TPS723xx 200mA Low-Noise, High-PSRR Negative Output Low-Dropout Linear Regulators

1 Features

- Ultralow Noise: 60 μV_{RMS} Typical
- High PSRR: 65 dB Typical at 1 kHz
- Low Dropout Voltage: 280 mV Typical at 200 mA, 2.5 V
- Available in –2.5-V and Adjustable (–1.2 V to –10 V) Versions
- Stable With a 2.2-µF Ceramic Output Capacitor
- Less Than 2-µA Typical Quiescent Current in Shutdown Mode
- 2% Overall Accuracy (Line, Load, Temperature)
- Thermal and Over-Current Protection
- SOT23-5 (DBV) Package
- SOT-5 (DDC) Package
- Operating Junction Temperature Range: –40°C to 125°C

2 Applications

- Optical Drives
- Optical Networking
- Noise Sensitive Circuitry
- GaAs FET Gate Bias
- Video Amplifiers

3 Description

The TPS723xx family of low-dropout (LDO) negative voltage regulators offers an ideal combination of features to support low noise applications. These devices are capable of operating with input voltages from –10 V to –2.7 V, and support outputs from –10 V to –1.2 V. These regulators are stable with small, low-cost ceramic capacitors, and include enable (EN) and noise reduction (NR) functions. Thermal short-circuit and over-current protections are provided by internal detection and shutdown logic. High PSRR (65 dB at 1 kHz) and low noise (60 μV_{RMS}) make the TPS723xx ideal for low-noise applications.

The TPS723xx uses a precision voltage reference to achieve 2% overall accuracy over load, line, and temperature variations. Available in a small SOT23-5 package, the TPS723xx family is fully specified over a temperature range of –40°C to 125°C.

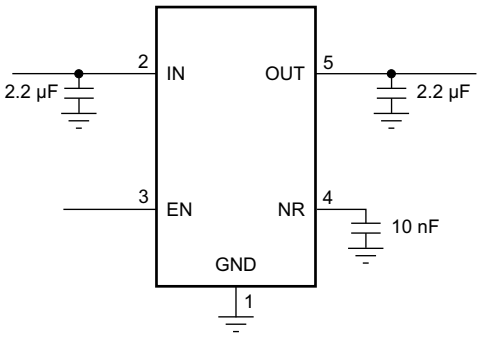
Device Information(1)

PART NUMBER	PACKAGE(2)	BODY SIZE (NOM)
TPS723xx	SOT-23 (5)	2.90 mm x 1.60 mm
	SOT (5)	2.90 mm x 1.60 mm

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

(2) The two SOT23 packages are identical in size, but the SOT package is thinner.

Typical Application Circuit



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4 Revision History

Changes from Revision B (July 2007) to Revision C — **Page**

- Changed format to meet latest data sheet standards; added new sections, and moved existing sections ... 1
- Added bullet item for DDC package to Features list ... 1
- Revised *Device Information* table to include SOT-5 package ... 1
- Updated *Typical Application Circuit* to show SOT-5 (DDC) package pin configuration ... 1
- Added pin configuration drawings ... 3
- Deleted *Dissipation Ratings* table; see *Thermal Information* ... 4
- Changed y-axis title in Figure 11 to *Feedback Current* from *Supply Current* ... 6
- Reworded second paragraph in *Current Limit* subsection. ... 12

Changes from Revision A (June 2007) to Revision B — **Page**

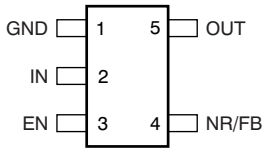
- Added second paragraph in *Current Limit* subsection ... 12
- Changed equation shown in Figure 27 ... 13

Changes from Original (September 2003) to Revision A — **Page**

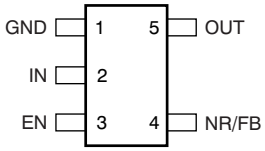
- Changed document format to correspond to current product line standards ... 1
- Removed *Output Voltage vs Output Current* graph (original Fig 2) ... 6

5 Pin Configuration and Functions

DBV PACKAGE
SOT23-5
Top View



DDC PACKAGE
SOT-5
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
GND	1	—	Ground
IN	2	I	Input supply
EN	3	I	Bipolar enable pin. Driving this pin above the positive enable threshold or below the negative enable threshold turns on the regulator. Driving this pin below the positive disable threshold and above the negative disable threshold puts the regulator into shutdown mode.
NR	4	—	Fixed voltage versions only. Connecting an external capacitor between this pin and ground, bypasses noise generated by the internal bandgap. This configuration allows output noise to be reduced to very low levels.
FB	4	I	Adjustable voltage version only. This pin is the input to the control loop error amplifier. It is used to set the output voltage of the device.
OUT	5	O	Regulated output voltage. A small, 2.2-µF ceramic capacitor is needed from this pin to GND to ensure stability.

6 Specifications

6.1 Absolute Maximum Ratings

over operating junction temperature range (unless otherwise noted)(1)(2)

		MIN	MAX	UNIT
Voltage	IN	–11	+0.3	V
	NR	–11	+5.5	V
	EN	$-V_I$	+5.5	V
	OUT	–11	+0.3	V
Current	OUT	Internally limited		A
Output short-circuit duration		Indefinite		
Continuous total power dissipation		See Thermal Information table		
Operating junction temperature, T_J		–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.
(2) All voltage values are with respect to network ground terminal.

6.2 Handling Ratings

			MIN	MAX	UNIT
T_{stg}	Storage temperature range		–65	150	°C
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins	–1000	1000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins	–500	500	

6.3 Recommended Operating Conditions

over operating junction temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_I	Input supply voltage range	–10		–2.7	V
I_O	Output current	0		200	mA
T_J	Operating junction temperature	–40		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		TPS723xx		UNIT
		DBV	DDC	
		5 PINS	5 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	206.9	194.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	120.5	41.4	
$R_{\theta JB}$	Junction-to-board thermal resistance	35.9	35.9	
ψ_{JT}	Junction-to-top characterization parameter	13.3	1.0	
ψ_{JB}	Junction-to-board characterization parameter	35.0	35.7	
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	

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

6.5 Electrical Characteristics

Over operating junction temperature range, $V_I = V_{O(NOM)} – 0.5$ V, $I_O = 1$ mA, $V_{EN} = 1.5$ V, $C_O = 2.2$ µF, and $C_{NR} = 0.01$ µF, unless otherwise noted. Typical values are at $T_J = 25°C$.

PARAMETER			TEST CONDITIONS	TPS723xx			UNIT
				MIN	TYP	MAX	
V_I	Input voltage range(1)			–10		–2.7	V
V_{FB}	Feedback reference voltage	TPS72301	$T_J = 25°C$	–1.210	–1.186	–1.162	V
V_O	Output voltage range	TPS72301		$–10 + V_{DO}$		V_{FB}	V
	Accuracy	Nominal	$T_J = 25°C$	–1%		1%	
		TPS72325 vs $V_I/I_O/T$	$–10\ V \le V_I \le V_O – 0.5\ V$, $10\ µA \le I_O \le 200\ mA$	–2%	±1%	2%	
		TPS72301 vs $V_I/I_O/T$		–3%	±1	3%	
$ΔV_{O(ΔVI)}$	Line regulation		$–10\ V \le V_I \le V_{O(NOM)} – 0.5\ V$		0.04		%/V
$ΔV_{O(ΔIO)}$	Load regulation		$0\ mA \le I_O \le 200\ mA$		0.002		%/mA
V_{DO}	Dropout voltage at $V_O = 0.96 × V_{O(NOM)}$	TPS72325	$I_O = 200$ mA		280	500	mV
$I_{(LIM)}$	Current limit		$V_O = 0.85 × V_{O(NOM)}$	300	550	800	mA
$I_{(GND)}$	Ground pin current		$I_O = 0$ mA (I_Q), $–10\ V \le V_I \le V_O – 0.5\ V$		130	200	µA
			$I_O = 200$ mA, $–10\ V \le V_I \le V_O – 0.5\ V$		350	500	
$I_{(SHDN)}$	Shutdown ground pin current		$–0.4\ V \le V_{EN} \le 0.4\ V$, $–10\ V \le V_I \le V_O – 0.5\ V$		0.1	2.0	µA
$I_{(FB)}$	Feedback pin current		$–10\ V \le V_I \le V_O – 0.5\ V$		0.05	1.0	µA
PSRR	Power-supply rejection ratio	TPS72325	$I_O = 200$ mA, 1 kHz, $C_I = C_O = 10$ µF		65		dB
			$I_O = 200$ mA, 10 kHz, $C_I = C_O = 10$ µF		48		
V_n	Output noise voltage	TPS72325	$C_O = 10$ µF, 10 Hz to 100 kHz, $I_O = 200$ mA		60		$µV_{RMS}$
t_{STR}	Startup time		$V_O = –2.5$ V, $C_O = 1$ µF, $R_L = 25\ Ω$		1		ms
$V_{EN(HI)}$	Enable threshold positive			1.5			V
$V_{EN(LO)}$	Enable threshold negative					–1.5	V
$V_{DIS(HI)}$	Disable threshold positive					0.4	V
$V_{DIS(LO)}$	Disable threshold negative			–0.4			V
$I_{(EN)}$	Enable pin current		$–10\ V \le V_I \le V_O – 0.5\ V$, $–10\ V \le V_{EN} \le ±3.5\ V$		0.1	2.0	µA
T_{sd}	Thermal shutdown temperature		Shutdown, temperature increasing		165		°C
			Reset, temperature decreasing		145		
T_J	Operating junction temperature			–40		125	°C

(1) Maximum $V_I = (V_O – V_{DO})$ or – 2.7 V, whichever is more negative.

6.6 Typical Characteristics

TPS72325 at $V_I = V_{O(NOM)} – 0.5$ V, $I_O = 1$ mA, $V_{EN} = 1.5$ V, $C_O = 2.2$ µF, and $C_{NR} = 0.01$ µF, unless otherwise noted.

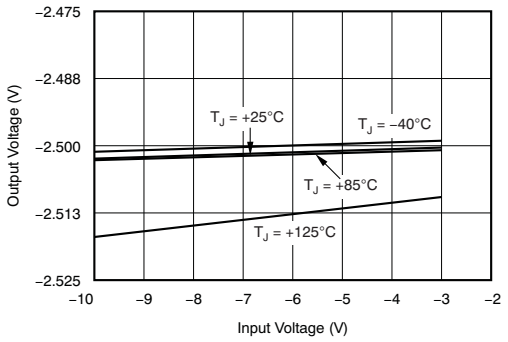


Figure 1. Output Voltage vs Input Voltage

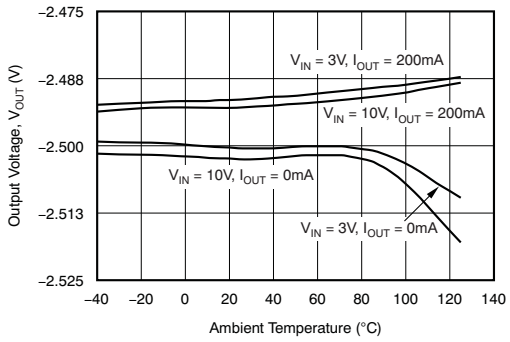


Figure 2. Output Voltage vs Ambient Temperature

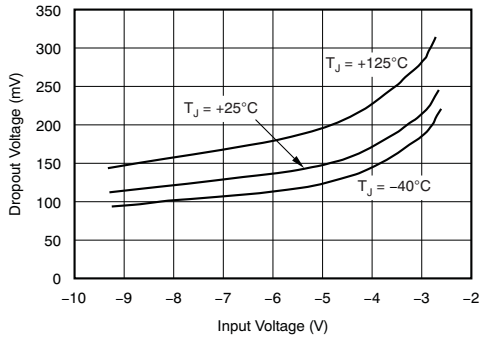


Figure 3. TPS72301 Dropout Voltage vs Input Voltage

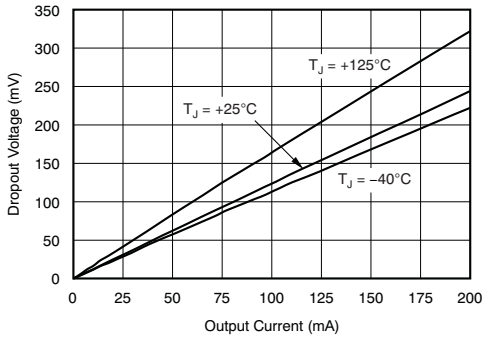


Figure 4. Dropout Voltage vs Output Current

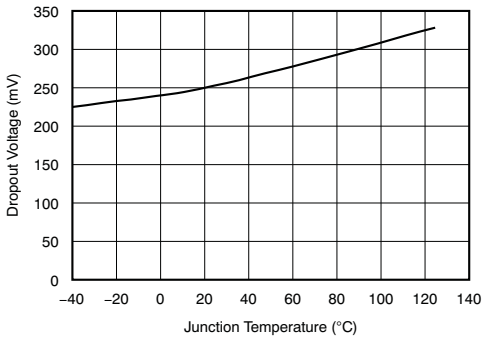


Figure 5. TPS72325 Dropout Voltage vs Junction Temperature

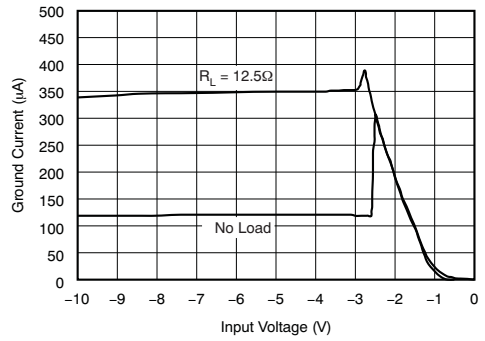


Figure 6. Ground Current vs Input Voltage

Typical Characteristics (continued)

TPS72325 at $V_I = V_{O(NOM)} - 0.5$ V, $I_O = 1$ mA, $V_{EN} = 1.5$ V, $C_O = 2.2$ µF, and $C_{NR} = 0.01$ µF, unless otherwise noted.

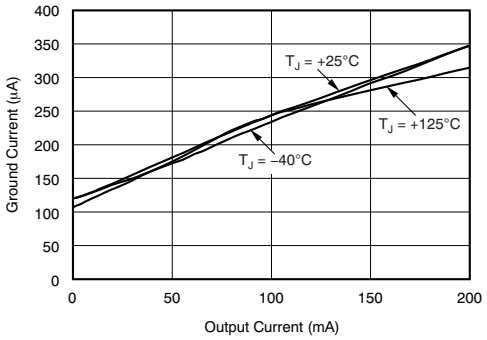


Figure 7. Ground Current vs Output Current

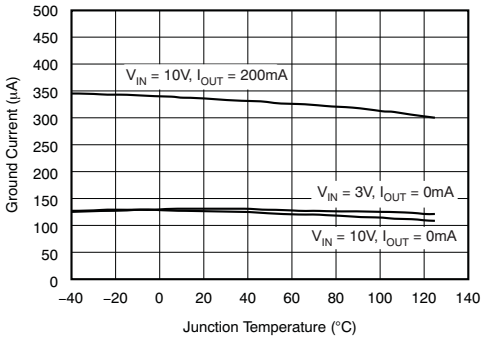


Figure 8. Ground Current vs Junction Temperature

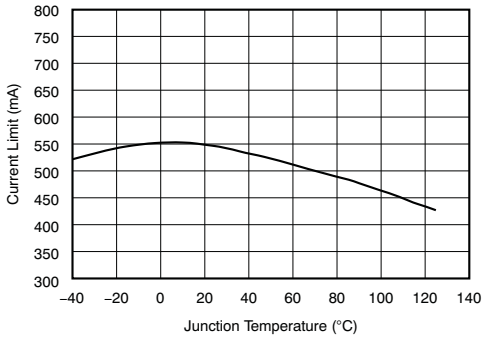


Figure 9. TPS72325 Current Limit vs Junction Temperature

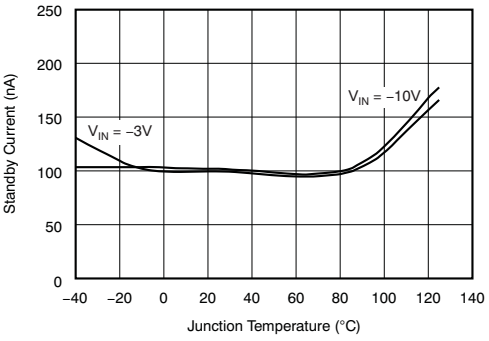


Figure 10. Standby Current vs Junction Temperature

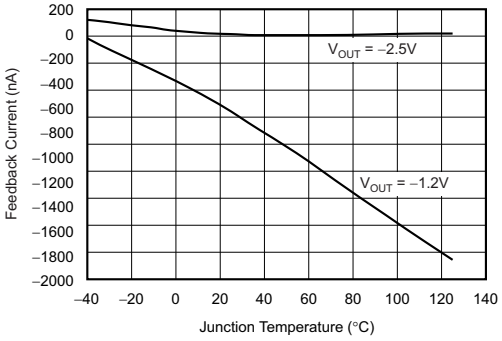


Figure 11. TPS72301 Feedback Pin Current vs Junction Temperature

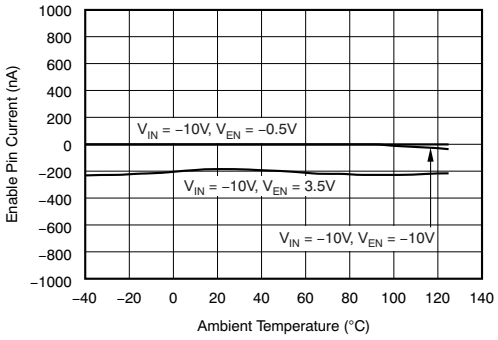


Figure 12. Enable Pin Current vs Junction Temperature

Typical Characteristics (continued)

TPS72325 at $V_I = V_{O(NOM)} - 0.5$ V, $I_O = 1$ mA, $V_{EN} = 1.5$ V, $C_O = 2.2$ µF, and $C_{NR} = 0.01$ µF, unless otherwise noted.

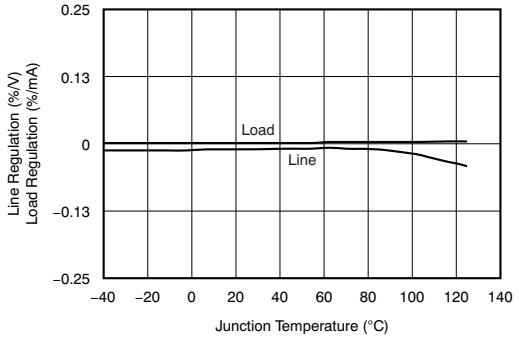


Figure 13. Line And Load Regulation vs Junction Temperature

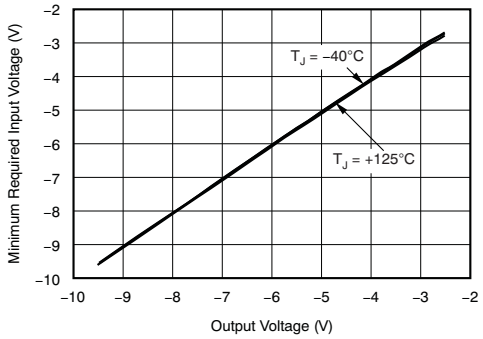


Figure 14. TPS72301 Minimum Required Input Voltage vs Output Voltage

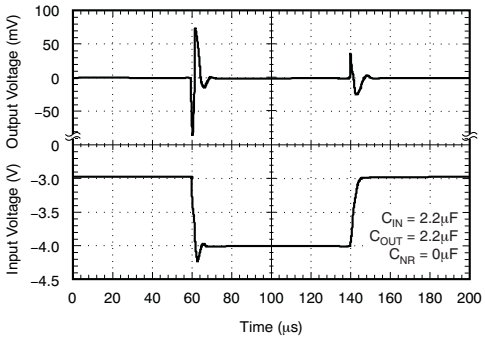


Figure 15. TPS72325 Line Transient Response

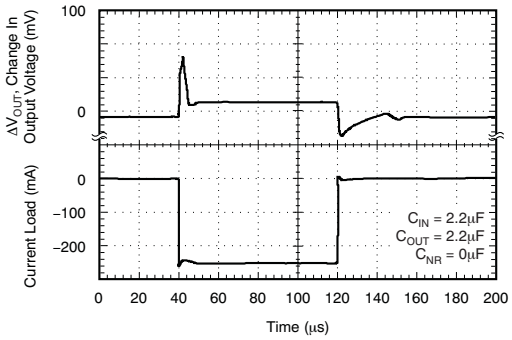


Figure 16. TPS72325 Load Transient Response

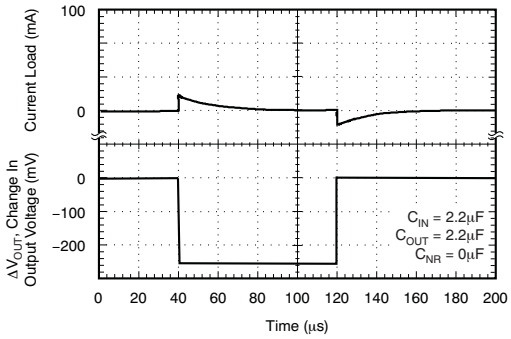


Figure 17. TPS72325 Load Transient Response

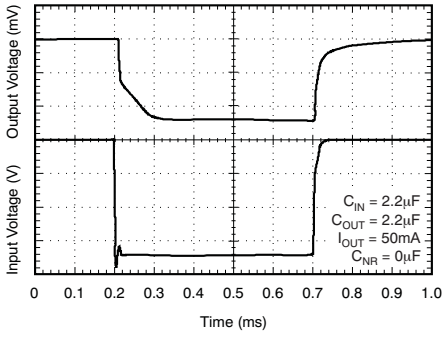


Figure 18. TPS72325 Start-Up Response

Typical Characteristics (continued)

TPS72325 at $V_I = V_{O(NOM)} – 0.5$ V, $I_O = 1$ mA, $V_{EN} = 1.5$ V, $C_O = 2.2$ µF, and $C_{NR} = 0.01$ µF, unless otherwise noted.

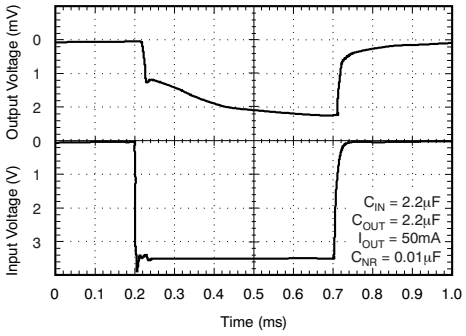


Figure 19. TPS72325 Start-Up Response

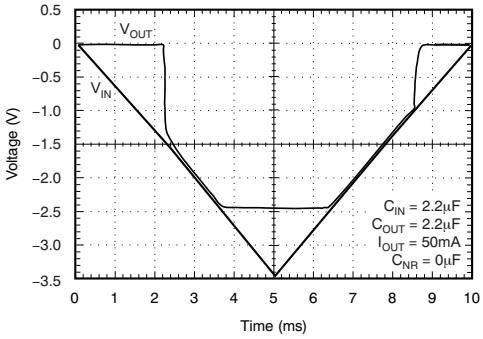


Figure 20. TPS72325 Power-Up/Power-Down

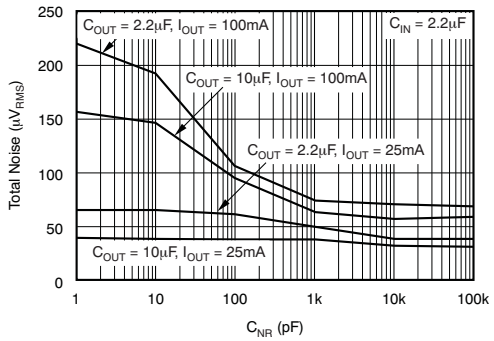


Figure 21. TPS72325 Total Noise vs C_{NR} (10 Hz to 100 kHz)

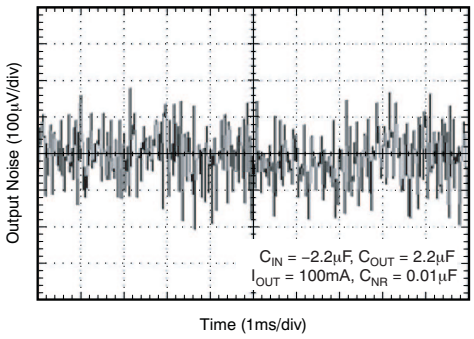


Figure 22. TPS72325 Output Noise vs Time

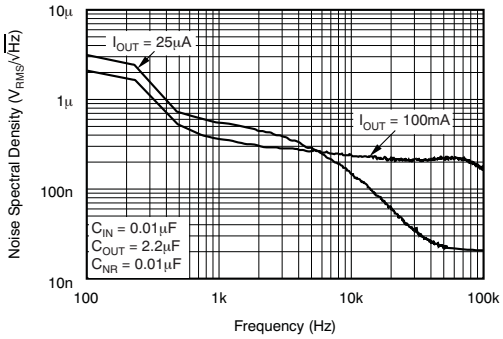


Figure 23. TPS72325 Noise Spectral Density vs Frequency

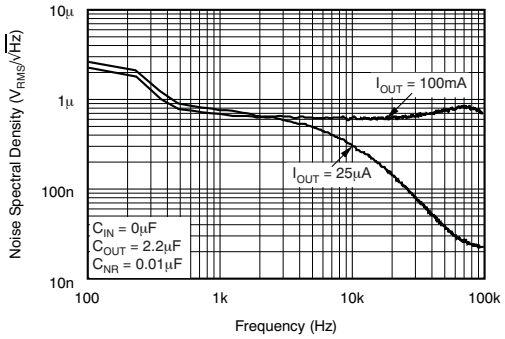


Figure 24. TPS72325 Noise Spectral Density vs Frequency

Typical Characteristics (continued)

TPS72325 at $V_I = V_{O(NOM)} – 0.5$ V, $I_O = 1$ mA, $V_{EN} = 1.5$ V, $C_O = 2.2$ µF, and $C_{NR} = 0.01$ µF, unless otherwise noted.

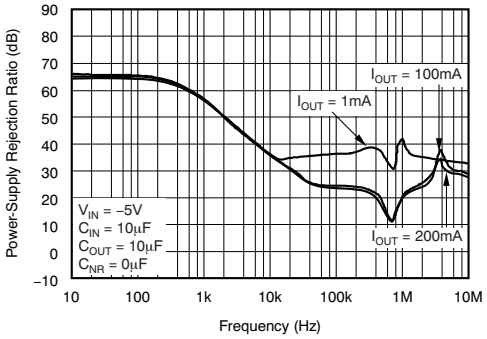


Figure 25. PSRR vs Frequency

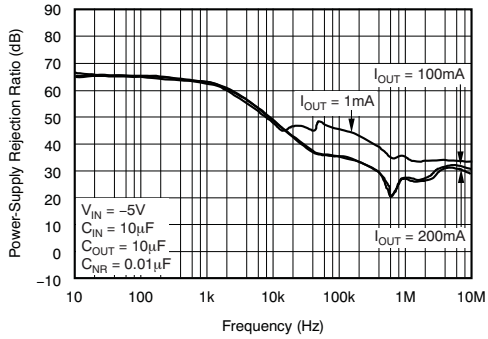


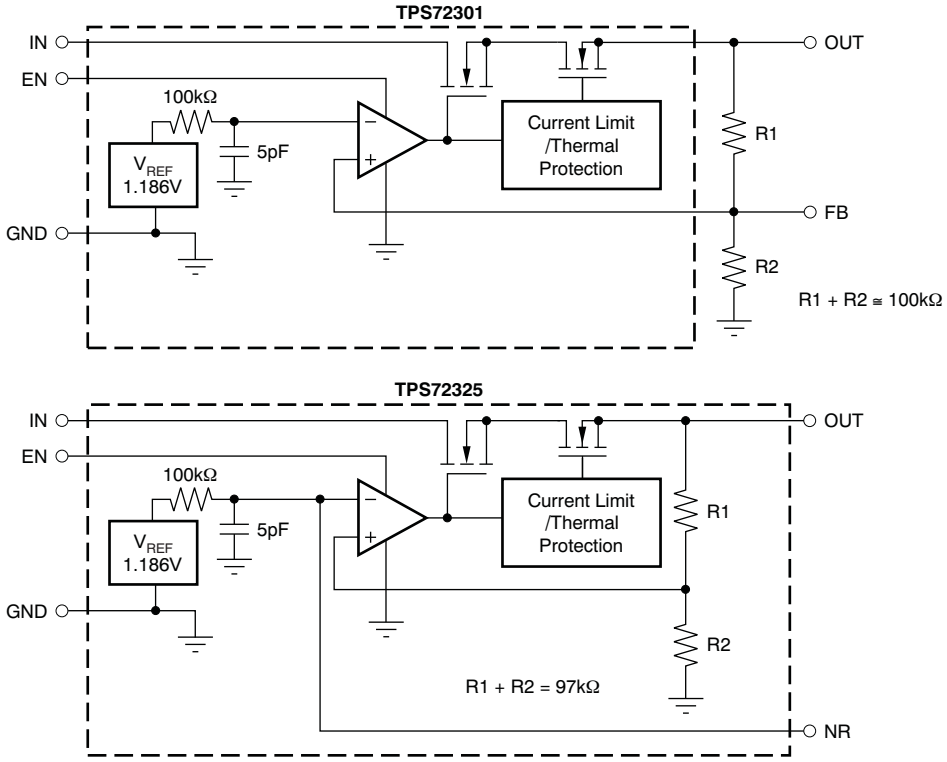
Figure 26. PSRR vs Frequency

7 Detailed Description

7.1 Overview

The TPS723xx is a low-dropout, negative linear voltage regulator with a rated current of 200 mA. It is offered in trimmed output voltages between –1.5 V and –5.2 V and as an adjustable regulator from –1.2 V to –10 V. It features very low noise and high power-supply rejection ratio (PSRR), making it ideal for high-sensitivity analog and RF applications. A shutdown mode is available, reducing ground current to 2 µA maximum over temperature and process.

7.2 Functional Block Diagrams



7.3 Feature Description

7.3.1 Current Limit

The TPS723xx has internal circuitry that monitors and limits output current to protect the regulator from damage under all load conditions. When output current reaches the output current limit (550 mA typical), protection circuitry turns on, reducing output voltage to ensure that current does not increase. See Figure 9 in the *Typical Characteristics* section.

Do not drive the output more than 0.3 V above the input. An output voltage more than 0.3 V above the input voltage biases the body diode in the pass FET, and allows current to flow from the output to the input. This current is not limited by the device. If this condition is expected, make sure to externally limit the reverse current.

7.3.2 Enable

The enable pin is active above +1.5 V and below –1.5 V, allowing it to be controlled by a standard TTL signal or by connection to V_I if not used. When driven to GND most internal circuitry is turned off, putting the TPS723xx into shutdown mode, drawing 2-μA maximum ground current.

7.4 Device Functional Modes

Driving EN over 1.5 V or below –1.5 V turns on the regulator. Driving EN between –1.5 V and +1.5 V puts the regulator into shutdown mode, thus reducing the operating current to 100 nA, nominal.

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 TPS723xx family of LDO regulators provides high PSRR and low noise. These features make the family a good fit for high-sensitivity analog and RF applications.

8.2 Typical Application

The TPS72301 allows designers to specify any output voltage from –10 V to –1.2 V. As shown in the application circuit in Figure 27, an external resistor divider is used to scale the output voltage (V_O) to the reference voltage. For best accuracy, use precision resistors for R1 and R2. Use the equations in Figure 27 to determine the values for the resistor divider.

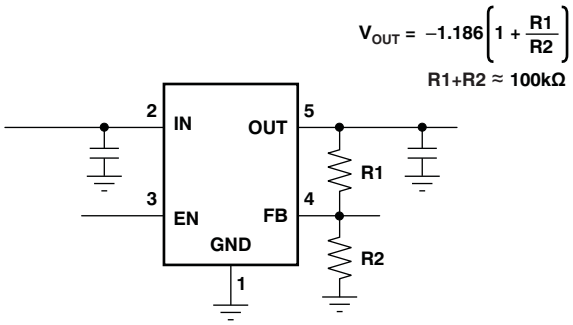


Figure 27. TPS72301 Adjustable LDO Regulator Programming

8.2.1 Design Requirements

8.2.1.1 Capacitor Selection for Stability

Appropriate input and output capacitors should be used for the intended application. The TPS723xx only requires a 2.2-µF ceramic output capacitor to be used for stable operation. Both the capacitor value and equivalent series resistance (ESR) affect stability, output noise, PSRR, and transient response. For typical applications, a 2.2-µF ceramic output capacitor located close to the regulator is sufficient.

8.2.1.2 Output Noise

Without external bypassing, output noise of the TPS723xx from 10 Hz to 100 kHz is 200 μV_{RMS} typical. The dominant contributor to output noise is the internal bandgap reference. Adding an external 0.01-µF capacitor to ground reduces noise to 60 μV_{RMS}. Best noise performance is achieved using appropriate low ESR capacitors for bypassing noise at the NR and OUT pins. See Figure 21 in the *Typical Characteristics* section.

8.2.1.3 Power-Supply Rejection

The TPS723xx offers a very high PSRR for applications with noisy input sources or highly sensitive output supply lines. For best PSRR, use high-quality input and output capacitors.

8.2.2 Detailed Design Procedure

Select the desired device based on the output voltage.

Provide an input supply with adequate headroom to account for dropout and output current to account for the GND terminal current, and power the load.

Typical Application (continued)

8.2.3 Application Curves

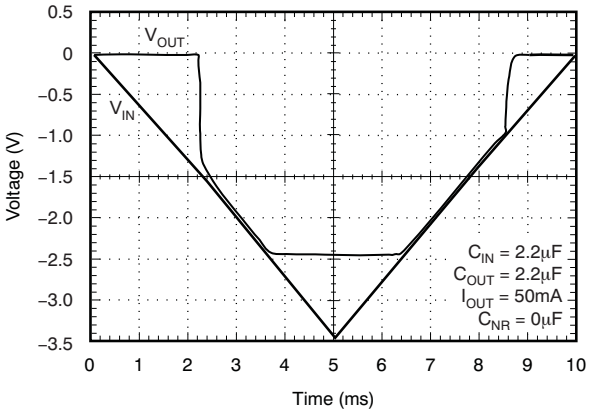


Figure 28. TPS72325 Power-Up/Power-Down

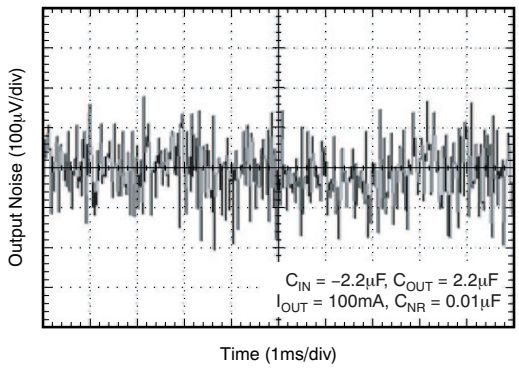


Figure 29. TPS72325 Output Noise vs Time

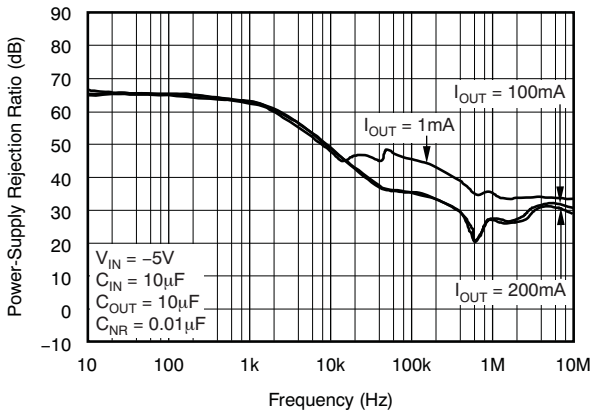


Figure 30. PSRR vs Frequency

8.3 Do's and Don'ts

Do place at least one 2.2-µF ceramic capacitor as close as possible to the OUT terminal of the regulator.

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

Do connect a 0.1-µF to 2.2-µF low ESR capacitor across the IN terminal and GND input of the regulator.

Do not exceed the absolute maximum ratings.

9 Power-Supply Recommendations

These devices are designed to operate from an input voltage supply range between –10 V and –2.7 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. 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

To improve ac performance (such as PSRR, output noise, and transient response), design the board with separate ground planes for V_I and V_O, with each ground plane connected only at the GND pin of the device. In addition, connect the bypass capacitor directly to the GND pin of the device.

10.2 Layout Example

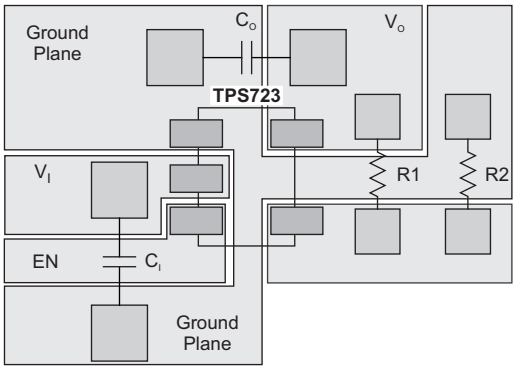


Figure 31. Example Layout

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 head from the device to the ambient air. Performance data for JEDEC low- and high-K boards are given in the *Thermal Information* table near the front of this data sheet. Using heavier copper increases the effectiveness in removing heat from the device. The addition of plated through-holes to heat-dissipating layers also improves heatsink effectiveness. Power dissipation depends on input voltage and load conditions. Power dissipation is equal to the product of the output current times the voltage drop across the output pass element, as shown in Equation 1:

$$P_D = \left(V_{IN} - V_{OUT}\right) \cdot I_{OUT} \quad (1)$$

10.4 Thermal Protection

As protection from damage due to excessive junction temperatures, the TPS723xx has internal protection circuitry. When junction temperature reaches approximately 165°C, the output device is turned off. After the device has cooled to 145°C, the output device is enabled, allowing normal operation. For reliable operation, design is for worst-case junction temperature of ≤ 125°C taking into account worst-case ambient temperature and load conditions.

11 Device and Documentation Support

11.1 Device Support

11.1.1 Development Support

11.1.1.1 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 TPS723xx is available through the product folders under *Simulation Models*.

11.1.2 Device Nomenclature

Table 1. Device Nomenclature(1)

PRODUCT	V_{OUT}
TPS723**xx** ***yyy z***	**XX** is nominal output voltage (for example, 25 = 2.5 V, 01 = Adjustable). **YYY** is package designator. **Z** is package quantity.

(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 at www.ti.com.

11.2 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 2. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TPS72301	Click here	Click here	Click here	Click here	Click here
TPS72325	Click here	Click here	Click here	Click here	Click here

11.3 Trademarks

All trademarks are the property of their respective owners.

11.4 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.

11.5 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 (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
TPS72301DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T08I	Samples
TPS72301DBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T08I	Samples
TPS72301DBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T08I	Samples
TPS72301DBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T08I	Samples
TPS72301DDCR	ACTIVE	SOT	DDC	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T08I	Samples
TPS72301DDCT	ACTIVE	SOT	DDC	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T08I	Samples
TPS72325DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T02I	Samples
TPS72325DBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T02I	Samples
TPS72325DBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T02I	Samples
TPS72325DBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T02I	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.
OBSOLETE: 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.

OTHER QUALIFIED VERSIONS OF TPS72301, TPS72325 :

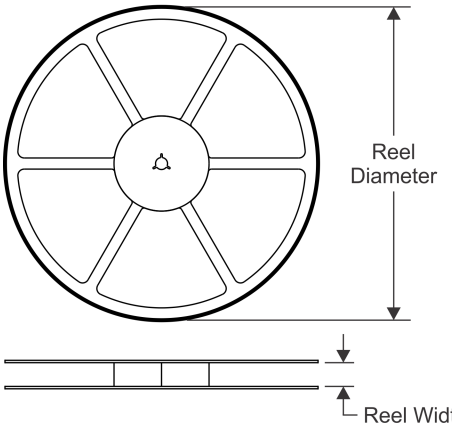
- Automotive: TPS72301-Q1, TPS72325-Q1

NOTE: Qualified Version Definitions:

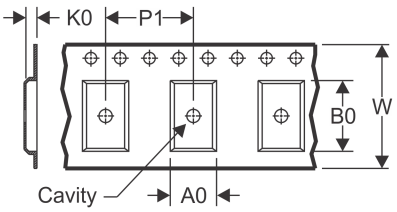
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

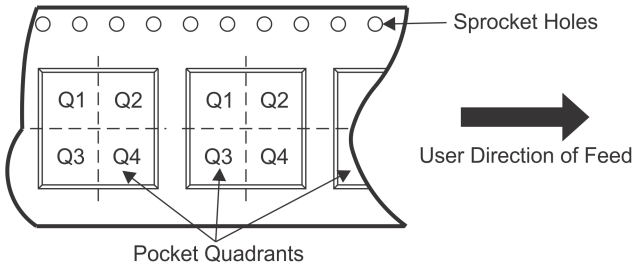


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

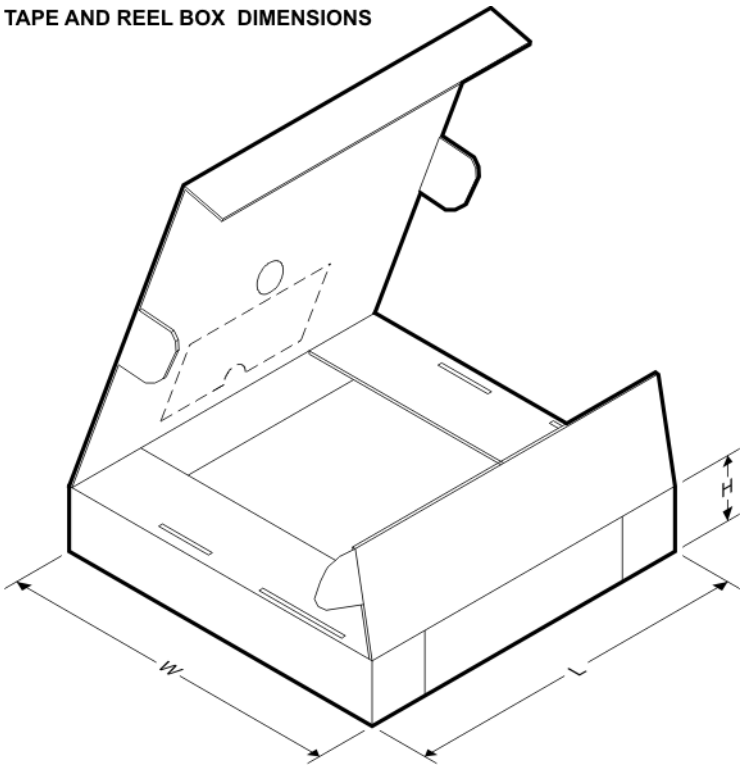
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS72301DBVR	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS72301DBVT	SOT-23	DBV	5	250	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS72301DDCR	SOT	DDC	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS72301DDCT	SOT	DDC	5	250	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS72325DBVR	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS72325DBVT	SOT-23	DBV	5	250	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

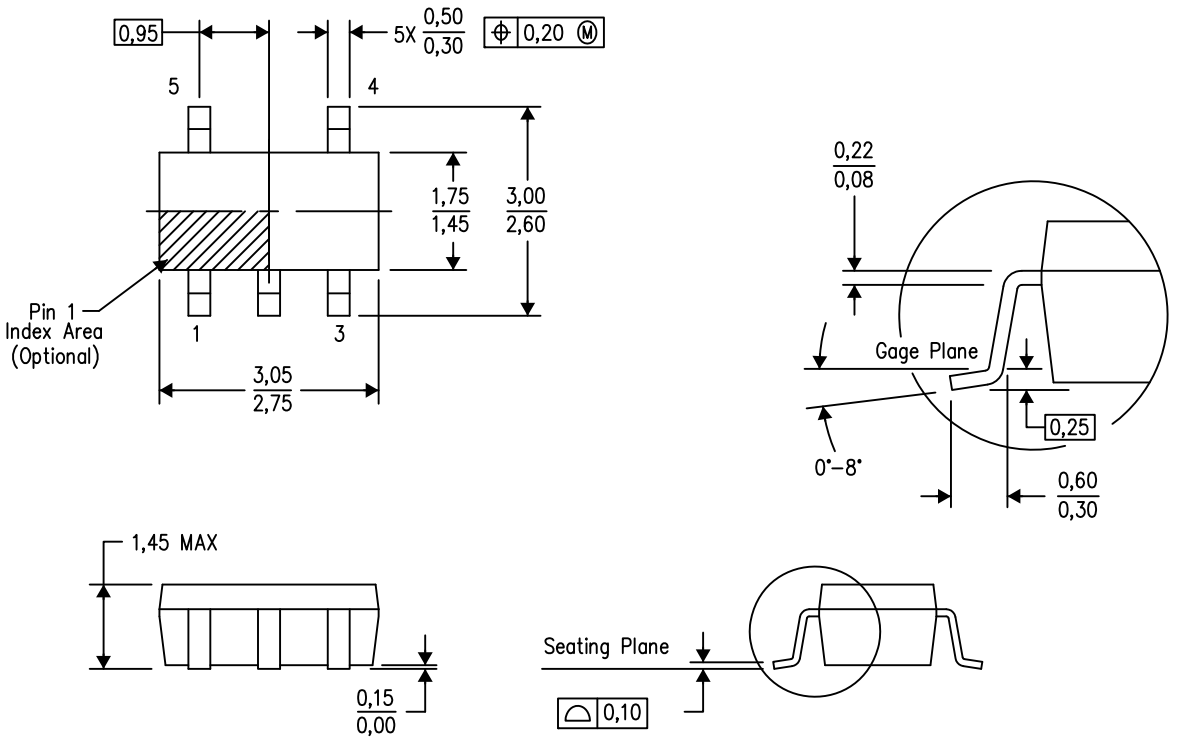
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS72301DBVR	SOT-23	DBV	5	3000	203.0	203.0	35.0
TPS72301DBVT	SOT-23	DBV	5	250	203.0	203.0	35.0
TPS72301DDCR	SOT	DDC	5	3000	195.0	200.0	45.0
TPS72301DDCT	SOT	DDC	5	250	195.0	200.0	45.0
TPS72325DBVR	SOT-23	DBV	5	3000	203.0	203.0	35.0
TPS72325DBVT	SOT-23	DBV	5	250	203.0	203.0	35.0

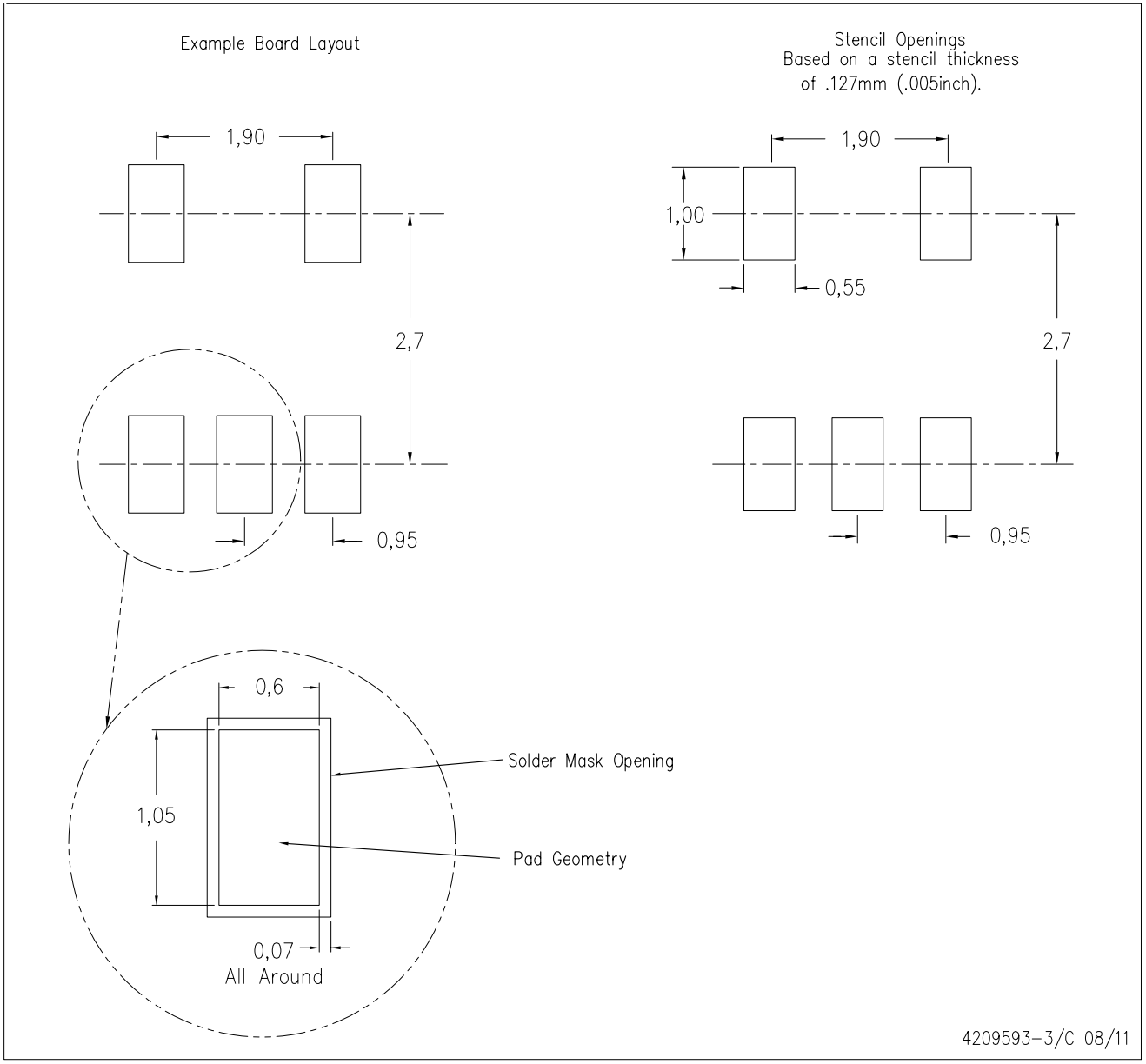
DBV (R–PDSO–G5) PLASTIC SMALL–OUTLINE PACKAGE



4073253–4/N 12/14

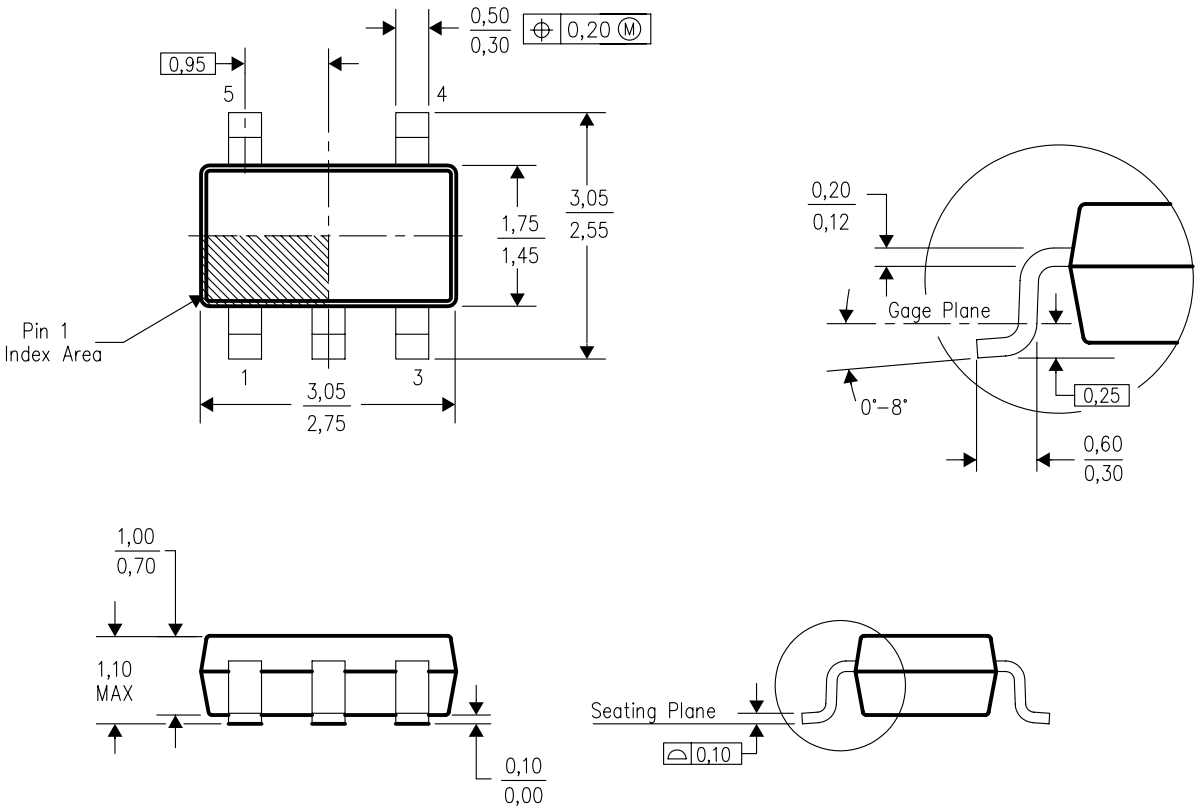
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO–178 Variation AA.

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.

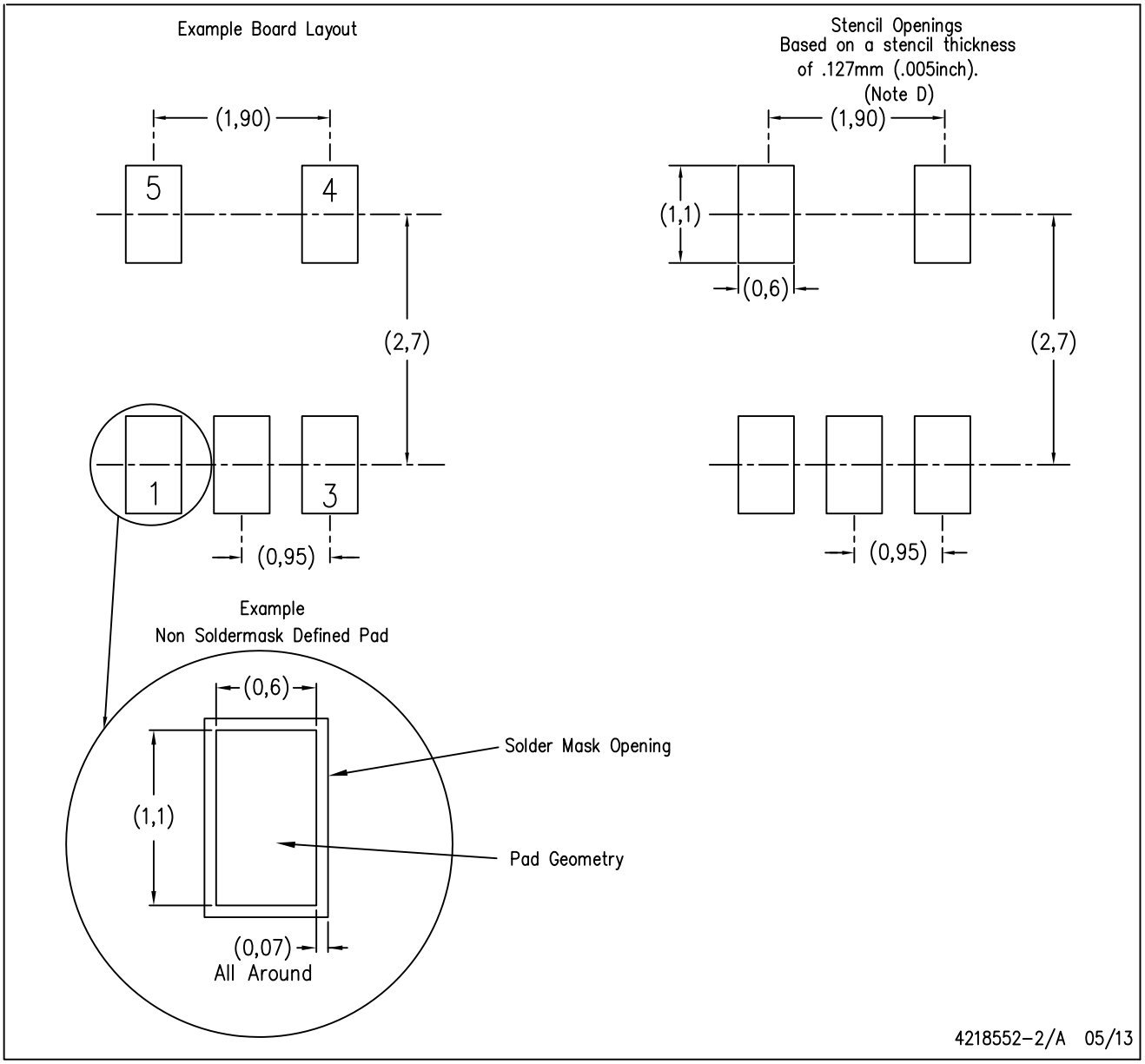
DDC (R–PDSO–G5) PLASTIC SMALL–OUTLINE



4204403–2/E 06/05

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.
D. Falls within JEDEC MO–193 variation AB (5 pin).

DDC (R–PDSO–G5) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. 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.

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Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
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