LM26NV SOT-23, ±3°C Accurate, Factory Preset Thermostat (LM26 without V_{TEMP} output)

Check for Samples: LM26NV

FEATURES

- **Internal Comparator with Pin Programmable 2°C or 10°C Hysteresis**
- **No External Components Required**
- **Open Drain or Push-Pull Digital Output; Supports CMOS Logic Levels**
- **Internal Temperature Sensor**
- **Internal Voltage Reference and DAC for Trip-Point Setting**
- **Currently Available in 5-Pin SOT-23 Plastic Package**
- **Excellent Power Supply Noise Rejection**

APPLICATIONS

- **Microprocessor Thermal Management**
- **Appliances**
- **Portable Battery Powered Systems**
- **Fan Control**
- **Industrial Process Control**
- **HVAC Systems**
- **Remote Temperature Sensing**
- **Electronic System Protection**

DESCRIPTION

The LM26NV is a precision, single digital-output, low-power thermostat comprised of an internal reference, DAC, temperature sensor and comparator. Utilizing factory programming, it can be manufactured with different trip points as well as different digital output functionality. The trip point (T_{OS}) can be preset at the factory to any temperature in the range of −55°C to +110°C in 1°C increments. The LM26NV has one digital output (OS/$\overline{OS}$/US/$\overline{US}$) and one digital input (HYST). The digital output stage can be preset as either open-drain or push-pull. In addition, it can be factory programmed to be active HIGH or LOW. The digital output can be factory programmed to indicate an over temperature shutdown event (OS or $\overline{OS}$) or an under temperature shutdown event (US or $\overline{US}$). When preset as an overtemperature shutdown ($\overline{OS}$), it will go LOW to indicate that the die temperature is over the internally preset T_{OS} and go HIGH when the temperature goes below (T_{OS}–T_{HYST}). Similarly, when preprogrammed as an undertemperature shutdown (US) it will go HIGH to indicate that the temperature is below T_{US} and go LOW when the temperature is above (T_{US}+T_{HYST}). The typical hysteresis, T_{HYST}, can be set to 2°C or 10°C and is controlled by the state of the HYST pin.

Available parts are detailed in the ordering information. For other part options, contact a National Semiconductor Distributor or Sales Representative for information on minimum order qualification. The LM26NV is currently available in a 5-lead SOT-23 package.

Table 1. Key Specifications

	VALUE	UNIT
Power Supply Voltage	2.7V to 5.5	V
Power Supply Current	40µA(max) 20µA(typ)	
Hysteresis Temperature	2°C or 10°C(typ)	

Table 2. Temperature Trip Point Accuracy

Temperature Range	LM26NV
−55°C to +110°C	±3°C (max)
+120°C	±4°C (max)

Connection Diagram

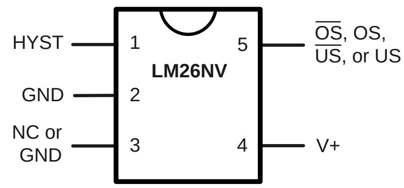


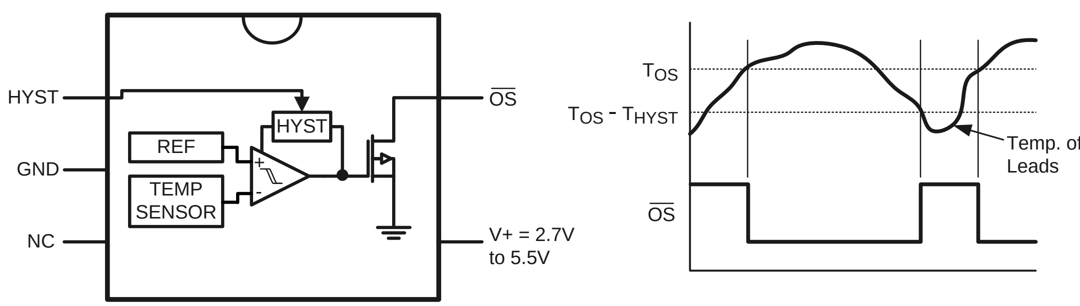
Figure 1. 5-Lead SOT-23 See DBV Package

PIN DESCRIPTIONS

Pin Number	Pin Name	Function	Connection
1	HYST	Hysteresis control, digital input	GND for 10°C or V+ for 2°C
2	GND	Ground, connected to the back side of the die through lead frame.	System GND
3	NC	Not Connected Inside Part	Ground or No Connect
4	V+	Supply input	2.7V to 5.5V with a 0.1µF bypass capacitor. For PSRR information see *Section Titled NOISE CONSIDERATIONS*.
5 (1)	$\overline{OS}$	Overtemperature Shutdown open-drain active low thermostat digital output	Controller interrupt, system or power supply shutdown; pull-up resistor ≥ 10kΩ
	OS	Overtemperature Shutdown push-pull active high thermostat digital output	Controller interrupt, system or power supply shutdown
	$\overline{US}$	Undertemperature Shutdown open-drain active low thermostat digital output	System or power supply shutdown; pull-up resistor ≥ 10kΩ
	US	Undertemperature Shutdown push-pull active high thermostat digital output	System or power supply shutdown

(1) Pin 5 functionality and trip point setting are programmed during LM26NV manufacture.

LM26CIM5-YPE Simplified Block Diagram and Connection Diagram



HYST = GND for 10℃ Hysteresis
HYST = V+ for 2℃ Hysteresis

The LM26CIM5-YPE has a fixed trip point of 115°C. For other trip point and output function availability, please see ordering information or contact Texas Instruments.

Figure 2.

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.

Absolute Maximum Ratings [1]

Input Voltage		6.0V
Input Current at any pin [2]		5mA
Package Input Current[2]		20mA
Package Dissipation at T_A = 25°C[3]		500mW
Soldering Information[4]		
SOT-23 Package	Vapor Phase (60 seconds)	215°C
	Infrared (15 seconds)	220°C
Storage Temperature		−65°C to + 150°C
ESD Susceptibility [5]	Human Body Model	2500V
	Machine Model	250V

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
(2) When the input voltage (V_I) at any pin exceeds the power supply (V_I < GND or $V_I > V^+$), the current at that pin should be limited to 5mA. The 20mA maximum package input current rating limits the number of pins that can safely exceed the power supplies with an input current of 5mA to four. Under normal operating conditions the maximum current that pins 2, 4 or 5 can handle is limited to 5mA each.
(3) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (junction to ambient thermal resistance) and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $P_D = (T_{Jmax}–T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. For this device, T_{Jmax} = 150°C. For this device the typical thermal resistance (θ_{JA}) of the different package types when board mounted follow:
(4) See the URL ”http://www.ti.com/packaging“ for other recommendations and methods of soldering surface mount devices.
(5) The human body model is a 100pF capacitor discharge through a 1.5kΩ resistor into each pin. The machine model is a 200pF capacitor discharged directly into each pin.

Operating Ratings [1]

Specified Temperature Range	**$T_{MIN} \le T_A \le T_{MAX}$**
LM26NV	−55°C ≤ T_A ≤ +125°C
Positive Supply Voltage (V^+)	+2.7V to +5.5V
Maximum V_{OUT}	+5.5V

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

LM26NV Electrical Characteristics

The following specifications apply for V^+ = 2.7V_{DC} to 5.5V_{DC}, and V_{TEMP} load current = 0µA unless otherwise specified. **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}**; all other limits $T_A = T_J$ = 25°C unless otherwise specified.

Symbol	Parameter	Conditions	Typical (1)	LM26NV Limits (2)	Units (Limits)
Temperature Sensor					
	Trip Point Accuracy (Includes V_{REF}, DAC, Comparator Offset, and Temperature Sensitivity errors)	-55°C ≤ T_A ≤ +110°C		±3	°C (max)
		+120°C		±4	°C (max)
	Trip Point Hysteresis	HYST = GND	11		°C
		HYST = V^+	2		°C
I_S	Supply Current		16	20 **40**	µA (max) µA (max)
Digital Output and Input					
$I_{OUT(“1”)}$	Logical “1” Output Leakage Current (3)	V^+ = +5.0V	0.001	1	µA (max)
$V_{OUT(“0”)}$	Logical “0” Output Voltage	I_{OUT} = +1.2mA and V^+≥2.7V; I_{OUT} = +3.2mA and V^+≥4.5V; (4)		**0.4**	V (max)
$V_{OUT(“1”)}$	Logical “1” Push-Pull Output Voltage	I_{SOURCE} = 500µA, V^+ ≥ 2.7V		**0.8 × V+**	V (min)
		I_{SOURCE} = 800µA, V^+≥4.5V		**V+ − 1.5**	V (min)
V_{IH}	HYST Input Logical ”1“ Threshold Voltage			**0.8 × V+**	V (min)
V_{IL}	HYST Input Logical ”0“ Threshold Voltage			**0.2 × V+**	V (max)

(1) Typicals are at $T_J = T_A$ = 25°C and represent most likely parametric norm.
(2) Limits are guaranteed to National's AOQL (Average Outgoing Quality Level).
(3) The 1µA limit is based on a testing limitation and does not reflect the actual performance of the part. Expect to see a doubling of the current for every 15°C increase in temperature. For example, the 1nA typical current at 25°C would increase to 16nA at 85°C.
(4) Care should be taken to include the effects of self heating when setting the maximum output load current. The power dissipation of the LM26NV would increase by 1.28mW when I_{OUT}=3.2mA and V_{OUT}=0.4V. With a thermal resistance of 250°C/W, this power dissipation would cause an increase in the die temperature of about 0.32°C due to self heating. Self heating is not included in the trip point accuracy specification.

Package Type	θ_{JA}
SOT-23, DBV	250°C/W

Part Number Template

The series of characters labeled "xyz" in the part number LM26CIM5-xyz, describe the set point value and the function of the output. The character at "x" and "y" define the set point temperature (at which the digital output will go active). The "z" character defines the type and function of the digital output. These place holders are defined in the following tables.

The place holders xy describe the set point temperature as shown in the following table.

x (10x)	y (1x)	Temperature (°C)
A	-	−5
B	-	−4
C	-	−3
D	-	−2
E	-	−1
F	-	−0
H	H	0
J	J	1
K	K	2
L	L	3

x (10x)	y (1x)	Temperature (°C)
N	N	4
P	P	5
R	R	6
S	S	7
T	T	8
V	V	9
X	-	10
Y	-	11
Z	-	12

The value of z describes the assignment/function of the output as shown in the following table:

Active-$\overline{\text{Low}}$/High	$\overline{\text{Open-Drain}}$/ Push-Pull	$\overline{\text{OS}}$/US	Value of z	Digital Output Function
0	0	0	E	Active-Low, Open-Drain, $\overline{\text{OS}}$ output
0	0	1	F	Active-Low, Open-Drain, $\overline{\text{US}}$ output
1	1	0	G	Active-High, Push-Pull, OS output
1	1	1	H	Active-High, Push-Pull, US output

EXAMPLE:

- The part number LM26CIM5-YPE has T_{OS} = 115°C, and has an active-low open-drain overtemperature shutdown output. The "Y" represents the tens value "11", the "P" represents the ones value "5", and the "E" means that the output will be an active-low, open-drain, over-temperature output.

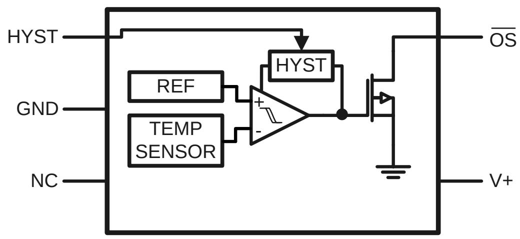
Many active-high open-drain and active-low push-pull options are available, please contact Texas Instruments for more information.

FUNCTIONAL DESCRIPTION

LM26NV OPTIONS

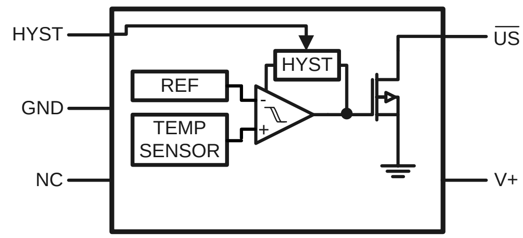
The LM26NV can be factory programmed to have a trip point anywhere in the range of −55°C to +110°C. It is also available in any of four output options, as indicated by the last letter in the part number.

Output Pin Options Block Diagrams



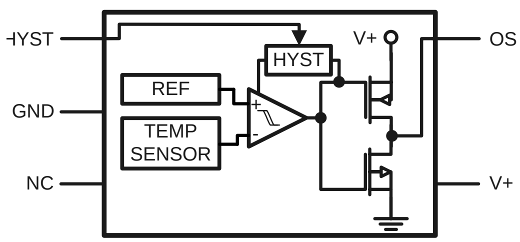
The "E" in "LM26CIM5 - _ _ E " indicates that the digital output is Active-Low Open-Drain and will trip as temperature is rising (OS)

Figure 3. LM26CIM5 - _ _ E



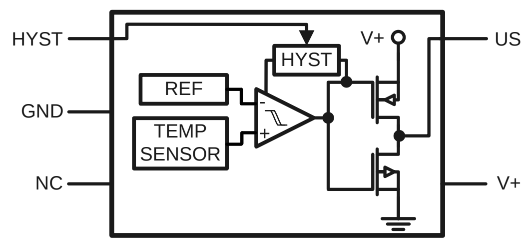
The "F" in "LM26CIM5 - _ _ F " indicates that the digital output is Active-Low Open-Drain and will trip as temperature is falling ($\overline{US}$)

Figure 4. LM26CIM5 - _ _ F



The "G" in "LM26CIM5 - _ _G " indicates that the digital output is Active-High Push-Pull and will trip as temperature is rising (OS)

Figure 5. LM26CIM5 - _ _G



The "H" in "LM26CIM5 - _ _H" indicates that the digital output is Active-High Push-Pull and will trip as temperature is falling (US)

Figure 6. LM26CIM5 - _ _H

Applications Hints

NOISE CONSIDERATIONS

The LM26NV has excellent power supply noise rejection. Listed below is a variety of signals used to test the LM26NV power supply rejection. False triggering of the output was not observed when these signals where coupled into the V+ pin of the LM26NV.

- Square Wave 400kHz, 1Vp-p
- Square Wave 2kHz, 200mVp-p
- Sine Wave 100Hz to 1MHz, 200mVp-p

Testing was done while maintaining the temperature of the LM26NV one degree centigrade way from the trip point with the output not activated.

MOUNTING CONSIDERATIONS

The LM26NV can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface. The temperature that the LM26NV is sensing will be within about +0.06°C of the surface temperature to which the LM26NV's leads are attached to.

This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature measured would be at an intermediate temperature between the surface temperature and the air temperature.

To ensure good thermal conductivity, the backside of the LM26NV die is directly attached to the GND pin (pin 2). The temperatures of the lands and traces to the other leads of the LM26NV will also affect the temperature that is being sensed.

Alternatively, the LM26NV can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the LM26NV and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. Printed-circuit coatings and varnishes such as Humiseal and epoxy paints or dips are often used to ensure that moisture cannot corrode the LM26NV or its connections.

The junction to ambient thermal resistance (θ_{JA}) is the parameter used to calculate the rise of a part's junction temperature due to its power dissipation. For the LM26NV the equation used to calculate the rise in the die junction temperature is as follows:

$$T_J = T_A + \Theta_{JA}(V^{+}I_Q + V_{DO}I_{DO})$$

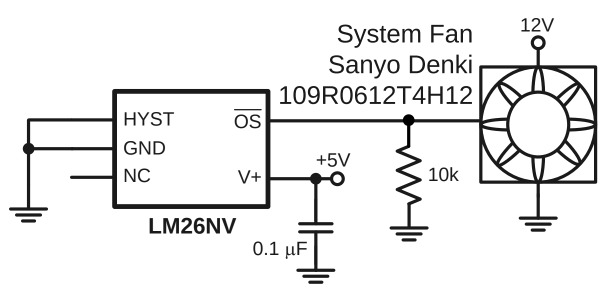
where
- T_A is the ambient temperature
- V^+ is the power supply voltage
- I_Q is the quiescent current
- V_{DO} is the voltage on the digital output
- I_{DO} is the load current on the digital output (1)

Table 3 summarizes the thermal resistance for different conditions and the rise in die temperature of the LM26NV and a 10k pull-up resistor on an open-drain digital output with a 5.5V power supply.

Table 3. Thermal resistance (θ_{JA}) and temperature rise due to self heating (T_J–T_A)

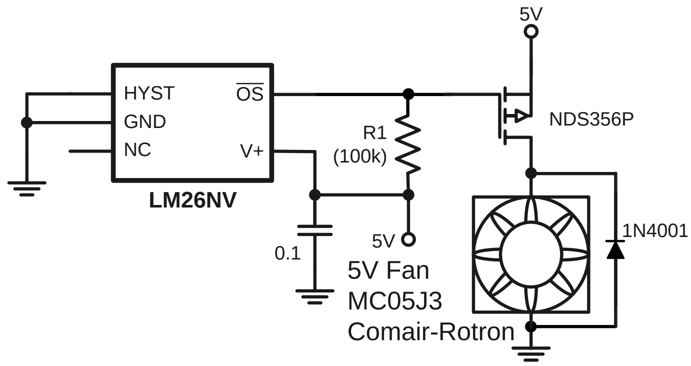
	SOT-23 no heat sink		SOT-23 small heat sink	
	θ_{JA} (°C/W)	T_J–T_A (°C)	θ_{JA} (°C/W)	T_J–T_A (°C)
Still Air	250	0.11	TBD	TBD
Moving Air	TBD	TBD	TBD	TBD

Typical Applications



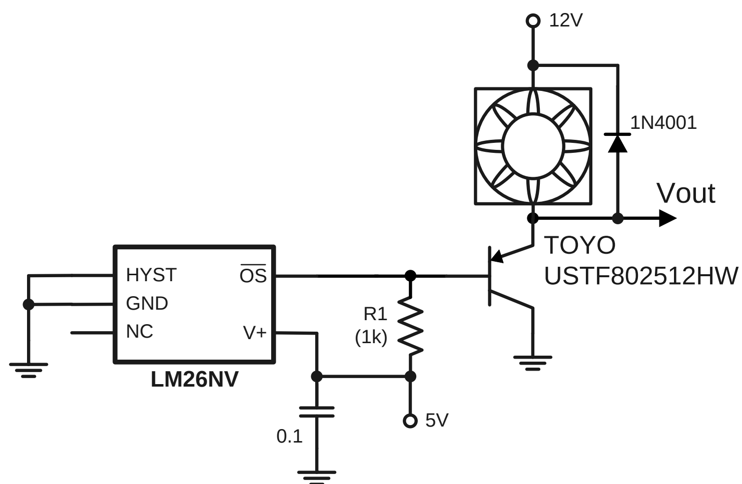
The fan's control pin has an internal pull-up. The 10 kOhm pull-down sets a slow fan speed. When the output of the LM26NV goes low, the fan will speed up.

Figure 7. Two Speed Fan Speed Control



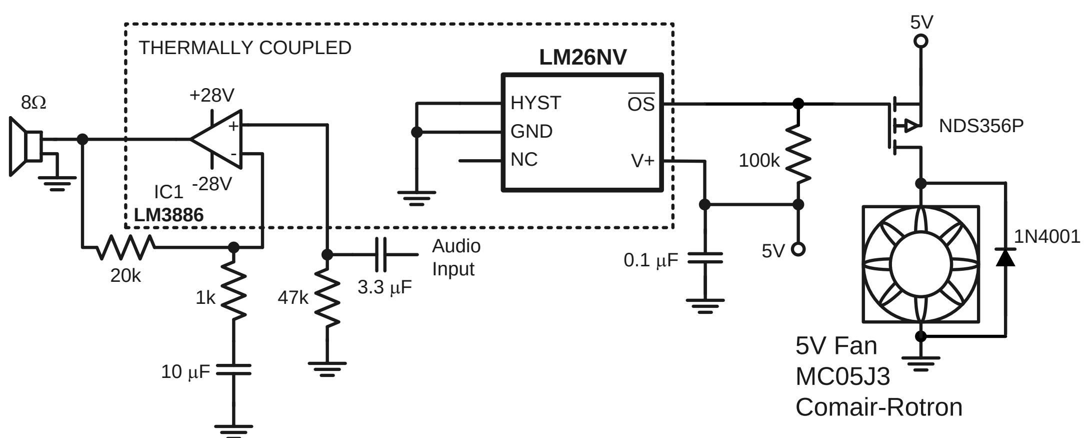
The LM26NV switches the fan on when the measured temperature exceeds the trip temperature.

Figure 8. Fan High Side Drive



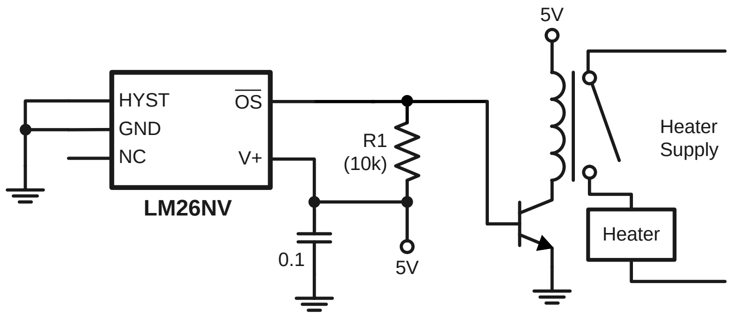
The LM26LV sinks causes the switch to sink the fan current when the measured temperature exceeds the trip temperature.

Figure 9. Fan Low Side Drive



By thermally coupling the LM26NV to the audio power amplifier, the LM26NV safeguards the amplifier from overheating, turning on the fan when it temperature exceeds the trip temperature.

Figure 10. Audio Power Amplifier Thermal Protection



When the measured temperature is below the trip temperature of the LM26NV, the $\overline{\text{OS}}$ output will be high, causing the switch and relay to close. When the temperature exceeds the trip point, $\overline{\text{OS}}$ goes low and shuts off the relay and heater.

Figure 11. Simple Thermostat

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LM26CIM5-YPE/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-55 to 125	TYPE	Samples
LM26CIM5X-YPE/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-55 to 125	TYPE	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) Only one of markings shown within the brackets will appear on the physical device.

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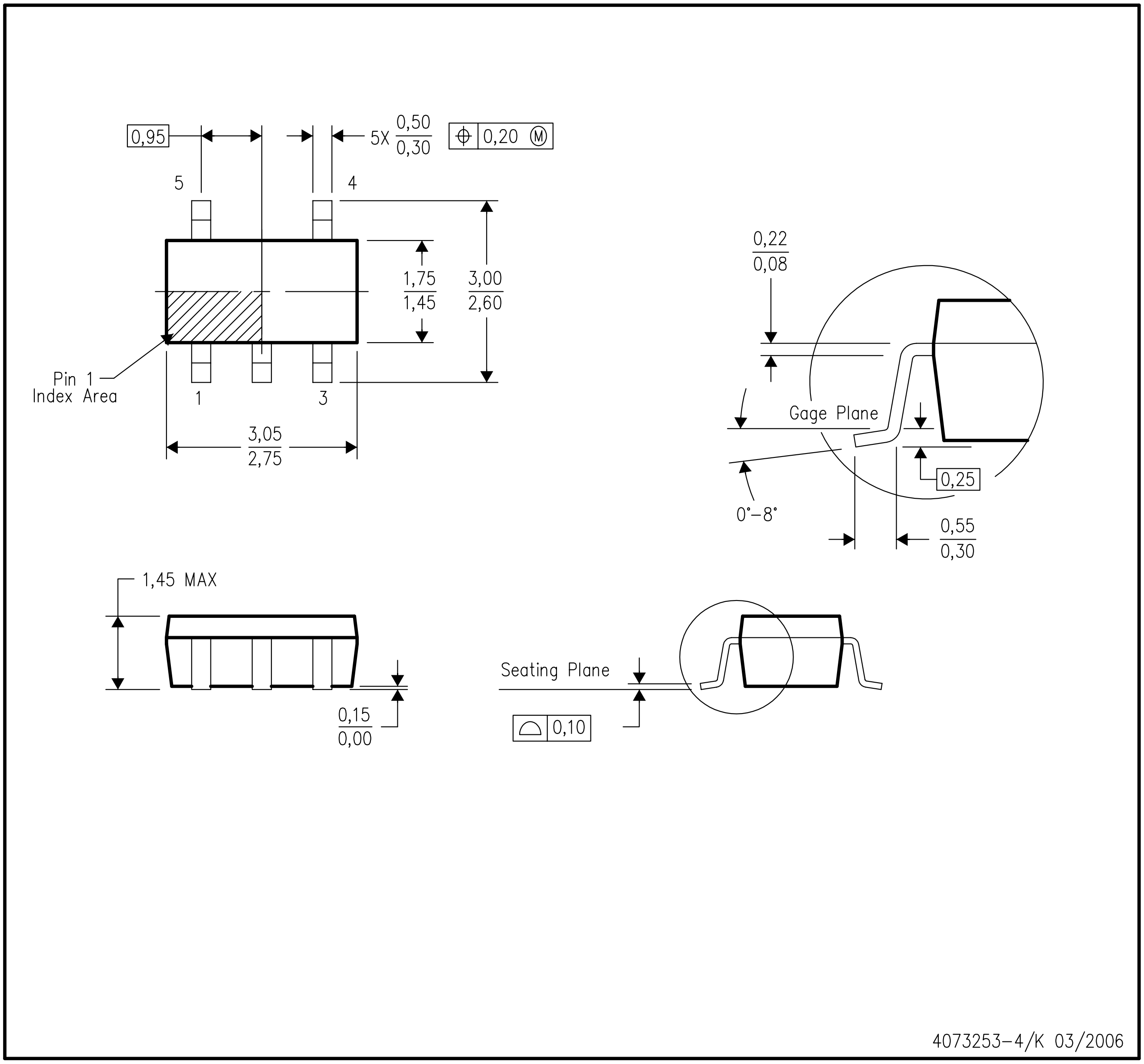
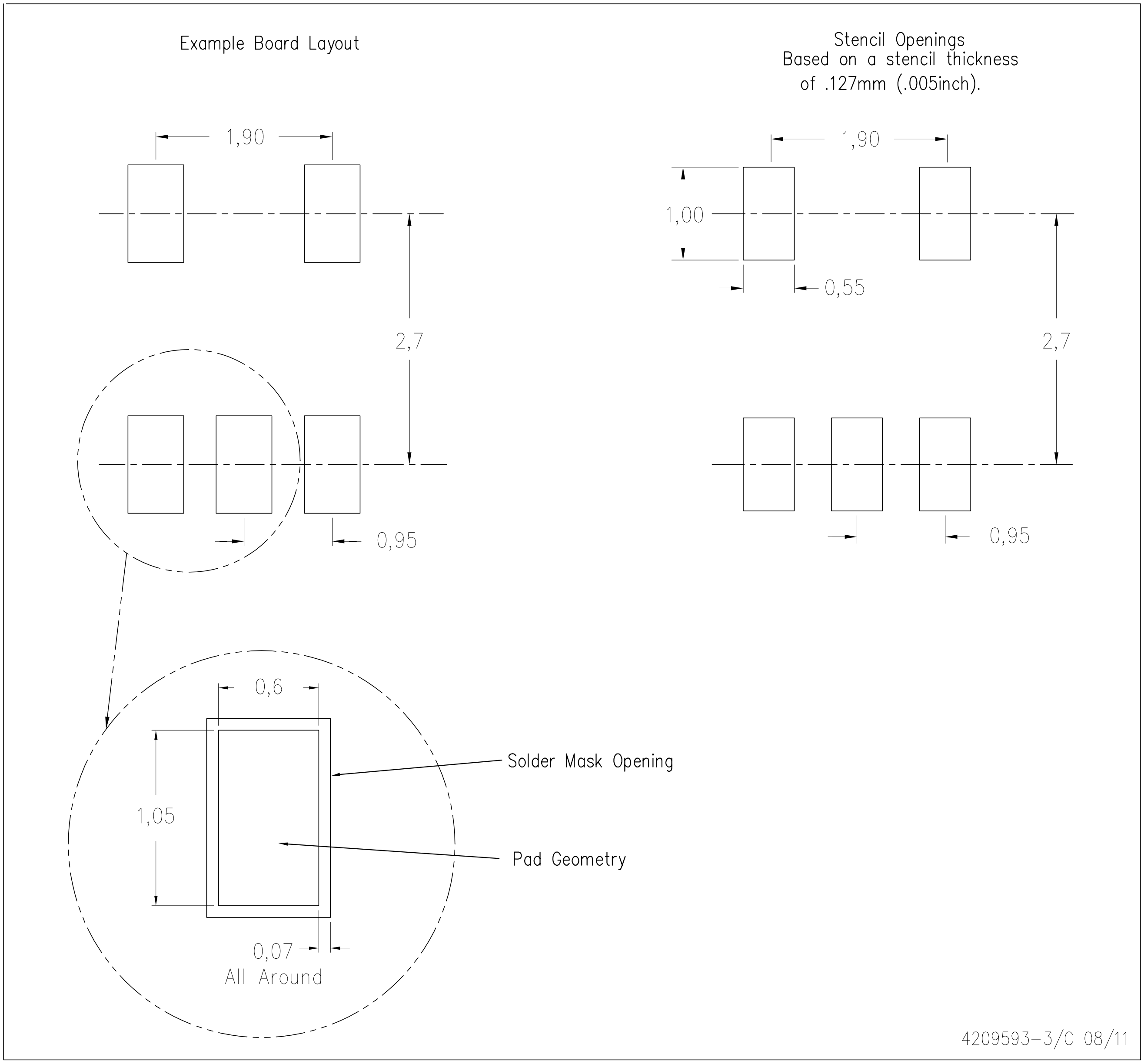
DBV (R-PDSO-G5) PLASTIC SMALL-OUTLINE PACKAGE



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

DBV (R-PDSO-G5) PLASTIC SMALL OUTLINE



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

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265