

## 74VCX16721

### Low Voltage 20-Bit D-Type Flip-Flops with 3.6V Tolerant Inputs and Outputs

#### General Description

The VCX16721 contains twenty non-inverting D-type flip-flops with 3-STATE outputs and is intended for bus oriented applications.

The 74VCX16721 is designed for low voltage (1.4V to 3.6V)  $V_{CC}$  applications with I/O compatibility up to 3.6V.

The 74VCX16721 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
- $t_{PD}$  (CLK to  $O_n$ )  
3.5 ns max for 3.0V to 3.6V  $V_{CC}$
- Power-off high impedance inputs and outputs
- Supports live insertion and withdrawal (Note 1)
- Static Drive ( $I_{OH}/I_{OL}$ )  
 $\pm 24$  mA @ 3.0V  $V_{CC}$
- Uses patented noise/EMI reduction circuitry
- Latch-up performance exceeds 300 mA
- ESD performance:  
Human body model > 2000V  
Machine model > 200V

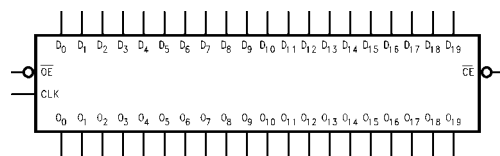
**Note 1:** To ensure the high-impedance state during power up or power down,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pull-up resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

#### Ordering Code:

Order Number	Package Number	Package Description
74VCX16721MTD	MTD56	56-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 6.1mm Wide

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

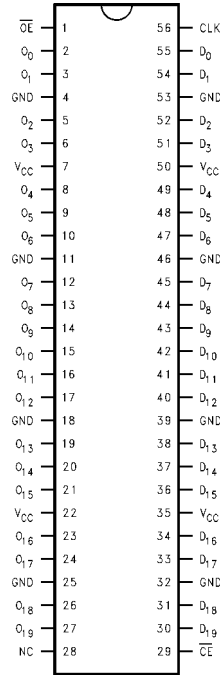
#### Logic Symbol



#### Pin Descriptions

Pin Names	Description
$\overline{OE}$	Output Enable Input (Active LOW)
CLK	Clock Input
$D_0$ – $D_{19}$	Inputs
$O_0$ – $O_{19}$	Outputs
$\overline{CE}$	Clock Enable Input (Active LOW)

**Connection Diagram**



**Truth Table**

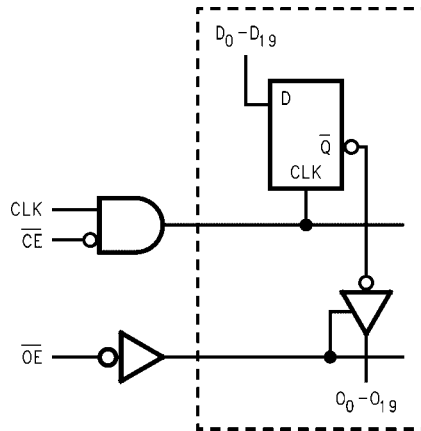
CLK	$\overline{CE}$	$\overline{OE}$	D <sub>0</sub> -D <sub>19</sub>	O <sub>0</sub> -O <sub>19</sub>
X	X	H	X	Z
X	H	L	X	O <sub>0</sub>
↗	L	L	L	L
↗	L	L	H	H
L or H	L	L	X	O <sub>0</sub>

H = HIGH Voltage Level  
 L = LOW Voltage Level  
 X = Immaterial (HIGH or LOW, inputs may not float)  
 Z = High Impedance  
 O<sub>0</sub> = Previous O<sub>0</sub> before LOW-to-HIGH transition of Clock  
 ↗ = LOW-to-HIGH transition

**Functional Description**

The VCX16721 contains twenty D-type flip-flops with 3-STATE standard outputs. The twenty flip-flops will store the state of their individual D-type inputs that meet the setup and hold time requirements on the LOW-HIGH Clock (CLK) transition, when the Clock-Enable ( $\overline{CE}$ ) is LOW. The 3-STATE standard outputs are controlled by the Output-Enable ( $\overline{OE}$ ). When  $\overline{OE}$  is HIGH, the standard outputs are in high impedance mode but this does not interfere with entering new data into the flip-flops.

**Logic Diagram**



**Absolute Maximum Ratings** (Note 2)

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 3)	-0.5V 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 GND Current per	
Supply Pin ( $I_{CC}$ or GND)	$\pm 100$ mA
Storage Temperature Range ( $T_{STG}$ )	-65°C to +150°C

**Recommended Operating Conditions** (Note 4)

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	$\pm 24$ mA
$V_{CC} = 2.3V$ to 2.7V	$\pm 18$ mA
$V_{CC} = 1.65V$ to 2.3V	$\pm 6$ mA
$V_{CC} = 1.4V$ to 1.6V	$\pm 2$ 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 2:** 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.

**Note 3:**  $I_O$  Absolute Maximum Rating must be observed.

**Note 4:** Floating or unused inputs 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	$0.65 \times V_{CC}$		
			1.4 - 1.6	$0.65 \times V_{CC}$		
$V_{IL}$	LOW Level Input Voltage		2.7 - 3.6		0.8	V
			2.3 - 2.7		0.7	
			1.65 - 2.3		$0.35 \times V_{CC}$	
			1.4 - 1.6		$0.35 \times V_{CC}$	
$V_{OH}$	HIGH Level Output Voltage	$I_{OH} = -100 \mu A$ $I_{OH} = -12 mA$ $I_{OH} = -18 mA$ $I_{OH} = -24 mA$	2.7 - 3.6	$V_{CC} - 0.2$		V
			2.7	2.2		
			3.0	2.4		
			3.0	2.2		
		$I_{OH} = -100 \mu A$ $I_{OH} = -6 mA$ $I_{OH} = -12 mA$ $I_{OH} = -18 mA$	2.3 - 2.7	$V_{CC} - 0.2$		
			2.3	2.0		
			2.3	1.8		
			2.3	1.7		
		$I_{OH} = -100 \mu A$ $I_{OH} = -6 mA$ $I_{OH} = -100 \mu A$ $I_{OH} = -12 mA$	1.65 - 2.3	$V_{CC} - 0.2$		
			1.65	1.25		
			1.4 - 1.6	$V_{CC} - 0.2$		
			1.4	1.05		

## DC Electrical Characteristics (Continued)

Symbol	Parameter	Conditions	V <sub>CC</sub> (V)	Min	Max	Units
V <sub>OL</sub>	LOW Level Output Voltage	I <sub>OL</sub> = 100 μA	2.7 - 3.6		0.2	V
		I <sub>OL</sub> = 12 mA	2.7		0.4	
		I <sub>OL</sub> = 18 mA	3.0		0.4	
		I <sub>OL</sub> = 24 mA	3.0		0.55	
		I <sub>OL</sub> = 100 μA	2.3 - 2.7		0.2	
		I <sub>OL</sub> = 12 mA	2.3		0.4	
		I <sub>OL</sub> = 18 mA	2.3		0.6	
		I <sub>OL</sub> = 100 μA	1.65 - 2.3		0.2	
		I <sub>OL</sub> = 6 mA	1.65		0.3	
		I <sub>OL</sub> = 100 μA	1.4 - 1.6		0.2	
		I <sub>OL</sub> = 2 mA	1.4		0.35	
I <sub>I</sub>	Input Leakage Current	0 ≤ V <sub>I</sub> ≤ 3.6V	1.4 - 3.6		±5.0	μA
I <sub>OZ</sub>	3-STATE Output Leakage	0 ≤ V <sub>O</sub> ≤ 3.6V V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>	1.4 - 3.6		±10.0	μA
I <sub>OFF</sub>	Power-OFF Leakage Current	0 ≤ (V <sub>I</sub> , V <sub>O</sub> ) ≤ 3.6V	0		10.0	μA
I <sub>CC</sub>	Quiescent Supply Current	V <sub>I</sub> = V <sub>CC</sub> or GND	1.4 - 3.6		20.0	μA
		V <sub>CC</sub> ≤ (V <sub>I</sub> , V <sub>O</sub> ) ≤ 3.6V (Note 5)	1.4 - 3.6		±20.0	
ΔI <sub>CC</sub>	Increase in I <sub>CC</sub> per Input	V <sub>IH</sub> = V <sub>CC</sub> - 0.6V	2.7 - 3.6		750	μA

**Note 5:** Outputs disabled or 3-STATE only.

AC Electrical Characteristics (Note 6)							
Symbol	Parameter	Conditions	V <sub>CC</sub> (V)	T <sub>A</sub> = -40°C to +85°C		Units	Figure Number
				Min	Max		
f <sub>MAX</sub>	Maximum Clock Frequency	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω	3.3 ± 0.3	250		MHz	
			2.5 ± 0.2	200			
			1.8 ± 0.15	100			
		C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ	1.5 ± 0.1	80.0			
t <sub>PHL</sub>	Propagation Delay	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω	3.3 ± 0.3	0.8	3.5	ns	Figures 1, 2
t <sub>PLH</sub>			2.5 ± 0.2	1.0	4.4		
				1.8 ± 0.15	1.5		8.8
		C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ	1.5 ± 0.1	1.0	17.6		
t <sub>PZL</sub>	Output Enable Time	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω	3.3 ± 0.3	0.8	3.8	ns	Figures 1, 3, 4
t <sub>PZH</sub>			2.5 ± 0.2	1.0	4.9		
				1.8 ± 0.15	1.5		9.8
		C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ	1.5 ± 0.1	1.0	19.6		
t <sub>PLZ</sub>	Output Disable Time	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω	3.3 ± 0.3	0.8	3.7	ns	Figures 1, 3, 4
t <sub>PHZ</sub>			2.5 ± 0.2	1.0	4.2		
				1.8 ± 0.15	1.5		7.6
		C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ	1.5 ± 0.1	1.0	15.2		
t <sub>S</sub>	Setup Time	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω	3.3 ± 0.3	1.5		ns	Figure 6
			2.5 ± 0.2	1.5			
			1.8 ± 0.15	2.5			
		C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ	1.5 ± 0.1	3.0			
t <sub>H</sub>	Hold Time	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω	3.3 ± 0.3	1.0		ns	Figure 6
			2.5 ± 0.2	1.0			
			1.8 ± 0.15	1.0			
		C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ	1.5 ± 0.1	2.0			
t <sub>W</sub>	Pulse Width	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω	3.3 ± 0.3	1.5		ns	Figure 5
			2.5 ± 0.2	1.5			
			1.8 ± 0.15	4.0			
		C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ	1.5 ± 0.1	4.0			
t <sub>OSSL</sub>	Output to Output Skew (Note 7)	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500Ω	3.3 ± 0.3		0.5	ns	
t <sub>OSLH</sub>			2.5 ± 0.2		0.5		
			1.8 ± 0.15		0.75		
			1.5 ± 0.1		1.5		
		C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2kΩ	1.5 ± 0.1		1.5		

**Note 6:** For C<sub>L</sub> = 50pF, add approximately 300 ps to the AC maximum specification.

**Note 7:** 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> (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> = 30 pF, V <sub>IH</sub> = V <sub>CC</sub> , V <sub>IL</sub> = 0V	1.8	0.25	V
			2.5	0.6	
			3.3	0.8	
V <sub>OLV</sub>	Quiet Output Dynamic Valley V <sub>OL</sub>	C <sub>L</sub> = 30 pF, V <sub>IH</sub> = V <sub>CC</sub> , V <sub>IL</sub> = 0V	1.8	-0.25	V
			2.5	-0.6	
			3.3	-0.8	
V <sub>OHV</sub>	Quiet Output Dynamic Valley V <sub>OH</sub>	C <sub>L</sub> = 30 pF, V <sub>IH</sub> = V <sub>CC</sub> , V <sub>IL</sub> = 0V	1.8	1.5	V
			2.5	1.9	
			3.3	2.2	

### Capacitance

Symbol	Parameter	Conditions	T <sub>A</sub> = +25°C	Units
			Typical	
C <sub>IN</sub>	Input Capacitance	V <sub>CC</sub> = 1.8V, 2.5V or 3.3V, V <sub>I</sub> = 0V or V <sub>CC</sub>	6	pF
C <sub>OUT</sub>	Output Capacitance	V <sub>I</sub> = 0V or V <sub>CC</sub> , V <sub>CC</sub> = 1.8V, 2.5V or 3.3V	7	pF
C <sub>PD</sub>	Power Dissipation Capacitance	V <sub>I</sub> = 0V or V <sub>CC</sub> , f = 10 MHz, V <sub>CC</sub> = 1.8V, 2.5V or 3.3V	20	pF

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

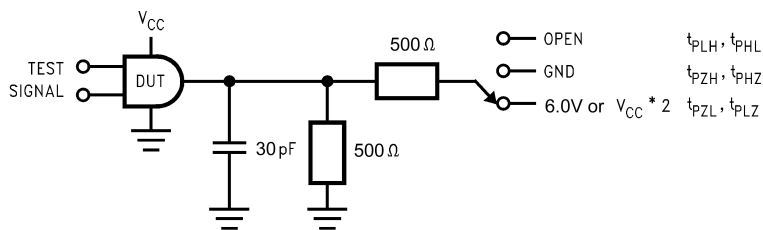


FIGURE 1. AC Test Circuit

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

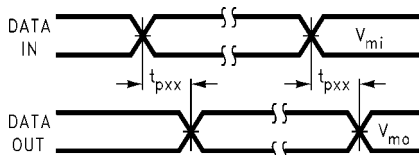


FIGURE 2. Waveform for Inverting and Non-Inverting Functions

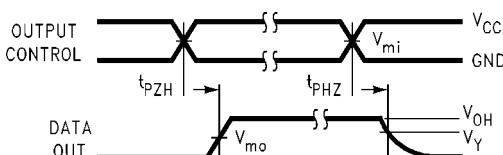


FIGURE 3. 3-STATE Output High Enable and Disable Times for Low Voltage Logic

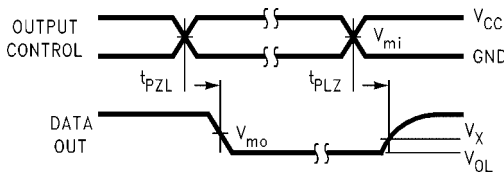


FIGURE 4. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic

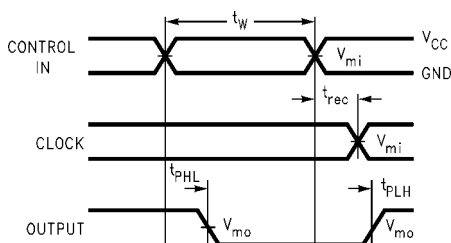


FIGURE 5. Propagation Delay, Pulse Width and  $t_{rec}$  Waveforms

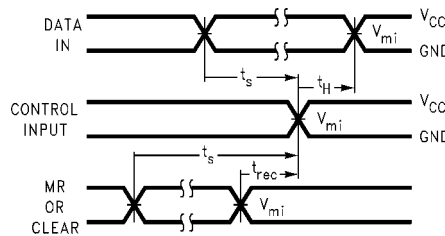
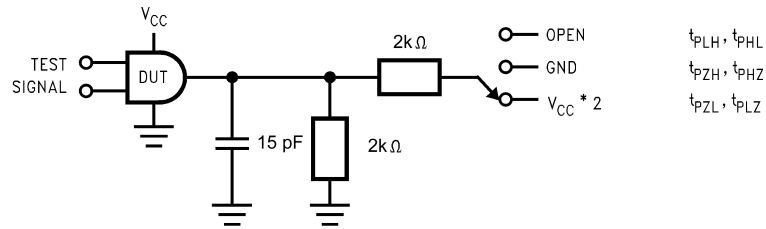


FIGURE 6. Setup Time, Hold Time and Recovery Time for Low Voltage Logic

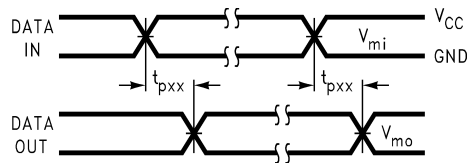
Symbol	$V_{CC}$		
	3.3V ± 0.3V	2.5V ± 0.2V	1.8V ± 0.15V
$V_{mi}$	1.5V	$V_{CC}/2$	$V_{CC}/2$
$V_{mo}$	1.5V	$V_{CC}/2$	$V_{CC}/2$
$V_X$	$V_{OL} + 0.3V$	$V_{OL} + 0.15V$	$V_{OL} + 0.15V$
$V_Y$	$V_{OH} - 0.3V$	$V_{OH} - 0.15V$	$V_{OH} - 0.15V$

**AC Loading and Waveforms ( $V_{CC} 1.5V \pm 0.1V$ )**

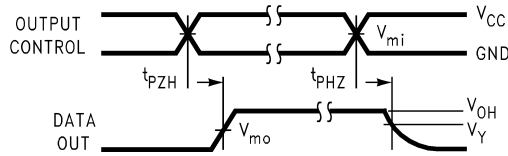


TEST	SWITCH
$t_{PLH}, t_{PHL}$	Open
$t_{PZL}, t_{PLZ}$	$V_{CC} \times 2$ at $V_{CC} = 1.5V \pm 0.1V$
$t_{PZH}, t_{PHZ}$	GND

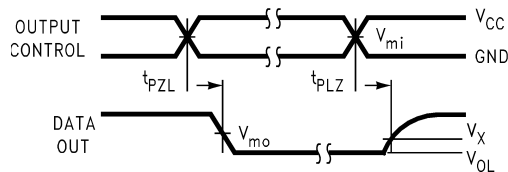
**FIGURE 7. AC Test Circuit**



**FIGURE 8. Waveform for Inverting and Non-Inverting Functions**



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

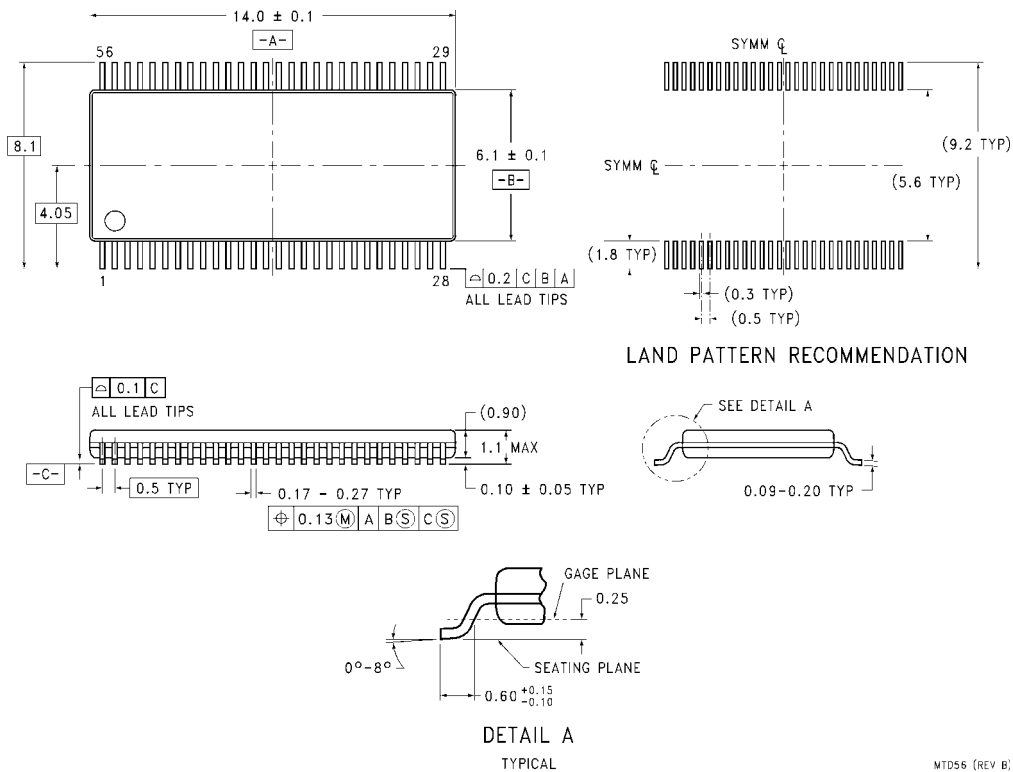


**FIGURE 10. 3-STATE Output Low Enable and Disable Times for Low Voltage Logic**

Symbol	$V_{CC}$
	$1.5V \pm 0.1V$
$V_{mi}$	$V_{CC}/2$
$V_{mo}$	$V_{CC}/2$
$V_X$	$V_{OL} + 0.1V$
$V_Y$	$V_{OH} - 0.1V$



**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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