

SN75ALS194 Quadruple Differential Line Drivers

1 Features

- Meet or exceed the requirements of ANSI standard EIA/TIA-422-B and ITU recommendation V.11
- Designed to operate up to 20 Mbaud
- 3-state TTL-compatible outputs
- Single 5V supply operation
- High output impedance in power-off condition
- Two pairs of drivers, independently enabled
- Designed as improved replacements for the MC3487

2 Applications

- [Factory automation](#)
- ATM and cash counters
- [Smart grid](#)
- AC and [servo motor drives](#)

3 Description

These four differential line drivers are designed for data transmission over twisted-pair or parallel-wire transmission lines. They meet the requirements of ANSI Standard EIA/TIA-422-B and ITU Recommendation V.11 and are compatible with 3-state TTL circuits. Advanced low-power Schottky technology provides high speed without the usual power penalty. Standby supply current is typically only 26mA. Typical propagation delay time is less than 10ns, and enable/disable times are typically less than 16ns.

High-impedance inputs keep input currents low: less than 1μA for a high level and less than 100μA for a low level. The driver circuits can be enabled in pairs by separate active-high enable inputs. The SN75ALS194 is capable of data rates in excess of 20 megabits per second and is designed to operate with the SN75ALS195 quadruple line receiver.

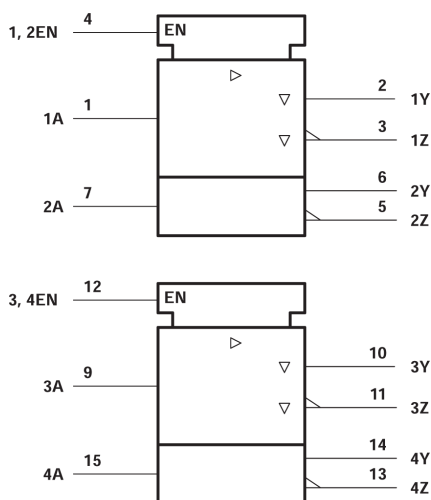
The SN75ALS194 is characterized for operation from 0°C to 70°C.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
SN75ALS194	NS (SOP, 16)	10.2mm × 7.8mm
	D (SOIC, 16)	9.9mm × 6mm
	N (PDIP, 16)	19.3mm × 9.4mm

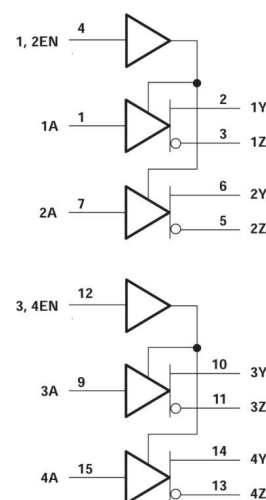
(1) For more information, [Section 10](#).

(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Pin numbers shown are for the D, J, N, and W packages.

Logic Symbol¹



Logic Diagram (Positive Logic)

¹ This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.



Table of Contents

1 Features	1	6 Parameter Measurement Information	10
2 Applications	1	7 Detailed Description	12
3 Description	1	7.1 Device Functional Modes.....	12
4 Pin Configuration and Functions	3	8 Device and Documentation Support	13
5 Specifications	4	8.1 Receiving Notification of Documentation Updates....	13
5.1 Absolute Maximum Ratings.....	4	8.2 Support Resources.....	13
5.2 Dissipation Ratings.....	4	8.3 Trademarks.....	13
5.3 Recommended Operating Conditions.....	4	8.4 Electrostatic Discharge Caution.....	13
5.4 Thermal Information.....	4	8.5 Glossary.....	13
5.5 Electrical Characteristics.....	5	9 Revision History	13
5.6 Switching Characteristics.....	5	10 Mechanical, Packaging, and Orderable	
5.7 Typical Characteristics	7	Information	13

4 Pin Configuration and Functions

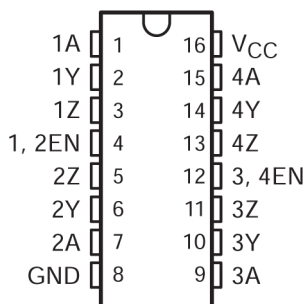


**Figure 4-1. D, N, or NS Package
(Top View)**

Table 4-1. Pin Functions

PIN		TYPE ⁽¹⁾	DESCRIPTION
NAME	NO.		
1A	1	I	Single Ended Data Input for Channel 1
1Y	2	O	Non-Inverting Output for Differential Driver on Channel 1
1Z	3	O	Inverting Output of Differential Driver on Channel 1
1, 2EN	4	I	Channel 1 and 2 Enable
2Z	5	O	Inverting Output of Differential Driver on Channel 2
2Y	6	O	Non-Inverting Output for Differential Driver on Channel 2
2A	7	I	Single Ended Data Input for Channel 2
GND	8	GND	Device GND
3A	9	I	Single Ended Data Input for Channel 3
3Y	10	O	Non-Inverting Output for Differential Driver on Channel 3
3Z	11	O	Inverting Output of Differential Driver on Channel 3
3, 4EN	12	I	Channel 3 and 4 Enable
4Z	13	O	Inverting Output of Differential Driver on Channel 4
4Y	14	O	Non-Inverting Output for Differential Driver on Channel 4
4A	15	I	Single Ended Data Input for Channel 4
V _{CC}	16	PWR	Device VCC (4.75V to 5.25V)

(1) Signal Types: I = Input, O = Output, I/O = Input or Output.

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

			MIN	MAX	UNIT
V _{CC}	Supply voltage, (see ⁽²⁾)			7	V
V _I	Input voltage			5.5	V
V _O	Output voltage			7	V
	Continuous total dissipation		See <i>Dissipation Ratings</i> table		
T _A	Operating free-air temperature range:	SN75ALS194	0	70	°C
	Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds:	D or N package		260	°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) All voltage values are with respect to network ground terminal

5.2 Dissipation Ratings

PACKAGE	T _A ≤ 25°C POWER RATING	DERATING FACTOR ABOVE T _A = 25°C	T _A = 70°C POWER RATING	T _A = 125°C POWER RATING
D	950 mW	7.6 mW/°C	608 mW	N/A
N	1150 mW	9.2 mW/°C	736 mW	N/A

5.3 Recommended Operating Conditions

⁽¹⁾		SN75ALS194			UNIT
		MIN	NOM	MAX	
Supply voltage, V _{CC}		4.75	5	5.25	V
High-level input voltage, V _{IH}	All inputs, T _A = 25°C	2			
	A inputs, T _A = Full range	2			V
	EN inputs, T _A = Full range	2			
Low-level input voltage, V _{IL}				0.8	V
High-level output current, I _{OH}				–20	mA
Low-level output current, I _{OL}	T _A = 25°C			48	mA
	T _A = Full range			48	
Operating free-air temperature, T _A		0		70	°C

- (1) Full range is T_A = 0°C to 70°C for SN75ALS194.

5.4 Thermal Information

THERMAL METRIC ⁽¹⁾		D (SOIC)	N (PDIP)	NS (SOP)	UNIT
		16-PINS			
R _{θJA}	Junction-to-ambient thermal resistance	84.6	60.6	88.5	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	43.5	48.1	46.2	°C/W
R _{θJB}	Junction-to-board thermal resistance	43.2	40.6	50.7	°C/W
ψ _{JT}	Junction-to-top characterization parameter	10.4	27.5	13.5	°C/W
ψ _{JB}	Junction-to-board characterization parameter	42.8	40.3	50.3	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	N/A	N/A	N/A	°C/W

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC package thermal metrics](#) application report.

5.5 Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS ⁽¹⁾		MIN	TYP ⁽²⁾	MAX	UNIT
V _{IK}	Input clamp voltage	V _{CC} = MIN,	I _I = –18mA			–1.5	V
V _{OH}	High-level output voltage	V _{CC} = MIN, I _{OH} = –20mA	SN75ALS194	2.5			V
V _{OL}	Low-level output voltage	V _{CC} = MIN,	I _{OL} = MAX			0.5	V
V _O	Output voltage	I _O = 0		0		6	V
V _{OD1}	Differential output voltage	I _O = 0		1.5		6	V
V _{OD2}	Differential output voltage	R _L = 100W,	See Figure 5-1	1/2 V _{OD1} or 2 ⁽³⁾			V
Δ V _{OD}	Change in magnitude of differential output voltage ⁽⁴⁾					±0.4	V
V _{OC}	Common-mode output voltage					±3	V
Δ V _{OC}	Change in magnitude of common-mode output voltage ⁽⁴⁾					±0.4	V
I _O	Output current with power off	V _{CC} = 0	V _O = 6V			100	mA
			V _O = –0.25V			–100	
I _{OZ}	High-impedance-state output current	V _{CC} = MAX, Output enables at 0.8V	V _O = 2.7V			100	mA
			V _O = 0.5V			–100	
I _I	Input current at maximum input voltage	V _{CC} = MAX,	V _I = 5.5V			100	mA
I _{IH}	High-level input current	V _{CC} = MAX,	V _I = 2.7V			50	mA
I _{IL}	Low-level input current	V _{CC} = MAX,	V _I = 0.5V			–200	mA
I _{OS}	Short-circuit output current ⁽⁵⁾	V _{CC} = MAX,	V _I = 2V	–40		–140	mA
I _{CC}	Supply current (all drivers)	V _{CC} = MAX,	All outputs disabled		26	45	mA

(1) For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

(2) All typical values are at V_{CC} = 5V, T_A = 25°C.

(3) The minimum V_{OD2} with a 100Ω load is either 1/2V_{OD1} or 2V, whichever is greater.

(4) Δ|V_{OD}| and Δ|V_{OC}| are the changes in magnitude of V_{OD} and V_{OC}, respectively, that occur when the input is changed from a high level to a low level.

(5) Not more than one output should be shorted at a time, and duration of the short circuit should not exceed one second.

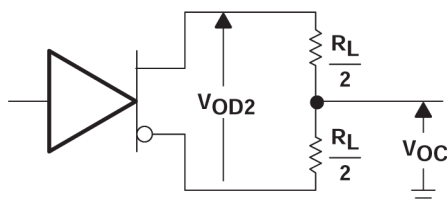
5.6 Switching Characteristics

V_{CC} = 5V, T_A = 25°C

PARAMETER		TEST CONDITIONS	SN75ALS194			UNIT
			MIN	TYP	MAX	
t _{PLH}	Propagation delay time, low- to high-level output	C 15 F L = 15pF, See Figure 6-1		6	13	ns
t _{PHL}	Propagation delay time, high- to low-level output			9	14	ns
	Output-to-output skew			3.5	6	ns
t _{t(OD)}	Differential output transition time	C _L = 15pF, See Figure 6-2		8	14	ns
t _{PZH}	Output enable time to high level	C _L = 15pF, See Figure 6-3		9	12	ns
t _{PZL}	Output enable time to low level			12	20	ns
t _{PHZ}	Output disable time from high level			9	14	ns
t _{PLZ}	Output disable time from low level			12	15	ns

Table 5-1. Symbol Equivalents

DATA SHEET PARAMETER	EIA/TIA-422-B
V_O	V_{oa}, V_{ob}
$ V_{OD1} $	V_o
$ V_{OD2} $	$V_t (R_L = 100 \Omega)$
$\Delta V_{OD} $	$ V_i - \bar{V}_i $
V_{OC}	$ V_{os} $
$\Delta V_{OC} $	$ V_{os} - \bar{V}_{os} $
I_{OS}	$ I_{sa} , I_{sb} $
I_O	$ I_{xa} , I_{xb} $

**Figure 5-1. Driver V_{OD} And V_{OC}**

5.7 Typical Characteristics

Data for temperatures below 0°C and above 70°C are applicable to the SN55ALS194 circuits only.

The A input is connected to V_{CC} during the testing of the Y outputs and to GND during the testing of the Z outputs.

The A input is connected to ground during the testing of the Y outputs and to V_{CC} during the testing of the Z outputs.

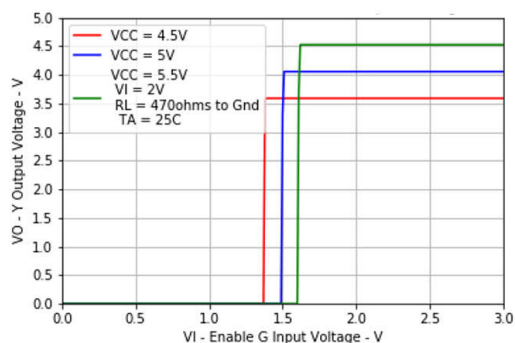


Figure 5-2. Y Output Voltage vs Data Input Voltage

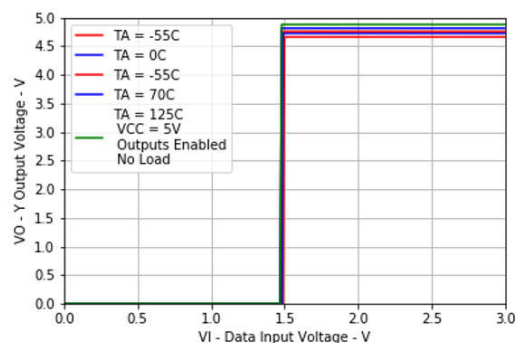


Figure 5-3. Y Output Voltage vs Data Input Voltage

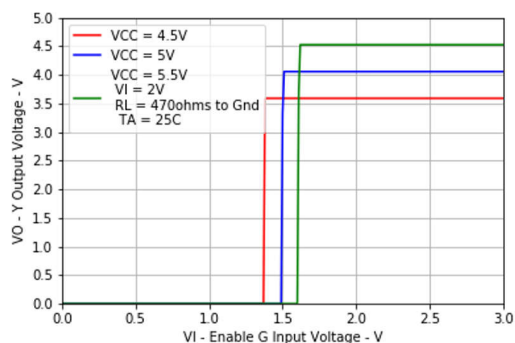


Figure 5-4. Y Output Voltage vs Enable G Input Voltage

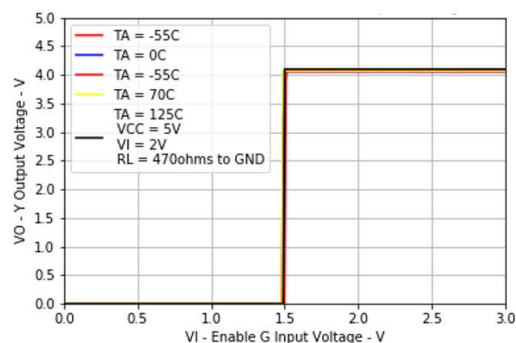


Figure 5-5. Y Output Voltage vs Enable G Input Voltage

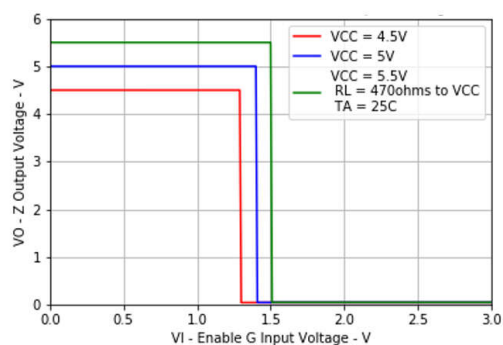


Figure 5-6. Z Output Voltage vs Enable G Input Voltage

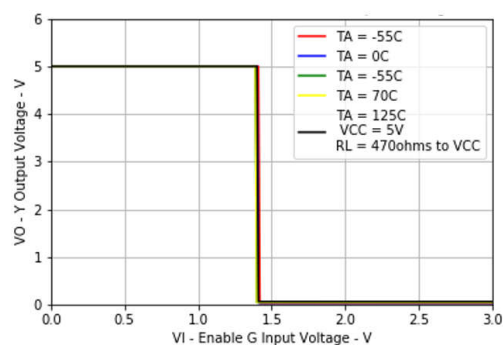


Figure 5-7. Z Output Voltage vs Enable G Input Voltage

5.7 Typical Characteristics (continued)

Data for temperatures below 0°C and above 70°C are applicable to the SN55ALS194 circuits only.

The A input is connected to V_{CC} during the testing of the Y outputs and to GND during the testing of the Z outputs.

The A input is connected to ground during the testing of the Y outputs and to V_{CC} during the testing of the Z outputs.

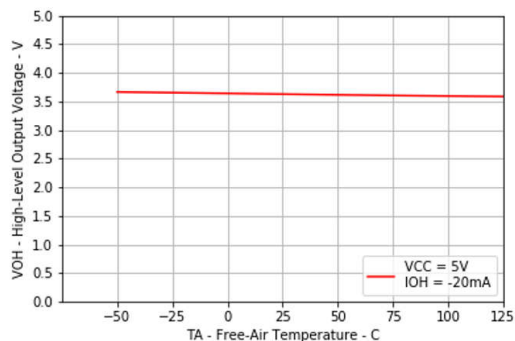


Figure 5-8. High-level Output Voltage vs Free-air Temperature

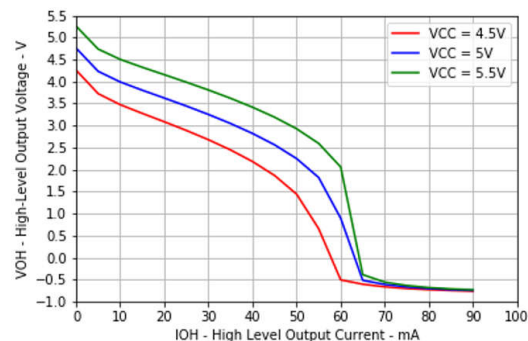


Figure 5-9. High-level Output Voltage vs High-level Output Current

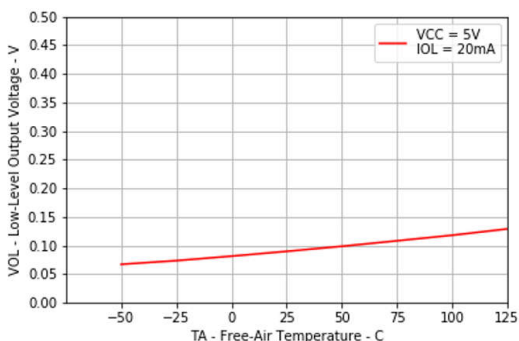


Figure 5-10. Low-level Output Voltage vs Free-air Temperature

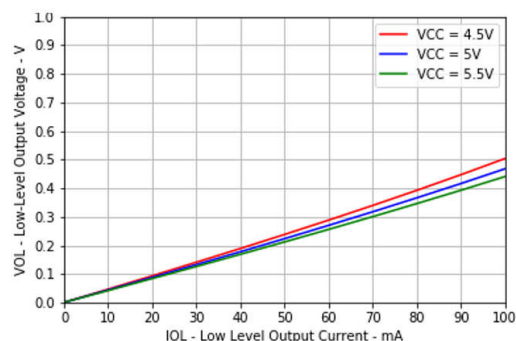


Figure 5-11. Low-level Output Voltage vs Low-level Output Current

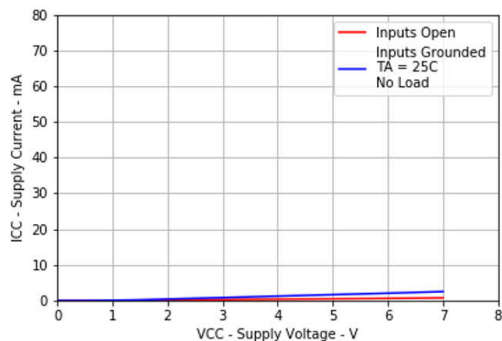


Figure 5-12. Supply Current vs Supply Voltage

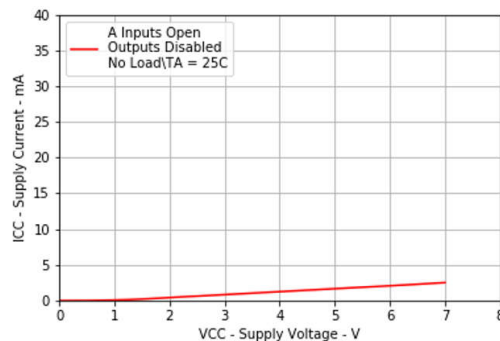


Figure 5-13. Supply Current vs Supply Voltage

5.7 Typical Characteristics (continued)

Data for temperatures below 0°C and above 70°C are applicable to the SN55ALS194 circuits only.

The A input is connected to V_{CC} during the testing of the Y outputs and to GND during the testing of the Z outputs.

The A input is connected to ground during the testing of the Y outputs and to V_{CC} during the testing of the Z outputs.

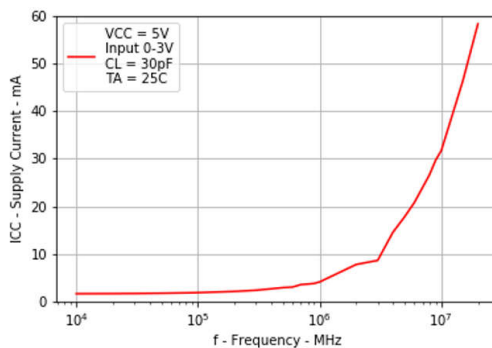
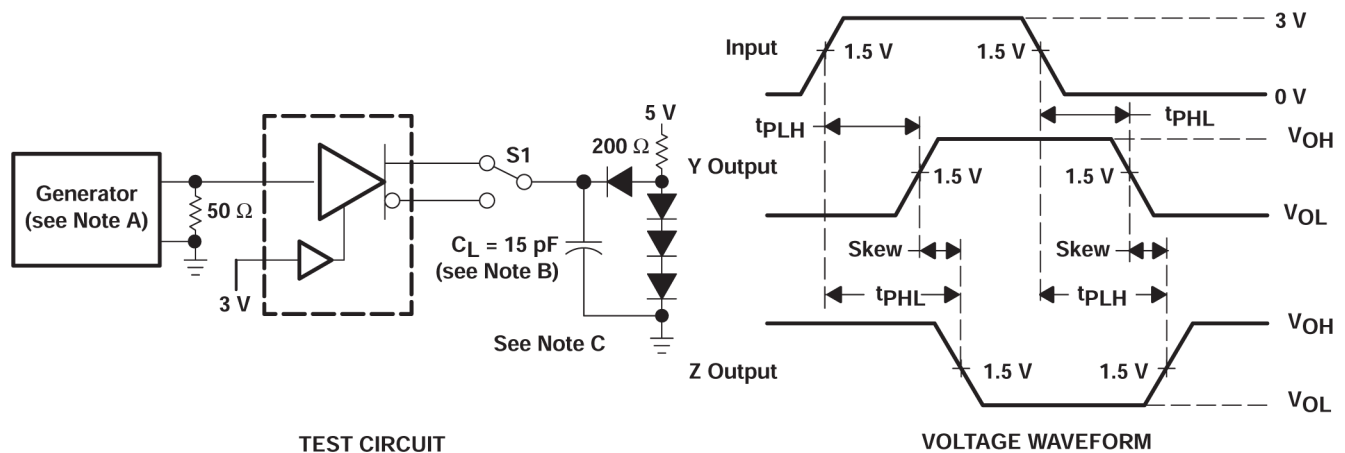


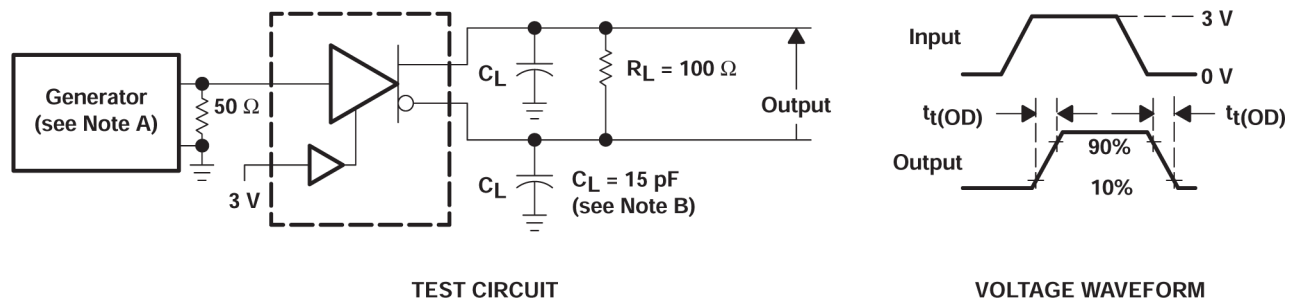
Figure 5-14. Supply Current vs Frequency

6 Parameter Measurement Information



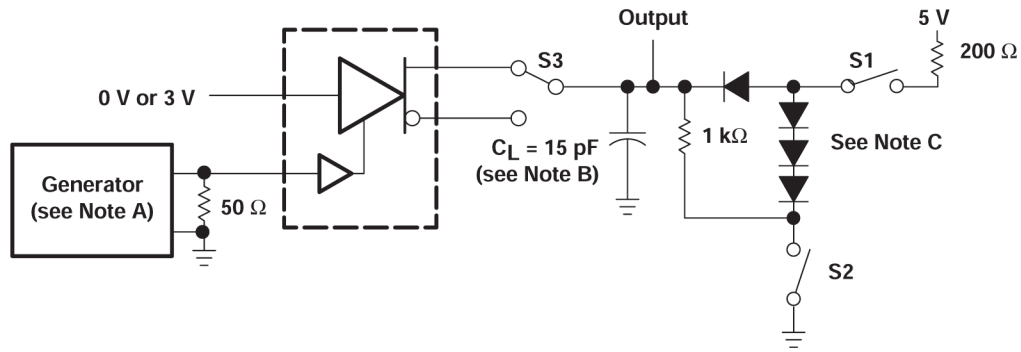
- A. The input pulse is supplied by a generator having the following characteristics: $t_r \leq 5\text{ns}$, $t_f \leq 5\text{ns}$, $\text{PRR} \leq 1\text{MHz}$, duty cycle $\leq 50\%$, $Z_O \approx 50\Omega$.
- B. C_L includes probe and stray capacitance.
- C. All diodes are 1N916 or 1N3064.

Figure 6-1. Test Circuit and Voltage Waveform

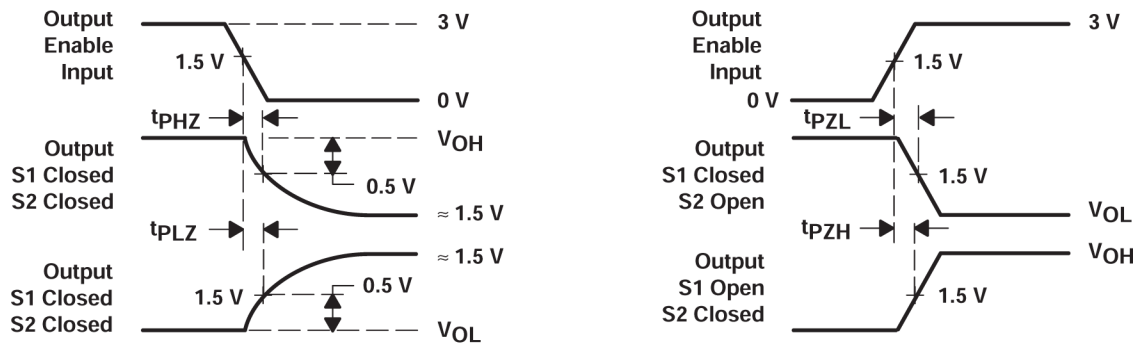


- A. The input pulse is supplied by a generator having the following characteristics: $t_r \leq 5\text{ns}$, $t_f \leq 5\text{ns}$, $\text{PRR} \leq 1\text{MHz}$, duty cycle $\leq 50\%$, $Z_O \approx 50\Omega$.
- B. C_L includes probe and stray capacitance.

Figure 6-2. Differential-Output Test Circuit and Voltage Waveform



TEST CIRCUIT



VOLTAGE WAVEFORMS

- A. The input pulse is supplied by a generator having the following characteristics: $t_r \leq 5\text{ns}$, $t_f \leq 5\text{ns}$, $\text{PRR} \leq 1\text{MHz}$, duty cycle $\leq 50\%$, $Z_O \approx 50\Omega$.
- B. C_L includes probe and stray capacitance.
- C. All diodes are 1N916 or 1N3064.

Figure 6-3. Driver Test Circuit and Voltage Waveforms

7 Detailed Description

7.1 Device Functional Modes

Function Table (Each Driver)

INPUTS A ⁽¹⁾	OUTPUT EN	OUTPUTS	
		Y	Z
H	H	H	L
L	H	L	H
X	L	Z	Z

(1) H = high level, L = low level, X = irrelevant, Z = high impedance

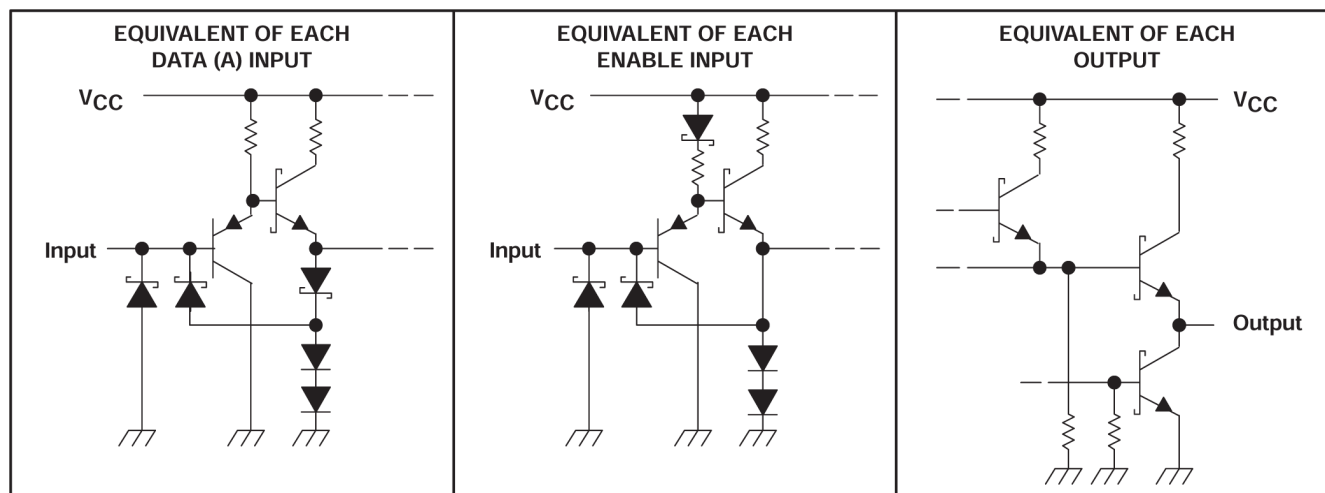


Figure 7-1. Schematics of Inputs and Outputs

8 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

8.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.2 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

8.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

8.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (May 1995) to Revision E (March 2024)	Page
• Changed the numbering format for tables, figures, and cross-references throughout the document.....	1

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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)
SN75ALS194D	Obsolete	Production	SOIC (D) 16	-	-	Call TI	Call TI	0 to 70	75ALS194
SN75ALS194DR	Active	Production	SOIC (D) 16	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	75ALS194
SN75ALS194DR.A	Active	Production	SOIC (D) 16	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	75ALS194
SN75ALS194N	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	SN75ALS194N
SN75ALS194N.A	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	SN75ALS194N
SN75ALS194NSR	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	75ALS194
SN75ALS194NSR.A	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	75ALS194

⁽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.

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.

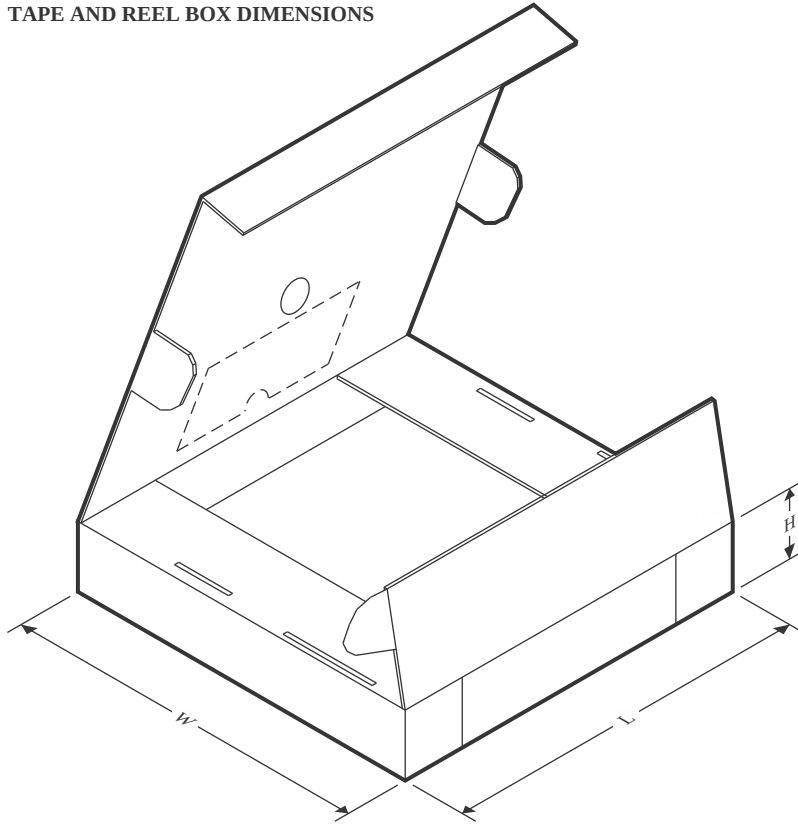
TAPE AND REEL INFORMATION



*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
SN75ALS194DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN75ALS194DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN75ALS194NSR	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

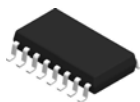
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN75ALS194DR	SOIC	D	16	2500	340.5	336.1	32.0
SN75ALS194DR	SOIC	D	16	2500	353.0	353.0	32.0
SN75ALS194NSR	SOP	NS	16	2000	353.0	353.0	32.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
SN75ALS194N	N	PDIP	16	25	506	13.97	11230	4.32
SN75ALS194N.A	N	PDIP	16	25	506	13.97	11230	4.32

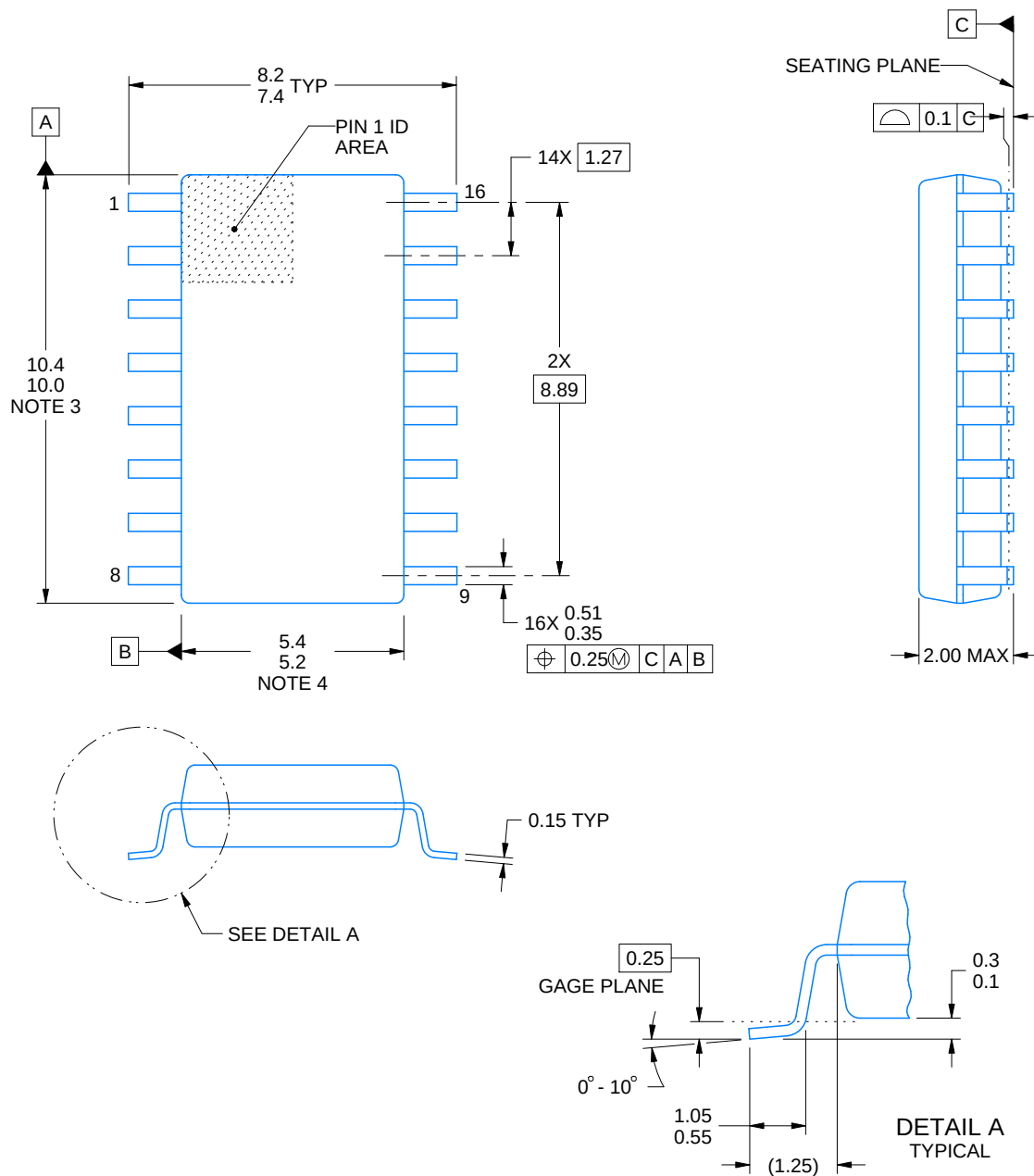


PACKAGE OUTLINE

NS0016A

SOP - 2.00 mm max height

SOP



4220735/A 12/2021

NOTES:

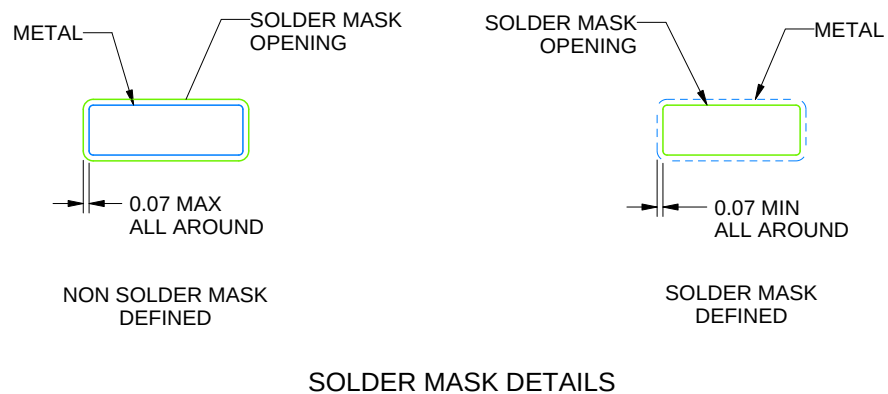
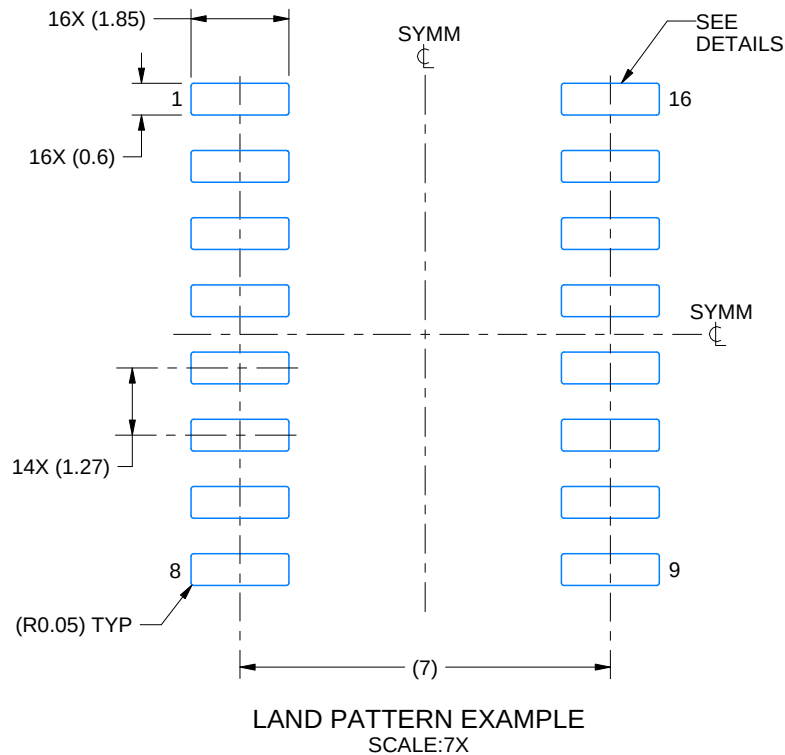
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate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

EXAMPLE BOARD LAYOUT

NS0016A

SOP - 2.00 mm max height

SOP

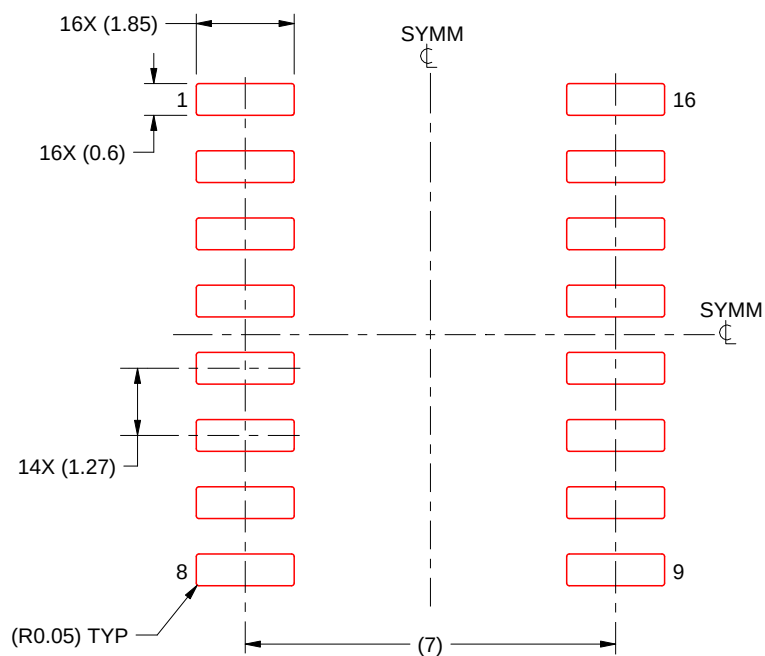


4220735/A 12/2021

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

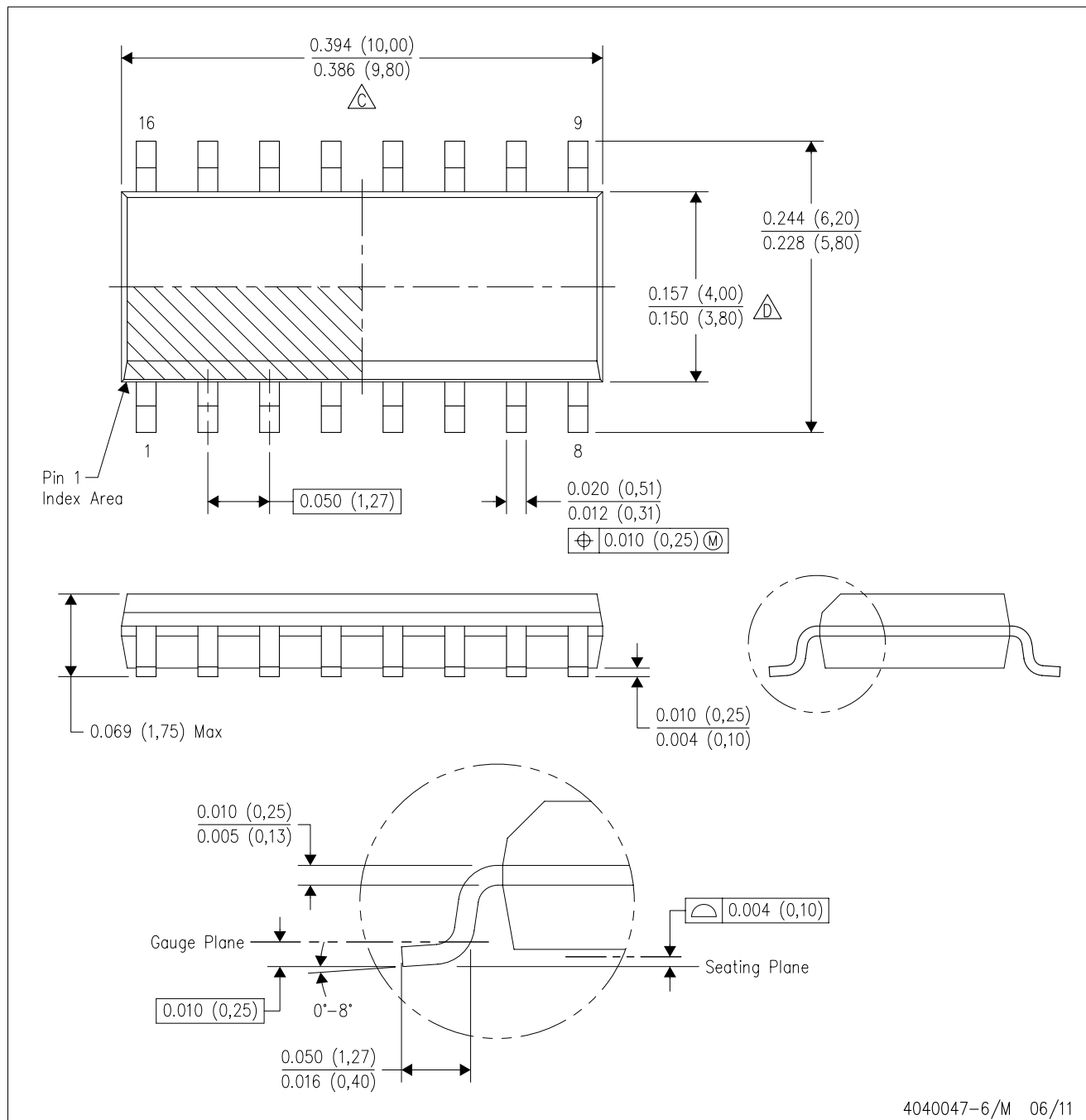
4220735/A 12/2021

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.

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



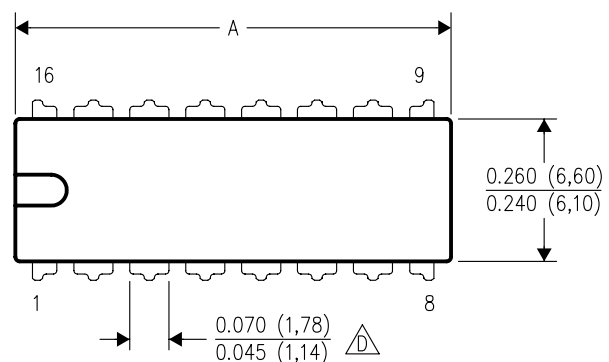
4040047-6/M 06/11

- 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.

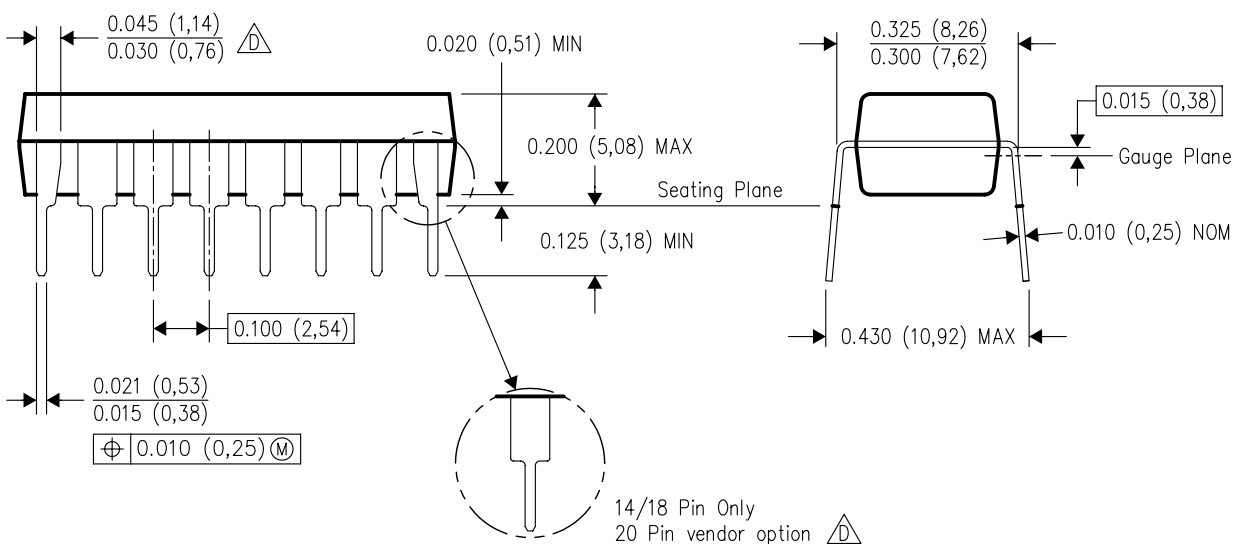
N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



PINS ** DIM	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	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.
-  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 The 20 pin end lead shoulder width is a vendor option, either half or full width.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025