TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC74VCX574FT, TC74VCX574FK

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

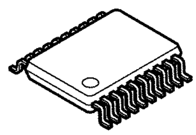
The TC74VCX574 is a high performance CMOS octal D-type flip-flop which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5 V, 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

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

This 8 bit D-type flip-flop is controlled by a clock input (CK) and an output enable input ($\overline{\mathrm{OE}}$). When $\overline{\mathrm{OE}}$ input is high, the eight outputs are in a high impedance state.

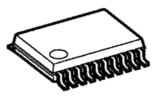
All inputs are equipped with protection circuits against static discharge.

TC74VCX574FT



TSSOP20-P-0044-0.65A

TC74VCX574FK



VSSOP20-P-0030-0.50

Weight

TSSOP20-P-0044-0.65A : 0.08 g (typ.)

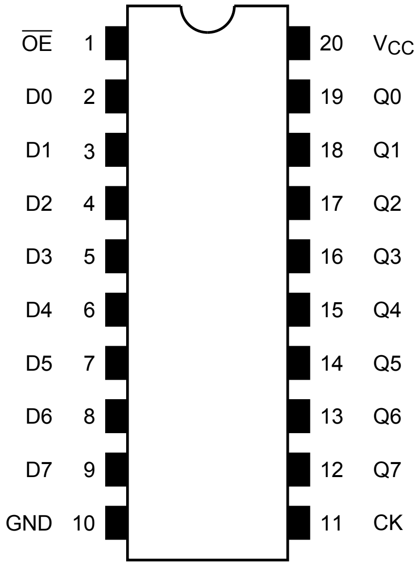
VSSOP20-P-0030-0.50 : 0.03 g (typ.)

Features

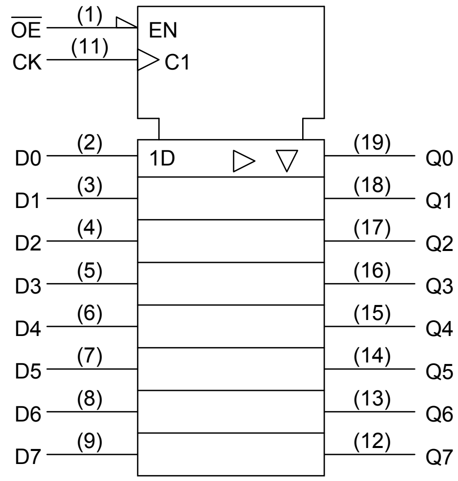
- Low voltage operation: V_{CC} = 1.2 to 3.6 V
- High speed operation: t_{pd} = 4.2 ns (max) (V_{CC} = 3.0 to 3.6 V)
  t_{pd} = 4.8 ns (max) (V_{CC} = 2.3 to 2.7 V)
  t_{pd} = 9.6 ns (max) (V_{CC} = 1.65 to 1.95 V)
  t_{pd} = 19.2 ns (max) (V_{CC} = 1.4 to 1.6 V)
  t_{pd} = 48.0 ns (max) (V_{CC} = 1.2 V)
- 3.6 V tolerant inputs and outputs.
- Output current: I_{OH}/I_{OL} = ±24 mA (min) (V_{CC} = 3.0 V)
  I_{OH}/I_{OL} = ±18 mA (min) (V_{CC} = 2.3 V)
  I_{OH}/I_{OL} = ±6 mA (min) (V_{CC} = 1.65 V)
  I_{OH}/I_{OL} = ±2 mA (min) (V_{CC} = 1.4 V)
- Latch-up performance: −300 mA
- ESD performance: Machine model ≥ ±200 V
  Human body model ≥ ±2000 V
- Package: TSSOP and VSSOP (US)
- Power down protection is provided on all inputs and outputs.

Start of commercial production
1998-06

Pin Assignment (top view)



IEC Logic Level



Truth Table

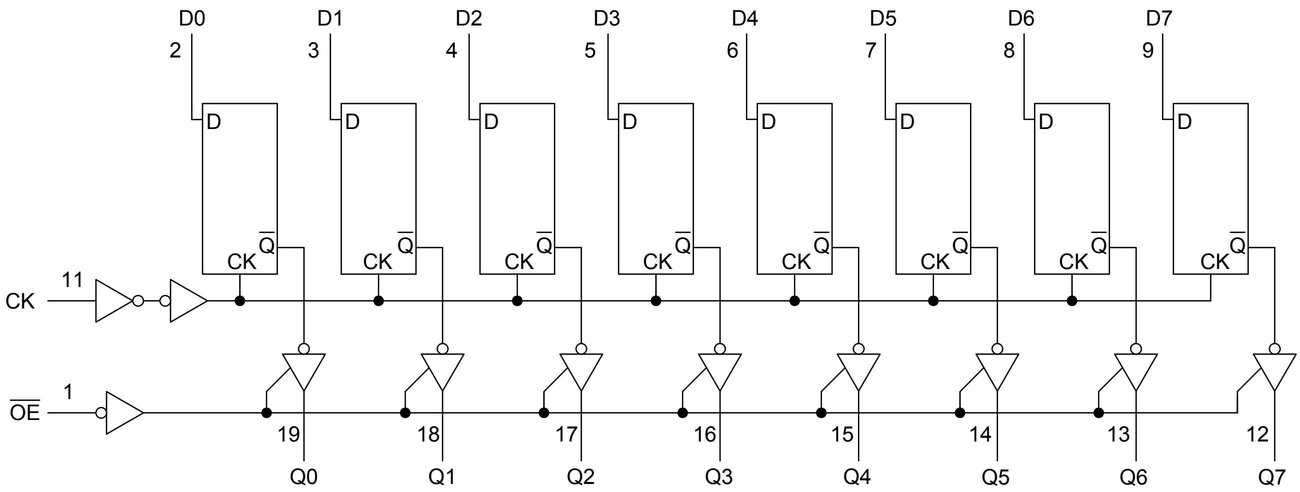
Inputs			Outputs
$\overline{OE}$	CK	D	
H	X	X	Z
L	↓	X	Q_n
L	↑	L	L
L	↑	H	H

X: Don't care

Z: High impedance

Q_n: 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}	±50 (Note 4)	mA
DC output current	I_{OUT}	±50	mA
Power dissipation	P_D	180	mW
DC V_{CC}/ground current	I_{CC}/I_{GND}	±100	mA
Storage temperature	T_{stg}	−65 to 150	°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
Supply voltage	V_{CC}	1.2 to 3.6	V
Input voltage	V_{IN}	−0.3 to 3.6	V
Output voltage	V_{OUT}	0 to 3.6 (Note 2)	V
		0 to V_{CC} (Note 3)	
Output current	I_{OH}/I_{OL}	±24 (Note 4)	mA
		±18 (Note 5)	
		±6 (Note 6)	
		±2 (Note 7)	
Operating temperature	T_{opr}	−40 to 85	°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: Off-state

Note 3: High or low state

Note 4: V_{CC} = 3.0 to 3.6 V

Note 5: V_{CC} = 2.3 to 2.7 V

Note 6: V_{CC} = 1.65 to 1.95 V

Note 7: V_{CC} = 1.4 to 1.6 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 < V_{CC} ≤ 3.6 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	High level	V_{IH}	—		2.7 to 3.6	2.0	—	V
	Low level	V_{IL}	—		2.7 to 3.6	—	0.8	
Output voltage	High level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = −100 μA	2.7 to 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	—	
	Low level	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 100 μA	2.7 to 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	
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	
		ΔI_{CC}	V_{IH} = V_{CC} − 0.6 V (per input)		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	High level	V_{IH}	—		2.3 to 2.7	1.6	—	V
	Low level	V_{IL}	—		2.3 to 2.7	—	0.7	
Output voltage	High level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = −100 μA	2.3 to 2.7	V_{CC} − 0.2	—	V
				I_{OH} = −6 mA	2.3	2.0	—	
				I_{OH} = −12 mA	2.3	1.8	—	
				I_{OH} = −18 mA	2.3	1.7	—	
	Low level	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 100 μA	2.3 to 2.7	—	0.2	
				I_{OL} = 12 mA	2.3	—	0.4	
				I_{OL} = 18 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, 1.65 V ≤ V_{CC} < 2.3 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	High level	V_{IH}	—		1.65 to 2.3	0.65 × V_{CC}	—	V
	Low level	V_{IL}	—		1.65 to 2.3	—	0.2 × V_{CC}	
Output voltage	High level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = –100 μA	1.65 to 2.3	V_{CC} – 0.2	—	V
				I_{OH} = –6 mA	1.65	1.25	—	
	Low level	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 100 μA	1.65 to 2.3	—	0.2	
				I_{OL} = 6 mA	1.65	—	0.3	
Input leakage current		I_{IN}	V_{IN} = 0 to 3.6 V		1.65 to 2.3	—	±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		1.65	—	±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		1.65 to 2.3	—	20.0	μA
			V_{CC} ≤ (V_{IN}, V_{OUT}) ≤ 3.6 V		1.65 to 2.3	—	±20.0	

DC Characteristics (Ta = –40 to 85°C, 1.4V ≤ V_{CC} <1.65 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	High level	V_{IH}	—		1.4 to 1.65	0.65 × V_{CC}	—	V
	Low level	V_{IL}	—		1.4 to 1.65	—	0.05 × V_{CC}	
Output voltage	High level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = –100 μA	1.4 to 1.65	V_{CC} – 0.2	—	V
				I_{OH} = –2 mA	1.4	1.05	—	
	Low level	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 100 μA	1.4 to 1.65	—	0.05	
				I_{OL} = 2 mA	1.4	—	0.35	
Input leakage current		I_{IN}	V_{IN} = 0 to 3.6 V		1.4 to 1.65	—	±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		1.4 to 1.65	—	±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		1.4 to 1.65	—	20.0	μA
			V_{CC} ≤ (V_{IN}, V_{OUT}) ≤ 3.6 V		1.4 to 1.65	—	±20.0	

DC Characteristics (Ta = –40 to 85°C, 1.2 V ≤ V_{CC} < 1.4 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	High level	V_{IH}	—		1.2 to 1.4	0.8 × V_{CC}	—	V
	Low level	V_{IL}	—		1.2 to 1.4	—	0.05 × V_{CC}	
Output voltage	High level	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OH} = -100$ μA	1.2	V_{CC} − 0.1	—	V
	Low level	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OL} = 100$ μA	1.2	—	0.05	
Input leakage current		I_{IN}	V_{IN} = 0 to 3.6 V		1.2	—	±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		1.2	—	±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		1.2	—	20.0	μA
			$V_{CC} \le (V_{IN}, V_{OUT}) \le 3.6$ V		1.2	—	±20.0	

AC Characteristics (Ta = –40 to 85°C, Input: $t_r = t_f = 2.0$ ns) (Note 1)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Maximum clock frequency	f_{max}	Figure 1, Figure 2	$C_L = 15$ pF, $R_L = 2$ kΩ	1.2	40	—	MHz
				1.5 ± 0.1	80	—	
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	100	—	
				2.5 ± 0.2	200	—	
				3.3 ± 0.3	250	—	
Propagation delay time (CK-Q)	t_{pLH} t_{pHL}	Figure 1, Figure 2	$C_L = 15$ pF, $R_L = 2$ kΩ	1.2	1.5	48	ns
				1.5 ± 0.1	1.0	19.2	
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	1.5	9.6	
				2.5 ± 0.2	0.8	4.8	
				3.3 ± 0.3	0.6	4.2	
3-state output enable time	t_{pZL} t_{pZH}	Figure 1, Figure 3	$C_L = 15$ pF, $R_L = 2$ kΩ	1.2	1.5	49.0	ns
				1.5 ± 0.1	1.0	19.6	
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	1.5	9.8	
				2.5 ± 0.2	0.8	5.5	
				3.3 ± 0.3	0.6	4.5	
3-state output disable time	t_{pLZ} t_{pHZ}	Figure 1, Figure 3	$C_L = 15$ pF, $R_L = 2$ kΩ	1.2	1.5	32.5	ns
				1.5 ± 0.1	1.0	13.0	
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	1.5	6.5	
				2.5 ± 0.2	0.8	3.6	
				3.3 ± 0.3	0.6	3.3	
Minimum pulse width (CK)	$t_{w(H)}$ $t_{w(L)}$	Figure 1, Figure 2	$C_L = 15$ pF, $R_L = 2$ kΩ	1.2	24	—	ns
				1.5 ± 0.1	8.0	—	
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	4.0	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum set-up time	t_s	Figure 1, Figure 2	$C_L = 15$ pF, $R_L = 2$ kΩ	1.2	20	—	ns
				1.5 ± 0.1	7.5	—	
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	2.5	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum hold time	t_h	Figure 1, Figure 2	$C_L = 15$ pF, $R_L = 2$ kΩ	1.2	0.8	—	ns
				1.5 ± 0.1	3.0	—	
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	1.0	—	
				2.5 ± 0.2	1.0	—	
				3.3 ± 0.3	1.0	—	
Output to output skew	t_{osLH} t_{osHL}	(Note 2)	$C_L = 15$ pF, $R_L = 2$ kΩ	1.2	—	1.5	ns
				1.5 ± 0.1	—	1.5	
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	—	0.5	
				2.5 ± 0.2	—	0.5	
				3.3 ± 0.3	—	0.5	

Note 1: For $C_L = 50$ pF, add approximately 300 ps to the AC maximum specification.

Note 2: This parameter is 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)

Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Quiet output maximum dynamic V_{OL}	V_{OLP}	$V_{IH} = 1.8$ V, $V_{IL} = 0$ V (Note)	1.8	0.25	V
		$V_{IH} = 2.5$ V, $V_{IL} = 0$ V (Note)	2.5	0.6	
		$V_{IH} = 3.3$ V, $V_{IL} = 0$ V (Note)	3.3	0.8	
Quiet output minimum dynamic V_{OL}	V_{OLV}	$V_{IH} = 1.8$ V, $V_{IL} = 0$ V (Note)	1.8	−0.25	V
		$V_{IH} = 2.5$ V, $V_{IL} = 0$ V (Note)	2.5	−0.6	
		$V_{IH} = 3.3$ V, $V_{IL} = 0$ V (Note)	3.3	−0.8	
Quiet output minimum dynamic V_{OH}	V_{OHV}	$V_{IH} = 1.8$ V, $V_{IL} = 0$ V (Note)	1.8	1.5	V
		$V_{IH} = 2.5$ V, $V_{IL} = 0$ V (Note)	2.5	1.9	
		$V_{IH} = 3.3$ V, $V_{IL} = 0$ V (Note)	3.3	2.2	

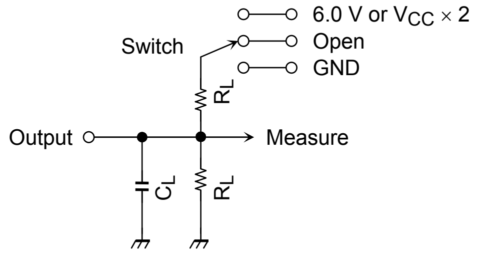
Note: This parameter is guaranteed by design.

Capacitive Characteristics (Ta = 25°C)

Characteristics	Symbol	Test Condition	VCC (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)	1.8, 2.5, 3.3	20	pF

Note: 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:
$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/8$ (per bit)

AC Test Circuit



Parameter	Switch
t_{pLH}, t_{pHL}	Open
t_{pLZ}, t_{pZL}	6.0 V @V_{CC} = 3.3 ± 0.3 V $V_{CC} \times 2$ @V_{CC} = 2.5 ± 0.2 V @V_{CC} = 1.8 ± 0.15 V @V_{CC} = 1.5 ± 0.1 V @V_{CC} = 1.2 V
t_{pHZ}, t_{pZH}	GND

Symbol	V_{CC}	
	3.3 ± 0.3 V 2.5 ± 0.2 V 1.8 ± 0.15 V	1.5 ± 0.1 V 1.2 V
R_L	500Ω	2kΩ
C_L	30pF	15pF

Figure 1

AC Waveform

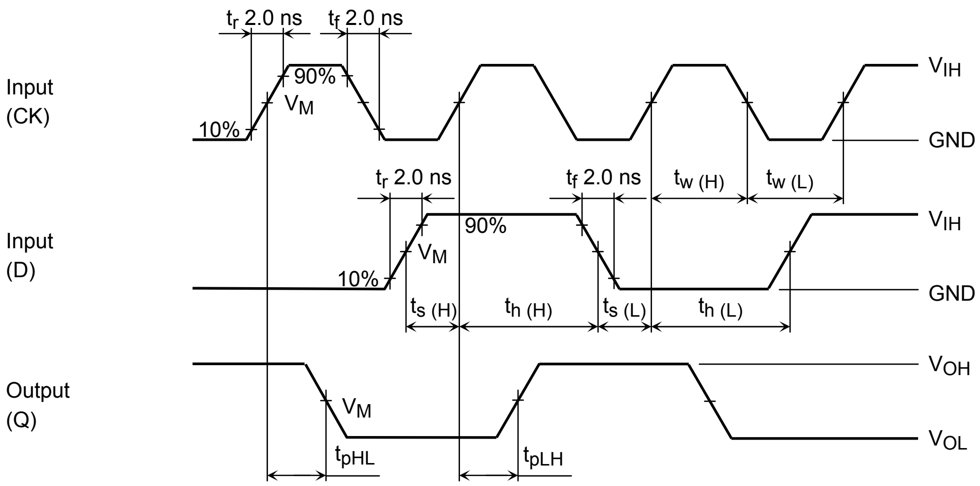


Figure 2 t_{pLH}, t_{pHL}, t_w, t_s, t_h

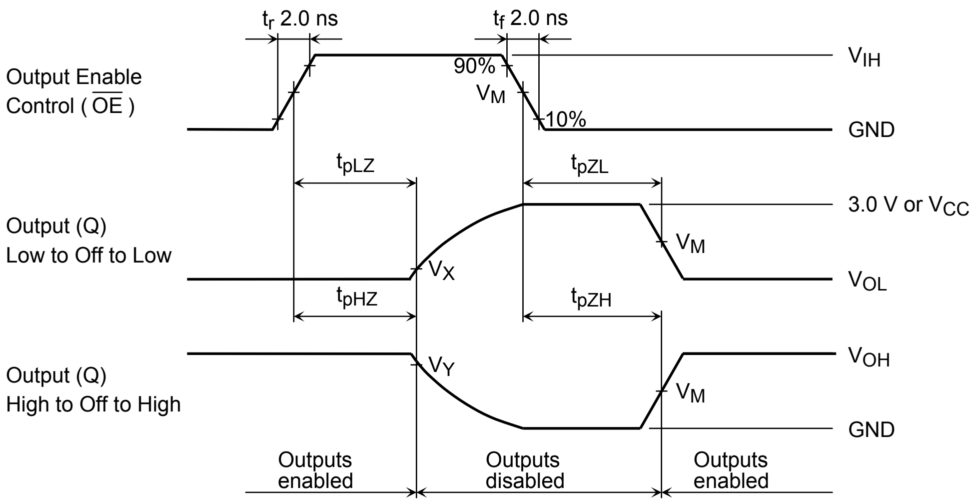
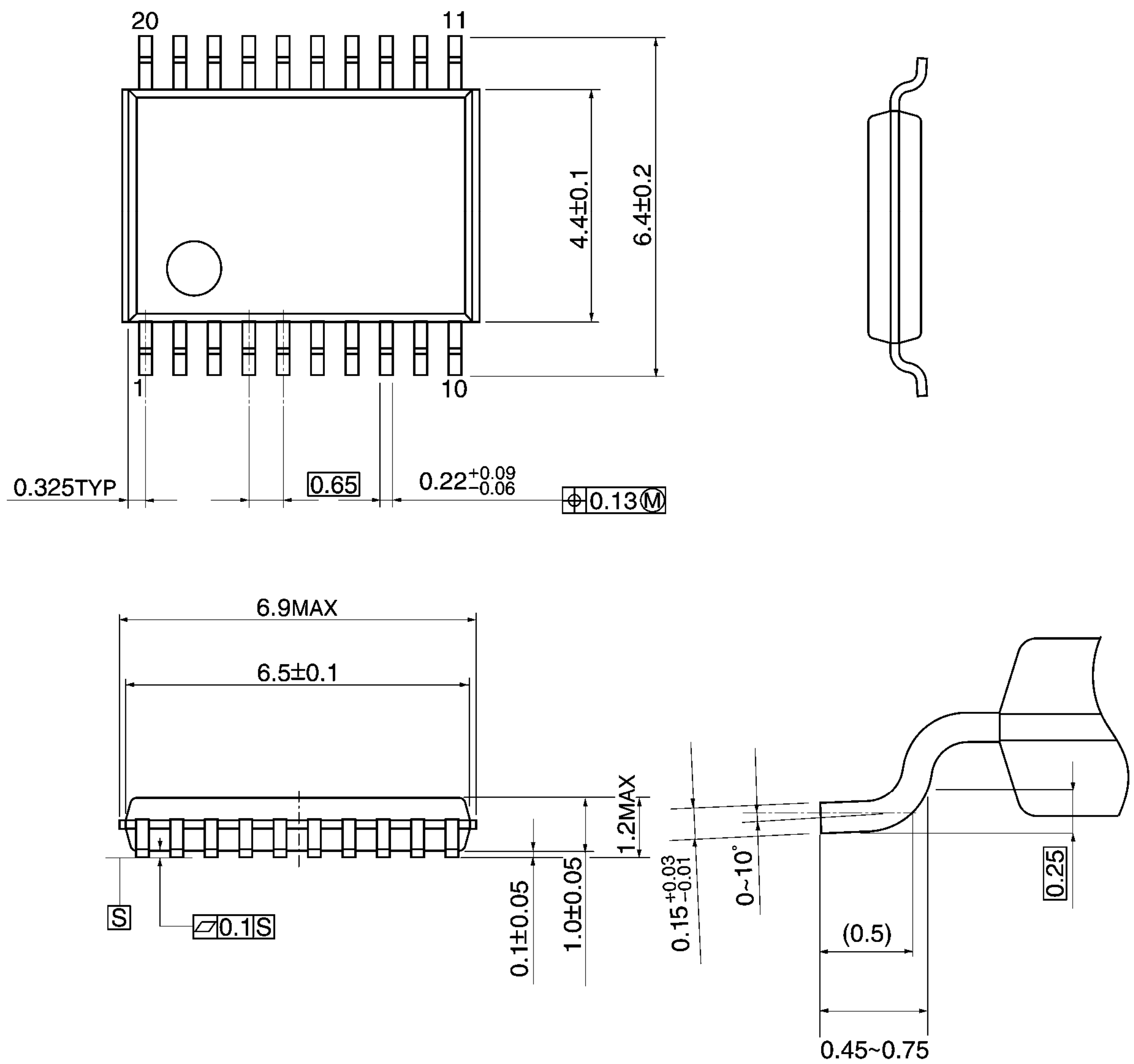


Figure 3 t_{pLZ}, t_{pHZ}, t_{pZL}, t_{pZH}

Symbol	V_{CC}				
	3.3 ± 0.3 V	2.5 ± 0.2 V	1.8 ± 0.15 V	1.5 ± 0.1 V	1.2 V
V_{IH}	2.7 V	V_{CC}	V_{CC}	V_{CC}	V_{CC}
V_M	1.5 V	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$
V_X	V_{OL} + 0.3 V	V_{OL} + 0.15 V	V_{OL} + 0.15 V	V_{OL} + 0.1 V	V_{OL} + 0.1 V
V_Y	V_{OH} − 0.3 V	V_{OH} − 0.15 V	V_{OH} − 0.15 V	V_{OH} − 0.1 V	V_{OH} − 0.1 V

Package Dimensions

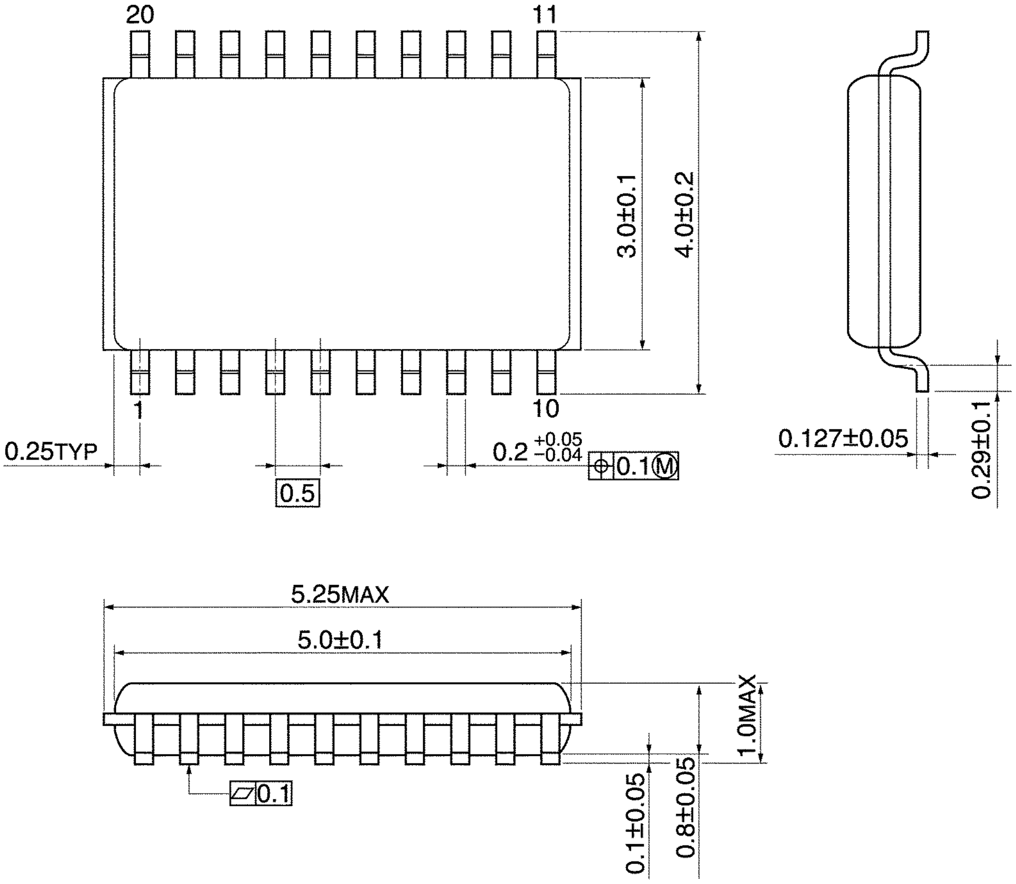
TSSOP20-P-0044-0.65A Unit: mm



Weight: 0.08 g (typ.)

Package Dimensions

VSSOP20-P-0030-0.50 Unit: mm



Weight: 0.03 g (typ.)

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