LM385-1.2-MIL Micropower Voltage References

1 Features

- Operating Current Range
  - LM385-1.2-MIL: 15 µA to 20 mA
- 1% and 2% Initial Voltage Tolerance
- Reference Impedance
  - LM385-1.2-MIL: 1 Ω maximum at 25°C
  - All devices: 1.5 Ω maximum over Full Temperature Range
- Very Low Power Consumption
- Interchangeable with Industry Standard LM385-1.2-MIL

2 Applications

- Portable Meter References
- Portable Test Instruments
- Battery-Operated Systems
- Current-Loop Instrumentation
- Panel Meters

3 Description

These micropower, two-terminal, band-gap voltage references operate over a 10-µA to 20-mA current range and feature exceptionally low dynamic impedance and good temperature stability. On-chip trimming provides tight voltage tolerance. The band-gap reference for these devices has low noise and long-term stability.

The design makes these devices exceptionally tolerant of capacitive loading and, thus, easier to use in most reference applications. The wide dynamic operating temperature range accommodates varying current supplies, with excellent regulation.

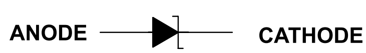
The extremely low power drain of this series makes them useful for micropower circuitry. These voltage references can be used to make portable meters, regulators, or general-purpose analog circuitry, with battery life approaching shelf life. The wide operating current range allows them to replace older references with tighter-tolerance parts.

Device Information(1)

PART NUMBER	PACKAGE (PIN)	BODY SIZE (NOM)
LM385-1.2-MIL	SOIC (8)	4.90 mm × 3.91 mm
	SOP (8)	6.20 mm × 5.30 mm
	TSSOP (8)	3.00 mm × 4.40 mm
	TO-226 (3)	4.30 mm × 4.30 mm

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

Simplified Schematic



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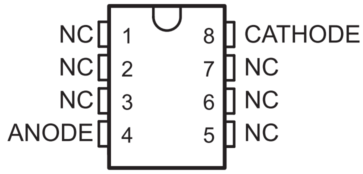
4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
June 2017	*	Initial release.

5 Pin Configuration and Functions

D, PS, PW or LP
8-Pin SOIC,SOP,TSSOP or TO-226
Top View



NC − No internal connection

(TOP VIEW)

NC − No internal connection

Pin Functions

PIN			TYPE	DESCRIPTION
NAME	LP	D, PS or PW		
ANODE	1	4	I	Shunt Current/Voltage input
CATHODE	2	8	O	Common pin, normally connected to ground
NC	3	1, 2, 3, 5, 6, 7	—	No internal connection

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
I_R	Reverse current		30	mA
I_F	Forward current		10	mA
T_J	Operating virtual junction temperature		150	°C
T_{stg}	Storage temeprature	–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.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	±2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins(2)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
I_{ZZ}	Reference current	0.01	20	mA
T_A	Operating free-air temperature	0	70	°C

6.4 Thermal Information

THERMAL METRIC(1)		LMx85-1.2-MIL				UNIT
		D	LP	PS	PW	
		8 PINS	3 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	97	140	95	149	°C/W

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

6.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	T_A (1)	MIN	TYP	MAX	UNIT
V_Z	Reference voltage	I_Z = I(min) to 20 mA (2)	25°C	1.21	1.235	1.26	V
α_{VZ}	Average temperature coefficient of reference voltage (3)	I_Z = I(min) to 20 mA (2)	Full range		±20		ppm/°C
Δ_{VZ}	Change in reference voltage with current	I_Z = I(min) to 1 mA (2)	25°C			1	mV
			Full range			1.5	
		I_Z = I(min) to 20 mA	25°C			20	
			Full range			30	
$\Delta V_Z/\Delta t$	Long-term change in reference voltage	I_Z = 100 µA	25°C		±20		ppm/khr
I_Z(min)	Minimum reference current		Full range		8	15	µA
Z_Z	Reference impedance	I_Z = 100 µA, f = 25 Hz	25°C		0.4	1	Ω
			Full range			1.5	
V_n	Broadband noise voltage	I_Z = 100 µA, f = 10 Hz to 10 kHz	25°C		60		µV

(1) Full range is −40°C to 85°C for the LM385-1.2-MIL.
(2) I(min) = 15 µA for the LM385-1.2-MIL.
(3) The average temperature coefficient of reference voltage is defined as the total change in reference voltage divided by the specified temperature range.

6.6 Typical Characteristics

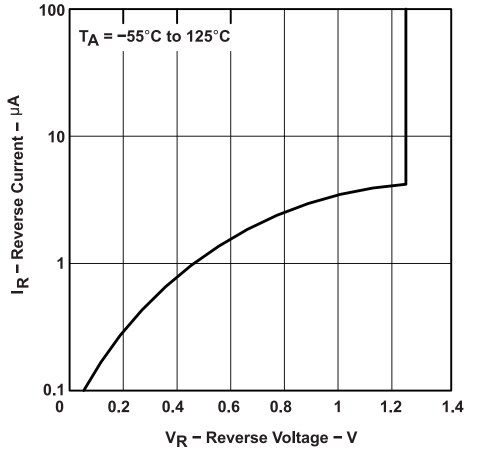


Figure 1. Reverse Current vs Reverse Voltage

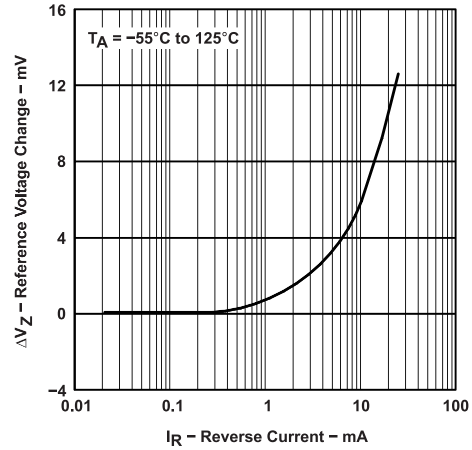


Figure 2. Reference Voltage Change vs Reverse Current

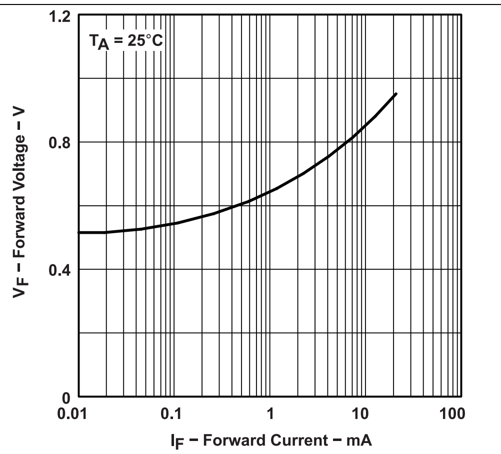


Figure 3. Forward Voltage vs Forward Current

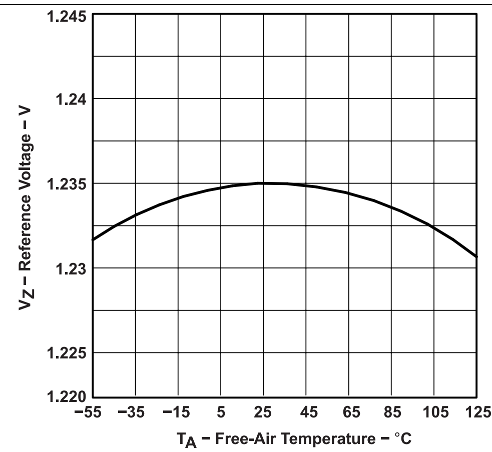


Figure 4. Reference Voltage vs Free-Air Temperature

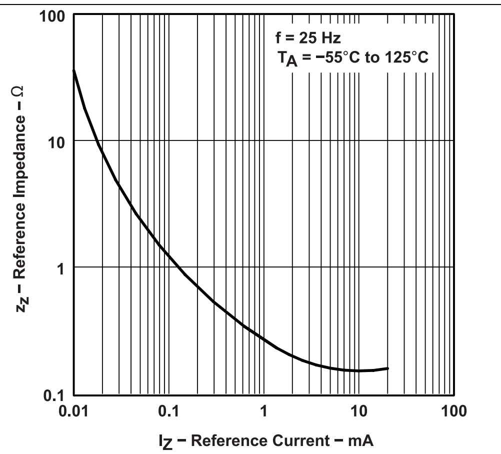


Figure 5. Reference Impedance vs Reference Current

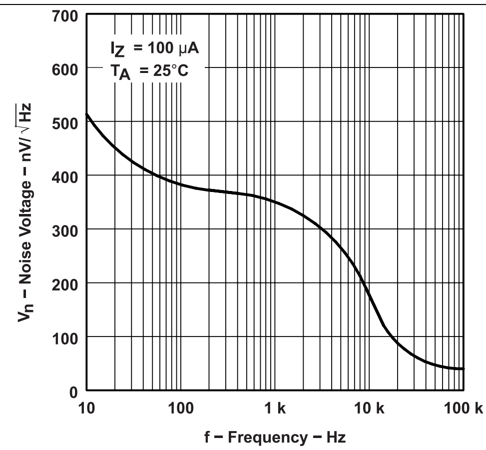


Figure 6. Noise Voltage vs Frequency

Typical Characteristics (continued)

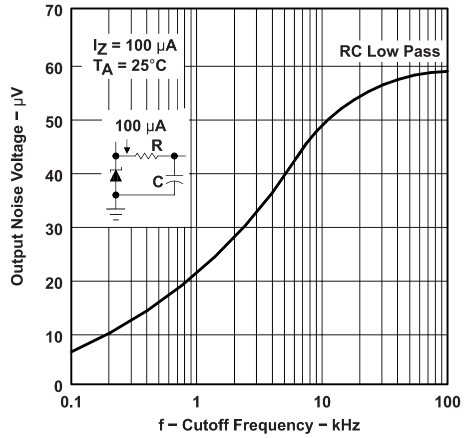


Figure 7. Output Noise Voltage vs Cutoff Frequency

7 Detailed Description

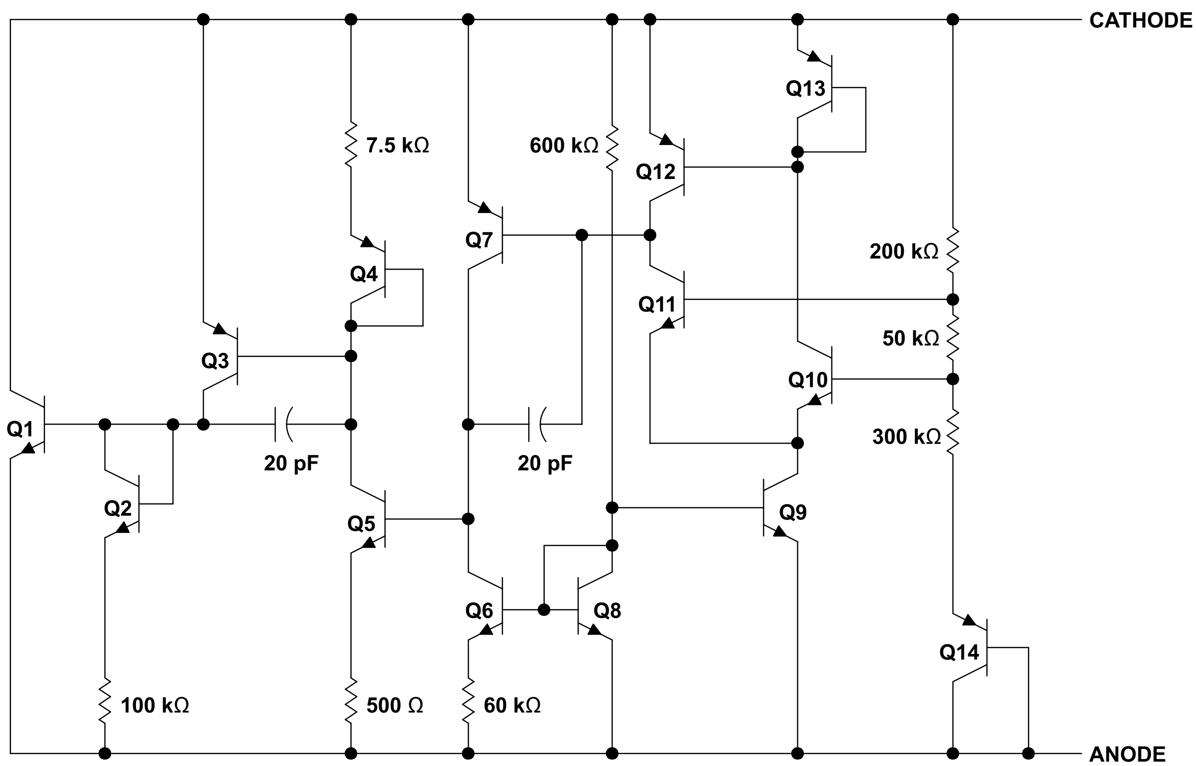
7.1 Overview

The LM385-1.2-MIL device is micropower, two-terminal, band-gap voltage references which operate over a 10-μA to 20-mA current range. On-chip trimming provides tight voltage tolerance. The band-gap reference for these devices has low noise and long-term stability.

The design makes these devices exceptionally tolerant of capacitive loading and, thus, easier to use in most reference applications. The wide dynamic operating temperature range accommodates varying current supplies, with excellent regulation.

The extremely low power drain of this series makes them useful for micropower circuitry. These voltage references can be used to make portable meters, regulators, or general-purpose analog circuitry, with battery life approaching shelf life.

7.2 Functional Block Diagram



A. Component values shown are nominal.

7.3 Feature Description

A band gap voltage reference controls high gain amplifier and shunt pass element to maintain a nearly constant voltage between cathode and anode. Regulation occurs after a minimum current is provided to power the voltage divider and amplifier. Internal frequency compensation provides a stable loop for all capacitor loads. Floating shunt design is useful for both positive and negative regulation applications.

7.4 Device Functional Modes

The LM385-1.2-MIL device operates in one mode, which is as a fixed voltage reference that cannot be adjusted.

In order for a proper Reverse Voltage to be developed, current must be sourced into the cathode of LM285. The minimum current needed for proper regulation is denoted in *Electrical Characteristics* as $I_{Z,min}$.

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 LM385-1.2-MIL device creates a voltage reference for to be used for a variety of applications including amplifiers, power supplies, and current-sensing circuits. The following application shows how to use these devices to establish a voltage reference.

8.2 Typical Application

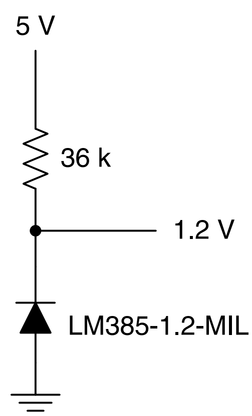


Figure 8. Generating Reference Voltage With a Resistive Current Source

8.2.1 Design Requirements

The key design requirement when using this device as a voltage reference is to supply the LM385 with a minimum Cathode Current (I_Z), as indicated in *Electrical Characteristics*.

8.2.2 Detailed Design Procedure

In order to generate a constant and stable reference voltage, a current greater than $I_{Z(MIN)}$ must be sourced into the cathode of this device. This can be accomplished using a current regulating device such as LM334 or a simple resistor. For a resistor, its value should be equal to or greater than (V_{supply} - $V_{reference}$) ÷ $I_{Z(MIN)}$.

Typical Application (continued)

8.2.3 Application Curve

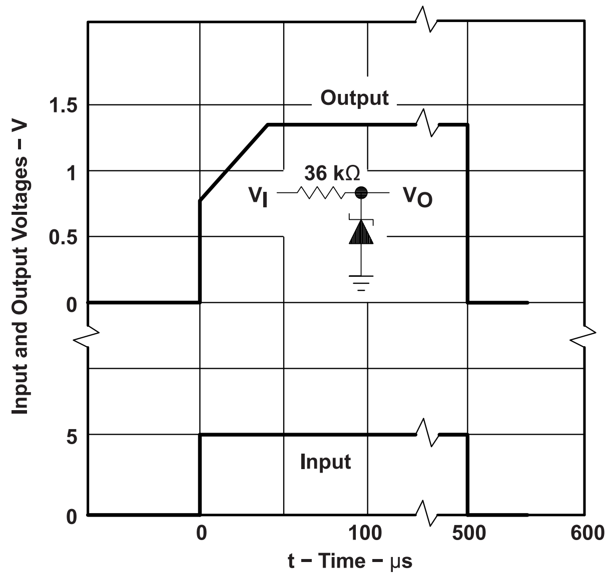


Figure 9. Transient Response

8.3 System Examples

8.3.1 Thermocouple Cold-Junction Compensator

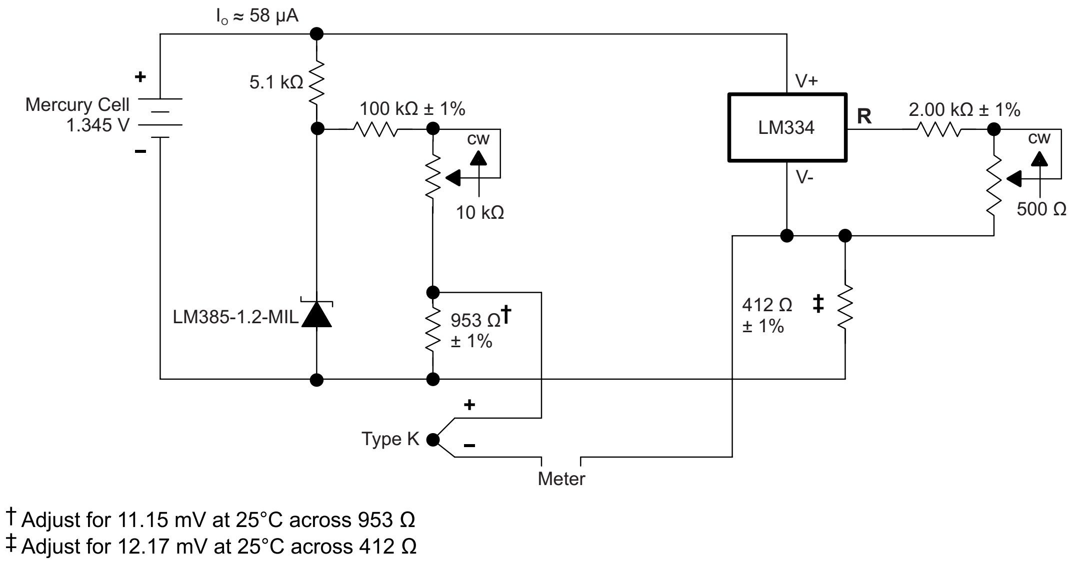


Figure 10. Thermocouple Cold-Junction Compensator

8.3.2 Generating Reference Voltage with a Constant Current Source

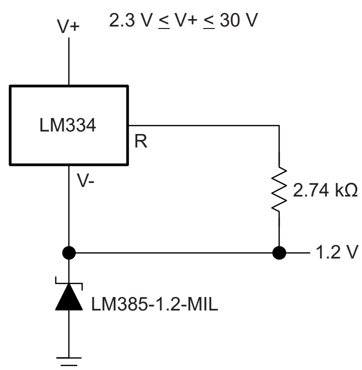


Figure 11. Generating Reference Voltage With a Constant Current Source Device

9 Power Supply Recommendations

In order to not exceed the maximum cathode current, be sure that the supply voltage is current limited.

For applications shunting high currents (30 mA max), pay attention to the cathode and anode trace lengths, adjusting the width of the traces to have the proper current density.

10 Layout

10.1 Layout Guidelines

Figure 12 shows an example of a PCB layout of LM385x-1.2-MIL. Some key V_{ref} niose considerations are:

- Connect a low-ESR, 0.1-µF (C_L) ceramic bypass capacitor on the cathode pin node.
- Decouple other active devices in the system per the device specifications.
- Using a solid ground plane helps distribute heat and reduces electromagnetic interference (EMI) noise pickup.
- Place the external components as close to the device as possible. This configuration prevents parasitic errors (such as the Seebeck effect) from occurring.
- Do not run sensitive analog traces in parallel with digital traces. Avoid crossing digital and analog traces if possible and only make perpendicular crossings when absolutely necessary.

10.2 Layout Example

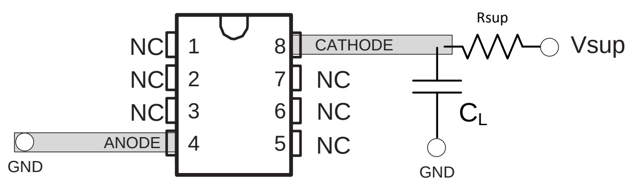


Figure 12. Layout Diagram

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation see the following:

- *AN-715 LM385 Feedback Provides Regulator Isolation*
- *AN-284 Single-Supply Applications of CMOS MICRODACs*
- *AN-777 LM2577 Three Output, Isolated Flyback Regulator*

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.4 Trademarks

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All other trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.6 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 finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM385-1.2-MWC	ACTIVE	WAFERSALE	YS	0	1	RoHS & Green	Call TI	Level-1-NA-UNLIM	-40 to 85		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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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 finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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