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## 74VCX16501 Low Voltage 18-Bit Universal Bus Transceivers with 3.6V Tolerant Inputs and Outputs

### General Description

The VCX16501 is an 18-bit universal bus transceiver which combines D-type latches and D-type flip-flops to allow data flow in transparent, latched, and clocked modes.

Data flow in each direction is controlled by output-enable (OEAB and OEBA), latch-enable (LEAB and LEBA), and clock (CLKAB and CLKBA) inputs. For A-to-B data flow, the device operates in the transparent mode when LEAB is HIGH. When LEAB is LOW, the A data is latched if CLKAB is held at a HIGH or LOW logic level. If LEAB is LOW, the A bus data is stored in the latch/flip-flop on the LOW-to-HIGH transition of CLKAB. When OEAB is HIGH, the outputs are active. When OEAB is LOW, the outputs are in a high-impedance state.

Data flow for B to A is similar to that of A to B but uses OEBA, LEBA, and CLKBA. The output enables are complementary (OEAB is active HIGH and OEBA is active LOW).

The VCX16501 is designed for low voltage (1.65V to 3.6V)  $V_{CC}$  applications with I/O capability up to 3.6V.

The VCX16501 is fabricated with an advanced CMOS technology to achieve high speed operation while maintaining low CMOS power dissipation.

### Features

- 1.65V–3.6V  $V_{CC}$  supply operation
- 3.6V tolerant inputs and outputs
- $t_{PD}$  (A to B, B to A)
  - 2.9 ns max for 3.0V to 3.6V  $V_{CC}$
  - 3.5 ns max for 2.3V to 2.7V  $V_{CC}$
  - 7.0 ns max for 1.65V to 1.95V  $V_{CC}$
- Power-down high impedance inputs and outputs
- Supports live insertion/withdrawal (Note 1)
- Static Drive ( $I_{OH}/I_{OL}$ )
  - $\pm 24$  mA @ 3.0V  $V_{CC}$
  - $\pm 18$  mA @ 2.3V  $V_{CC}$
  - $\pm 6$  mA @ 1.65V  $V_{CC}$
- Uses patented noise/EMI reduction circuitry
- Latchup performance exceeds 300 mA
- ESD performance:
  - Human body model > 2000V
  - Machine model > 200V

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

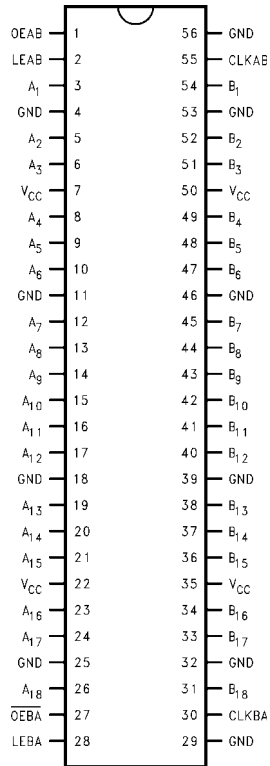
### Ordering Code:

| Order Number  | Package Number | Package Description   |
|---------------|----------------|---|
| 74VCX16501MTD | MTD56          | 56-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 6.1mm Wide |

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

74VCX16501 Low Voltage 18-Bit Universal Bus Transceivers with 3.6V Tolerant Inputs and Outputs

## Connection Diagram



## Pin Descriptions

| Pin Names                       | Description  |
|---------------------------------|--|
| OEAB                            | Output Enable Input for A to B Direction (Active HIGH) |
| $\overline{\text{OEBA}}$        | Output Enable Input for B to A Direction (Active LOW)  |
| LEAB, LEBA                      | Latch Enable Inputs                                    |
| CLKAB, CLKBA                    | Clock Inputs   |
| A <sub>1</sub> -A <sub>18</sub> | Side A Inputs or 3-STATE Outputs                       |
| B <sub>1</sub> -B <sub>18</sub> | Side B Inputs or 3-STATE Outputs                       |

## Function Table (Note 2)

| Inputs |      |       |                | Outputs                 |
|--------|------|-------|----------------|-------------------------|
| OEAB   | LEAB | CLKAB | A <sub>n</sub> | B <sub>n</sub>          |
| L      | X    | X     | X              | Z                       |
| H      | H    | X     | L              | L                       |
| H      | H    | X     | H              | H                       |
| H      | L    | ↑     | L              | L                       |
| H      | L    | ↑     | H              | H                       |
| H      | L    | H     | X              | B <sub>0</sub> (Note 3) |
| H      | L    | L     | X              | B <sub>0</sub> (Note 4) |

H = HIGH Voltage Level

L = LOW Voltage Level

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

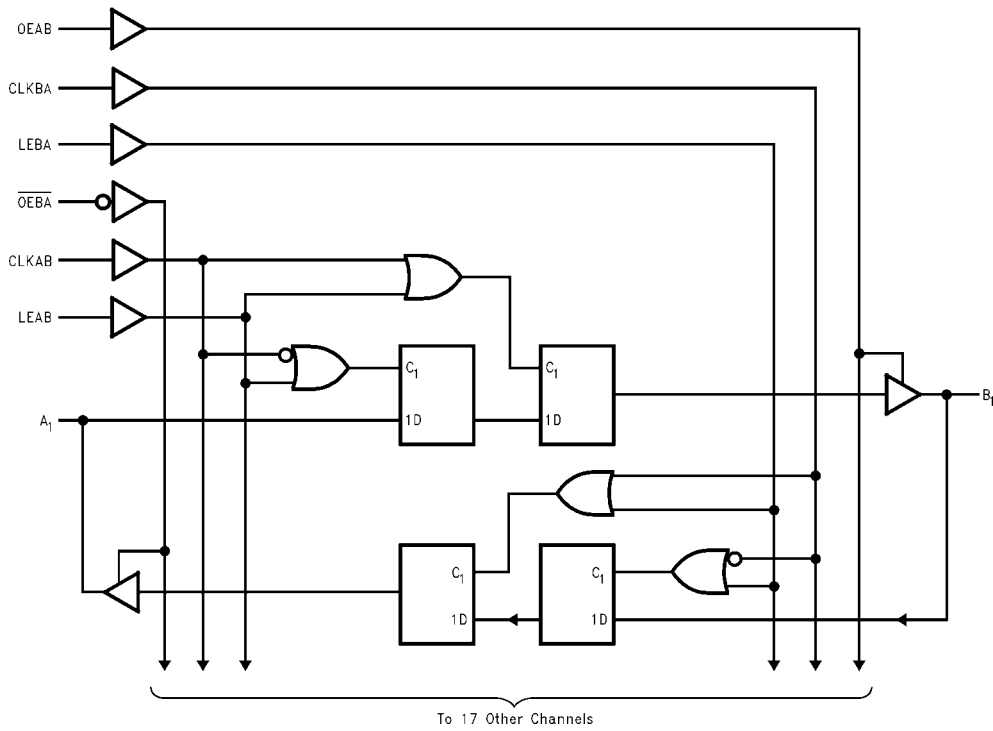
Z = High Impedance

**Note 2:** A-to-B data flow is shown; B-to-A flow is similar but uses  $\overline{\text{OEBA}}$ , LEBA and CLKBA.  $\overline{\text{OEBA}}$  is active LOW.

**Note 3:** Output level before the indicated steady-state input conditions were established.

**Note 4:** Output level before the indicated steady-state input conditions were established, provided that CLKAB was HIGH before LEAB went LOW.

### Logic Diagram



**Absolute Maximum Ratings** (Note 5)

|  |                         |
|--|-------------------------|
| 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-States                               | -0.5V to +4.6V          |
| Outputs Active (Note 6)                        | -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                  |                         |
| ( $I_{OH}/I_{OL}$ )                            | $\pm 50$ mA             |
| DC $V_{CC}$ or Ground Current per              |                         |
| Supply Pin ( $I_{CC}$ or Ground)               | $\pm 100$ mA            |
| Storage Temperature Range ( $T_{STG}$ )        | -65°C to +150°C         |

**Recommended Operating Conditions** (Note 7)

|   |                |
|---|----------------|
| Power Supply                                    |                |
| Operating                                       | 1.65V to 3.6V  |
| Data Retention Only                             | 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 $3.6V$                       | $\pm 24$ mA    |
| $V_{CC} = 2.3V$ to $2.7V$                       | $\pm 18$ mA    |
| $V_{CC} = 1.65V$ to $2.3V$                      | $\pm 6$ mA     |
| 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 5:** 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 tables will define the conditions for actual device operation.

**Note 6:**  $I_O$  Absolute Maximum Rating must be observed.

**Note 7:** Floating or unused pin (inputs or I/O's) must be held HIGH or LOW.

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

| Symbol          | Parameter                      | Conditions   | $V_{CC}$<br>(V)                | Min                                 | Max                       | Units   |
|-----------------|--------------------------------|--|--------------------------------|-------------------------------------|---------------------------|---------|
| $V_{IH}$        | HIGH Level Input Voltage       |  | 2.7 - 3.6                      | 2.0                                 |                           | V       |
| $V_{IL}$        | LOW Level Input Voltage        |  | 2.7 - 3.6                      |                                     | 0.8                       | 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       |
| $V_{OL}$        | 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       |
| $I_I$           | Input Leakage Current          | $0V \leq V_I \leq 3.6V$  | 2.7 - 3.6                      |                                     | $\pm 5.0$                 | $\mu A$ |
| $I_{OZ}$        | 3-STATE Output Leakage         | $0V \leq V_O \leq 3.6V$<br>$V_I = V_{IH}$ or $V_{IL}$  | 2.7 - 3.6                      |                                     | $\pm 10$                  | $\mu A$ |
| $I_{OFF}$       | Power Off Leakage Current      | $0V \leq (V_I, V_O) \leq 3.6V$   | 0                              |                                     | 10                        | $\mu A$ |
| $I_{CC}$        | Quiescent Supply Current       | $V_I = V_{CC}$ or GND<br>$V_{CC} \leq (V_I, V_O) \leq 3.6V$ (Note 8)   | 2.7 - 3.6<br>2.7 - 3.6         |                                     | 20<br>$\pm 20$            | $\mu A$ |
| $\Delta I_{CC}$ | Increase in $I_{CC}$ per Input | $V_{IH} = V_{CC} - 0.6V$   | 2.7 - 3.6                      |                                     | 750                       | $\mu A$ |

**Note 8:** Outputs disabled or 3-STATE only.

| DC Electrical Characteristics ( $2.3V \leq V_{CC} \leq 2.7V$ ) |                           |   |                                |                                     |                      |         |
|--|---------------------------|---|--------------------------------|-------------------------------------|----------------------|---------|
| Symbol   | Parameter                 | Conditions  | $V_{CC}$<br>(V)                | Min                                 | Max                  | Units   |
| $V_{IH}$   | HIGH Level Input Voltage  |   | 2.3 - 2.7                      | 1.6                                 |                      | V       |
| $V_{IL}$   | LOW Level Input Voltage   |   | 2.3 - 2.7                      |                                     | 0.7                  | V       |
| $V_{OH}$   | HIGH Level Output Voltage | $I_{OH} = -100 \mu A$<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 |                      | V       |
| $V_{OL}$   | LOW Level Output Voltage  | $I_{OL} = 100 \mu A$<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    | V       |
| $I_I$  | Input Leakage Current     | $0 \leq V_I \leq 3.6V$  | 2.3 - 2.7                      |                                     | $\pm 5.0$            | $\mu A$ |
| $I_{OZ}$   | 3-STATE Output Leakage    | $0 \leq V_O \leq 3.6V$<br>$V_I = V_{IH}$ or $V_{IL}$  | 2.3 - 2.7                      |                                     | $\pm 10$             | $\mu A$ |
| $I_{OFF}$  | Power Off Leakage Current | $0 \leq (V_I, V_O) \leq 3.6V$   | 0                              |                                     | 10                   | $\mu A$ |
| $I_{CC}$   | Quiescent Supply Current  | $V_I = V_{CC}$ or GND<br>$V_{CC} \leq (V_I, V_O) \leq 3.6V$ (Note 9)  | 2.3 - 2.7<br>2.3 - 2.7         |                                     | 20<br>$\pm 20$       | $\mu A$ |
| <b>Note 9:</b> Outputs disabled or 3-STATE only.               |                           |   |                                |                                     |                      |         |
| DC Electrical Characteristics ( $1.65V \leq V_{CC} < 2.3V$ )   |                           |   |                                |                                     |                      |         |
| Symbol   | Parameter                 | Conditions  | $V_{CC}$<br>(V)                | Min                                 | Max                  | Units   |
| $V_{IH}$   | HIGH Level Input Voltage  |   | 1.65 - 2.3                     | $0.65 \times V_{CC}$                |                      | V       |
| $V_{IL}$   | LOW Level Input Voltage   |   | 1.65 - 2.3                     |                                     | $0.35 \times V_{CC}$ | V       |
| $V_{OH}$   | HIGH Level Output Voltage | $I_{OH} = -100 \mu A$<br>$I_{OH} = -6 \text{ mA}$   | 1.65 - 2.3<br>1.65             | $V_{CC} - 0.2$<br>1.25              |                      | V       |
| $V_{OL}$   | LOW Level Output Voltage  | $I_{OL} = 100 \mu A$<br>$I_{OL} = 6 \text{ mA}$   | 1.65 - 2.3<br>1.65             |                                     | 0.2<br>0.3           | V       |
| $I_I$  | Input Leakage Current     | $0 \leq V_I \leq 3.6V$  | 1.65 - 2.3                     |                                     | $\pm 5.0$            | $\mu A$ |
| $I_{OZ}$   | 3-STATE Output Leakage    | $0 \leq V_O \leq 3.6V$<br>$V_I = V_{IH}$ or $V_{IL}$  | 1.65 - 2.3                     |                                     | $\pm 10$             | $\mu A$ |
| $I_{OFF}$  | Power Off Leakage Current | $0 \leq (V_I, V_O) \leq 3.6V$   | 0                              |                                     | 10                   | $\mu A$ |
| $I_{CC}$   | Quiescent Supply Current  | $V_I = V_{CC}$ or GND<br>$V_{CC} \leq (V_I, V_O) \leq 3.6V$ (Note 10)                                       | 1.65 - 2.3<br>1.65 - 2.3       |                                     | 20<br>$\pm 20$       | $\mu A$ |
| <b>Note 10:</b> Outputs disabled or 3-STATE only.              |                           |   |                                |                                     |                      |         |

| AC Electrical Characteristics (Note 11) |                                    |  |     |                         |     |                          |      |       |
|---|------------------------------------|--|-----|-------------------------|-----|--------------------------|------|-------|
| Symbol                                  | Parameter                          | $T_A = -40^\circ\text{C to } +85^\circ\text{C}, C_L = 30\text{ pF}, R_L = 500\Omega$ |     |                         |     |                          |      | Units |
|   |                                    | $V_{CC} = 3.3V \pm 0.3V$   |     | $V_{CC} = 2.5 \pm 0.2V$ |     | $V_{CC} = 1.8 \pm 0.15V$ |      |       |
|   |                                    | Min  | Max | Min                     | Max | Min                      | Max  |       |
| $f_{MAX}$                               | Maximum Clock Frequency            | 250  |     | 200                     |     | 100                      |      | MHz   |
| $t_{PHL}$<br>$t_{PLH}$                  | Propagation Delay<br>Bus to Bus    | 0.6  | 2.9 | 0.8                     | 3.5 | 1.5                      | 7.0  | ns    |
| $t_{PHL}$<br>$t_{PLH}$                  | Propagation Delay<br>Clock to Bus  | 0.6  | 3.5 | 0.8                     | 4.4 | 1.5                      | 8.8  | ns    |
| $t_{PHL}$<br>$t_{PLH}$                  | Propagation Delay<br>LE to Bus     | 0.6  | 3.8 | 0.8                     | 4.9 | 1.5                      | 9.8  | ns    |
| $t_{PZL}$<br>$t_{PZH}$                  | Output Enable Time                 | 0.6  | 3.8 | 0.8                     | 4.9 | 1.5                      | 9.8  | ns    |
| $t_{PLZ}$<br>$t_{PHZ}$                  | Output Disable Time                | 0.8  | 3.7 | 0.8                     | 4.2 | 0.8                      | 7.6  | ns    |
| $t_S$                                   | Setup Time                         | 1.5  |     | 1.5                     |     | 2.5                      |      | ns    |
| $t_H$                                   | Hold Time                          | 1.0  |     | 1.0                     |     | 1.0                      |      | ns    |
| $t_W$                                   | Pulse Width                        | 1.5  |     | 1.5                     |     | 4.0                      |      | ns    |
| $t_{OSHL}$<br>$t_{OSLH}$                | Output to Output<br>Skew (Note 12) |  | 0.5 |                         | 0.5 |                          | 0.75 | ns    |

**Note 11:** For  $C_L = 50\text{pF}$ , add approximately 300ps to the AC maximum specification.

**Note 12:** 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 ( $t_{OSHL}$ ) or LOW-to-HIGH ( $t_{OSLH}$ ).

### Dynamic Switching Characteristics

| Symbol    | Parameter                               | Conditions   | $V_{CC}$<br>(V)   | $T_A = +25^\circ\text{C}$ | Units |
|-----------|---|--|-------------------|---------------------------|-------|
|           |   |  |                   | Typical                   |       |
| $V_{OLP}$ | Quiet Output Dynamic<br>Peak $V_{OL}$   | $C_L = 30\text{ pF}, V_{IH} = V_{CC}, V_{IL} = 0V$ | 1.8<br>2.5<br>3.3 | 0.25<br>0.6<br>0.8        | V     |
| $V_{OLV}$ | Quiet Output Dynamic<br>Valley $V_{OL}$ | $C_L = 30\text{ pF}, V_{IH} = V_{CC}, V_{IL} = 0V$ | 1.8<br>2.5<br>3.3 | -0.25<br>-0.6<br>-0.8     | V     |
| $V_{OHV}$ | Quiet Output Dynamic<br>Valley $V_{OH}$ | $C_L = 30\text{ pF}, V_{IH} = V_{CC}, V_{IL} = 0V$ | 1.8<br>2.5<br>3.3 | 1.5<br>1.9<br>2.2         | V     |

### Capacitance

| Symbol    | Parameter                     | Conditions  | $T_A = +25^\circ\text{C}$ | Units |
|-----------|-------------------------------|---|---------------------------|-------|
| $C_{IN}$  | Input Capacitance             | $V_I = 0V$ or $V_{CC}$<br>$V_{CC} = 1.8V, 2.5V, \text{ or } 3.3V,$                  | 6                         | pF    |
| $C_{I/O}$ | Output Capacitance            | $V_I = 0V$ , or $V_{CC}, V_{CC} = 1.8V, 2.5V \text{ or } 3.3V$                      | 7                         | pF    |
| $C_{PD}$  | Power Dissipation Capacitance | $V_I = 0V$ or $V_{CC}, f = 10\text{ MHz}$<br>$V_{CC} = 1.8V, 2.5V \text{ or } 3.3V$ | 20                        | pF    |

## AC Loading and Waveforms

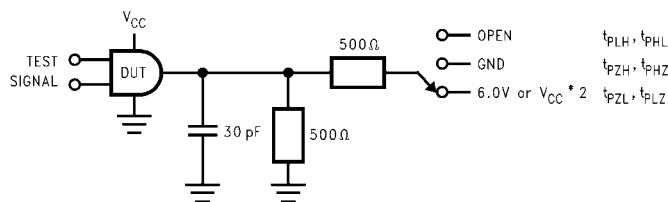


FIGURE 1. AC Test Circuit

| 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 $V_{CC} = 2.5 \pm 0.2V; 1.8 \pm 0.15V$ |
| $t_{PZH}, t_{PHZ}$ | GND  |

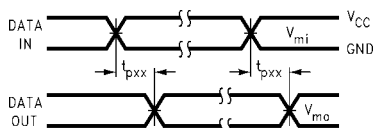


FIGURE 2. Waveform for Inverting and Non-inverting Functions

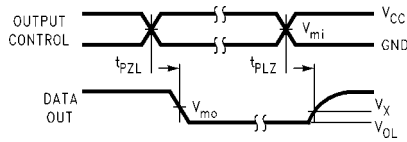


FIGURE 4. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic

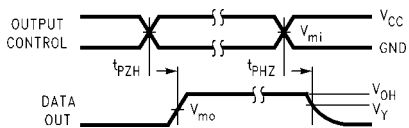


FIGURE 3. 3-STATE Output High Enable and Disable Times for Low Voltage Logic

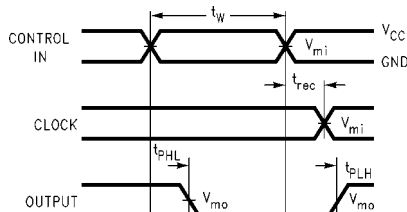


FIGURE 5. Propagation Delay, Pulse Width and  $t_{rec}$  Waveforms

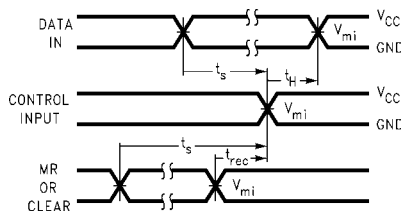
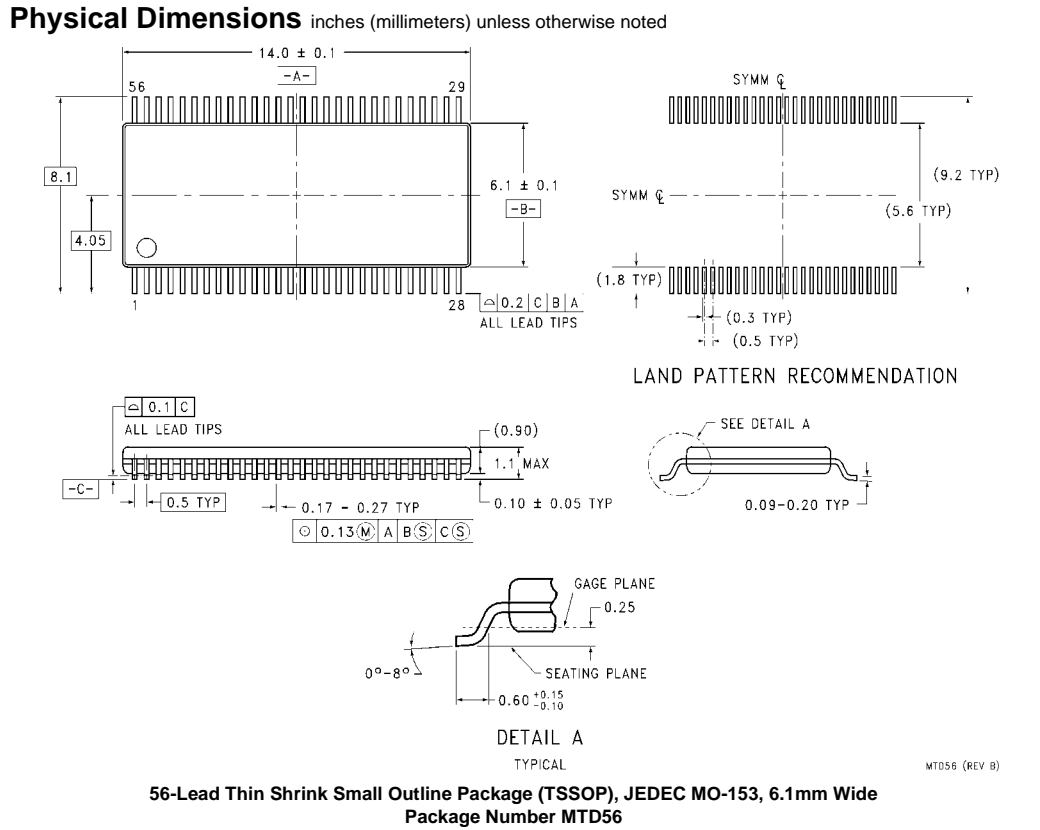


FIGURE 6. Setup Time, Hold Time and Recovery Time for Low Voltage Logic

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



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