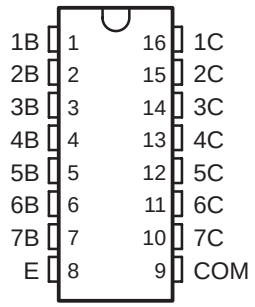
- **500-mA-Rated Collector Current (Single Output)**
- **High-Voltage Outputs . . . 50 V**
- **Output Clamp Diodes**
- **Inputs Compatible With Various Types of Logic**
- **Relay-Driver Applications**

D, N, OR NS PACKAGE
(TOP VIEW)



description/ordering information

The ULN2004AI is a high-voltage, high-current Darlington transistor array. This device consists of seven npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher-current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers.

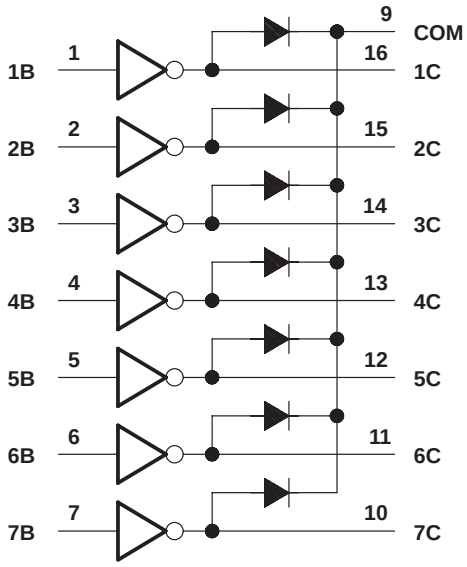
The ULN2004AI has a 10.5-kΩ series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices.

ORDERING INFORMATION

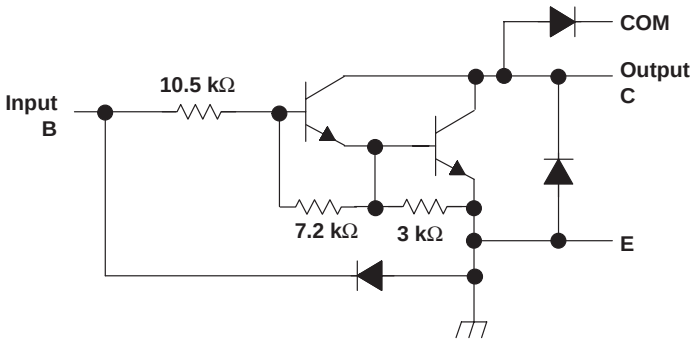
T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−40°C to 105°C	PDIP (N)	Tube of 25	ULN2004AIN	ULN2004AIN
	SOIC (D)	Tube of 40	ULN2004AID	ULN2004AI
		Reel of 2500	ULN2004AIDR	
	SOP (NS)	Reel of 2000	ULN2004AINSR	ULN2004AI

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

logic diagram



schematics (each Darlington pair)



All resistor values shown are nominal.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)†

Collector-emitter voltage . . . . . 50 V
Clamp diode reverse voltage (see Note 1) . . . . . 50 V
Input voltage, V_I (see Note 1) . . . . . 30 V
Peak collector current (see Notes 2 and 4) . . . . . 500 mA
Output clamp current, I_{OK} . . . . . 500 mA
Total emitter-terminal current . . . . . −2.5 A
Operating free-air temperature range, T_A . . . . . −40°C to 105°C
Package thermal impedance, θ_{JA} (see Notes 2 and 3): D package . . . . . 73°C/W
N package . . . . . 67°C/W
NS package . . . . . 64°C/W
Operating virtual 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. All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.
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 $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
3. The package thermal impedance is calculated in accordance with JESD 51-7.

electrical characteristics, T_A = 25°C

PARAMETER		TEST FIGURE	TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{I(on)}$	On-state input voltage	6	V_{CE} = 2 V	I_C = 125 mA			5	V
				I_C = 200 mA			6	
				I_C = 275 mA			7	
				I_C = 350 mA			8	
$V_{CE(sat)}$	Collector-emitter saturation voltage	5	I_I = 250 μA,	I_C = 100 mA		0.9	1.1	V
			I_I = 350 μA,	I_C = 200 mA		1	1.3	
			I_I = 500 μA,	I_C = 350 mA		1.2	1.6	
I_{CEX}	Collector cutoff current	1	V_{CE} = 50 V,	I_I = 0			50	μA
V_F	Clamp forward voltage	8	I_F = 350 mA			1.7	2	V
I_I	Input current	4	V_I = 5 V			0.35	0.5	mA
			V_I = 12 V			1	1.45	
I_R	Clamp reverse current	7	V_R = 50 V				50	μA
C_i	Input capacitance		V_I = 0,	f = 1 MHz		15	25	pF

electrical characteristics, T_A = −40°C to 105°C

PARAMETER		TEST FIGURE	TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{I(on)}$	On-state input voltage	6	V_{CE} = 2 V	I_C = 125 mA			5	V
				I_C = 200 mA			6	
				I_C = 275 mA			7	
				I_C = 350 mA			8	
$V_{CE(sat)}$	Collector-emitter saturation voltage	5	I_I = 250 µA,	I_C = 100 mA		0.9	1.1	V
			I_I = 350 µA,	I_C = 200 mA		1	1.3	
			I_I = 500 µA,	I_C = 350 mA		1.2	1.6	
I_{CEX}	Collector cutoff current	1	V_{CE} = 50 V,	I_I = 0			50	µA
		2	V_{CE} = 50 V	I_I = 0			100	
				V_I = 1 V			500	
V_F	Clamp forward voltage	8	I_F = 350 mA			1.7	2	V
$I_{I(off)}$	Off-state input current	3	V_{CE} = 50 V,	I_C = 500 µA	50	65		µA
I_I	Input current	4	V_I = 5 V			0.35	0.5	mA
			V_I = 12 V			1	1.45	
I_R	Clamp reverse current	7	V_R = 50 V				100	µA
C_i	Input capacitance		V_I = 0,	f = 1 MHz		15	25	pF

switching characteristics, T_A = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{PLH}	Propagation delay time, low- to high-level output	See Figure 8			0.25	1	µs
t_{PHL}	Propagation delay time, high- to low-level output	See Figure 8			0.25	1	µs
V_{OH}	High-level output voltage after switching	V_S = 50 V, See Figure 9	$I_O \approx$ 300 mA,	V_S − 20			mV

switching characteristics, T_A = −40°C to 105°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{PLH}	Propagation delay time, low- to high-level output	See Figure 8			1	10	µs
t_{PHL}	Propagation delay time, high- to low-level output	See Figure 8			1	10	µs
V_{OH}	High-level output voltage after switching	V_S = 50 V, See Figure 9	$I_O \approx$ 300 mA,	V_S − 500			mV

PARAMETER MEASUREMENT INFORMATION

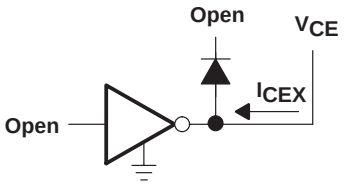


Figure 1. I_{CEX} Test Circuit

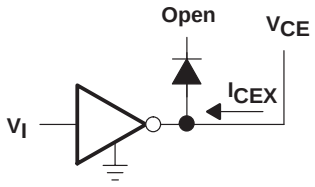


Figure 2. I_{CEX} Test Circuit

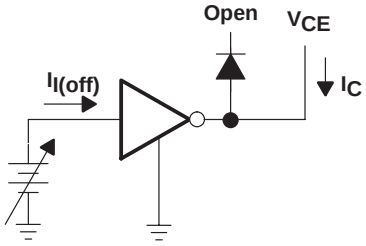


Figure 3. $I_{I(off)}$ Test Circuit

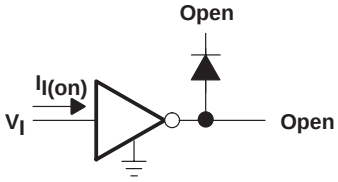
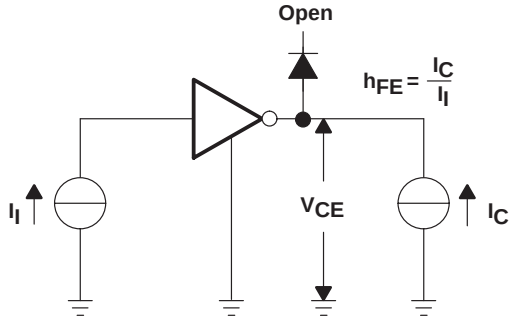


Figure 4. I_I Test Circuit



NOTE: I_I is fixed for measuring $V_{CE(sat)}$, variable for measuring h_{FE}.

Figure 5. h_{FE}, $V_{CE(sat)}$ Test Circuit

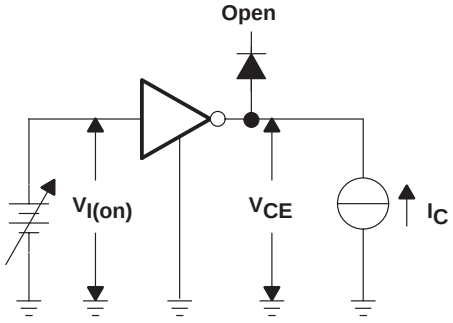


Figure 6. $V_{I(on)}$ Test Circuit

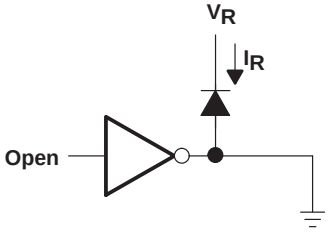


Figure 7. I_R Test Circuit

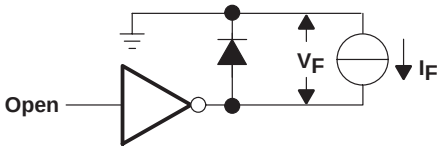
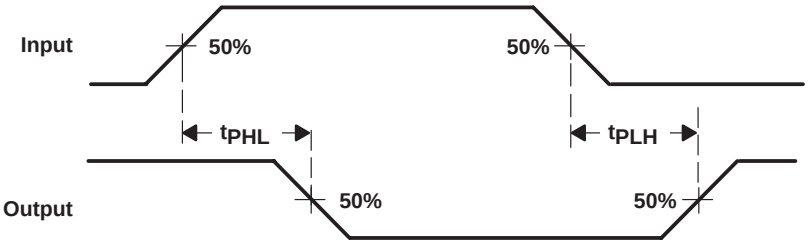


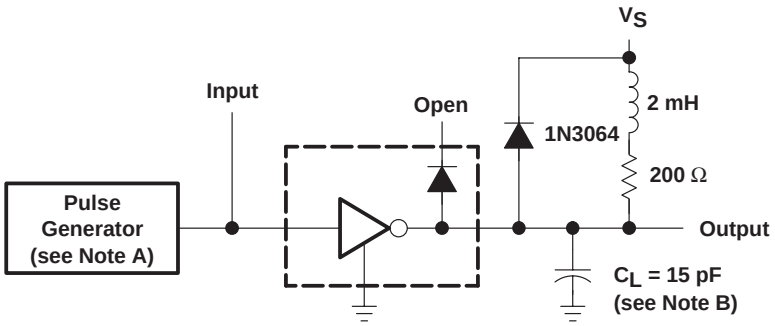
Figure 8. V_F Test Circuit

PARAMETER MEASUREMENT INFORMATION

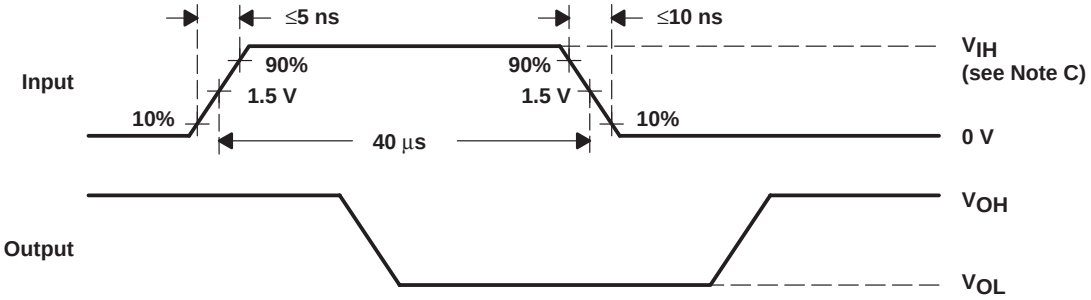


VOLTAGE WAVEFORMS

Figure 9. Propagation Delay-Time Waveforms



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: A. The pulse generator has the following characteristics: PRR = 12.5 kHz, Z_O = 50 Ω.
B. C_L includes probe and jig capacitance.
C. For testing, V_{IH} = 3 V

Figure 10. Latch-Up Test Circuit and Voltage Waveforms

TYPICAL CHARACTERISTICS

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT (ONE DARLINGTON)

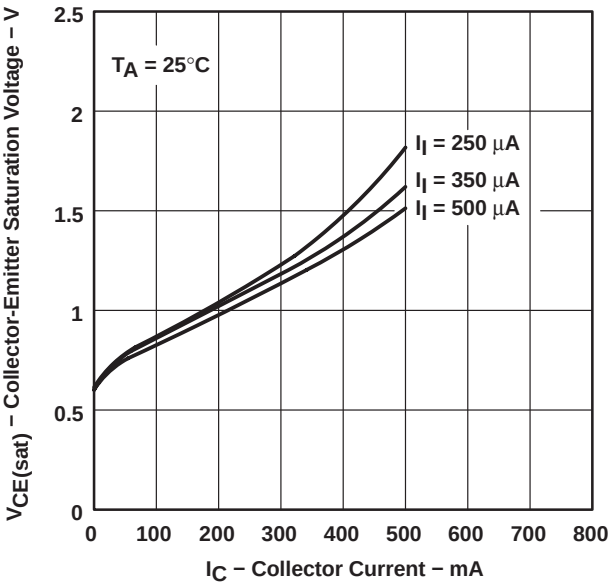


Figure 11

COLLECTOR-EMITTER SATURATION VOLTAGE vs TOTAL COLLECTOR CURRENT (TWO DARLINGTONS IN PARALLEL)

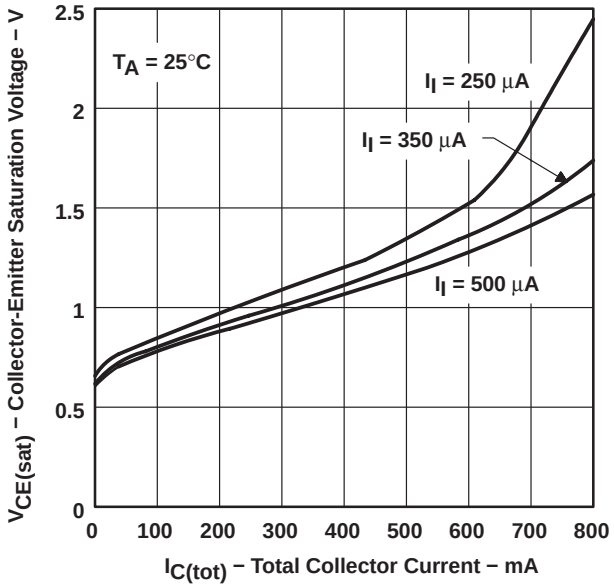


Figure 12

COLLECTOR CURRENT vs INPUT CURRENT

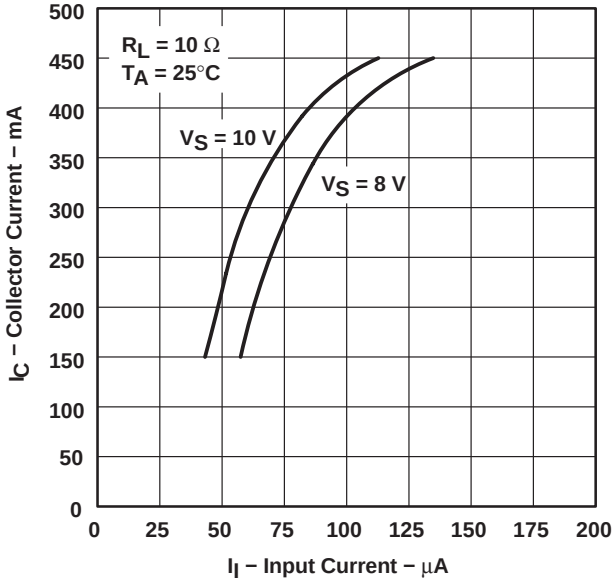


Figure 13

APPLICATION INFORMATION

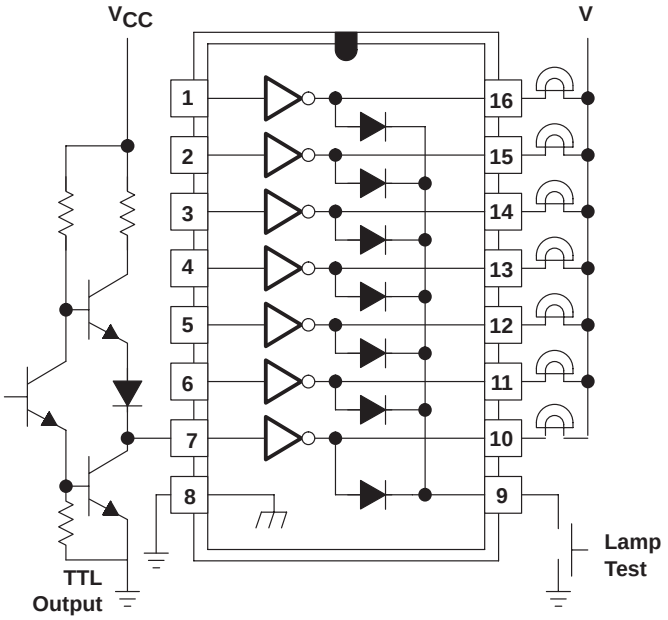


Figure 14. TTL to Load

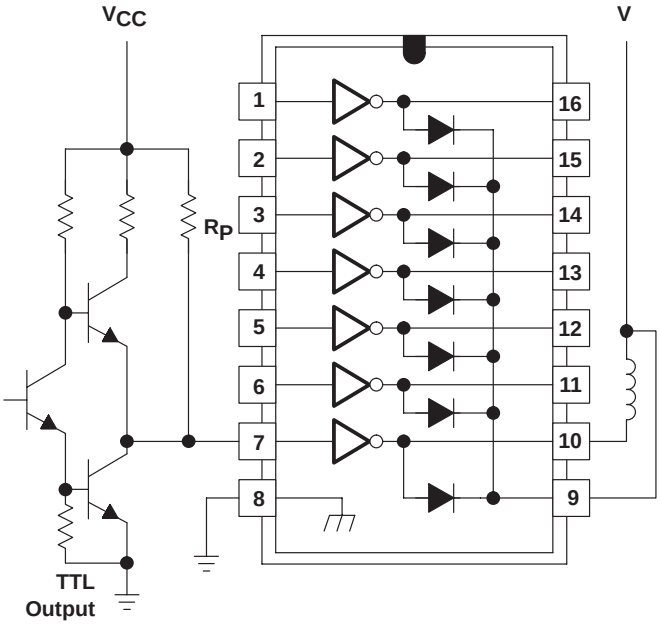


Figure 15. Use of Pullup Resistors to Increase Drive Current

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
ULN2004AID	Active	Production	SOIC (D) | 16	40 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 105	ULN2004AI
ULN2004AID.A	Active	Production	SOIC (D) | 16	40 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 105	ULN2004AI
ULN2004AIDR	Active	Production	SOIC (D) | 16	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 105	ULN2004AI
ULN2004AIDR.A	Active	Production	SOIC (D) | 16	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 105	ULN2004AI
ULN2004AIN	Active	Production	PDIP (N) | 16	25 | TUBE	Yes	NIPDAU	N/A for Pkg Type	-40 to 105	ULN2004AIN
ULN2004AIN.A	Active	Production	PDIP (N) | 16	25 | TUBE	Yes	NIPDAU	N/A for Pkg Type	-40 to 105	ULN2004AIN
ULN2004AINSR	Active	Production	SOP (NS) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 105	ULN2004AI
ULN2004AINSR.A	Active	Production	SOP (NS) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 105	ULN2004AI

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

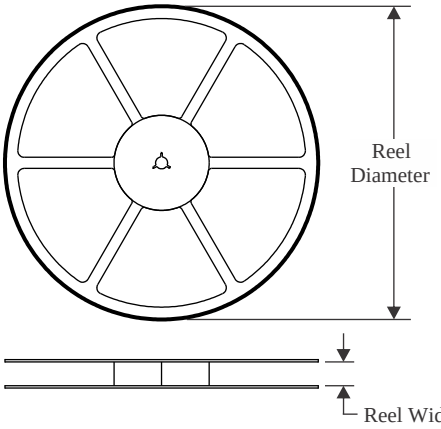
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

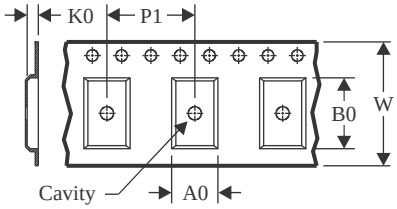
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

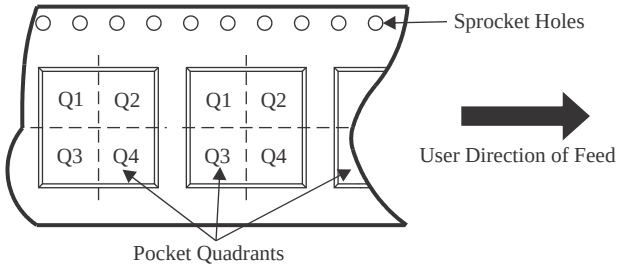


TAPE DIMENSIONS



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

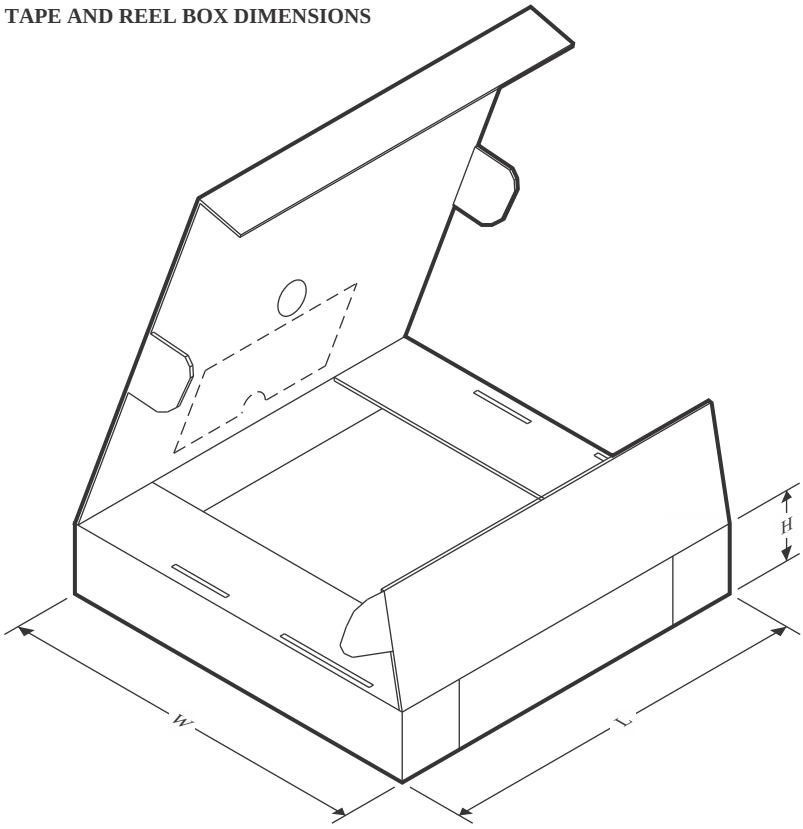
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
ULN2004AIDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
ULN2004AINSR	SOP	NS	16	2000	330.0	16.4	8.1	10.4	2.5	12.0	16.0	Q1

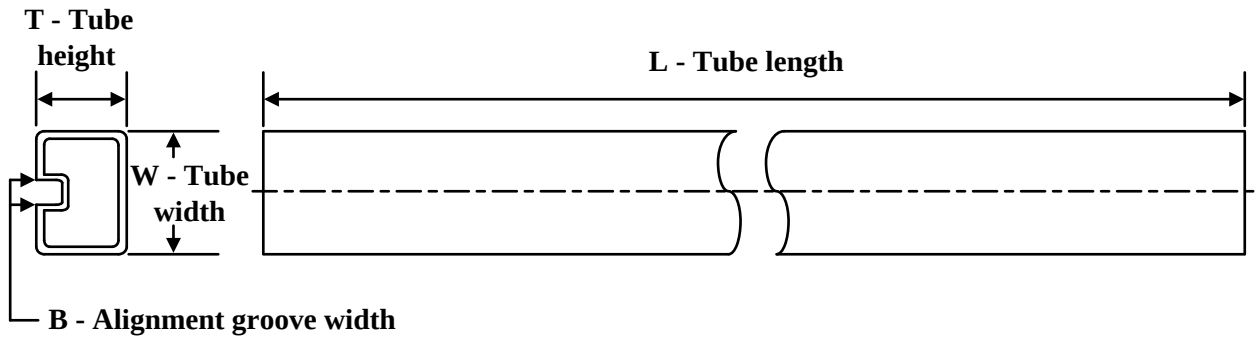
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ULN2004AIDR	SOIC	D	16	2500	353.0	353.0	32.0
ULN2004AINSR	SOP	NS	16	2000	353.0	353.0	32.0

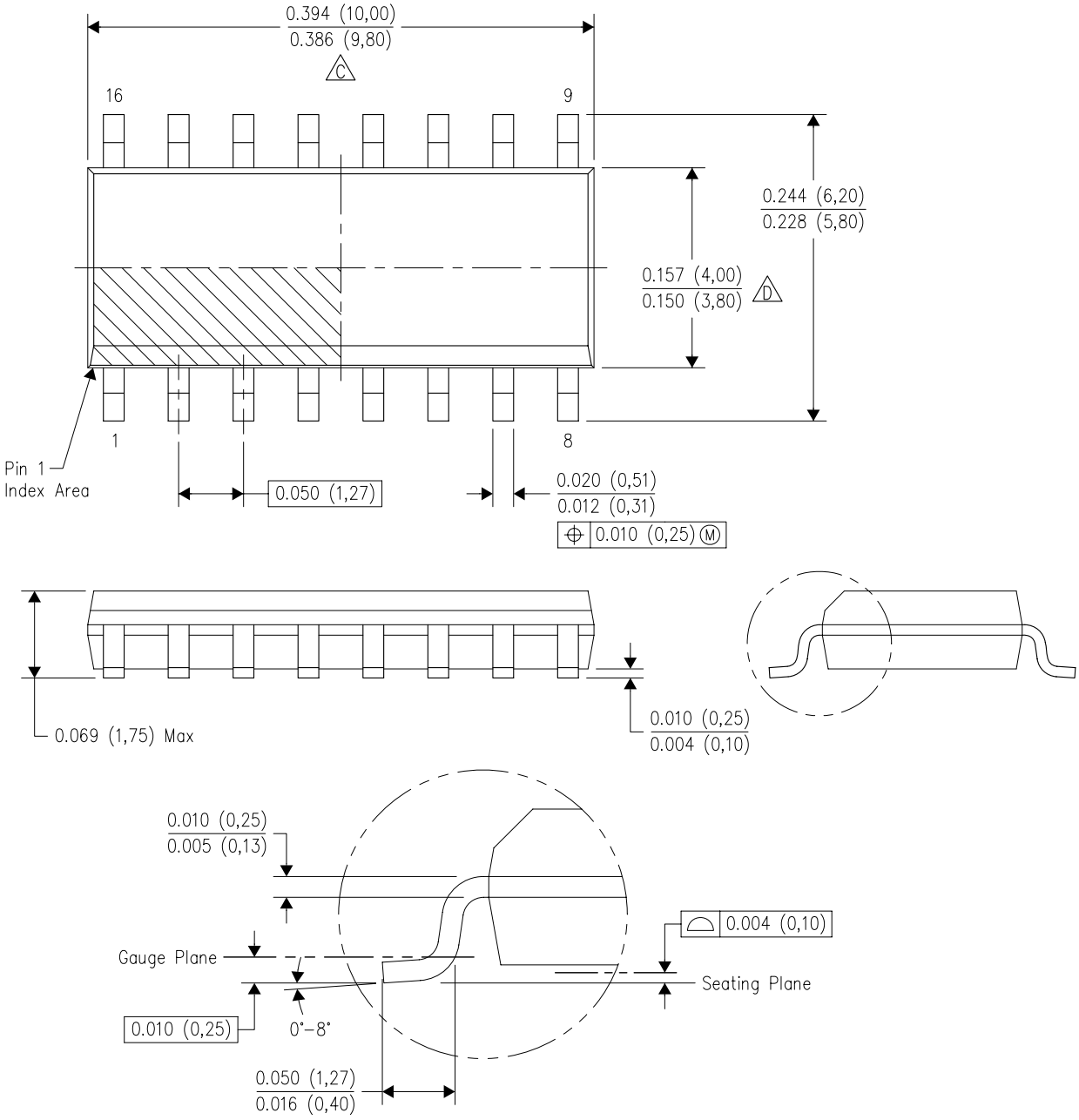
TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
ULN2004AID	D	SOIC	16	40	507	8	3940	4.32
ULN2004AID.A	D	SOIC	16	40	507	8	3940	4.32
ULN2004AIN	N	PDIP	16	25	506	13.97	11230	4.32
ULN2004AIN	N	PDIP	16	25	506	13.97	11230	4.32
ULN2004AIN.A	N	PDIP	16	25	506	13.97	11230	4.32
ULN2004AIN.A	N	PDIP	16	25	506	13.97	11230	4.32

D (R–PDSO–G16) PLASTIC SMALL OUTLINE

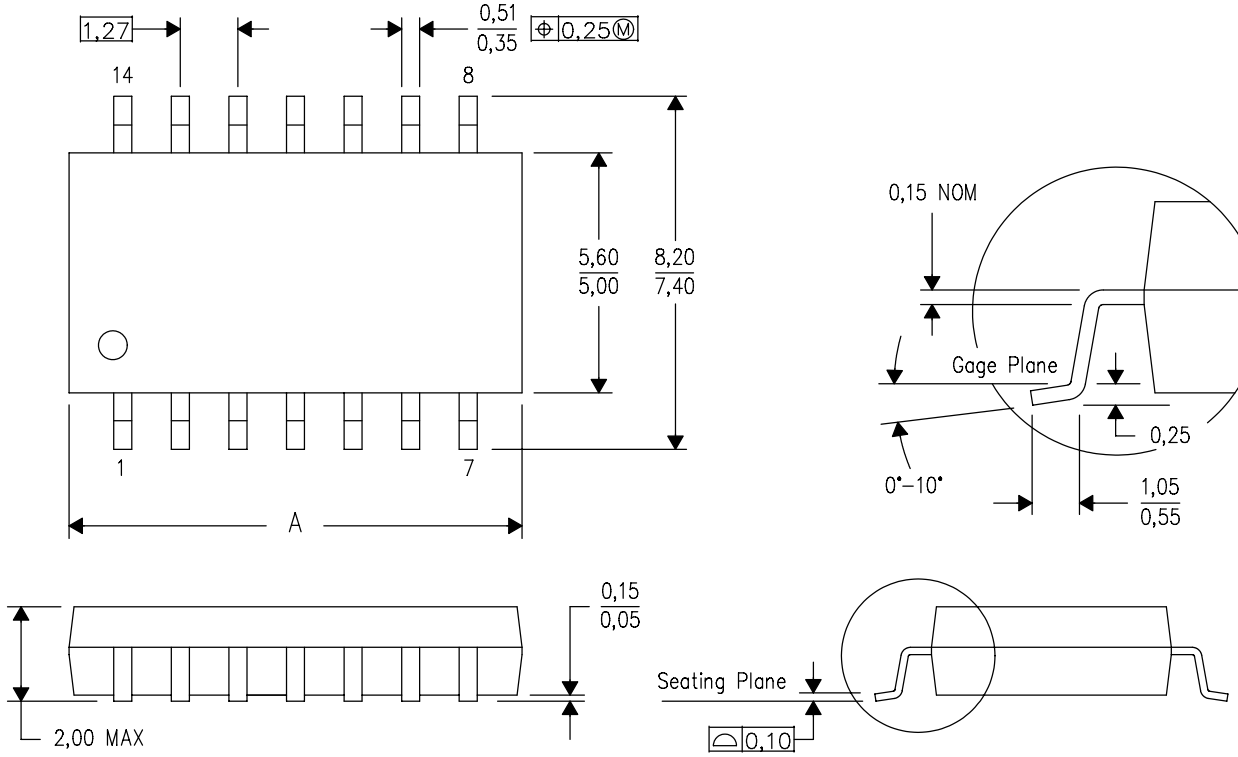


NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AC.

MECHANICAL DATA

NS (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14-PINS SHOWN



DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

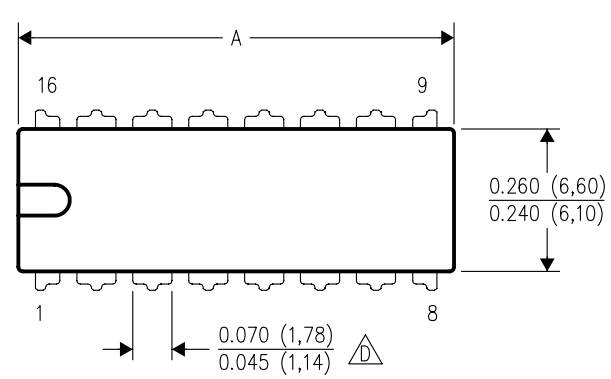
4040062/C 03/03

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.

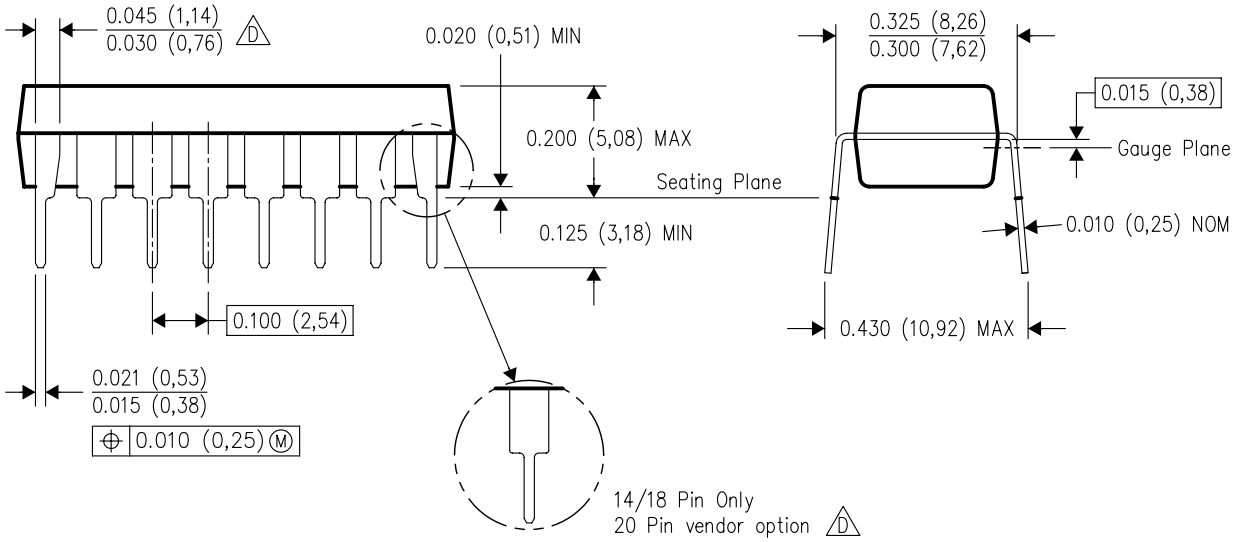
N (R–PDIP–T**)

PLASTIC DUAL–IN–LINE PACKAGE

16 PINS SHOWN

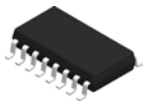


DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS–001 VARIATION (C)	AA	BB	AC	AD



4040049/E 12/2002

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001, except 18 and 20 pin minimum body length (Dim A).
D. The 20 pin end lead shoulder width is a vendor option, either half or full width.

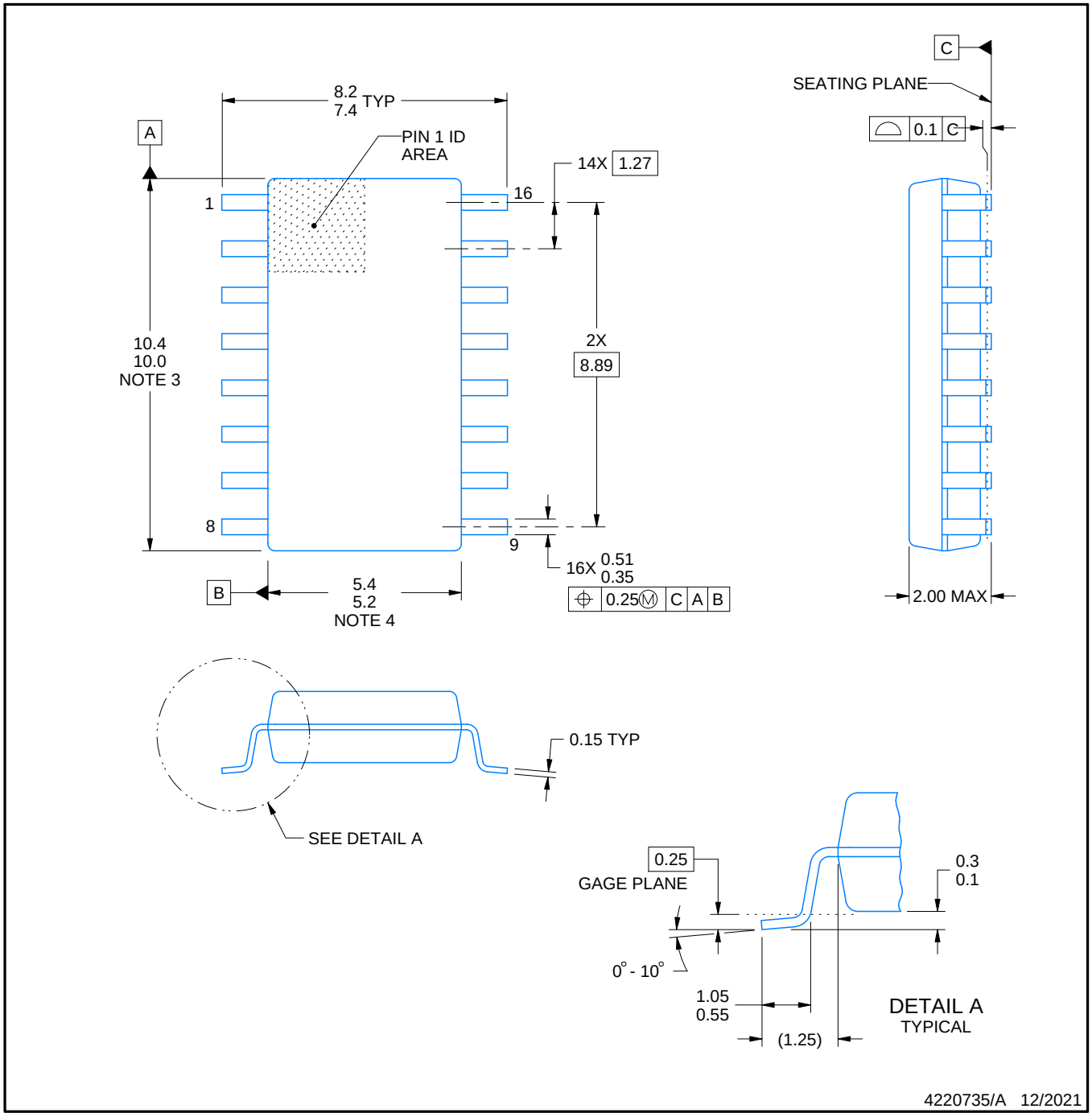


PACKAGE OUTLINE

NS0016A

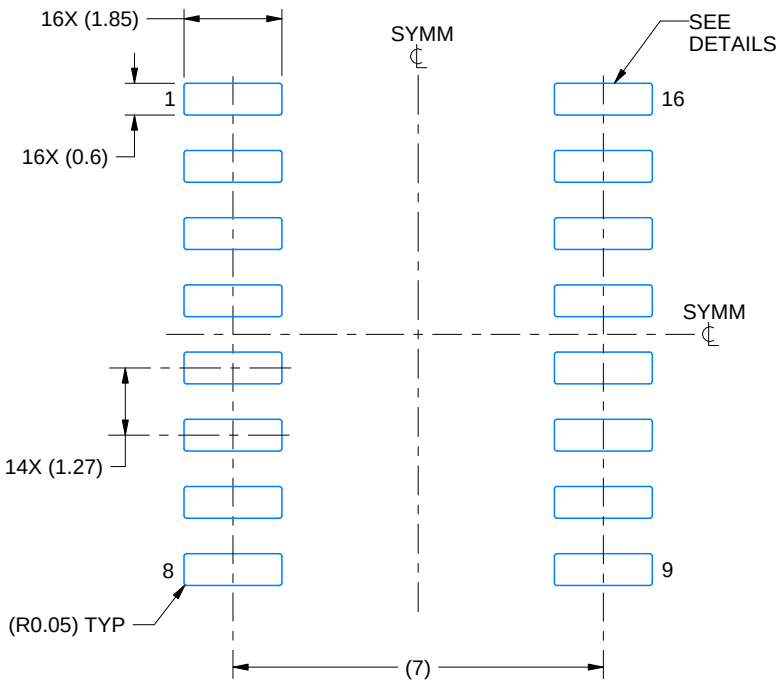
SOP - 2.00 mm max height

SOP

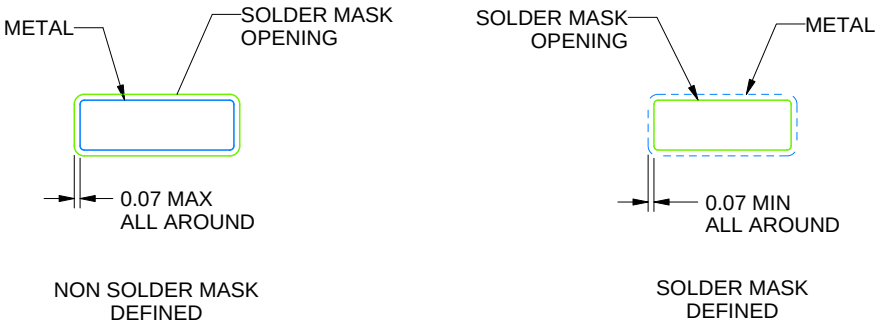


NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm, per side.



LAND PATTERN EXAMPLE
SCALE:7X



NON SOLDER MASK
DEFINED

SOLDER MASK
DEFINED

SOLDER MASK DETAILS

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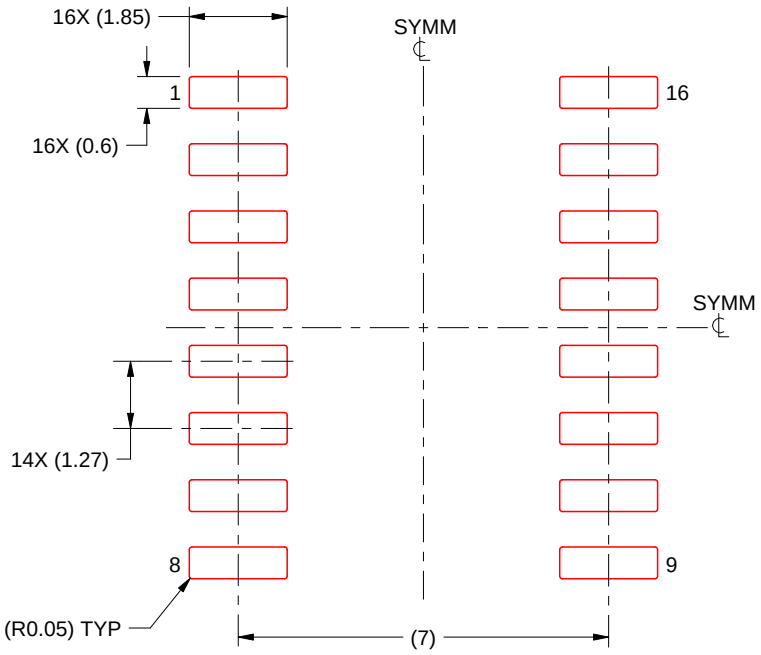
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:7X

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NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

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