March 1998
Revised October 2004

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 $\overline{\text{OEBA}}$), 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 $\overline{\text{OEBA}}$, LEBA, and CLKBA. The output enables are complementary (OEAB is active HIGH and $\overline{\text{OEBA}}$ is active LOW).

The VCX16501 is designed for low voltage (1.4V 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

- 1.4V to 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}
- Power-down high impedance inputs and outputs
- Supports live insertion/withdrawal (Note 1)
- Static Drive (I_{OH}/I_{OL})
  ±24 mA @ 3.0V V_{CC}
- Uses patented noise/EMI reduction circuitry
- Latchup performance exceeds 300 mA
- ESD performance:
  Human body model > 2000V
  Machine model >200V

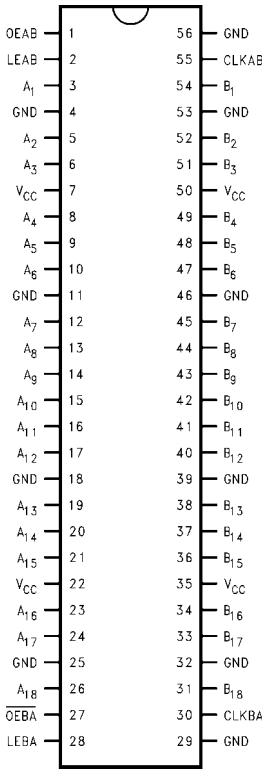
Note 1: To ensure the high-impedance state during power up or power down, $\overline{\text{OEBA}}$ should be tied to V_{CC} through a pull-up resistor and OEAB should be tied to GND through a pull-down resistor; the minimum value of the resistors is determined by the current-sourcing capability of the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

Connection Diagram



Pin Descriptions

Pin Names	Description
OEAB	Output Enable Input for A to B Direction (Active HIGH)
$\overline{OEBA}$	Output Enable Input for B to A Direction (Active LOW)
LEAB, LEBA	Latch Enable Inputs
CLKAB, CLKBA	Clock Inputs
A_1–A_{18}	Side A Inputs or 3-STATE Outputs
B_1–B_{18}	Side B Inputs or 3-STATE Outputs

Function Table (Note 2)

Inputs				Outputs
OEAB	**LEAB**	**CLKAB**	**A_n**	**B_n**
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_0 (Note 3)
H	L	L	X	B_0 (Note 4)

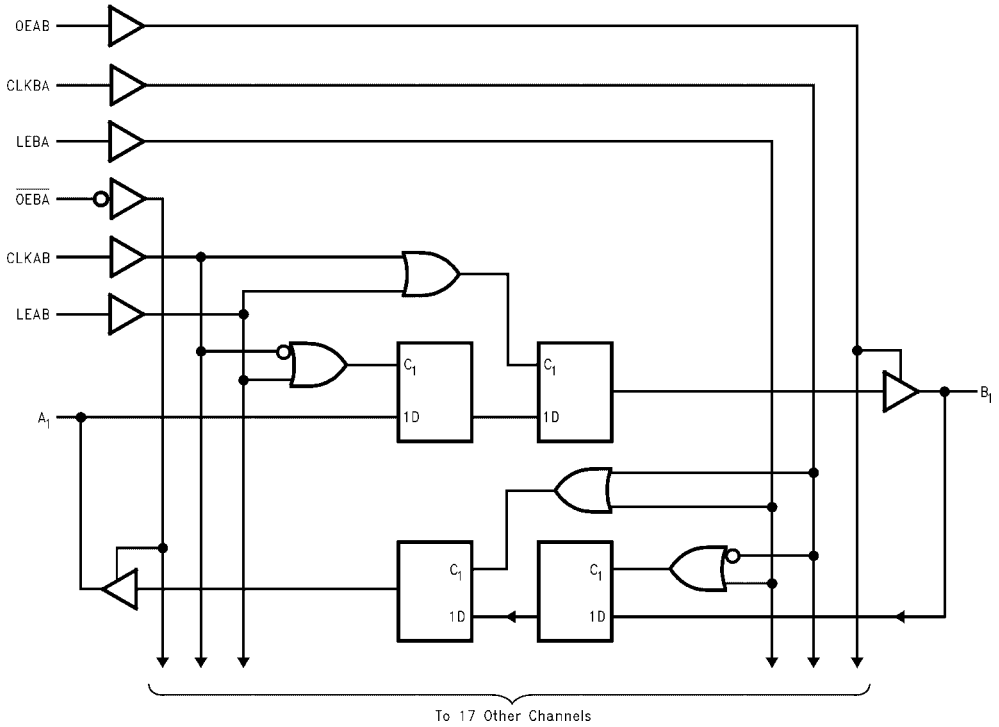
H = HIGH Voltage Level
L = LOW Voltage Level
X = Immaterial (HIGH or LOW, inputs may not float)
Z = High Impedance

Note 2: A-to-B data flow is shown; B-to-A flow is similar but uses $\overline{OEBA}$, LEBA and CLKBA. $\overline{OEBA}$ 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-STATED	−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})	±50 mA
DC V_{CC} or Ground Current per	
Supply Pin (I_{CC} or Ground)	±100 mA
Storage Temperature Range (T_{STG})	−65°C to +150°C

Recommended Operating Conditions (Note 7)

Power Supply	
Operating	1.4V to 3.6V
Input Voltage	−0.3V to 3.6V
Output Voltage (V_O)	
Output in Active States	0V to V_{CC}
Output in 3-STATE	0.0V to 3.6V
Output Current in I_{OH}/I_{OL}	
V_{CC} = 3.0V to 3.6V	±24 mA
V_{CC} = 2.3V to 2.7V	±18 mA
V_{CC} = 1.65V to 2.3V	±6 mA
V_{CC} = 1.4V to 1.6V	±2 mA
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

Symbol	Parameter	Conditions	V_{CC} (V)	Min	Max	Units
V_{IH}	HIGH Level Input Voltage		2.7 - 3.6	2.0		V
			2.3 - 2.7	1.6		
			1.65 - 2.3	0.65 x V_{CC}		
			1.4 - 1.6	0.65 x V_{CC}		
V_{IL}	LOW Level Input Voltage		2.7 - 3.6		0.8	V
			2.3 - 2.7		0.7	
			1.65 - 2.3		0.35 x V_{CC}	
			1.4 - 1.6		0.35 x V_{CC}	
V_{OH}	HIGH Level Output Voltage	I_{OH} = −100 µA	2.7 - 3.6	V_{CC} − 0.2		V
		I_{OH} = −12 mA	2.7	2.2		
		I_{OH} = −18 mA	3.0	2.4		
		I_{OH} = −24 mA	3.0	2.2		
		I_{OH} = −100 µA	2.3 - 2.7	V_{CC} - 0.2		
		I_{OH} = −6 mA	2.3	2.0		
		I_{OH} = −12 mA	2.3	1.8		
		I_{OH} = −18 mA	2.3	1.7		
		I_{OH} = −100 µA	1.65 - 2.3	V_{CC} - 0.2		
		I_{OH} = −6 mA	1.65	1.25		
		I_{OH} = −100 µA	1.4 - 1.6	V_{CC} - 0.2		
		I_{OH} = −12 mA	1.4	1.05		

DC Electrical Characteristics (Continued)

Symbol	Parameter	Conditions	V_{CC} (V)	Min	Max	Units
V_{OL}	LOW Level Output Voltage	I_{OL} = 100 μA	2.7 - 3.6		0.2	
		I_{OL} = 12 mA	2.7		0.4	
		I_{OL} = 18 mA	3.0		0.4	
		I_{OL} = 24 mA	3.0		0.55	
		I_{OL} = 100 μA	2.3 - 2.7		0.2	
		I_{OL} = 12 mA	2.3		0.4	V
		I_{OL} = 18 mA	2.3		0.6	
		I_{OL} = 100 μA	1.65 - 2.3		0.2	
		I_{OL} = 6 mA	1.65		0.3	
		I_{OL} = 100 μA	1.4 - 1.6		0.2	
		I_{OL} = 2 mA	1.4		0.35	
I_I	Input Leakage Current	0V ≤ V_I ≤ 3.6V	1.4 - 3.6		±5.0	μA
I_{OZ}	3-STATE Output Leakage	0V ≤ V_O ≤ 3.6V V_I = V_{IH} or V_{IL}	1.4 - 3.6		±10.0	μA
I_{OFF}	Power Off Leakage Current	0V ≤ (V_I, V_O) ≤ 3.6V	0		10.0	μA
I_{CC}	Quiescent Supply Current	V_I = V_{CC} or GND	1.4 - 3.6		20.0	μA
		V_{CC} ≤ (V_I, V_O) ≤ 3.6V (Note 8)	1.4 - 3.6		±20.0	
ΔI_{CC}	Increase in I_{CC} per Input	V_{IH} = V_{CC} − 0.6V	2.7 - 3.6		750	μA

Note 8: Outputs disabled or 3-STATE only.

AC Electrical Characteristics (Note 9)

Symbol	Parameter	Conditions	V_{CC} (V)	$T_A = -40°C$ to $+85°C$		Units	Figure Number
				Min	Max		
f_{MAX}	Maximum Clock Frequency	C_L = 30 pF	3.3 ± 0.3	250		MHz	
			2.5 ± 0.2	200			
			1.8 ± 0.15	100			
		C_L = 15 pF	1.5 ± 0.1	80.0			
t_{PHL} t_{PLH}	Propagation Delay	C_L = 30 pF, R_L = 500Ω	3.3 ± 0.3	0.6	2.9	ns	Figures 1, 2
			2.5 ± 0.2	0.8	3.5		
			1.8 ± 0.15	1.5	7.0		
		C_L = 15 pF, R_L = 2kΩ	1.5 ± 0.1	1.0	14.0		Figures 7, 8
t_{PHL} t_{PLH}	Propagation Delay Clock-to-Bus	C_L = 15 pF, R_L = 500Ω	3.3 ± 0.3	0.6	3.5	ns	Figures 1, 2
			2.5 ± 0.2	0.8	4.4		
			1.8 ± 0.15	1.5	8.8		
		C_L = 15 pF, R_L = 500Ω	1.5 ± 0.1	1.0	17.6		Figures 7, 8
t_{PHL} t_{PLH}	Propagation Delay LE-to-Bus	C_L = 30 pF, R_L = 500Ω	3.3 ± 0.3	0.6	3.8	ns	Figures 1, 2
			2.5 ± 0.2	0.8	4.9		
			1.8 ± 0.15	1.5	9.8		
		C_L = 15 pF, R_L = 500Ω	1.5 ± 0.1	1.0	19.6		Figures 7, 8
t_{PZL} t_{PZH}	Output Enable Time	C_L = 30 pF, R_L = 500Ω	3.3 ± 0.3	0.6	3.8	ns	Figures 1, 3, 4
			2.5 ± 0.2	0.8	4.9		
			1.8 ± 0.15	1.5	9.8		
		C_L = 15 pF, R_L = 2kΩ	1.5 ± 0.1	1.0	19.6		Figures 7, 9, 10
t_{PLZ} t_{PHZ}	Output Disable Time	C_L = 30 pF, R_L = 500Ω	3.3 ± 0.3	0.8	3.7	ns	Figures 1, 3, 4
			2.5 ± 0.2	0.8	4.2		
			1.8 ± 0.15	0.8	7.6		
		C_L = 15 pF, R_L = 2kΩ	1.5 ± 0.1	1.0	15.2		Figures 7, 9, 10
t_S	Setup Time	C_L = 30 pF, R_L = 500Ω	3.3 ± 0.3	1.5		ns	Figures 1, 6
			2.5 ± 0.2	1.5			
			1.8 ± 0.15	2.5			
		C_L = 15 pF, R_L = 500Ω	1.5 ± 0.1	3.0			Figures 6, 7
t_H	Hold Time	C_L = 30 pF, R_L = 500Ω	3.3 ± 0.3	1.0		ns	Figures 1, 6
			2.5 ± 0.2	1.0			
			1.8 ± 0.15	1.0			
		C_L = 15 pF, R_L = 500Ω	1.5 ± 0.1	2.0			Figures 6, 7
t_W	Pulse Width	C_L = 30 pF, R_L = 500Ω	3.3 ± 0.3	1.5		ns	Figures 1, 5
			2.5 ± 0.2	1.5			
			1.8 ± 0.15	4.0			
		C_L = 15 pF, R_L = 500Ω	1.5 ± 0.1	4.0			Figures 5, 7
t_{OSHL} t_{OSLH}	Output-to-Output Skew (Note 10)	C_L = 30 pF, R_L = 500Ω	3.3 ± 0.3		0.5	ns	
			2.5 ± 0.2		0.5		
			1.8 ± 0.15		0.75		
		C_L = 15 pF, R_L = 2kΩ	1.5 ± 0.1		1.5		

Note 9: For C_L = 50pF, add approximately 300ps to the AC maximum specification.

Note 10: 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}).

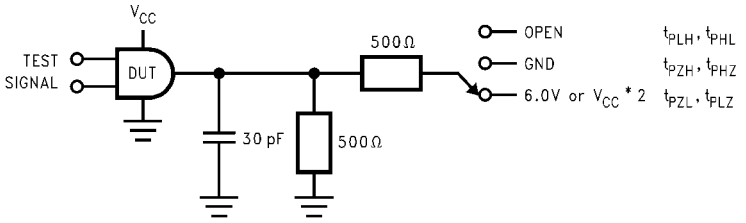
Dynamic Switching Characteristics

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

Capacitance

Symbol	Parameter	Conditions	$T_A = +25°C$	Units
C_{IN}	Input Capacitance	$V_{CC} = 1.8V$, 2.5V, or 3.3V, $V_I = 0V$ or V_{CC}	6.0	pF
$C_{I/O}$	Output Capacitance	$V_I = 0V$, or V_{CC}, $V_{CC} = 1.8V$, 2.5V or 3.3V	7.0	pF
C_{PD}	Power Dissipation Capacitance	$V_I = 0V$ or V_{CC}, f = 10 MHz, $V_{CC} = 1.8V$, 2.5V or 3.3V	20.0	pF

AC Loading and Waveforms (V_{CC} 3.3V ± 0.3V to 1.8V ± 0.15V)



TEST	SWITCH
t_{PLH}, t_{PHL}	Open
t_{PZL}, t_{PLZ}	6V at V_{CC} = 3.3V ± 0.3V; V_{CC} x 2 at V_{CC} = 2.5V ± 0.2V; 1.8V ± 0.15V
t_{PZH}, t_{PHZ}	GND

FIGURE 1. AC Test Circuit

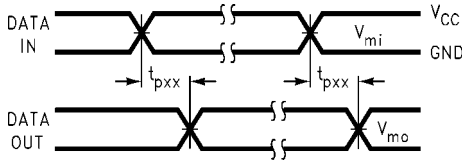


FIGURE 2. Waveform for Inverting and Non-inverting Functions

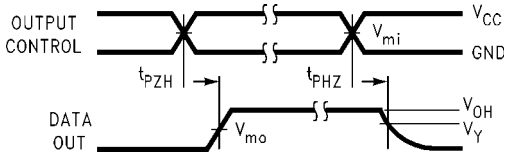


FIGURE 3. 3-STATE Output High Enable and Disable Times for Low Voltage Logic

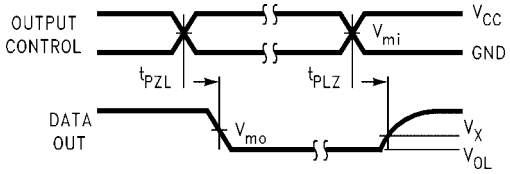


FIGURE 4. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic

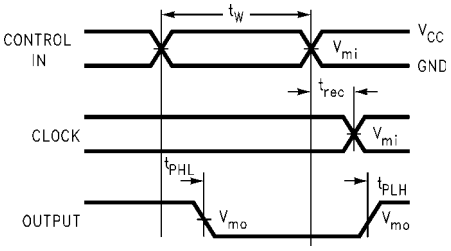


FIGURE 5. Propagation Delay, Pulse Width and t_{rec} Waveforms

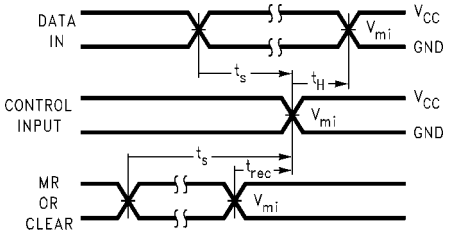
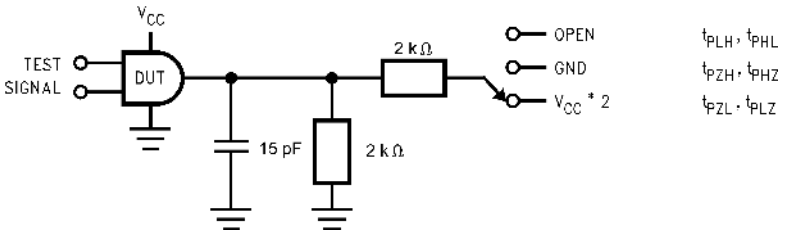


FIGURE 6. Setup Time, Hold Time and Recovery Time for Low Voltage Logic

Symbol	V_{CC}		
	3.3V ± 0.3V	2.5V ± 0.2V	1.8 ± 0.15V
V_{mi}	1.5V	V_{CC}/2	V_{CC}/2
V_{mo}	1.5V	V_{CC}/2	V_{CC}/2
V_X	V_{OL} + 0.3V	V_{OL} + 0.15V	V_{OL} + 0.15V
V_Y	V_{OH} − 0.3V	V_{OH} − 0.15V	V_{OH} − 0.15V

AC Loading and Waveforms (V_{CC} 1.5V ± 0.1V)



TEST	SWITCH
t_{PLH}, t_{PHL}	Open
t_{PZL}, t_{PLZ}	V_{CC} x 2 at V_{CC} = 1.5V ± 0.1V
t_{PZH}, t_{PHZ}	GND

FIGURE 7. AC Test Circuit

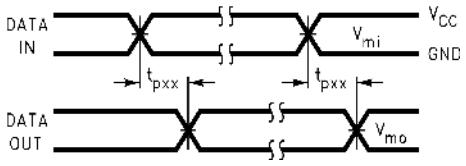


FIGURE 8. Waveform for Inverting and Non-inverting Functions

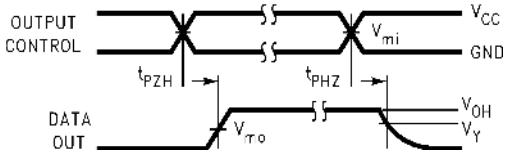


FIGURE 9. 3-STATE Output High Enable and Disable Times for Low Voltage Logic

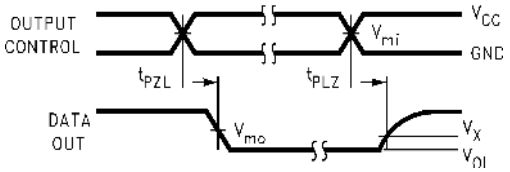
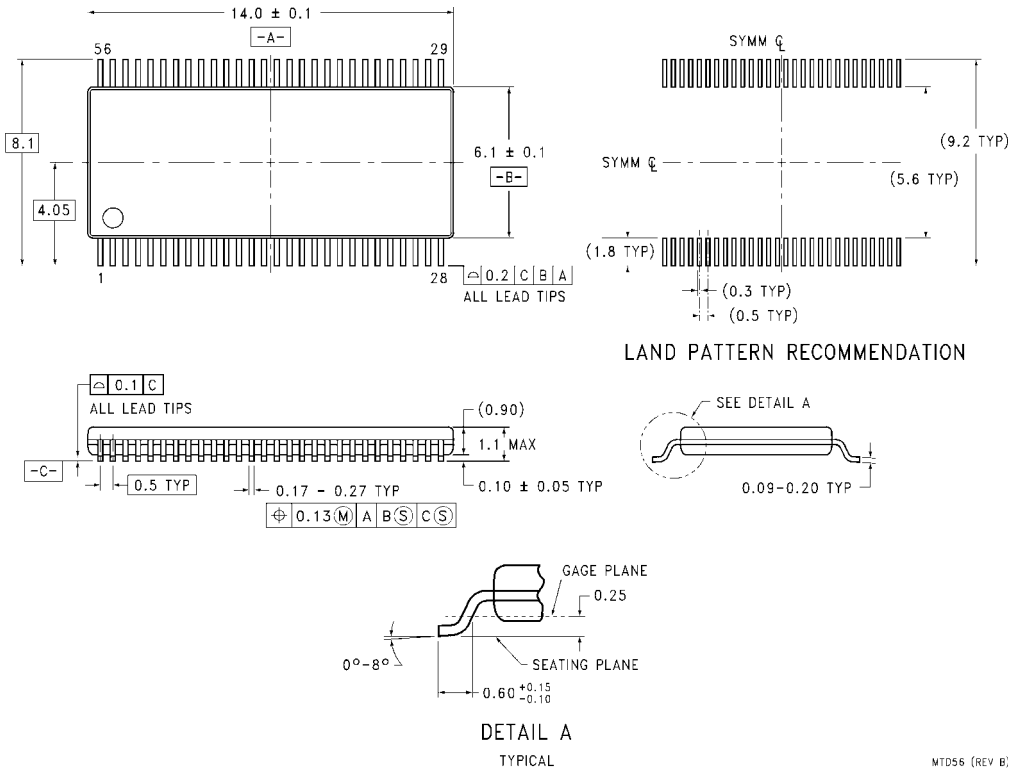


FIGURE 10. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic

Symbol	V_{CC}
	1.5v ± 0.1V
V_{mi}	$V_{CC}/2$
V_{mo}	$V_{CC}/2$
V_X	V_{OL} + 0.1V
V_Y	V_{OH} − 0.1V

Physical Dimensions inches (millimeters) unless otherwise noted



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

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