

## 74VCX32244

### Low Voltage 32-Bit Buffer/Line Driver with 3.6V Tolerant Inputs and Outputs

#### General Description

The VCX32244 contains thirty-two non-inverting buffers with 3-STATE outputs to be employed as a memory and address driver, clock driver, or bus oriented transmitter/receiver. The device is nibble (4-bit) controlled. Each nibble has separate 3-STATE control inputs which can be shorted together for 8-bit, 16-bit or full 32-bit operation.

The 74VCX32244 is designed for low voltage (1.2V to 3.6V)  $V_{CC}$  applications with I/O capability up to 3.6V.

The 74VCX32244 is fabricated with an advanced CMOS technology to achieve high speed operation while maintaining low CMOS power dissipation.

#### Features

- 1.2V to 3.6V  $V_{CC}$  supply operation
- 3.6V tolerant inputs and outputs
- $t_{PD}$   
2.5 ns max for 3.0V to 3.6V  $V_{CC}$
- Power-off high impedance inputs and outputs
- Supports live insertion and withdrawal (Note 1)
- Static Drive ( $I_{OH}/I_{OL}$ )  
 $\pm 24$  mA @ 3.0V  $V_{CC}$
- Uses patented noise/EMI reduction circuitry
- Latch-up performance exceeds 300 mA
- ESD performance:  
Human body model > 2000V  
Machine model > 200V
- Packages in plastic Fine-Pitch Ball Grid Array (FBGA)

**Note 1:** To ensure the high-impedance state during power up or power down, OE should be tied to  $V_{CC}$  through a pull-up resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

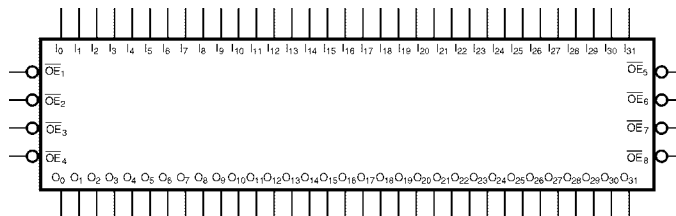
#### Ordering Code:

| Order Number                    | Package Number | Package Description                                                 |
|---------------------------------|----------------|---------------------------------------------------------------------|
| 74VCX32244G<br>(Note 2)(Note 3) | BGA96A         | 96-Ball Fine-Pitch Ball Grid Array (FBGA), JEDEC MO-205, 5.5mm Wide |

**Note 2:** Ordering code "G" indicates Trays.

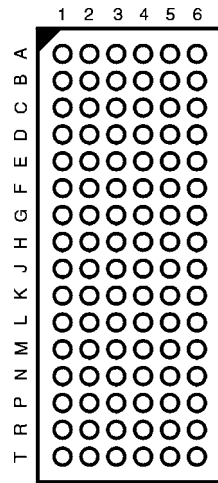
**Note 3:** Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

#### Logic Symbol



74VCX32244 Low Voltage 32-Bit Buffer/Line Driver with 3.6V Tolerant Inputs and Outputs

## Connection Diagram



(Top Thru View)

## Pin Descriptions

| Pin Names         | Description                      |
|-------------------|----------------------------------|
| $\overline{OE}_n$ | Output Enable Input (Active LOW) |
| $I_0-I_{31}$      | Inputs                           |
| $O_0-O_{31}$      | Outputs                          |

## FBGA Pin Assignments

|          | 1        | 2        | 3                 | 4                 | 5        | 6        |
|----------|----------|----------|-------------------|-------------------|----------|----------|
| <b>A</b> | $O_1$    | $O_0$    | $\overline{OE}_1$ | $\overline{OE}_2$ | $I_0$    | $I_1$    |
| <b>B</b> | $O_3$    | $O_2$    | GND               | GND               | $I_2$    | $I_3$    |
| <b>C</b> | $O_5$    | $O_4$    | $V_{CC}$          | $V_{CC}$          | $I_4$    | $I_5$    |
| <b>D</b> | $O_7$    | $O_6$    | GND               | GND               | $I_6$    | $I_7$    |
| <b>E</b> | $O_9$    | $O_8$    | GND               | GND               | $I_8$    | $I_9$    |
| <b>F</b> | $O_{11}$ | $O_{10}$ | $V_{CC}$          | $V_{CC}$          | $I_{10}$ | $I_{11}$ |
| <b>G</b> | $O_{13}$ | $O_{12}$ | GND               | GND               | $I_{12}$ | $I_{13}$ |
| <b>H</b> | $O_{14}$ | $O_{15}$ | $\overline{OE}_4$ | $\overline{OE}_3$ | $I_{15}$ | $I_{14}$ |
| <b>J</b> | $O_{17}$ | $O_{16}$ | $\overline{OE}_5$ | $\overline{OE}_6$ | $I_{16}$ | $I_{17}$ |
| <b>K</b> | $O_{19}$ | $O_{18}$ | GND               | GND               | $I_{18}$ | $I_{19}$ |
| <b>L</b> | $O_{21}$ | $O_{20}$ | $V_{CC}$          | $V_{CC}$          | $I_{20}$ | $I_{21}$ |
| <b>M</b> | $O_{23}$ | $O_{22}$ | GND               | GND               | $I_{22}$ | $I_{23}$ |
| <b>N</b> | $O_{25}$ | $O_{24}$ | GND               | GND               | $I_{24}$ | $I_{25}$ |
| <b>P</b> | $O_{27}$ | $O_{26}$ | $V_{CC}$          | $V_{CC}$          | $I_{26}$ | $I_{27}$ |
| <b>R</b> | $O_{29}$ | $O_{28}$ | GND               | GND               | $I_{28}$ | $I_{29}$ |
| <b>T</b> | $O_{30}$ | $O_{31}$ | $\overline{OE}_8$ | $\overline{OE}_7$ | $I_{31}$ | $I_{30}$ |

## Truth Tables

| Inputs            |           | Outputs   |
|-------------------|-----------|-----------|
| $\overline{OE}_1$ | $I_0-I_3$ | $O_0-O_3$ |
| L                 | L         | L         |
| L                 | H         | H         |
| H                 | X         | Z         |

| Inputs            |           | Outputs   |
|-------------------|-----------|-----------|
| $\overline{OE}_2$ | $I_4-I_7$ | $O_4-O_7$ |
| L                 | L         | L         |
| L                 | H         | H         |
| H                 | X         | Z         |

| Inputs            |              | Outputs      |
|-------------------|--------------|--------------|
| $\overline{OE}_3$ | $I_8-I_{11}$ | $O_8-O_{11}$ |
| L                 | L            | L            |
| L                 | H            | H            |
| H                 | X            | Z            |

| Inputs            |                 | Outputs         |
|-------------------|-----------------|-----------------|
| $\overline{OE}_4$ | $I_{12}-I_{15}$ | $O_{12}-O_{15}$ |
| L                 | L               | L               |
| L                 | H               | H               |
| H                 | X               | Z               |

| Inputs            |                 | Outputs         |
|-------------------|-----------------|-----------------|
| $\overline{OE}_5$ | $I_{16}-I_{19}$ | $O_{16}-O_{19}$ |
| L                 | L               | L               |
| L                 | H               | H               |
| H                 | X               | Z               |

| Inputs            |                 | Outputs         |
|-------------------|-----------------|-----------------|
| $\overline{OE}_6$ | $I_{20}-I_{23}$ | $O_{20}-O_{23}$ |
| L                 | L               | L               |
| L                 | H               | H               |
| H                 | X               | Z               |

| Inputs            |                 | Outputs         |
|-------------------|-----------------|-----------------|
| $\overline{OE}_7$ | $I_{24}-I_{27}$ | $O_{24}-O_{27}$ |
| L                 | L               | L               |
| L                 | H               | H               |
| H                 | X               | Z               |

| Inputs            |                 | Outputs         |
|-------------------|-----------------|-----------------|
| $\overline{OE}_8$ | $I_{28}-I_{31}$ | $O_{28}-O_{31}$ |
| L                 | L               | L               |
| L                 | H               | H               |
| H                 | X               | Z               |

H = HIGH Voltage Level

L = LOW Voltage Level

X = Immaterial (HIGH or LOW, inputs may not float)

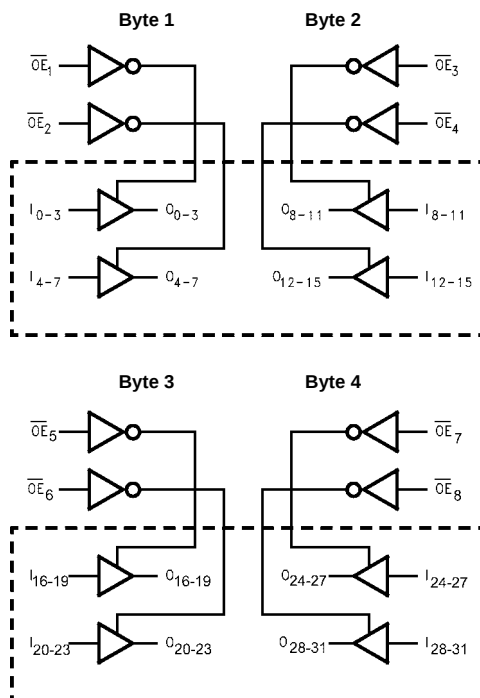
Z = High Impedance

## Functional Description

The 74VCX32244 contains thirty-two non-inverting buffers with 3-STATE outputs. The device is nibble (4 bits) controlled with each nibble functioning identically, but independent of each other. The control pins may be shorted together to obtain full 32-bit operation. The 3-STATE out-

puts are controlled by an Output Enable ( $\overline{OE}_n$ ) input. When  $\overline{OE}_n$  is LOW, the outputs are in the 2-state mode. When  $\overline{OE}_n$  is HIGH, the standard outputs are in the high impedance mode but this does not interfere with entering new data into the inputs.

## Logic Diagrams



**Note:** Please note that these diagrams are provided only for the understanding of logic operations and should not be used to estimate propagation delays.

**Absolute Maximum Ratings** (Note 4)

|                                                |                          |
|------------------------------------------------|--------------------------|
| Supply Voltage ( $V_{CC}$ )                    | −0.5V to +4.6V           |
| DC Input Voltage ( $V_I$ )                     | −0.5V to +4.6V           |
| Output Voltage ( $V_O$ )                       |                          |
| Outputs 3-STATED                               | −0.5V to +4.6V           |
| Outputs Active (Note 5)                        | −0.5V to $V_{CC} + 0.5V$ |
| DC Input Diode Current ( $I_{IK}$ ) $V_I < 0V$ | −50 mA                   |
| DC Output Diode Current ( $I_{OK}$ )           |                          |
| $V_O < 0V$                                     | −50 mA                   |
| $V_O > V_{CC}$                                 | +50 mA                   |
| DC Output Source/Sink Current                  |                          |
| ( $I_{OH}/I_{OL}$ )                            | ±50 mA                   |
| DC $V_{CC}$ or GND Current per                 |                          |
| Supply Pin ( $I_{CC}$ or GND)                  | ±100 mA                  |
| Storage Temperature Range ( $T_{STG}$ )        | −65°C to +150°C          |

**Recommended Operating Conditions** (Note 6)

|                                                 |                |
|-------------------------------------------------|----------------|
| Power Supply                                    |                |
| Operating                                       | 1.2V to 3.6V   |
| Input Voltage                                   | −0.3V to +3.6V |
| Output Voltage ( $V_O$ )                        |                |
| Output in Active States                         | 0V to $V_{CC}$ |
| Output in 3-STATE                               | 0.0V to 3.6V   |
| Output Current in $I_{OH}/I_{OL}$               |                |
| $V_{CC} = 3.0V$ to 3.6V                         | ±24 mA         |
| $V_{CC} = 2.3V$ to 2.7V                         | ±18 mA         |
| $V_{CC} = 1.65V$ to 2.3V                        | ±6 mA          |
| $V_{CC} = 1.2V$                                 | ±100 $\mu A$   |
| Free Air Operating Temperature ( $T_A$ )        | −40°C to +85°C |
| Minimum Input Edge Rate ( $\Delta t/\Delta V$ ) |                |
| $V_{IN} = 0.8V$ to 2.0V, $V_{CC} = 3.0V$        | 10 ns/V        |

**Note 4:** The Absolute Maximum Ratings are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the Absolute Maximum Ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

**Note 5:**  $I_O$  Absolute Maximum Rating must be observed.

**Note 6:** Floating or unused inputs must be held HIGH or LOW.

**DC Electrical Characteristics** (2.7V <  $V_{CC}$  ≤ 3.6V)

| Symbol   | Parameter                 | Conditions                                                                                                   | $V_{CC}$<br>(V)                                          | Min                                                                 | Max                                                                 | Units |
|----------|---------------------------|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|-------|
| $V_{IH}$ | HIGH Level Input Voltage  |                                                                                                              | 2.7 - 3.6<br>2.3 - 2.7<br>1.65 - 2.3<br>1.4 - 1.6<br>1.2 | 2.0<br>1.6<br>0.65 x $V_{CC}$<br>0.65 x $V_{CC}$<br>0.65 x $V_{CC}$ |                                                                     | V     |
| $V_{IL}$ | LOW Level Input Voltage   |                                                                                                              | 2.7 - 3.6<br>2.3 - 2.7<br>1.65 - 2.3<br>1.4 - 1.6<br>1.2 |                                                                     | 0.8<br>0.7<br>0.35 x $V_{CC}$<br>0.35 x $V_{CC}$<br>0.05 x $V_{CC}$ | V     |
| $V_{OH}$ | HIGH Level Output Voltage | $I_{OH} = -100 \mu A$<br>$I_{OH} = -12 \text{ mA}$<br>$I_{OH} = -18 \text{ mA}$<br>$I_{OH} = -24 \text{ mA}$ | 2.7 - 3.6<br>2.7<br>3.0<br>3.0                           | $V_{CC} - 0.2$<br>2.2<br>2.4<br>2.2                                 |                                                                     | V     |
|          |                           | $I_{OH} = -100 \mu A$<br>$I_{OH} = -6 \text{ mA}$<br>$I_{OH} = -12 \text{ mA}$<br>$I_{OH} = -18 \text{ mA}$  | 2.3 - 2.7<br>2.3<br>2.3<br>2.3                           | $V_{CC} - 0.2$<br>2.0<br>1.8<br>1.7                                 |                                                                     |       |
|          |                           | $I_{OH} = -100 \mu A$<br>$I_{OH} = -6 \text{ mA}$                                                            | 1.65 - 2.3<br>1.65                                       | $V_{CC} - 0.2$<br>1.25                                              |                                                                     |       |
|          |                           | $I_{OH} = -100 \mu A$<br>$I_{OH} = -2 \text{ mA}$                                                            | 1.4 - 1.6<br>1.4                                         | $V_{CC} - 0.2$<br>1.05                                              |                                                                     |       |
|          |                           | $I_{OH} = -100 \mu A$                                                                                        | 1.2                                                      | $V_{CC} - 0.2$                                                      |                                                                     |       |
|          |                           |                                                                                                              |                                                          |                                                                     |                                                                     |       |
|          |                           |                                                                                                              |                                                          |                                                                     |                                                                     |       |
|          |                           |                                                                                                              |                                                          |                                                                     |                                                                     |       |

**DC Electrical Characteristics** (Continued)

| Symbol                   | Parameter                             | Conditions                                                                                 | V <sub>CC</sub><br>(V) | Min | Max       | Units   |
|--------------------------|---------------------------------------|--------------------------------------------------------------------------------------------|------------------------|-----|-----------|---------|
| V <sub>OL</sub>          | LOW Level Output Voltage              | I <sub>OL</sub> = 100 $\mu$ A                                                              | 2.7 - 3.6              |     | 0.2       | V       |
|                          |                                       | I <sub>OL</sub> = 12 mA                                                                    | 2.7                    |     | 0.4       |         |
|                          |                                       | I <sub>OL</sub> = 18 mA                                                                    | 3.0                    |     | 0.4       |         |
|                          |                                       | I <sub>OL</sub> = 24 mA                                                                    | 3.0                    |     | 0.55      |         |
|                          |                                       | I <sub>OL</sub> = 100 $\mu$ A                                                              | 2.3 - 2.7              |     | 0.2       |         |
|                          |                                       | I <sub>OL</sub> = 12 mA                                                                    | 2.3                    |     | 0.4       |         |
|                          |                                       | I <sub>OL</sub> = 18 mA                                                                    | 2.3                    |     | 0.6       |         |
|                          |                                       | I <sub>OL</sub> = 100 $\mu$ A                                                              | 1.65 - 2.3             |     | 0.2       |         |
|                          |                                       | I <sub>OL</sub> = 6 mA                                                                     | 1.65                   |     | 0.3       |         |
| I <sub>I</sub>           | Input Leakage Current                 | I <sub>OL</sub> = 100 $\mu$ A                                                              | 1.4 - 1.6              |     | 0.2       |         |
|                          |                                       | I <sub>OL</sub> = 2 mA                                                                     | 1.4                    |     | 0.35      |         |
| I <sub>OZ</sub>          | 3-STATE Output Leakage                | I <sub>OL</sub> = 100 $\mu$ A                                                              | 1.2                    |     | 0.05      |         |
|                          |                                       |                                                                                            |                        |     |           |         |
| I <sub>OFF</sub>         | Power-OFF Leakage Current             | 0 $\leq$ V <sub>I</sub> $\leq$ 3.6V                                                        | 1.2 - 3.6              |     | $\pm$ 5.0 | $\mu$ A |
| I <sub>CC</sub>          | Quiescent Supply Current              | 0 $\leq$ V <sub>O</sub> $\leq$ 3.6V<br>V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 1.2 - 3.6              |     | $\pm$ 10  | $\mu$ A |
| I <sub>CC</sub>          | Quiescent Supply Current              | 0 $\leq$ (V <sub>I</sub> , V <sub>O</sub> ) $\leq$ 3.6V                                    | 0                      |     | 10        | $\mu$ A |
|                          |                                       | V <sub>I</sub> = V <sub>CC</sub> or GND                                                    | 1.2 - 3.6              |     | 40        | $\mu$ A |
| $\Delta$ I <sub>CC</sub> | Increase in I <sub>CC</sub> per Input | V <sub>CC</sub> $\leq$ (V <sub>I</sub> , V <sub>O</sub> ) $\leq$ 3.6V (Note 7)             | 1.2 - 3.6              |     | $\pm$ 40  | $\mu$ A |
|                          |                                       | V <sub>IH</sub> = V <sub>CC</sub> - 0.6V                                                   | 2.7 - 3.6              |     | 750       | $\mu$ A |

**Note 7:** Outputs disabled or 3-STATE only.

**AC Electrical Characteristics** (Note 8)

| Symbol                                 | Parameter           | Conditions                                            | V <sub>CC</sub><br>(V) | T <sub>A</sub> = -40°C to +85°C |      | Units | Figure<br>Number   |
|----------------------------------------|---------------------|-------------------------------------------------------|------------------------|---------------------------------|------|-------|--------------------|
|                                        |                     |                                                       |                        | Min                             | Max  |       |                    |
| t <sub>PHL</sub> ,<br>t <sub>PLH</sub> | Propagation Delay   | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 $\Omega$ | 3.3 $\pm$ 0.3          | 0.8                             | 2.5  | ns    | Figures<br>1, 2    |
|                                        |                     |                                                       | 2.5 $\pm$ 0.2          | 1.0                             | 3.0  |       |                    |
|                                        |                     |                                                       | 1.8 $\pm$ 0.15         | 1.5                             | 6.0  |       |                    |
|                                        |                     | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2k $\Omega$  | 1.5 $\pm$ 0.1          | 1.0                             | 12.0 |       | Figures<br>5, 6    |
|                                        |                     |                                                       | 1.2                    | 1.5                             | 30   |       |                    |
| t <sub>PZL</sub> ,<br>t <sub>PZH</sub> | Output Enable Time  | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 $\Omega$ | 3.3 $\pm$ 0.3          | 0.8                             | 3.5  | ns    | Figures<br>1, 3, 4 |
|                                        |                     |                                                       | 2.5 $\pm$ 0.2          | 1.0                             | 4.1  |       |                    |
|                                        |                     |                                                       | 1.8 $\pm$ 0.15         | 1.5                             | 8.2  |       |                    |
|                                        |                     | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2k $\Omega$  | 1.5 $\pm$ 0.1          | 1.0                             | 16.4 |       | Figures<br>5, 6, 7 |
|                                        |                     |                                                       | 1.2                    | 1.5                             | 41   |       |                    |
| t <sub>PLZ</sub> ,<br>t <sub>PHZ</sub> | Output Disable Time | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 $\Omega$ | 3.3 $\pm$ 0.3          | 0.8                             | 3.5  |       | Figures<br>1, 3, 4 |
|                                        |                     |                                                       | 2.5 $\pm$ 0.2          | 1.0                             | 3.8  |       |                    |
|                                        |                     |                                                       | 1.8 $\pm$ 0.15         | 1.5                             | 6.8  |       |                    |
|                                        |                     | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2k $\Omega$  | 1.5 $\pm$ 0.1          | 1.0                             | 13.6 |       | Figures<br>5, 7, 8 |
|                                        |                     |                                                       | 1.2                    | 1.5                             | 34   |       |                    |

**Note 8:** For C<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

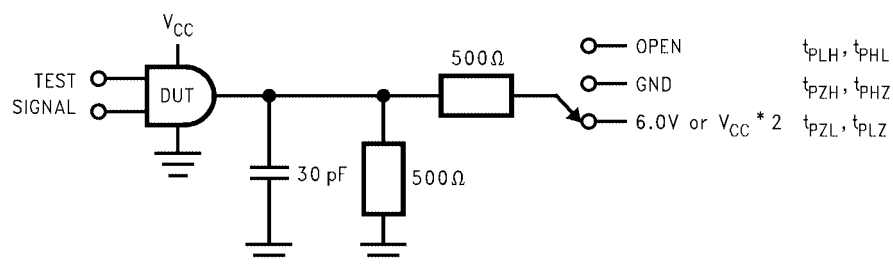
### Dynamic Switching Characteristics

| Symbol           | Parameter                                   | Conditions                                                                       | V <sub>CC</sub><br>(V) | T <sub>A</sub> = +25°C | Units |
|------------------|---------------------------------------------|----------------------------------------------------------------------------------|------------------------|------------------------|-------|
|                  |                                             |                                                                                  |                        | Typical                |       |
| V <sub>OLP</sub> | Quiet Output Dynamic Peak V <sub>OL</sub>   | C <sub>L</sub> = 30 pF, V <sub>IH</sub> = V <sub>CC</sub> , V <sub>IL</sub> = 0V | 1.8<br>2.5<br>3.3      | 0.25<br>0.6<br>0.8     | V     |
| V <sub>OLV</sub> | Quiet Output Dynamic Valley V <sub>OL</sub> | C <sub>L</sub> = 30 pF, V <sub>IH</sub> = V <sub>CC</sub> , V <sub>IL</sub> = 0V | 1.8<br>2.5<br>3.3      | -0.25<br>-0.6<br>-0.8  | V     |
| V <sub>OHV</sub> | Quiet Output Dynamic Valley V <sub>OH</sub> | C <sub>L</sub> = 30 pF, V <sub>IH</sub> = V <sub>CC</sub> , V <sub>IL</sub> = 0V | 1.8<br>2.5<br>3.3      | 1.5<br>1.9<br>2.2      | V     |

### Capacitance

| Symbol           | Parameter                     | Conditions                                                                                | T <sub>A</sub> = +25°C | Units |
|------------------|-------------------------------|-------------------------------------------------------------------------------------------|------------------------|-------|
|                  |                               |                                                                                           | Typical                |       |
| C <sub>IN</sub>  | Input Capacitance             | V <sub>CC</sub> = 1.8, 2.5V or 3.3V, V <sub>I</sub> = 0V or V <sub>CC</sub>               | 6                      | pF    |
| C <sub>OUT</sub> | Output Capacitance            | V <sub>I</sub> = 0V or V <sub>CC</sub> , V <sub>CC</sub> = 1.8V, 2.5V or 3.3V             | 7                      | pF    |
| C <sub>PD</sub>  | Power Dissipation Capacitance | V <sub>I</sub> = 0V or V <sub>CC</sub> , f = 10 MHz, V <sub>CC</sub> = 1.8V, 2.5V or 3.3V | 20                     | pF    |

# AC Loading and Waveforms ( $V_{CC}$ $3.3V \pm 0.3V$ to $1.8V \pm 0.15V$ )



| TEST               | SWITCH                                                                                          |
|--------------------|-------------------------------------------------------------------------------------------------|
| $t_{PLH}, t_{PHL}$ | Open                                                                                            |
| $t_{PZL}, t_{PLZ}$ | 6V at $V_{CC} = 3.3 \pm 0.3V$ ;<br>$V_{CC} \times 2$ at $V_{CC} = 2.5 \pm 0.2V; 1.8V \pm 0.15V$ |
| $t_{PZH}, t_{PHZ}$ | GND                                                                                             |

FIGURE 1. AC Test Circuit

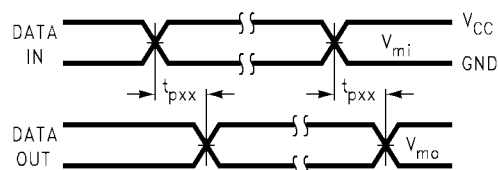


FIGURE 2. Waveform for Inverting and Non-Inverting Functions

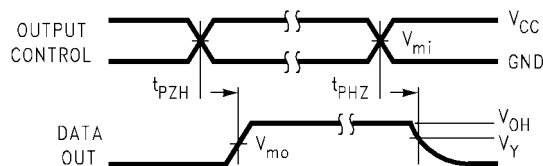


FIGURE 3. 3-STATE Output High Enable and Disable Times for Low Voltage Logic

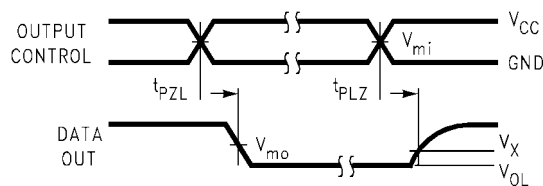
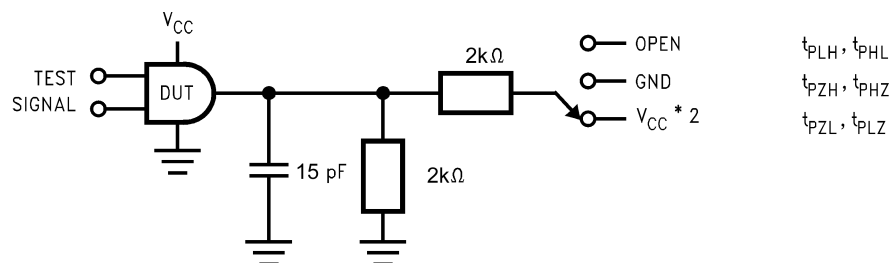


FIGURE 4. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic

| Symbol   | $V_{CC}$        |                  |                  |
|----------|-----------------|------------------|------------------|
|          | $3.3V \pm 0.3V$ | $2.5V \pm 0.2V$  | $1.8V \pm 0.15V$ |
| $V_{mi}$ | 1.5V            | $V_{CC}/2$       | $V_{CC}/2$       |
| $V_{mo}$ | 1.5V            | $V_{CC}/2$       | $V_{CC}/2$       |
| $V_X$    | $V_{OL} + 0.3V$ | $V_{OL} + 0.15V$ | $V_{OL} + 0.15V$ |
| $V_Y$    | $V_{OH} - 0.3V$ | $V_{OH} - 0.15V$ | $V_{OH} - 0.15V$ |

# AC Loading and Waveforms ( $V_{CC} 1.5 \pm 0.1V$ to $1.2V$ )



| TEST               | SWITCH                                       |
|--------------------|----------------------------------------------|
| $t_{PLH}, t_{PHL}$ | Open                                         |
| $t_{PZL}, t_{PLZ}$ | $V_{CC} \times 2$ at $V_{CC} = 1.5 \pm 0.1V$ |
| $t_{PZH}, t_{PHZ}$ | GND                                          |

FIGURE 5. AC Test Circuit

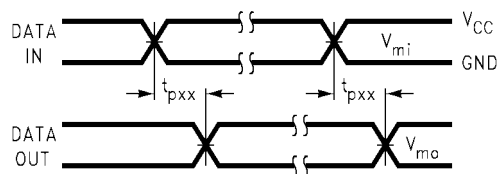


FIGURE 6. Waveform for Inverting and Non-Inverting Functions

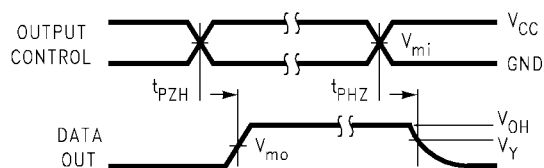


FIGURE 7. 3-STATE Output High Enable and Disable Times for Low Voltage Logic

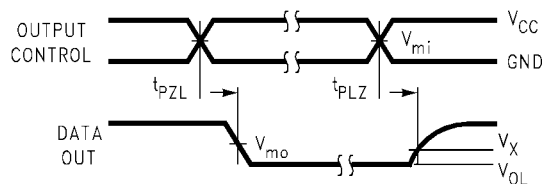


FIGURE 8. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic

| Symbol   | $V_{CC}$        |
|----------|-----------------|
|          | $1.5V \pm 0.1V$ |
| $V_{mi}$ | $V_{CC}/2$      |
| $V_{mo}$ | $V_{CC}/2$      |
| $V_X$    | $V_{OL} + 0.1V$ |
| $V_Y$    | $V_{OH} - 0.1V$ |

