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## 74LCX162374

### Low Voltage 16-Bit D-Type Flip-Flop with 5V Tolerant Inputs and Outputs and 26Ω Series Resistors

#### General Description

The LCX162374 contains sixteen non-inverting D-type flip-flops with 3-STATE outputs and is intended for bus oriented applications. The device is byte controlled. A buffered clock (CP) and Output Enable ( $\overline{OE}$ ) are common to each byte and can be shorted together for full 16-bit operation.

The LCX162374 is designed for low voltage (2.5V or 3.3V)  $V_{CC}$  applications with capability of interfacing to a 5V signal environment. The 26Ω series resistor in the output helps reduce output overshoot and undershoot.

The LCX162374 is fabricated with an advanced CMOS technology to achieve high speed operation while maintaining CMOS low power dissipation.

#### Features

- 5V tolerant inputs and outputs
- 2.3V–3.6V  $V_{CC}$  specifications provided
- Equivalent 26Ω series resistor on outputs
- 7.0 ns  $t_{PD}$  max ( $V_{CC} = 3.3V$ ), 20  $\mu A$   $I_{CC}$  max
- Power down high impedance inputs and outputs
- Supports live insertion/withdrawal (Note 1)
- $\pm 12$  mA output drive ( $V_{CC} = 3.0V$ )
- Implements proprietary noise/EMI reduction circuitry
- Latch-up performance exceeds 500 mA
- ESD performance:
  - Human body model > 2000V
  - Machine model > 200V
- Also packaged in plastic Fine-Pitch Ball Grid Array (FBGA) (Preliminary)

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

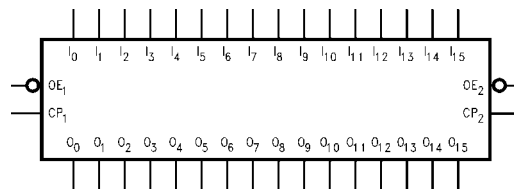
#### Ordering Code:

| Order Number               | Package Number          | Package Description   |
|----------------------------|-------------------------|---|
| 74LCX162374GX<br>(Note 2)  | BGA54A<br>(Preliminary) | 54-Ball Fine-Pitch Ball Grid Array (FBGA), JEDEC MO-205, 5.5mm Wide [TAPE and REEL] |
| 74LCX162374MEA<br>(Note 3) | MS48A                   | 48-Lead Small Shrink Outline Package (SSOP), JEDEC MO-118, 0.300" Wide              |
| 74LCX162374MTD<br>(Note 3) | MTD48                   | 48-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 6.1mm Wide         |

**Note 2:** BGA package available in Tape and Reel only.

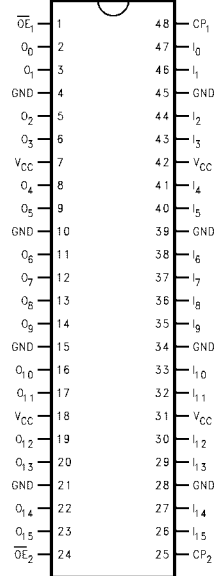
**Note 3:** Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

#### Logic Symbol

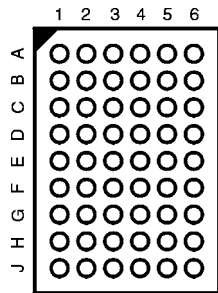


### Connection Diagrams

Pin Assignment for SSOP and TSSOP



Pin Assignment for FBGA



(Top Thru View)

### Pin Descriptions

| Pin Names         | Description                      |
|-------------------|----------------------------------|
| $\overline{OE}_n$ | Output Enable Input (Active LOW) |
| $CP_n$            | Clock Pulse Input                |
| $I_0-I_{15}$      | Inputs                           |
| $O_0-O_{15}$      | Outputs                          |
| NC                | No Connect                       |

### FBGA Pin Assignments

|          | 1        | 2        | 3                 | 4        | 5        | 6        |
|----------|----------|----------|-------------------|----------|----------|----------|
| <b>A</b> | $O_0$    | NC       | $\overline{OE}_1$ | $CP_1$   | NC       | $I_0$    |
| <b>B</b> | $O_2$    | $O_1$    | NC                | NC       | $I_1$    | $I_2$    |
| <b>C</b> | $O_4$    | $O_3$    | $V_{CC}$          | $V_{CC}$ | $I_3$    | $I_4$    |
| <b>D</b> | $O_6$    | $O_5$    | GND               | GND      | $I_5$    | $I_6$    |
| <b>E</b> | $O_8$    | $O_7$    | GND               | GND      | $I_7$    | $I_8$    |
| <b>F</b> | $O_{10}$ | $O_9$    | GND               | GND      | $I_9$    | $I_{10}$ |
| <b>G</b> | $O_{12}$ | $O_{11}$ | $V_{CC}$          | $V_{CC}$ | $I_{11}$ | $I_{12}$ |
| <b>H</b> | $O_{14}$ | $O_{13}$ | NC                | NC       | $I_{13}$ | $I_{14}$ |
| <b>J</b> | $O_{15}$ | NC       | $\overline{OE}_2$ | $CP_2$   | NC       | $I_{15}$ |

### Truth Tables

| Inputs |                   |           | Outputs   |
|--------|-------------------|-----------|-----------|
| $CP_1$ | $\overline{OE}_1$ | $I_0-I_7$ | $O_0-O_7$ |
| ↗      | L                 | H         | H         |
| ↗      | L                 | L         | L         |
| L      | L                 | X         | $O_0$     |
| X      | H                 | X         | Z         |

| Inputs |                   |              | Outputs      |
|--------|-------------------|--------------|--------------|
| $CP_2$ | $\overline{OE}_2$ | $I_8-I_{15}$ | $O_8-O_{15}$ |
| ↗      | L                 | H            | H            |
| ↗      | L                 | L            | L            |
| L      | L                 | X            | $O_0$        |
| X      | H                 | X            | Z            |

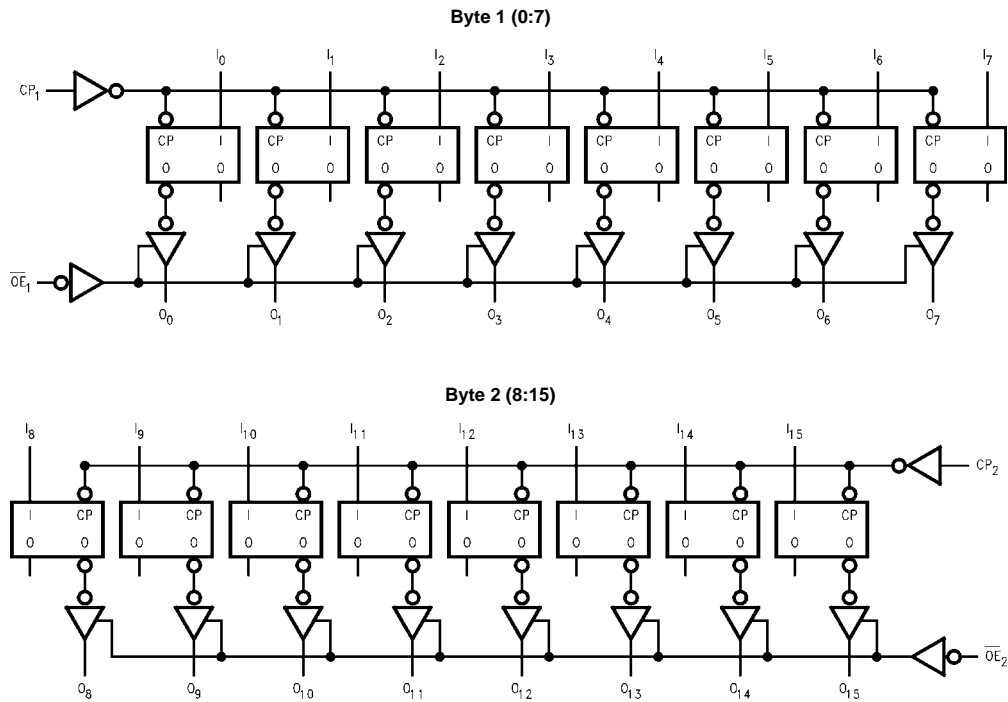
H = HIGH Voltage Level  
 L = LOW Voltage Level  
 X = Immaterial  
 Z = High Impedance  
 $O_0$  = Previous  $O_0$  before HIGH-to-LOW of CP

## Functional Description

The LCX162374 consists of sixteen edge-triggered flip-flops with individual D-type inputs and 3-STATE true outputs. The device is byte controlled with each byte functioning identically, but independent of the other. The control pins can be shorted together to obtain full 16-bit operation. Each byte has a buffered clock and buffered Output Enable. The description which follows applies to each byte. Each flip-flop will store

the state of their individual D inputs that meet the setup and hold time requirements on the LOW-to-HIGH Clock ( $CP_n$ ) transition. With the Output Enable ( $\overline{OE}_n$ ) LOW, the contents of the flip-flops are available at the outputs. When  $\overline{OE}_n$  is HIGH, the outputs go to the high impedance state. Operation of the  $\overline{OE}_n$  input does not affect the state of the flip-flops.

## Logic Diagrams



Please note that this diagram is provided only for the understanding of logic operations and should not be used to estimate propagation delays.

| Absolute Maximum Ratings (Note 4)   |  |  |  |                                 |      |       |
|---|--|--|--|---------------------------------|------|-------|
| 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 +7.0   |  | V                               |      |       |
| V <sub>O</sub>  | DC Output Voltage  | -0.5 to +7.0<br>-0.5 to V <sub>CC</sub> + 0.5                                    | 3-STATE<br>Output in HIGH or LOW State (Note 5)          | 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 6)   |  |  |  |                                 |      |       |
| 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  | 5.5  | V                               |      |       |
| V <sub>O</sub>  | Output Voltage   | HIGH or LOW State  | 0  | V <sub>CC</sub>                 | V    |       |
|   |  | 3-STATE  | 0  | 5.5                             |      |       |
| I <sub>OH</sub> /I <sub>OL</sub>  | Output Current   | V <sub>CC</sub> = 3.0V – 3.6V  |  | ±12                             | mA   |       |
|   |  | V <sub>CC</sub> = 2.7V – 3.0V  |  | ±8                              |      |       |
|   |  | V <sub>CC</sub> = 2.3V – 2.7V  |  | ±4                              |      |       |
| 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 4:</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 5:</b> I<sub>O</sub> Absolute Maximum Rating must be observed.</p> <p><b>Note 6:</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> = -4 mA  | 2.3  | 1.8                             |      |       |
|   |  | I <sub>OH</sub> = -4 mA  | 2.7  | 2.2                             |      |       |
|   |  | I <sub>OH</sub> = -6 mA  | 3.0  | 2.4                             |      |       |
|   |  | I <sub>OH</sub> = -8 mA  | 2.7  | 2.0                             |      |       |
|   |  | I <sub>OH</sub> = -12 mA   | 3.0  | 2.0                             |      |       |
| 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> = 4 mA   | 2.3  |                                 | 0.6  |       |
|   |  | I <sub>OL</sub> = 4 mA   | 2.7  |                                 | 0.4  |       |
|   |  | I <sub>OL</sub> = 6 mA   | 3.0  |                                 | 0.55 |       |
|   |  | I <sub>OL</sub> = 8 mA   | 2.7  |                                 | 0.6  |       |
|   |  | I <sub>OL</sub> = 12 mA  | 3.0  |                                 | 0.8  |       |
| I <sub>I</sub>  | Input Leakage Current  | 0 ≤ V <sub>I</sub> ≤ 5.5V  | 2.3 – 3.6  |                                 | ±5.0 | μA    |
| I <sub>OZ</sub>   | 3-STATE Output Leakage   | 0 ≤ V <sub>O</sub> ≤ 5.5V<br>V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.3 – 3.6  |                                 | ±5.0 | μA    |

| 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>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                            |     |       |
|  |   | 3.6V ≤ V <sub>I</sub> , V <sub>O</sub> ≤ 5.5V (Note 7)                      | 2.3 – 3.6              |                                 | ±20 |                               |     |       |
| 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                            |     |       |
| <b>Note 7:</b> Outputs disabled or 3-STATE only.   |   |   |                        |                                 |     |                               |     |       |
| AC Electrical Characteristics  |   |   |                        |                                 |     |                               |     |       |
| Symbol   | Parameter                                   | T <sub>A</sub> = -40° 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 |       |
| f <sub>MAX</sub>   | Maximum Clock Frequency                     | 170   |                        |                                 |     |                               |     | MHz   |
| t <sub>PHL</sub>   | Propagation Delay                           | 1.5   | 7.0                    | 1.5                             | 7.3 | 1.5                           | 8.4 | ns    |
| t <sub>PLH</sub>   | CP to O <sub>n</sub>                        | 1.5   | 7.0                    | 1.5                             | 7.3 | 1.5                           | 8.4 |       |
| t <sub>PZL</sub>   | Output Enable time                          | 1.5   | 6.9                    | 1.5                             | 7.1 | 1.5                           | 9.0 | ns    |
| t <sub>PZH</sub>   |   | 1.5   | 6.9                    | 1.5                             | 7.1 | 1.5                           | 9.0 |       |
| t <sub>PLZ</sub>   | Output Disable Time                         | 1.5   | 6.0                    | 1.5                             | 6.2 | 1.5                           | 7.2 | ns    |
| t <sub>PHZ</sub>   |   | 1.5   | 6.0                    | 1.5                             | 6.2 | 1.5                           | 7.2 |       |
| t <sub>S</sub>   | Setup Time                                  | 2.5   |                        | 2.5                             |     | 3.0                           |     | ns    |
| t <sub>H</sub>   | Hold Time                                   | 1.5   |                        | 1.5                             |     | 2.0                           |     | ns    |
| t <sub>W</sub>   | Pulse Width                                 | 3.0   |                        | 3.0                             |     | 3.5                           |     | ns    |
| t <sub>OSSL</sub>  | Output to Output Skew (Note 8)              |   | 1.0                    |                                 |     |                               |     | ns    |
| t <sub>OSLH</sub>  |   |   | 1.0                    |                                 |     |                               |     |       |
| <b>Note 8:</b> Skew is defined as the absolute value of the differences 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                    | 0.35                            |     | V                             |     |       |
|  |   | C <sub>L</sub> = 30 pF, V <sub>IH</sub> = 2.5V, V <sub>IL</sub> = 0V        | 2.5                    | 0.25                            |     |                               |     |       |
| 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                    | -0.35                           |     | V                             |     |       |
|  |   | C <sub>L</sub> = 30 pF, V <sub>IH</sub> = 2.5V, V <sub>IL</sub> = 0V        | 2.5                    | -0.25                           |     |                               |     |       |
| 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>OUT</sub>   | 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 $V_{CC} = 3.3 \pm 0.3V$ , and 2.7V<br>$V_{CC} \times 2$ 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**



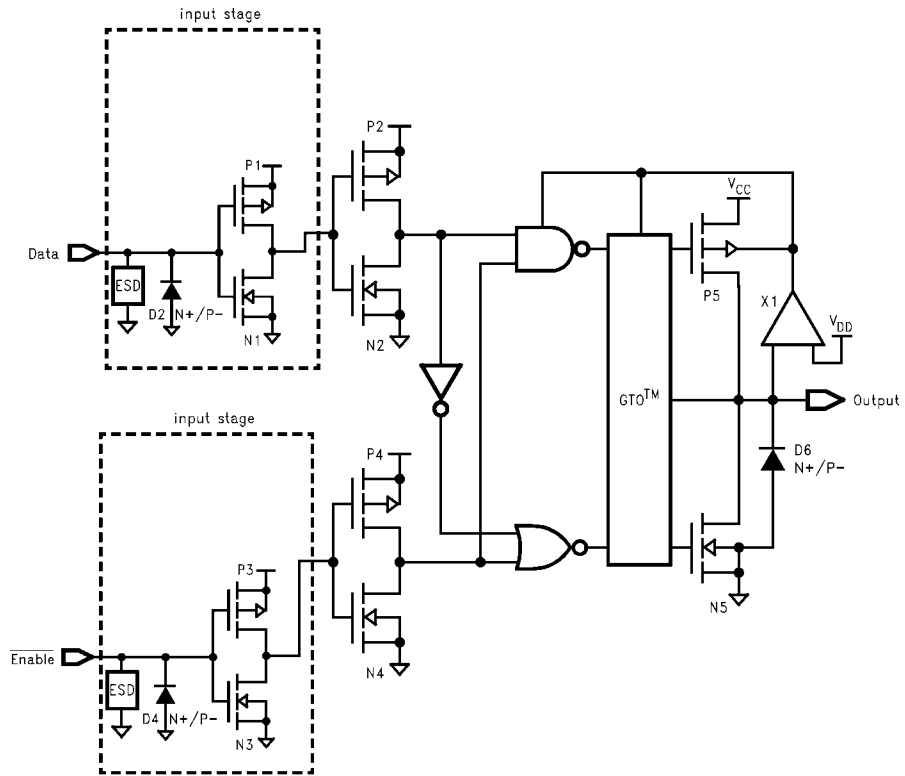
**3-STATE Output Low Enable and Disable Times for Logic**



**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            | $V_{CC}/2$       |
| $V_x$    | $V_{OL} + 0.3V$ | $V_{OL} + 0.3V$ | $V_{OL} + 0.15V$ |
| $V_y$    | $V_{OH} - 0.3V$ | $V_{OH} - 0.3V$ | $V_{OH} - 0.15V$ |

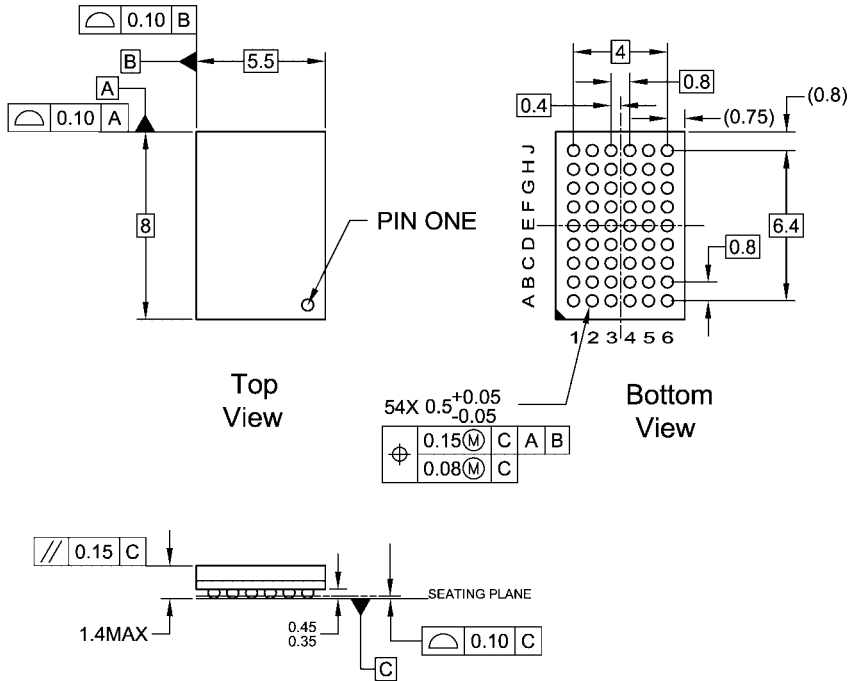
Schematic Diagram Generic for LCX Family



74LCX162374



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



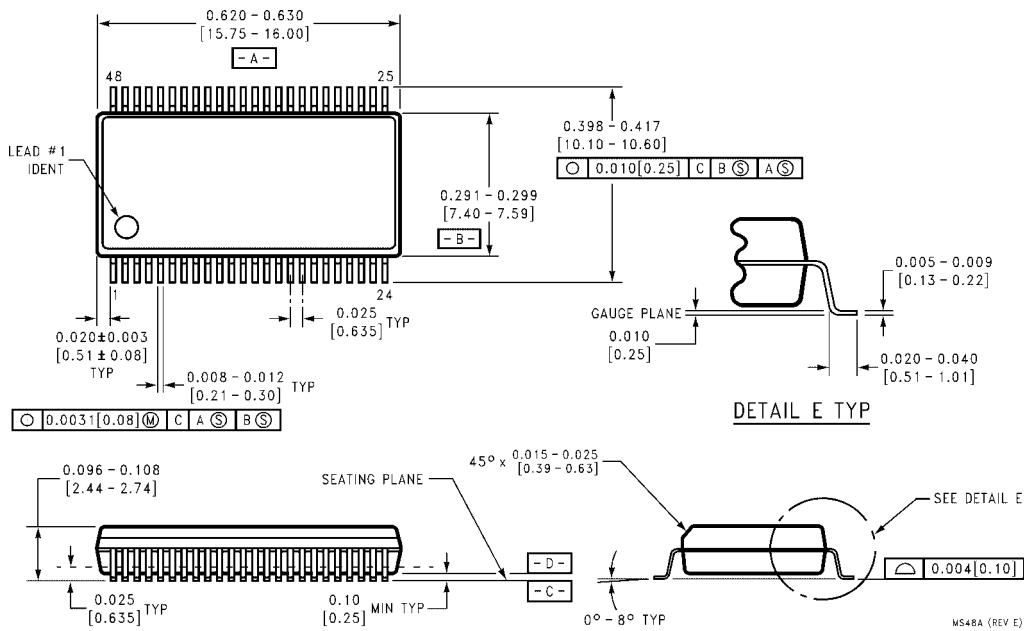
**NOTES:**

- 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  
Preliminary**

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



**48-Lead Small Shrink Outline Package (SSOP), JEDEC MO-118, 0.300" Wide  
Package Number MS48A**

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



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

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