

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VCX162721FT

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

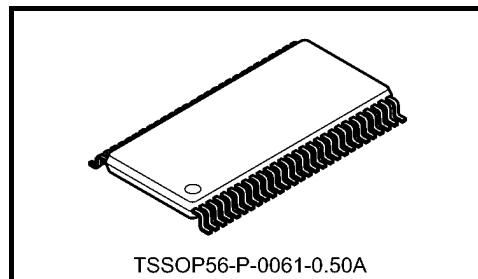
The TC74VCX162721FT is a high-performance CMOS 20-bit D-type flip-flop. Designed for use in 1.8-V, 2.5-V or 3.3-V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

It is also designed with overvoltage tolerant inputs and outputs up to 3.6 V.

The TC74VCX162721FT is an edge-triggered D-type flip-flop with qualified clock storage. On the positive transition of the clock (CK) input, the device provides true data at the Q outputs if the clock-enable ( $\overline{\text{CKEN}}$ ) input is low. If  $\overline{\text{CKEN}}$  is high, no data is stored. When the  $\overline{\text{OE}}$  input is high, the outputs are in a high-impedance state. This device is designed to be used with 3-state memory address drivers, etc.

The 26- $\Omega$  series resistor helps reducing output overshoot and undershoot without external resistor.

All inputs are equipped with protection circuits against static discharge.

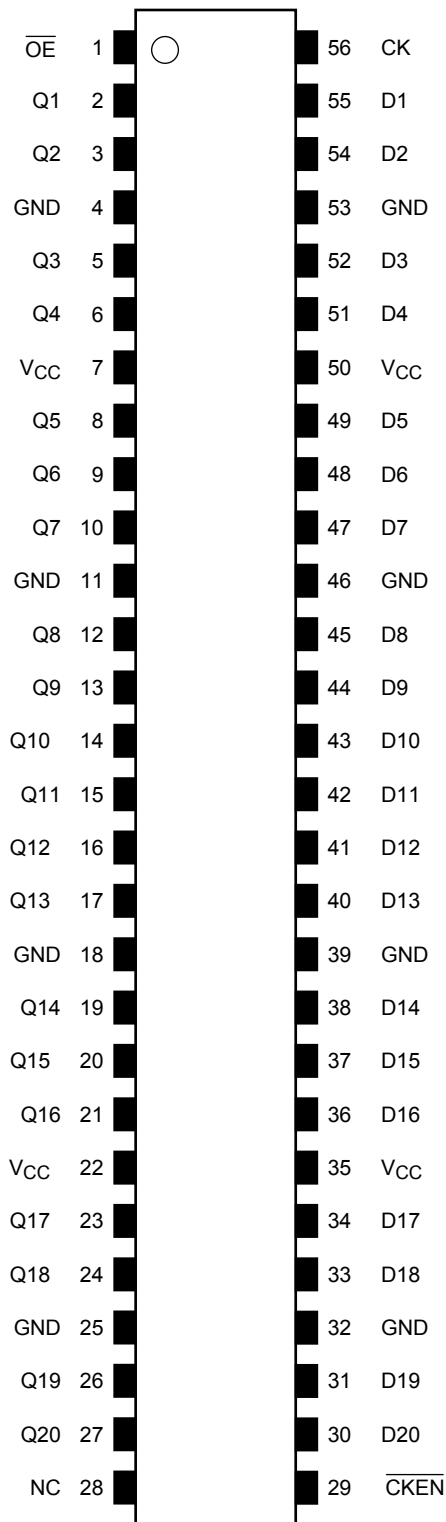


Weight: 0.25 g (typ.)

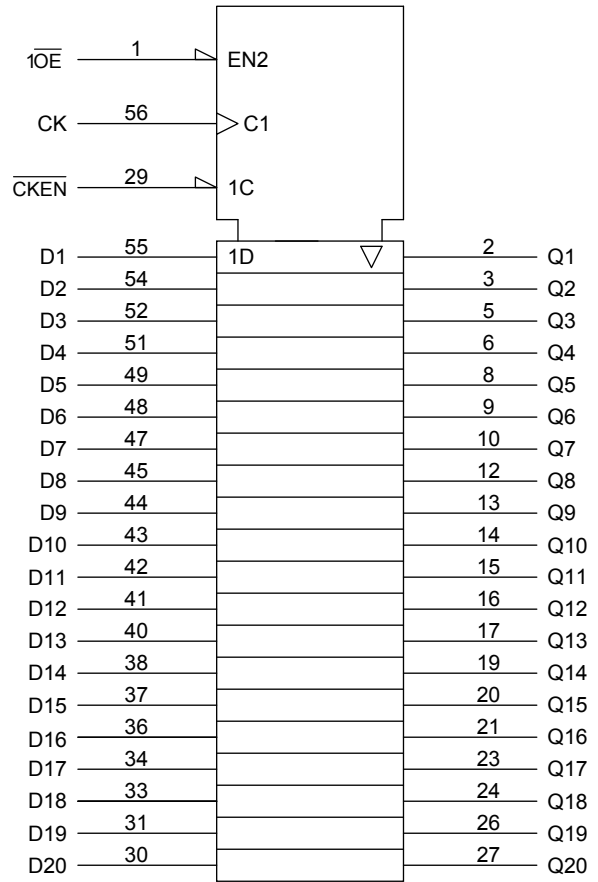
### Features

- 26- $\Omega$  series resistors on outputs
- Low-voltage operation:  $V_{CC} = 1.8$  to 3.6 V
- High-speed operation
  - :  $t_{pd} = 4.4$  ns (max) ( $V_{CC} = 3.0$  to 3.6 V)
  - :  $t_{pd} = 5.8$  ns (max) ( $V_{CC} = 2.3$  to 2.7 V)
  - :  $t_{pd} = 9.8$  ns (max) ( $V_{CC} = 1.8$  V)
- Output current:  $I_{OH}/I_{OL} = \pm 12$  mA (min) ( $V_{CC} = 3.0$  V)
  - :  $I_{OH}/I_{OL} = \pm 8$  mA (min) ( $V_{CC} = 2.3$  V)
  - :  $I_{OH}/I_{OL} = \pm 4$  mA (min) ( $V_{CC} = 1.8$  V)
- Latch-up performance: -300 mA
- ESD performance: Machine model  $\geq \pm 200$  V  
Human body model  $\geq \pm 2000$  V
- Package: TSSOP
- 3.6-V tolerant function and power-down protection provided on all inputs and outputs



**Pin Assignment (top view)**



**IEC Logic Symbol**



**Truth Table (each flip-flop)**

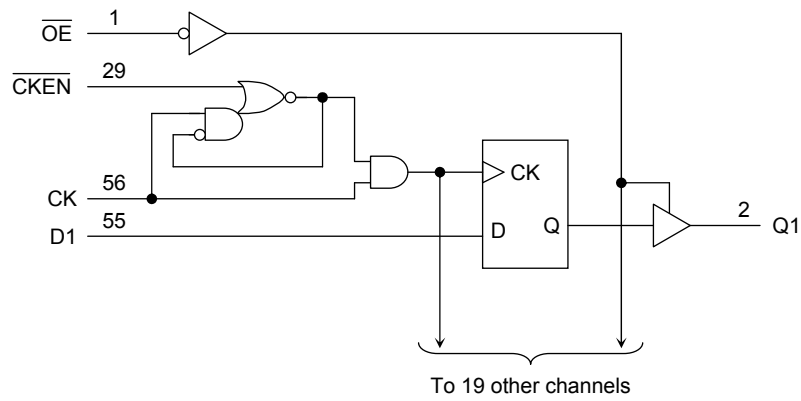
Inputs				Outputs Q
$\overline{OE}$	$\overline{CKEN}$	CK	D	
L	H	X	X	Qn
L	L		H	H
L	L		L	L
L	L	L or H	X	Qn
H	X	X	X	Z

X: Don't care

Z: High impedance

Qn: No change

**System Diagram**



## Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CC}$	-0.5 to 4.6	V
DC input voltage	$V_{IN}$	-0.5 to 4.6	V
DC output voltage	$V_{OUT}$	-0.5 to 4.6 (Note 2)	V
		-0.5 to $V_{CC} + 0.5$ (Note 3)	
Input diode current	$I_{IK}$	-50	mA
Output diode current	$I_{OK}$	$\pm 50$ (Note 4)	mA
DC output current	$I_{OUT}$	$\pm 50$	mA
Power dissipation	$P_D$	400	mW
DC $V_{CC}$ /ground current per supply pin	$I_{CC}/I_{GND}$	$\pm 100$	mA
Storage temperature	$T_{stg}$	-65 to 150	$^{\circ}C$

Note 1: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.

Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 2: OFF state

Note 3: High or low state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 4:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## Operating Ranges (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CC}$	1.8 to 3.6	V
		1.2 to 3.6 (Note 2)	
Input voltage	$V_{IN}$	-0.3 to 3.6	V
Output voltage	$V_{OUT}$	0 to 3.6 (Note 3)	V
		0 to $V_{CC}$ (Note 4)	
Output current	$I_{OH}/I_{OL}$	$\pm 12$ (Note 5)	mA
		$\pm 8$ (Note 6)	
		$\pm 4$ (Note 7)	
Operating temperature	$T_{opr}$	-40 to 85	$^{\circ}C$
Input rise and fall time	$dt/dv$	0 to 10 (Note 8)	ns/V

Note 1: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs must be tied to either  $V_{CC}$  or GND.

Note 2: Data retention only

Note 3: OFF state

Note 4: High or low state

Note 5:  $V_{CC} = 3.0$  to 3.6 V

Note 6:  $V_{CC} = 2.3$  to 2.7 V

Note 7:  $V_{CC} = 1.8$  V

Note 8:  $V_{IN} = 0.8$  to 2.0 V,  $V_{CC} = 3.0$  V

## Electrical Characteristics

### DC Characteristics (Ta = -40 to 85°C, 2.7 V < VCC ≤ 3.6 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>IH</sub>	—		2.7 to 3.6	2.0	—	V
	L-level	V <sub>IL</sub>	—		2.7 to 3.6	—	0.8	
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.7 to 3.6	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -6 mA	2.7	2.2	—	
				I <sub>OH</sub> = -8 mA	3.0	2.4	—	
				I <sub>OH</sub> = -12 mA	3.0	2.2	—	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	2.7 to 3.6	—	0.2	
				I <sub>OL</sub> = 6 mA	2.7	—	0.4	
				I <sub>OL</sub> = 8 mA	3.0	—	0.55	
				I <sub>OL</sub> = 12 mA	3.0	—	0.8	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		2.7 to 3.6	—	±5.0	μA
3-state output OFF state current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0 to 3.6 V		2.7 to 3.6	—	±10.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.7 to 3.6	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		2.7 to 3.6	—	±20.0	
Increase in I <sub>CC</sub> per input		ΔI <sub>CC</sub>	V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V		2.7 to 3.6	—	750	

### DC Characteristics (Ta = -40 to 85°C, 2.3 V ≤ VCC ≤ 2.7 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>IH</sub>	—		2.3 to 2.7	1.6	—	V
	L-level	V <sub>IL</sub>	—		2.3 to 2.7	—	0.7	
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.3 to 2.7	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -4 mA	2.3	2.0	—	
				I <sub>OH</sub> = -6 mA	2.3	1.8	—	
				I <sub>OH</sub> = -8 mA	2.3	1.7	—	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	2.3 to 2.7	—	0.2	
				I <sub>OL</sub> = 6 mA	2.3	—	0.4	
				I <sub>OL</sub> = 8 mA	2.3	—	0.6	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		2.3 to 2.7	—	±5.0	μA
3-state output OFF state current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0 to 3.6 V		2.3 to 2.7	—	±10.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.3 to 2.7	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		2.3 to 2.7	—	±20.0	

**DC Characteristics (Ta = -40 to 85°C, 1.8 V ≤ VCC < 2.3 V)**

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>IH</sub>	—		1.8 to 2.3	0.7 × V <sub>CC</sub>	—	V
	L-level	V <sub>IL</sub>	—		1.8 to 2.3	—	0.2 × V <sub>CC</sub>	
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	1.8	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -4 mA	1.8	1.4	—	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	1.8	—	0.2	
				I <sub>OL</sub> = 4 mA	1.8	—	0.3	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		1.8	—	±5.0	μA
3-state output OFF state current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0 to 3.6 V		1.8	—	±10.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		1.8	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		1.8	—	±20.0	

## AC Characteristics (Ta = -40 to 85°C, input: tr = tf = 2.0 ns, CL = 30 pF, RL = 500 Ω) (Note 1)

Characteristics	Symbol	Test Condition	VCC (V)	Min	Max	Unit
Maximum clock frequency	f <sub>max</sub>	Figure 1, Figure 2	1.8	100	—	MHz
			2.5 ± 0.2	200	—	
			3.3 ± 0.3	250	—	
Propagation delay time (CK-Q)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	5.8	
			3.3 ± 0.3	0.6	4.4	
3-state output enable time	t <sub>pZL</sub> t <sub>pZH</sub>	Figure 1, Figure 3	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	5.9	
			3.3 ± 0.3	0.6	4.3	
3-state output disable time	t <sub>pLZ</sub> t <sub>pHZ</sub>	Figure 1, Figure 3	1.8	1.5	8.8	ns
			2.5 ± 0.2	0.8	4.9	
			3.3 ± 0.3	0.6	4.3	
Minimum pulse width (CK)	t <sub>W</sub> (H) t <sub>W</sub> (L)	Figure 1, Figure 2	1.8	4.0	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum setup time (D, $\overline{\text{CKEN}}$ )	t <sub>s</sub>	Figure 1, Figure 2, Figure 4	1.8	2.5	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum hold time (D, $\overline{\text{CKEN}}$ )	t <sub>h</sub>	Figure 1, Figure 2, Figure 4	1.8	1.0	—	ns
			2.5 ± 0.2	1.0	—	
			3.3 ± 0.3	1.0	—	
Output to output skew	t <sub>osLH</sub> t <sub>osHL</sub>	(Note 2)	1.8	—	0.5	ns
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

Note 1: For C<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

Note 2: Parameter guaranteed by design.

(t<sub>osLH</sub> = |t<sub>pLHm</sub> - t<sub>pLHn</sub>|, t<sub>osHL</sub> = |t<sub>pHLm</sub> - t<sub>pHLn</sub>|)

## Dynamic Switching Characteristics

( $T_a = 25^\circ\text{C}$ , input:  $t_r = t_f = 2.0 \text{ ns}$ ,  $C_L = 30 \text{ pF}$ ,  $R_L = 500 \Omega$ )

Characteristics	Symbol	Test Condition	V <sub>CC</sub> (V)	Typ.	Unit
Quiet output maximum dynamic V <sub>OL</sub>	V <sub>OLP</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note)	1.8	0.15	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note)	2.5	0.25	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note)	3.3	0.35	
Quiet output minimum dynamic V <sub>OL</sub>	V <sub>OLV</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note)	1.8	-0.15	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note)	2.5	-0.25	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note)	3.3	-0.35	
Quiet output minimum dynamic V <sub>OH</sub>	V <sub>OHV</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note)	1.8	1.55	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note)	2.5	2.05	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note)	3.3	2.65	

Note: Parameter guaranteed by design.

## Capacitive Characteristics ( $T_a = 25^\circ\text{C}$ )

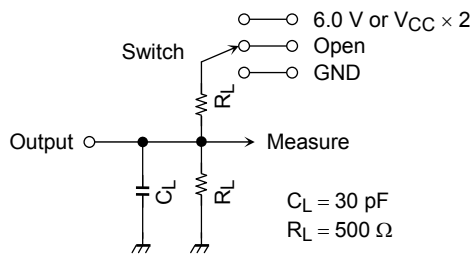
Characteristics	Symbol	Test Condition	V <sub>CC</sub> (V)	Typ.	Unit
Input capacitance	C <sub>IN</sub>	—	1.8, 2.5, 3.3	6	pF
Output capacitance	C <sub>O</sub>	—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C <sub>PD</sub>	f <sub>IN</sub> = 10 MHz (Note)	1.8, 2.5, 3.3	60	pF

Note: C<sub>PD</sub> is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation:

$$I_{CC(\text{opr})} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/20 \text{ (per bit)}$$

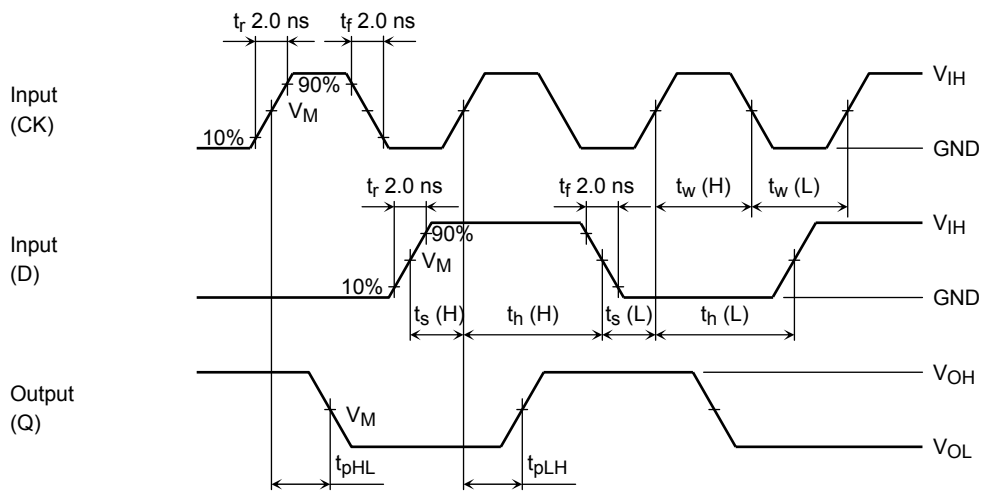
**AC Test Circuit**



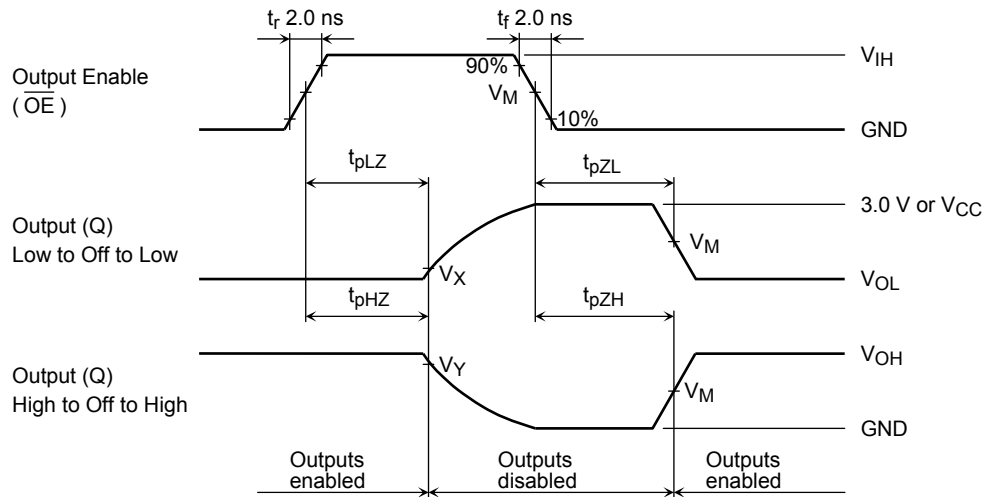
Parameter	Switch
$t_{pLH}$ , $t_{pHL}$	Open
$t_{pLZ}$ , $t_{pZL}$	6.0 V $V_{CC} \times 2$
	@ $V_{CC} = 3.3 \pm 0.3 \text{ V}$ @ $V_{CC} = 2.5 \pm 0.2 \text{ V}$ @ $V_{CC} = 1.8 \text{ V}$
$t_{pHZ}$ , $t_{pZH}$	GND

**Figure 1**

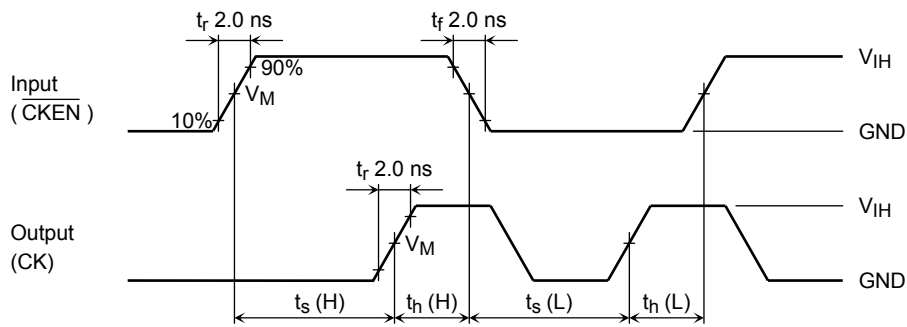
**AC Waveform**



**Figure 2  $t_{pLH}$ ,  $t_{pHL}$ ,  $t_w$ ,  $t_s$ ,  $t_h$**



**Figure 3**  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$



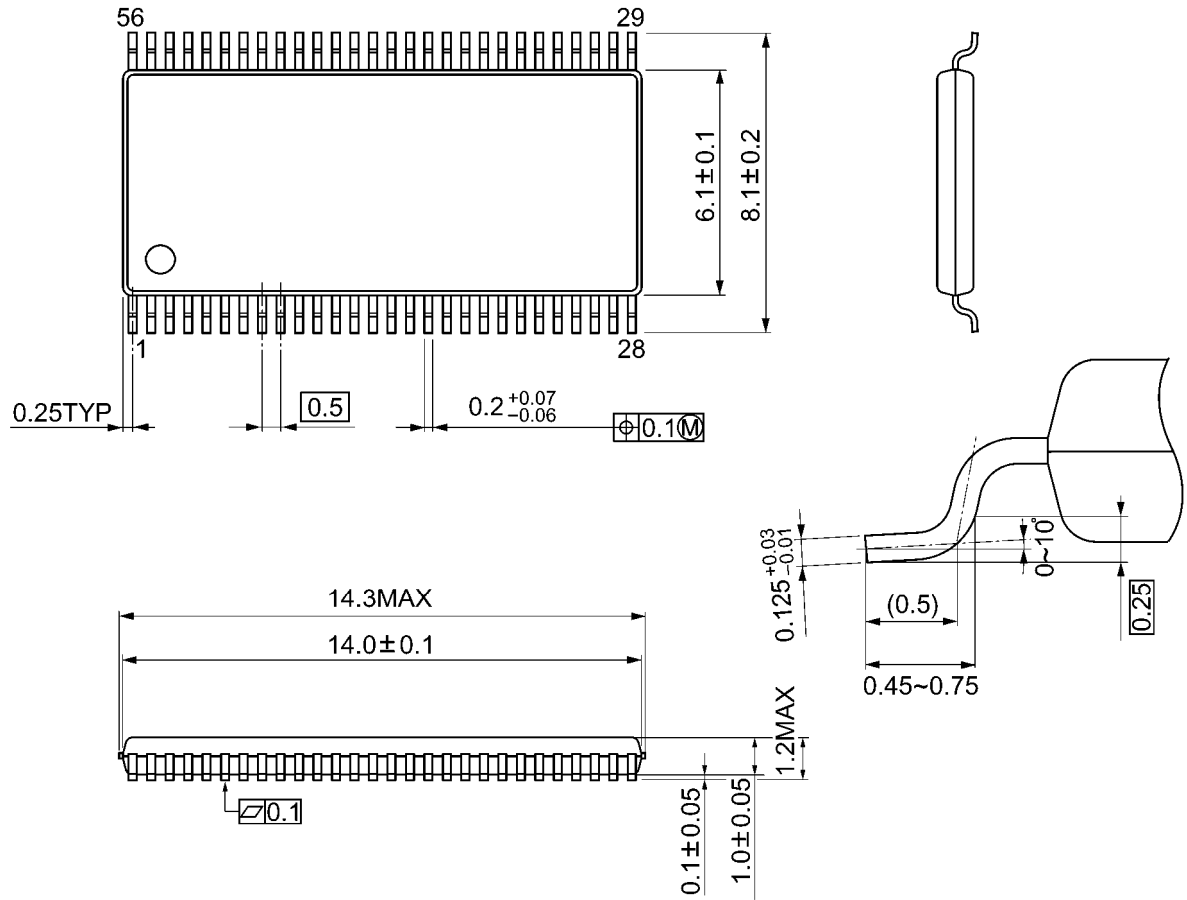
**Figure 4**  $t_s$ ,  $t_h$

Symbol	$V_{CC}$		
	$3.3 \pm 0.3 \text{ V}$	$2.5 \pm 0.2 \text{ V}$	$1.8 \text{ V}$
$V_{IH}$	$2.7 \text{ V}$	$V_{CC}$	$V_{CC}$
$V_M$	$1.5 \text{ V}$	$V_{CC}/2$	$V_{CC}/2$
$V_X$	$V_{OL} + 0.3 \text{ V}$	$V_{OL} + 0.15 \text{ V}$	$V_{OL} + 0.15 \text{ V}$
$V_Y$	$V_{OH} - 0.3 \text{ V}$	$V_{OH} - 0.15 \text{ V}$	$V_{OH} - 0.15 \text{ V}$

**Package Dimensions**

TSSOP56-P-0061-0.50A

Unit: mm



Weight: 0.25 g (typ.)

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