

## 74VCX16245

### Low Voltage 16-Bit Bidirectional Transceiver with 3.6V Tolerant Inputs and Outputs

#### General Description

The VCX16245 contains sixteen non-inverting bidirectional buffers with 3-STATE outputs and is intended for bus oriented applications. The device is byte controlled. Each byte has separate 3-STATE control inputs which can be shorted together for full 16-bit operation. The  $T/\bar{R}$  inputs determine the direction of data flow through the device. The  $\overline{OE}$  inputs disable both the A and B ports by placing them in a high impedance state.

The 74VCX16245 is designed for low voltage (1.2V to 3.6V)  $V_{CC}$  applications with I/O compatibility up to 3.6V.

The 74VCX16245 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/withdrawal (Note 1)
- Static Drive ( $I_{OH}/I_{OL}$ )
  - $\pm 24$  mA @ 3.0V  $V_{CC}$
- Uses proprietary noise/EMI reduction circuitry
- Latchup performance exceeds 300 mA
- ESD performance:
  - Human body model > 2000V
  - Machine model > 200V
- Also packaged in plastic Fine-Pitch Ball Grid Array (FBGA)

**Note 1:** To ensure the high-impedance state during power up or power down,  $\overline{OE}$  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.

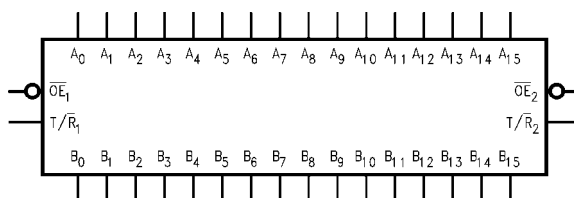
#### Ordering Code:

| Order Number                    | Package Number | Package Description                                                         |
|---------------------------------|----------------|-----------------------------------------------------------------------------|
| 74VCX16245G<br>(Note 2)(Note 3) | BGA54A         | 54-Ball Fine-Pitch Ball Grid Array (FBGA), JEDEC MO-205, 5.5mm Wide         |
| 74VCX16245MTD<br>(Note 3)       | MTD48          | 48-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 6.1mm 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.

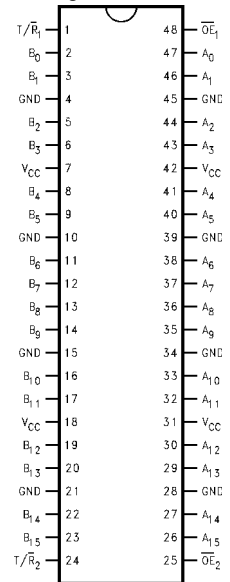
#### Logic Symbol



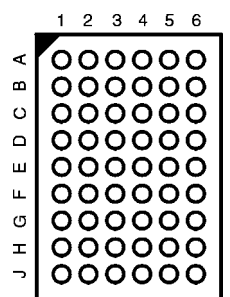
74VCX16245 Low Voltage 16-Bit Bidirectional Transceiver with 3.6V Tolerant Inputs and Outputs

# Connection Diagrams

Pin Assignment of TSSOP



Pin Assignment for FBGA



(Top Thru View)

# Pin Descriptions

| Pin Names          | Description                      |
|--------------------|----------------------------------|
| $\overline{OE}_n$  | Output Enable Input (Active LOW) |
| $T/\overline{R}_n$ | Transmit/Receive Input           |
| $A_0-A_{15}$       | Side A Inputs or 3-STATE Outputs |
| $B_0-B_{15}$       | Side B Inputs or 3-STATE Outputs |
| NC                 | No Connect                       |

# FBGA Pin Assignments

|          | 1        | 2        | 3                  | 4                 | 5        | 6        |
|----------|----------|----------|--------------------|-------------------|----------|----------|
| <b>A</b> | $B_0$    | NC       | $T/\overline{R}_1$ | $\overline{OE}_1$ | NC       | $A_0$    |
| <b>B</b> | $B_2$    | $B_1$    | NC                 | NC                | $A_1$    | $A_2$    |
| <b>C</b> | $B_4$    | $B_3$    | $V_{CC}$           | $V_{CC}$          | $A_3$    | $A_4$    |
| <b>D</b> | $B_6$    | $B_5$    | GND                | GND               | $A_5$    | $A_6$    |
| <b>E</b> | $B_8$    | $B_7$    | GND                | GND               | $A_7$    | $A_8$    |
| <b>F</b> | $B_{10}$ | $B_9$    | GND                | GND               | $A_9$    | $A_{10}$ |
| <b>G</b> | $B_{12}$ | $B_{11}$ | $V_{CC}$           | $V_{CC}$          | $A_{11}$ | $A_{12}$ |
| <b>H</b> | $B_{14}$ | $B_{13}$ | NC                 | NC                | $A_{13}$ | $A_{14}$ |
| <b>J</b> | $B_{15}$ | NC       | $T/\overline{R}_2$ | $\overline{OE}_2$ | NC       | $A_{15}$ |

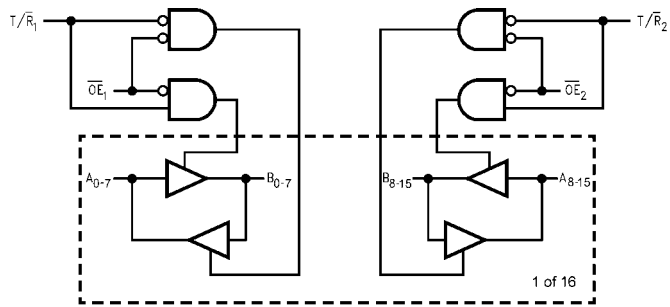
# Truth Tables

| Inputs            |                    | Outputs                               |
|-------------------|--------------------|---------------------------------------|
| $\overline{OE}_1$ | $T/\overline{R}_1$ |                                       |
| L                 | L                  | Bus $B_0-B_7$ Data to Bus $A_0-A_7$   |
| L                 | H                  | Bus $A_0-A_7$ Data to Bus $B_0-B_7$   |
| H                 | X                  | HIGH Z State on $A_0-A_7$ , $B_0-B_7$ |

| Inputs            |                    | Outputs                                     |
|-------------------|--------------------|---------------------------------------------|
| $\overline{OE}_2$ | $T/\overline{R}_2$ |                                             |
| L                 | L                  | Bus $B_8-B_{15}$ Data to Bus $A_8-A_{15}$   |
| L                 | H                  | Bus $A_8-A_{15}$ Data to Bus $B_8-B_{15}$   |
| H                 | X                  | HIGH Z State on $A_8-A_{15}$ , $B_8-B_{15}$ |

H = HIGH Voltage Level  
L = LOW Voltage Level  
X = Immaterial (HIGH or LOW, inputs and I/O's may not float)  
Z = High Impedance

# Logic Diagram



**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-STATE                                                    | -0.5V to +4.6V          |
| Outputs Active (Note 5)                                            | -0.5 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 Ground Current per Supply Pin ( $I_{CC}$ or Ground) | ±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          |
| $V_{CC} = 1.4V$ to 1.6V                         | ±2 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" table are not guaranteed at the Absolute Maximum Ratings. The Recommended Operating Conditions tables will define the conditions for actual device operation.

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

**Note 6:** Floating or unused pin (inputs or I/O's) must be held HIGH or LOW.

**DC Electrical Characteristics**

| 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>$0.65 \times V_{CC}$<br>$0.65 \times V_{CC}$<br>$0.65 \times V_{CC}$ |                                                                                    | 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>$0.35 \times V_{CC}$<br>$0.35 \times V_{CC}$<br>$0.05 \times V_{CC}$ | 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              | $I_{OL} = 100 \mu A$<br>$I_{OL} = 12 \text{ mA}$<br>$I_{OL} = 18 \text{ mA}$<br>$I_{OL} = 24 \text{ mA}$ | 2.7 - 3.6<br>2.7<br>3.0<br>3.0 |     | 0.2<br>0.4<br>0.4<br>0.55 | V     |
|                  |                                       | $I_{OL} = 100 \mu A$<br>$I_{OL} = 12 \text{ mA}$<br>$I_{OL} = 18 \text{ mA}$                             | 2.3 - 2.7<br>2.3<br>2.3        |     | 0.2<br>0.4<br>0.6         |       |
|                  |                                       | $I_{OL} = 100 \mu A$<br>$I_{OL} = 6 \text{ mA}$                                                          | 1.65 - 2.3<br>1.65             |     | 0.2<br>0.3                |       |
|                  |                                       | $I_{OL} = 100 \mu A$<br>$I_{OL} = 2 \text{ mA}$                                                          | 1.4 - 1.6<br>1.4               |     | 0.2<br>0.35               |       |
|                  |                                       | $I_{OL} = 100 \mu A$                                                                                     | 1.2                            |     | V <sub>CC</sub> - 0.1     |       |
| I <sub>I</sub>   | Input Leakage Current                 | $0V \leq V_I \leq 3.6V$                                                                                  | 1.2 - 3.6                      |     | ±5.0                      | μA    |
| I <sub>OZ</sub>  | 3-STATE Output Leakage                | $0V \leq V_O \leq 3.6V$<br>$V_I = V_{IH} \text{ or } V_{IL}$                                             | 1.2 - 3.6                      |     | ±10                       | μA    |
| I <sub>OFF</sub> | Power Off Leakage Current             | $0V \leq (V_I, V_O) \leq 3.6V$                                                                           | 0                              |     | 10                        | μA    |
| I <sub>CC</sub>  | Quiescent Supply Current              | $V_I = V_{CC} \text{ or GND}$<br>$V_{CC} \leq (V_I, V_O) \leq 3.6V \text{ (Note 7)}$                     | 1.2 - 3.6<br>1.2 - 3.6         |     | 20<br>±20                 | μA    |
| ΔI <sub>CC</sub> | Increase in I <sub>CC</sub> per Input | $V_{IH} = V_{CC} - 0.6V$                                                                                 | 2.7 - 3.6                      |     | 750                       | μA    |

Note 7: Outputs disabled or 3-STATE only.

## AC Electrical Characteristics (Note 8)

| Symbol                                 | Parameter                      | Conditions                                    | V <sub>CC</sub> | T <sub>A</sub> = -40°C to +85°C |      | Units | Figure Number   |
|----------------------------------------|--------------------------------|-----------------------------------------------|-----------------|---------------------------------|------|-------|-----------------|
|                                        |                                |                                               | (V)             | Min                             | Max  |       |                 |
| t <sub>PHL</sub><br>t <sub>PLH</sub>   | Propagation Delay              | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω | 3.3 ± 0.3       | 0.8                             | 2.5  | ns    | Figures 1, 2    |
|                                        |                                |                                               | 2.5 ± 0.2       | 1.0                             | 3.0  |       |                 |
|                                        |                                | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ  | 1.8 ± 0.15      | 1.0                             | 6.0  |       | Figures 5, 6    |
|                                        |                                |                                               | 1.5 ± 0.1       | 1.0                             | 12.0 |       |                 |
|                                        |                                |                                               | 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> = 500Ω | 3.3 ± 0.3       | 0.8                             | 3.8  | ns    | Figures 1, 3, 4 |
|                                        |                                |                                               | 2.5 ± 0.2       | 1.0                             | 4.9  |       |                 |
|                                        |                                | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ  | 1.8 ± 0.15      | 1.5                             | 9.3  |       | Figures 5, 7, 8 |
|                                        |                                |                                               | 1.5 ± 0.1       | 1.0                             | 18.6 |       |                 |
|                                        |                                |                                               | 1.2             | 1.5                             | 46.5 |       |                 |
| t <sub>PLZ</sub><br>t <sub>PHZ</sub>   | Output Disable Time            | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω | 3.3 ± 0.3       | 0.8                             | 3.7  | ns    | Figures 1, 3, 4 |
|                                        |                                |                                               | 2.5 ± 0.2       | 1.0                             | 4.2  |       |                 |
|                                        |                                | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ  | 1.8 ± 0.15      | 1.5                             | 7.6  |       | Figures 5, 7, 8 |
|                                        |                                |                                               | 1.5 ± 0.1       | 1.0                             | 15.2 |       |                 |
|                                        |                                |                                               | 1.2             | 1.5                             | 38   |       |                 |
| t <sub>OSHL</sub><br>t <sub>OSLH</sub> | Output to Output Skew (Note 9) | C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω | 3.3 ± 0.3       |                                 | 0.5  | ns    |                 |
|                                        |                                |                                               | 2.5 ± 0.2       |                                 | 0.5  |       |                 |
|                                        |                                | C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ  | 1.8 ± 0.15      |                                 | 0.75 |       |                 |
|                                        |                                |                                               | 1.5 ± 0.1       |                                 | 1.5  |       |                 |
|                                        |                                |                                               | 1.2             |                                 | 1.5  |       |                 |

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

Note 9: Skew is defined as the absolute value of the difference between the actual propagation delay for any two separate outputs of the same device. The specification applies to any outputs switching in the same direction, either HIGH-to-LOW (t<sub>OSHL</sub>) or LOW-to-HIGH (t<sub>OSLH</sub>).

### 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> = 1.8V, 2.5V, or 3.3V, V <sub>I</sub> = 0V or V <sub>CC</sub>             | 6                      | pF    |
| C <sub>I/O</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)

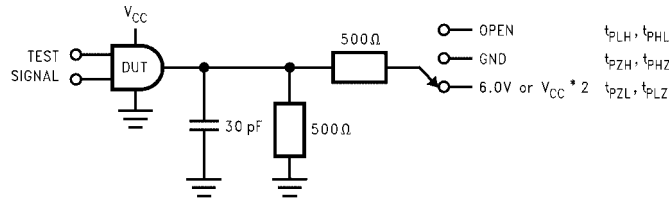


FIGURE 1. AC Test Circuit

| 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                                                                                                |

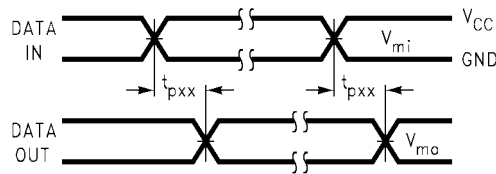


FIGURE 2. Waveform for Inverting and Non-inverting Functions

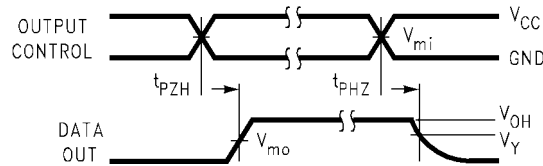


FIGURE 3. 3-STATE Output High Enable and Disable Times for Low Voltage Logic

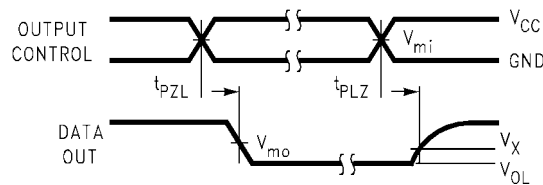
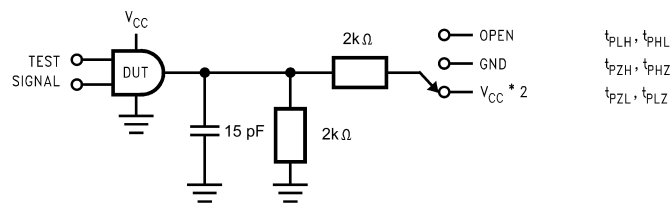


FIGURE 4. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic

| 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 ( $V_{CC} 1.5V \pm 0.1V$ to $1.2V$ )



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

FIGURE 5. AC Test Circuit

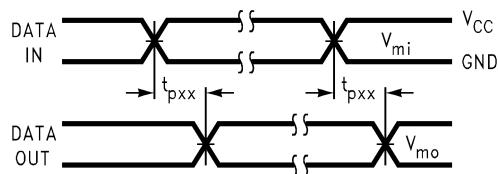


FIGURE 6. Waveform for Inverting and Non-Inverting Functions

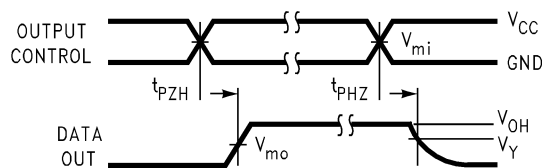


FIGURE 7. 3-STATE Output High Enable and Disable Times for Low Voltage Logic

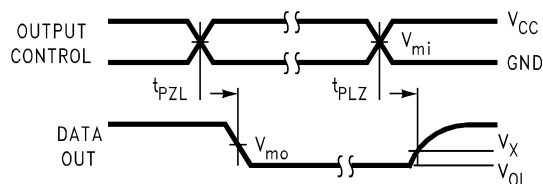
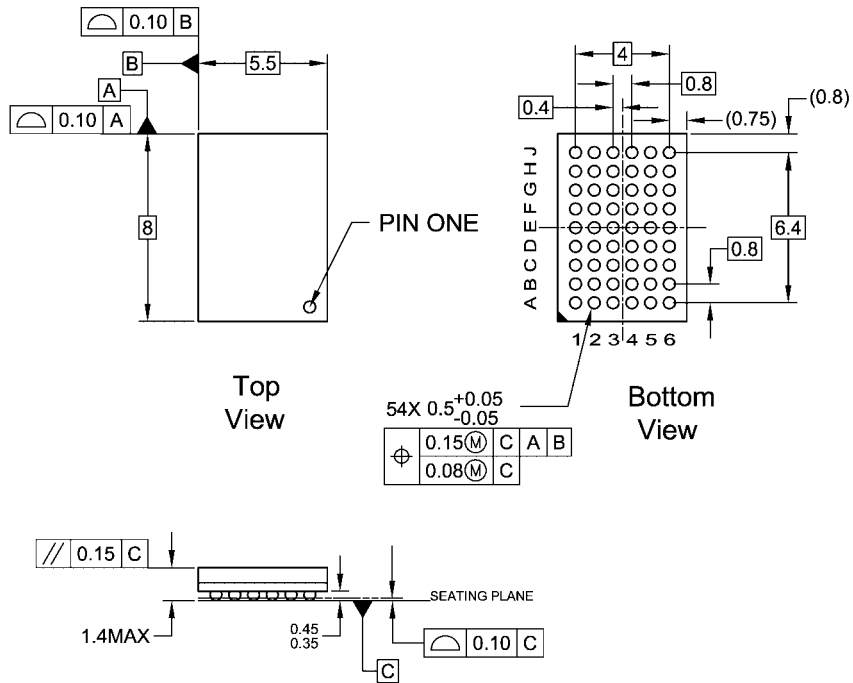


FIGURE 8. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic

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

# Physical Dimensions inches (millimeters) unless otherwise noted



## NOTES:

- A. THIS PACKAGE CONFORMS TO JEDEC M0-205
- B. ALL DIMENSIONS IN MILLIMETERS
- C. LAND PATTERN RECOMMENDATION: NSMD (Non Solder Mask Defined)  
.35MM DIA PADS WITH A SOLDERMASK OPENING OF .45MM CONCENTRIC TO PADS
- D. DRAWING CONFORMS TO ASME Y14.5M-1994

BGA54ArevD

**54-Ball Fine-Pitch Ball Grid Array (FBGA), JEDEC MO-205, 5.5mm Wide  
Package Number BGA54A**





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