SN74LV165A Parallel-Load 8-Bit Shift Registers

1 Features

- V_{CC} operation of 2 V to 5.5 V
- Maximum t_{pd} of 10.5 ns at 5 V
- Support mixed-mode voltage operation on all ports
- I_{off} supports partial-power-down mode operation
- Latch-up performance exceeds 250 mA per JESD 17

2 Applications

Increase the Number of Inputs on a Microcontroller

3 Description

The SN74LV165A device is a parallel-load, 8-bit shift registers designed for 2 V to 5.5 V V_{CC} operation.

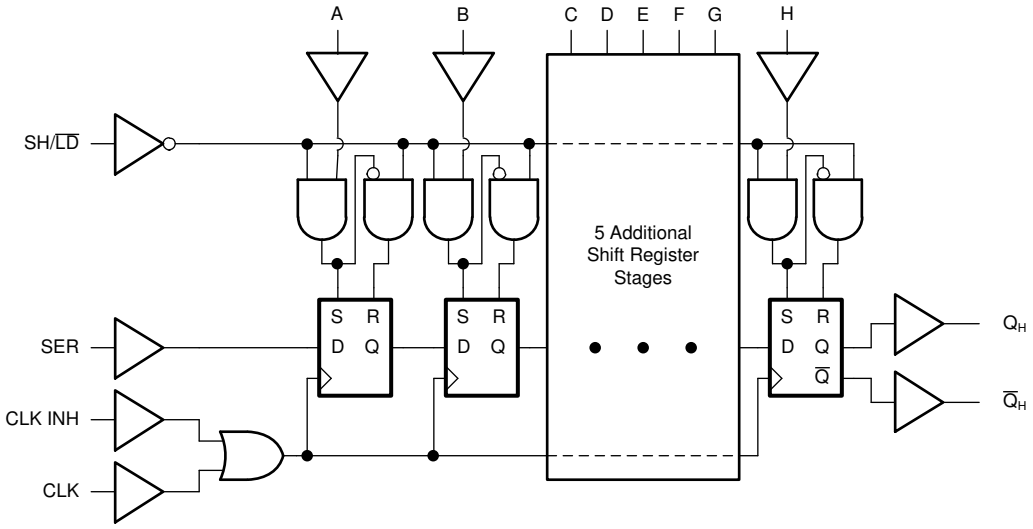
When the device is clocked, data is shifted toward the serial output Q_H. Parallel-in access to each stage is provided by eight individual direct data inputs that are enabled by a low level at the shift/load (SH/ $\overline{LD}$) input. The 'LV165A devices feature a clock-inhibit function and a complemented serial output, $\overline{Q}_H$.

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 devices when they are powered down.

Package Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
SN74LV165A	D (SOIC, 16)	9.90 mm × 3.90 mm
	DB (SSOP, 16)	6.20 mm × 5.30 mm
	NS (SO, 16)	10.20 mm × 5.30 mm
	PW (TSSOP, 16)	5.00 mm × 4.40 mm
	DGV (TVSOP, 16)	3.60 mm × 4.40 mm
	RGY (VQFN, 16)	4.00 mm × 3.50 mm
	BQB (WQFN, 16)	3.60 mm × 2.60 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Logic Diagram (Positive Logic)

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. UNLESS OTHERWISE NOTED, this document contains PRODUCTION DATA.

Table of Contents

1 Features....1
2 Applications....1
3 Description....1
4 Revision History....2
5 Pin Configuration and Functions....3
6 Specifications....4
6.1 Absolute Maximum Ratings....4
6.2 ESD Ratings....4
6.3 Recommended Operating Conditions....5
6.4 Thermal Information....5
6.5 Electrical Characteristics....6
6.6 Timing Requirements, V_{CC} = 2.5 V ± 0.2 V....6
6.7 Timing Requirements, V_{CC} = 3.3 V ± 0.3 V....6
6.8 Timing Requirements, V_{CC} = 5 V ± 0.5 V....7
6.9 Switching Characteristics, V_{CC} = 2.5 V ± 0.2 V....7
6.10 Switching Characteristics, V_{CC} = 3.3 V ± 0.3 V....7
6.11 Switching Characteristics,V_{CC} = 5 V ± 0.5 V....8
6.12 Timing Diagrams....8
6.13 Operating Characteristics....9
6.14 Typical Characteristics....9
7 Parameter Measurement Information....10
8 Detailed Description....11
8.1 Overview....11
8.2 Functional Block Diagram....11
8.3 Feature Description....11
8.4 Device Functional Modes....13
9 Application and Implementation....14
9.1 Application Information....14
9.2 Typical Application....14
9.3 Power Supply Recommendations....16
9.4 Layout....16
10 Device and Documentation Support....17
10.1 Documentation Support....17
10.2 Receiving Notification of Documentation Updates....17
10.3 Support Resources....17
10.4 Trademarks....17
10.5 Electrostatic Discharge Caution....17
10.6 Glossary....17
11 Mechanical, Packaging, and Orderable Information....17

4 Revision History

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

Changes from Revision Q (December 2022) to Revision R (March 2023)	Page
• Updated structural layout of document and formatted tables to current standard	1

Changes from Revision P (June 2022) to Revision Q (December 2022)	Page
• Changed data sheet status from Advanced Information to Production Data	1

Changes from Revision O (November 2016) to Revision P (June 2022)	Page
• Added BQB (WQFN) package information to Device Information, Pin Configuration and Thermal Information tables	1
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Updated specifications table formatting	6

Changes from Revision N (July 2013) to Revision O (November 2016)	Page
• Added *Applications* section, *Device Information* table, *Table of Contents*, *Pin Configuration and Functions* section, *Specifications* section, *ESD Ratings* table, *Thermal Information* table, *Typical Characteristics* section, *Detailed Description* section, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section	1

Copyright © 2023 Texas Instruments Incorporated

5 Pin Configuration and Functions

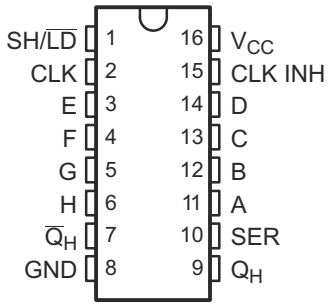


Figure 5-1. D, DB, DGV, N or PW Package, 16-Pin SOIC, SSOP, TVSOP, SOP or TSSOP (Top View)

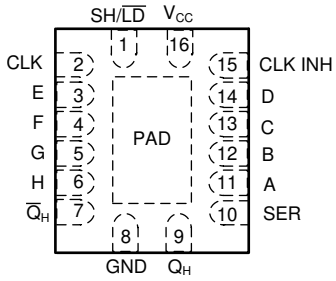


Figure 5-2. RGY or BQB Package, 16-Pin VQFN or WQFN (Top View)

Table 5-1. Pin Functions

PIN		TYPE (1)	DESCRIPTION
NAME	NO.		
A	11	I	Serial input A
B	12	I	Serial input B
C	13	I	Serial input C
CLK	2	I	Storage clock
CLK INH	15	I	Storage clock
D	14	I	Serial input D
E	3	I	Serial input E
F	4	I	Serial input F
G	5	I	Serial input G
GND	8	G	Ground pin
H	6	I	Serial input H
$\overline{Q}_H$	7	O	Output H, inverted
Q_H	9	O	Output H
SH/ $\overline{LD}$	1	I	Load Input
SER	10	I	Serial input
V_{CC}	16	P	Power pin
PAD		—	Thermal Pad(2)

(1) I = Input, O = Output, I/O = Input or Output, G = Ground, P = Power.
(2) RGY and BQB Package Only

Copyright © 2023 Texas Instruments Incorporated

6 Specifications

6.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage		–0.5	7	V
V_I	Input voltage(2)		–0.5	7	V
V_O	Voltage range applied to any output in the high-impedance or power-off state(2)		–0.5	7	V
V_O	Output voltage (2) (3)		–0.5	V_{CC} + 0.5	V
I_{IK}	Input clamp current	V_I < 0		–20	mA
I_{OK}	Output clamp current	V_O < 0		–50	mA
I_O	Continuous output current	V_O = 0 to V_{CC}		±25	mA
	Continuous current through V_{CC} or GND			±50	mA
T_{jmax}	Maximum virtual junction temperature			150	°C
T_{stg}	Storage temperature		–65	150	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) The input and output negative-voltage ratings may be exceeded if the input and output current ratings are observed.
(3) This value is limited to 5.5 V maximum.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Machine Model (MM), per JEDEC specification	±200	
		Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002 (2)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Copyright © 2023 Texas Instruments Incorporated

6.3 Recommended Operating Conditions

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage		2	5.5	V
V_{IH}	High-level input voltage	V_{CC} = 2 V	1.5		V
		V_{CC} = 2.3 V to 2.7 V	V_{CC} × 0.7		
		V_{CC} = 3 V to 3.6 V	V_{CC} × 0.7		
		V_{CC} = 4.5 V to 5.5 V	V_{CC} × 0.7		
V_{IL}	Low-level input voltage	V_{CC} = 2 V		0.5	V
		V_{CC} = 2.3 V to 2.7 V		V_{CC} × 0.3	
		V_{CC} = 3 V to 3.6 V		V_{CC} × 0.3	
		V_{CC} = 4.5 V to 5.5 V		V_{CC} × 0.3	
V_I	Input voltage		0	5.5	V
V_O	Output voltage		0	V_{CC}	V
I_{OH}	High-level output current	V_{CC} = 2 V		–50	μA
		V_{CC} = 2.3 V to 2.7 V		–2	mA
		V_{CC} = 3 V to 3.6 V		–6	
		V_{CC} = 4.5 V to 5.5 V		–12	
I_{OL}	Low-level output current	V_{CC} = 2 V		50	μA
		V_{CC} = 2.3 V to 2.7 V		2	mA
		V_{CC} = 3 V to 3.6 V		6	
		V_{CC} = 4.5 V to 5.5 V		12	
Δt/Δv	Input transition rise or fall rate	V_{CC} = 2.3 V to 2.7 V		200	ns/V
		V_{CC} = 3 V to 3.6 V		100	
		V_{CC} = 4.5 V to 5.5 V		20	
T_A	Operating free-air temperature		–40	125	°C

(1) All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. See *Implications of Slow or Floating CMOS Inputs*

6.4 Thermal Information

THERMAL METRIC(1)		SN74LV165A							UNIT
		D (SOIC)	DB (SSOP)	NS (SO)	PW (TSSOP)	DGV (TVSOP)	RGY (VQFN)	BQB (WQFN)	
		16 PINS	16 PINS	16 PINS	16 PINS	16 PINS	16 PINS	16 PINS	
$R_{θJA}$	Junction-to-ambient thermal resistance	86.2	102.8	89.4	113.3	125.9	48.8	85.9	°C/W
$R_{θJC(top)}$	Junction-to-case (top) thermal resistance	46.1	53.3	47.9	48.3	51	46.7	82.4	°C/W
$R_{θJB}$	Junction-to-board thermal resistance	43.8	53.5	49.8	58.4	57.7	24.9	55.6	°C/W
$ψ_{JT}$	Junction-to-top characterization parameter	13.2	16.6	16.6	6.4	5.7	2	9.4	°C/W
$ψ_{JB}$	Junction-to-board characterization parameter	43.5	52.9	49.5	57.8	57.2	24.9	55.6	°C/W
$R_{θJC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	N/A	N/A	N/A	11.7	33.3	°C/W

(1) For more information about traditional and new thermal metrics, see *Semiconductor and IC Package Thermal Metrics*

Copyright © 2023 Texas Instruments Incorporated

6.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	V_{CC}	–40°C to 85°C			–40°C to 125°C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{OH}	High-level output voltage	I_{OH} = –50 mA	2 V to 5.5 V	V_{CC} – 0.1			V_{CC} – 0.1			V
		I_{OH} = –2 mA	2.3 V	2			2			
		I_{OH} = –6 mA	3 V	2.48			2.48			
		I_{OH} = –12 mA	4.5 V	3.8			3.8			
V_{OL}	Low-level output voltage	I_{OL} = 50 mA	2 V to 5.5 V			0.1			0.1	V
		I_{OL} = 2 mA	2.3 V			0.4			0.4	
		I_{OL} = 6 mA	3 V			0.44			0.44	
		I_{OL} = 12 mA	4.5 V			0.55			0.55	
I_I	Input leakage current	V_I = 5.5 V or GND	0 V to 5.5 V			±1			±1	µA
I_{CC}	Static supply current	V_I = V_{CC} or GND, I_O = 0	5.5 V			20			20	µA
I_{off}	Partial power down current	V_I or V_O = 0 to 5.5 V	0			5			5	µA
C_i	Input capacitance	V_I = V_{CC} or GND	3.3 V		1.7			1.7		pF

6.6 Timing Requirements, V_{CC} = 2.5 V ± 0.2 V

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 7-1)

PARAMETER		TEST CONDITION	25°C		–40°C to 85°C		–40°C to 125°C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_w	Pulse duration	CLK high or low	8.5		9		9		ns
		SH/ $\overline{LD}$ low	11		13		13		
t_{su}	Setup time	SH/ $\overline{LD}$ high before CLK↑	7		8.5		8.5		ns
		SER before CLK↑	8.5		9.5		9.5		
		CLK INH before CLK↑	7		7		7		
		Data before SH/ $\overline{LD}$↑	11.5		12		12		
t_h	Hold time	SER data after CLK↑	-1		0		0		ns
		Parallel data after SH/ $\overline{LD}$↑	0		0		0		
		SH/ $\overline{LD}$ high after CLK↑	0		0		0		

6.7 Timing Requirements, V_{CC} = 3.3 V ± 0.3 V

over recommended operating free-air temperature range (unless otherwise noted (see Figure 7-1)

PARAMETER		TEST CONDITION	25°C		–40°C to 85°C		–40°C to 125°C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_w	Pulse duration	CLK high or low	6		7		7		ns
		SH/ $\overline{LD}$ low	7.5		9		9		
t_{su}	Setup time	SH/ $\overline{LD}$ high before CLK↑	5		6		6		ns
		SER before CLK↑	5		6		6		
		CLK INH before CLK↑	5		5		5		
		Data before SH/ $\overline{LD}$↑	7.5		8.5		8.5		
t_h	Hold time	SER data after CLK↑	0		0		0		ns
		Parallel data after SH/ $\overline{LD}$↑	0.5		0.5		0.5		
		SH/ $\overline{LD}$ high after CLK↑	0		0		0		

Copyright © 2023 Texas Instruments Incorporated

6.8 Timing Requirements, V_{CC} = 5 V ± 0.5 V

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 7-1)

PARAMETER		TEST CONDITION	25°C		–40°C to 85°C		–40°C to 125°C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_w	Pulse duration	CLK high or low	4		4		4		ns
		SH/ $\overline{LD}$ low	5		6		6		
t_{su}	Setup time	SH/ $\overline{LD}$ high before CLK↑	4		4		4		ns
		SER before CLK↑	4		4		4		
		CLK INH before CLK↑	3.5		3.5		3.5		
		Data before SH/ $\overline{LD}$↑	5		5		5		
t_h	Hold time	SER data after CLK↑	0.5		0.5		0.5		ns
		Parallel data after SH/ $\overline{LD}$↑	1		1		1		
		SH/ $\overline{LD}$ high after CLK↑	0.5		0.5		0.5		

6.9 Switching Characteristics, V_{CC} = 2.5 V ± 0.2 V

over operating free-air temperature range (unless otherwise noted), (see Figure 7-1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAP	25°C			–40°C to 85°C			–40°C to 125°C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
f_{max}			C_L = 15 pF	50	80		45			45			MHz
			C_L = 50 pF	40	65		35			35			
t_{pd}	CLK	Q_H or $\overline{Q}$	C_L = 15 pF		12.2	19.8	1		22	1		22	ns
	SH/ $\overline{LD}$				13.1	21.5	1		23.5	1		23.5	
	H				12.9	21.7	1		24	1		24	
t_{pd}	CLK	Q_H or $\overline{Q}$	C_L = 50 pF		15.3	23.3	1		26	1		26	ns
	SH/ $\overline{LD}$				16.1	25.1	1		28	1		28	
	H				15.9	25.3	1		28	1		28	

6.10 Switching Characteristics, V_{CC} = 3.3 V ± 0.3 V

over operating free-air temperature range (unless otherwise noted), (see Figure 7-1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAP	25°C			–40°C to 85°C			–40°C to 125°C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
f_{max}			C_L = 15 pF	65	115		55			55			MHz
			C_L = 50 pF	60	90		50			50			
t_{pd}	CLK	Q_H or $\overline{Q}$	C_L = 15 pF		8.6	15.4	1		18	1		18	ns
	SH/ $\overline{LD}$				9.1	15.8	1		18.5	1		18.5	
	H				8.9	14.1	1		16.5	1		16.5	
t_{pd}	CLK	Q_H or $\overline{Q}$	C_L = 50 pF		10.9	14.9	1		16.9	1		16.9	ns
	SH/ $\overline{LD}$				11.3	19.3	1		22	1		22	
	H				11.1	17.6	1		20	1		20	

Copyright © 2023 Texas Instruments Incorporated

6.11 Switching Characteristics, V_{CC} = 5 V ± 0.5 V

over recommended operating free-air temperature range (see Figure 7-1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAP	25°C			–40°C to 85°C			–40°C to 125°C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
f_{max}			C_L = 15 pF	110	165		90			90			MHz
			C_L = 50 pF	95	125		85			85			
t_{pd}	CLK	Q_H or $\overline{Q}$	C_L = 15 pF		6	9.9	1		11.5	1		11.5	ns
	SH/ $\overline{LD}$				6	9.9	1		11.5	1		11.5	
	H				6	9.9	1		10.5	1		10.5	
t_{pd}	CLK	Q_H or $\overline{Q}$	C_L = 50 pF		7.7	11.9	1		13.5	1		13.5	ns
	SH/ $\overline{LD}$				7.7	11.9	1		13.5	1		13.5	
	H				7.6	11	1		12.5	1		12.5	

6.12 Timing Diagrams

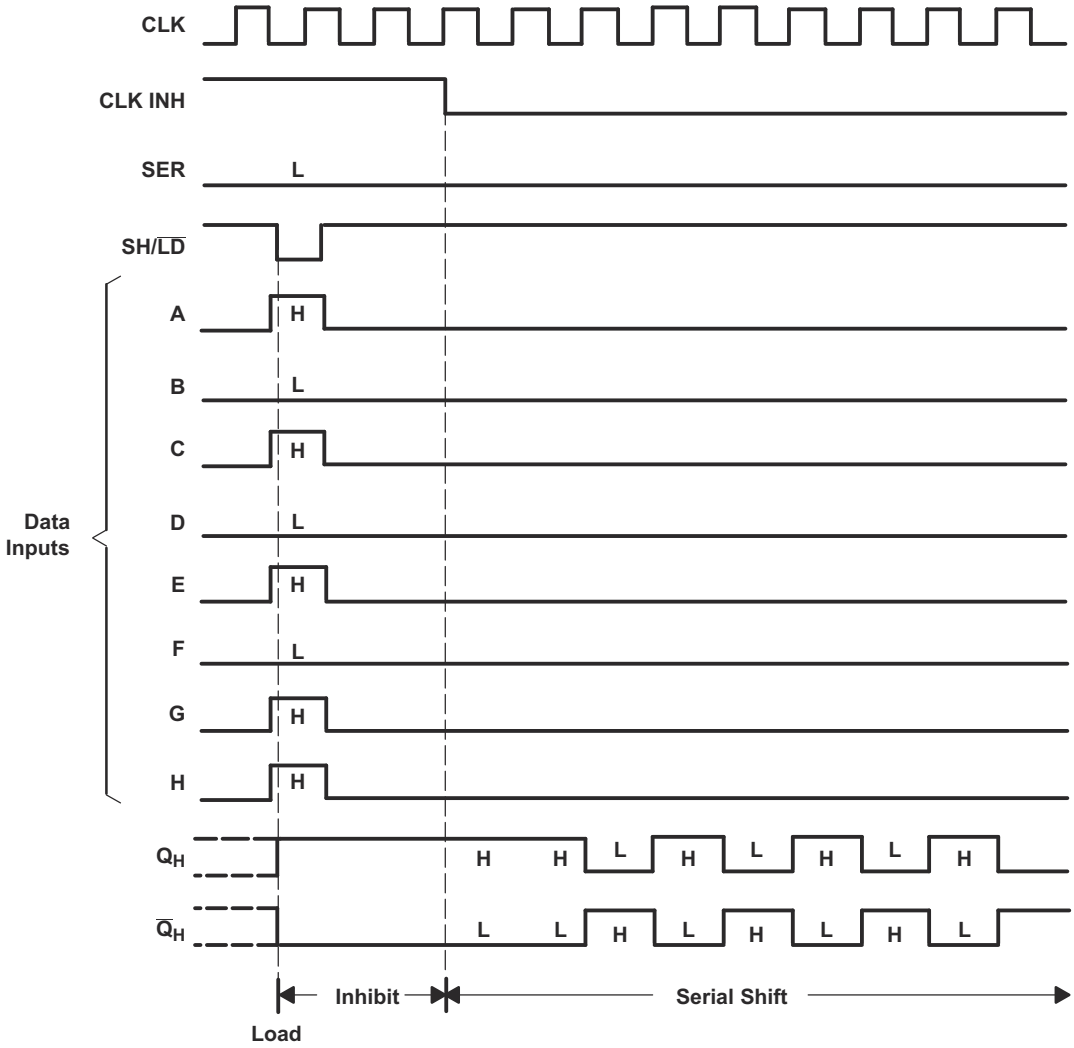


Figure 6-1. Typical Shift, Load, and Inhibit Sequences

Copyright © 2023 Texas Instruments Incorporated

6.13 Operating Characteristics

T_A = 25°C

PARAMETER		TEST CONDITIONS		V_{CC}	TYP	UNIT
C_{pd}	Power dissipation capacitance	C_L = 50 pF	f = 10 MHz	3.3 V	36.1	pF
				5 V	37.5	

6.14 Typical Characteristics

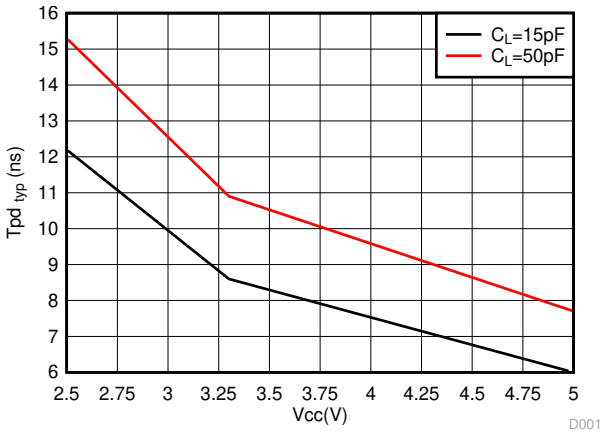
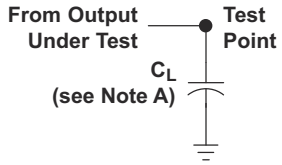
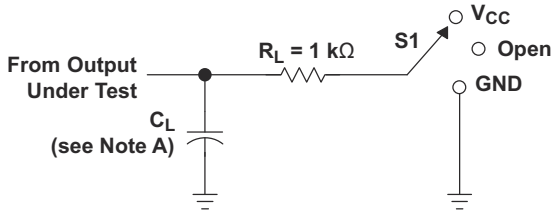


Figure 6-2. T_{PD} Typical (25°C) vs V_{cc}

7 Parameter Measurement Information

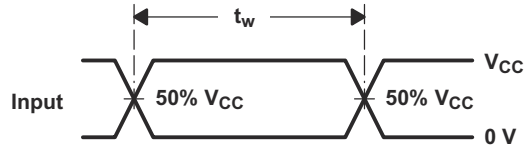


LOAD CIRCUIT FOR
TOTEM-POLE OUTPUTS

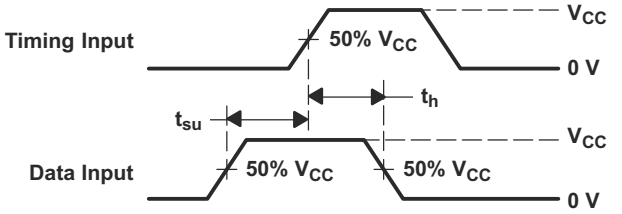


TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	V_{CC}
t_{PHZ}/t_{PZH}	GND
Open Drain	V_{CC}

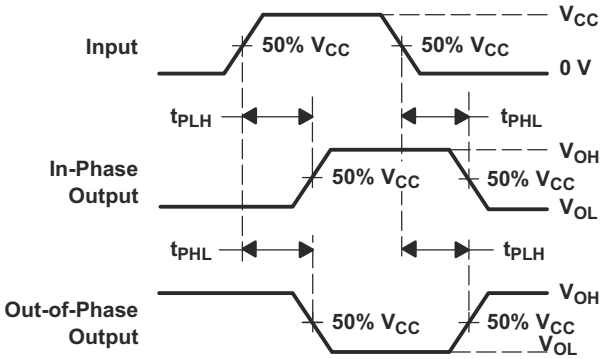
LOAD CIRCUIT FOR
3-STATE AND OPEN-DRAIN OUTPUTS



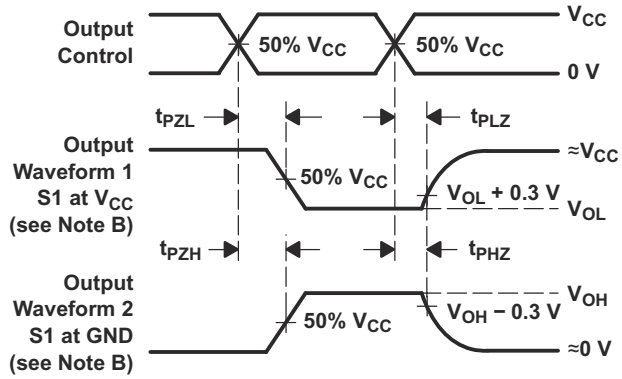
VOLTAGE WAVEFORMS
PULSE DURATION



VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
INVERTING AND NONINVERTING OUTPUTS



VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES
LOW- AND HIGH-LEVEL ENABLING

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 ≤ 1 MHz, Z_O = 50 Ω, t_r ≤ 3 ns, t_f ≤ 3 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 7-1. Load Circuit and Voltage Waveforms

Copyright © 2023 Texas Instruments Incorporated

8 Detailed Description

8.1 Overview

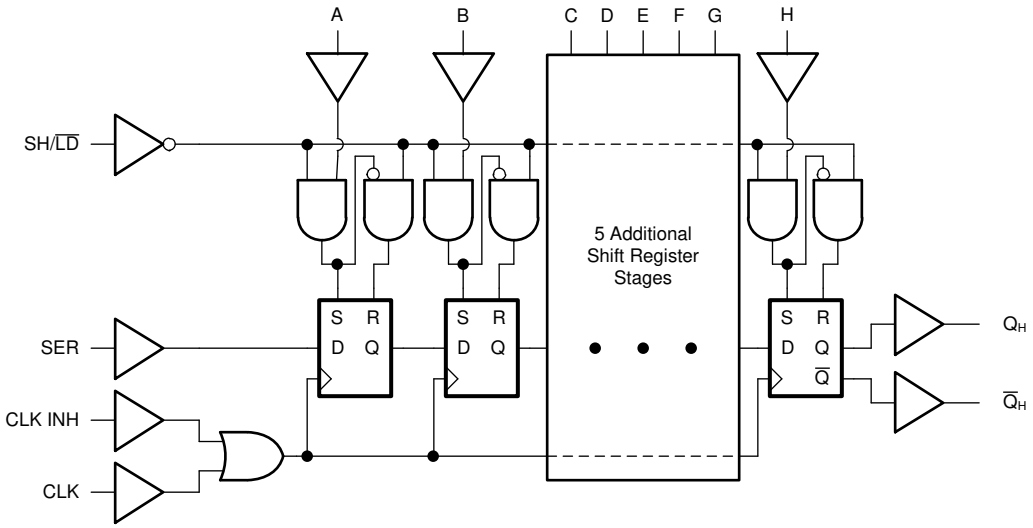
The SN74LV165A device is a parallel-load, 8-bit shift registers designed for 2 V to 5.5 V V_{CC} operation.

When the device is clocked, data is shifted toward the serial output Q_H. Parallel-in access to each stage is provided by eight individual direct data inputs that are enabled by a low level at the shift/load (SH/ $\overline{LD}$) input. The 'LV165A devices feature a clock-inhibit function and a complemented serial output, $\overline{Q}_H$.

Clocking is accomplished by a low-to-high transition of the clock (CLK) input while SH/ $\overline{LD}$ is held high and clock inhibit (CLK INH) is held low. The functions of CLK and CLK INH are interchangeable. Since a low CLK and a low-to-high transition of CLK INH accomplishes clocking, CLK INH must be changed to the high level only while CLK is high. Parallel loading is inhibited when SH/ $\overline{LD}$ is held high. The parallel inputs to the register are enabled while SH/ $\overline{LD}$ is held low, independently of the levels of CLK, CLK INH, or SER.

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 devices when they are powered down.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Balanced CMOS Push-Pull Outputs

This device includes balanced CMOS push-pull outputs. The term *balanced* indicates that the device can sink and source similar currents. The drive capability of this device may create fast edges into light loads, so routing and load conditions should be considered to prevent ringing. Additionally, the outputs of this device are capable of driving larger currents than the device can sustain without being damaged. It is important for the output power of the device to be limited to avoid damage due to overcurrent. The electrical and thermal limits defined in the *Absolute Maximum Ratings* must be followed at all times.

Unused push-pull CMOS outputs should be left disconnected.

8.3.2 Latching Logic

This device includes latching logic circuitry. Latching circuits commonly include D-type latches and D-type flip-flops, but include all logic circuits that act as volatile memory.

When the device is powered on, the state of each latch is unknown. There is no default state for each latch at start-up.

The output state of each latching logic circuit only remains stable as long as power is applied to the device within the supply voltage range specified in the *Recommended Operating Conditions* table.

Copyright © 2023 Texas Instruments Incorporated

8.3.3 Partial Power Down (I_{off})

This device includes circuitry to disable all outputs when the supply pin is held at 0 V. When disabled, the outputs will neither source nor sink current, regardless of the input voltages applied. The amount of leakage current at each output is defined by the I_{off} specification in the *Electrical Characteristics* table.

8.3.4 Clamp Diode Structure

Figure 8-1 shows the inputs and outputs to this device have negative clamping diodes only.

CAUTION

Voltages beyond the values specified in the *Absolute Maximum Ratings* table can cause damage to the device. The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.

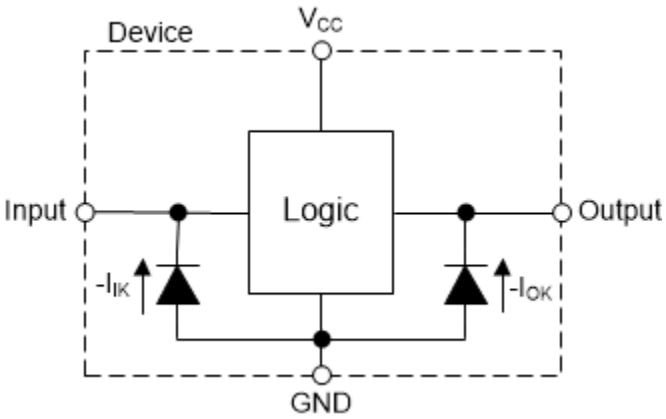


Figure 8-1. Electrical Placement of Clamping Diodes for Each Input and Output

Copyright © 2023 Texas Instruments Incorporated

8.4 Device Functional Modes

The Operating Mode Table and the Output Function Table list the functional modes of the SN74LV165A.

Table 8-1. Operating Mode Table

INPUTS(1)			FUNCTION
SH/$\overline{LD}$	CLK	CLK INH	
L	X	X	Parallel load
H	H	X	No change
H	X	H	No change
H	L	↑	Shift(2)
H	↑	L	Shift(2)

(1) H = High Voltage Level, L = Low Voltage Level, X = Do Not Care, ↑ = Low to High transition
(2) Shift : Content of each internal register shifts towards serial output Q_H. Data at SER is shifted into the first register.

Table 8-2. Output Function Table

INTERNAL REGISTERS(1) (2)		OUTPUTS(2)	
A — G	H	Q	$\overline{Q}$
X	L	L	H
X	H	H	L

(1) Internal registers refer to the shift registers inside the device. These values are set by either loading data from the parallel inputs, or by clocking data in from the serial input.
(2) H = High Voltage Level, L = Low Voltage Level, X = Do Not Care

Copyright © 2023 Texas Instruments Incorporated

9 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

9.1 Application Information

The SN74LV165A is a low drive CMOS device that can be used for a multitude of bus interface type applications where output ringing is a concern. The low-drive and slow-edge rates minimize overshoot and undershoot on the outputs.

9.2 Typical Application

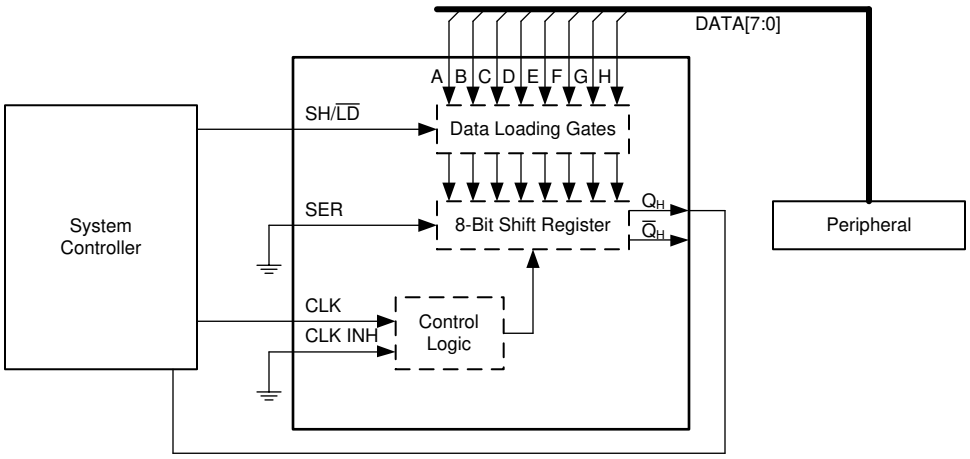


Figure 9-1. Input Expansion with Shift Registers

9.2.1 Power Considerations

Ensure the desired supply voltage is within the range specified in the *Recommended Operating Conditions*. The supply voltage sets the device's electrical characteristics as described in the *Electrical Characteristics* section.

The positive voltage supply must be capable of sourcing current equal to the total current to be sourced by all outputs of the SN74LV165A plus the maximum static supply current, I_{CC}, listed in the *Electrical Characteristics*, and any transient current required for switching. The logic device can only source as much current that is provided by the positive supply source. Be sure to not exceed the maximum total current through V_{CC} listed in the *Absolute Maximum Ratings*.

The ground must be capable of sinking current equal to the total current to be sunk by all outputs of the SN74LV165A plus the maximum supply current, I_{CC}, listed in the *Electrical Characteristics*, and any transient current required for switching. The logic device can only sink as much current that can be sunk into its ground connection. Be sure to not exceed the maximum total current through GND listed in the *Absolute Maximum Ratings*.

The SN74LV165A can drive a load with a total capacitance less than or equal to 50 pF while still meeting all of the data sheet specifications. Larger capacitive loads can be applied; however, it is not recommended to exceed 50 pF.

The SN74LV165A can drive a load with total resistance described by $R_L \geq V_O / I_O$, with the output voltage and current defined in the *Electrical Characteristics* table with V_{OH} and V_{OL}. When outputting in the HIGH state, the output voltage in the equation is defined as the difference between the measured output voltage and the supply voltage at the V_{CC} pin.

Copyright © 2023 Texas Instruments Incorporated

Total power consumption can be calculated using the information provided in *CMOS Power Consumption and Cpd Calculation*.

Thermal increase can be calculated using the information provided in *Thermal Characteristics of Standard Linear and Logic (SLL) Packages and Devices*.

CAUTION

The maximum junction temperature, $T_{J(max)}$ listed in the *Absolute Maximum Ratings*, is an additional limitation to prevent damage to the device. Do not violate any values listed in the *Absolute Maximum Ratings*. These limits are provided to prevent damage to the device.

9.2.2 Input Considerations

Input signals must cross $V_{IL(max)}$ to be considered a logic LOW, and $V_{IH(min)}$ to be considered a logic HIGH. Do not exceed the maximum input voltage range found in the *Absolute Maximum Ratings*.

Unused inputs must be terminated to either V_{CC} or ground. The unused inputs can be directly terminated if the input is completely unused, or they can be connected with a pull-up or pull-down resistor if the input will be used sometimes, but not always. A pull-up resistor is used for a default state of HIGH, and a pull-down resistor is used for a default state of LOW. The drive current of the controller, leakage current into the SN74LV165A (as specified in the *Electrical Characteristics*), and the desired input transition rate limits the resistor size. A 10-kΩ resistor value is often used due to these factors.

The SN74LV165A has CMOS inputs and thus requires fast input transitions to operate correctly, as defined in the *Recommended Operating Conditions* table. Slow input transitions can cause oscillations, additional power consumption, and reduction in device reliability.

Refer to the *Feature Description* section for additional information regarding the inputs for this device.

9.2.3 Output Considerations

The positive supply voltage is used to produce the output HIGH voltage. Drawing current from the output will decrease the output voltage as specified by the V_{OH} specification in the *Electrical Characteristics*. The ground voltage is used to produce the output LOW voltage. Sinking current into the output will increase the output voltage as specified by the V_{OL} specification in the *Electrical Characteristics*.

Push-pull outputs that could be in opposite states, even for a very short time period, should never be connected directly together. This can cause excessive current and damage to the device.

Two channels within the same device with the same input signals can be connected in parallel for additional output drive strength.

Unused outputs can be left floating. Do not connect outputs directly to V_{CC} or ground.

Refer to the *Feature Description* section for additional information regarding the outputs for this device.

9.2.4 Detailed Design Procedure

1. Add a decoupling capacitor from V_{CC} to GND. The capacitor needs to be placed physically close to the device and electrically close to both the V_{CC} and GND pins. An example layout is shown in the *Layout* section.
2. Ensure the capacitive load at the output is ≤ 50 pF. This is not a hard limit; it will, however, ensure optimal performance. This can be accomplished by providing short, appropriately sized traces from the SN74LV165A to one or more of the receiving devices.
3. Ensure the resistive load at the output is larger than (V_{CC} / $I_{O(max)}$) Ω. This will ensure that the maximum output current from the *Absolute Maximum Ratings* is not violated. Most CMOS inputs have a resistive load measured in MΩ; much larger than the minimum calculated previously.
4. Thermal issues are rarely a concern for logic gates; the power consumption and thermal increase, however, can be calculated using the steps provided in the application report, *CMOS Power Consumption and Cpd Calculation*.

Copyright © 2023 Texas Instruments Incorporated

9.2.5 Application Curve

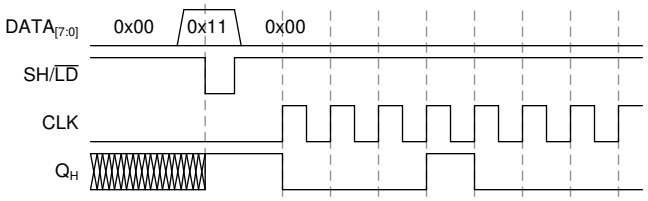


Figure 9-2. Application Timing Diagram

9.3 Power Supply Recommendations

The power supply can be any voltage between the minimum and maximum supply voltage rating located in the *Section 6.1* section. Each V_{CC} terminal must have a good bypass capacitor to prevent power disturbance. For devices with a single supply, TI recommends a 0.1-µF capacitor and if there are multiple V_{CC} terminals then TI recommends a 0.01-µF or 0.022-µF capacitor for each power terminal. Multiple bypass capacitors can be paralleled to reject different frequencies of noise. Frequencies of 0.1 µF and 1 µF are commonly used in parallel. The bypass capacitor must be installed as close as possible to the power terminal for best results.

9.4 Layout

9.4.1 Layout Guidelines

When using multiple bit logic devices, inputs should not float. In many cases, functions or parts of functions of digital logic devices are unused. Some examples are when only two inputs of a triple-input AND gate are used, or when only 3 of the 4-buffer gates are used. Such unused input pins must not be left unconnected because the undefined voltages at the outside connections result in undefined operational states. All unused inputs of digital logic devices must be connected to a logic high or logic low voltage, as defined by the input voltage specifications, to prevent them from floating. The logic level that must be applied to any particular unused input depends on the function of the device. Generally, the inputs are tied to GND or V_{CC}, whichever makes more sense for the logic function or is more convenient.

9.4.2 Layout Example

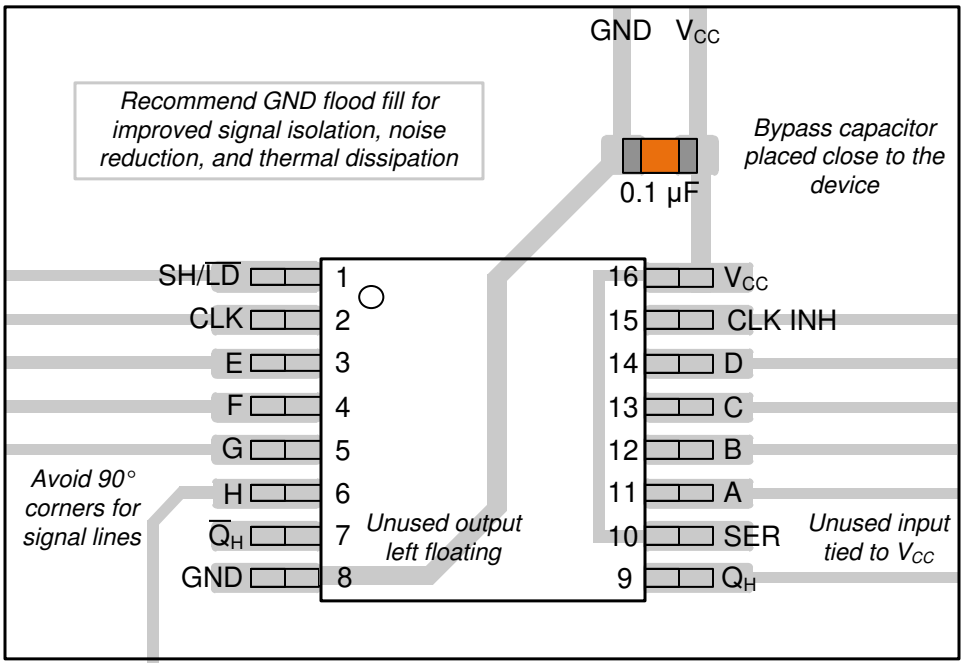


Figure 9-3. Example Layout for the SN74LV165A in the PW Package

Copyright © 2023 Texas Instruments Incorporated

10 Device and Documentation Support

10.1 Documentation Support

10.1.1 Related Documentation

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 10-1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
SN74LV165A	Click here	Click here	Click here	Click here	Click here

10.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates—including silicon errata—go to the product folder for your device on ti.com. In the upper right-hand corner, click the *Alert me* button. This registers you to receive a weekly digest of product information that has changed (if any). For change details, check the revision history of any revised document.

10.3 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.

10.4 Trademarks

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

10.5 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.

10.6 Glossary

TI Glossary — This glossary lists and explains terms, acronyms, and definitions.

11 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.

Copyright © 2023 Texas Instruments Incorporated

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)
SN74LV165ABQBR	Active	Production	WQFN (BQB) | 16	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ABQBR.A	Active	Production	WQFN (BQB) | 16	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165AD	Obsolete	Production	SOIC (D) | 16	-	-	Call TI	Call TI	-40 to 125	LV165A
SN74LV165ADBR	Active	Production	SSOP (DB) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADBR.A	Active	Production	SSOP (DB) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADGVR	Active	Production	TVSOP (DGV) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADGVR.A	Active	Production	TVSOP (DGV) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADR	Active	Production	SOIC (D) | 16	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADR.A	Active	Production	SOIC (D) | 16	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADRG3	Active	Production	SOIC (D) | 16	2500 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADRG3.A	Active	Production	SOIC (D) | 16	2500 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADRG4	Active	Production	SOIC (D) | 16	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ADRG4.A	Active	Production	SOIC (D) | 16	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ANSR	Last Time Buy	Production	SOP (NS) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	74LV165A
SN74LV165ANSR.A	Last Time Buy	Production	SOP (NS) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	74LV165A
SN74LV165APW	Obsolete	Production	TSSOP (PW) | 16	-	-	Call TI	Call TI	-40 to 125	LV165A
SN74LV165APWR	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165APWR.A	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165APWRG3	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165APWRG3.A	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165APWRG4	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165APWRG4.A	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ARGYR	Active	Production	VQFN (RGY) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ARGYR.A	Active	Production	VQFN (RGY) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A
SN74LV165ARGYRG4	Active	Production	VQFN (RGY) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LV165A

(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.

OTHER QUALIFIED VERSIONS OF SN74LV165A :

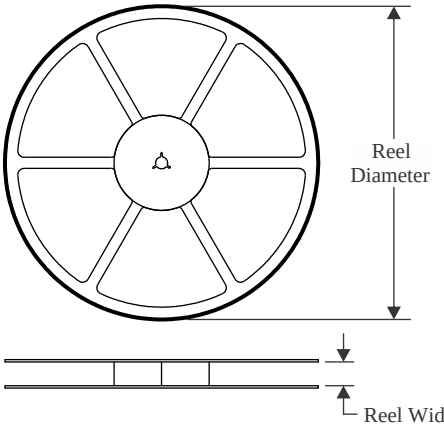
- Automotive : SN74LV165A-Q1
- Enhanced Product : SN74LV165A-EP

NOTE: Qualified Version Definitions:

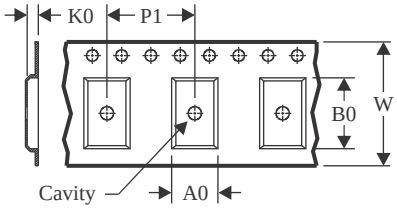
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

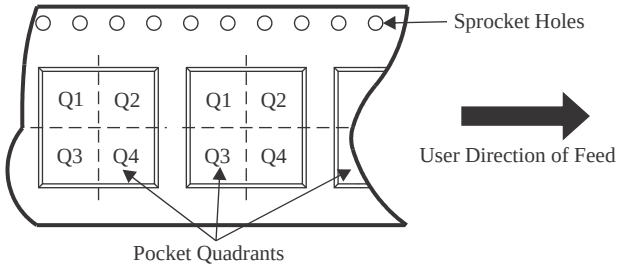


TAPE DIMENSIONS



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

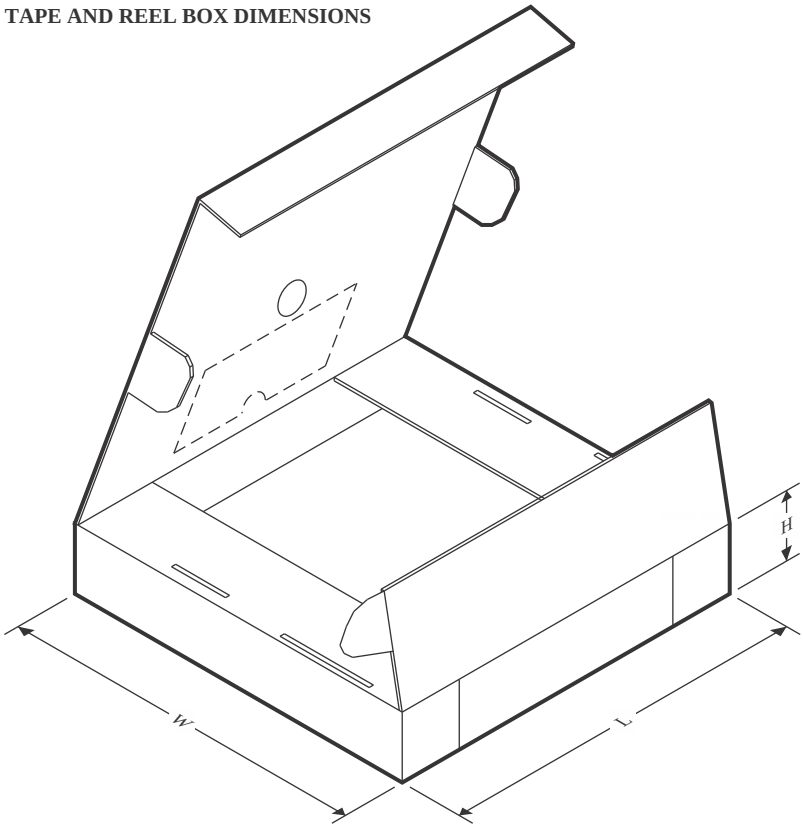
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
SN74LV165ABQBR	WQFN	BQB	16	3000	180.0	12.4	2.8	3.8	1.2	4.0	12.0	Q1
SN74LV165ADBR	SSOP	DB	16	2000	330.0	16.4	8.35	6.6	2.4	12.0	16.0	Q1
SN74LV165ADGVR	TVSOP	DGV	16	2000	330.0	12.4	6.8	4.0	1.6	8.0	12.0	Q1
SN74LV165ADR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN74LV165ADRG3	SOIC	D	16	2500	330.0	16.8	6.5	10.3	2.1	8.0	16.0	Q1
SN74LV165ADRG4	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN74LV165ANSR	SOP	NS	16	2000	330.0	16.4	8.1	10.4	2.5	12.0	16.0	Q1
SN74LV165APWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74LV165APWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.3	1.6	8.0	12.0	Q1
SN74LV165APWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74LV165APWRG3	TSSOP	PW	16	2000	330.0	12.4	6.85	5.45	1.6	8.0	12.0	Q1
SN74LV165APWRG4	TSSOP	PW	16	2000	330.0	12.4	6.9	5.3	1.6	8.0	12.0	Q1
SN74LV165APWRG4	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74LV165APWRG4	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74LV165ARGYR	VQFN	RGY	16	3000	330.0	12.4	3.8	4.3	1.5	8.0	12.0	Q1

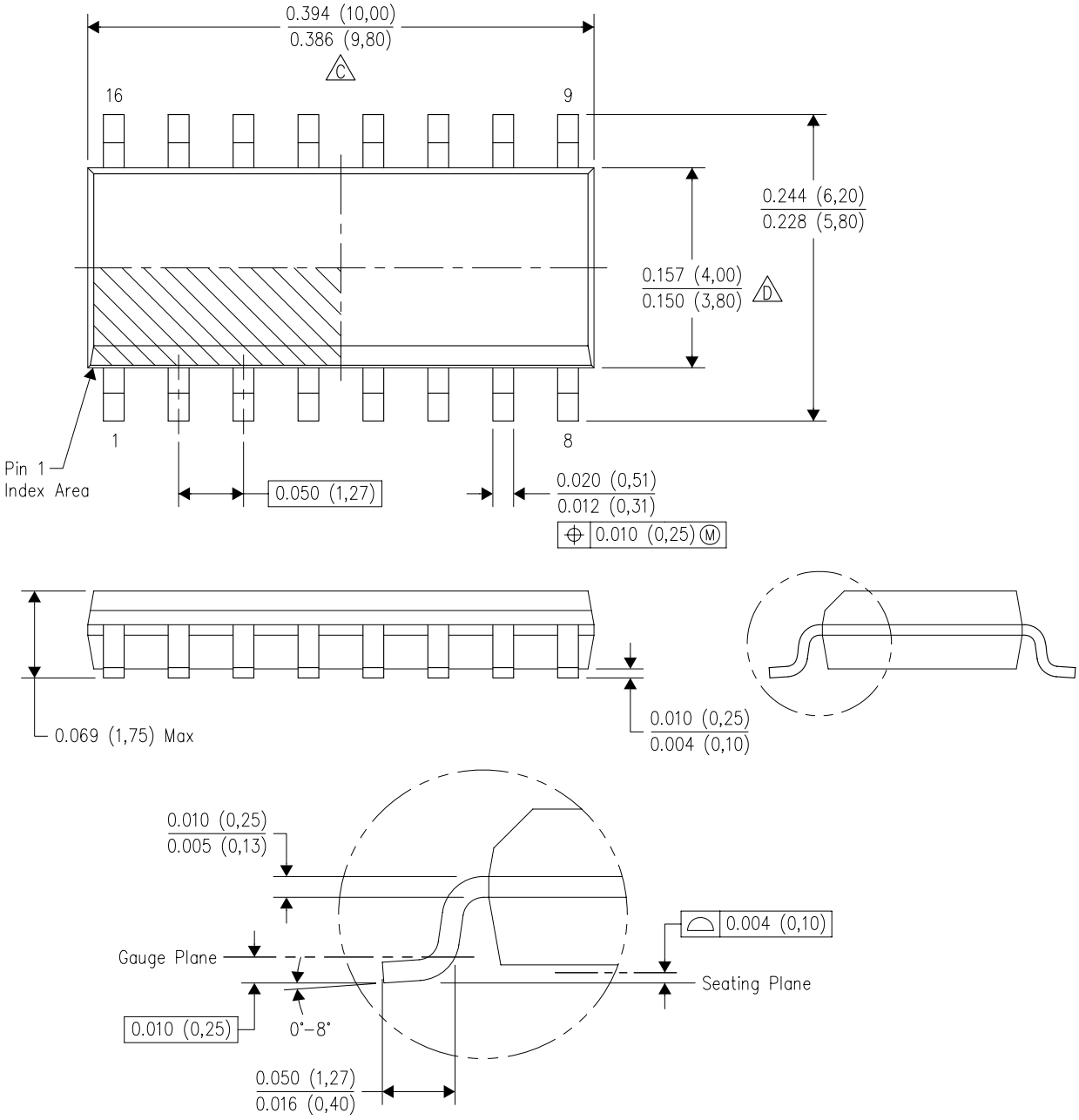
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74LV165ABQBR	WQFN	BQB	16	3000	210.0	185.0	35.0
SN74LV165ADBR	SSOP	DB	16	2000	353.0	353.0	32.0
SN74LV165ADGVR	TVSOP	DGV	16	2000	353.0	353.0	32.0
SN74LV165ADR	SOIC	D	16	2500	353.0	353.0	32.0
SN74LV165ADRG3	SOIC	D	16	2500	364.0	364.0	27.0
SN74LV165ADRG4	SOIC	D	16	2500	340.5	336.1	32.0
SN74LV165ANSR	SOP	NS	16	2000	353.0	353.0	32.0
SN74LV165APWR	TSSOP	PW	16	2000	356.0	356.0	35.0
SN74LV165APWR	TSSOP	PW	16	2000	367.0	367.0	35.0
SN74LV165APWR	TSSOP	PW	16	2000	353.0	353.0	32.0
SN74LV165APWRG3	TSSOP	PW	16	2000	366.0	364.0	50.0
SN74LV165APWRG4	TSSOP	PW	16	2000	367.0	367.0	35.0
SN74LV165APWRG4	TSSOP	PW	16	2000	353.0	353.0	32.0
SN74LV165APWRG4	TSSOP	PW	16	2000	353.0	353.0	32.0
SN74LV165ARGYR	VQFN	RGY	16	3000	360.0	360.0	36.0

D (R–PDSO–G16) PLASTIC SMALL OUTLINE



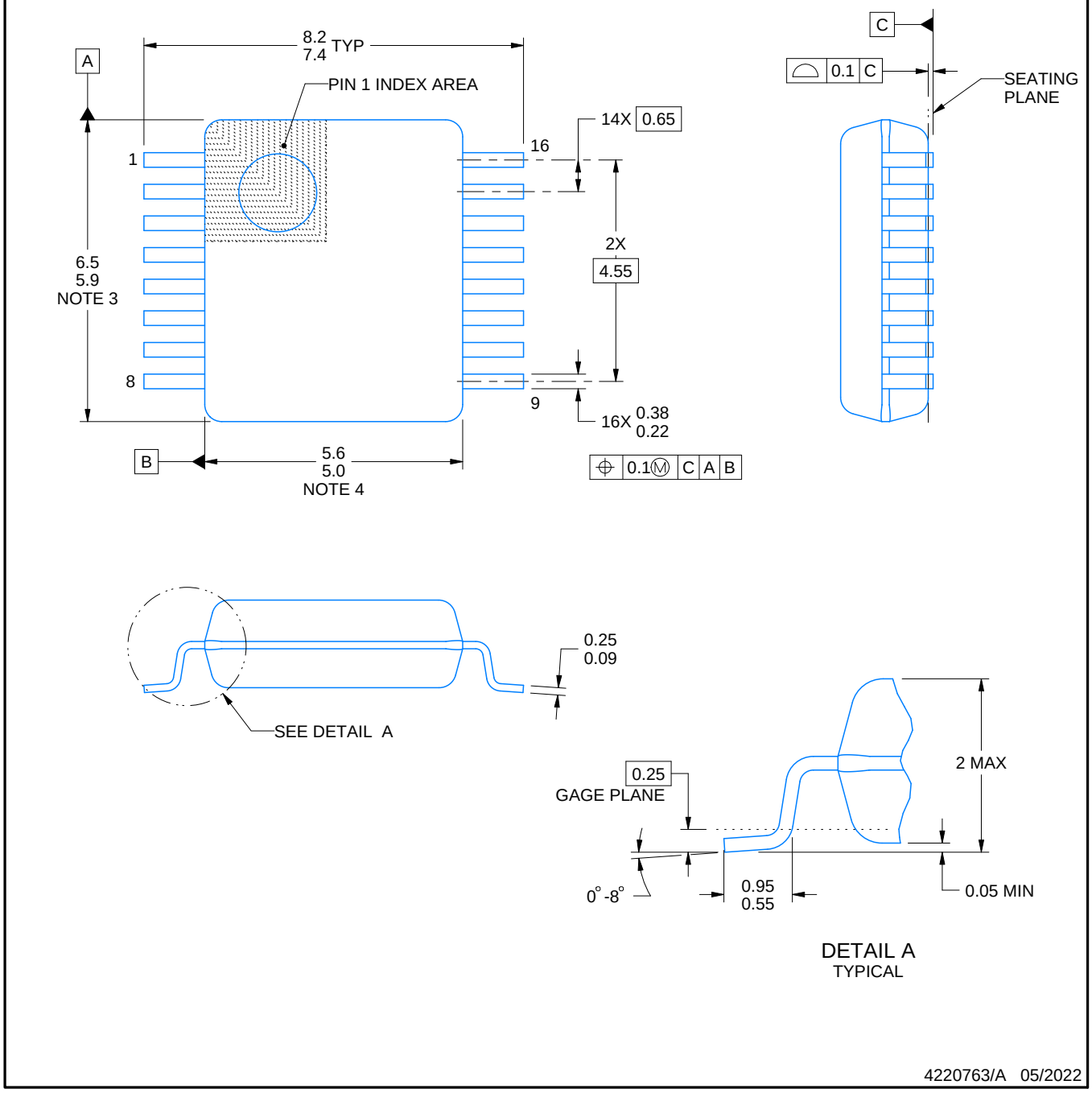
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead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

PACKAGE OUTLINE

DB0016A

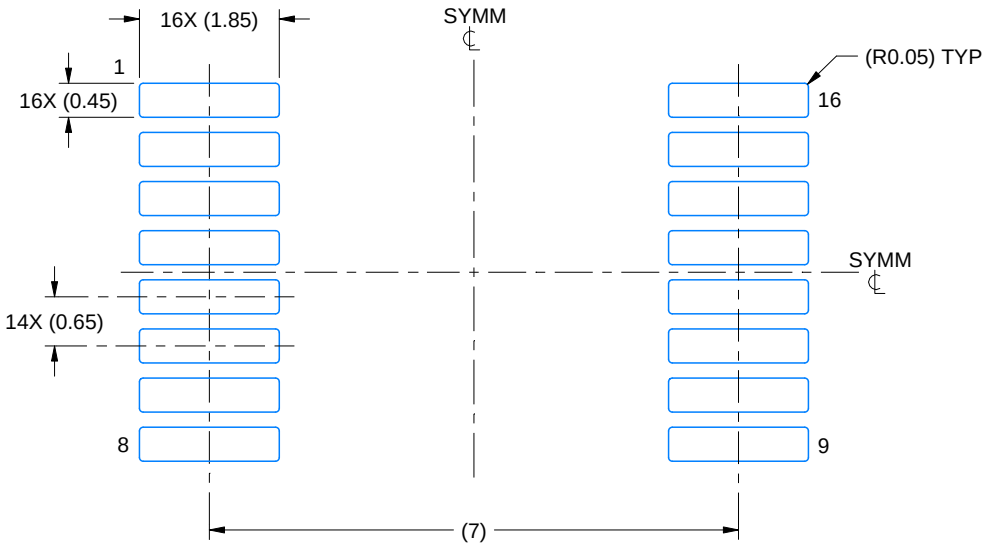
SSOP - 2 mm max height

SMALL OUTLINE PACKAGE

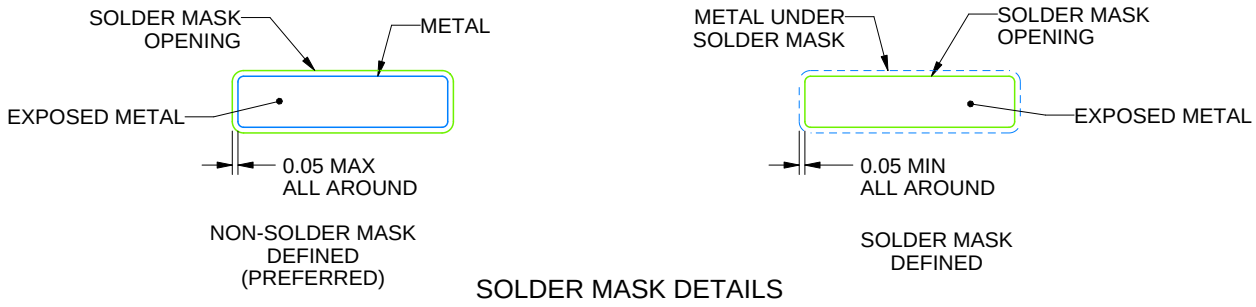


NOTES:

1. All linear dimensions are in millimeters. Any 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. Reference JEDEC registration MO-150.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

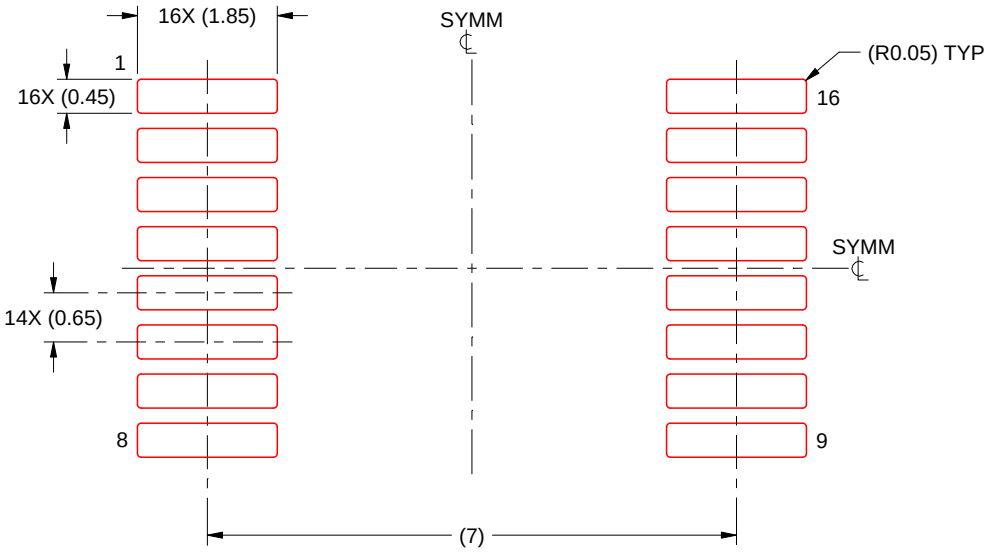


SOLDER MASK DETAILS

4220763/A 05/2022

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: 10X

4220763/A 05/2022

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.

GENERIC PACKAGE VIEW

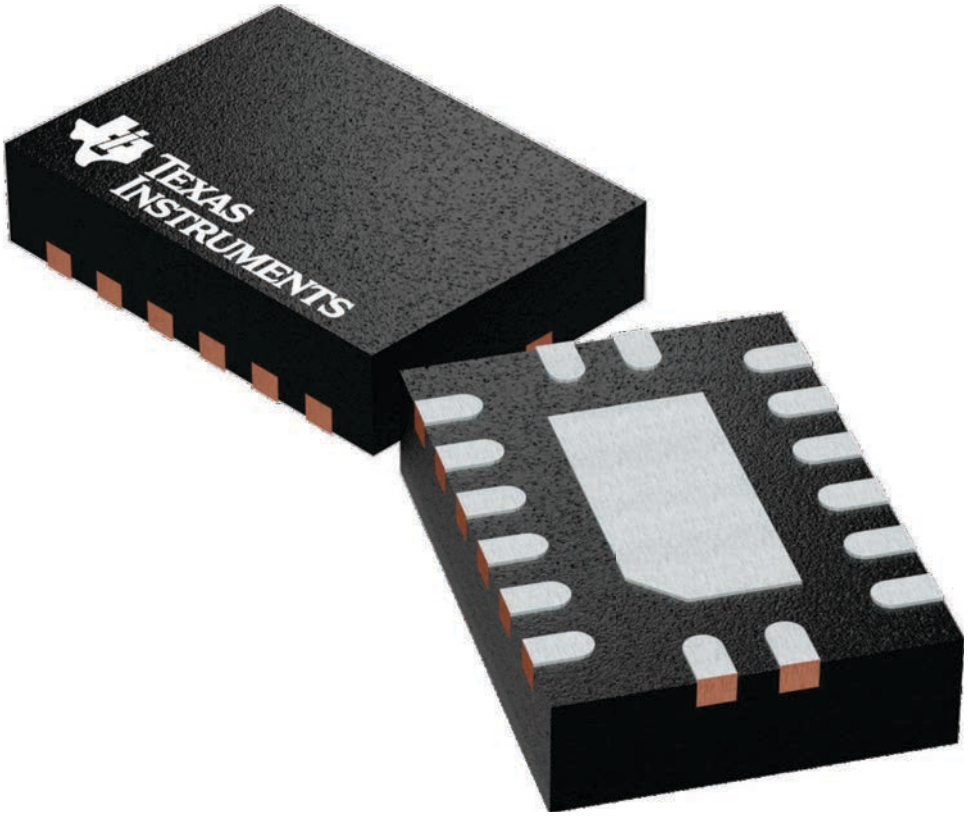
BQB 16

WQFN - 0.8 mm max height

2.5 x 3.5, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



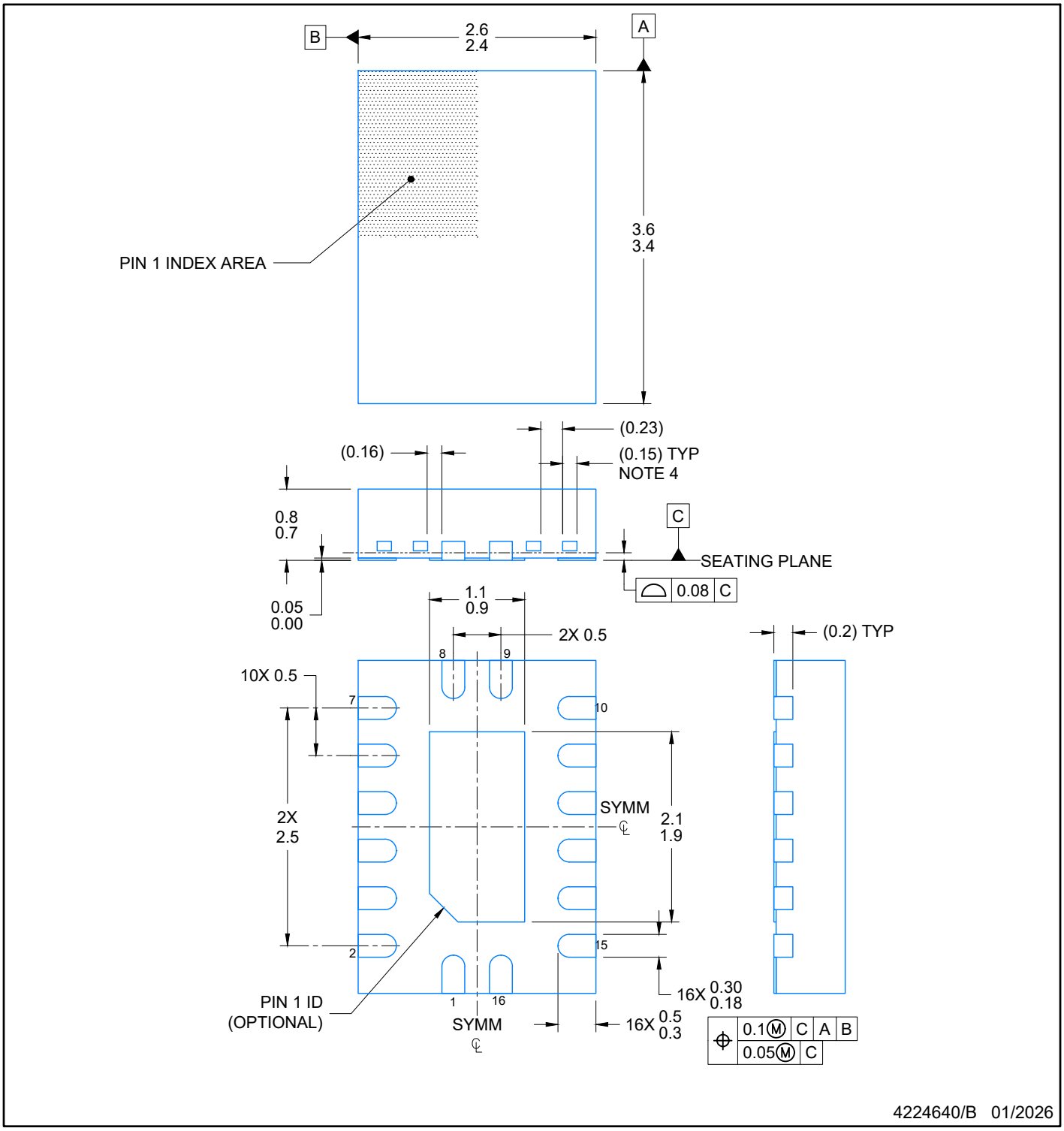
4226161/A

PACKAGE OUTLINE

BQB0016A

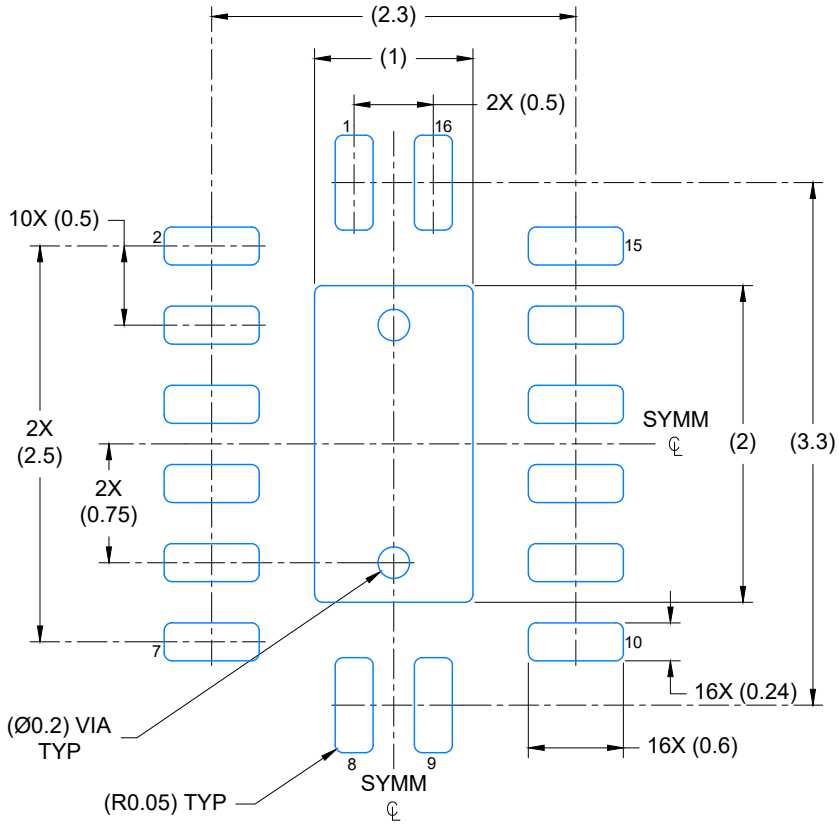
WQFN - 0.8 mm max height

PLASTIC QUAD FLAT PACK-NO LEAD

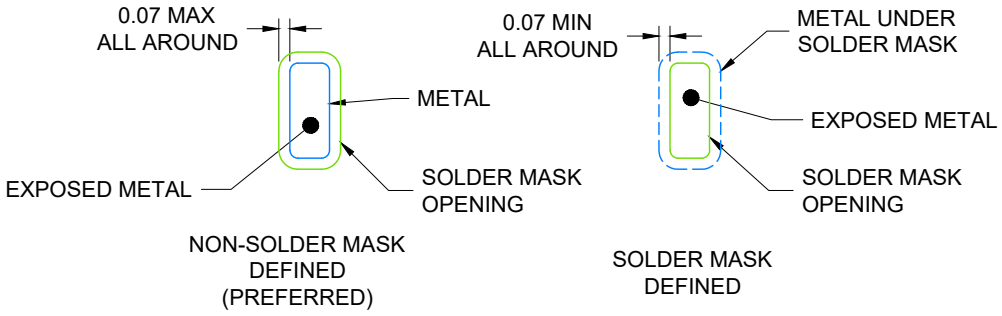


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.
4. Features may differ or may not be present



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X

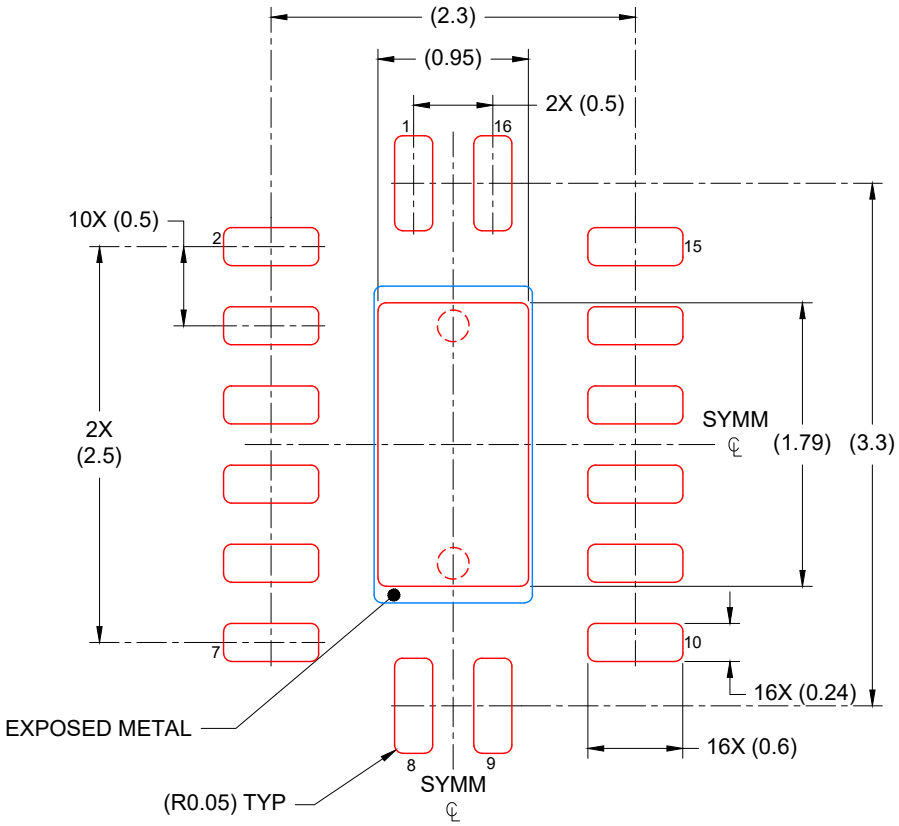


4224640/B 01/2026

1. NOTES: (continued)

5. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).

6. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
85% PRINTED COVERAGE BY AREA
SCALE: 20X

4224640/B 01/2026

NOTES: (continued)

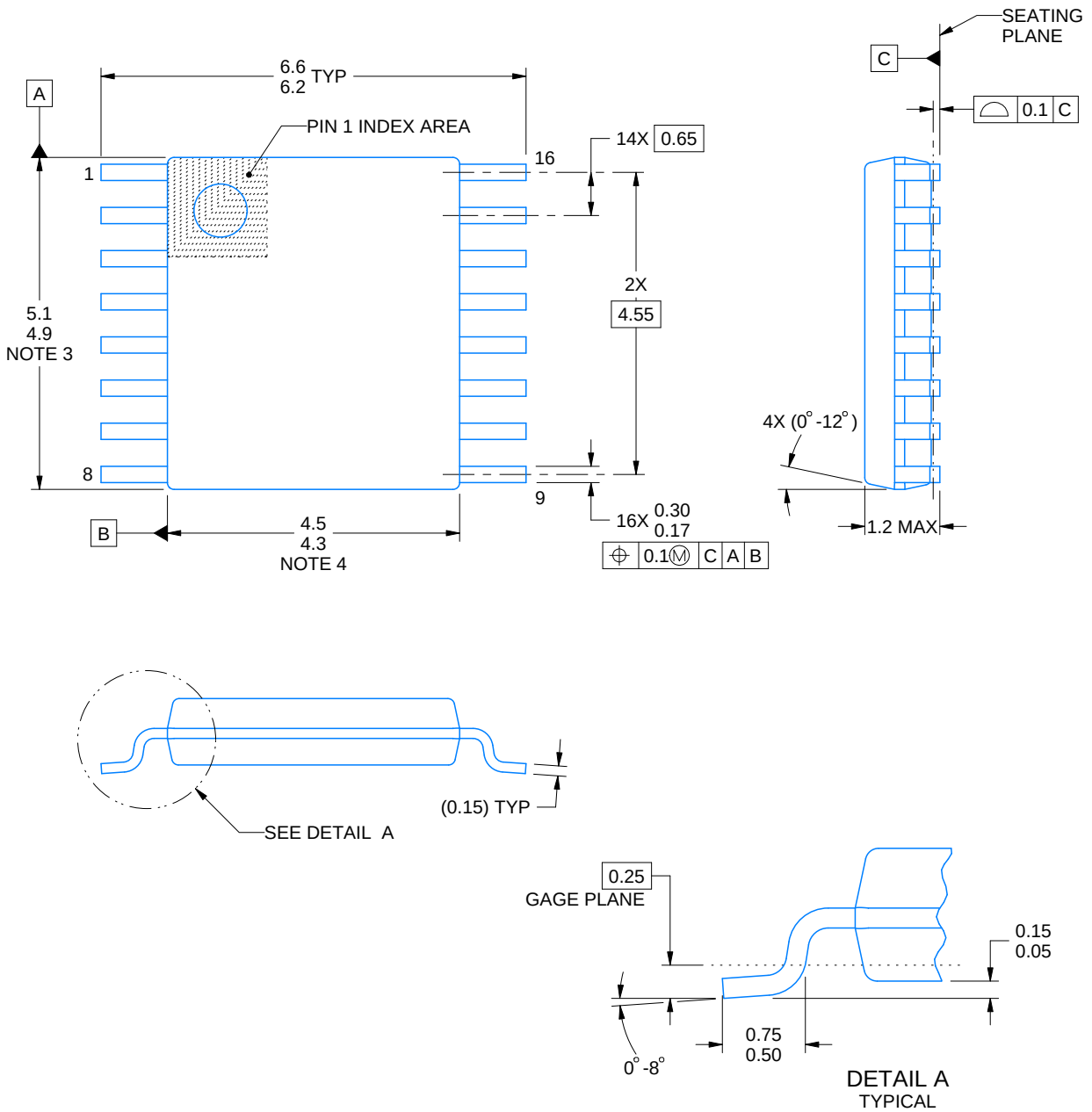
7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

PACKAGE OUTLINE

PW0016A

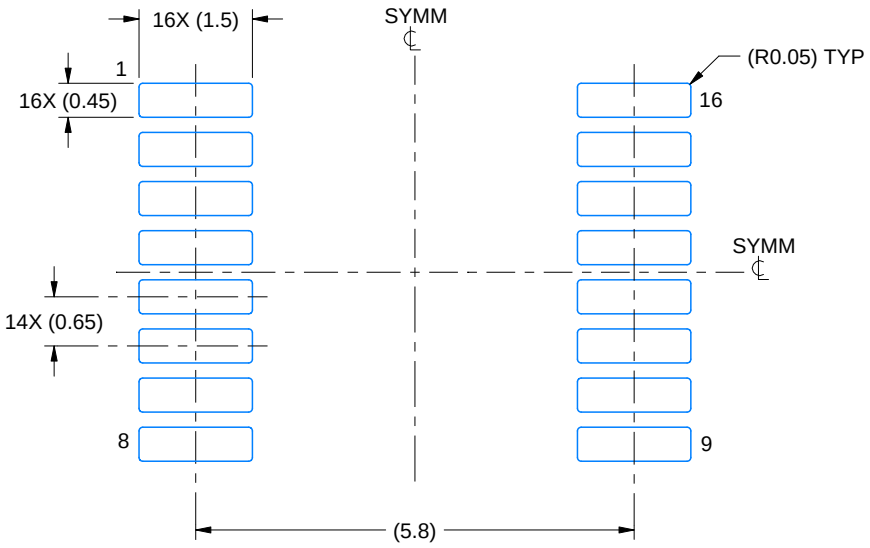
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES:

1. All linear dimensions are in millimeters. Any 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.
5. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

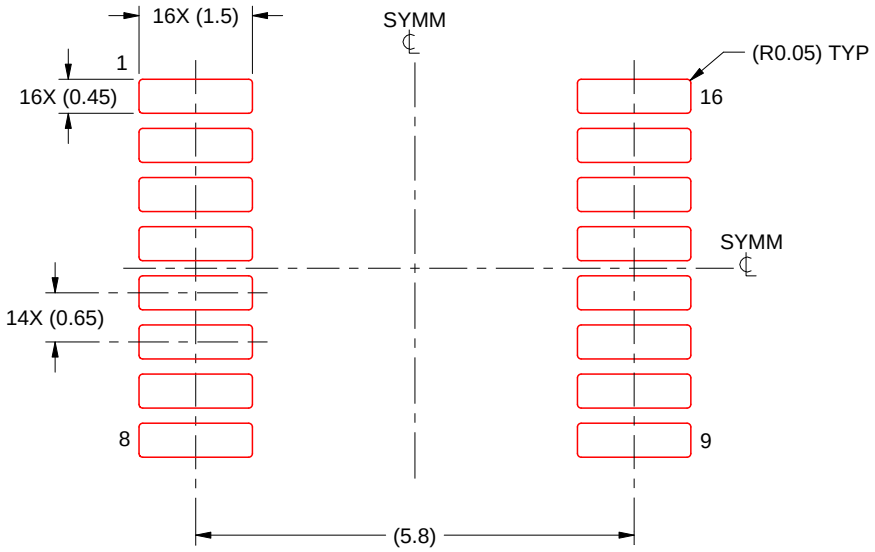


SOLDER MASK DETAILS

4220204/B 12/2023

NOTES: (continued)

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

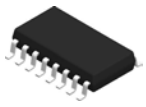


SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220204/B 12/2023

NOTES: (continued)

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

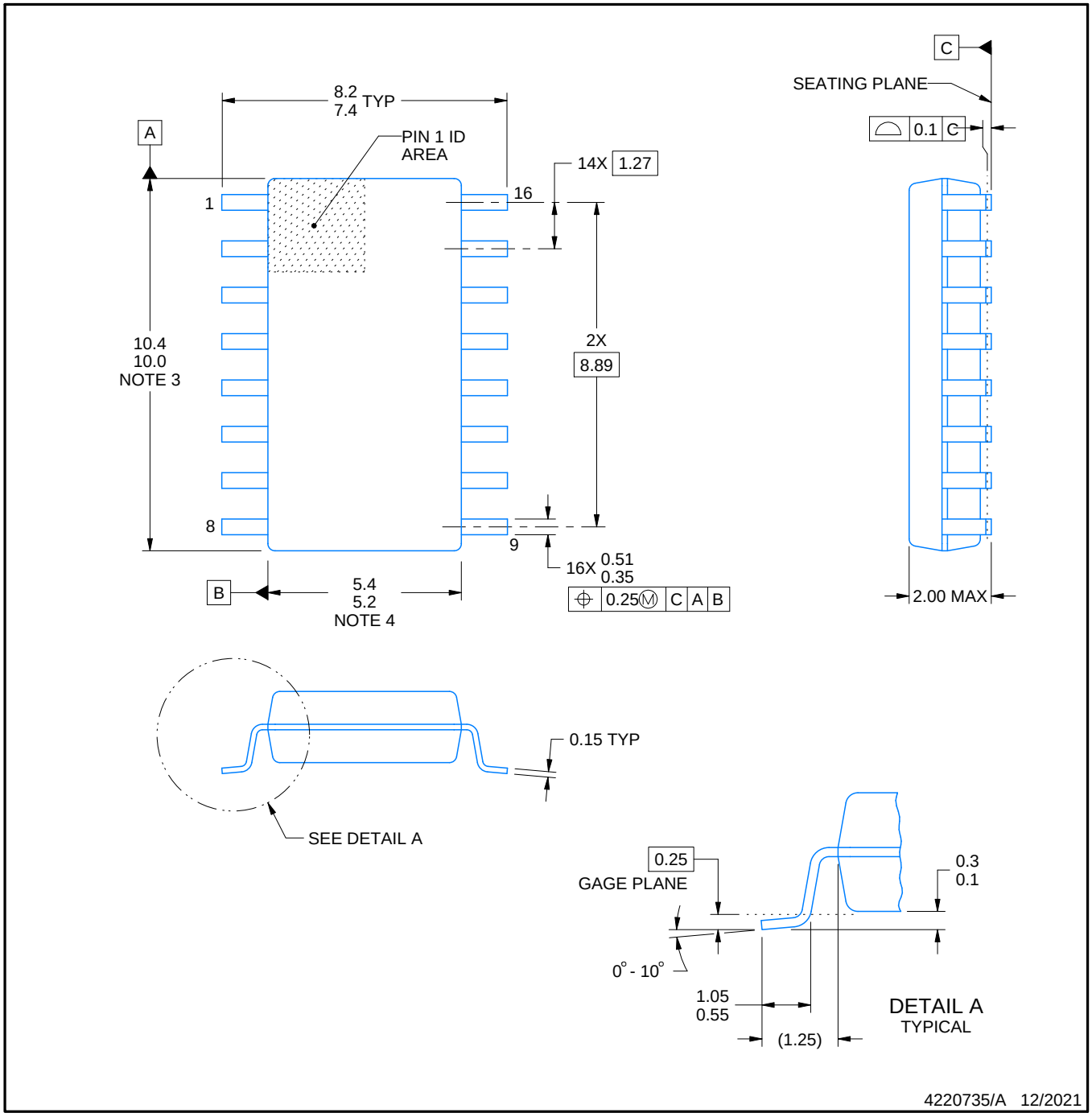


PACKAGE OUTLINE

NS0016A

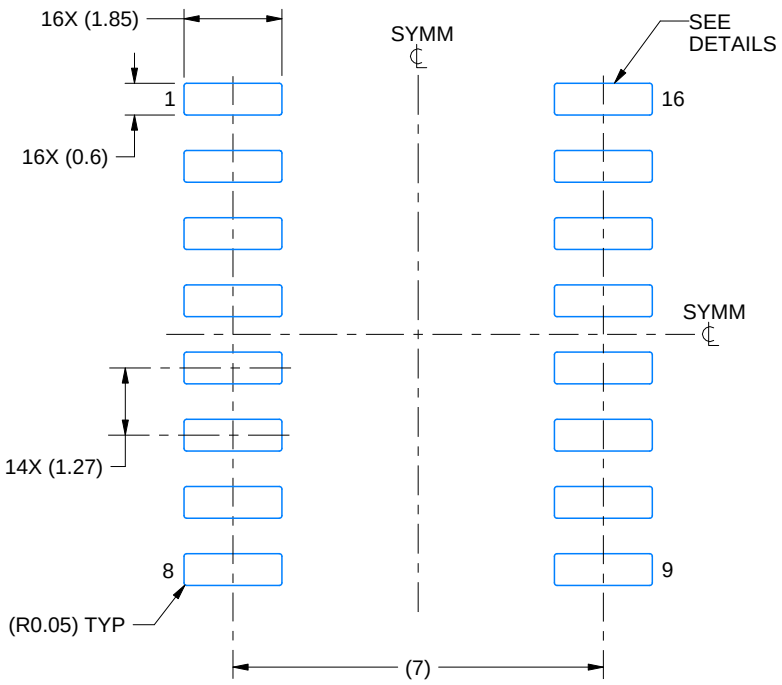
SOP - 2.00 mm max height

SOP

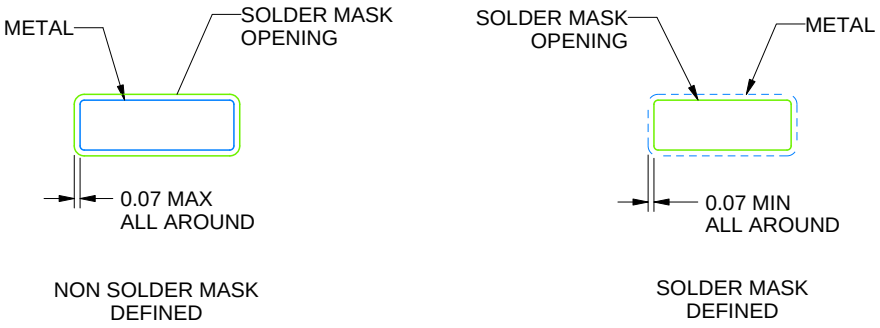


NOTES:

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

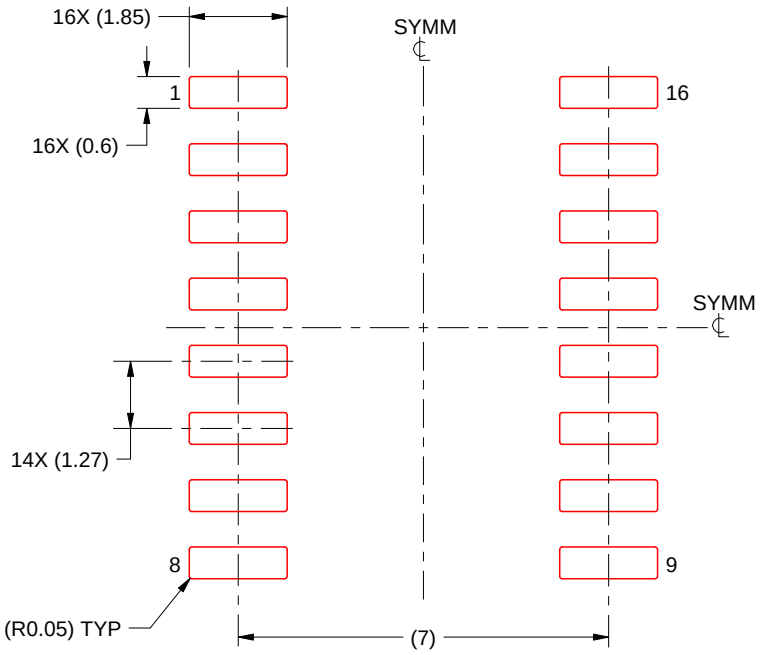
SOLDER MASK
DEFINED

SOLDER MASK DETAILS

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)

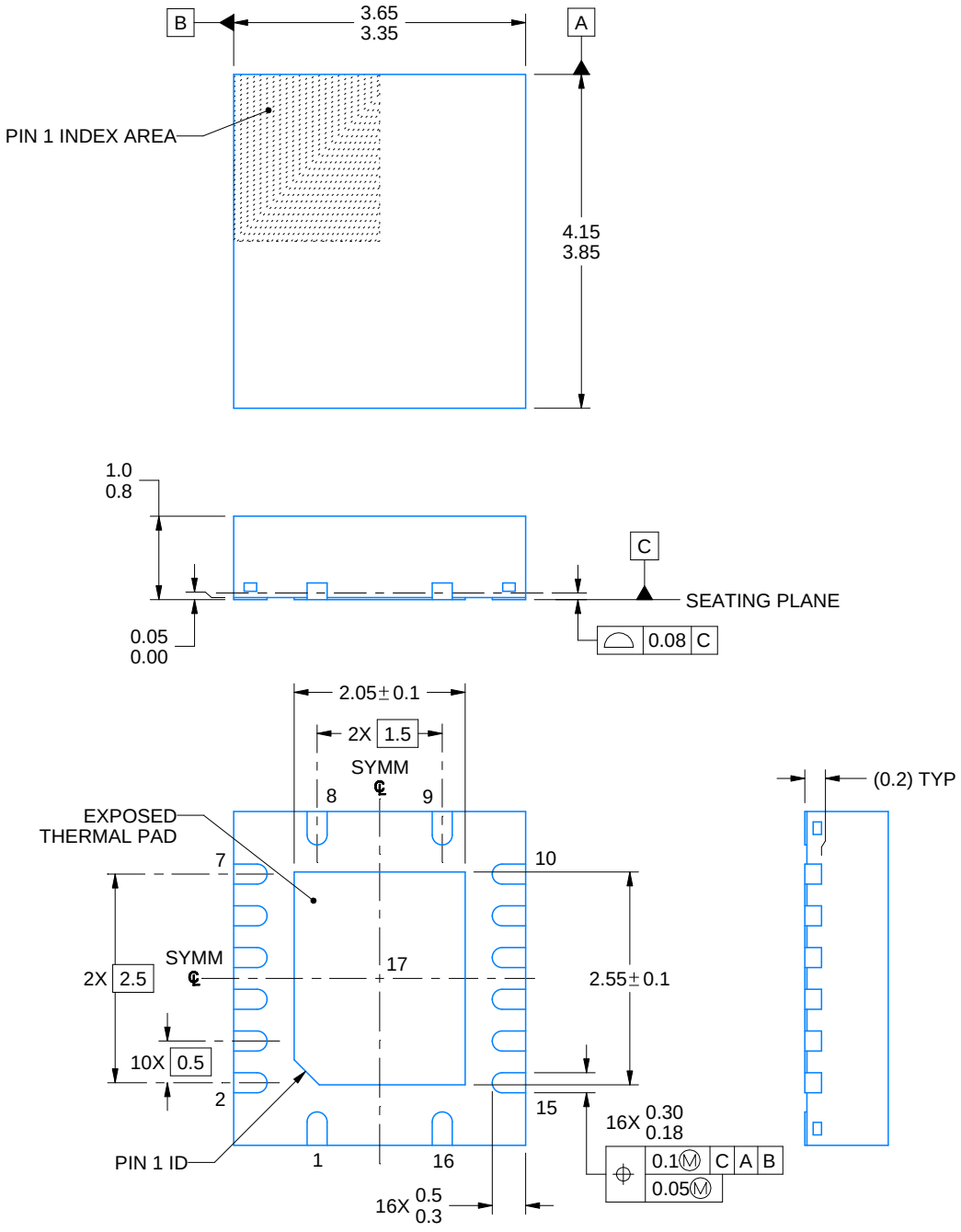
7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

RGY0016A

PACKAGE OUTLINE

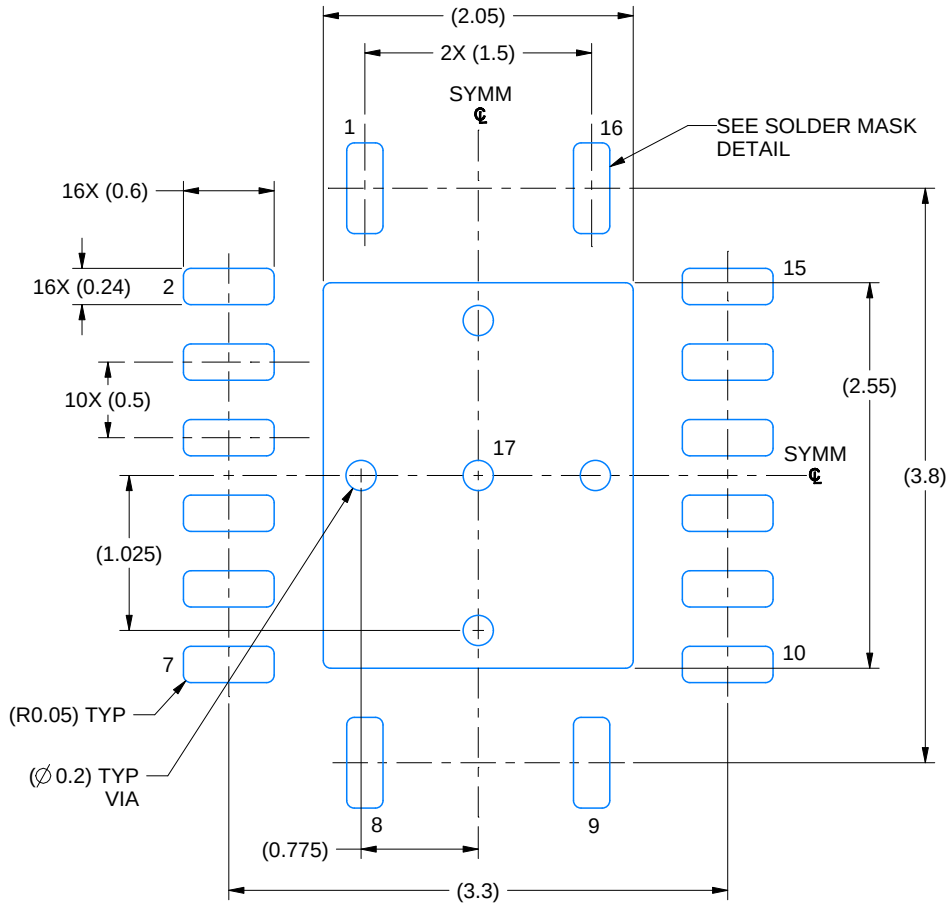
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

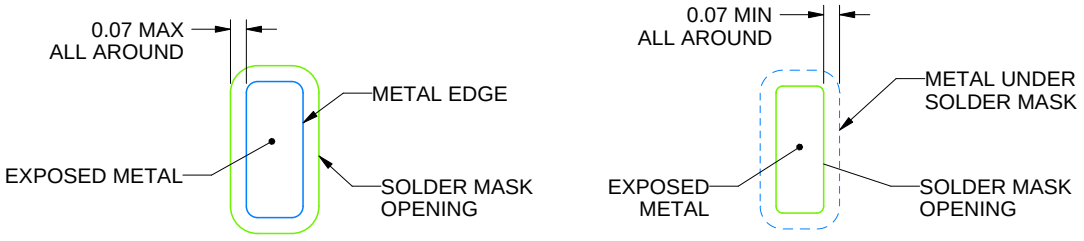


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X

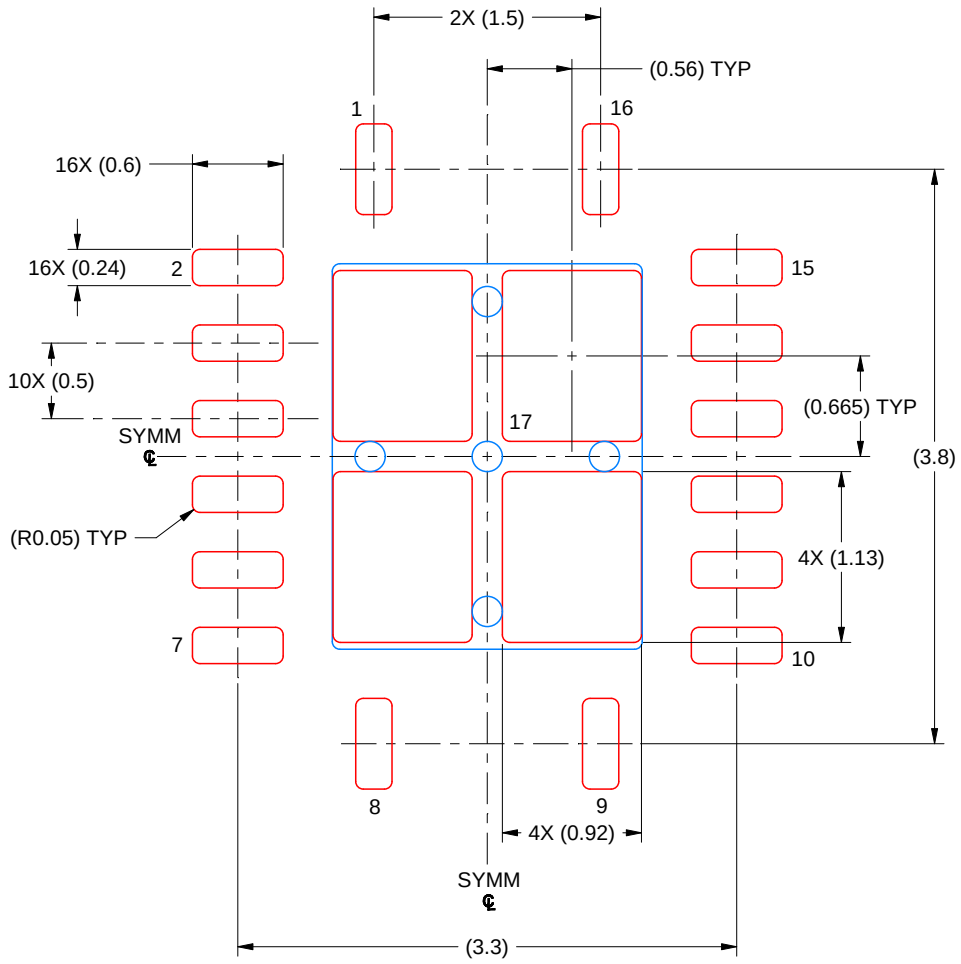


SOLDER MASK DETAILS

4225140/A 07/2019

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 20X

EXPOSED PAD 17
80% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

4225140/A 07/2019

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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