

# SN54ALS645A, SN54AS645, SN74ALS645A, SN74AS645 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

SDAS278 – JANUARY 1995

- Bidirectional Bus Transceivers in High-Density 20-Pin Packages
- True Logic
- 3-State Outputs
- Package Options Include Plastic Small-Outline (DW) Packages, Ceramic Chip Carriers (FK), and Standard Plastic (N) and Ceramic (J) 300-mil DIPs

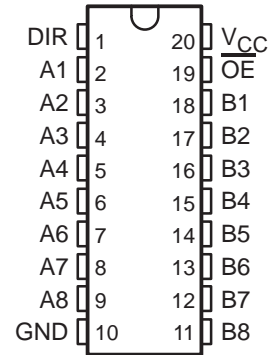
## description

These octal bus transceivers are designed for asynchronous two-way communication between data buses. These devices transmit data from the A bus to the B bus or from the B bus to the A bus, depending on the level at the direction-control (DIR) input. The output-enable ( $\overline{OE}$ ) input can be used to disable the device so that the buses are effectively isolated.

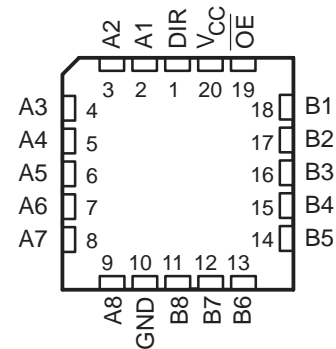
The -1 version of the SN74ALS645A is identical to the standard version, except that the recommended maximum  $I_{OL}$  is increased to 48 mA. There is no -1 version of the SN54ALS645A.

The SN54ALS645A and SN54AS645 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74ALS645A and SN74AS645 are characterized for operation from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ .

SN54ALS645A, SN54AS645 . . . J PACKAGE  
SN74ALS645A, SN74AS645 . . . DW OR N PACKAGE  
(TOP VIEW)



SN54ALS645A, SN54AS645 . . . FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE

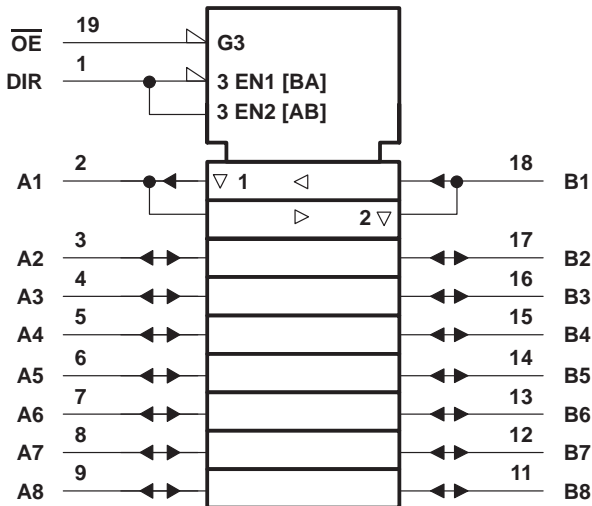
INPUTS		OPERATION
$\overline{OE}$	DIR	
L	L	B data to A bus
L	H	A data to B bus
H	X	Isolation

# SN54ALS645A, SN54AS645, SN74ALS645A, SN74AS645

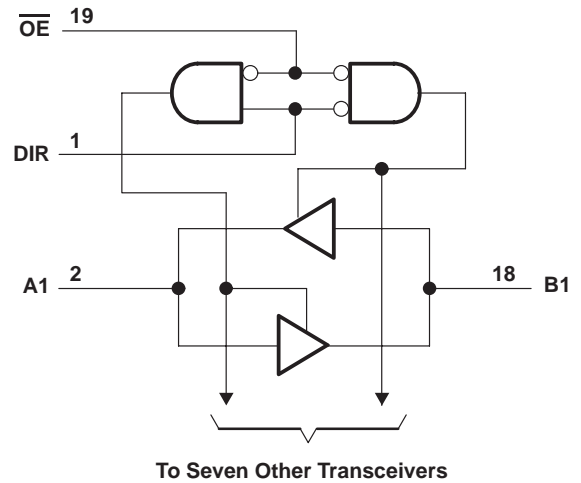
## OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

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### logic symbol†



### logic diagram (positive logic)



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

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

Supply voltage, $V_{CC}$	7 V
Input voltage, $V_I$ : All inputs	7 V
I/O ports	5.5 V
Operating free-air temperature range, $T_A$ : SN54ALS645A	-55°C to 125°C
SN74ALS645A	0°C to 70°C
Storage temperature range	-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.

### recommended operating conditions

	SN54ALS645A			SN74ALS645A			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$ Supply voltage	4.5	5	5.5	4.5	5	5.5	V
$V_{IH}$ High-level input voltage	2			2			V
$V_{IL}$ Low-level input voltage			0.7			0.8	V
$I_{OH}$ High-level output current			-12			-15	mA
$I_{OL}$ Low-level output current			12			24	mA
						48§	
$T_A$ Operating free-air temperature	-55		125	0		70	°C

§ Applies only to the -1 version and only if  $V_{CC}$  is between 4.75 V and 5.25 V

**SN54ALS645A, SN54AS645, SN74ALS645A, SN74AS645**  
**OCTAL BUS TRANSCEIVERS**  
**WITH 3-STATE OUTPUTS**

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

PARAMETER	TEST CONDITIONS	SN54ALS645A		SN74ALS645A		UNIT	
		MIN	TYP†	MAX	MIN		TYP†
$V_{IK}$	$V_{CC} = 4.5\text{ V}$ , $I_I = -18\text{ mA}$			-1.5			V
$V_{OH}$	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$ , $I_{OH} = -0.4\text{ mA}$	$V_{CC} - 2$		$V_{CC} - 2$		V	
	$V_{CC} = 4.5\text{ V}$	$I_{OH} = -3\text{ mA}$	2.4	3.2	2.4		3.2
		$I_{OH} = -12\text{ mA}$	2				
$V_{OL}$	$V_{CC} = 4.5\text{ V}$	$I_{OL} = 12\text{ mA}$	0.25	0.4	0.25	0.4	V
		$I_{OL} = 24\text{ mA}$			0.35	0.5	
		$I_{OL} = 48\text{ mA}^\ddagger$			0.35	0.5	
$I_I$	Control inputs	$V_{CC} = 5.5\text{ V}$	$V_I = 7\text{ V}$	0.1		0.1	mA
	A or B ports		$V_I = 5.5\text{ V}$	0.1		0.1	
$I_{IH}$	Control inputs	$V_{CC} = 5.5\text{ V}$ , $V_I = 2.7\text{ V}$	20		20		$\mu\text{A}$
	A or B ports§		20		20		
$I_{IL}$	Control inputs	$V_{CC} = 5.5\text{ V}$ , $V_I = 0.4\text{ V}$	-0.1		-0.1		mA
	A or B ports§		-0.1		-0.1		
$I_{O}^\parallel$	$V_{CC} = 5.5\text{ V}$ , $V_O = 2.25\text{ V}$	-20	-112	-30	-112	mA	
$I_{CC}$	$V_{CC} = 5.5\text{ V}$	Outputs high	30	48	30	45	mA
		Outputs low	36	60	36	55	
		Outputs disabled	38	63	38	58	

† All typical values are at  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

‡ Applies only to the -1 version and only if  $V_{CC}$  is between 4.75 V and 5.25 V

§ For I/O ports, the parameters  $I_{IH}$  and  $I_{IL}$  include the off-state output current.

¶ The output conditions have been chosen to produce a current that closely approximates one half of the true short-circuit output current,  $I_{OS}$ .

**switching characteristics (see Figure 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$ , $C_L = 50\text{ pF}$ , $R_1 = 500\ \Omega$ , $R_2 = 500\ \Omega$ , $T_A = \text{MIN to MAX}^\#$				UNIT
			SN54ALS645A		SN74ALS645A		
			MIN	MAX	MIN	MAX	
$t_{PLH}$	A or B	B or A	1	19	3	10	ns
$t_{PHL}$			1	14	3	10	
$t_{PZH}$	$\overline{OE}$	A or B	2	30	5	20	ns
$t_{PZL}$			2	29	5	20	
$t_{PHZ}$	$\overline{OE}$	A or B	2	14	2	10	ns
$t_{PLZ}$			2	30	4	15	

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



# SN54ALS645A, SN54AS645, SN74ALS645A, SN74AS645

## OCTAL BUS TRANSCEIVERS

### WITH 3-STATE OUTPUTS

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

Supply voltage, $V_{CC}$	7 V
Input voltage, $V_I$ : All inputs	7 V
I/O ports	5.5 V
Operating free-air temperature range, $T_A$ : SN54AS645	-55°C to 125°C
SN74AS645	0°C to 70°C
Storage temperature range	-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.

#### recommended operating conditions

		SN54AS645			SN74AS645			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage	4.5	5	5.5	4.5	5	5.5	V
$V_{IH}$	High-level input voltage	2			2			V
$V_{IL}$	Low-level input voltage			0.8			0.8	V
$I_{OH}$	High-level output current			-12			-15	mA
$I_{OL}$	Low-level output current			48			64	mA
$T_A$	Operating free-air temperature	-55		125	0		70	°C

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

PARAMETER	TEST CONDITIONS	SN54AS645			SN74AS645			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
$V_{IK}$	$V_{CC} = 4.5$ V, $I_I = -18$ mA			-1.2			-1.2	V
$V_{OH}$	$V_{CC} = 4.5$ V to 5.5 V, $I_{OH} = -2$ mA	$V_{CC} - 2$		$V_{CC} - 2$				V
	$V_{CC} = 4.5$ V, $I_{OH} = -3$ mA	2.4	3.2	2.4	3.2			
	$V_{CC} = 4.5$ V, $I_{OH} = -12$ mA	2.4						
	$V_{CC} = 4.5$ V, $I_{OH} = -15$ mA				2.4			
$V_{OL}$	$V_{CC} = 4.5$ V, $I_{OL} = 48$ mA		0.3	0.55				V
	$V_{CC} = 4.5$ V, $I_{OL} = 64$ mA				0.35	0.55		
$I_I$	Control inputs	$V_{CC} = 5.5$ V		$V_I = 7$ V		0.1		mA
	A or B ports	$V_{CC} = 5.5$ V		$V_I = 5.5$ V		0.1		
$I_{IH}$	Control inputs	$V_{CC} = 5.5$ V,		$V_I = 2.7$ V		20		$\mu$ A
	A or B ports§	$V_{CC} = 5.5$ V,		$V_I = 2.7$ V		70		
$I_{IL}$	Control inputs	$V_{CC} = 5.5$ V,		$V_I = 0.4$ V		-0.5		mA
	A or B ports§	$V_{CC} = 5.5$ V,		$V_I = 0.4$ V		-0.75		
$I_{O}^{\parallel}$	$V_{CC} = 5.5$ V, $V_O = 2.25$ V	-50		-150	-50		-150	mA
$I_{CC}$	$V_{CC} = 5.5$ V, Outputs high		62	97		62	97	mA
	$V_{CC} = 5.5$ V, Outputs low		95	149		95	149	
	$V_{CC} = 5.5$ V, Outputs disabled		79	123		79	123	

‡ All typical values are at  $V_{CC} = 5$  V,  $T_A = 25^\circ\text{C}$ .

§ For I/O ports, the parameters  $I_{IH}$  and  $I_{IL}$  include the off-state output current.

¶ The output conditions have been chosen to produce a current that closely approximates one half of the true short-circuit output current,  $I_{OS}$ .



SN54ALS645A, SN54AS645, SN74ALS645A, SN74AS645  
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**switching characteristics (see Figure 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub> = 4.5 V to 5.5 V, C <sub>L</sub> = 50 pF, R <sub>1</sub> = 500 Ω, R <sub>2</sub> = 500 Ω, T <sub>A</sub> = MIN to MAX†				UNIT
			SN54AS645		SN74AS645		
			MIN	MAX	MIN	MAX	
t <sub>PLH</sub>	A or B	B or A	2	11	2	9.5	ns
t <sub>PHL</sub>			2	10.5	2	9	
t <sub>PZH</sub>	$\overline{\text{OE}}$	A or B	2	12	2	11	ns
t <sub>PZL</sub>			2	12	2	10	
t <sub>PHZ</sub>	$\overline{\text{OE}}$	A or B	2	8	2	7	ns
t <sub>PLZ</sub>			2	13	2	12	

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

# SN54ALS645A, SN54AS645, SN74ALS645A, SN74AS645 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

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## PARAMETER MEASUREMENT INFORMATION SERIES 54ALS/74ALS AND 54AS/74AS DEVICES



- NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.  
 C. When measuring propagation delay items of 3-state outputs, switch S1 is open.  
 D. All input pulses have the following characteristics:  $PRR \leq 1$  MHz,  $t_r = t_f = 2$  ns, duty cycle = 50%.  
 E. The outputs are measured one at a time with one transition per measurement.

Figure 1. Load Circuits and Voltage Waveforms

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
8403301RA	ACTIVE	CDIP	J	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	8403301RA SNJ54ALS645AJ	<a href="#">Samples</a>
8403301SA	ACTIVE	CFP	W	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	8403301SA SNJ54ALS645AW	<a href="#">Samples</a>
SN54ALS645AJ	ACTIVE	CDIP	J	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	SN54ALS645AJ	<a href="#">Samples</a>
SN54AS645J	ACTIVE	CDIP	J	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	SN54AS645J	<a href="#">Samples</a>
SN74ALS645A-1DW	LIFEBUY	SOIC	DW	20	25	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	ALS645A-1	
SN74ALS645A-1DWR	ACTIVE	SOIC	DW	20	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	ALS645A-1	<a href="#">Samples</a>
SN74ALS645A-1N	ACTIVE	PDIP	N	20	20	RoHS & Non-Green	NIPDAU	N / A for Pkg Type	0 to 70	SN74ALS645A-1N	<a href="#">Samples</a>
SN74ALS645A-1NSR	ACTIVE	SO	NS	20	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	ALS645A-1	<a href="#">Samples</a>
SN74ALS645ADW	LIFEBUY	SOIC	DW	20	25	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	ALS645A	
SN74ALS645ADWR	ACTIVE	SOIC	DW	20	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	ALS645A	<a href="#">Samples</a>
SN74ALS645AN	ACTIVE	PDIP	N	20	20	RoHS & Non-Green	NIPDAU	N / A for Pkg Type	0 to 70	SN74ALS645AN	<a href="#">Samples</a>
SN74ALS645ANSR	ACTIVE	SO	NS	20	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	ALS645A	<a href="#">Samples</a>
SN74AS645N	ACTIVE	PDIP	N	20	20	RoHS & Non-Green	NIPDAU	N / A for Pkg Type	0 to 70	SN74AS645N	<a href="#">Samples</a>
SNJ54ALS645AJ	ACTIVE	CDIP	J	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	8403301RA SNJ54ALS645AJ	<a href="#">Samples</a>
SNJ54ALS645AW	ACTIVE	CFP	W	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	8403301SA SNJ54ALS645AW	<a href="#">Samples</a>
SNJ54AS645J	ACTIVE	CDIP	J	20	1	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	SNJ54AS645J	<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

<sup>(2)</sup> **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of  $\leq 1000$ ppm threshold. Antimony trioxide based flame retardants must also meet the  $\leq 1000$ ppm threshold requirement.

<sup>(3)</sup> MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices 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.

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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 SN54ALS645A, SN54AS645, SN74ALS645A, SN74AS645 :**

● Catalog : [SN74ALS645A](#), [SN74AS645](#)

● Military : [SN54ALS645A](#), [SN54AS645](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications



**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN74ALS645A-1DWR	SOIC	DW	20	2000	330.0	24.4	10.8	13.3	2.7	12.0	24.0	Q1
SN74ALS645A-1NSR	SO	NS	20	2000	330.0	24.4	8.4	13.0	2.5	12.0	24.0	Q1
SN74ALS645ADWR	SOIC	DW	20	2000	330.0	24.4	10.8	13.3	2.7	12.0	24.0	Q1
SN74ALS645ANSR	SO	NS	20	2000	330.0	24.4	8.4	13.0	2.5	12.0	24.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74ALS645A-1DWR	SOIC	DW	20	2000	367.0	367.0	45.0
SN74ALS645A-1NSR	SO	NS	20	2000	367.0	367.0	45.0
SN74ALS645ADWR	SOIC	DW	20	2000	367.0	367.0	45.0
SN74ALS645ANSR	SO	NS	20	2000	367.0	367.0	45.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
8403301SA	W	CFP	20	1	506.98	26.16	6220	NA
SN74ALS645A-1DW	DW	SOIC	20	25	507	12.83	5080	6.6
SN74ALS645A-1N	N	PDIP	20	20	506	13.97	11230	4.32
SN74ALS645ADW	DW	SOIC	20	25	507	12.83	5080	6.6
SN74ALS645AN	N	PDIP	20	20	506	13.97	11230	4.32
SN74AS645N	N	PDIP	20	20	506	13.97	11230	4.32
SNJ54ALS645AW	W	CFP	20	1	506.98	26.16	6220	NA

W (R-GDFP-F20)

CERAMIC DUAL FLATPACK



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a ceramic lid using glass frit.
  - D. Index point is provided on cap for terminal identification only.
  - E. Falls within Mil-Std 1835 GDFP2-F20

# MECHANICAL DATA

NS (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

J (R-GDIP-T\*\*)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



DIM \ PINS **	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



4040083/F 03/03

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - This package is hermetically sealed with a ceramic lid using glass frit.
  - Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
  - Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

N (R-PDIP-T\*\*)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



- 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.

# DW0020A



# PACKAGE OUTLINE

## SOIC - 2.65 mm max height

SOIC



4220724/A 05/2016

### 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 0.43 mm per side.
5. Reference JEDEC registration MS-013.



# EXAMPLE BOARD LAYOUT

DW0020A

SOIC - 2.65 mm max height

SOIC



LAND PATTERN EXAMPLE  
SCALE:6X



SOLDER MASK DETAILS

4220724/A 05/2016

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.

# EXAMPLE STENCIL DESIGN

DW0020A

SOIC - 2.65 mm max height

SOIC



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:6X

4220724/A 05/2016

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.

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