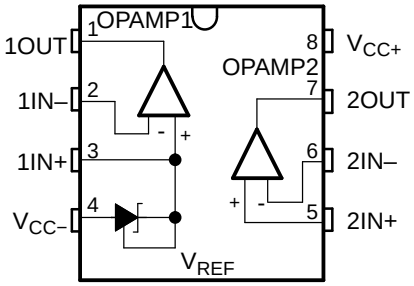
TL103W, TL103WA
DUAL OPERATIONAL AMPLIFIERS WITH INTERNAL REFERENCE

SLOS437J–APRIL 2004–REVISED JULY 2005

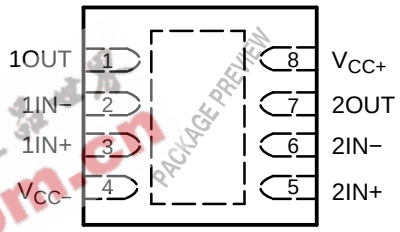
FEATURES

- **OPERATIONAL AMPLIFIER**
  - **Low Offset Voltage Max of:**
    - **TL103WA…3 mV (25°C) and 5 mV (Full Temperature)**
    - **TL103W…4 mV (25°C) and 5 mV (Full Temperature)**
  - **Low Supply Current…350 μA/Channel (Typ)**
  - **Unity Gain Bandwidth…0.9 MHz (Typ)**
  - **Input Common-Mode Range Includes GND**
  - **Large Output-Voltage Swing… 0 V to V_{CC} – 1.5 V**
  - **Wide Supply-Voltage Range…3 V to 32 V**
  - **2-kV ESD Protection (HBM)**
- **VOLTAGE REFERENCE**
  - **Fixed 2.5-V Reference**
  - **Tight Tolerance Max of:**
    - **TL103WA…0.4% (25°C) and 0.8% (Full Temperature)**
    - **TL103W . . . 0.7% (25°C) and 1.4% (Full Temperature)**
  - **Low Temperature Drift…7 mV (Typ) Over Operating Temperature Range**
  - **Wide Sink-Current Range . . . 0.5 mA (Typ) to 100 mA**
  - **Output Impedance…0.2 Ω (Typ)**

D (SOIC) PACKAGE
(TOP VIEW)



DRJ (QFN) PACKAGE
(TOP VIEW)



NOTE: Exposed thermal pad is connected internally to V_{CC-} via die attach.

TYPICAL APPLICATIONS

- **Battery Chargers**
- **Switch-Mode Power Supplies**
- **Linear Voltage Regulation**
- **Data-Acquisition Systems**

DESCRIPTION/ORDERING INFORMATION

The TL103W and TL103WA combine the building blocks of a dual operational amplifier and a fixed voltage reference – both of which often are used in the control circuitry of both switch-mode and linear power supplies. OPAMP1 has its noninverting input internally tied to a fixed 2.5-V reference, while OPAMP2 is independent, with both inputs uncommitted.

For the A grade, especially tight voltage regulation can be achieved through low offset voltages for both operational amplifiers (typically 0.5 mV) and tight tolerances for the voltage reference (0.4% at 25°C and 0.8% over operating temperature range).

The TL103W and TL103WA are characterized for operation from –40°C to 105°C.

ORDERING INFORMATION

T_A	MAX V_{IO} AND V_{REF} TOLERANCE (25°C)	PACKAGE(1)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 105°C	A grade 3 mV, 0.4%	QFN (DRJ)	Reel of 1000	TL103WAIDRJR	PREVIEW
		SOIC (D)	Tube of 75	TL103WAID	Z103WQ
			Reel of 2500	TL103WAIDR	
	Standard grade 4 mV, 0.7%	QFN (DRJ)	Reel of 1000	TL103WIDRJR	PREVIEW
		SOIC (D)	Tube of 75	TL103WID	Z103W
			Reel of 2500	TL103WIDR	

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

Typical Application Circuit

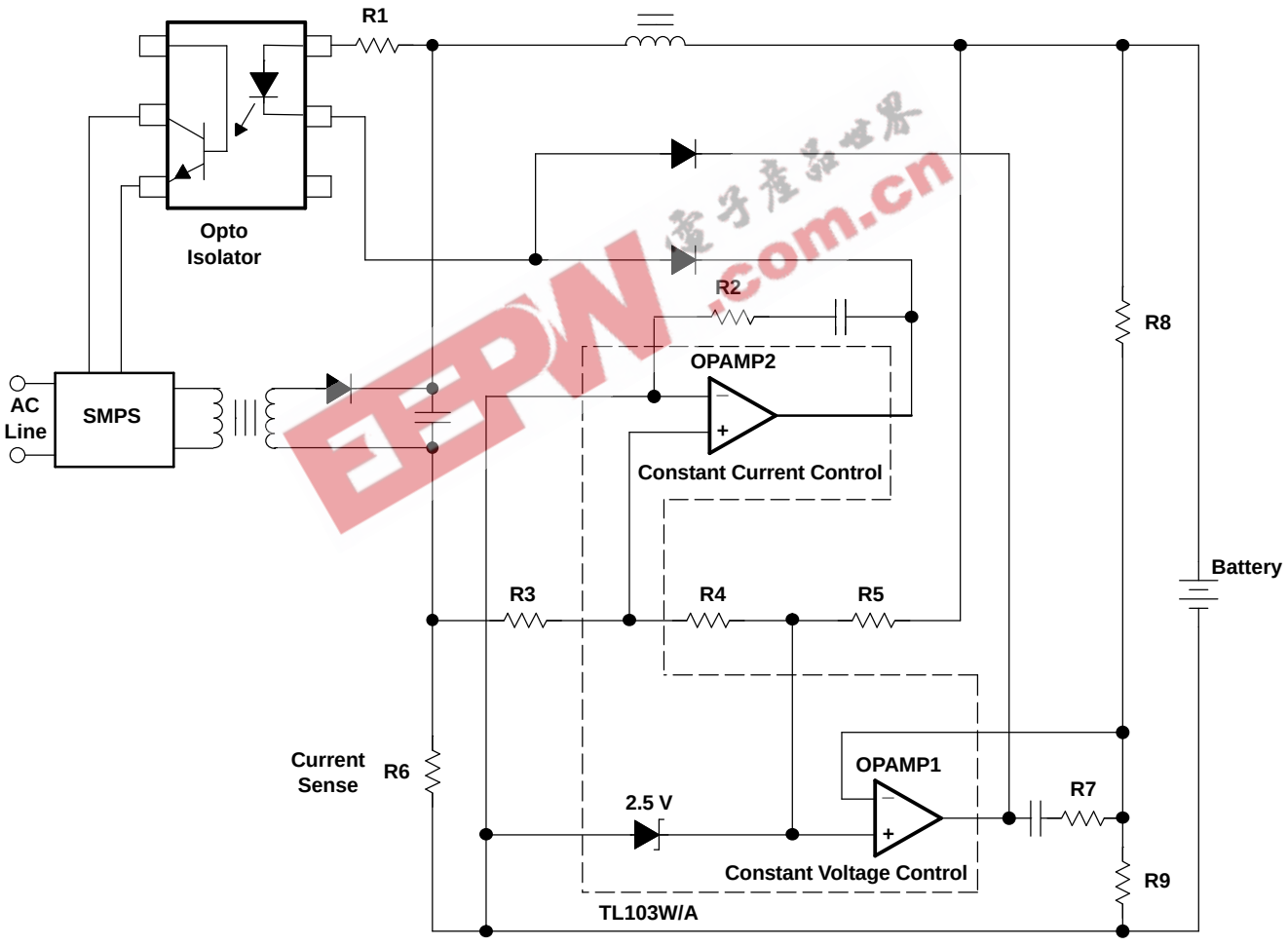


Figure 1. TL103W/A in a Constant-Current and Constant-Voltage Battery Charger

Absolute Maximum Ratings(1)

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage			36	V
V_{id}	Operational amplifier input differential voltage			36	V
V_I	Operational amplifier input voltage range		–0.3	36	V
I_{KA}	Voltage reference cathode current			100	mA
θ_{JA}	Package thermal impedance	D package(2)(3)		97	°C/W
		DRJ package(2)(4)		TBD	
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 $T_J(max)$, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Selecting the maximum of 150°C can affect reliability.

(3) The package thermal impedance is calculated in accordance with JESD 51-7.

(4) The package thermal impedance is calculated in accordance with JESD 51-5.

Recommended Operating Conditions

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

		MIN	MAX	UNIT
V_{IN}	Supply voltage	3	32	V
I_K	Cathode current	1	100	mA
T_A	Operating free-air temperature	–40	105	°C

OPAMP1, Operational Amplifier With Noninverting Input Connected to the Internal V_{REF} Electrical Characteristics

V_{CC+} = 5 V, V_{CC} = GND, T_A = 25°C (unless otherwise noted)

PARAMETER			TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	TL103W	V_{icm} = 0 V	25°C		1	4	mV
				Full range			5	
		TL103WA	V_{icm} = 0 V	25°C		0.5	3	
				Full range			5	
αV_{IO}	Input offset-voltage drift			25°C		7		µV/°C
I_{IB}	Input bias current (negative input)			25°C		20		nA
A_{VD}	Large-signal voltage gain		V_{CC+} = 15 V, R_L = 2 kΩ, V_{icm} = 0 V	25°C		100		V/mV
k_{SVR}	Supply-voltage rejection ratio		V_{CC+} = 5 V to 30 V, V_{icm} = 0 V	25°C	65	100		dB
I_{source}	Output source current		V_{CC+} = 15 V, V_O = 2 V, V_{id} = 1 V	25°C	20	40		mA
I_{SC}	Short circuit to GND		V_{CC+} = 15 V	25°C		40	60	mA
I_{sink}	Output sink current		V_{CC+} = 15 V, V_O = 2 V, V_{id} = –1 V	25°C	10	12		mA
			V_{CC+} = 15 V, V_O = 0.2 V, V_{id} = –1 V		12	50		µA
V_{OH}	High-level output voltage		V_{CC} = 30 V, R_L = 2 kΩ	25°C	26	27		V
				Full range	26			
			V_{CC} = 30 V, R_L = 10 kΩ	25°C	27	28		
				Full range	27			
V_{OL}	Low-level output voltage		R_L = 10 kΩ	25°C		5	20	mV
				Full range			20	
SR	Slew rate at unity gain		V_{CC+} = 15 V, C_L = 100 pF, R_L = 2 kΩ, V_I = 0.5 V to 2 V, unity gain	25°C	0.2	0.4		V/µs
GBW	Gain bandwidth product		V_{CC+} = 30 V, V_I = 10 mV, C_L = 100 pF, R_L = 2 kΩ, f = 100 kHz	25°C	0.5	0.9		MHz
THD	Total harmonic distortion		V_{CC+} = 30 V, V_O = 2 V_{pp}, C_L = 100 pF, R_L = 2 kΩ, f = 1 kHz, A_V = 20 dB	25°C		0.02		%

OPAMP2, Independent Operational Amplifier Electrical Characteristics

V_{CC+} = 5 V, V_{CC} = GND, V_O = 1.4 V, T_A = 25°C (unless otherwise noted)

PARAMETER			TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	TL103W	V_{icm} = 0 V	25°C		1	4	mV
				Full range			5	
		TL103WA	V_{icm} = 0 V	25°C		0.5	3	
				Full range			5	
αV_{IO}	Input offset voltage drift			25°C		7		µV/°C
I_{IO}	Input offset current			25°C		2	75	nA
				Full range			150	
I_{IB}	Input bias current			25°C		20	150	nA
				Full range			200	
A_{VD}	Large-signal voltage gain		V_{CC+} = 15 V, R_L = 2 kΩ, V_O = 1.4 V to 11.4 V	25°C	50	100		V/mV
				Full range	25			
k_{SVR}	Supply-voltage rejection ratio		V_{CC+} = 5 V to 30 V	25°C	65	100		dB
V_{ICR}	Input common-mode voltage range		V_{CC+} = 30 V (1)	25°C	0		V_{CC+} – 1.5	V
				Full range	0		V_{CC+} – 2	
CMRR	Common-mode rejection ratio			25°C	70	85		dB
				Full range	60			
I_{source}	Output source current		V_{CC+} = 15 V, V_O = 2 V, V_{id} = 1 V	25°C	20	40		mA
I_{SC}	Short circuit to GND		V_{CC+} = 15 V	25°C		40	60	mA
I_{sink}	Output sink current		V_{CC+} = 15 V, V_O = 2 V, V_{id} = –1 V	25°C	10	12		mA
			V_{CC+} = 15 V, V_O = 0.2 V, V_{id} = –1 V		12	50		µA
V_{OH}	High-level output voltage		V_{CC} = 30 V, R_L = 2 kΩ	25°C	26	27		V
				Full range	26			
			V_{CC} = 30 V, R_L = 10 kΩ	25°C	27	28		
				Full range	27			
V_{OL}	Low-level output voltage		R_L = 10 kΩ	25°C		5	20	mV
				Full range			20	
SR	Slew rate at unity gain		V_{CC+} = 15 V, C_L = 100 pF, R_L = 2 kΩ, V_I = 0.5 V to 3 V, unity gain	25°C	0.2	0.4		V/µs
GBW	Gain bandwidth product		V_{CC+} = 30 V, V_I = 10 mV, C_L = 100 pF, R_L = 2 kΩ, f = 100 kHz	25°C	0.5	0.9		MHz
THD	Total harmonic distortion		V_{CC+} = 30 V, V_O = 2 V_{pp}, C_L = 100 pF, R_L = 2 kΩ, f = 1 kHz, A_V = 20 dB	25°C		0.02		%
V_n	Equivalent input noise voltage		V_{CC} = 30 V, R_S = 100 Ω, f = 1 kHz	25°C		50		nV/√Hz

(1) The input common-mode voltage of either input should not be allowed to go below –0.3 V. The upper end of the common-mode voltage range is V_{CC+}– 1.5 V, but either input can go to V_{CC+} + 0.3 V (but ≤36 V) without damage.

Voltage Reference Electrical Characteristics

PARAMETER			TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
V_{REF}	Reference voltage	TL103W	I_K = 10 mA	25°C	2.482	2.5	2.518	V
				Full range	2.465		2.535	
		TL103WA	I_K = 10 mA	25°C	2.49	2.5	2.51	
				Full range	2.48		2.52	
ΔV_{REF}	Reference input voltage deviation over temperature range		$V_{KA} = V_{REF}$, I_K = 10 mA	Full range		7	30	mV
I_{min}	Minimum cathode current for regulation		$V_{KA} = V_{REF}$	25°C		0.5	1	mA
$\|z_{ka}\|$	Dynamic impedance (1)		$V_{KA} = V_{REF}$, ΔI_K = 1 mA to 100 mA, f < 1 kHz	25°C		0.2	0.5	Ω

(1) The dynamic impedance is defined as

$$|z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

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Total Device Electrical Characteristics

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
I_{CC}	Total supply current, excluding cathode-current reference	V_{CC+} = 5 V, No load	Full range		0.7	1.2	mA
		V_{CC+} = 30 V, No load				2	

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
TL103WAID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WAIDE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WAIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WAIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WAIDRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WAIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WIDE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WIDRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TL103WIDRG4	ACTIVE	SOIC	D	8	2500	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.
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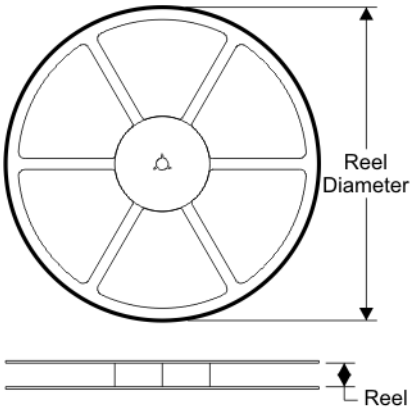
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & 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.

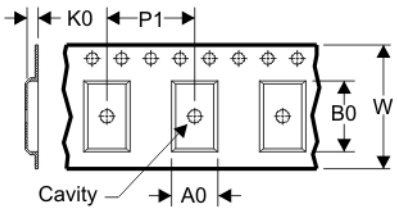
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL BOX INFORMATION

REEL DIMENSIONS

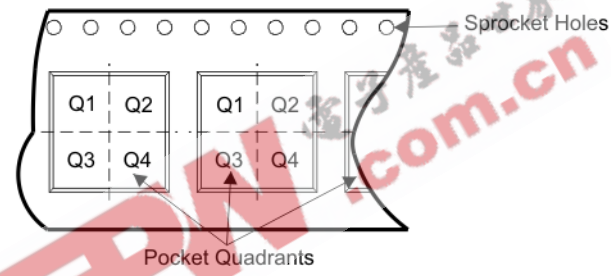


TAPE DIMENSIONS



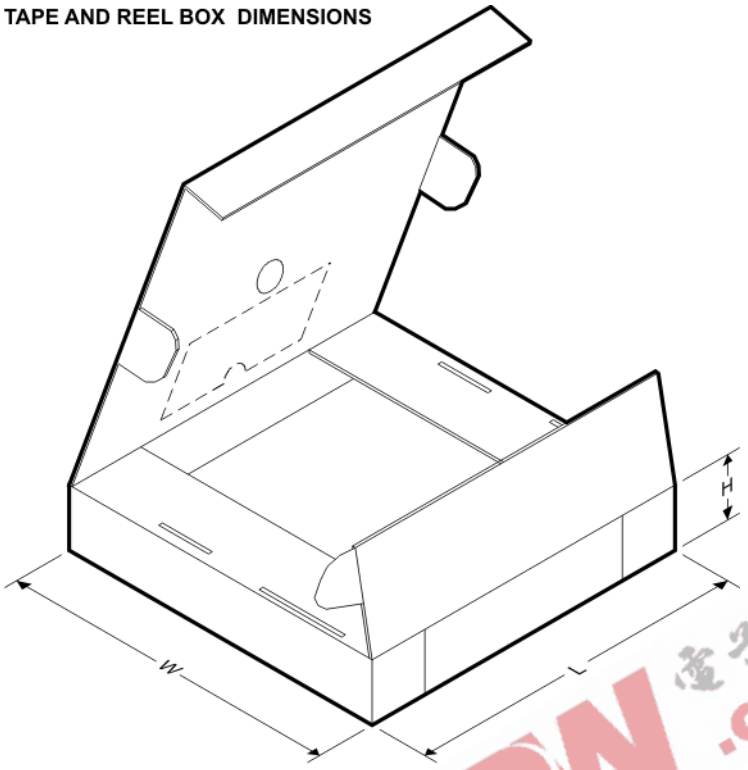
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



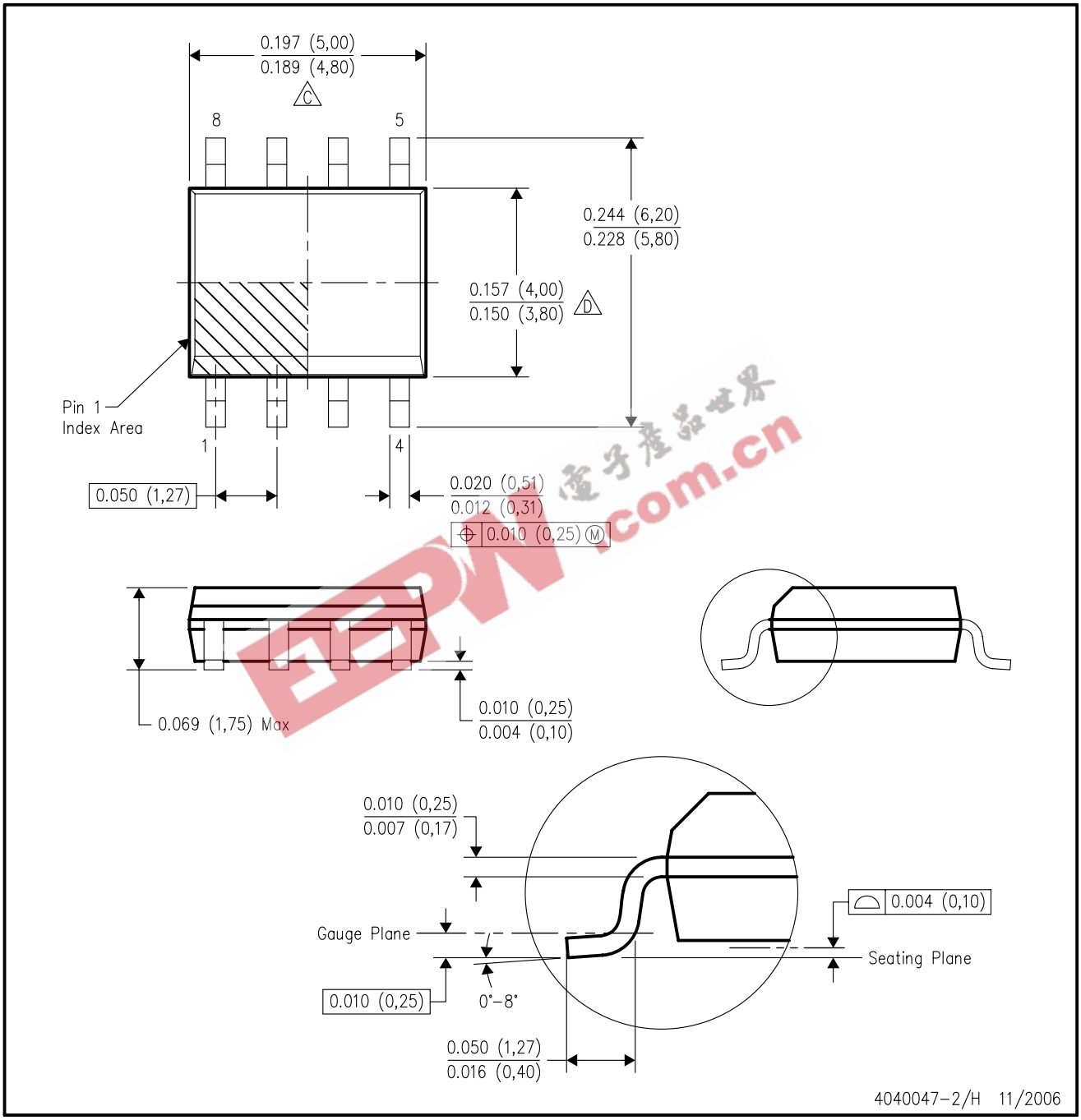
Device	Package	Pins	Site	Reel Diameter (mm)	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TL103WAIDR	D	8	SITE 27	330	12	6.4	5.2	2.1	8	12	Q1
TL103WIDR	D	8	SITE 27	330	12	6.4	5.2	2.1	8	12	Q1

TAPE AND REEL BOX DIMENSIONS



Device	Package	Pins	Site	Length (mm)	Width (mm)	Height (mm)
TL103WAIDR	D	8	SITE 27	342.9	338.1	20.64
TL103WIDR	D	8	SITE 27	342.9	338.1	20.64

D (R–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



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 AA.

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