

## 74LCX646

### Low Voltage Octal Transceiver/Register with 5V Tolerant Inputs and Outputs

#### General Description

The LCX646 consists of registered bus transceiver circuits, D-type flip-flops, and control circuitry providing multiplexed transmission of data directly from the input bus or from the internal storage registers. Data on the A or B bus will be loaded into the respective registers on the LOW-to-HIGH transition of the appropriate pin (CPAB or CPBA) (see Functional Description).

The LCX646 is designed for low voltage (2.5V or 3.3V)  $V_{CC}$  applications with capability of interfacing to a 5V signal environment.

The LCX646 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
- 7.0 ns  $t_{PD}$  max ( $V_{CC} = 3.3V$ ), 10  $\mu A$   $I_{CC}$  max
- Power down high impedance inputs and outputs
- Supports live insertion/withdrawal (Note 1)
- $\pm 24$  mA output drive ( $V_{CC} = 3.0V$ )
- Implements patented noise/EMI reduction circuitry
- Latch-up performance exceeds 500 mA
- ESD performance:
  - Human body model > 2000V
  - Machine model > 200V

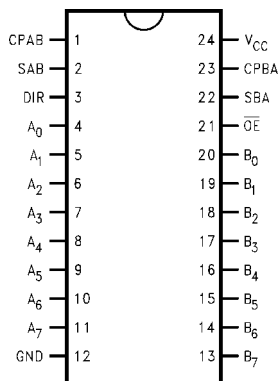
**Note 1:** To ensure the high-impedance state during power up or down,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pull-up resistor; the minimum value or the resistor is determined by the current-sourcing capability of the driver.

#### Ordering Code:

| Order Number | Package Number | Package Description   |
|--------------|----------------|---|
| 74LCX646WMM  | M24B           | 24-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300 Wide   |
| 74LCX646MSA  | MSA24          | 24-Lead Shrink Small Outline Package (SSOP), EIAJ TYPE II, 5.3mm Wide       |
| 74LCX646MTC  | MTC24          | 24-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 4.4mm Wide |

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

#### Connection Diagram

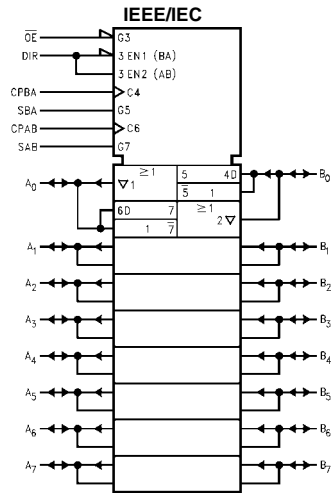
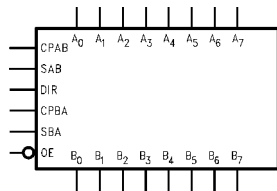


#### Pin Descriptions

| Pin Names       | Description             |
|-----------------|-------------------------|
| $A_0$ – $A_7$   | Data Register A Inputs  |
|                 | Data Register A Outputs |
| $B_0$ – $B_7$   | Data Register B Inputs  |
|                 | Data Register B Outputs |
| CPAB, CPBA      | Clock Pulse Inputs      |
| SAB, SBA        | Transmit/Receive Inputs |
| $\overline{OE}$ | Output Enable Input     |
| DIR             | Direction Control Input |

74LCX646 Low Voltage Octal Transceiver/Register with 5V Tolerant Inputs and Outputs

### Logic Symbols



### Truth Table

(Note 2)

| Inputs                 |     |        |        |     |     | Data I/O                       |                                | Function   |
|------------------------|-----|--------|--------|-----|-----|--------------------------------|--------------------------------|--|
| $\overline{\text{OE}}$ | DIR | CPAB   | CPBA   | SAB | SBA | A <sub>0</sub> -A <sub>7</sub> | B <sub>0</sub> -B <sub>7</sub> |  |
| H                      | X   | H or L | H or L | X   | X   |                                |                                | Isolation  |
| H                      | X   | ↗      | X      | X   | X   | Input                          | Input                          | Clock A <sub>n</sub> Data into A Register                              |
| H                      | X   | X      | ↗      | X   | X   |                                |                                | Clock B <sub>n</sub> Data into B Register                              |
| L                      | H   | X      | X      | L   | X   | Input                          | Output                         | A <sub>n</sub> to B <sub>n</sub> —Real Time (Transparent Mode)         |
| L                      | H   | ↗      | X      | L   | X   |                                |                                | Clock A <sub>n</sub> Data into A Register                              |
| L                      | H   | H or L | X      | H   | X   |                                |                                | A Register to B <sub>n</sub> (Stored Mode)                             |
| L                      | H   | ↗      | X      | H   | X   |                                |                                | Clock A <sub>n</sub> Data into A Register and Output to B <sub>n</sub> |
| L                      | L   | X      | X      | X   | L   | Output                         | Input                          | B <sub>n</sub> to A <sub>n</sub> —Real Time (Transparent Mode)         |
| L                      | L   | X      | ↗      | X   | L   |                                |                                | Clock B <sub>n</sub> Data into B Register                              |
| L                      | L   | X      | H or L | X   | H   |                                |                                | B Register to A <sub>n</sub> (Stored Mode)                             |
| L                      | L   | X      | ↗      | X   | H   |                                |                                | Clock B <sub>n</sub> Data into B Register and Output to A <sub>n</sub> |

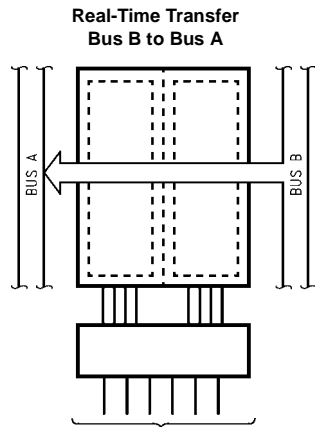
H = HIGH Voltage Level  
 L = LOW Voltage Level  
 X = Immaterial  
 ↗ = LOW-to-HIGH Transition

**Note 2:** The data output functions may be enabled or disabled by various signals at the  $\overline{\text{OE}}$  and DIR inputs. Data input functions are always enabled; i.e., data at the bus pins will be stored on every LOW-to-HIGH transition of the appropriate clock inputs.

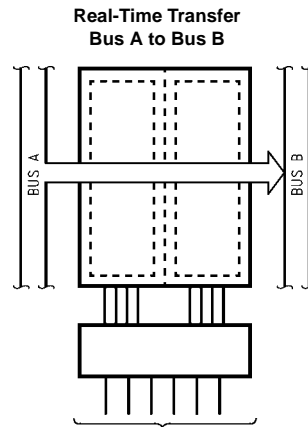
### Functional Description

In the transceiver mode, data present at the HIGH impedance port may be stored in either the A or B register or both. The select (SAB, SBA) controls can multiplex stored and real-time. The examples shown below demonstrate the four fundamental bus-management functions that can be performed.

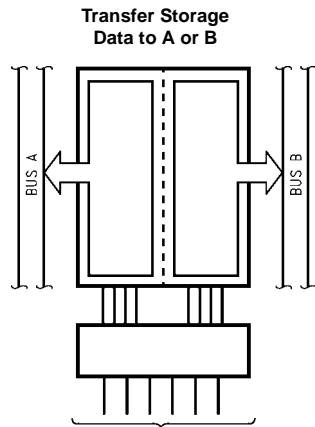
The direction control (DIR) determines which bus will receive data when  $\overline{OE}$  is LOW. In the isolation mode ( $\overline{OE}$  HIGH), A data may be stored in one register and/or B data may be stored in the other register. When an output function is disabled, the input function is still enabled and may be used to store and transmit data. Only one of the two busses, A or B, may be driven at a time.



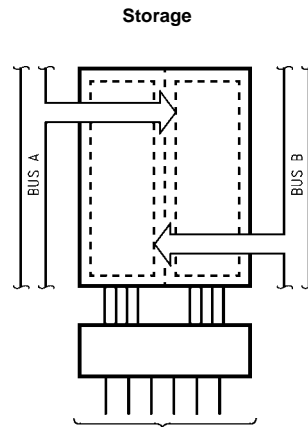
| $\overline{OE}$ | DIR | CPAB | CPBA | SAB | SBA |
|-----------------|-----|------|------|-----|-----|
| L               | L   | X    | X    | X   | L   |



| $\overline{OE}$ | DIR | CPAB | CPBA | SAB | SBA |
|-----------------|-----|------|------|-----|-----|
| L               | H   | X    | X    | L   | X   |



| $\overline{OE}$ | DIR | CPAB   | CPBA   | SAB | SBA |
|-----------------|-----|--------|--------|-----|-----|
| L               | L   | X      | H or L | X   | H   |
| L               | H   | H or L | X      | H   | X   |



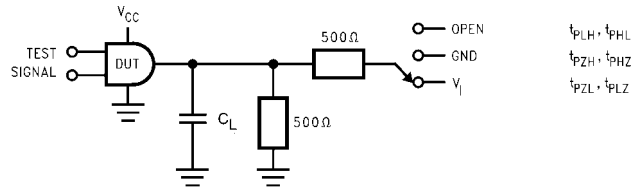
| $\overline{OE}$ | DIR | CPAB | CPBA | SAB | SBA |
|-----------------|-----|------|------|-----|-----|
| L               | H   | ↗    | X    | L   | X   |
| L               | L   | X    | ↗    | X   | L   |
| H               | X   | ↗    | X    | X   | X   |
| H               | X   | X    | ↗    | X   | X   |



| 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 +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                                    | 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  | 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  |   | ±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> Unused inputs or I/Os must be held HIGH or LOW. They may not float.</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  | 0 ≤ V <sub>I</sub> ≤ 5.5V  | 2.3 – 3.6   |                                 | ±5.0 | μA    |
| I <sub>OZ</sub>  | 3-STATE I/O 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    |
| I <sub>OFF</sub>   | Power-Off Leakage Current  | V <sub>I</sub> or V <sub>O</sub> = 5.5V  | 0   |                                 | 10   | μA    |

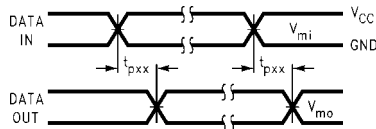
| DC Electrical Characteristics (Continued)   |   |   |                        |                                 |     |                               |      |       |
|---|---|---|------------------------|---------------------------------|-----|-------------------------------|------|-------|
| Symbol  | Parameter                                   | Conditions  | V <sub>CC</sub><br>(V) | T <sub>A</sub> = -40°C to +85°C |     | Units                         |      |       |
|   |   |   |                        | Min                             | Max |                               |      |       |
| I <sub>CC</sub>   | Quiescent Supply Current                    | V <sub>I</sub> = V <sub>CC</sub> or GND                                     | 2.3 – 3.6              |                                 | 10  | μA                            |      |       |
|   |   | 3.6V ≤ V <sub>I</sub> , V <sub>O</sub> ≤ 5.5V (Note 6)                      | 2.3 – 3.6              |                                 | ±10 |                               |      |       |
| 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 6:</b> Outputs disabled or 3-STATE only.  |   |   |                        |                                 |     |                               |      |       |
| 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>MAX</sub>  | Maximum Clock Frequency                     | 150   |                        |                                 |     |                               | MHz  |       |
| t <sub>PHL</sub>  | Propagation Delay                           | 1.5   | 7.0                    | 1.5                             | 8.0 | 1.5                           | 8.4  | ns    |
| t <sub>PLH</sub>  | Bus to Bus                                  | 1.5   | 7.0                    | 1.5                             | 8.0 | 1.5                           | 8.4  |       |
| t <sub>PHL</sub>  | Propagation Delay                           | 1.5   | 8.5                    | 1.5                             | 9.5 | 1.5                           | 10.5 | ns    |
| t <sub>PLH</sub>  | Clock to Bus                                | 1.5   | 8.5                    | 1.5                             | 9.5 | 1.5                           | 10.5 |       |
| t <sub>PHL</sub>  | Propagation Delay                           | 1.5   | 8.5                    | 1.5                             | 9.5 | 1.5                           | 10.5 | ns    |
| t <sub>PLH</sub>  | Select to Bus                               | 1.5   | 8.5                    | 1.5                             | 9.5 | 1.5                           | 10.5 |       |
| t <sub>PZL</sub>  | Output Enable Time                          | 1.5   | 8.5                    | 1.5                             | 9.5 | 1.5                           | 10.5 | ns    |
| t <sub>PZH</sub>  | Output Disable Time                         | 1.5   | 8.5                    | 1.5                             | 9.5 | 1.5                           | 10.5 |       |
| t <sub>PLZ</sub>  | Output Disable Time                         | 1.5   | 8.5                    | 1.5                             | 9.5 | 1.5                           | 10.5 | ns    |
| t <sub>PHZ</sub>  | Output Enable Time                          | 1.5   | 8.5                    | 1.5                             | 9.5 | 1.5                           | 10.5 |       |
| t <sub>S</sub>  | Setup Time                                  | 2.5   |                        | 2.5                             |     | 4.0                           |      | ns    |
| t <sub>H</sub>  | Hold Time                                   | 1.5   |                        | 1.5                             |     | 2.0                           |      | ns    |
| t <sub>W</sub>  | Pulse Width                                 | 3.3   |                        | 3.3                             |     | 4.0                           |      | ns    |
| t <sub>OSSL</sub>   | Output to Output Skew                       |   | 1.0                    |                                 |     |                               |      | ns    |
| t <sub>OSLH</sub>   | (Note 7)                                    |   | 1.0                    |                                 |     |                               |      |       |
| <b>Note 7:</b> 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> ). |   |   |                        |                                 |     |                               |      |       |
| 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 | 25                     | pF                              |     |                               |      |       |

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

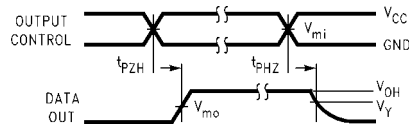


**FIGURE 1. AC Test Circuit** ( $C_L$  includes probe and jig capacitance)

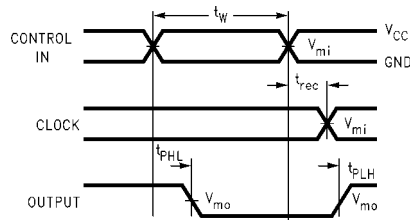
| Test               | Switch  |
|--------------------|---|
| $t_{PLH}, t_{PHL}$ | Open  |
| $t_{PZH}, t_{PHZ}$ | 6V at $V_{CC} = 3.3 \pm 0.3V$<br>$V_{CC} \times 2$ at $V_{CC} = 2.5 \pm 0.2V$ |
| $t_{PZL}, t_{PLZ}$ | GND   |



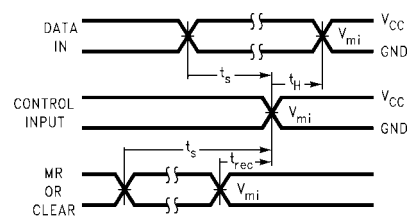
**Waveform for Inverting and Non-Inverting Functions**



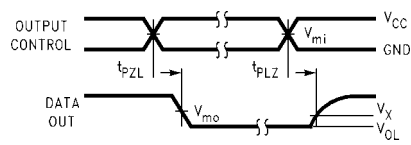
**3-STATE Output High Enable and Disable Times for Logic**



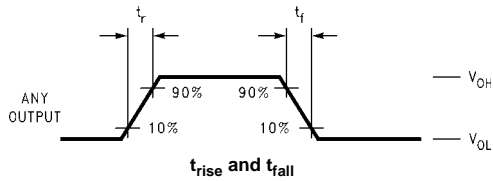
**Propagation Delay, Pulse Width and  $t_{rec}$  Waveforms**



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



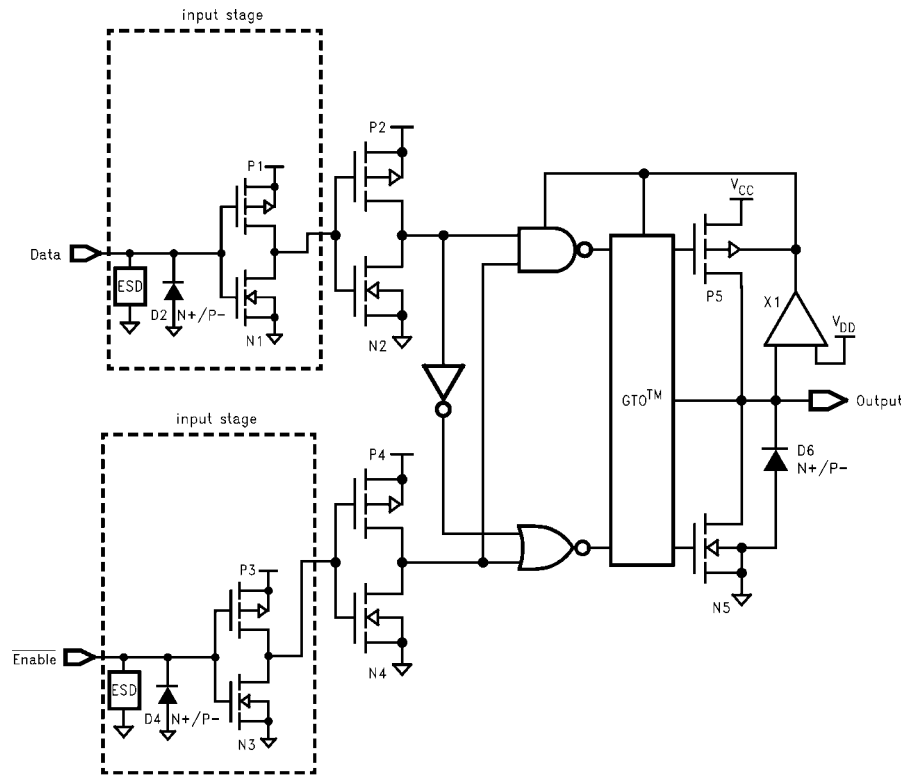
**3-STATE Output Low Enable and Disable Times for Logic**



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

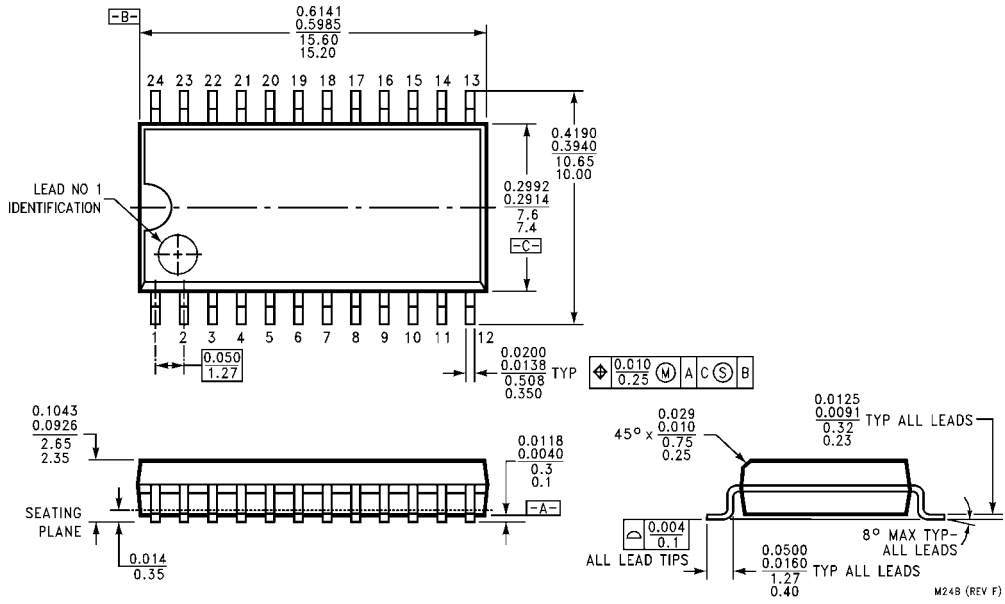
| Symbol   | $V_{CC}$        |                 |                  |
|----------|-----------------|-----------------|------------------|
|          | $3.3V \pm 0.3V$ | 2.7V            | $2.5V \pm 0.2V$  |
| $V_{mi}$ | 1.5V            | 1.5V            | $V_{CC}/2$       |
| $V_{mo}$ | 1.5V            | 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

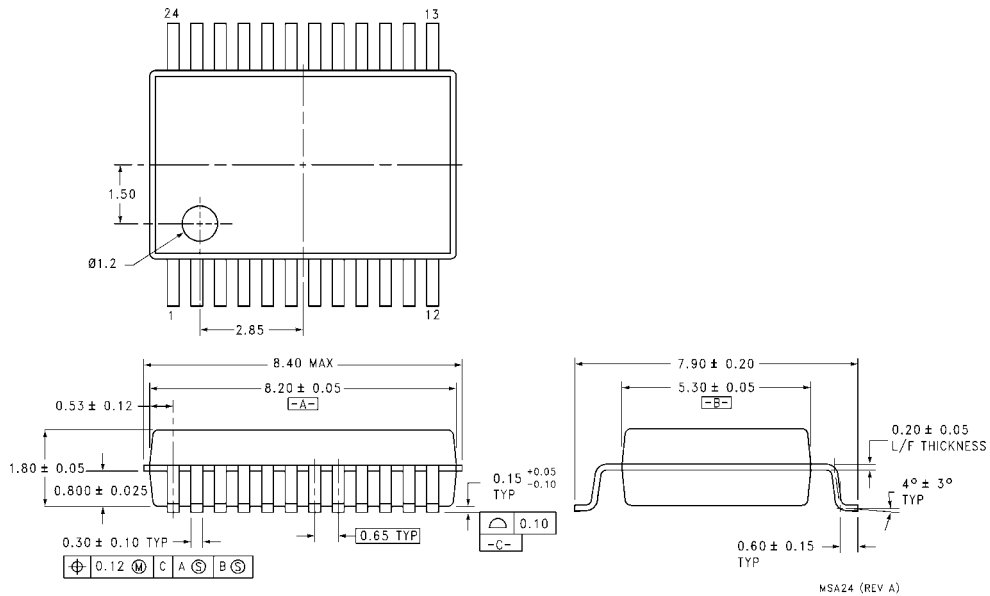




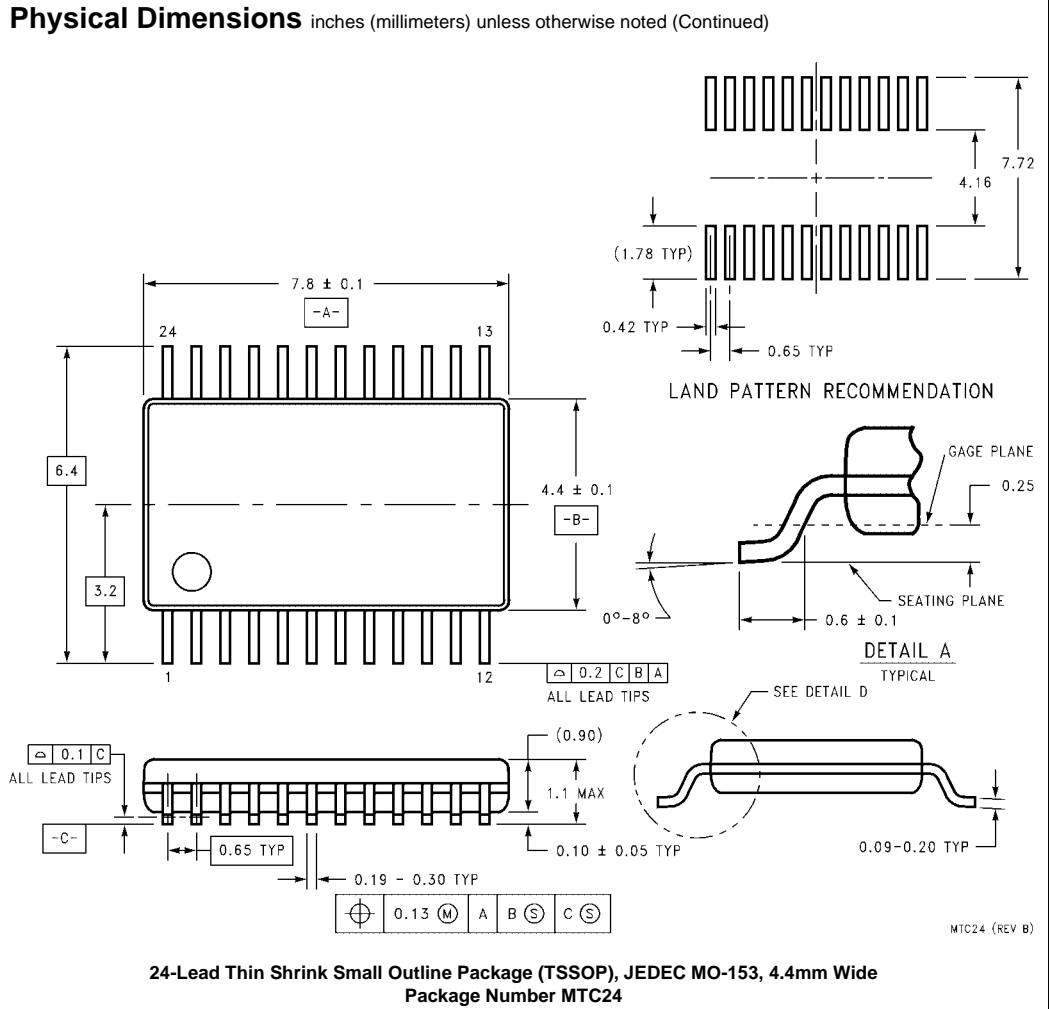
**Physical Dimensions** inches (millimeters) unless otherwise noted



**24-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300 Wide Package Number M24B**



**24-Lead Shrink Small Outline Package (SSOP), EIAJ TYPE II, 5.3mm Wide Package Number MSA24**



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