## 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)**

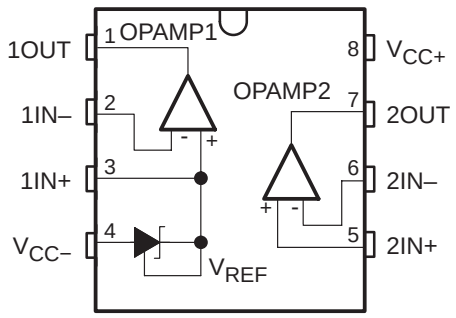
## VOLTAGE REFERENCE

- **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)**

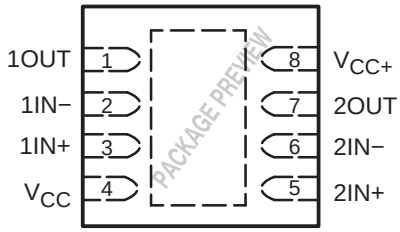
## TYPICAL APPLICATIONS

- **Battery Charger**
- **Switch-Mode Power Supply**
- **Linear Voltage Regulation**
- **Data-Acquisition Systems**

**D (SOIC) PACKAGE**
**(TOP VIEW)**




**DRJ (QFN) PACKAGE**
**(TOP VIEW)**




## 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† | | 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 | Z103WA |
| | | | 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 | |

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

### absolute maximum ratings over free-air temperature range (unless otherwise noted)‡

Supply voltage, $V_{CC}$ . . . . . 36 V
Operational amplifier input differential voltage, $V_{id}$ . . . . . 36 V
Operational amplifier input voltage range, $V_I$ . . . . . −0.3 V to 36 V
Voltage reference cathode current, $I_{KA}$ . . . . . 100 mA
Package thermal impedance, $\theta_{JA}$ (see Notes 1 and 2): D package . . . . . 97°C/W
(see Notes 1 and 3): DRJ package . . . . . TBD°C/W
Maximum junction temperature, $T_J$ . . . . . 150°C
Storage temperature range, $T_{stg}$ . . . . . −65°C to 150°C

‡ 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.

NOTES: 1. Maximum power dissipation is a function of $T_J(max)$, $\theta_{JA}$, 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
2. The package thermal impedance is calculated in accordance with JESD 51-7.
3. The package thermal impedance is calculated in accordance with JESD 51-5.

### recommended operating conditions

| | | 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 |

## typical application circuit

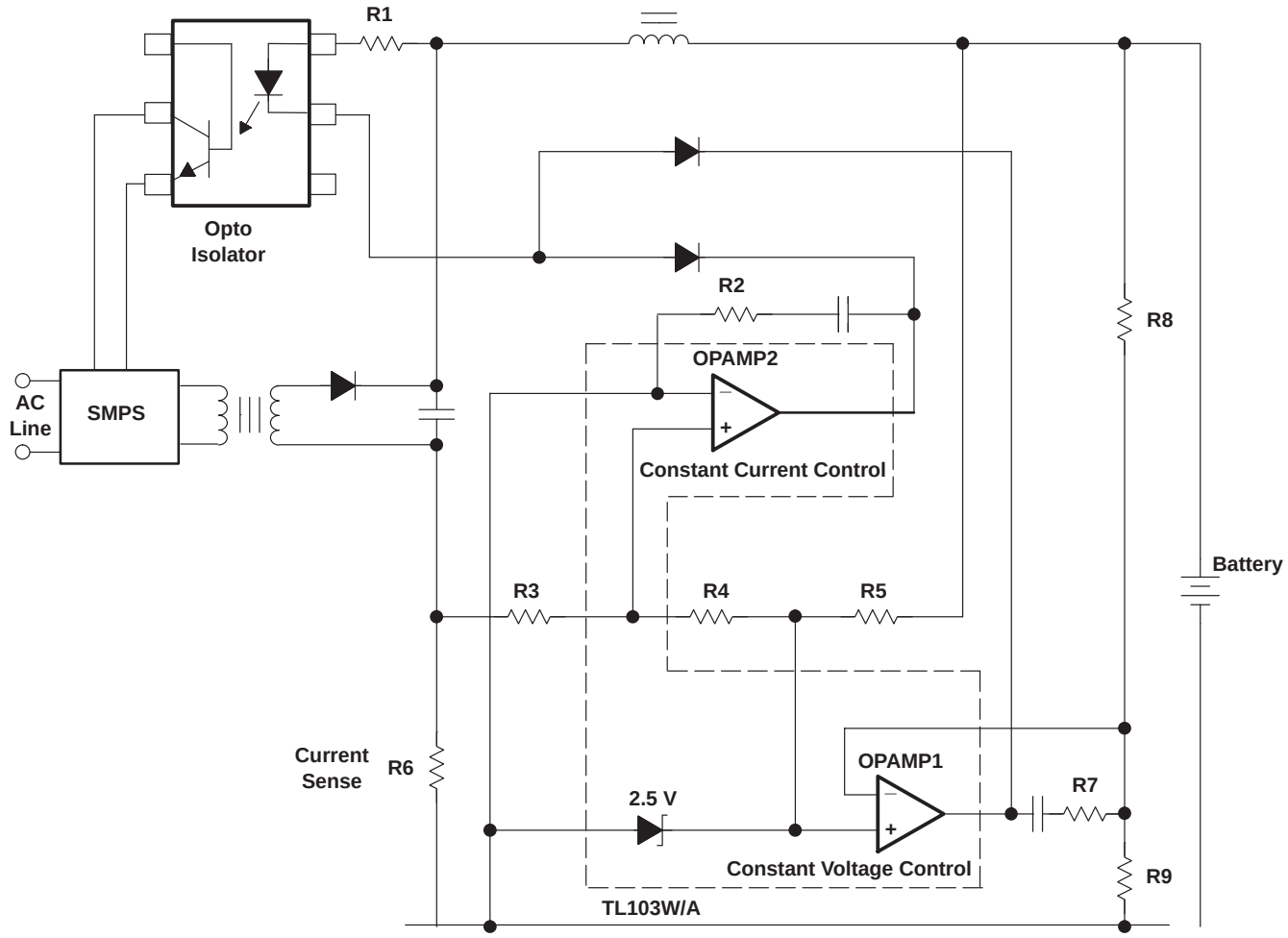



**Figure 1. TL103W/A in a Constant-Current and Constant-Voltage Battery Charger**

## 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 | |
| $\propto V_{IO}$ | 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 | |
| $\propto V_{IO}$ | 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 (see Note 4) | 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 | | | 50 | | nV/√Hz |

NOTE 4: 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 | |
| $\Delta V_{REF}$ | 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 |
| $\lvert z_{ka} \rvert$ | Dynamic impedance (see Note 5) | | $V_{KA} = V_{REF}$, $\Delta I_K$ = 1 mA to 100 mA, f < 1 kHz | 25°C | | 0.2 | 0.5 | Ω |

NOTE 5: The dynamic impedance is defined as $\lvert z_{ka} \rvert = \frac{\Delta V_{KA}}{\Delta I_K}$.

## 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

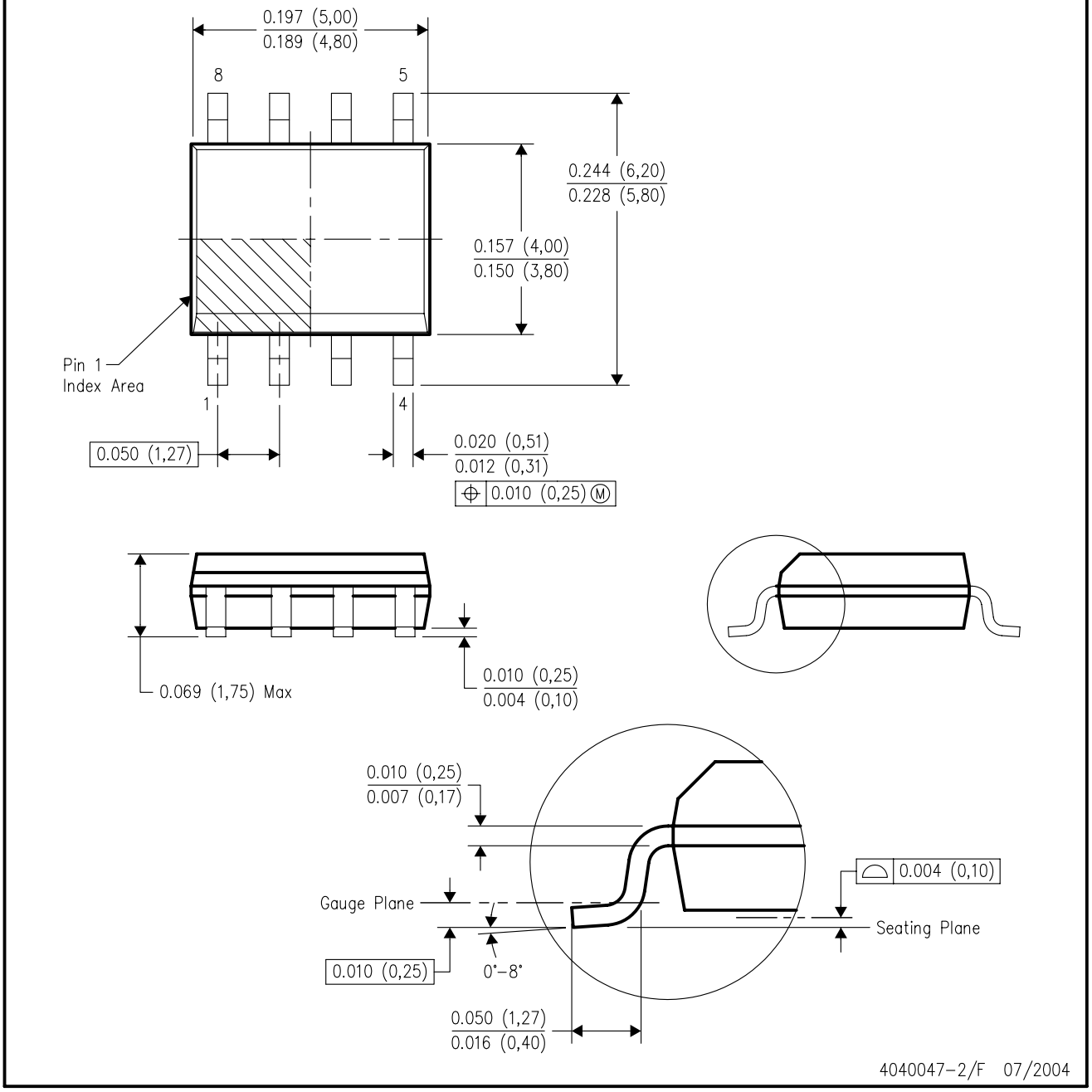
| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) |
|---|---|---|---|---|---|---|---|---|
| TL103WAID | ACTIVE | SOIC | D | 8 | 75 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-UNLIM |
| TL103WAIDR | ACTIVE | SOIC | D | 8 | 2500 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-UNLIM |
| TL103WID | ACTIVE | SOIC | D | 8 | 75 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-UNLIM |
| TL103WIDR | ACTIVE | SOIC | D | 8 | 2500 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-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) 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.
**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.

## 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 dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–012 variation AA.

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