LP2981-29, LP2981-50, LP2981A-29, LP2981A-50
100-mA ULTRA-LOW DROPOUT REGULATOR WITH SHUTDOWN

SLVS768 – MARCH 2007

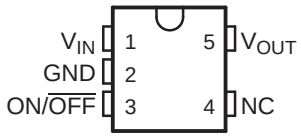
FEATURES

- **Output Tolerance of**
  - **0.75% (A Grade)**
  - **1.25% (Standard Grade)**
- **Ultra-Low Dropout, Typically**
  - **200 mV at Full Load of 100 mA**
  - **7 mV at 1 mA**
- **Wide V_{IN} Range…16 V Max**
- **Low I_Q…600 μA Typ at Full Load of 100 mA**
- **Shutdown Current…0.01 μA Typ**
- **Fast Transient Response to Line and Load**
- **Overcurrent and Thermal Protection**
- **High Peak Current Capability**

PORTABLE APPLICATIONS

- **Mobile Phones**
- **Laptops**
- **Personal Digital Assistants (PDAs)**
- **Digital Cameras and Camcorders**
- **CD and MP3 Players**

DBV (SOT-23) PACKAGE
(TOP VIEW)



NC − No connect; must be left open

DESCRIPTION/ORDERING INFORMATION

The LP2981 family of fixed-output, low-dropout regulators offers exceptional, cost-effective performance for both portable and nonportable applications. Available in fixed voltages of 2.9 V and 5 V, the family has an output tolerance of 0.75% for the A-grade devices (1.25% for the standard grade) and is capable of delivering 100-mA continuous load current. Standard regulator features, such as overcurrent and overtemperature protection, are included.

The LP2981 has features that make the regulator an ideal candidate for a variety of portable applications:

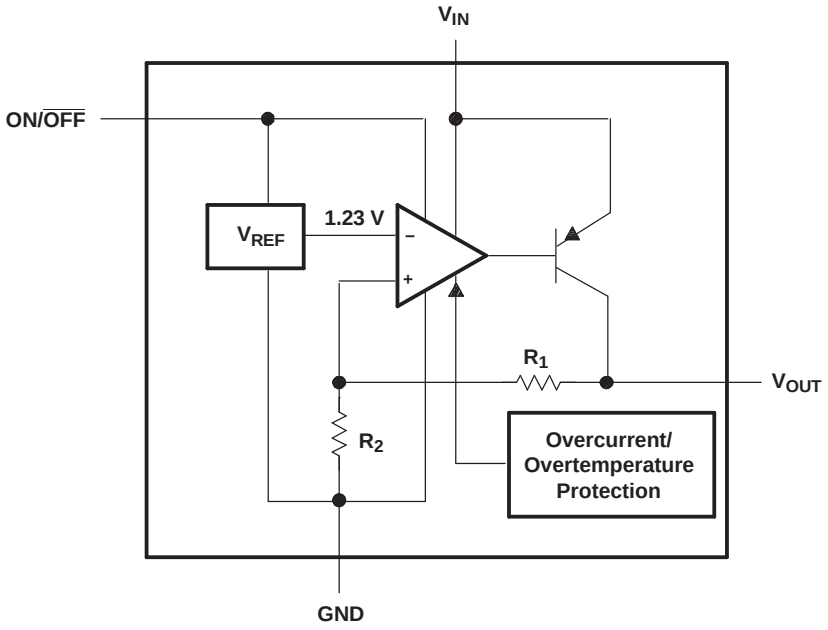
- Low dropout: A PNP pass element allows a typical dropout of 200 mV at 100-mA load current and 7 mV at 1-mA load.
- Low quiescent current: The use of a vertical PNP process allows for quiescent currents that are considerably lower than those associated with traditional lateral PNP regulators.
- Shutdown: A shutdown feature is available, allowing the regulator to consume only 0.01 μA when the ON/$\overline{\text{OFF}}$ pin is pulled low.
- Small packaging: For the most space-constrained needs, the regulator is available in the SOT-23 package.

ORDERING INFORMATION(1)

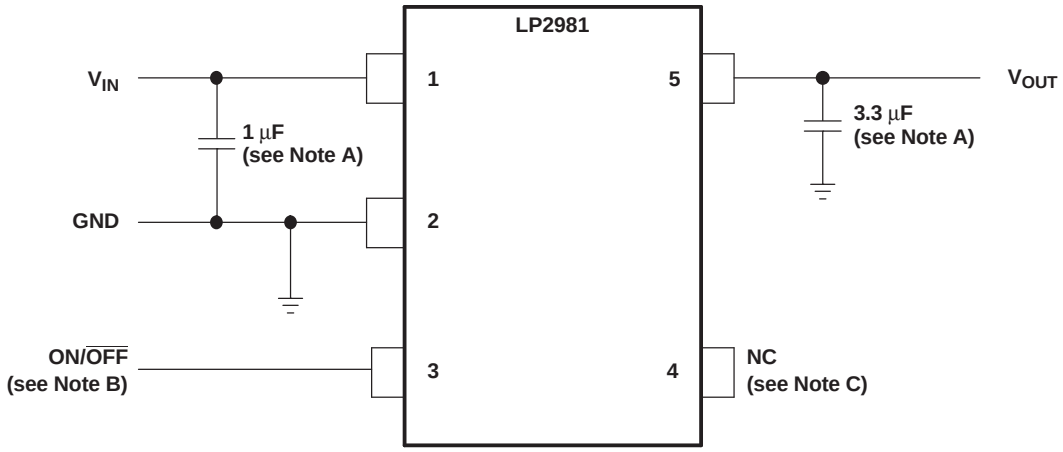
T_J	PART GRADE	V_{OUT} (NOM)	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING(3)
–40°C to 125°C	A grade: 0.75% tolerance	2.9 V	SOT-23-5 – DBV	Reel of 3000	LP2981A-29DBVR	LRB_
				Reel of 250	LP2981A-29DBVT	
		5 V	SOT-23-5 – DBV	Reel of 3000	LP2981A-50DBVR	LPE_
				Reel of 250	LP2981A-50DBVT	
	Standard grade: 1.25% tolerance	2.9 V	SOT-23-5 – DBV	Reel of 3000	LP2981-29DBVR	LP3_
				Reel of 250	LP2981-29DBVT	
		5 V	SOT-23-5 – DBV	Reel of 3000	LP2981-50DBVR	LPD_
				Reel of 250	LP2981-50DBVT	

(1) 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.
(2) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
(3) The actual top-side marking has one additional character that designates the assembly/test site.

FUNCTIONAL BLOCK DIAGRAM



BASIC APPLICATION CIRCUIT



A. Minimum C_{OUT} value for stability (can be increased without limit for improved stability and transient response)

B. ON/$\overline{OFF}$ must be actively terminated. Connect to V_{IN} if shutdown feature is not used.

C. Pin 4 (NC) must be left open. Do not connect anything to this pin.

Figure 1.

Absolute Maximum Ratings(1)

over virtual junction temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{IN}	Continuous input voltage range	–0.3	16	V
$V_{ON/\overline{OFF}}$	ON/$\overline{OFF}$ input voltage range	–0.3	16	V
V_O	Output voltage range(2)	–0.3	9	V
$V_{IN} – V_{OUT}$	Input/output voltage differential range(3)	–0.3	16	V
I_{OUT}	Output current(4)	Internally limited (short-circuit protected)		
θ_{JA}	Package thermal impedance(4)(5)		206	°C/W
T_J	Operating virtual junction temperature		150	°C
T_{stg}	Storage temperature range	–65	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) If load is returned to a negative power supply, the output must be diode clamped to GND.
(3) The PNP pass transistor has a parasitic diode connected between the input and output. This diode normally is reverse biased ($V_{IN} > V_{OUT}$), but will be forward biased if the output voltage exceeds the input voltage by a diode drop (see *Application Information* for more details).
(4) Maximum power dissipation is a function of $T_J(max)$, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(5) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions

		MIN	MAX	UNIT
V_{IN}	Supply input voltage	2.2(1)	16	V
$V_{ON/\overline{OFF}}$	ON/$\overline{OFF}$ input voltage	0	V_{IN}	V
$V_{IN} – V_{OUT}$	Input-output differential	0.7	11	V
I_{OUT}	Output current		100	mA
T_J	Virtual junction temperature	–40	125	°C

(1) Minimum V_{IN} of 2.2 V is needed for proper biasing of LDO control circuitry.

Electrical Characteristics

at specified free-air temperature range, $V_{IN} = V_{OUT(NOM)} + 1$ V, $V_{ON/\overline{OFF}} = 2$ V, $C_{IN} = 1$ µF, $I_L = 1$ mA, $C_{OUT} = 4.7$ µF (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	LP2981A-xx			LP2981-xx			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
ΔV_{OUT}	Output voltage tolerance	I_L = 1 mA	25°C	–0.75		0.75	–1.25		1.25	%V_{NOM}
		I_L = 1 mA to 100 mA	25°C	–1		1	–2		2	
			–40°C to 125°C	–2.5		2.5	–3.5		3.5	
$\Delta V_{OUT}/\Delta V_{IN}$	Output voltage line regulation	V_{IN} = ($V_{OUT(NOM)}$ + 1 V) to 16 V	25°C		0.007	0.014		0.007	0.014	%/V
			–40°C to 125°C			0.032			0.032	
$V_{IN} – V_{OUT}$	Dropout voltage(1)	I_L = 0	25°C		1	3		1	3	mV
			–40°C to 125°C			5			5	
		I_L = 1 mA	25°C		7	10		7	10	
			–40°C to 125°C			15			15	
		I_L = 25 mA	25°C		70	100		70	100	
			–40°C to 125°C			150			150	
		I_L = 100 mA	25°C		200	250		200	250	
			–40°C to 125°C			375			375	
I_{GND}	Ground pin current	I_L = 0	25°C		65	95		65	95	µA
			–40°C to 125°C			125			125	
		I_L = 1 mA	25°C		80	110		80	110	
			–40°C to 125°C			170			170	
		I_L = 25 mA	25°C		200	300		200	300	
			–40°C to 125°C			550			550	
		I_L = 100 mA	25°C		600	1000		600	1000	
			–40°C to 125°C			1700			1700	
		$V_{ON/\overline{OFF}}$ < 0.3 V (OFF)	25°C		0.01	0.8		0.01	0.8	
		$V_{ON/\overline{OFF}}$ < 0.15 V (OFF)	–40°C to 105°C		0.05	2		0.05	2	
			–40°C to 125°C			5			5	
$V_{ON/\overline{OFF}}$	ON/$\overline{OFF}$ input voltage(2)	High = O/P ON	25°C		1.4			1.4		V
			–40°C to 125°C	1.6			1.6			
		Low = O/P OFF	25°C		0.5			0.5		
			–40°C to 125°C			0.15			0.15	
$I_{ON/\overline{OFF}}$	ON/$\overline{OFF}$ input current	$V_{ON/\overline{OFF}}$ = 0	25°C		0.01			0.01		µA
			–40°C to 125°C			–1			–1	
		$V_{ON/\overline{OFF}}$ = 5 V	25°C		5			5		
			–40°C to 125°C			15			15	
$I_{OUT(PK)}$	Peak output current	$V_{OUT} \geq V_{OUT(NOM)} – 5\%$	25°C	150	400			400		mA
V_n	Output noise voltage (RMS)	BW = 300 Hz to 50 kHz, C_{OUT} = 10 µF	25°C		160			160		µV
$\Delta V_{OUT}/\Delta V_{IN}$	Ripple rejection	f = 1 kHz, C_{OUT} = 10 µF	25°C		63			63		dB
$I_{OUT(MAX)}$	Short-circuit current	R_L = 0 (steady state)	25°C		150			150		mA

(1) Dropout voltage is defined as the input-to-output differential at which the output voltage drops 100 mV below the value measured with a 1-V differential. This dropout specification does not apply to the 1.8-V option, as the minimum V_{IN} = 2.2 V must be observed for proper biasing of LDO control circuitry.
(2) The ON/$\overline{OFF}$ input must be actively terminated. Connect to V_{IN} if this function is not used (see *Application Information*).

APPLICATION INFORMATION

Capacitors

Input Capacitor (C_{in})

A minimum value of 1 µF (over the entire operating temperature range) is required at the input of the LP2981. In addition, this input capacitor should be located within 1 cm of the input pin and connected to a clean analog ground. There is no Equivalent Series Resistance (ESR) requirement for this capacitor, and the capacitance can be increased without limit. A good quality ceramic or tantalum capacitor can be used.

Output Capacitor (C_{out})

As a PNP regulator, the LP2981 requires the output capacitor to meet both a minimum capacitance and ESR value. Required ESR values as a function of load current are provided for various output voltages, load currents, and capacitances (see Figure 2 through Figure 5).

- Minimum C_{out}: 3.3 µF (can be increased without limit to improve transient response stability margin)
- ESR range: see Figure 2 through Figure 5

It is critical that both the minimum capacitance and ESR requirement be met over the entire operating temperature range. Depending on the type of capacitor used, both of these parameters can vary significantly with temperature (see capacitor characteristics section).

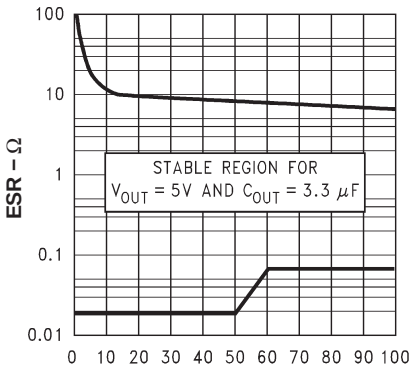


Figure 2. 5-V/3.3-µF ESR Curves

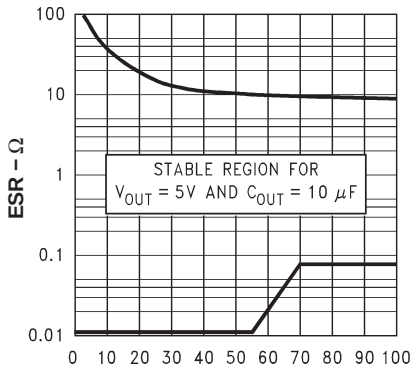


Figure 3. 5-V/10-µF ESR Curves

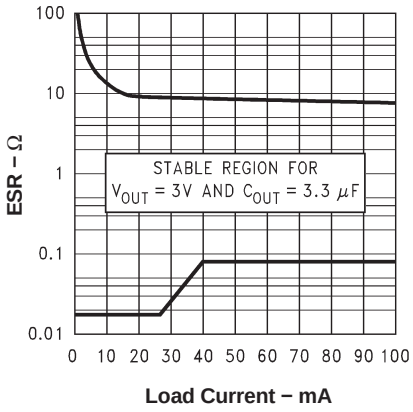


Figure 4. 3-V/3.3-µF ESR Curves

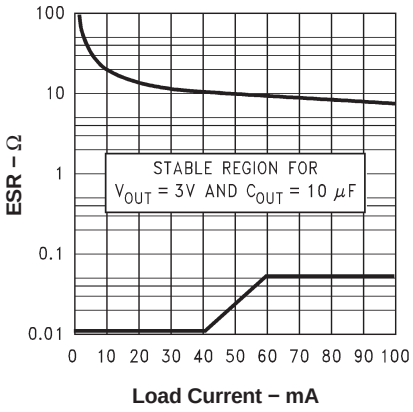


Figure 5. 3-V/10-µF ESR Curves

APPLICATION INFORMATION (continued)

Capacitor Characteristics

Ceramics

Due to their very low ESR values, ceramic capacitors are not suitable for use as the output capacitor. For instance, a typical 2.2-µF ceramic capacitor has an ESR in the range of 10 mΩ to 20 mΩ and, thus, easily can fall out of minimum ESR requirements under certain operating conditions.

If a ceramic capacitor is used at the output, a 1-Ω resistor should be placed in series with the capacitor to raise the ESR seen by the regulator.

Tantalum

Solid tantalum capacitors are optimal choices for the LP2981, but they still must meet the minimum ESR requirement. Note that the ESR of a tantalum capacitor increases as temperature drops, as much as doubling from 25°C to –40°C. Thus, ESR margins must be maintained over the temperature range to prevent regulator instability. For operation at very low temperatures, paralleling a tantalum capacitor with a ceramic one keeps the combined ESR from increasing near the upper limit of the ESR curve.

Aluminum

Aluminum capacitors can be used, but use with the LP2981 is impractical due to their large physical dimensions. They also must meet the ESR requirements over the full temperature range. In this regard, aluminium capacitors are at a big disadvantage due to their sharp ESR increase as temperature drops. For example, over a temperature drop from 20°C to –40°C, the ESR of an aluminum electrolytic capacitor can increase by a factor of 50. In addition, some of the electrolytes used in these capacitors can freeze at –25°C, making the capacitor nonoperational.

ON/$\overline{\text{OFF}}$ Operation

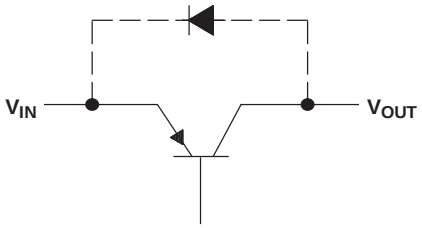
The LP2981 allows for a shutdown mode via the ON/$\overline{\text{OFF}}$ pin. If the shutdown feature is not used, ON/$\overline{\text{OFF}}$ should be connected to the input to ensure that the regulator is on at all times. To drive ON/$\overline{\text{OFF}}$:

- A LOW (≤0.3 V) turns the regulator OFF; a HIGH (≥1.6 V) turns it ON.
- Use either a totem-pole output or an open-collector output with a pullup resistor tied to V_{IN} (or another logic supply). The HIGH signal can exceed V_{IN}, but must not exceed the absolute maximum ratings of 20 V for the ON/$\overline{\text{OFF}}$ pin.
- Apply a signal with a slew rate of ≥40 mV/µs. A slow slew rate can cause the shutdown function to operate incorrectly.

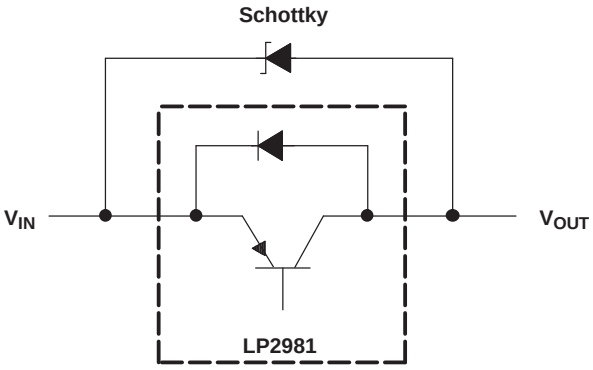
APPLICATION INFORMATION (continued)

Reverse Input-Output Voltage

An inherent diode is present across the PNP pass element of the LP2981.



With the anode connected to the output, this diode is reverse biased during normal operation, since the input voltage is higher than the output. However, if the output is pulled one V_{BE} higher than the input, or if the input is abruptly stepped below the output, this diode is forward biased and can cause a parasitic silicon-controlled rectifier (SCR) to latch, resulting in current flowing from the output to the input (values in excess of 100 mA can cause damage). Thus, to prevent possible damage to the regulator in any application where the output may be pulled above the input, an external Schottky diode must be connected between the output and input. With the anode on output, this Schottky limits the reverse voltage across the output and input pins to ~0.3 V, preventing the regulator's internal diode from forward biasing.



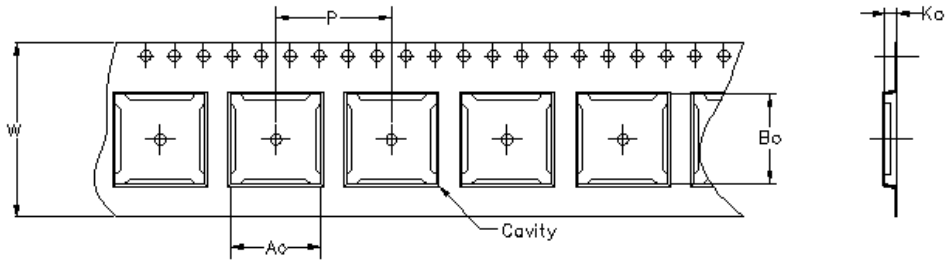
PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
LP2981-29DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981-29DBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981-29DBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981-29DBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981-50DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981-50DBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981-50DBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981-50DBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981A-29DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981A-29DBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981A-29DBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981A-29DBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981A-50DBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981A-50DBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981A-50DBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2981A-50DBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[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.

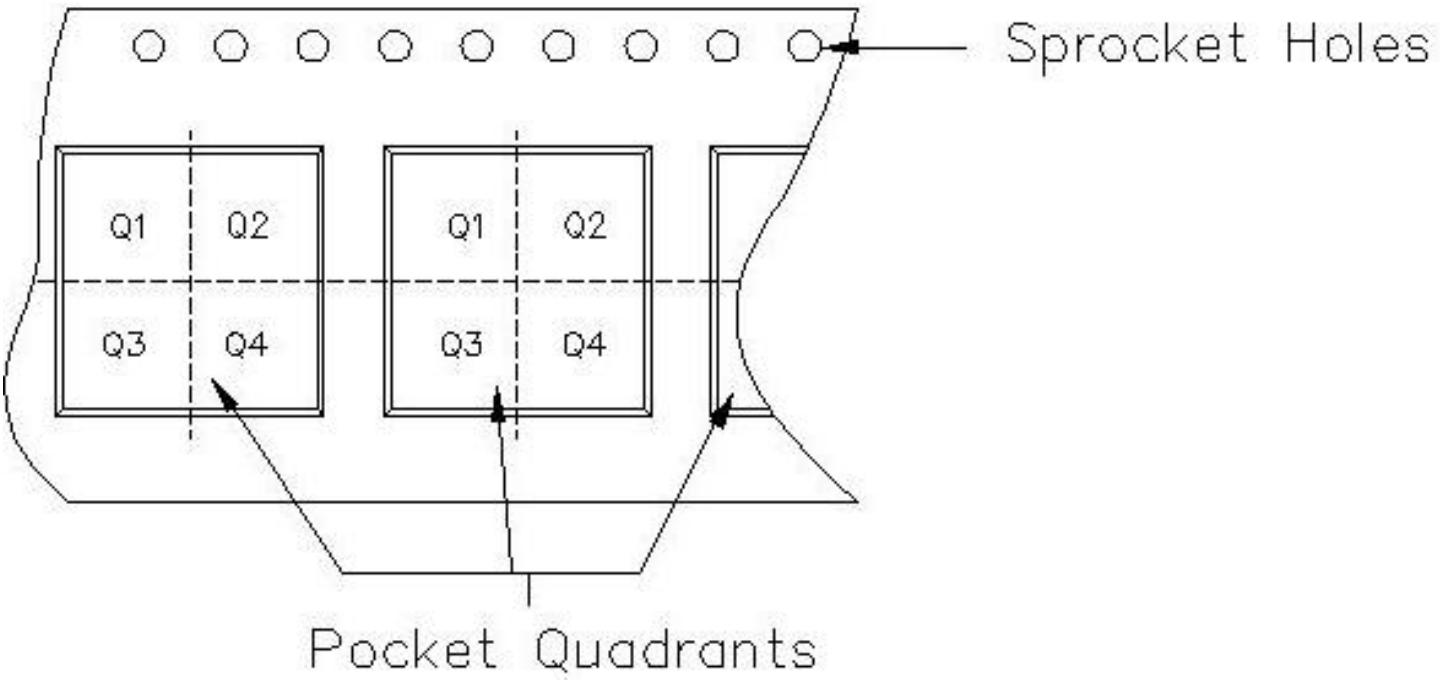
[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been 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.



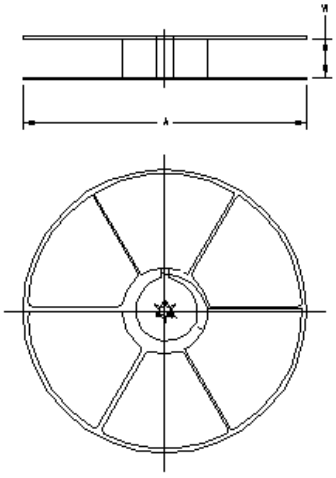
Carrier tape design is defined largely by the component lentgh, width, and thickness.

Ao = Dimension designed to accommodate the component width.
Bo = Dimension designed to accommodate the component length.
Ko = Dimension designed to accommodate the component thickness.
W = Overall width of the carrier tape.
P = Pitch between successive cavity centers.



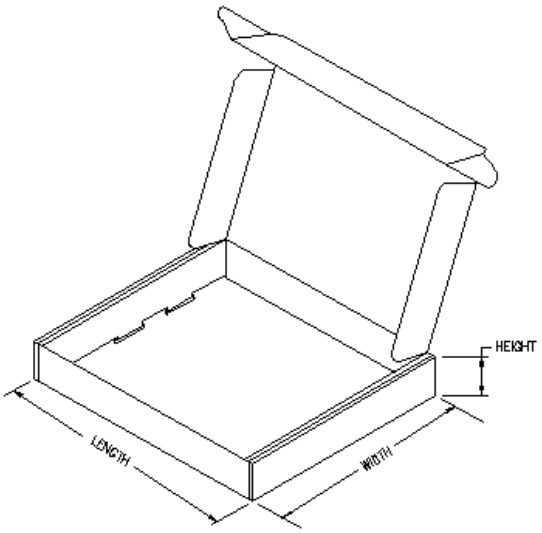
TAPE AND REEL INFORMATION

Device	Package	Pins	Site	Reel Diameter (mm)	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LP2981-29DBVR	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	Q3
LP2981-29DBVT	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	Q3
LP2981-50DBVR	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	Q3
LP2981-50DBVT	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	Q3
LP2981A-29DBVR	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	Q3
LP2981A-29DBVT	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	Q3
LP2981A-50DBVR	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	Q3
LP2981A-50DBVT	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	Q3

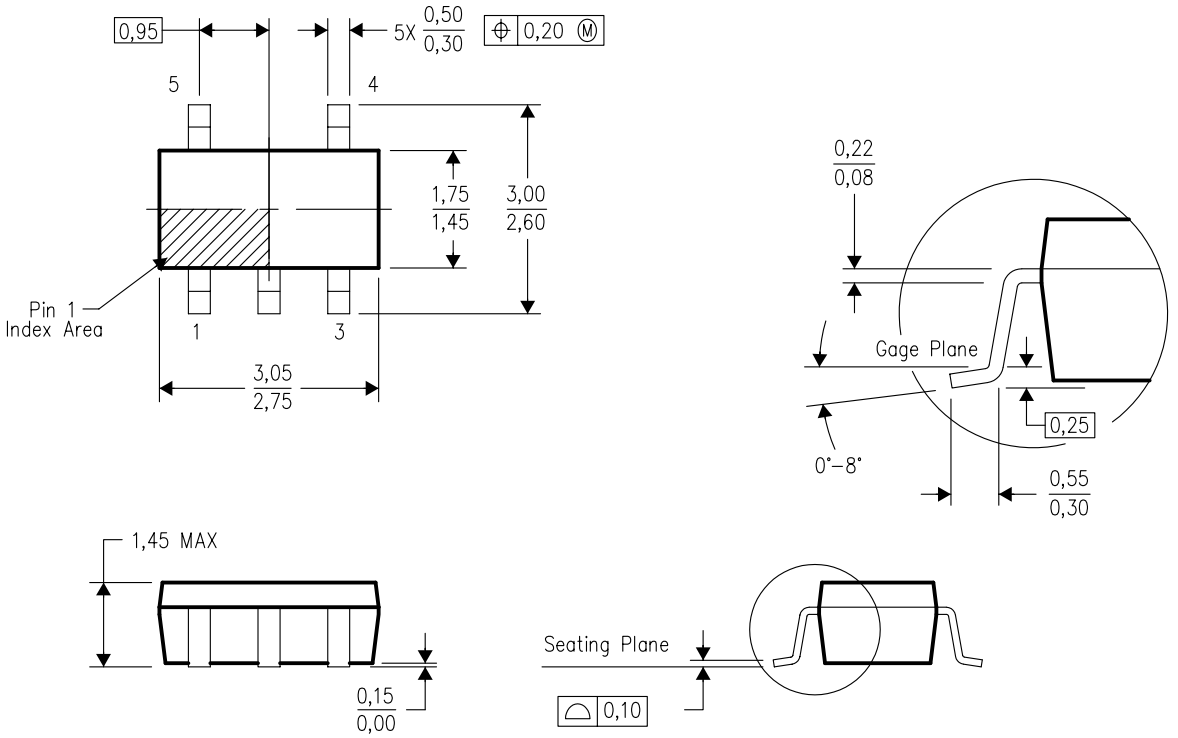


TAPE AND REEL BOX INFORMATION

Device	Package	Pins	Site	Length (mm)	Width (mm)	Height (mm)
LP2981-29DBVR	DBV	5	LEN	182.0	182.0	20.0
LP2981-29DBVT	DBV	5	LEN	182.0	182.0	20.0
LP2981-50DBVR	DBV	5	LEN	182.0	182.0	20.0
LP2981-50DBVT	DBV	5	LEN	182.0	182.0	20.0
LP2981A-29DBVR	DBV	5	LEN	182.0	182.0	20.0
LP2981A-29DBVT	DBV	5	LEN	182.0	182.0	20.0
LP2981A-50DBVR	DBV	5	LEN	182.0	182.0	20.0
LP2981A-50DBVT	DBV	5	LEN	182.0	182.0	20.0


HEIGHT
LENGTH
WIDTH

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



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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.

IMPORTANT NOTICE

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