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## 74LCXH16245

### Low Voltage 16-Bit Bidirectional Transceiver with Bushold

#### General Description

The LCXH16245 contains sixteen non-inverting bidirectional buffers with 3-STATE outputs and is intended for bus oriented applications. The device is designed for low voltage (2.5V or 3.3V)  $V_{CC}$  applications with capability of interfacing to a 5V signal environment. The device is byte controlled. Each byte has separate control inputs which could be shorted together for full 16-bit operation. The T/R inputs determine the direction of data flow through the device. The OE inputs disable both the A and B Ports by placing them in a high impedance state.

The LCXH16245 data inputs include active bushold circuitry, eliminating the need for external pull-up resistors to hold unused or floating data inputs at a valid logic level.

The LCXH16245 is fabricated with an advanced CMOS technology to achieve high speed operation while maintaining CMOS low power dissipation.

#### Features

- 2.3V–3.6V  $V_{CC}$  specifications provided
- 4.5 ns  $t_{PD}$  max ( $V_{CC} = 3.3V$ ), 20  $\mu A$   $I_{CC}$  max
- Power-down high impedance outputs
- Bushold on inputs eliminates the need for external pull-up/pull-down resistors
- $\pm 24$  mA output drive ( $V_{CC} = 3.0V$ )
- Implements patented noise/EMI reduction circuitry
- Latch-up performance conforms to the requirements of JESD78
- ESD performance:
  - Human body model > 2000V
  - Machine model > 200V
- Also packaged in plastic Fine-Pitch Ball Grid Array (FBGA)

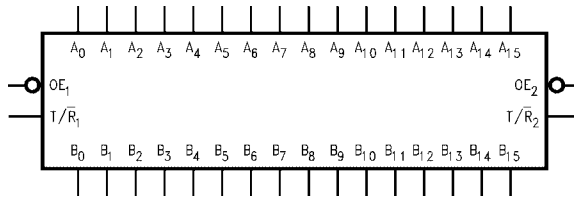
#### Ordering Code:

| Order Number                      | Package Number | Package Description   |
|-----------------------------------|----------------|---|
| 74LCXH16245G<br>(Note 1) (Note 2) | BGA54A         | 54-Ball Fine-Pitch Ball Grid Array (FBGA), JEDEC MO-205, 5.5mm Wide         |
| 74LCXH16245MTD<br>(Note 2)        | MTD48          | 48-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 6.1mm Wide |

**Note 1:** Ordering Code "G" indicates Trays.

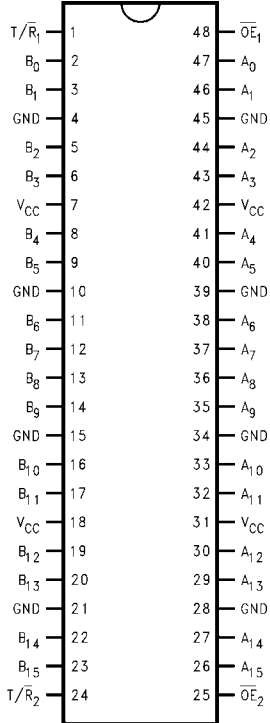
**Note 2:** Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

#### Logic Symbol

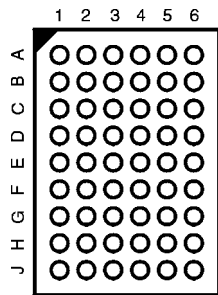


## Connection Diagrams

Pin Assignment for SSOP and TSSOP



Pin Assignment for FBGA



(Top Thru View)

## Pin Descriptions

| Pin Names          | Description                                |
|--------------------|--|
| $\overline{OE}_n$  | Output Enable Input                        |
| $T/\overline{R}_n$ | Transmit/Receive Input                     |
| $A_0-A_{15}$       | Side A Inputs or 3-STATE Outputs (Bushold) |
| $B_0-B_{15}$       | Side B Inputs or 3-STATE Outputs (Bushold) |

## 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       | $A_{15}$ |

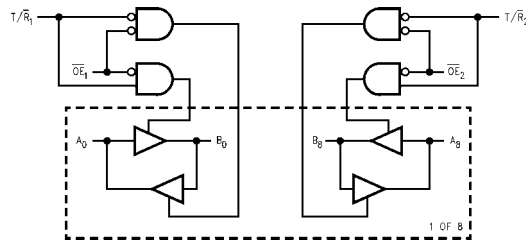
## Truth Tables

| 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  
 Z = High Impedance

## Logic Diagram



| Absolute Maximum Ratings <sup>(Note 3)</sup>  |  |   |   |                                 |      |       |
|---|--|---|---|---------------------------------|------|-------|
| Symbol  | Parameter  | Value   | Conditions  | Units                           |      |       |
| V <sub>CC</sub>   | Supply Voltage   | -0.5 to +7.0                                  |   | V                               |      |       |
| V <sub>I</sub>  | DC Input Voltage   | -0.5 to V <sub>CC</sub> + 0.5                 |   | V                               |      |       |
| V <sub>O</sub>  | DC Output Voltage  | -0.5 to +7.0<br>-0.5 to V <sub>CC</sub> + 0.5 | Output in 3-STATE<br>Output in HIGH or LOW State (Note 4) | V                               |      |       |
| I <sub>IK</sub>   | DC Input Diode Current   | -50   | V <sub>I</sub> < GND                                      | mA                              |      |       |
| I <sub>OK</sub>   | DC Output Diode Current  | -50<br>+50                                    | V <sub>O</sub> < GND<br>V <sub>O</sub> > V <sub>CC</sub>  | mA                              |      |       |
| I <sub>O</sub>  | DC Output Source/Sink Current  | ±50   |   | mA                              |      |       |
| I <sub>CC</sub>   | DC Supply Current per Supply Pin                                     | ±100  |   | mA                              |      |       |
| I <sub>GND</sub>  | DC Ground Current per Ground Pin                                     | ±100  |   | mA                              |      |       |
| T <sub>STG</sub>  | Storage Temperature  | -65 to +150                                   |   | °C                              |      |       |
| Recommended Operating Conditions (Note 5)   |  |   |   |                                 |      |       |
| Symbol  | Parameter  | Min   | Max   | Units                           |      |       |
| V <sub>CC</sub>   | Supply Voltage   | Operating                                     | 2.0   | 3.6                             | V    |       |
|   |  | Data Retention                                | 1.5   | 3.6                             |      |       |
| V <sub>I</sub>  | Input Voltage  | 0   | V <sub>CC</sub>   | V                               |      |       |
| V <sub>O</sub>  | Output Voltage   | HIGH or LOW State                             | 0   | V <sub>CC</sub>                 | V    |       |
|   |  | 3-STATE                                       | 0   | V <sub>CC</sub>                 |      |       |
| I <sub>OH</sub> /I <sub>OL</sub>  | Output Current   | V <sub>CC</sub> = 3.0V – 3.6V                 |   | ±24                             | mA   |       |
|   |  | V <sub>CC</sub> = 2.7V – 3.0V                 |   | ±12                             |      |       |
|   |  | V <sub>CC</sub> = 2.3V – 2.7V                 |   | ±8                              |      |       |
| T <sub>A</sub>  | Free-Air Operating Temperature                                       | -40   | 85  | °C                              |      |       |
| Δt/ΔV   | Input Edge Rate, V <sub>IN</sub> = 0.8V–2.0V, V <sub>CC</sub> = 3.0V | 0   | 10  | ns/V                            |      |       |
| <p><b>Note 3:</b> 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.</p> <p><b>Note 4:</b> I<sub>O</sub> Absolute Maximum Rating must be observed.</p> <p><b>Note 5:</b> Floating or unused control inputs must be HIGH or LOW.</p> |  |   |   |                                 |      |       |
| DC Electrical Characteristics   |  |   |   |                                 |      |       |
| Symbol  | Parameter  | Conditions                                    | V <sub>CC</sub><br>(V)                                    | T <sub>A</sub> = -40°C to +85°C |      | Units |
|   |  |   |   | Min                             | Max  |       |
| V <sub>IH</sub>   | HIGH Level Input Voltage   |   | 2.3 – 2.7   | 1.7                             |      | V     |
|   |  |   | 2.7 – 3.6   | 2.0                             |      |       |
| V <sub>IL</sub>   | LOW Level Input Voltage  |   | 2.3 – 2.7   |                                 | 0.7  | V     |
|   |  |   | 2.7 – 3.6   |                                 | 0.8  |       |
| V <sub>OH</sub>   | HIGH Level Output Voltage  | I <sub>OH</sub> = -100 μA                     | 2.3 – 3.6   | V <sub>CC</sub> - 0.2           |      | V     |
|   |  | I <sub>OH</sub> = -8 mA                       | 2.3   | 1.8                             |      |       |
|   |  | I <sub>OH</sub> = -12 mA                      | 2.7   | 2.2                             |      |       |
|   |  | I <sub>OH</sub> = -18 mA                      | 3.0   | 2.4                             |      |       |
|   |  | I <sub>OH</sub> = -24 mA                      | 3.0   | 2.2                             |      |       |
| V <sub>OL</sub>   | LOW Level Output Voltage   | I <sub>OL</sub> = 100 μA                      | 2.3 – 3.6   |                                 | 0.2  | V     |
|   |  | I <sub>OL</sub> = 8 mA                        | 2.3   |                                 | 0.6  |       |
|   |  | I <sub>OL</sub> = 12 mA                       | 2.7   |                                 | 0.4  |       |
|   |  | I <sub>OL</sub> = 16 mA                       | 3.0   |                                 | 0.4  |       |
|   |  | I <sub>OL</sub> = 24 mA                       | 3.0   |                                 | 0.55 |       |
| I <sub>I</sub>  | Input Leakage Current  | Data  | V <sub>I</sub> = V <sub>CC</sub> or GND                   | 2.3 – 3.6                       | ±5.0 | μA    |
|   |  | Control                                       | 0 ≤ V <sub>I</sub> ≤ 5.5                                  | 2.3 – 3.6                       | ±5.0 |       |

## DC Electrical Characteristics (Continued)

| Symbol               | Parameter  | Conditions                               | V <sub>CC</sub><br>(V) | T <sub>A</sub> = -40°C to +85°C |      | Units |
|----------------------|--|--|------------------------|---------------------------------|------|-------|
|                      |  |  |                        | Min                             | Max  |       |
| I <sub>I(HOLD)</sub> | Bushold Input Minimum Drive Hold Current         | V <sub>IN</sub> = 0.7V                   | 2.3                    | 45                              |      | μA    |
|                      |  | V <sub>IN</sub> = 1.7V                   |                        | -45                             |      |       |
|                      |  | V <sub>IN</sub> = 0.8V                   | 3.0                    | 75                              |      |       |
|                      |  | V <sub>IN</sub> = 2.0V                   |                        | -75                             |      |       |
| I <sub>I(OD)</sub>   | Bushold Input Over-Drive Current to Change State | (Note 6)                                 | 2.7                    | 300                             |      | μA    |
|                      |  | (Note 7)                                 |                        | -300                            |      |       |
|                      |  | (Note 6)                                 | 3.6                    | 450                             |      |       |
|                      |  | (Note 7)                                 |                        | -450                            |      |       |
| I <sub>OZ</sub>      | 3-STATE I/O Leakage                              | V <sub>O</sub> = V <sub>CC</sub> or GND  | 2.3 – 3.6              |                                 | ±5.0 | μA    |
| I <sub>OFF</sub>     | Power-Off Leakage Current                        | V <sub>I</sub> or V <sub>O</sub> = 5.5V  | 0                      |                                 | 10   | μA    |
| I <sub>CC</sub>      | Quiescent Supply Current                         | V <sub>I</sub> = V <sub>CC</sub> or GND  | 2.3-3.6                |                                 | 20   | μA    |
| ΔI <sub>CC</sub>     | Increase in I <sub>CC</sub> per Input            | V <sub>IH</sub> = V <sub>CC</sub> - 0.6V | 2.3-3.6                |                                 | 500  | μA    |

**Note 6:** An external driver must source at least the specified current to switch from LOW-to-HIGH.

**Note 7:** An external driver must sink at least the specified current to switch from HIGH-to-LOW.

## AC Electrical Characteristics

| Symbol            | Parameter  | T <sub>A</sub> = -40°C to +85°C, R <sub>L</sub> = 500Ω |     |                        |     |                               |     | Units |
|-------------------|--|--|-----|------------------------|-----|-------------------------------|-----|-------|
|                   |  | V <sub>CC</sub> = 3.3V ± 0.3V                          |     | V <sub>CC</sub> = 2.7V |     | V <sub>CC</sub> = 2.5V ± 0.2V |     |       |
|                   |  | C <sub>L</sub> = 50 pF                                 |     | C <sub>L</sub> = 50 pF |     | C <sub>L</sub> = 30 pF        |     |       |
|                   |  | Min  | Max | Min                    | Max | Min                           | Max |       |
| t <sub>PHL</sub>  | Propagation Delay  | 1.0  | 4.5 | 1.0                    | 5.2 | 1.0                           | 5.4 | ns    |
| t <sub>PLH</sub>  | A <sub>n</sub> to B <sub>n</sub> or B <sub>n</sub> to A <sub>n</sub> | 1.0  | 4.5 | 1.0                    | 5.2 | 1.0                           | 5.4 |       |
| t <sub>PZL</sub>  | Output Enable Time   | 1.0  | 6.5 | 1.0                    | 7.2 | 1.0                           | 8.5 | ns    |
| t <sub>PZH</sub>  | Output Disable Time  | 1.0  | 6.5 | 1.0                    | 7.2 | 1.0                           | 8.5 |       |
| t <sub>PLZ</sub>  | Output Disable Time  | 1.0  | 6.4 | 1.0                    | 6.9 | 1.0                           | 7.7 | ns    |
| t <sub>PHZ</sub>  | Output Enable Time   | 1.0  | 6.4 | 1.0                    | 6.9 | 1.0                           | 7.7 |       |
| t <sub>OSSL</sub> | Output to Output Skew (Note 8)                                       |  | 1.0 |                        |     |                               |     | ns    |
| t <sub>OSLH</sub> |  |  | 1.0 |                        |     |                               |     |       |

**Note 8:** 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>OSSL</sub>) or LOW-to-HIGH (t<sub>OSLH</sub>). Parameter guaranteed by design.

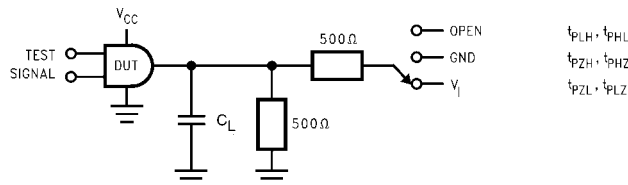
## Dynamic Switching Characteristics

| 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> = 50 pF, V <sub>IH</sub> = 3.3V, V <sub>IL</sub> = 0V | 3.3                    | 0.8                   | V     |
|                  |   | C <sub>L</sub> = 30 pF, V <sub>IH</sub> = 2.5V, V <sub>IL</sub> = 0V | 2.5                    | 0.6                   |       |
| V <sub>OLV</sub> | Quiet Output Dynamic Valley V <sub>OL</sub> | C <sub>L</sub> = 50 pF, V <sub>IH</sub> = 3.3V, V <sub>IL</sub> = 0V | 3.3                    | -0.8                  | V     |
|                  |   | C <sub>L</sub> = 30 pF, V <sub>IH</sub> = 2.5V, V <sub>IL</sub> = 0V | 2.5                    | -0.6                  |       |

## Capacitance

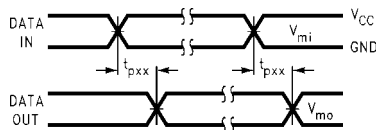
| Symbol           | Parameter                     | Conditions  | Typical | Units |
|------------------|-------------------------------|---|---------|-------|
| C <sub>IN</sub>  | Input Capacitance             | V <sub>CC</sub> = Open, V <sub>I</sub> = 0V or V <sub>CC</sub>              | 7       | pF    |
| C <sub>I/O</sub> | Input/Output Capacitance      | V <sub>CC</sub> = 3.3V, V <sub>I</sub> = 0V or V <sub>CC</sub>              | 8       | pF    |
| C <sub>PD</sub>  | Power Dissipation Capacitance | V <sub>CC</sub> = 3.3V, V <sub>I</sub> = 0V or V <sub>CC</sub> , f = 10 MHz | 20      | pF    |

**AC LOADING and WAVEFORMS** Generic for LCX Family

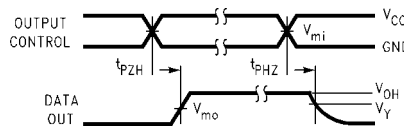


**FIGURE 1. AC Test Circuit ( $C_L$  includes probe and jig capacitance)**

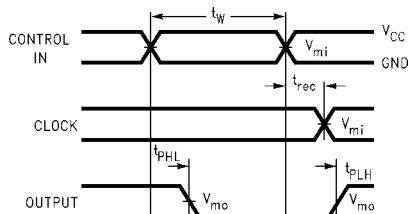
| Test                  | Switch  |
|-----------------------|---|
| $t_{PLH}$ , $t_{PHL}$ | Open  |
| $t_{PZL}$ , $t_{PLZ}$ | 6V at $V_{CC} = 3.3 \pm 0.3V$ , 2.7V and $V_{CC} \times 2$ at $V_{CC} = 2.5 \pm 0.2V$ |
| $t_{PZH}$ , $t_{PHZ}$ | GND   |



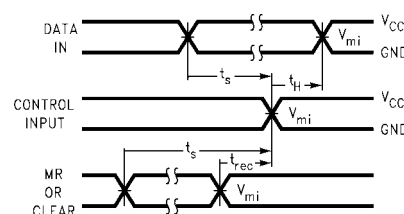
**Waveform for Inverting and Non-Inverting Functions**



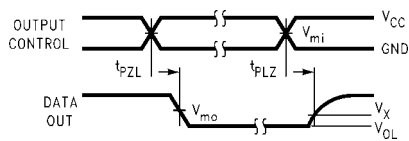
**3-STATE Output High Enable and Disable Times for Logic**



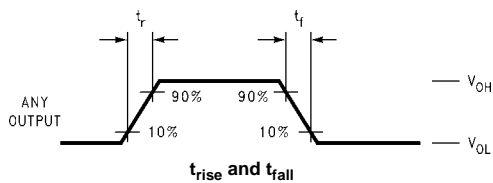
**Propagation Delay, Pulse Width and  $t_{rec}$  Waveforms**



**Setup Time, Hold Time and Recovery Time for Logic**



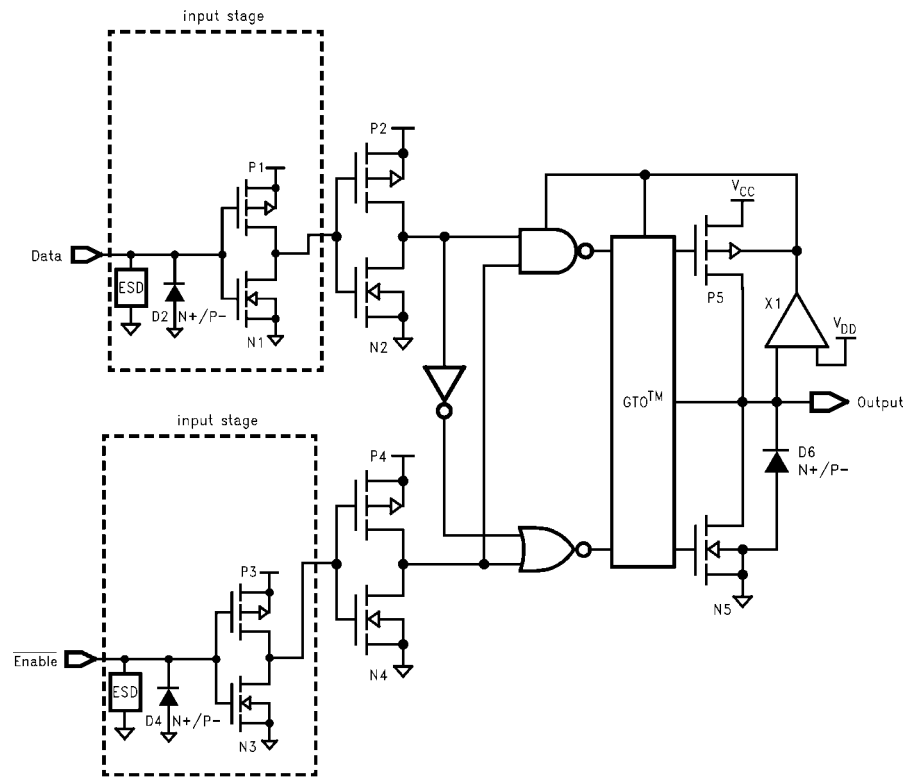
**3-STATE Output Low Enable and Disable Times for Logic**



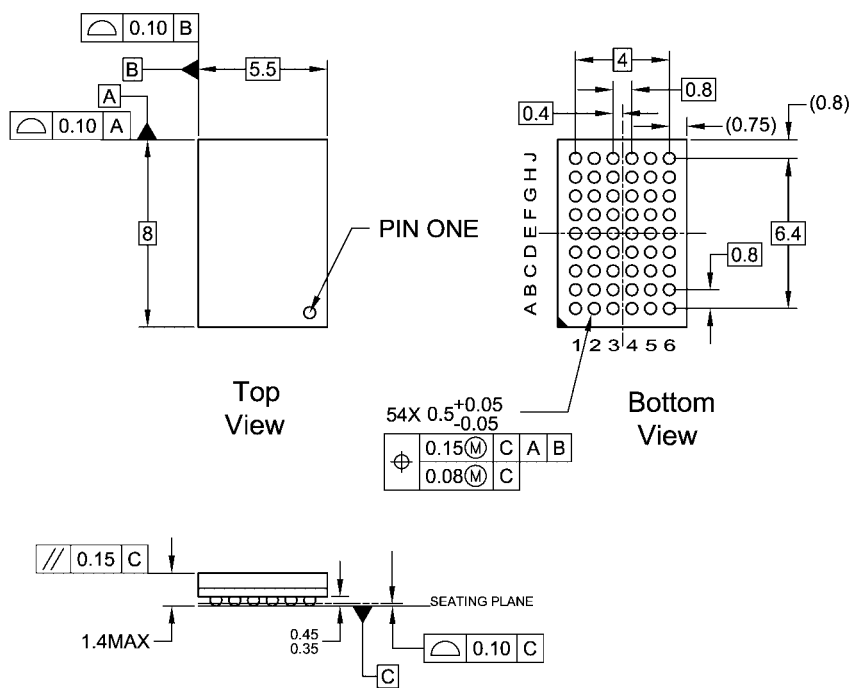
**FIGURE 2. Waveforms (Input Characteristics;  $f = 1MHz$ ,  $t_r = t_f = 3ns$ )**

| Symbol   | $V_{CC}$        |                 |                  |
|----------|-----------------|-----------------|------------------|
|          | $3.3V \pm 0.3V$ | 2.7V            | $2.5V \pm 0.2V$  |
| $V_{mi}$ | 1.5V            | 1.5V            | $V_{CC}/2$       |
| $V_{mo}$ | 1.5V            | 1.5V            | $V_{CC}/2$       |
| $V_x$    | $V_{OL} + 0.3V$ | $V_{OL} + 0.3V$ | $V_{OL} + 0.15V$ |
| $V_y$    | $V_{OH} - 0.3V$ | $V_{OH} - 0.3V$ | $V_{OH} - 0.15V$ |

**Schematic Diagram** Generic for LCX Family



**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 M0-205, 5.5mm Wide  
Package Number BGA54A**



**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



MTD48REV C

**48-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 6.1mm Wide Package Number MTD48**

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