

# SN54AHC16541, SN74AHC16541 16-BIT BUFFERS/DRIVERS WITH 3-STATE OUTPUTS

SCLS332 – MARCH 1998

- Members of the Texas Instruments *Widebus™* Family
- Operating Range 2-V to 5.5-V  $V_{CC}$
- *EPIC™* (Enhanced-Performance Implanted CMOS) Process
- Distributed  $V_{CC}$  and GND Pin Configuration Minimizes High-Speed Switching Noise
- Flow-Through Architecture Optimizes PCB Layout
- Package Options Include Plastic 300-mil Shrink Small-Outline (DL) and Thin Shrink Small-Outline (DGG) Packages and 380-mil Fine-Pitch Ceramic Flat (WD) Package Using 25-mil Center-to-Center Spacings

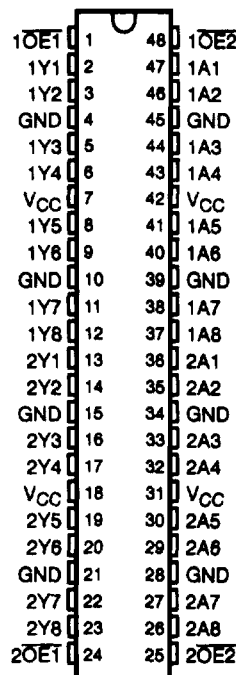
## description

The 'AHC16541 are noninverting 16-bit buffers composed of two 8-bit sections with separate output-enable signals. For either 8-bit buffer section, the two output-enable ( $1\overline{OE}1$  and  $1\overline{OE}2$  or  $2\overline{OE}1$  and  $2\overline{OE}2$ ) inputs must both be low for the corresponding Y outputs to be active. If either output-enable input is high, the outputs of that 8-bit buffer section are in the high-impedance state.

The SN74AHC16541 is available in TI's shrink small-outline (DL) and thin shrink small-outline (DGG) packages, which provide twice the I/O pin count and functionality of standard small-outline packages in the same printed-circuit-board area.

The SN54AHC16541 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74AHC16541 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54AHC16541 ... WD PACKAGE  
SN74AHC16541 ... DGG OR DL PACKAGE  
(TOP VIEW)



FUNCTION TABLE  
(each 8-bit section)

| INPUTS           |                  |   | OUTPUT<br>Y |
|------------------|------------------|---|-------------|
| $\overline{OE}1$ | $\overline{OE}2$ | A |             |
| L                | L                | L | L           |
| L                | L                | H | H           |
| H                | X                | X | Z           |
| X                | H                | X | Z           |

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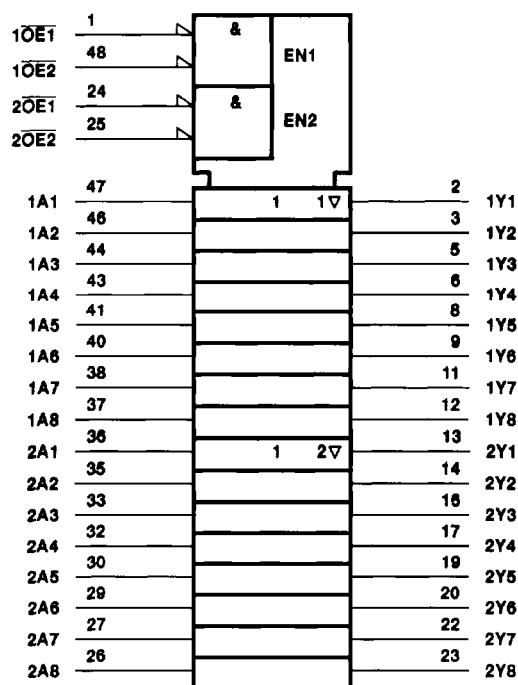
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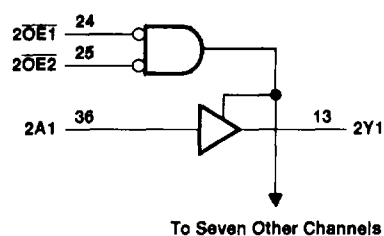
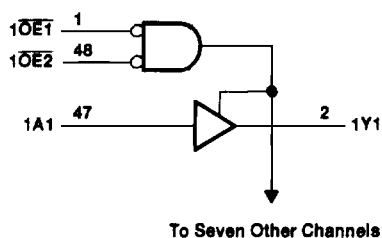
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 SCLS332 – MARCH 1996

logic symbol†



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

logic diagram (positive logic)



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**TEXAS**  
**INSTRUMENTS**

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# SN54AHC16541, SN74AHC16541 16-BIT BUFFERS/DRIVERS WITH 3-STATE OUTPUTS

SCLS332 – MARCH 1996

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

|                                                                                                |                            |
|------------------------------------------------------------------------------------------------|----------------------------|
| Supply voltage range, $V_{CC}$                                                                 | –0.5 V to 7 V              |
| Input voltage range, $V_I$ (see Note 1)                                                        | –0.5 V to 7 V              |
| Output voltage range, $V_O$ (see Note 1)                                                       | –0.5 V to $V_{CC} + 0.5$ V |
| Input clamp current, $I_{IK}$ ( $V_I < 0$ or $V_I > V_{CC}$ )                                  | –20 mA                     |
| Output clamp current, $I_{OK}$ ( $V_O < 0$ or $V_O > V_{CC}$ )                                 | ±20 mA                     |
| Continuous output current, $I_O$ ( $V_O = 0$ to $V_{CC}$ )                                     | ±25 mA                     |
| Continuous current through each $V_{CC}$ or GND                                                | ±75 mA                     |
| Maximum power dissipation at $T_A = 55^\circ\text{C}$ (in still air) (see Note 2): DGG package | 0.85 W                     |
| DL package                                                                                     | 1.2 W                      |
| Storage temperature range, $T_{stg}$                                                           | –65°C to 150°C             |

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

- NOTES: 1. The input and output voltage ratings may be exceeded if the input and output current ratings are observed.  
2. The maximum package power dissipation is calculated using a junction temperature of 150°C and a board trace length of 750 mils.

## recommended operating conditions (see Note 3)

|                 |                                    |                               | SN54AHC16541 |                 | SN74AHC16541 |                 | UNIT |
|-----------------|------------------------------------|-------------------------------|--------------|-----------------|--------------|-----------------|------|
|                 |                                    |                               | MIN          | MAX             | MIN          | MAX             |      |
| V <sub>CC</sub> | Supply voltage                     |                               | 2            | 5.5             | 2            | 5.5             | V    |
| V <sub>IH</sub> | High-level input voltage           | V <sub>CC</sub> = 2 V         | 1.5          |                 | 1.5          |                 | V    |
|                 |                                    | V <sub>CC</sub> = 3 V         | 2.1          |                 | 2.1          |                 |      |
|                 |                                    | V <sub>CC</sub> = 5.5 V       | 3.85         |                 | 3.85         |                 |      |
| V <sub>IL</sub> | Low-level input voltage            | V <sub>CC</sub> = 2 V         | 0.5          |                 | 0.5          |                 | V    |
|                 |                                    | V <sub>CC</sub> = 3 V         | 0.9          |                 | 0.9          |                 |      |
|                 |                                    | V <sub>CC</sub> = 5.5 V       | 1.65         |                 | 1.65         |                 |      |
| V <sub>I</sub>  | Input voltage                      |                               | 0            | 5.5             | 0            | 5.5             | V    |
| V <sub>O</sub>  | Output voltage                     |                               | 0            | V <sub>CC</sub> | 0            | V <sub>CC</sub> | V    |
| I <sub>OH</sub> | High-level output current          | V <sub>CC</sub> = 2 V         | −50          |                 | −50          |                 | μA   |
|                 |                                    | V <sub>CC</sub> = 3.3 ± 0.3 V | −4           |                 | −4           |                 | mA   |
|                 |                                    | V <sub>CC</sub> = 5 ± 0.5 V   | −8           |                 | −8           |                 |      |
| I <sub>OL</sub> | Low-level output current           | V <sub>CC</sub> = 2 V         | 50           |                 | 50           |                 | μA   |
|                 |                                    | V <sub>CC</sub> = 3.3 ± 0.3 V | 4            |                 | 4            |                 | mA   |
|                 |                                    | V <sub>CC</sub> = 5 ± 0.5 V   | 8            |                 | 8            |                 |      |
| ΔV/Δv           | Input transition rise or fall rate | V <sub>CC</sub> = 3.3 ± 0.3 V | 100          |                 | 100          |                 | ns/V |
|                 |                                    | V <sub>CC</sub> = 5 ± 0.5 V   | 20           |                 | 20           |                 |      |
| T <sub>A</sub>  | Operating free-air temperature     |                               | −55          | 125             | −40          | 85              | °C   |

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

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**SN54AHC16541, SN74AHC16541**  
**16-BIT BUFFERS/DRIVERS**  
**WITH 3-STATE OUTPUTS**

SCLS332 – MARCH 1996

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

| PARAMETER                    | TEST CONDITIONS                                                                                      | V <sub>CC</sub>                         | T <sub>A</sub> = 25°C |     |       | SN54AHC16541 |      | SN74AHC16541 |      | UNIT |
|------------------------------|------------------------------------------------------------------------------------------------------|-----------------------------------------|-----------------------|-----|-------|--------------|------|--------------|------|------|
|                              |                                                                                                      |                                         | MIN                   | TYP | MAX   | MIN          | MAX  | MIN          | MAX  |      |
| V <sub>OH</sub>              | I <sub>OH</sub> = -50 µA                                                                             | 2 V                                     | 1.9                   | 2   |       | 1.9          |      | 1.9          |      | V    |
|                              |                                                                                                      | 3 V                                     | 2.9                   | 3   |       | 2.9          |      | 2.9          |      |      |
|                              |                                                                                                      | 4.5 V                                   | 4.4                   | 4.5 |       | 4.4          |      | 4.4          |      |      |
|                              | I <sub>OH</sub> = -4 mA                                                                              | 3 V                                     | 2.58                  |     |       | 2.48         |      | 2.48         |      |      |
|                              | I <sub>OH</sub> = -8 mA                                                                              | 4.5 V                                   | 3.94                  |     |       | 3.8          |      | 3.8          |      |      |
| V <sub>OL</sub>              | I <sub>OL</sub> = 50 µA                                                                              | 2 V                                     |                       |     | 0.1   |              | 0.1  |              | 0.1  | V    |
|                              |                                                                                                      | 3 V                                     |                       |     | 0.1   |              | 0.1  |              | 0.1  |      |
|                              |                                                                                                      | 4.5 V                                   |                       |     | 0.1   |              | 0.1  |              | 0.1  |      |
|                              | I <sub>OL</sub> = 4 mA                                                                               | 3 V                                     |                       |     | 0.36  |              | 0.5  |              | 0.44 |      |
|                              | I <sub>OL</sub> = 8 mA                                                                               | 4.5 V                                   |                       |     | 0.36  |              | 0.5  |              | 0.44 |      |
| I <sub>I</sub>               | Data inputs                                                                                          | V <sub>I</sub> = V <sub>CC</sub> or GND | 5.5 V                 |     | ±0.1  |              | ±1   |              | ±1   | µA   |
|                              | Control inputs                                                                                       |                                         |                       |     | ±0.1  |              | ±1   |              | ±1   |      |
| I <sub>OZ</sub> <sup>†</sup> | V <sub>O</sub> = V <sub>CC</sub> or GND,<br>V <sub>I</sub> (OE) = V <sub>IL</sub> or V <sub>IH</sub> | 5.5 V                                   |                       |     | ±0.25 |              | ±2.5 |              | ±2.5 | µA   |
| I <sub>CC</sub>              | V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0                                          | 5.5 V                                   |                       |     | 4     |              | 40   |              | 40   | µA   |
| C <sub>i</sub>               | V <sub>I</sub> = V <sub>CC</sub> or GND                                                              | 5 V                                     |                       |     | 2     | 10           |      |              | 10   | pF   |
| C <sub>o</sub>               | V <sub>O</sub> = V <sub>CC</sub> or GND                                                              | 5 V                                     |                       |     | 4     |              |      |              |      | pF   |

<sup>†</sup> For input and output, I<sub>OZ</sub> includes the input leakage current.

**switching characteristics over recommended operating free-air temperature range, V<sub>CC</sub> = 3.3 V ± 0.3 V (unless otherwise noted) (see Figure 1)**

| PARAMETER          | FROM (INPUT) | TO (OUTPUT) | LOAD CAPACITANCE       | T <sub>A</sub> = 25°C |     |      | SN54AHC16541 |      | SN74AHC16541 |      | UNIT |
|--------------------|--------------|-------------|------------------------|-----------------------|-----|------|--------------|------|--------------|------|------|
|                    |              |             |                        | MIN                   | TYP | MAX  | MIN          | MAX  | MIN          | MAX  |      |
| t <sub>PLH</sub> * | A            | Y           | C <sub>L</sub> = 15 pF |                       | 5   | 7    | 1            | 8.5  | 1            | 8.5  | ns   |
| t <sub>PHL</sub> * |              |             |                        |                       | 5   | 7    | 1            | 8.5  | 1            | 8.5  |      |
| t <sub>PZH</sub> * | OE           | Y           | C <sub>L</sub> = 15 pF |                       | 6   | 10.5 | 1            | 11   | 1            | 11   | ns   |
| t <sub>PZL</sub> * |              |             |                        |                       | 6   | 10.5 | 1            | 11   | 1            | 11   |      |
| t <sub>PHZ</sub> * | OE           | Y           | C <sub>L</sub> = 15 pF |                       | 7   | 11   | 1            | 12   | 1            | 12   | ns   |
| t <sub>PLZ</sub> * |              |             |                        |                       | 7   | 11   | 1            | 12   | 1            | 12   |      |
| t <sub>PLH</sub>   | A            | Y           | C <sub>L</sub> = 50 pF |                       | 7.5 | 10.5 | 1            | 12   | 1            | 12   | ns   |
| t <sub>PHL</sub>   |              |             |                        |                       | 7.5 | 10.5 | 1            | 12   | 1            | 12   |      |
| t <sub>PZH</sub>   | OE           | Y           | C <sub>L</sub> = 50 pF |                       | 8   | 14   | 1            | 16   | 1            | 16   | ns   |
| t <sub>PZL</sub>   |              |             |                        |                       | 8   | 14   | 1            | 16   | 1            | 16   |      |
| t <sub>PHZ</sub>   | OE           | Y           | C <sub>L</sub> = 50 pF |                       | 9   | 15.4 | 1            | 17.5 | 1            | 17.5 | ns   |
| t <sub>PLZ</sub>   |              |             |                        |                       | 9   | 15.4 | 1            | 17.5 | 1            | 17.5 |      |

\* On products compliant to MIL-PRF-38535, this parameter is ensured but not production tested.

PRODUCT PREVIEW



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**16-BIT BUFFERS/DRIVERS**  
**WITH 3-STATE OUTPUTS**

SCLS332 – MARCH 1996

**switching characteristics over recommended operating free-air temperature range,  $V_{CC} = 5\text{ V} \pm 0.5\text{ V}$  (unless otherwise noted) (see Figure 1)**

| PARAMETER   | FROM<br>(INPUT) | TO<br>(OUTPUT) | LOAD<br>CAPACITANCE  | $T_A = 25^\circ\text{C}$ |     |     | SN54AHC16541 |      | SN74AHC16541 |      | UNIT |
|-------------|-----------------|----------------|----------------------|--------------------------|-----|-----|--------------|------|--------------|------|------|
|             |                 |                |                      | MIN                      | TYP | MAX | MIN          | MAX  | MIN          | MAX  |      |
| $t_{PLH}^*$ | A               | Y              | $C_L = 15\text{ pF}$ | 3.5                      | 5   |     | 1            | 6    | 1            | 6    | ns   |
| $t_{PHL}^*$ |                 |                |                      | 3.5                      | 5   |     | 1            | 6    | 1            | 6    |      |
| $t_{PZH}^*$ | $\overline{OE}$ | Y              | $C_L = 15\text{ pF}$ | 4.7                      | 7.2 |     | 1            | 8.5  | 1            | 8.5  | ns   |
| $t_{PZL}^*$ |                 |                |                      | 4.7                      | 7.2 |     | 1            | 8.5  | 1            | 8.5  |      |
| $t_{PHZ}^*$ | $\overline{OE}$ | Y              | $C_L = 15\text{ pF}$ | 5                        | 7.5 |     | 1            | 8    | 1            | 8    | ns   |
| $t_{PLZ}^*$ |                 |                |                      | 5                        | 7.5 |     | 1            | 8    | 1            | 8    |      |
| $t_{PLH}$   | A               | Y              | $C_L = 50\text{ pF}$ | 5                        | 7   |     | 1            | 8    | 1            | 8    | ns   |
| $t_{PHL}$   |                 |                |                      | 5                        | 7   |     | 1            | 8    | 1            | 8    |      |
| $t_{PZH}$   | $\overline{OE}$ | Y              | $C_L = 50\text{ pF}$ | 6.2                      | 9.2 |     | 1            | 10.5 | 1            | 10.5 | ns   |
| $t_{PZL}$   |                 |                |                      | 6.2                      | 9.2 |     | 1            | 10.5 | 1            | 10.5 |      |
| $t_{PHZ}$   | $\overline{OE}$ | Y              | $C_L = 50\text{ pF}$ | 6                        | 8.8 |     | 1            | 10   | 1            | 10   | ns   |
| $t_{PLZ}$   |                 |                |                      | 6                        | 8.8 |     | 1            | 10   | 1            | 10   |      |

\* On products compliant to MIL-PRF-38535, this parameter is ensured but not production tested.

**output-skew characteristics,  $C_L = 50\text{ pF}$  (see Note 4)**

| PARAMETER          | FROM<br>(INPUT) | TO<br>(OUTPUT) | VCC           | SN74AHC16541 |     |     |     | UNIT |
|--------------------|-----------------|----------------|---------------|--------------|-----|-----|-----|------|
|                    |                 |                |               | TA = 25°C    |     | MIN | MAX |      |
|                    |                 |                |               | MIN          | MAX |     |     |      |
| t <sub>sk(o)</sub> | A               | Y              | 3.3 V ± 0.3 V | 1.5          |     | 1.5 |     | ns   |
|                    |                 |                | 5 V ± 0.5 V   | 1            |     | 1   |     |      |

NOTE 4: Characteristics are determined during product characterization and ensured by design.

**noise characteristics,  $V_{CC} = 5\text{ V}$ ,  $C_L = 50\text{ pF}$ ,  $T_A = 25^\circ\text{C}$  (see Note 5)**

| PARAMETER   |                                        | SN74AHC16541 |      | UNIT |
|-------------|----------------------------------------|--------------|------|------|
|             |                                        | MIN          | MAX  |      |
| $V_{OL(P)}$ | Quiet output, maximum dynamic $V_{OL}$ |              | 0.8  | V    |
| $V_{OL(V)}$ | Quiet output, minimum dynamic $V_{OL}$ |              | -0.8 | V    |
| $V_{OH(V)}$ | Quiet output, minimum dynamic $V_{OH}$ | 4.7          |      | V    |
| $V_{IH(D)}$ | High-level dynamic input voltage       | 3.5          |      | V    |
| $V_{IL(D)}$ | Low-level dynamic input voltage        |              | 1.5  | V    |

NOTE 5: Characteristics are determined during product characterization and ensured by design for surface-mount packages only.

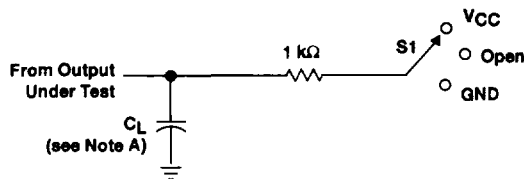
**operating characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

| PARAMETER                              | TEST CONDITIONS             | TYP | UNIT |
|----------------------------------------|-----------------------------|-----|------|
| $C_{pd}$ Power dissipation capacitance | No load, $f = 1\text{ MHz}$ | 12  | pF   |



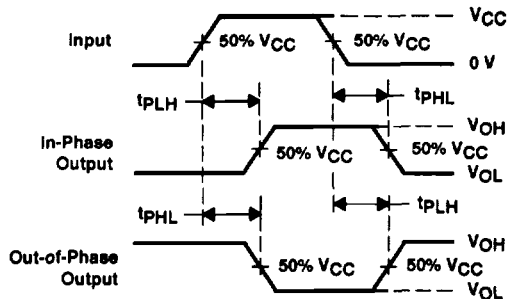
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## PARAMETER MEASUREMENT INFORMATION

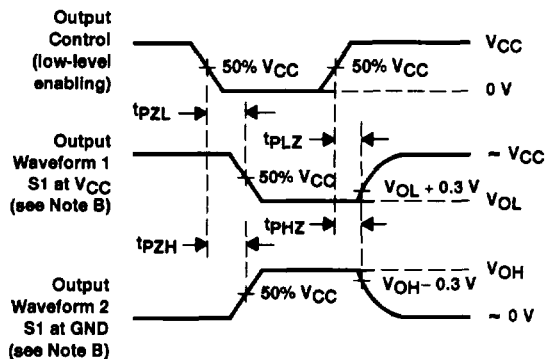


LOAD CIRCUIT

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



VOLTAGE WAVEFORMS  
DELAY TIMES



VOLTAGE WAVEFORMS  
ENABLE AND DISABLE TIMES

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  $\leq$  1 MHz,  $Z_O = 50 \Omega$ ,  $t_r = 3$  ns,  $t_f = 3$  ns.

D. The outputs are measured one at a time with one input transition per measurement.

Figure 1. Load Circuit and Voltage Waveforms