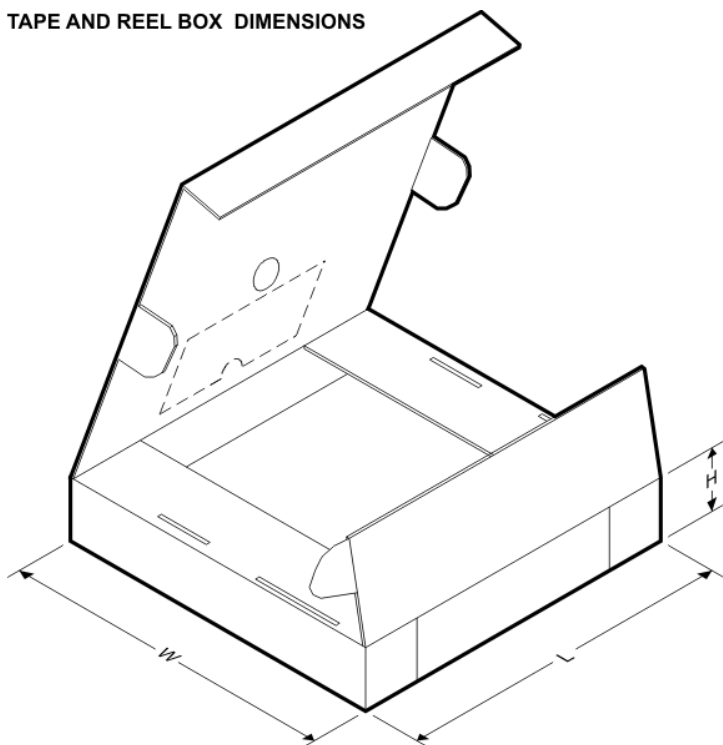
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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 |
|-------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS76901QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76901QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76912QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76912QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76915QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76915QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76918QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76918QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76925QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76925QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76927QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76927QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76928QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76928QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76930QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76930QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76933QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76933QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76950QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76950QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TPS76950QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 178.0 | 9.0 | 3.3 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |

TAPE AND REEL BOX DIMENSIONS



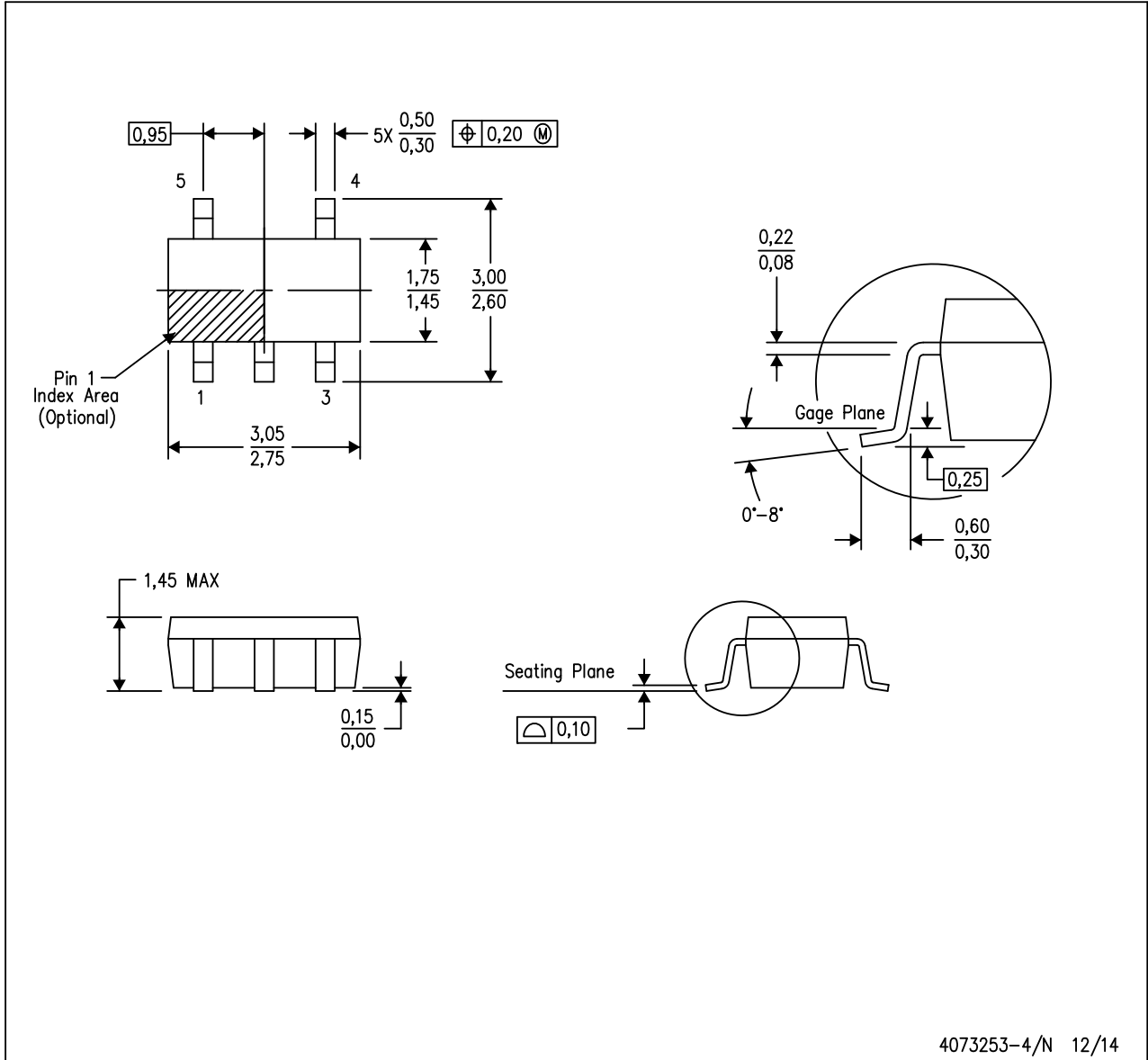
*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS76901QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76901QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76912QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76915QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76918QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76918QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76925QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76925QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76927QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76928QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76930QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76930QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76933QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76933QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76950QDBVRG4Q1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76950QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TPS76950QDBVRQ1 | SOT-23 | DBV | 5 | 3000 | 180.0 | 180.0 | 18.0 |

MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



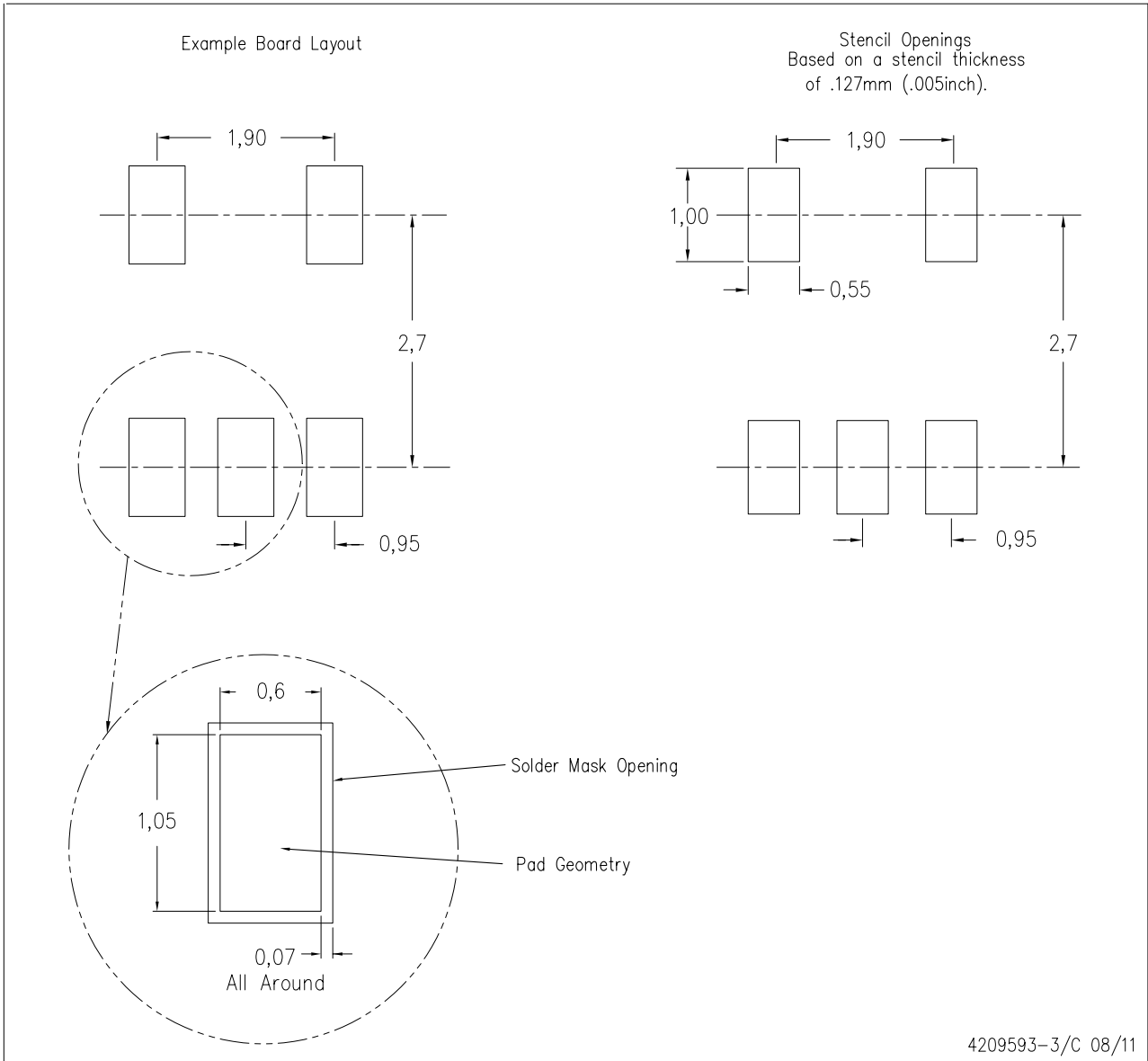
4073253-4/N 12/14

- 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.

LAND PATTERN DATA

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.

IMPORTANT NOTICE

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