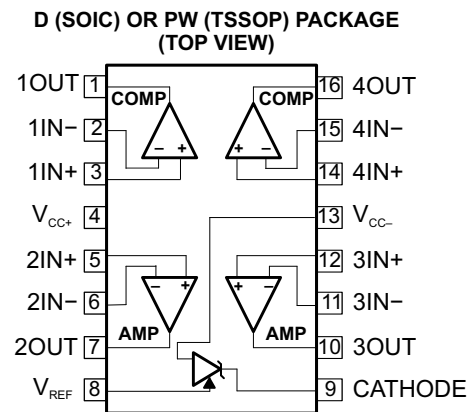


FEATURES

- **OPERATIONAL AMPLIFIERS**
 - Low Supply Current...200 μ A/A
 - Medium Speed...2.1 MHz
 - Low-Level Output Voltage Close to V_{CC} ...0.1 V Typ ($R_L = 10\text{ k}\Omega$)
 - Input Common-Mode Voltage Range Includes Ground
- **COMPARATORS**
 - Low Supply Current...200 μ A/A ($V_{CC} = 5\text{ V}$)
 - Input Common-Mode Voltage Range Includes Ground
 - Low Output Saturation Voltage... Typically 250 mV ($I_{\text{sink}} = 4\text{ mA}$)
- **VOLTAGE REFERENCE**
 - Adjustable Output Voltage... V_{REF} to 36 V
 - Sink Current Capability...1 mA to 100 mA
 - 0.4% (A Grade) and 1% (Standard Grade) Precision
 - Latch-Up Immunity

APPLICATIONS

- Switch-Mode Power Supplies
- Battery Chargers
- Voltage and Current Sensing
- Power-Good, Overvoltage, Undervoltage, Overcurrent Detection
- Window Comparators
- Alarms, Detectors, and Sensors



DESCRIPTION/ORDERING INFORMATION

The TSM102 and TSM102A combine the building blocks of a dual operational amplifier, a dual comparator, and a precision voltage reference, all of which often are used to implement a wide variety of power-management functions, including overcurrent detection, undervoltage/overvoltage detection, power-good detection, window comparators, error amplifiers, etc. Additional applications include alarm and detector/sensor applications.

The TSM102A offers a tight V_{REF} tolerance of 0.4% at 25°C. The TSM102 and TSM102A are characterized for operation from -40°C to 85°C.

ORDERING INFORMATION

T_A	MAX V_{REF} TOLERANCE (25°C)	PACKAGE ⁽¹⁾		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 85°C	A grade: 0.4% precision	SOIC – D	Tube of 75	TSM102AID	TSM102AI
			Reel of 2500	TSM102AIDR	
		TSSOP – PW	Tube of 90	TSM102AIPW	SN102AI
			Reel of 2000	TSM102AIPWR	
	Standard grade: 1% precision	SOIC – D	Tube of 75	TSM102ID	TSM102I
			Reel of 2500	TSM102IDR	
TSSOP – PW		Tube of 90	TSM102IPW	SN102I	
		Reel of 2000	TSM102IPWR		

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

TSM102, TSM102A DUAL OPERATIONAL AMPLIFIER, DUAL COMPARATOR, AND VOLTAGE REFERENCE

SLVS602–MARCH 2006

Absolute Maximum Ratings⁽¹⁾

over free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{CC}	Supply voltage		36	V
V_{ID}	Input differential voltage		36	V
V_I	Input voltage range	-0.3	36	V
I_{KA}	Voltage reference cathode current		100	mA
θ_{JA}	Package thermal impedance ⁽²⁾⁽³⁾	D package	73	°C/W
		PW package	108	
T_J	Maximum 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) Maximum power dissipation is a function of $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. Selecting the maximum of 150°C can affect reliability.
- (3) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions

		MIN	MAX	UNIT
$V_{CC+} - V_{CC-}$	Supply voltage	3	30	V
V_{ID}	Comparator differential input voltage		$V_{CC+} - V_{CC-}$	V
V_{KA}	Cathode-to-anode voltage	V_{REF}	36	V
I_K	Reference cathode current	1	100	mA
T_A	Operating free-air temperature	-40	85	°C

Total Device Electrical Characteristics

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
I_{CC}	Total supply current, excluding reference cathode current	$V_{CC+} = 5\text{ V}$, $V_{CC-} = 0\text{ V}$, No load	25°C		0.8	1.5	mA
			Full range			2	

Operational Amplifier Electrical Characteristics
 $V_{CC+} = 5\text{ V}$, $V_{CC-} = \text{GND}$, R_1 connected to $V_{CC-}/2$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage		25°C		1	4.5	mV
			Full range			6.5	
αV_{IO}	Input offset voltage drift		25°C		10		$\mu\text{V}/^\circ\text{C}$
I_{IO}	Input offset current		25°C		5	20	nA
			Full range			40	
I_{IB}	Input bias current		25°C		20	100	nA
			Full range			200	
A_{VD}	Large-signal voltage gain	$V_{CC+} = 30\text{ V}$, $R_1 = 10\text{ k}\Omega$, $V_O = 5\text{ V to }25\text{ V}$	25°C	50	100		V/mV
			Full range		25		
k_{SVR}	Supply-voltage rejection ratio	$V_{CC+} = 5\text{ V to }30\text{ V}$	25°C	80	100		dB
V_{ICM}	Input common-mode voltage		25°C	V_{CC-}		$V_{CC+} - 1.8$	V
			Full range	V_{CC-}		$V_{CC+} - 2.2$	
CMRR	Common-mode rejection ratio	$V_{CC+} = 30\text{ V}$, $V_{ICM} = 0\text{ V to }V_{CC+} - 1.8\text{ V}$	25°C	70	90		dB
I_{SC}	Short-circuit current	$V_{ID} = \pm 1\text{ V}$, $V_O = 2.5\text{ V}$		Source	3	6	mA
				Sink	3	6	
V_{OH}	High-level output voltage	$V_{CC+} = 30\text{ V}$, $R_L = 10\text{ k}\Omega$	25°C	27	28		V
			Full range		26		
V_{OL}	Low-level output voltage	$R_L = 10\text{ k}\Omega$	25°C		130	170	mV
			Full range			200	
SR	Slew rate	$V_{CC} = \pm 15\text{ V}$, $C_L = 100\text{ pF}$, $V_I = \pm 10\text{ V}$, $R_L = 10\text{ k}\Omega$	25°C	1.3	2		V/ μs
GBW	Gain bandwidth product	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$	25°C	1.4	2.1		MHz
Φ_m	Phase margin	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		45		°
THD	Total harmonic distortion		25°C		0.01		%
V_n	Equivalent input noise voltage	$f = 1\text{ kHz}$	25°C		19		$\text{nV}/\sqrt{\text{Hz}}$

TSM102, TSM102A DUAL OPERATIONAL AMPLIFIER, DUAL COMPARATOR, AND VOLTAGE REFERENCE

SLVS602–MARCH 2006

Comparator Electrical Characteristics

$V_{CC+} = 5\text{ V}$, $V_{CC-} = \text{GND}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	25°C			5	mV
		Full range			9	
V_{ID}	Comparator differential input voltage	Full range			V_{CC+}	V
I_{IO}	Input offset current	25°C			50	nA
		Full range			150	
I_{IB}	Input bias current	25°C			250	nA
		Full range			400	
I_{OH}	High-level output current	$V_{ID} = 1\text{ V}$, $V_{CC} = V_O = 30\text{ V}$		0.1		nA
		Full range			1	μA
V_{OL}	Low-level output voltage	$V_{ID} = -1\text{ V}$, $I_{\text{sink}} = 4\text{ mA}$		250	400	mV
		Full range			700	
A_{VD}	Large-signal voltage gain	$V_{CC+} = 15\text{ V}$, $R_1 = 15\text{ k}\Omega$, $V_O = 1\text{ V to }11\text{ V}$		200		V/mV
I_{sink}	Output sink current	$V_O = 1.5\text{ V}$, $V_{ID} = -1\text{ V}$	25°C	6	16	mA
V_{ICM}	Input common-mode voltage range		25°C	0	$V_{CC+} - 1.5$	V
			Full range	0	$V_{CC+} - 2$	
t_{RESP}	Response time ⁽¹⁾	$R_1 = 5.1\text{ k}\Omega$ to V_{CC+} , $V_{\text{REF}} = 1.4\text{ V}$	25°C		1.3	μs
$t_{\text{RESP,large}}$	Large-signal response time	$R_1 = 5.1\text{ k}\Omega$ to V_{CC+} , $V_{\text{REF}} = 1.4\text{ V}$, $V_I = \text{TTL}$	25°C		300	ns

(1) The response-time specification is for 100-mV input step with 5-mV overdrive. For larger overdrive signals, 300 ns can be obtained.

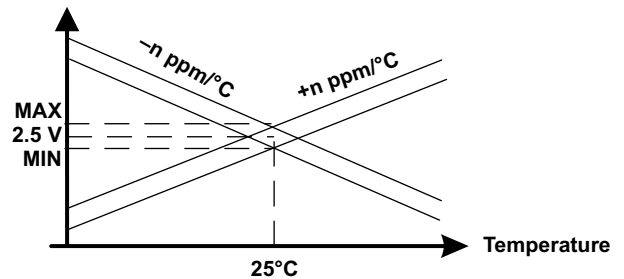
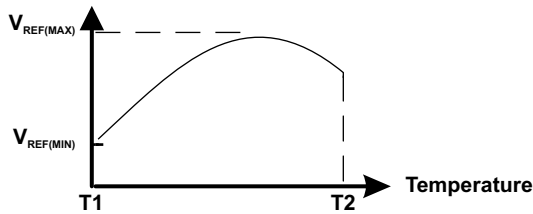
Voltage-Reference Electrical Characteristics

PARAMETER		TEST CONDITIONS	T _A	MIN	TYP	MAX	UNIT
V _{REF}	Reference voltage ⁽¹⁾	V _{KA} = V _{REF} , I _K = 10 mA, See Figure 1	25°C	2.475	2.5	2.525	V
			25°C	2.49	2.5	2.51	
ΔV _{REF}	Reference input voltage deviation over temperature range ⁽¹⁾	V _{KA} = V _{REF} , I _K = 10 mA, See Figure 1	Full range		7	30	mV
$\frac{\Delta V_{REF}}{\Delta T}$	Average temperature coefficient of reference input voltage ⁽²⁾	V _{KA} = V _{REF} , I _K = 10 mA	Full range		±22	±100	ppm/°C
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of change in reference voltage to change in cathode voltage	V _{KA} = 3 V to 36 V, I _K = 10 mA, See Figure 2	25°C		-1.1	-2	mV/V
I _{REF}	Reference input current	I _K = 10 mA, R ₁ = 10 kΩ, R ₂ = ∞, See Figure 2	25°C		1.5	2.5	μA
			Full range			3	
ΔI _{REF}	Reference input current deviation over temperature range	I _K = 10 mA, R ₁ = 10 kΩ, R ₂ = ∞, See Figure 2	Full range		0.5	1	μA
I _{min}	Minimum cathode current for regulation	V _{KA} = V _{REF} , See Figure 1	25°C		0.5	1	mA
I _{K,OFF}	Off-state cathode current	See Figure 3	25°C		180	500	nA

(1) ΔV_{REF} is defined as the difference between the maximum and minimum values obtained over the full temperature range.

$$\Delta V_{REF} = V_{REF(MAX)} - V_{REF(MIN)}$$

(2) The temperature coefficient is defined as the slopes (positive and negative) of the voltage vs temperature limits within which the reference voltage is specified.



PARAMETER MEASUREMENT INFORMATION

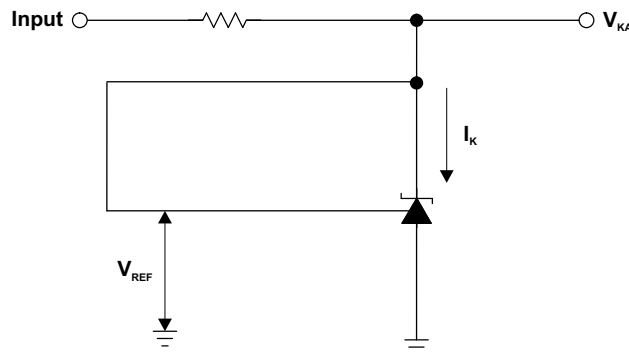


Figure 1. Test Circuit for $V_{KA} = V_{REF}$

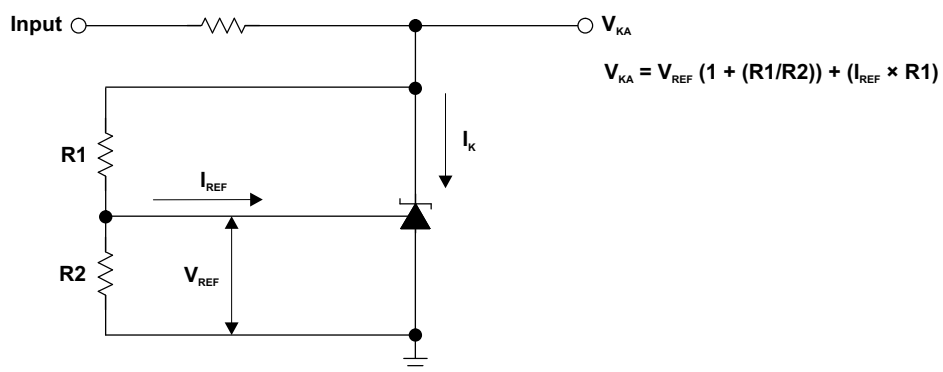


Figure 2. Test Circuit for $V_{KA} > V_{REF}$

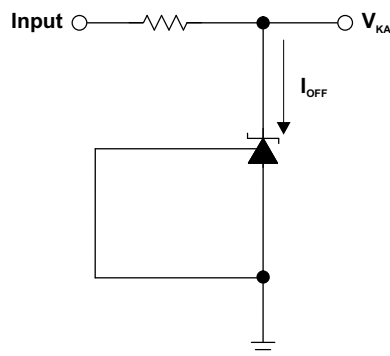


Figure 3. Test Circuit for I_{OFF}

TYPICAL CHARACTERISTICS

**AMPLIFIER TOTAL HARMONIC DISTORTION
VS
FREQUENCY**

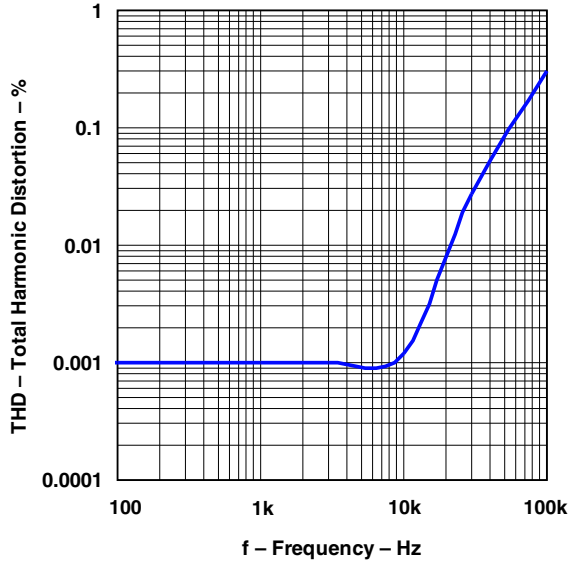


Figure 4.

**AMPLIFIER NOISE VOLTAGE
VS
FREQUENCY**

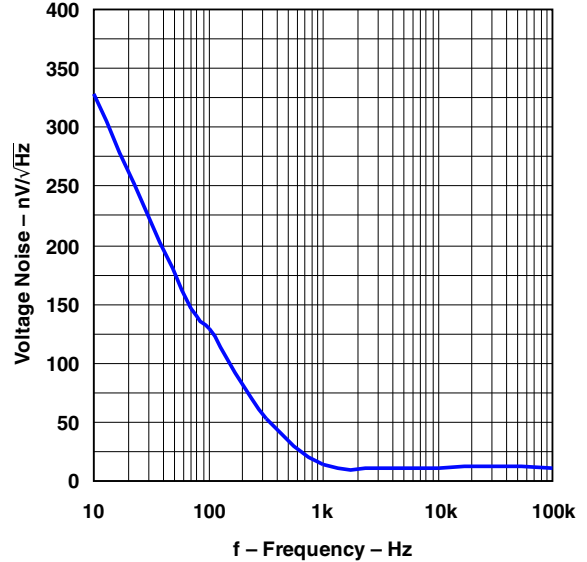


Figure 5.

**GAIN AND PHASE
VS
FREQUENCY**

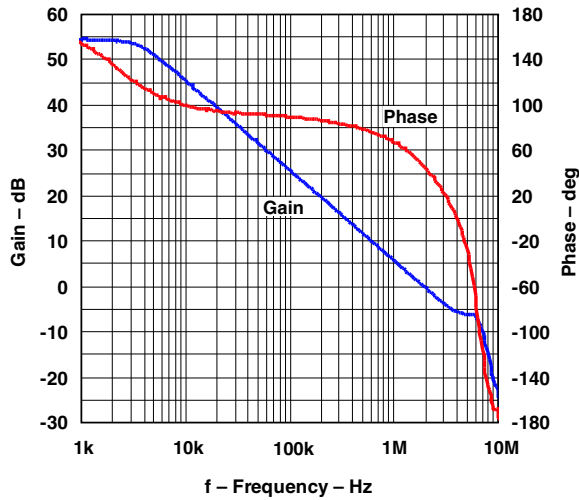


Figure 6.

**V_{REF} STABILITY
VS
CAPACITANCE**

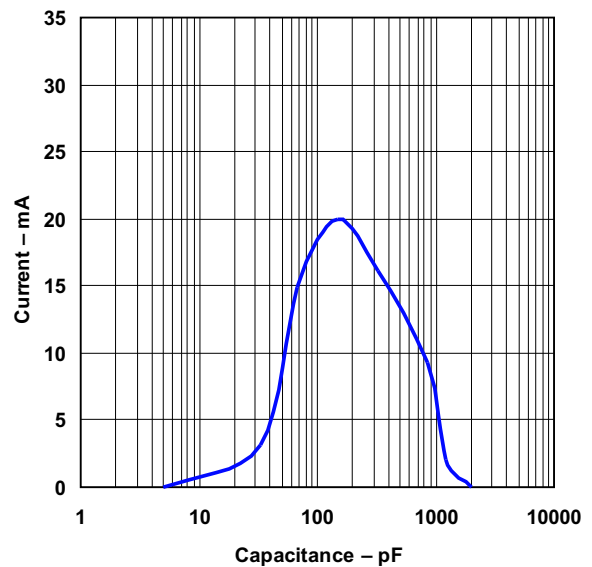


Figure 7.

TYPICAL CHARACTERISTICS (continued)

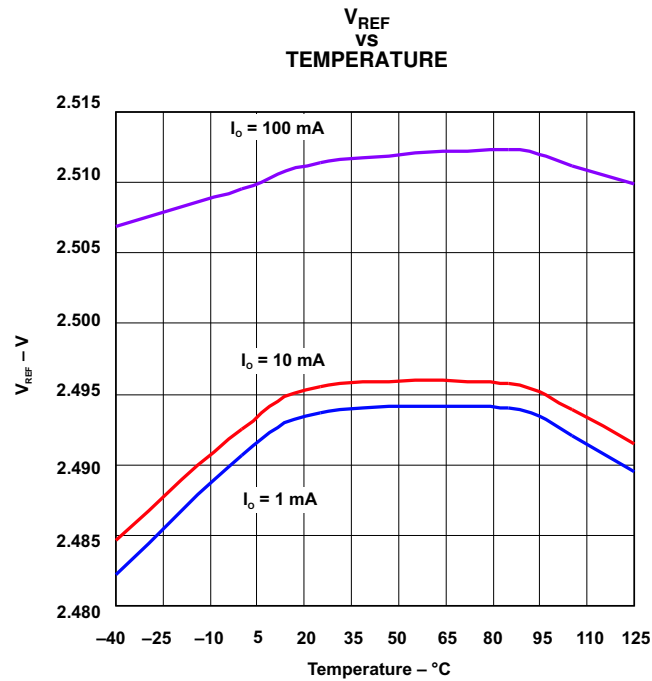


Figure 8.

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TSM102AID	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102AIDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102AIDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102AIDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102AIPW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102AIPWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102AIPWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102AIPWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102ID	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102IDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102IDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102IDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102IPW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102IPWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102IPWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TSM102IPWRG4	ACTIVE	TSSOP	PW	16	2000	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.

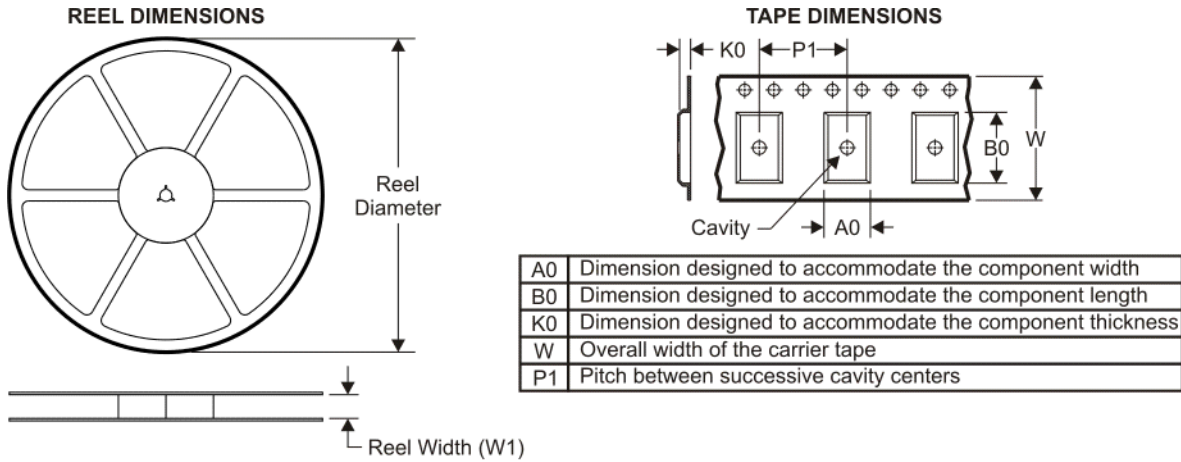
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

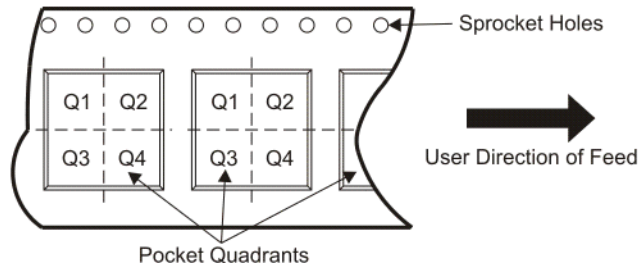
Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TSM102AIDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
TSM102AIPWR	TSSOP	PW	16	2000	330.0	12.4	7.0	5.6	1.6	8.0	12.0	Q1
TSM102IDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
TSM102IPWR	TSSOP	PW	16	2000	330.0	12.4	7.0	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



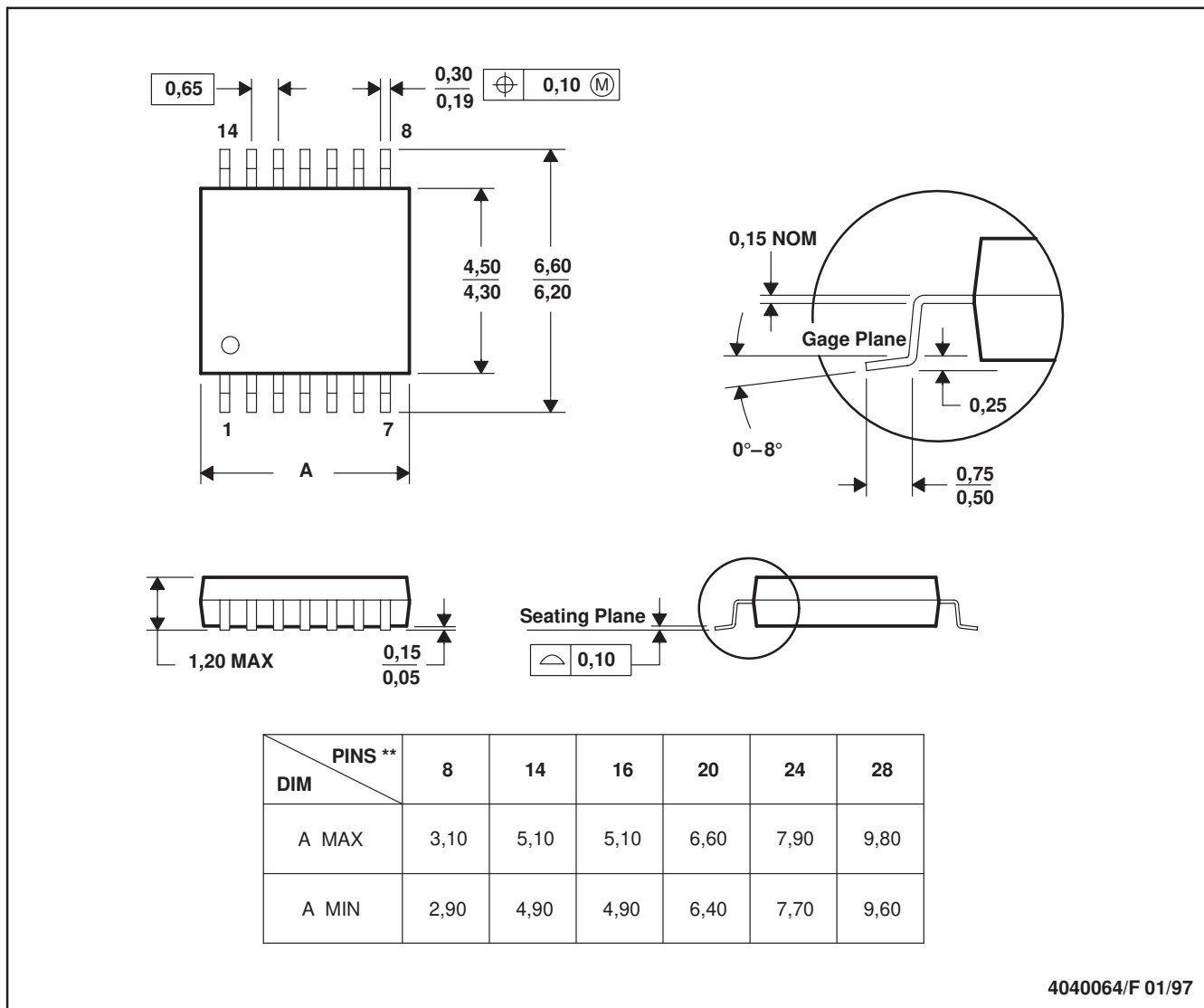
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TSM102AIDR	SOIC	D	16	2500	346.0	346.0	33.0
TSM102AIPWR	TSSOP	PW	16	2000	346.0	346.0	29.0
TSM102IDR	SOIC	D	16	2500	346.0	346.0	33.0
TSM102IPWR	TSSOP	PW	16	2000	346.0	346.0	29.0

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN

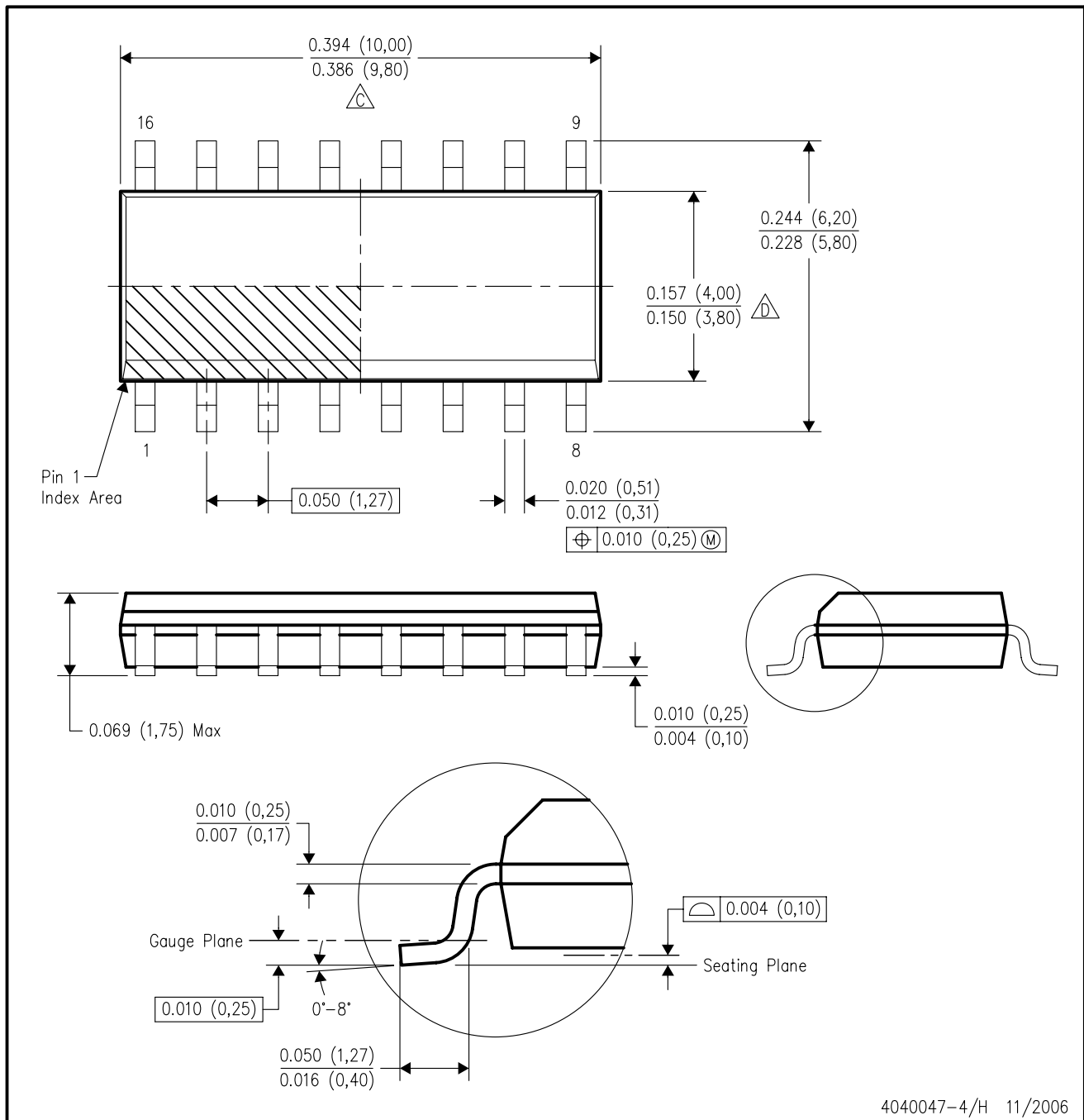


4040064/F 01/97

- 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 not to exceed 0,15.
 D. Falls within JEDEC MO-153

D (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



4040047-4/H 11/2006

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
 - E. Reference JEDEC MS-012 variation AC.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008, Texas Instruments Incorporated