TOSHIBA CMOS Digital Integrated Circuit   Silicon Monolithic

TC74VCX162821FT

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

The TC74VCX162821FT 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 device is byte controlled with each byte functioning identically, but independent of the other. Control pins can be shorted together to obtain full 20-bit operation. The following description applies to each byte. The twenty flip-flops will store the state of their individual D inputs that meet the setup and hold time requirements on the LOW-to-HIGH Clock (CK) transition. When the 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-Ω series resistor helps reducing output overshoot and undershoot without external resistor.

All inputs are equipped with protection circuits against static discharge.
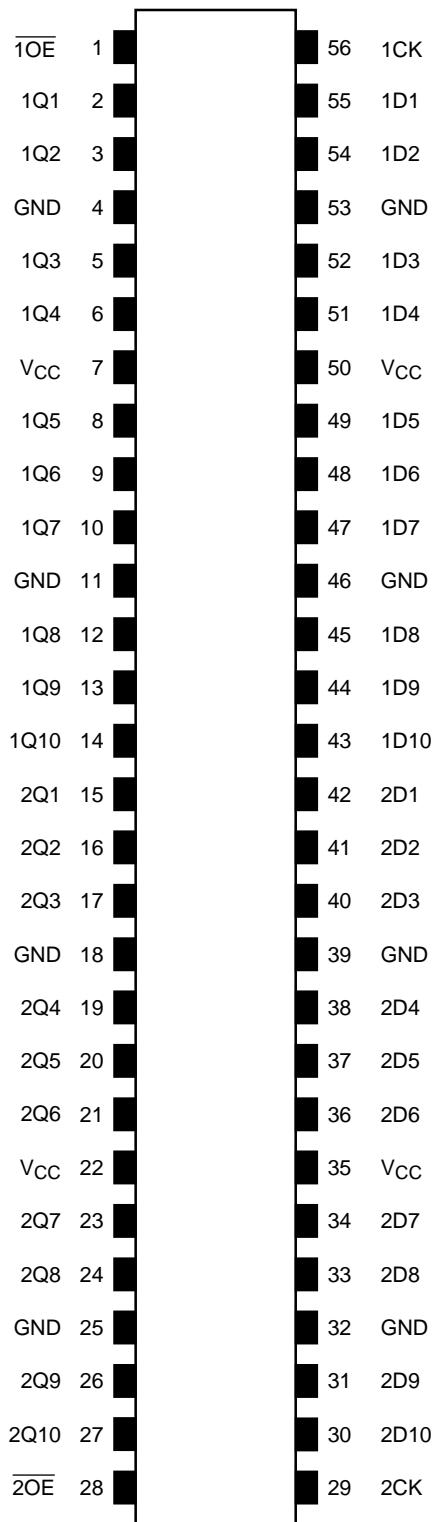

TSSOP56-P-0061-0.50
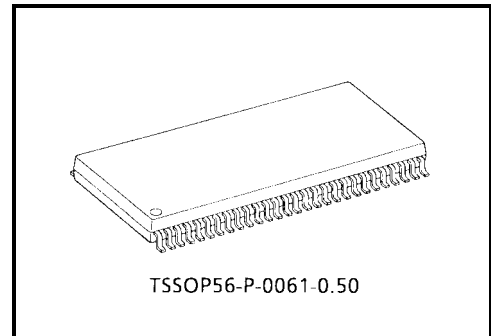
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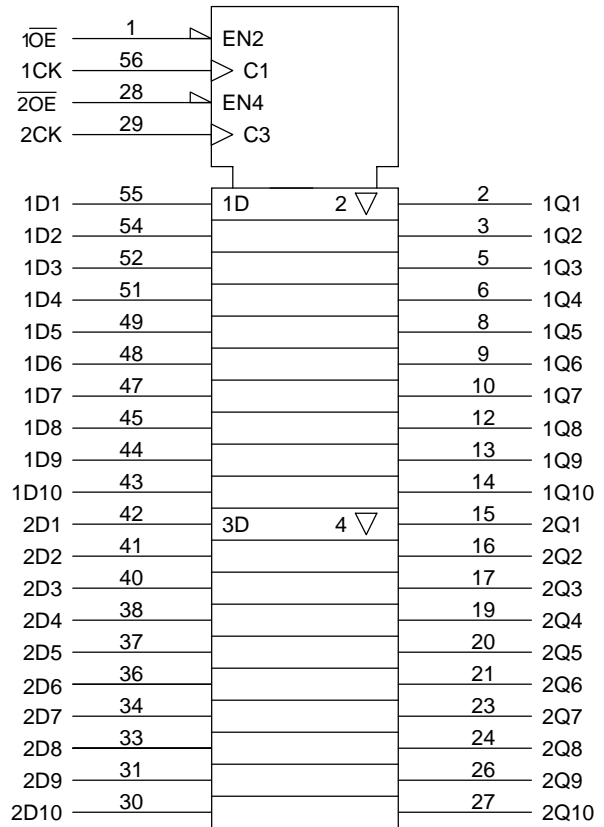
Features

- 26-Ω 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} = ±12 mA (min) (V_{CC} = 3.0 V)
  - : I_{OH}/I_{OL} = ±8 mA (min) (V_{CC} = 2.3 V)
  - : I_{OH}/I_{OL} = ±4 mA (min) (V_{CC} = 1.8 V)
- Latch-up performance: ±300 mA
- ESD performance: Machine model > ±200 V
  - : Human body model > ±2000 V
- Package: TSSOP (thin shrink small outline package)
- 3.6-V tolerant function and power-down protection provided on all inputs and outputs

Pin Assignment (top view)

$\overline{1OE}$	1	56	1CK
1Q1	2	55	1D1
1Q2	3	54	1D2
GND	4	53	GND
1Q3	5	52	1D3
1Q4	6	51	1D4
V$_{CC}$	7	50	V$_{CC}$
1Q5	8	49	1D5
1Q6	9	48	1D6
1Q7	10	47	1D7
GND	11	46	GND
1Q8	12	45	1D8
1Q9	13	44	1D9
1Q10	14	43	1D10
2Q1	15	42	2D1
2Q2	16	41	2D2
2Q3	17	40	2D3
GND	18	39	GND
2Q4	19	38	2D4
2Q5	20	37	2D5
2Q6	21	36	2D6
V$_{CC}$	22	35	V$_{CC}$
2Q7	23	34	2D7
2Q8	24	33	2D8
GND	25	32	GND
2Q9	26	31	2D9
2Q10	27	30	2D10
$\overline{2OE}$	28	29	2CK

IEC Logic Symbol

Truth Table

Inputs			Outputs
1$\overline{\text{OE}}$	1CK	1D1-1D10	1Q1-1Q10
H	X	X	Z
L	⌐↓	X	Qn
L	↑	L	L
L	↑	H	H

Inputs			Outputs
2$\overline{\text{OE}}$	2CK	2D1-2D10	2Q1-2Q10
H	X	X	Z
L	⌐↓	X	Qn
L	↑	L	L
L	↑	H	H

X: Don't care

Z: High impedance

Qn: No change

System Diagram
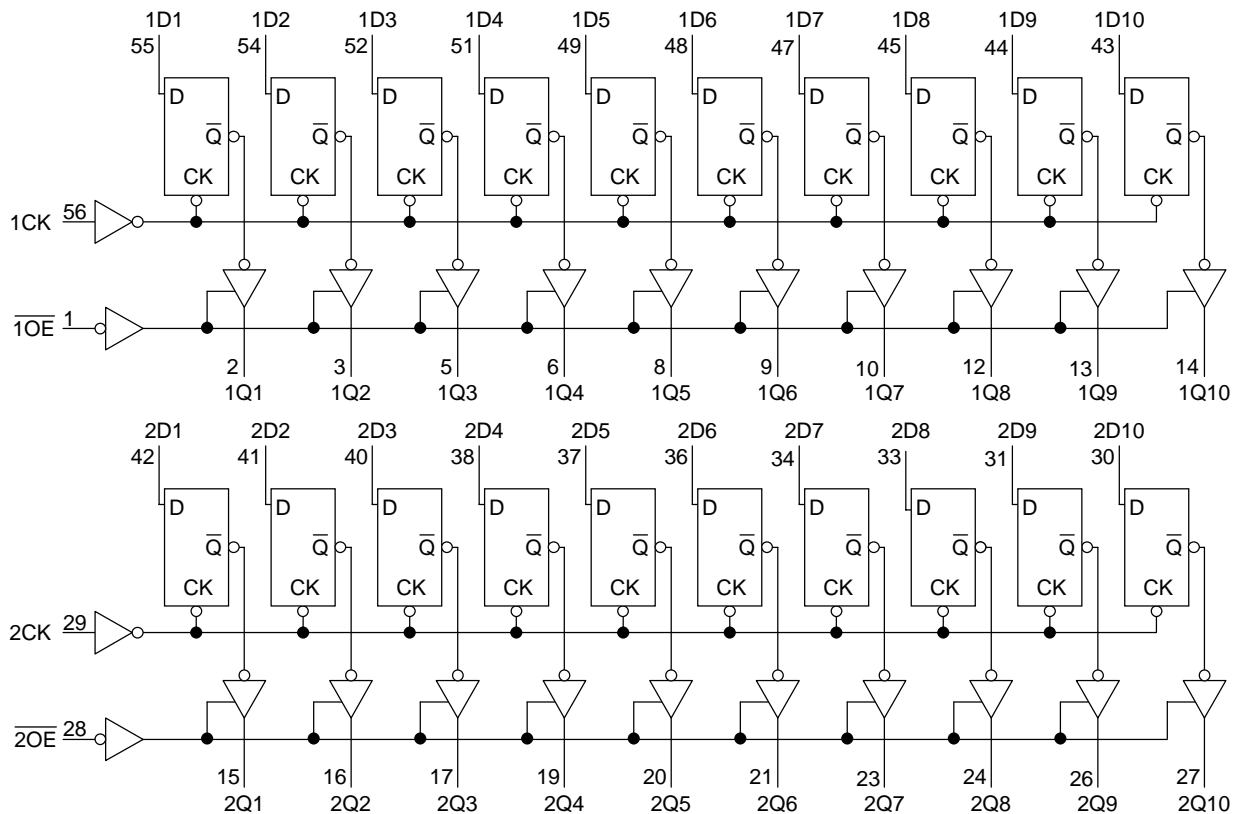
Maximum Ratings

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 1) −0.5 to V_{CC} + 0.5 (Note 2)	V
Input diode current	I_{IK}	−50	mA
Output diode current	I_{OK}	±50 (Note 3)	mA
DC output current	I_{OUT}	±50	mA
Power dissipation	P_D	400	mW
DC V_{CC}/ground current per supply pin	I_{CC}/I_{GND}	±100	mA
Storage temperature	T_{stg}	−65 to 150	°C

Note 1: OFF-state

Note 2: High or low state. I_{OUT} absolute maximum rating must be observed.

Note 3: V_{OUT} < GND, V_{OUT} > V_{CC}

Recommended Operating Range

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{CC}	1.8 to 3.6 1.2 to 3.6 (Note 4)	V
Input voltage	V_{IN}	−0.3 to 3.6	V
Output voltage	V_{OUT}	0 to 3.6 (Note 5) 0 to V_{CC} (Note 6)	V
Output current	I_{OH}/I_{OL}	±12 (Note 7) ±8 (Note 8) ±4 (Note 9)	mA
Operating temperature	T_{opr}	−40 to 85	°C
Input rise and fall time	dt/dv	0 to 10 (Note 10)	ns/V

Note 4: Data retention only

Note 5: OFF-state

Note 6: High or low state

Note 7: V_{CC} = 3.0 to 3.6 V

Note 8: V_{CC} = 2.3 to 2.7 V

Note 9: V_{CC} = 1.8 V

Note 10: 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 < V_{CC} ≦ 3.6 V)

Characteristics		Symbol	Test Condition			V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	—			2.7 to 3.6	2.0	—	V
	L-level	V_{IL}	—			2.7 to 3.6	—	0.8	
Output voltage	H-level	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}		$I_{OH} = -100\ \mu A$	2.7 to 3.6	$V_{CC} - 0.2$	—	V
					$I_{OH} = -6$ mA	2.7	2.2	—	
					$I_{OH} = -8$ mA	3.0	2.4	—	
					$I_{OH} = -12$ mA	3.0	2.2	—	
	L-level	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}		$I_{OL} = 100\ \mu A$	2.7 to 3.6	—	0.2	
					$I_{OL} = 6$ mA	2.7	—	0.4	
					$I_{OL} = 8$ mA	3.0	—	0.55	
					$I_{OL} = 12$ mA	3.0	—	0.8	
Input leakage current		I_{IN}	$V_{IN} = 0$ to 3.6 V			2.7 to 3.6	—	±5.0	μA
3-state output OFF state current		I_{OZ}	$V_{IN} = V_{IH}$ or V_{IL} $V_{OUT} = 0$ to 3.6 V			2.7 to 3.6	—	±10.0	μA
Power-off leakage current		I_{OFF}	$V_{IN}, V_{OUT} = 0$ to 3.6 V			0	—	10.0	μA
Quiescent supply current		I_{CC}	$V_{IN} = V_{CC}$ or GND			2.7 to 3.6	—	20.0	μA
			$V_{CC} ≦ (V_{IN}, V_{OUT}) ≦ 3.6$ V			2.7 to 3.6	—	±20.0	
Increase in I_{CC} per input		ΔI_{CC}	$V_{IH} = V_{CC} - 0.6$ V			2.7 to 3.6	—	750	

DC Characteristics (Ta = −40 to 85°C, 2.3 V ≦ V_{CC} ≦ 2.7 V)

Characteristics		Symbol	Test Condition			V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	—			2.3 to 2.7	1.6	—	V
	L-level	V_{IL}	—			2.3 to 2.7	—	0.7	
Output voltage	H-level	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}		$I_{OH} = -100\ \mu A$	2.3 to 2.7	$V_{CC} - 0.2$	—	V
					$I_{OH} = -4$ mA	2.3	2.0	—	
					$I_{OH} = -6$ mA	2.3	1.8	—	
					$I_{OH} = -8$ mA	2.3	1.7	—	
	L-level	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}		$I_{OL} = 100\ \mu A$	2.3 to 2.7	—	0.2	
					$I_{OL} = 6$ mA	2.3	—	0.4	
					$I_{OL} = 8$ mA	2.3	—	0.6	
Input leakage current		I_{IN}	$V_{IN} = 0$ to 3.6 V			2.3 to 2.7	—	±5.0	μA
3-state output OFF state current		I_{OZ}	$V_{IN} = V_{IH}$ or V_{IL} $V_{OUT} = 0$ to 3.6 V			2.3 to 2.7	—	±10.0	μA
Power-off leakage current		I_{OFF}	$V_{IN}, V_{OUT} = 0$ to 3.6 V			0	—	10.0	μA
Quiescent supply current		I_{CC}	$V_{IN} = V_{CC}$ or GND			2.3 to 2.7	—	20.0	μA
			$V_{CC} ≦ (V_{IN}, V_{OUT}) ≦ 3.6$ V			2.3 to 2.7	—	±20.0	

DC Characteristics (Ta = −40 to 85°C, 1.8 V ≦ V_{CC} < 2.3 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	—		1.8 to 2.3	$0.7 \times V_{CC}$	—	V
	L-level	V_{IL}	—		1.8 to 2.3	—	$0.2 \times V_{CC}$	
Output voltage	H-level	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OH} = -100\ \mu A$	1.8	$V_{CC} - 0.2$	—	V
				$I_{OH} = -4\ mA$	1.8	1.4	—	
	L-level	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OL} = 100\ \mu A$	1.8	—	0.2	
				$I_{OL} = 4\ mA$	1.8	—	0.3	
Input leakage current		I_{IN}	$V_{IN} = 0$ to 3.6 V		1.8	—	±5.0	μA
3-state output OFF state current		I_{OZ}	$V_{IN} = V_{IH}$ or V_{IL} $V_{OUT} = 0$ to 3.6 V		1.8	—	±10.0	μA
Power-off leakage current		I_{OFF}	V_{IN}, $V_{OUT} = 0$ to 3.6 V		0	—	10.0	μA
Quiescent supply current		I_{CC}	$V_{IN} = V_{CC}$ or GND		1.8	—	20.0	μA
			$V_{CC} \leqq (V_{IN}, V_{OUT}) \leqq 3.6$ V		1.8	—	±20.0	

AC Characteristics (Ta = −40 to 85°C, input: $t_r = t_f = 2.0$ ns, $C_L = 30$ pF, $R_L = 500\ \Omega$)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Min	Max	Unit
Maximum clock frequency	f_{max}	Figure 1, Figure 2	1.8	100	—	MHz
			2.5 ± 0.2	200	—	
			3.3 ± 0.3	250	—	
Propagation delay time (CK-Q)	t_{pLH} t_{pHL}	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_{pZL} t_{pZH}	Figure 1, Figure 3	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	5.7	
			3.3 ± 0.3	0.6	4.2	
3-state output disable time	t_{pLZ} t_{pHZ}	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	4.2	
Minimum pulse width (CK)	$t_{W (H)}$ $t_{W (L)}$	Figure 1, Figure 2	1.8	4.0	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum setup time	t_s	Figure 1, Figure 2	1.8	2.5	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum hold time	t_h	Figure 1, Figure 2	1.8	1.0	—	ns
			2.5 ± 0.2	1.0	—	
			3.3 ± 0.3	1.0	—	
Output to output skew	t_{osLH} t_{osHL}	(Note 11)	1.8	—	0.5	ns
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

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

Note 11: Parameter guaranteed by design.

$(t_{osLH} = |t_{pLHm} − t_{pLHn}|, t_{osHL} = |t_{pHLm} − t_{pHLn}|)$

Dynamic Switching Characteristics
(Ta = 25°C, input: t_r = t_f = 2.0 ns, C_L = 30 pF, R_L = 500 Ω)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Typ.	Unit
Quiet output maximum dynamic V_{OL}	V_{OLP}	V_{IH} = 1.8 V, V_{IL} = 0 V	(Note 12)	1.8	0.15	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note 12)	2.5	0.25	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note 12)	3.3	0.35	
Quiet output minimum dynamic V_{OL}	V_{OLV}	V_{IH} = 1.8 V, V_{IL} = 0 V	(Note 12)	1.8	−0.15	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note 12)	2.5	−0.25	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note 12)	3.3	−0.35	
Quiet output minimum dynamic V_{OH}	V_{OHV}	V_{IH} = 1.8 V, V_{IL} = 0 V	(Note 12)	1.8	1.55	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note 12)	2.5	2.05	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note 12)	3.3	2.65	

Note 12: Parameter guaranteed by design.

Capacitive Characteristics (Ta = 25°C)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}	—		1.8, 2.5, 3.3	6	pF
Output capacitance	C_O	—		1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C_{PD}	f_{IN} = 10 MHz	(Note 13)	1.8, 2.5, 3.3	20	pF

Note 13: C_{PD} 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:

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

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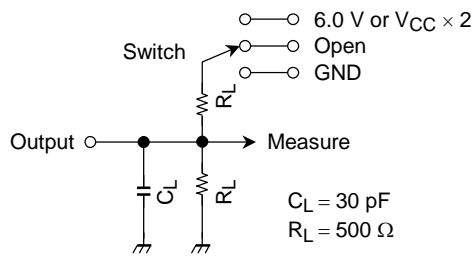
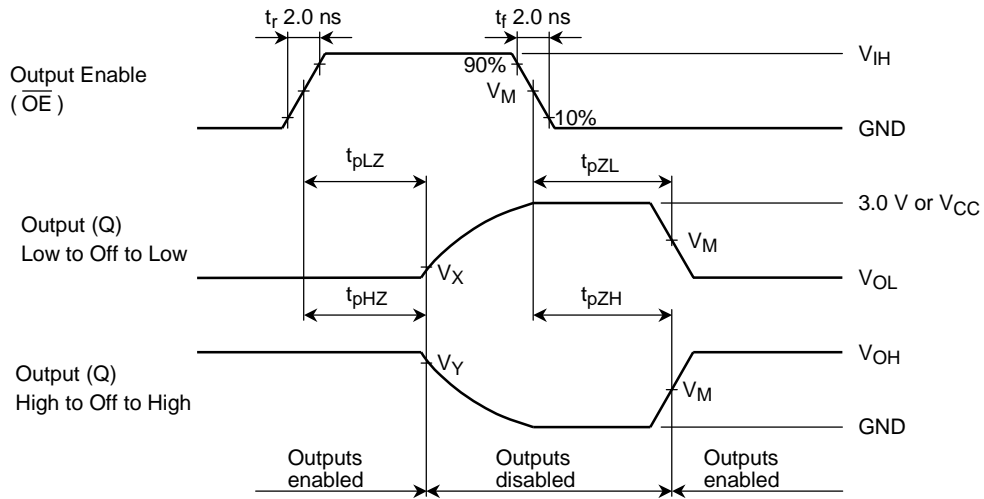| Parameter	Switch	
t_{pLH}, t_{pHL}	Open	
t_{pLZ}, t_{pZL}	6.0 V $V_{CC} \times 2$	@$V_{CC} = 3.3 \pm 0.3$ V @$V_{CC} = 2.5 \pm 0.2$ V @$V_{CC} = 1.8$ V
t_{pHZ}, t_{pZH}	GND	

Switch ○—○ 6.0 V or $V_{CC} \times 2$
○—○ Open
○—○ GND

R_L

Output ○———● ●——→ Measure

C_L R_L

$C_L = 30$ pF
$R_L = 500$ Ω

Figure 1

AC Waveform

t_r 2.0 ns t_f 2.0 ns

Input (CK)

90%
V_M
10%

V_{IH}
GND

t_r 2.0 ns t_f 2.0 ns t_w (H) t_w (L)

Input (D)

90%
V_M
10%

V_{IH}
GND

t_s (H) t_h (H) t_s (L) t_h (L)

Output (Q)

V_M

V_{OH}
V_{OL}
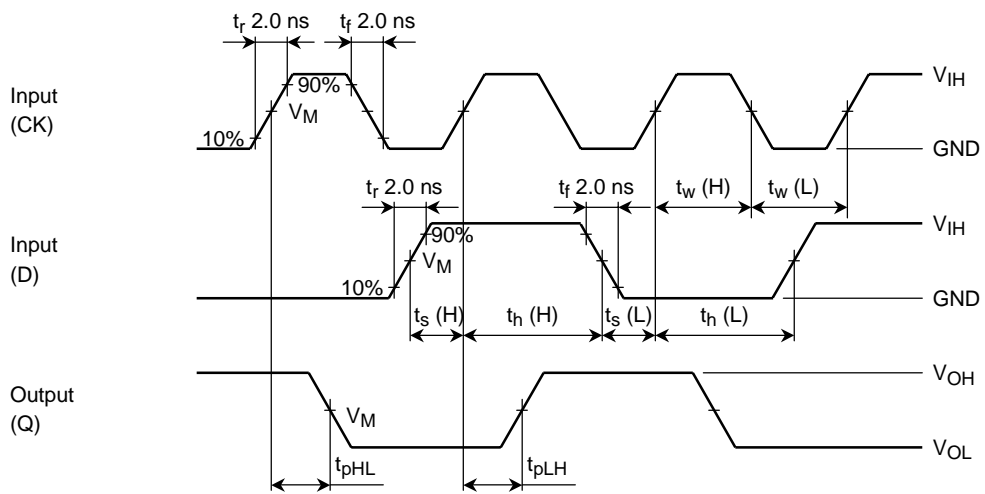
t_{pHL} t_{pLH}

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

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

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

Package Dimensions

TSSOP56-P-0061-0.50   Unit : mm
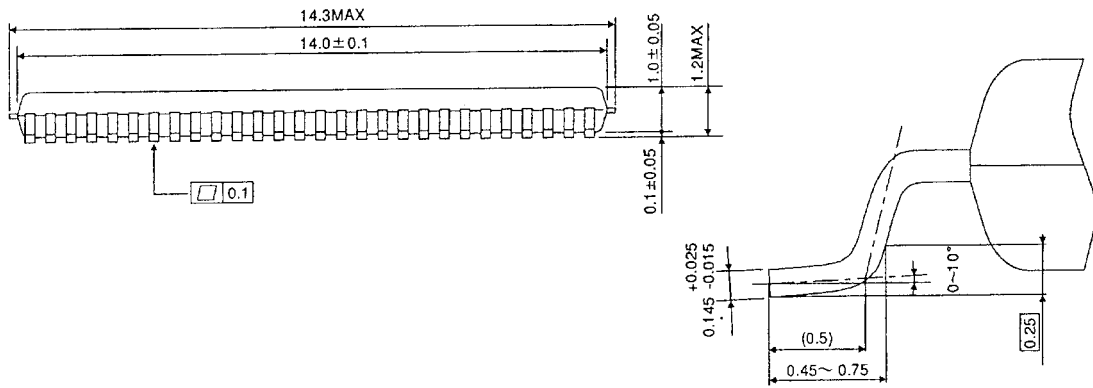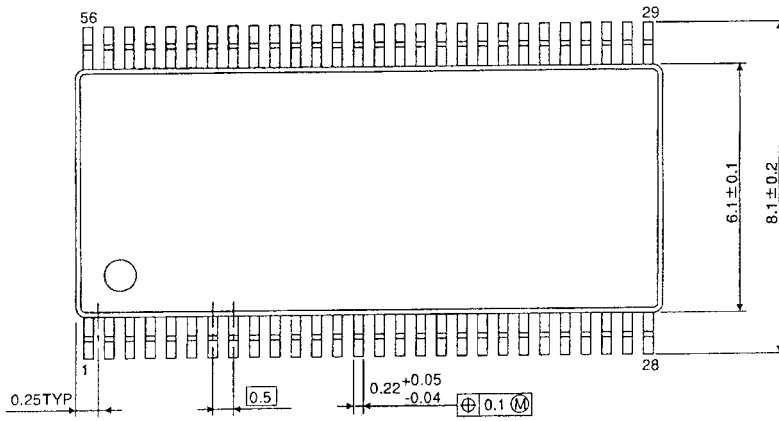
Weight: 0.25 g (typ.)

RESTRICTIONS ON PRODUCT USE

2001-10-11