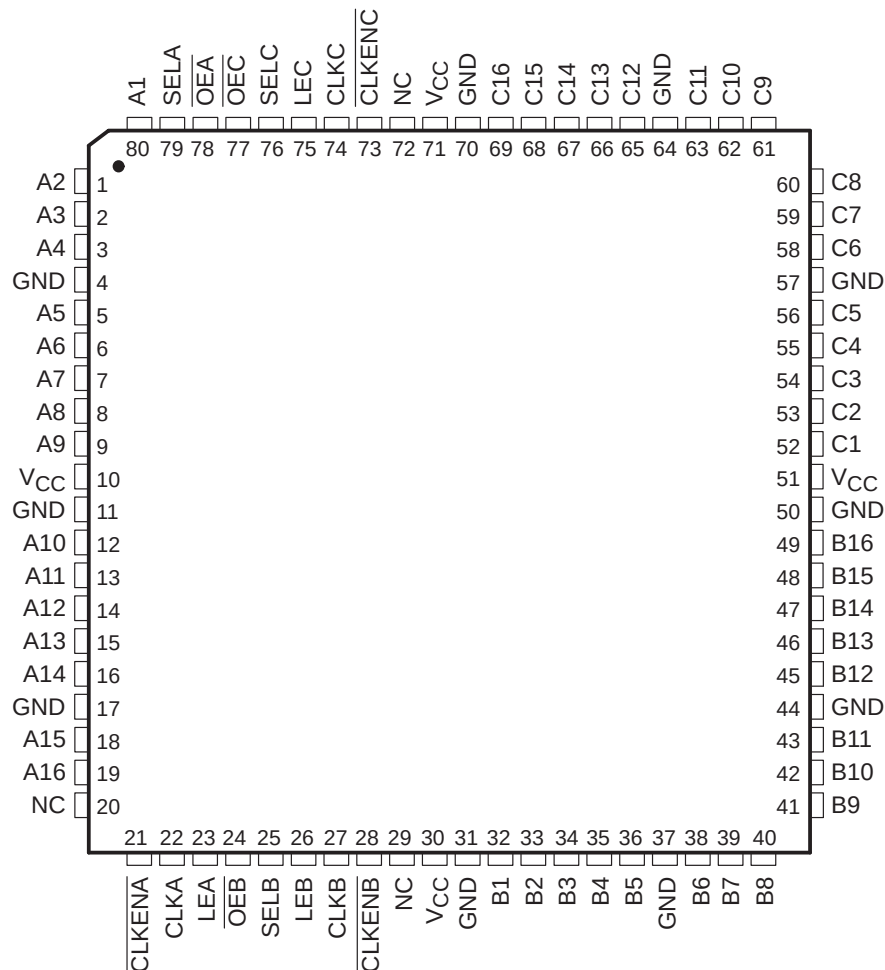


# SN54ABTH32316, SN74ABTH32316 16-BIT TRI-PORT UNIVERSAL BUS EXCHANGERS

SCBS179E – JUNE 1992 – REVISED MAY 1997

- Members of the Texas Instruments *Widebus+*™ Family
- State-of-the-Art *EPIC-II*B™ BiCMOS Design Significantly Reduces Power Dissipation
- *UBE*™ (Universal Bus Exchanger) Combines D-Type Latches and D-Type Flip-Flops for Operation in Transparent, Latched, Clocked, or Clock-Enabled Mode
- ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015
- Latch-Up Performance Exceeds 500 mA Per JEDEC Standard JESD-17
- Typical  $V_{OLP}$  (Output Ground Bounce) < 0.8 V at  $V_{CC} = 5$  V,  $T_A = 25^\circ\text{C}$
- High-Impedance State During Power Up and Power Down
- Distributed  $V_{CC}$  and GND Pin Configuration Minimizes High-Speed Switching Noise
- High-Drive Outputs ( $-32\text{-mA } I_{OH}$ ,  $64\text{-mA } I_{OL}$ )
- Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors
- Package Options Include 80-Pin Plastic Thin Quad Flat (PN) Package With  $12 \times 12\text{-mm}$  Body Using 0.5-mm Lead Pitch and 84-Pin Ceramic Quad Flat (HT) Package

'ABTH32316 . . . PN PACKAGE  
(TOP VIEW)



NC – No internal connection



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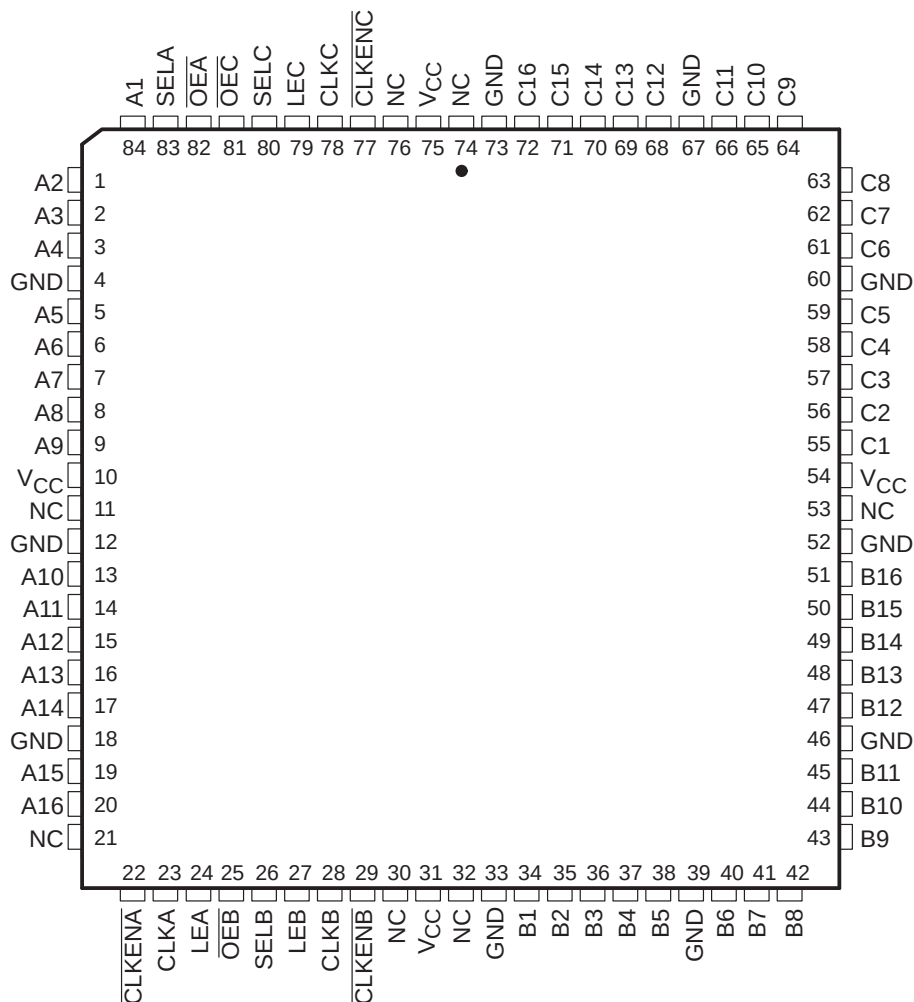
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# SN54ABTH32316, SN74ABTH32316 16-BIT TRI-PORT UNIVERSAL BUS EXCHANGERS

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SN54ABTH32316 . . . HT PACKAGE  
(TOP VIEW)



NC – No internal connection

## description

The 'ABTH32316 consist of three 16-bit registered input/output (I/O) ports. These registers combine D-type latches and flip-flops to allow data flow in transparent, latch, and clock modes. Data from one input port can be exchanged to one or more of the other ports. Because of the universal storage element, multiple combinations of real-time and stored data can be exchanged among the three ports.

Data flow in each direction is controlled by the output-enable ( $\overline{\text{OEA}}$ ,  $\overline{\text{OEB}}$ , and  $\overline{\text{OEC}}$ ), select-control (SELA, SELB, and SELC), latch-enable (LEA, LEB, and LEC), and clock (CLKA, CLKB, and CLKC) inputs. The A data register operates in the transparent mode when LEA is high. When LEA is low, data is latched if CLKA is held at a high or low logic level. If LEA and clock-enable A ( $\overline{\text{CLKENA}}$ ) are low, data is stored on the low-to-high transition of CLKA. Output data selection is accomplished by the select-control pins. All three ports have active-low output enables, so when the output-enable input is low, the outputs are active; when the output-enable input is high, the outputs are in the high-impedance state.

When  $V_{CC}$  is between 0 and 2.1 V, the device is in the high-impedance state during power up or power down. However, to ensure the high-impedance state above 2.1 V,  $\overline{\text{OE}}$  should be tied to  $V_{CC}$  through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.



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# SN54ABTH32316, SN74ABTH32316 16-BIT TRI-PORT UNIVERSAL BUS EXCHANGERS

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## description (continued)

Active bus-hold circuitry is provided to hold unused or floating data inputs at a valid logic level.

The SN54ABTH32316 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .  
The SN74ABTH32316 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## Function Tables

STORAGE<sup>†</sup>

| INPUTS |            |     |   | OUTPUT           |
|--------|------------|-----|---|------------------|
| CLKENA | CLKA       | LEA | A |                  |
| H      | X          | L   | X | $Q_0^{\ddagger}$ |
| L      | $\uparrow$ | L   | L | L                |
| L      | $\uparrow$ | L   | H | H                |
| X      | H          | L   | X | $Q_0^{\ddagger}$ |
| X      | L          | L   | X | $Q_0^{\ddagger}$ |
| X      | X          | H   | L | L                |
| X      | X          | H   | H | H                |

<sup>†</sup> A-port register shown. B and C ports are similar but use CLKENB, CLKENC, CLKB, CLKC, LEB, and LEC.

<sup>‡</sup> Output level before the indicated steady-state input conditions were established

A-PORT OUTPUT

| INPUTS                  |      | OUTPUT A             |
|-------------------------|------|----------------------|
| $\overline{\text{OEA}}$ | SELA |                      |
| H                       | X    | Z                    |
| L                       | H    | Output of C register |
| L                       | L    | Output of B register |

B-PORT OUTPUT

| INPUTS                  |      | OUTPUT B             |
|-------------------------|------|----------------------|
| $\overline{\text{OEB}}$ | SELB |                      |
| H                       | X    | Z                    |
| L                       | H    | Output of A register |
| L                       | L    | Output of C register |

C-PORT OUTPUT

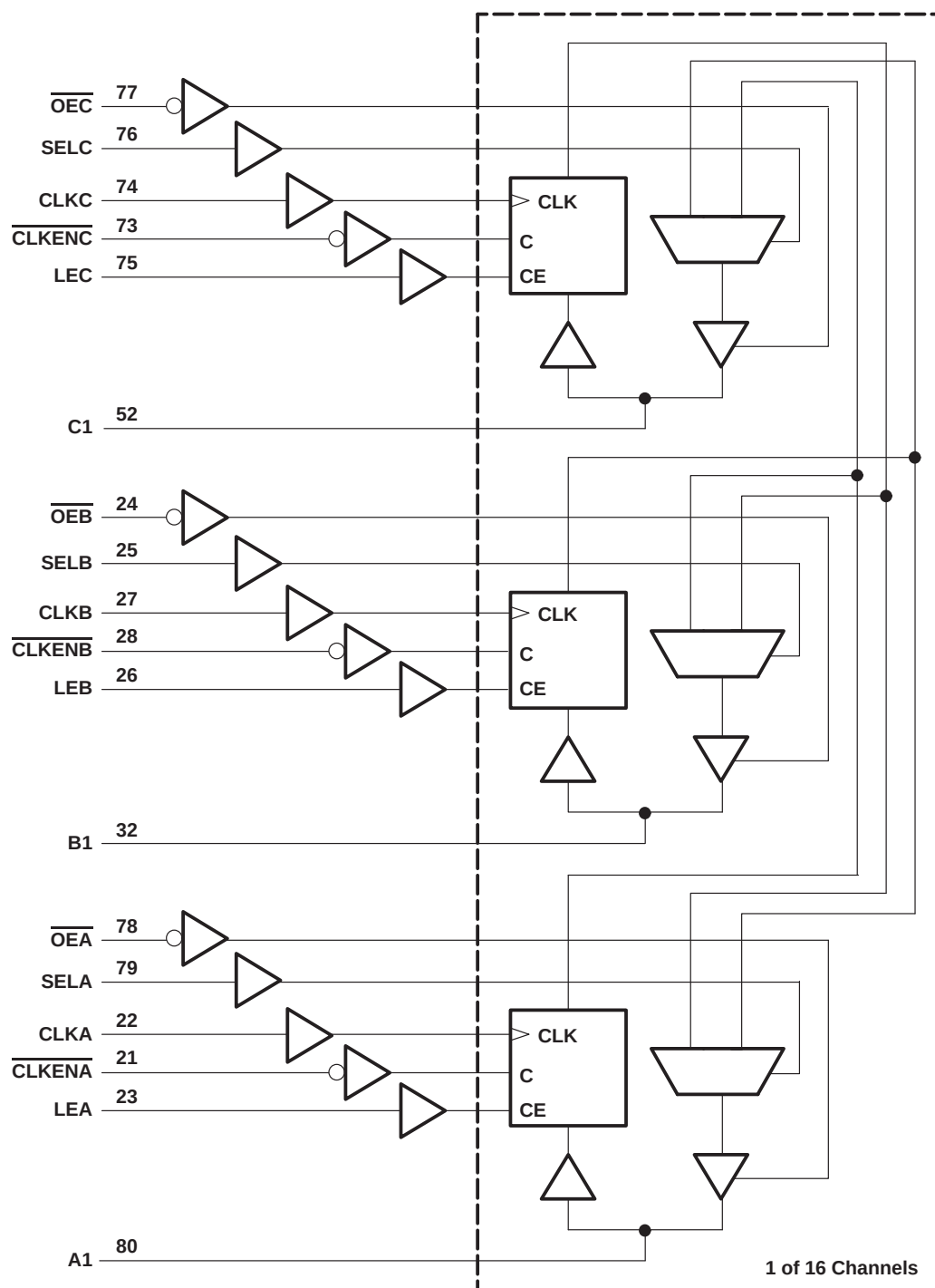
| INPUTS                  |      | OUTPUT C             |
|-------------------------|------|----------------------|
| $\overline{\text{OEC}}$ | SELC |                      |
| H                       | X    | Z                    |
| L                       | H    | Output of B register |
| L                       | L    | Output of A register |



# SN54ABTH32316, SN74ABTH32316 16-BIT TRI-PORT UNIVERSAL BUS EXCHANGERS

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## logic diagram (positive logic)



Pin numbers shown are for the PN package.

# SN54ABTH32316, SN74ABTH32316 16-BIT TRI-PORT UNIVERSAL BUS EXCHANGERS

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

|                                                                           |                 |
|---------------------------------------------------------------------------|-----------------|
| Supply voltage range, $V_{CC}$                                            | –0.5 V to 7 V   |
| Input voltage range, $V_I$ (except I/O ports) (see Note 1)                | –0.5 V to 7 V   |
| Voltage range applied to any output in the high or power-off state, $V_O$ | –0.5 V to 5.5 V |
| Current into any output in the low state, $I_O$ : SN54ABTH32316           | 96 mA           |
| SN74ABTH32316                                                             | 128 mA          |
| Input clamp current, $I_{IK}$ ( $V_I < 0$ )                               | –18 mA          |
| Output clamp current, $I_{OK}$ ( $V_O < 0$ )                              | –50 mA          |
| Package thermal impedance, $\theta_{JA}$ (see Note 2): PN package         | 62°C/W          |
| Storage temperature range, $T_{stg}$                                      | –65°C to 150°C  |

<sup>†</sup> Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.  
2. The package thermal impedance is calculated in accordance with EIA/JEDEC Std JESD51.

## recommended operating conditions (see Note 3)

|                          |                                    | SN54ABTH32316   |          | SN74ABTH32316 |          | UNIT |
|--------------------------|------------------------------------|-----------------|----------|---------------|----------|------|
|                          |                                    | MIN             | MAX      | MIN           | MAX      |      |
| $V_{CC}$                 | Supply voltage                     | 4.5             | 5.5      | 4.5           | 5.5      | V    |
| $V_{IH}$                 | High-level input voltage           | 2               |          | 2             |          | V    |
| $V_{IL}$                 | Low-level input voltage            |                 | 0.8      |               | 0.8      | V    |
| $V_I$                    | Input voltage                      | 0               | $V_{CC}$ | 0             | $V_{CC}$ | V    |
| $I_{OH}$                 | High-level output current          |                 | –24      |               | –32      | mA   |
| $I_{OL}$                 | Low-level output current           |                 | 48       |               | 64       | mA   |
| $\Delta t/\Delta v$      | Input transition rise or fall rate | Outputs enabled |          |               | 10       | ns/V |
| $\Delta t/\Delta V_{CC}$ | Power-up ramp rate                 | 200             |          | 200           |          | μs/V |
| $T_A$                    | Operating free-air temperature     | –55             | 125      | –40           | 85       | °C   |

NOTE 3: Unused control pins must be held high or low to prevent them from floating.

# SN54ABTH32316, SN74ABTH32316

## 16-BIT TRI-PORT UNIVERSAL BUS EXCHANGERS

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

| PARAMETER             |                  | TEST CONDITIONS                                                                                        | SN54ABTH32316 |      |      | SN74ABTH32316 |      |      | UNIT |
|-----------------------|------------------|--------------------------------------------------------------------------------------------------------|---------------|------|------|---------------|------|------|------|
|                       |                  |                                                                                                        | MIN           | TYP† | MAX  | MIN           | TYP† | MAX  |      |
| V <sub>IK</sub>       |                  | V <sub>CC</sub> = 4.5 V, I <sub>I</sub> = –18 mA                                                       |               |      | –1.2 |               |      | –1.2 | V    |
| V <sub>OH</sub>       |                  | V <sub>CC</sub> = 4.5 V, I <sub>OH</sub> = –3 mA                                                       | 2.5           |      |      | 2.5           |      |      | V    |
|                       |                  | V <sub>CC</sub> = 5 V, I <sub>OH</sub> = –3 mA                                                         | 3             |      |      | 3             |      |      |      |
|                       |                  | V <sub>CC</sub> = 4.5 V, I <sub>OH</sub> = –24 mA                                                      | 2             |      |      |               |      |      |      |
|                       |                  | V <sub>CC</sub> = 4.5 V, I <sub>OH</sub> = –32 mA                                                      |               |      |      | 2             |      |      |      |
| V <sub>OL</sub>       |                  | V <sub>CC</sub> = 4.5 V, I <sub>OL</sub> = 48 mA                                                       |               |      | 0.55 |               |      |      | V    |
|                       |                  | V <sub>CC</sub> = 4.5 V, I <sub>OL</sub> = 64 mA                                                       |               |      |      |               |      | 0.55 |      |
| V <sub>hys</sub>      |                  |                                                                                                        | 100           |      |      | 100           |      |      | mV   |
| I <sub>I</sub>        | Control inputs   | V <sub>CC</sub> = 0 to 5.5 V, V <sub>I</sub> = V <sub>CC</sub> or GND                                  |               |      | ±1   |               |      | ±1   | μA   |
|                       | A, B, or C ports | V <sub>CC</sub> = 2.1 V to 5.5 V, V <sub>I</sub> = V <sub>CC</sub> or GND                              |               |      | ±100 |               |      | ±20  |      |
| I <sub>I</sub> (hold) | A, B, or C ports | V <sub>CC</sub> = 4.5 V, V <sub>I</sub> = 0.8 V                                                        | 100           |      |      | 100           |      |      | μA   |
|                       |                  | V <sub>CC</sub> = 4.5 V, V <sub>I</sub> = 2 V                                                          | –100          |      |      | –100          |      |      |      |
| I <sub>OZPU</sub> ‡   |                  | V <sub>CC</sub> = 0 to 2.1 V, V <sub>O</sub> = 0.5 V to 2.7 V, $\overline{OE}$ = X                     |               |      | ±50  |               |      | ±50  | μA   |
| I <sub>OZPD</sub> ‡   |                  | V <sub>CC</sub> = 2.1 V to 0, V <sub>O</sub> = 0.5 V to 2.7 V, $\overline{OE}$ = X                     |               |      | ±50  |               |      | ±50  | μA   |
| I <sub>off</sub>      |                  | V <sub>CC</sub> = 0, V <sub>I</sub> or V <sub>O</sub> ≤ 4.5 V                                          |               |      | ±100 |               |      | ±100 | μA   |
| I <sub>CEX</sub>      |                  | V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 5.5 V, Outputs high                                          |               |      | 50   |               |      | 50   | μA   |
| I <sub>O</sub> §      |                  | V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 2.5 V                                                        | –50           | –100 | –180 | –50           | –100 | –180 | mA   |
| I <sub>CC</sub>       |                  | V <sub>CC</sub> = 5.5 V, I <sub>O</sub> = 0, V <sub>I</sub> = V <sub>CC</sub> or GND, Outputs high     |               |      | 2    |               |      | 2    | mA   |
|                       |                  | V <sub>CC</sub> = 5.5 V, I <sub>O</sub> = 0, V <sub>I</sub> = V <sub>CC</sub> or GND, Outputs low      |               |      | 40   |               |      | 40   |      |
|                       |                  | V <sub>CC</sub> = 5.5 V, I <sub>O</sub> = 0, V <sub>I</sub> = V <sub>CC</sub> or GND, Outputs disabled |               |      | 1    |               |      | 1    |      |
| ΔI <sub>CC</sub> ¶    |                  | V <sub>CC</sub> = 5.5 V, One input at 3.4 V, Other inputs at V <sub>CC</sub> or GND                    |               |      | 1    |               |      | 0.5  | mA   |
| C <sub>i</sub>        | Control inputs   | V <sub>I</sub> = 2.5 V or 0.5 V                                                                        |               |      | 3    |               |      | 3    | pF   |
| C <sub>io</sub>       | A, B, or C ports | V <sub>O</sub> = 2.5 V or 0.5 V                                                                        |               |      | 11.5 |               |      | 11.5 | pF   |

† All typical values are at V<sub>CC</sub> = 5 V, T<sub>A</sub> = 25°C.

‡ This parameter is specified by characterization.

§ Not more than one output should be tested at a time, and the duration of the test should not exceed one second.

¶ This is the increase in supply current for each input that is at the specified TTL voltage level rather than V<sub>CC</sub> or GND.

**timing requirements over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 1)**

|                    |                 |                        | SN54ABTH32316 |     | SN74ABTH32316 |     | UNIT |
|--------------------|-----------------|------------------------|---------------|-----|---------------|-----|------|
|                    |                 |                        | MIN           | MAX | MIN           | MAX |      |
| f <sub>clock</sub> | Clock frequency |                        | 0             | 150 | 0             | 150 | MHz  |
| t <sub>w</sub>     | Pulse duration  | LE high                | 3.3           |     | 3.3           |     | ns   |
|                    |                 | CLK high or low        | 3.3           |     | 3.3           |     |      |
| t <sub>su</sub>    | Setup time      | A, B, or C before CLK↑ | 2.6           |     | 2.4           |     | ns   |
|                    |                 | A or B before LE↓      | 2.5           |     | 2.1           |     |      |
|                    |                 | CLKEN before CLK↑      | 3.5           |     | 3.2           |     |      |
| t <sub>h</sub>     | Hold time       | A, B, or C after CLK↑  | 1.8           |     | 1.4           |     | ns   |
|                    |                 | A or B after LE↓       | 2.4           |     | 2.1           |     |      |
|                    |                 | CLKEN after CLK↑       | 1.5           |     | 1.1           |     |      |



# SN54ABTH32316, SN74ABTH32316 16-BIT TRI-PORT UNIVERSAL BUS EXCHANGERS

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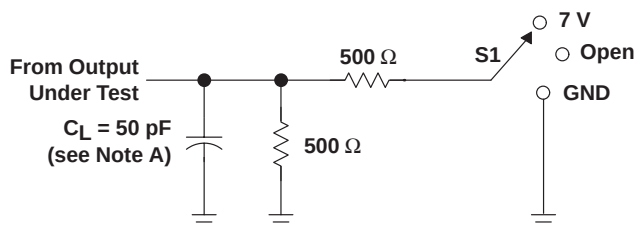
switching characteristics over recommended ranges of supply voltage and operating free-air temperature,  $C_L = 50$  pF (unless otherwise noted) (see Figure 1)

| PARAMETER | FROM<br>(INPUT) | TO<br>(OUTPUT) | SN54ABTH32316 |     | SN74ABTH32316 |     | UNIT |
|-----------|-----------------|----------------|---------------|-----|---------------|-----|------|
|           |                 |                | MIN           | MAX | MIN           | MAX |      |
| $f_{max}$ |                 |                | 150           |     | 150           |     | MHz  |
| $t_{PLH}$ | A, B, or C      | C, B, or A     | 0.8           | 6.5 | 1.4           | 6.1 | ns   |
| $t_{PHL}$ |                 |                | 0.5           | 6.8 | 1.1           | 6.6 |      |
| $t_{PLH}$ | SEL             | A, B, or C     | 0.8           | 6.7 | 1.4           | 6.5 | ns   |
| $t_{PHL}$ |                 |                | 0.8           | 6.8 | 1.8           | 6.5 |      |
| $t_{PLH}$ | LE              | A, B, or C     | 1.5           | 8   | 2.6           | 7.5 | ns   |
| $t_{PHL}$ |                 |                | 1.5           | 7.4 | 2.6           | 6.9 |      |
| $t_{PLH}$ | CLK             | A, B, or C     | 1.5           | 8   | 2.5           | 7.5 | ns   |
| $t_{PHL}$ |                 |                | 1.5           | 7.2 | 2.5           | 6.7 |      |
| $t_{PZH}$ | $\overline{OE}$ | A, B, or C     | 0.8           | 6.7 | 1.5           | 6.4 | ns   |
| $t_{PZL}$ |                 |                | 1.5           | 7.1 | 2.4           | 6.8 |      |
| $t_{PHZ}$ | $\overline{OE}$ | A, B, or C     | 0.8           | 7.2 | 1.5           | 6   | ns   |
| $t_{PLZ}$ |                 |                | 0.8           | 6.4 | 1.9           | 6.1 |      |

# SN54ABTH32316, SN74ABTH32316 16-BIT TRI-PORT UNIVERSAL BUS EXCHANGERS

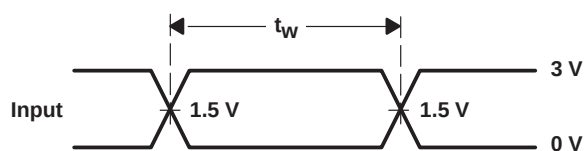
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## PARAMETER MEASUREMENT INFORMATION

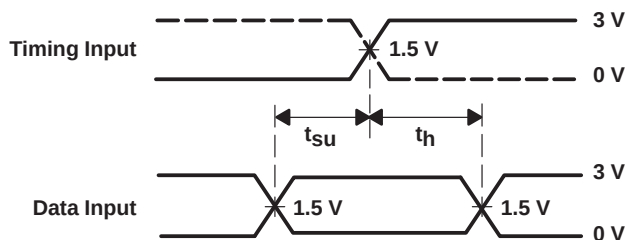


LOAD CIRCUIT

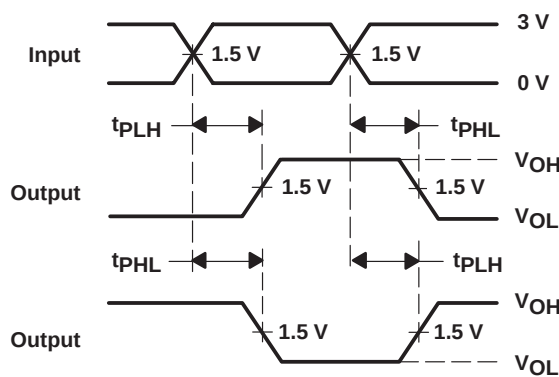
| TEST              | S1   |
|-------------------|------|
| $t_{PLH}/t_{PHL}$ | Open |
| $t_{PLZ}/t_{PZL}$ | 7 V  |
| $t_{PHZ}/t_{PZH}$ | Open |



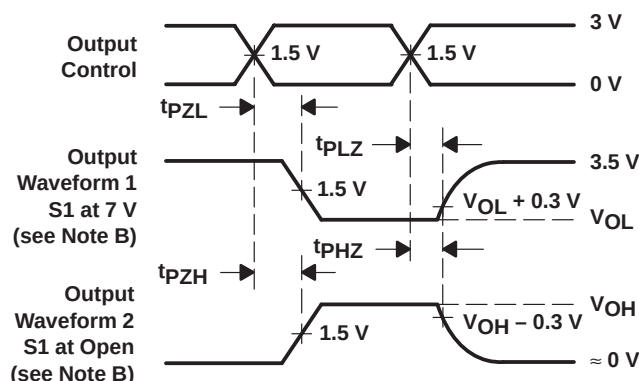
VOLTAGE WAVEFORMS  
PULSE DURATION



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

- NOTES: A.  $C_L$  includes probe and jig capacitance.  
B. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.  
C. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5 \text{ ns}$ ,  $t_f \leq 2.5 \text{ ns}$ .  
D. The outputs are measured one at a time with one transition per measurement.

Figure 1. Load Circuit and Voltage Waveforms



## PACKAGING INFORMATION

| Orderable Device  | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|-------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| 5962-9680801QXA   | ACTIVE                | CFP          | HT              | 84   | 1           | TBD                     | POST-PLATE       | N / A for Pkg Type           |
| SN74ABTH32316PN   | ACTIVE                | LQFP         | PN              | 80   | 119         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| SN74ABTH32316PNG4 | ACTIVE                | LQFP         | PN              | 80   | 119         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| SNJ54ABTH32316HT  | ACTIVE                | CFP          | HT              | 84   | 1           | TBD                     | POST-PLATE       | N / A for Pkg Type           |

<sup>(1)</sup> The marketing status values are defined as follows:

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

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

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

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

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

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

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

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

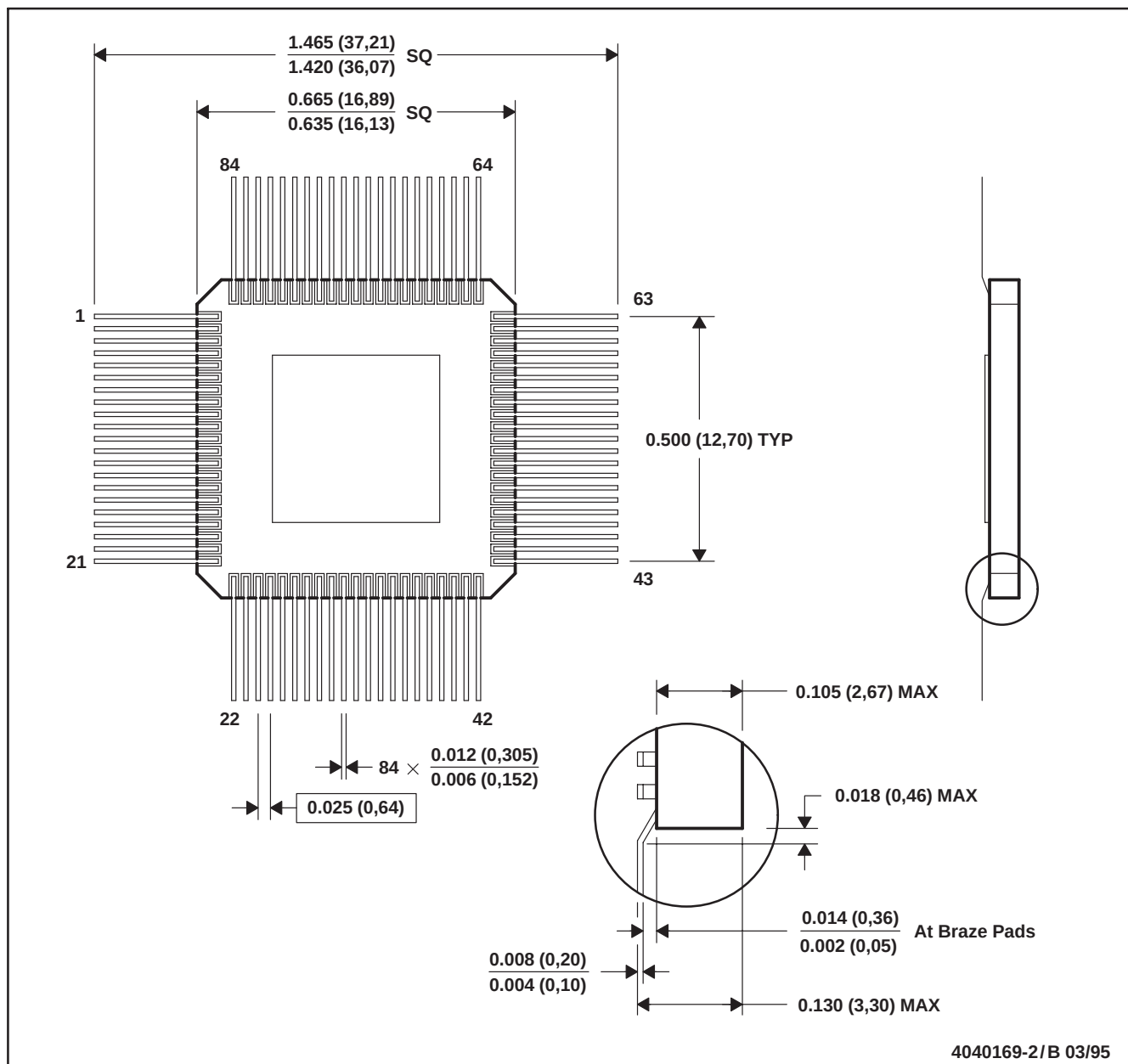
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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HT (S-CQFP-F84)

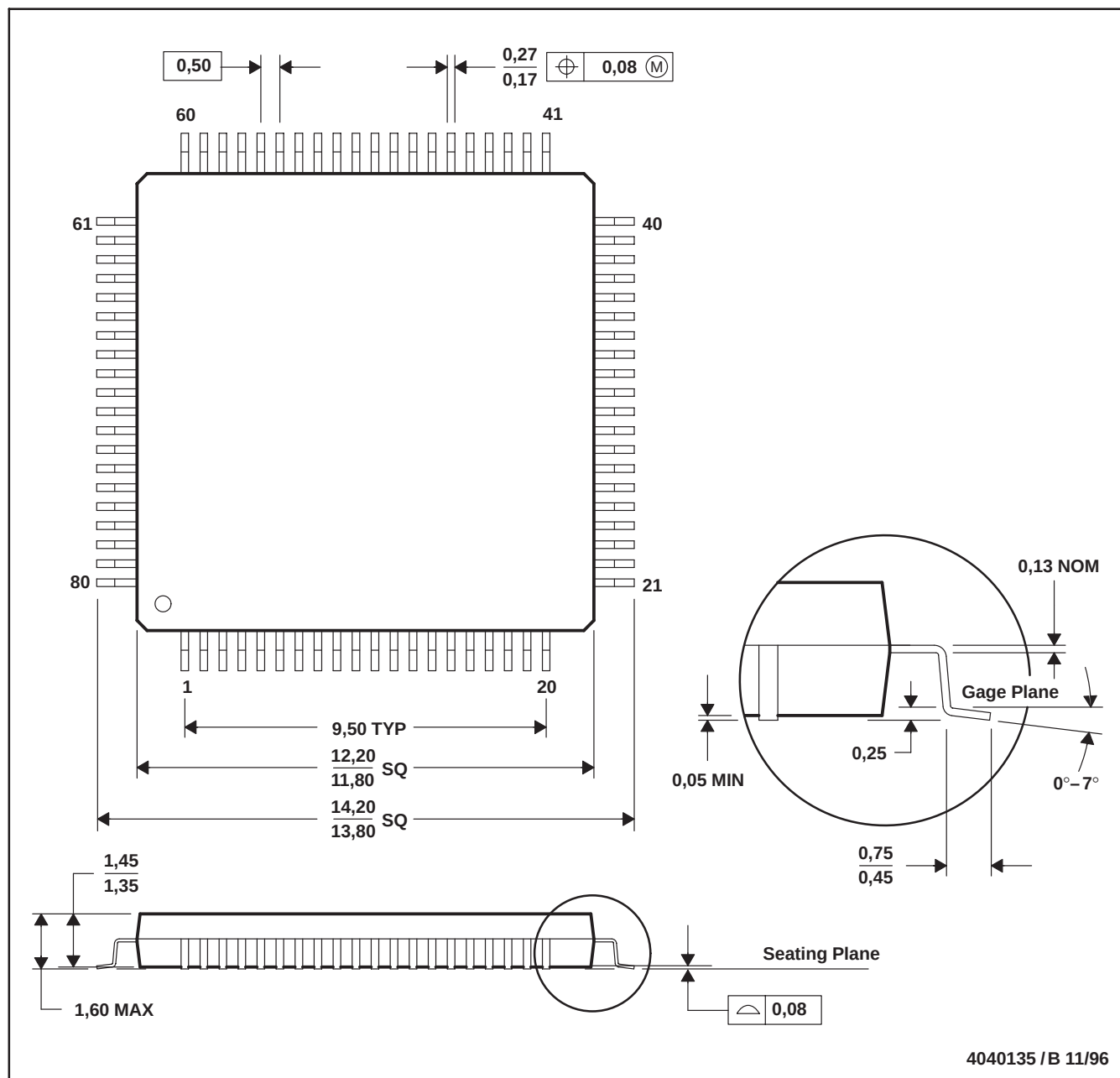
CERAMIC QUAD FLATPACK



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package is hermetically sealed with a metal lid.  
 D. The terminals are gold plated.  
 E. Falls within JEDEC MO-090 AA

## PN (S-PQFP-G80)

## PLASTIC QUAD FLATPACK



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-026

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