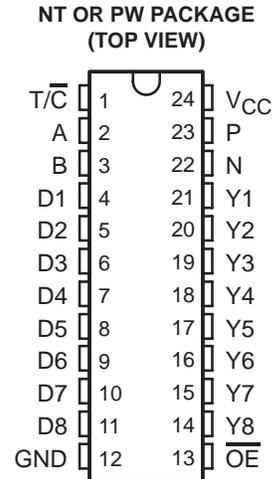


SN74LV8151

10-BIT UNIVERSAL SCHMITT-TRIGGER BUFFER WITH 3-STATE OUTPUTS

SCES610 – OCTOBER 2004

- 2-V to 5.5-V V_{CC} Operation
- Max t_{pd} of 15 ns at 5 V
- Schmitt-Trigger Inputs Allow for Slow Input Rise/Fall Time
- Polarity Control for Y Outputs Selects True or Complementary Logic
- Typical V_{OLP} (Output Ground Bounce) <0.8 V at $V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$
- Typical V_{OHV} (Output V_{OH} Undershoot) >2.3 V at $V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$
- I_{off} Supports Partial-Power-Down Mode Operation
- Supports Mixed-Mode Voltage Operation on All Ports
- Latch-Up Performance Exceeds 250 mA Per JESD 17
- ESD Protection Exceeds JESD 22
 - 2000-V Human-Body Model (A114-A)
 - 200-V Machine Model (A115-A)
 - 1000-V Charged-Device Model (C101)



description/ordering information

The SN74LV8151 is a 10-bit universal Schmitt-trigger buffer with 3-state outputs, designed for 2-V to 5.5-V V_{CC} operation. The logic control (T/\overline{C}) pin allows the user to configure Y1 to Y8 as noninverting or inverting outputs. When T/\overline{C} is high, the Y outputs are noninverted (true logic), and when T/\overline{C} is low, the Y outputs are inverted (complementary logic).

When output-enable (\overline{OE}) input is low, the device passes data from D_n to Y_n . When \overline{OE} is high, the Y outputs are in the high-impedance state. The path A to P is a simple Schmitt-trigger buffer, and the path B to N is a simple Schmitt-trigger inverter.

This device is fully specified for partial-power-down applications using I_{off} . The I_{off} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

To ensure the high-impedance state during power up or power down, \overline{OE} should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

ORDERING INFORMATION

| T_A | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---------------|------------|---------------|-----------------------|------------------|
| –40°C to 85°C | PDIP – NT | Tube | SN74LV8151NT | SN74LV8151NT |
| | TSSOP – PW | Tube | SN74LV8151PW | LV8151 |
| | | Tape and reel | SN74LV8151PWR | |

† 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.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS
INSTRUMENTS**

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SN74LV8151

10-BIT UNIVERSAL SCHMITT-TRIGGER BUFFER

WITH 3-STATE OUTPUTS

SCES610 – OCTOBER 2004

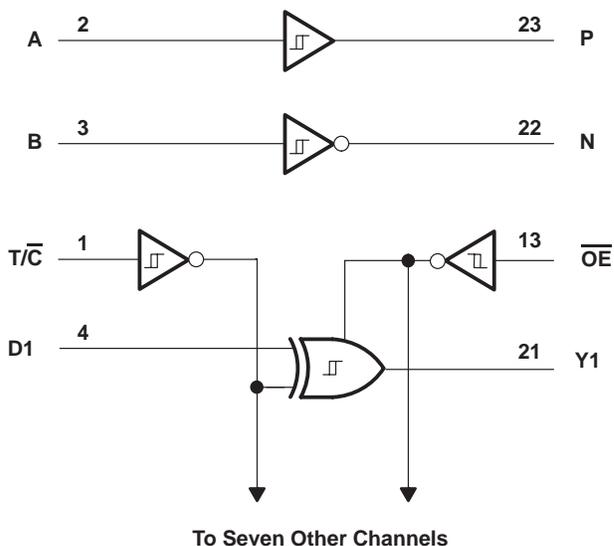
FUNCTION TABLES

| INPUT A | OUTPUT P |
|------------|-------------|
| L | L |
| H | H |

| INPUT B | OUTPUT N |
|------------|-------------|
| L | H |
| H | L |

| INPUTS | | | OUTPUT Y |
|-----------------|------------------|---|-------------|
| \overline{OE} | T/\overline{C} | D | |
| L | L | L | H |
| L | L | H | L |
| L | H | L | L |
| L | H | H | H |
| H | X | X | Z |

logic diagram



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

| | |
|---|----------------------------|
| Supply voltage range, V_{CC} | -0.5 V to 7 V |
| Input voltage range, V_I (see Note 1) | -0.5 V to 7 V |
| Voltage range applied to any output in the high-impedance or power-off state, V_O (see Note 1) | -0.5 V to 7 V |
| Output voltage range, V_O (see Notes 1 and 2) | -0.5 V to $V_{CC} + 0.5$ V |
| Input clamp current, I_{IK} ($V_I < 0$) | -20 mA |
| Output clamp current, I_{OK} ($V_O < 0$) | -50 mA |
| Continuous output current, I_O ($V_O = 0$ to V_{CC}) | ± 35 mA |
| Continuous current through V_{CC} or GND | ± 70 mA |
| Package thermal impedance, θ_{JA} (see Note 3): NT package | 67°C/W |
| (see Note 4): PW package | 88°C/W |
| 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. The input and output voltage ratings may be exceeded if the input and output current ratings are observed.
2. This value is limited to 5.5 V maximum.
3. The package thermal impedance is calculated in accordance with JESD 51-3.
4. The package thermal impedance is calculated in accordance with JESD 51-7.

SN74LV8151
10-BIT UNIVERSAL SCHMITT-TRIGGER BUFFER
WITH 3-STATE OUTPUTS

SCES610 – OCTOBER 2004

recommended operating conditions (see Note 5)

| | | V_{CC} | MIN | MAX | UNIT | | |
|---------------------|------------------------------------|----------------|--------------------------------------|----------------|----------------|------|------|
| V_{CC} | Supply voltage | | 2 | 5.5 | V | | |
| V_{IH} | High-level input voltage | 2 V | 1.5 | | V | | |
| | | 2.3 V to 2.7 V | $V_{CC} \times 0.7$ | | | | |
| | | 3 V to 3.6 V | $V_{CC} \times 0.7$ | | | | |
| | | 4.5 V to 5.5 V | $V_{CC} \times 0.7$ | | | | |
| V_{IL} | Low-level input voltage | 2 V | | 0.5 | V | | |
| | | 2.3 V to 2.7 V | $V_{CC} \times 0.3$ | | | | |
| | | 3 V to 3.6 V | $V_{CC} \times 0.3$ | | | | |
| | | 4.5 V to 5.5 V | $V_{CC} \times 0.3$ | | | | |
| V_I | Input voltage | | 0 | 5.5 | V | | |
| V_O | Output voltage | | High or low state | 0 | V_{CC} | V | |
| | | | 3-state | 0 | 5.5 | | |
| I_{OH} | High-level output current | 2 V | | -50 | μA | | |
| | | 2.3 V to 2.7 V | | -2 | mA | | |
| | | 3 V to 3.6 V | | -6 | | | |
| | | 4.5 V to 5.5 V | | -12 | | | |
| I_{OL} | Low-level output current | 2 V | | 50 | μA | | |
| | | 2.3 V to 2.7 V | | 2 | mA | | |
| | | 3 V to 3.6 V | | 6 | | | |
| | | 4.5 V to 5.5 V | | 12 | | | |
| $\Delta t/\Delta v$ | Input transition rise or fall rate | | T/\bar{C} , \overline{OE} inputs | 2.3 V to 2.7 V | 200 | ns/V | |
| | | | | 3 V to 3.6 V | 100 | | |
| | | | | 4.5 V to 5.5 V | 20 | | |
| | | | | A, B, D inputs | 2.3 V to 2.7 V | 4 | ms/V |
| | | | | | 3 V to 3.6 V | 3 | |
| | | | | | 4.5 V to 5.5 V | 2 | |
| T_A | Operating free-air temperature | | -40 | 85 | $^{\circ}C$ | | |

NOTES: 5. All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.



SN74LV8151

10-BIT UNIVERSAL SCHMITT-TRIGGER BUFFER WITH 3-STATE OUTPUTS

SCES610 – OCTOBER 2004

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

| PARAMETER | TEST CONDITIONS | V _{CC} | MIN | TYP | MAX | UNIT |
|---|---|-----------------|-----------------------|-----|------|------|
| V _{T+} Positive-going input threshold voltage | A, B, and D inputs | 2.5 V | | | 1.75 | V |
| | | 3.3 V | | | 2.31 | |
| | | 5 V | | | 3.5 | |
| V _{T-} Negative-going input threshold voltage | A, B, and D inputs | 2.5 V | 0.75 | | | V |
| | | 3.3 V | 0.99 | | | |
| | | 5 V | 1.5 | | | |
| ΔV _T Hysteresis (V _{T+} - V _{T-}) | A, B, and D inputs | 2.5 V | 0.25 | | 1 | V |
| | | 3.3 V | 0.33 | | 1.32 | |
| | | 5 V | 0.5 | | 2 | |
| V _{OH} | I _{OH} = -50 μA | 2 V to 5.5 V | V _{CC} - 0.1 | | | V |
| | I _{OH} = -2 mA | 2.3 V | 2 | | | |
| | I _{OH} = -6 mA | 3 V | 2.48 | | | |
| | I _{OH} = -12 mA | 4.5 V | 3.8 | | | |
| V _{OL} | I _{OL} = 50 μA | 2 V to 5.5 V | | | 0.1 | V |
| | I _{OL} = 2 mA | 2.3 V | | | 0.4 | |
| | I _{OL} = 6 mA | 3 V | | | 0.44 | |
| | I _{OL} = 12 mA | 4.5 V | | | 0.55 | |
| I _I | V _I = 5.5 V or GND | 0 to 5.5 V | | | ±1 | μA |
| I _{OZ} | V _O = V _{CC} or GND | 5.5 V | | | ±5 | μA |
| I _{CC} | V _I = V _{CC} or GND, I _O = 0 | 5.5 V | | | 20 | μA |
| I _{off} | V _I or V _O = 0 to 5.5 V | 0 | | | 5 | μA |
| C _i | V _I = V _{CC} or GND | 3.3 V | | 3 | | pF |
| | | 5 V | | 3 | | |
| C _o | V _O = V _{CC} or GND | 3.3 V | | 5 | | pF |
| | | 5 V | | 5 | | |

switching characteristics over recommended operating free-air temperature range, V_{CC} = 2.5 V ± 0.2 V (unless otherwise noted) (see Figure 1)

| PARAMETER | FROM (INPUT) | TO (OUTPUT) | LOAD CAPACITANCE | T _A = 25°C | | UNIT | |
|------------------|------------------------|----------------|------------------------|------------------------|---------|------|----|
| | | | | TYP | MIN MAX | | |
| t _{pd} | A or B | P or N | C _L = 15 pF | 22 | 1 45 | ns | |
| | D | Y | | 23 | 1 49 | | |
| | T/C | Y | | 24 | 1 50 | | |
| t _{en} | $\overline{\text{OE}}$ | Y | | 12 | 1 25 | ns | |
| t _{dis} | $\overline{\text{OE}}$ | Y | | 11 | 1 20 | ns | |
| t _{pd} | A or B | P or N | | C _L = 50 pF | 26 | 1 52 | ns |
| | D | Y | | | 28 | 1 57 | |
| | T/C | Y | | | 29 | 1 58 | |
| t _{en} | $\overline{\text{OE}}$ | Y | | | 15 | 1 30 | ns |
| t _{dis} | $\overline{\text{OE}}$ | Y | 15 | | 1 26 | ns | |

SN74LV8151

10-BIT UNIVERSAL SCHMITT-TRIGGER BUFFER WITH 3-STATE OUTPUTS

SCES610 – OCTOBER 2004

switching characteristics over recommended operating free-air temperature range, $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ (unless otherwise noted) (see Figure 1)

| PARAMETER | FROM (INPUT) | TO (OUTPUT) | LOAD CAPACITANCE | $T_A = 25^\circ\text{C}$ | | UNIT |
|-----------|-----------------------------|-------------|----------------------|--------------------------|---------|------|
| | | | | TYP | MIN MAX | |
| t_{pd} | A or B | P or N | $C_L = 15\text{ pF}$ | 14 | 1 26 | ns |
| | D | Y | | 15 | 1 29 | |
| | $\overline{T/\overline{C}}$ | Y | | 16 | 1 30 | |
| t_{en} | \overline{OE} | Y | | 9 | 1 16 | ns |
| t_{dis} | \overline{OE} | Y | | 8 | 1 14 | ns |
| t_{pd} | A or B | P or N | | $C_L = 50\text{ pF}$ | 17 | 1 32 |
| | D | Y | 18 | | 1 34 | |
| | $\overline{T/\overline{C}}$ | Y | 20 | | 1 36 | |
| t_{en} | \overline{OE} | Y | 11 | | 1 20 | ns |
| t_{dis} | \overline{OE} | Y | 11 | | 1 18 | ns |

switching characteristics over recommended operating free-air temperature range, $V_{CC} = 5\text{ V} \pm 0.5\text{ V}$ (unless otherwise noted) (see Figure 1)

| PARAMETER | FROM (INPUT) | TO (OUTPUT) | LOAD CAPACITANCE | $T_A = 25^\circ\text{C}$ | | UNIT |
|-----------|-----------------------------|-------------|----------------------|--------------------------|---------|------|
| | | | | TYP | MIN MAX | |
| t_{pd} | A or B | P or N | $C_L = 15\text{ pF}$ | 9 | 1 15 | ns |
| | D | Y | | 10 | 1 16 | |
| | $\overline{T/\overline{C}}$ | Y | | 11 | 1 17 | |
| t_{en} | \overline{OE} | Y | | 6 | 1 10.5 | ns |
| t_{dis} | \overline{OE} | Y | | 6 | 1 10 | ns |
| t_{pd} | A or B | P or N | | $C_L = 50\text{ pF}$ | 11 | 1 18 |
| | D | Y | 12 | | 1 20 | |
| | $\overline{T/\overline{C}}$ | Y | 13 | | 1 21 | |
| t_{en} | \overline{OE} | Y | 8 | | 1 12.5 | ns |
| t_{dis} | \overline{OE} | Y | 8 | | 1 11.5 | ns |

noise characteristics, $V_{CC} = 3.3\text{ V}$, $C_L = 50\text{ pF}$ (see Note 6)

| PARAMETER | $T_A = 25^\circ\text{C}$ | | | UNIT |
|--|--------------------------|------|------|------|
| | MIN | TYP | MAX | |
| $V_{OL(P)}$ Quiet output, maximum dynamic V_{OL} | | 0.6 | | V |
| $V_{OL(V)}$ Quiet output, minimum dynamic V_{OL} | | -0.6 | | V |
| $V_{OH(V)}$ Quiet output, minimum dynamic V_{OH} | | 2.9 | | V |
| $V_{IH(D)}$ High-level dynamic input voltage | | 2.31 | | V |
| $V_{IL(D)}$ Low-level dynamic input voltage | | | 0.99 | V |

NOTE 6: Characteristics are for surface-mount packages only.



SN74LV8151
10-BIT UNIVERSAL SCHMITT-TRIGGER BUFFER
WITH 3-STATE OUTPUTS
SCES610 – OCTOBER 2004

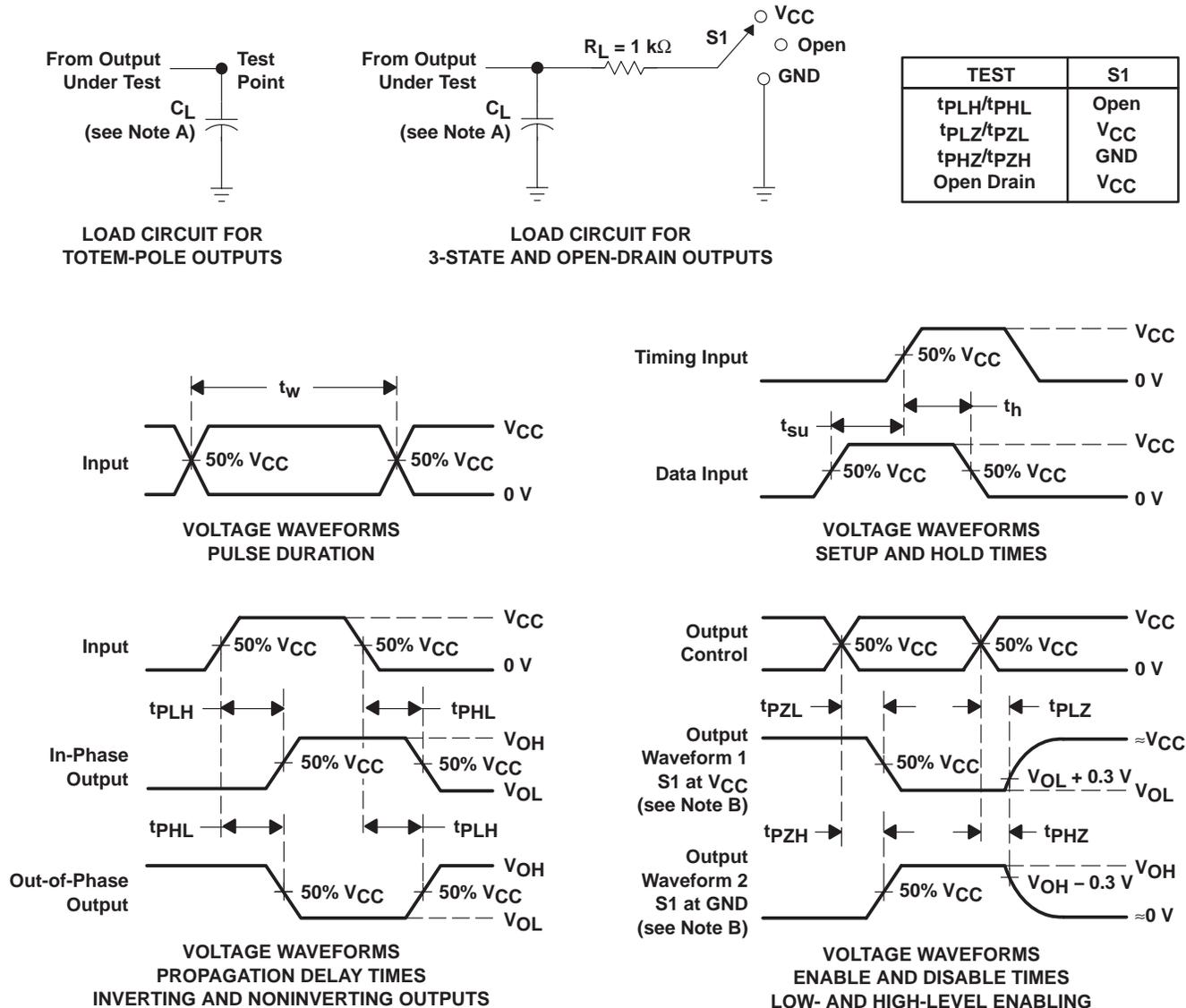
operating characteristics, $T_A = 25^\circ\text{C}$

| PARAMETER | TEST CONDITIONS | V _{CC} | TYP | UNIT |
|---|-------------------------------------|-----------------|-----|------|
| C _{pd} Power dissipation capacitance | C _L = No load, f = 1 MHz | 3.3 V | 15 | pF |
| | | 5 V | 16 | |

SN74LV8151 10-BIT UNIVERSAL SCHMITT-TRIGGER BUFFER WITH 3-STATE OUTPUTS

SCES610 – OCTOBER 2004

PARAMETER MEASUREMENT INFORMATION



- NOTES:
- A. C_L includes probe and jig capacitance.
 - B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
 - C. All input pulses are supplied by generators having the following characteristics: PRR $\leq 1\text{ MHz}$, $Z_O = 50\ \Omega$, $t_r \leq 3\text{ ns}$, $t_f \leq 3\text{ ns}$.
 - D. The outputs are measured one at a time, with one input transition per measurement.
 - E. t_{PLZ} and t_{PHZ} are the same as t_{dis} .
 - F. t_{PZL} and t_{PZH} are the same as t_{en} .
 - G. t_{PHL} and t_{PLH} are the same as t_{pd} .
 - H. All parameters and waveforms are not applicable to all devices.

Figure 1. Load Circuit and Voltage Waveforms

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/ Ball Finish | MSL Peak Temp ⁽³⁾ | Samples (Requires Login) |
|------------------|-----------------------|--------------|-----------------|------|-------------|----------------------------|----------------------|------------------------------|-----------------------------|
| SN74LV8151DGVR | ACTIVE | TVSOP | DGV | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151DGVRE4 | ACTIVE | TVSOP | DGV | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151DGVRG4 | ACTIVE | TVSOP | DGV | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151DW | ACTIVE | SOIC | DW | 24 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151DWE4 | ACTIVE | SOIC | DW | 24 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151DWG4 | ACTIVE | SOIC | DW | 24 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151DWR | ACTIVE | SOIC | DW | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151DWRE4 | ACTIVE | SOIC | DW | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151DWRG4 | ACTIVE | SOIC | DW | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151NT | ACTIVE | PDIP | NT | 24 | 15 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | |
| SN74LV8151NTE4 | ACTIVE | PDIP | NT | 24 | 15 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | |
| SN74LV8151PW | ACTIVE | TSSOP | PW | 24 | 60 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151PWE4 | ACTIVE | TSSOP | PW | 24 | 60 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151PWG4 | ACTIVE | TSSOP | PW | 24 | 60 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151PWR | ACTIVE | TSSOP | PW | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151PWRE4 | ACTIVE | TSSOP | PW | 24 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| SN74LV8151PWRG4 | ACTIVE | TSSOP | PW | 24 | 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.

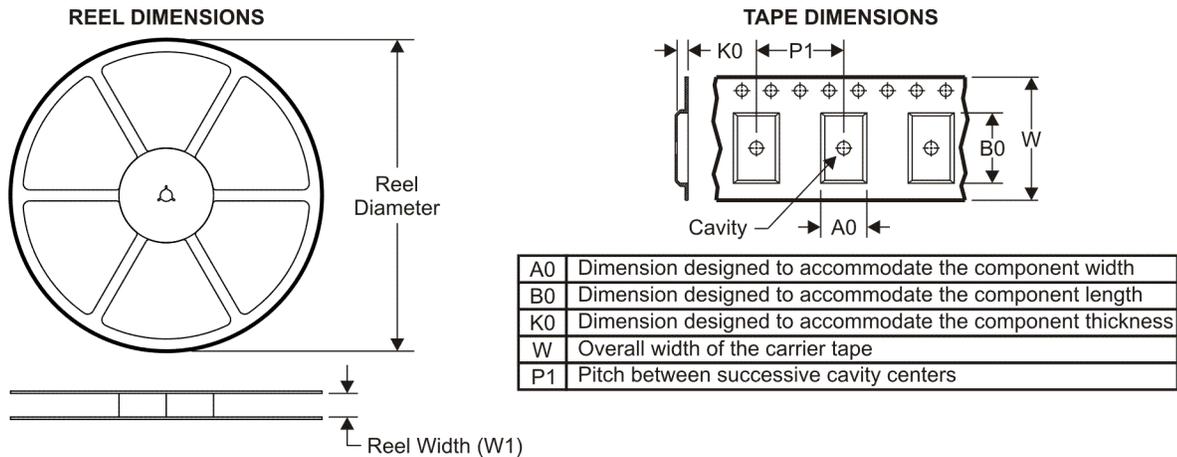
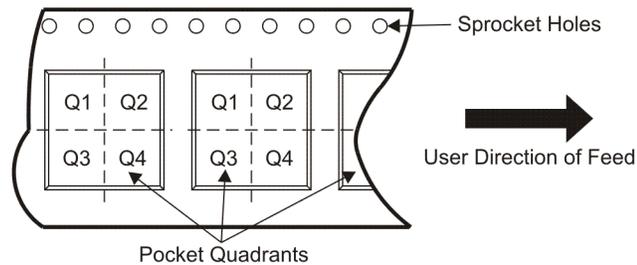
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

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.

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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 |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN74LV8151DGVR | TVSOP | DGV | 24 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| SN74LV8151PWR | TSSOP | PW | 24 | 2000 | 330.0 | 16.4 | 6.95 | 8.3 | 1.6 | 8.0 | 16.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS

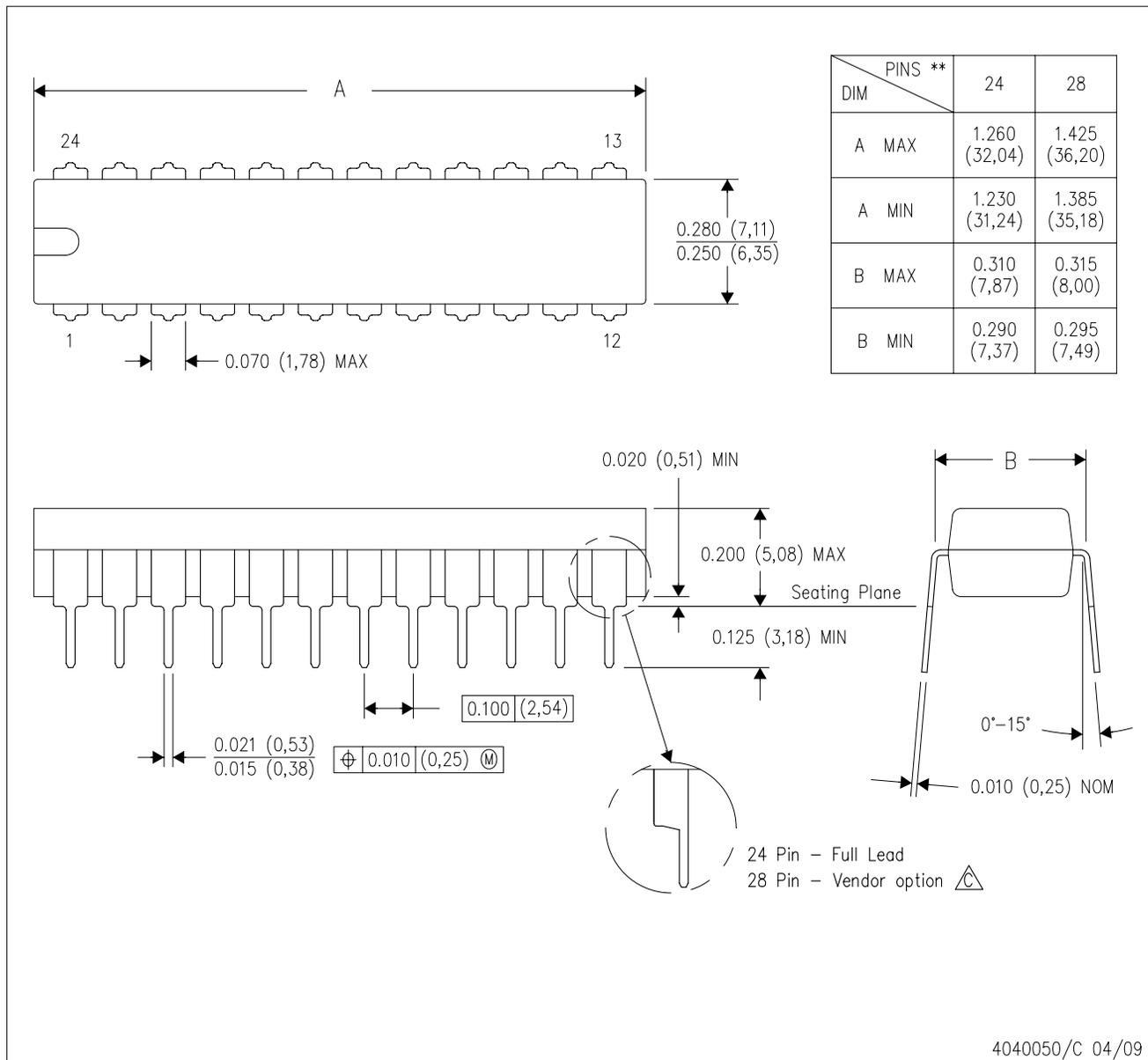

*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN74LV8151DGVR | TVSOP | DGV | 24 | 2000 | 346.0 | 346.0 | 29.0 |
| SN74LV8151PWR | TSSOP | PW | 24 | 2000 | 346.0 | 346.0 | 33.0 |

MECHANICAL DATA

NT (R-PDIP-T**) 24 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE

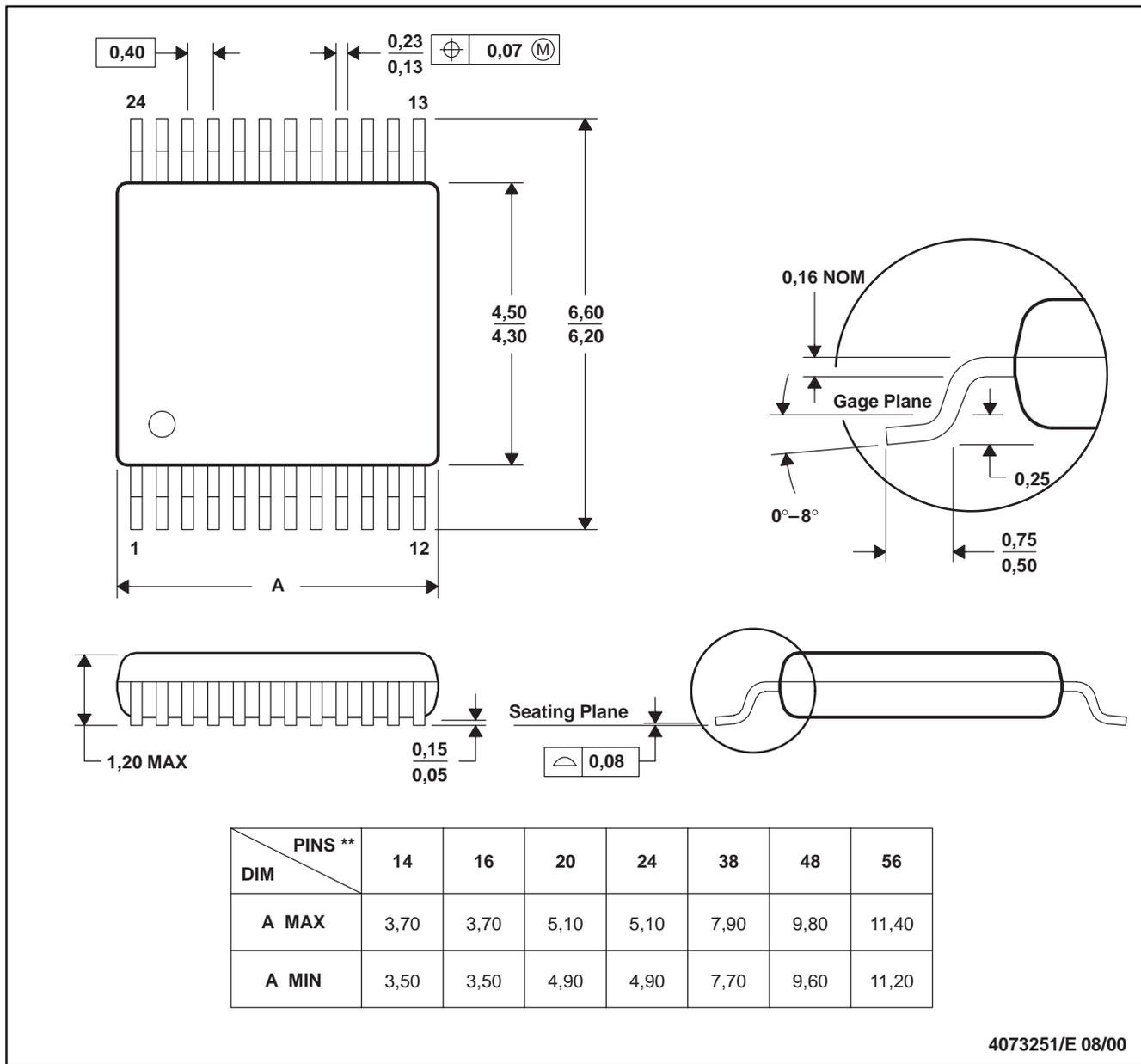


- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 -  The 28 pin end lead shoulder width is a vendor option, either half or full width.

DGV (R-PDSO-G**)

PLASTIC SMALL-OUTLINE

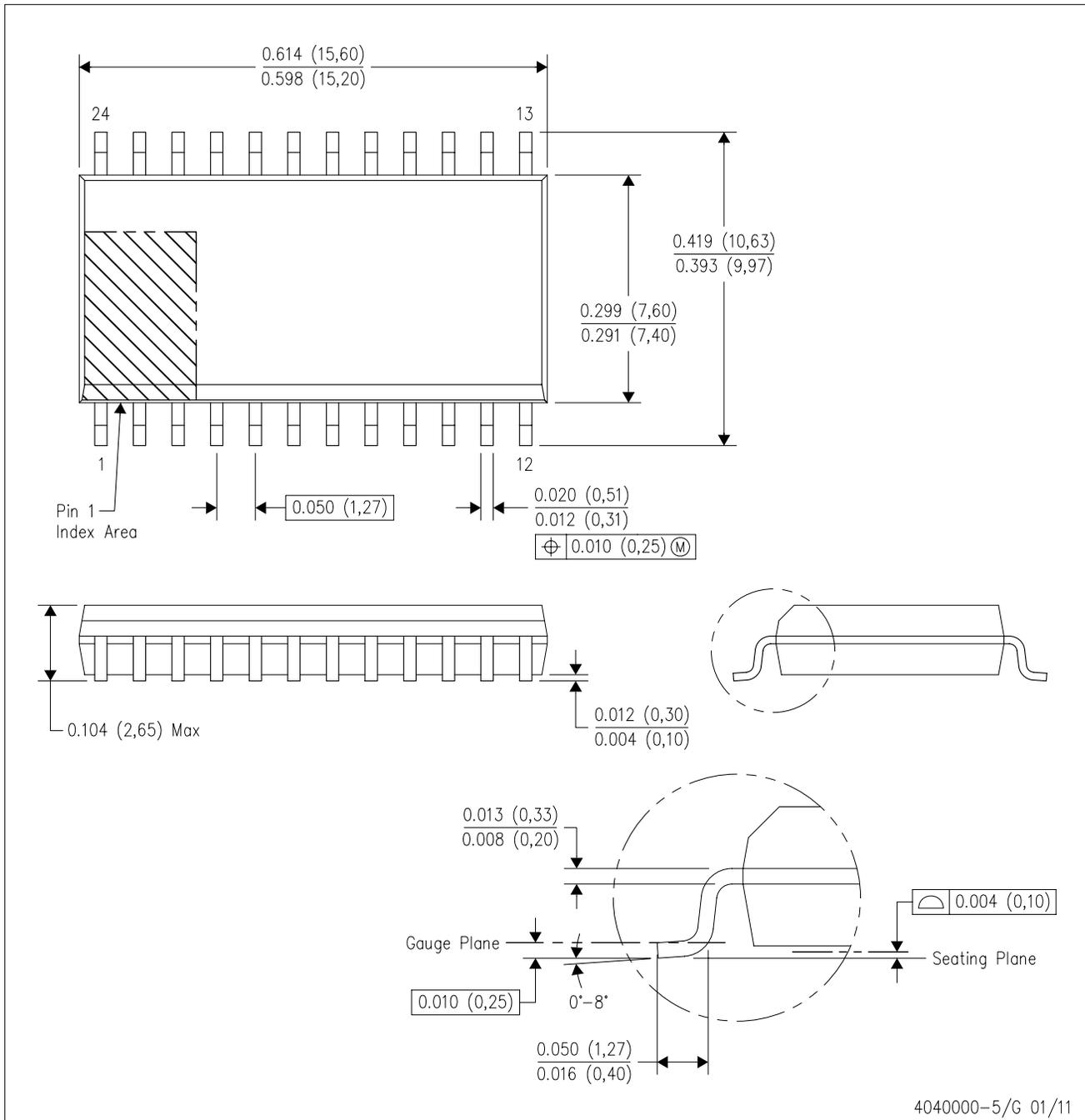
24 PINS SHOWN



- 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 per side.
 D. Falls within JEDEC: 24/48 Pins – MO-153
 14/16/20/56 Pins – MO-194

DW (R-PDSO-G24)

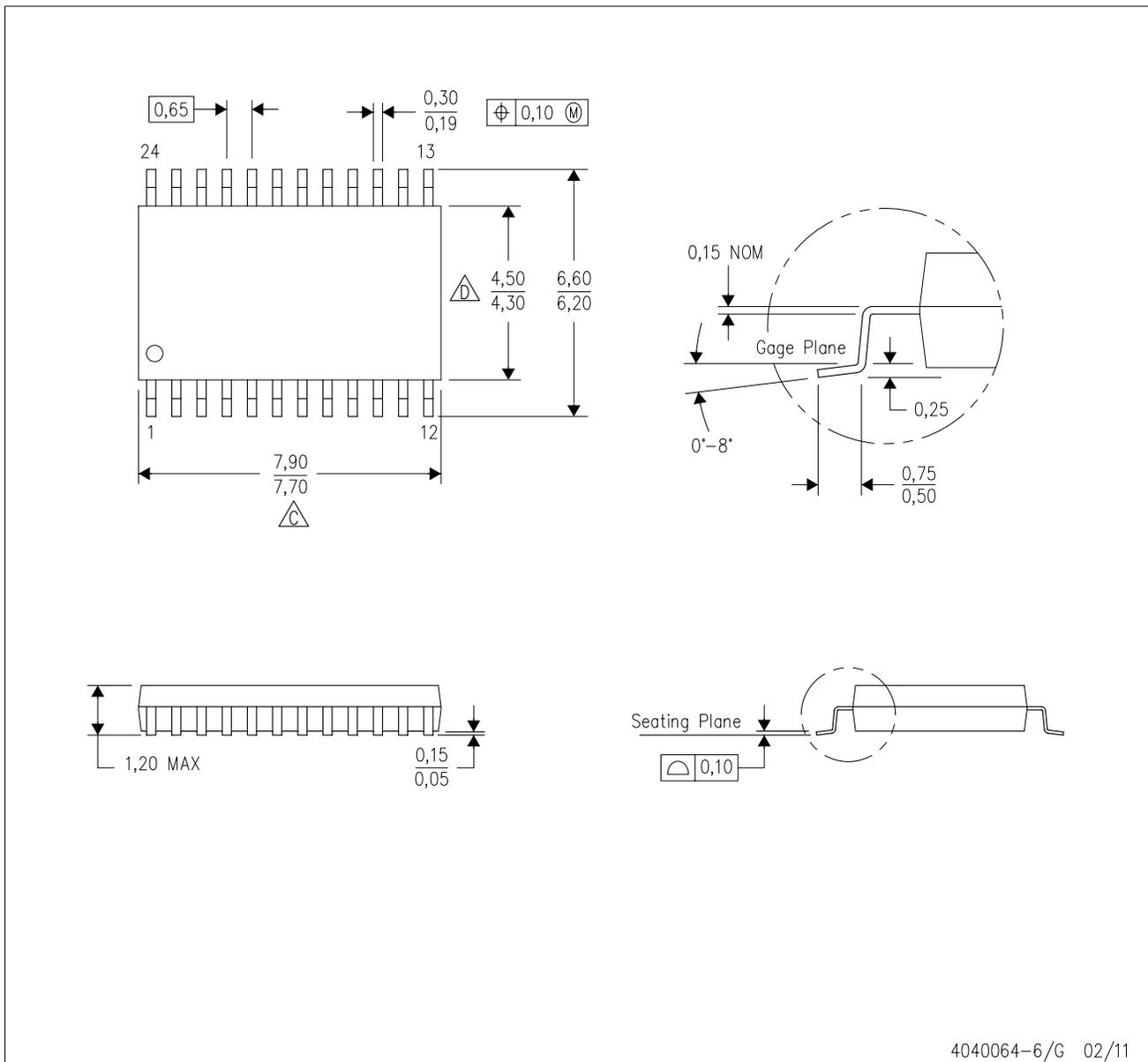
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters). Dimensioning and tolerancing per ASME Y14.5M-1994.
 - 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-013 variation AD.

PW (R-PDSO-G24)

PLASTIC SMALL OUTLINE

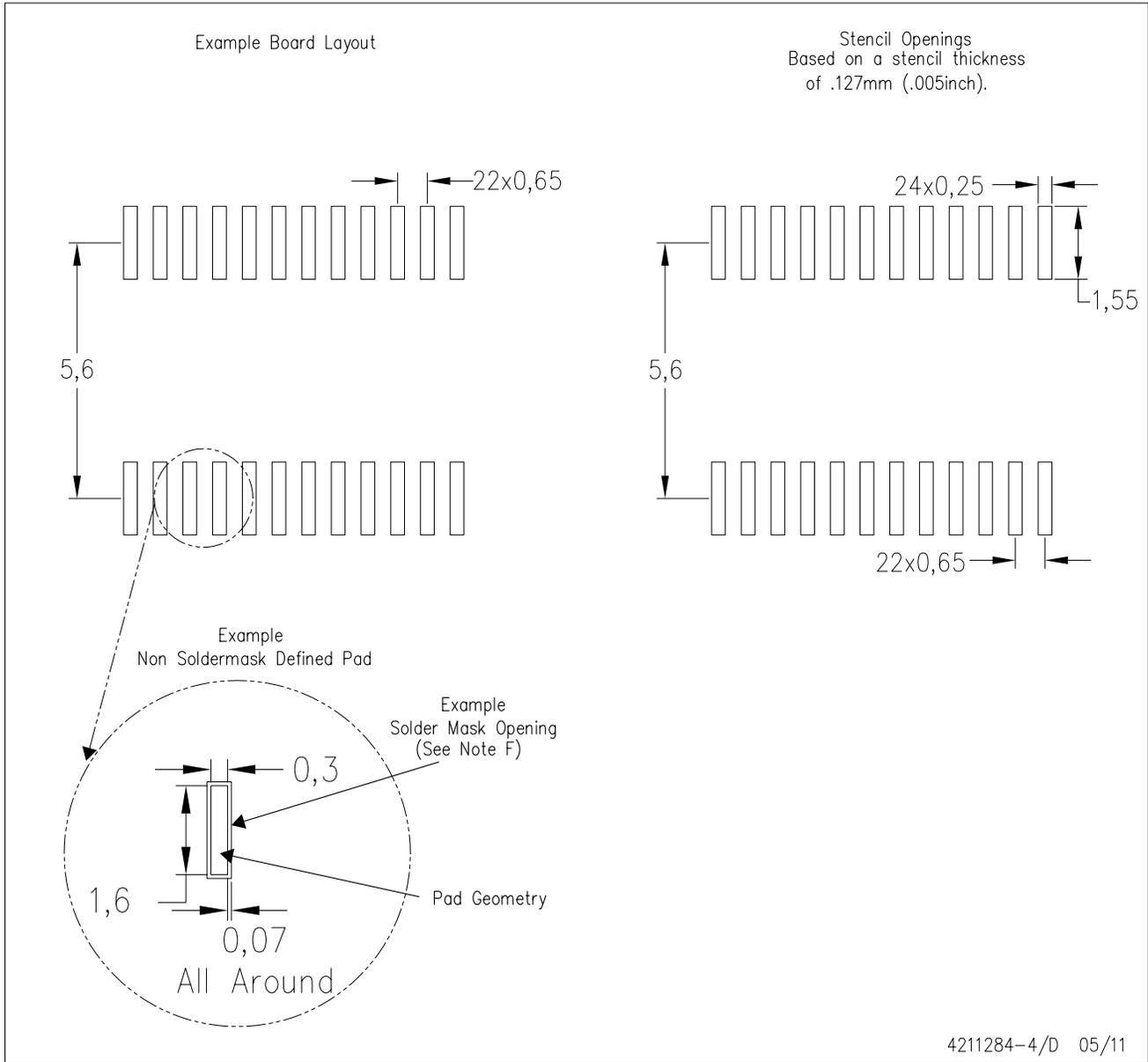


4040064-6/G 02/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - 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 0,15 each side.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
 - E. Falls within JEDEC MO-153

PW (R-PDSO-G24)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate design.
 - D. 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. Refer to IPC-7525 for other stencil recommendations.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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