CMOS Digital Integrated Circuits Silicon Monolithic

TC74VCX574FK

1. Functional Description

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

2. General

The TC74VCX574FK 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 ($\overline{OE}$). When the $\overline{OE}$ input is high, the eight outputs are in a high impedance state.

All inputs are equipped with protection circuits against static discharge.

3. Features

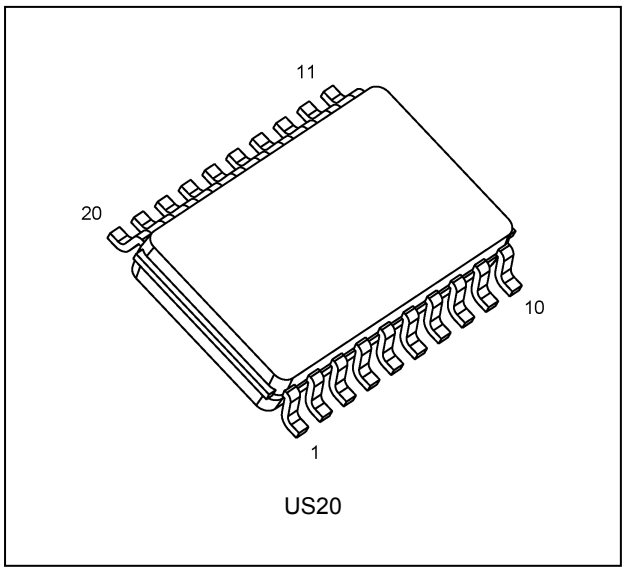
(1) Low-voltage operation: V_{CC} = 1.2 to 3.6 V

(2) 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) 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)

(4) 3.6 V tolerant function and power-down protection provided on all inputs and outputs.

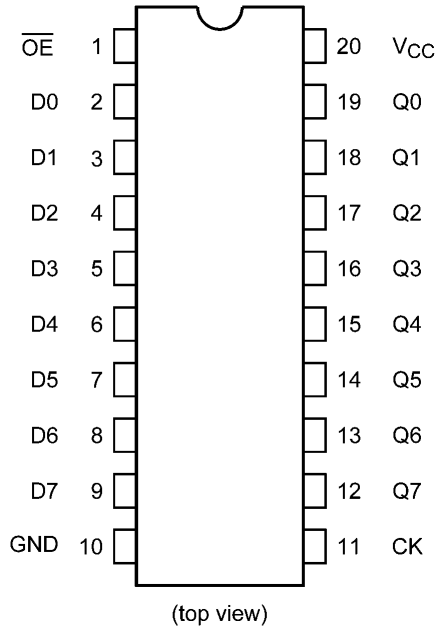
4. Packaging



US20

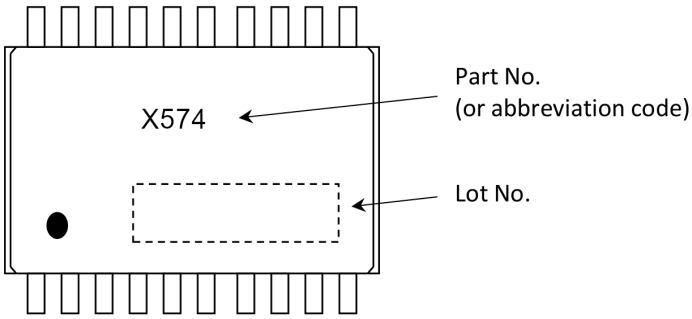
Start of commercial production
2006-04

5. Pin Assignment

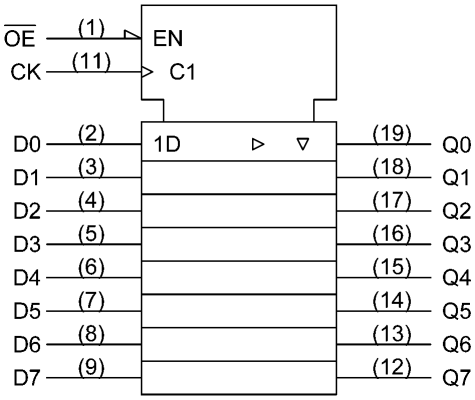


(top view)

6. Marking



7. IEC Logic Symbol

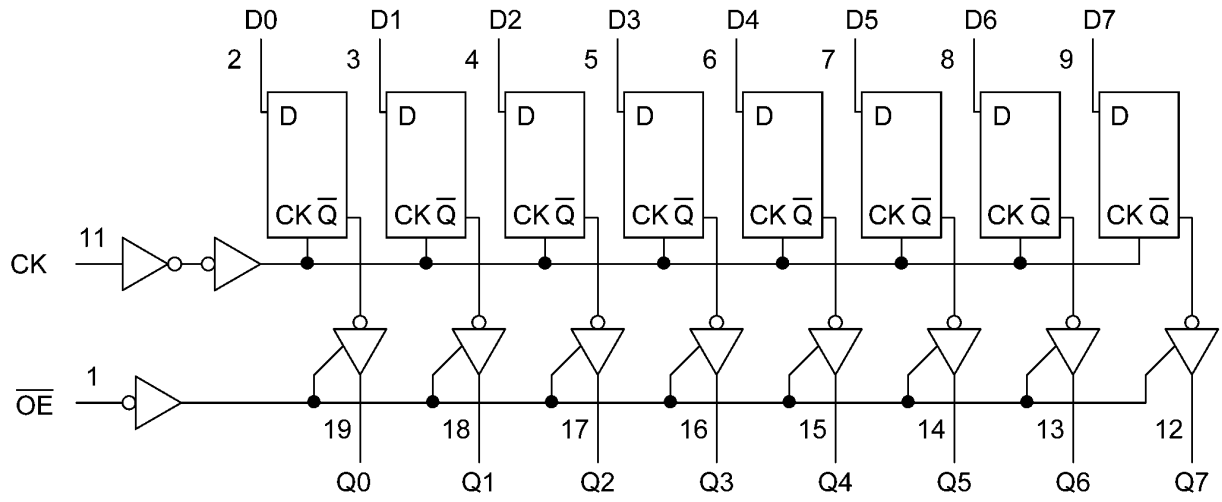


8. Truth Table

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

9. System Diagram



10. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		-0.5 to 4.6	V
Input voltage	V_{IN}		-0.5 to 4.6	V
Output voltage	V_{OUT}	(Note 1)	-0.5 to 4.6	V
		(Note 2)	-0.5 to V_{CC} + 0.5	
Input diode current	I_{IK}		-50	mA
Output diode current	I_{OK}	(Note 3)	±50	mA
Output current	I_{OUT}		±50	mA
Power dissipation	P_D		180	mW
V_{CC}/ground current	I_{CC}/I_{GND}		±100	mA
Storage temperature	T_{stg}		-65 to 150	°C

Note: 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 1: Output in OFF state.
Note 2: High (H) or Low (L) state. I_{OUT} absolute maximum rating must be observed.
Note 3: V_{OUT} < GND, V_{OUT} > V_{CC}

11. Operating Ranges (Note)

Characteristics	Symbol	Note	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}	(Note 1)	0 to 3.6	V
		(Note 2)	0 to V_{CC}	
Output current	I_{OH},I_{OL}	(Note 3)	±24	mA
		(Note 4)	±18	
		(Note 5)	±6	
		(Note 6)	±2	
Operating temperature	T_{opr}		-40 to 85	°C
Input rise and fall times	dt/dv	(Note 7)	0 to 10	ns/V

Note: 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 1: Output in OFF state.
Note 2: High (H) or Low (L) state.
Note 3: V_{CC} = 3.0 to 3.6 V
Note 4: V_{CC} = 2.3 to 2.7 V
Note 5: V_{CC} = 1.65 to 1.95 V
Note 6: V_{CC} = 1.4 to 1.6 V
Note 7: V_{IN} =0.8 to 2.0 V , V_{CC} = 3.0 V

12. Electrical Characteristics

12.1. DC Characteristics (Unless otherwise specified, T_a = -40 to 85 °C)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
High-level input voltage	V_{IH}	—		1.2 to 1.4	V_{CC} × 0.8	—	V
				1.4 to 1.65	V_{CC} × 0.65	—	
				1.65 to 2.3	V_{CC} × 0.65	—	
				2.3 to 2.7	1.6	—	
				2.7 to 3.6	2.0	—	
Low-level input voltage	V_{IL}	—		1.2 to 1.4	—	V_{CC} × 0.05	V
				1.4 to 1.65	—	V_{CC} × 0.05	
				1.65 to 2.3	—	V_{CC} × 0.2	
				2.3 to 2.7	—	0.7	
				2.7 to 3.6	—	0.8	
High-level output voltage	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = -100 μA	1.2	V_{CC} - 0.1	—	V
				1.4 to 1.65	V_{CC} - 0.2	—	
				1.65 to 3.6	V_{CC} - 0.2	—	
			I_{OH} = -2 mA	1.4	1.05	—	
			I_{OH} = -6 mA	1.65	1.25	—	
				2.3	2.0	—	
			I_{OH} = -12 mA	2.3	1.8	—	
				2.7	2.2	—	
			I_{OH} = -18 mA	2.3	1.7	—	
				3.0	2.4	—	
			I_{OH} = -24 mA	3.0	2.2	—	
Low-level output voltage	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 100 μA	1.2	—	0.05	V
				1.4 to 1.65	—	0.05	
				1.65 to 3.6	—	0.2	
			I_{OL} = 2 mA	1.4	—	0.35	
			I_{OL} = 6 mA	1.65	—	0.3	
			I_{OL} = 12 mA	2.3	—	0.4	
				2.7	—	0.4	
			I_{OL} = 18 mA	2.3	—	0.6	
				3.0	—	0.4	
			I_{OL} = 24 mA	3.0	—	0.55	
Input leakage current	I_{IN}	V_{IN} = 0 to 3.6 V		1.2 to 3.6	—	±5.0	μA
3-state output OFF-state leakage current	I_{OZ}	V_{IN} = V_{IH} or V_{IL} V_{OUT} = 0 to 3.6 V		1.2 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		1.2 to 3.6	—	20.0	μA
		V_{CC} ≤ (V_{IN}/V_{OUT}) ≤ 3.6 V		1.2 to 3.6	—	±20.0	
	ΔI_{CC}	V_{IH} = V_{CC} - 0.6 V (per input)		2.7 to 3.6	—	750	μA

12.2. AC Characteristics (Unless otherwise specified, T_a = -40 to 85 °C)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Min	Max	Unit
Maximum clock frequency	f_{MAX}		See 12.5 AC Test Circuit, Table 12.5.1, Fig. 12.6.1, Table 12.6.1	1.2	40	—	MHz
				1.5 ± 0.1	80	—	
				1.8 ± 0.15	100	—	
				2.5 ± 0.2	200	—	
				3.3 ± 0.3	250	—	
Propagation delay time (CK-Q)	t_{PLH},t_{PHL}		See 12.5 AC Test Circuit, Table 12.5.1, Fig. 12.6.1, Table 12.6.1	1.2	1.5	48.0	ns
				1.5 ± 0.1	1.0	19.2	
				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}		See 12.5 AC Test Circuit, Table 12.5.1, Fig. 12.6.2, Table 12.6.1	1.2	1.5	49.0	ns
				1.5 ± 0.1	1.0	19.6	
				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}		See 12.5 AC Test Circuit, Table 12.5.1, Fig. 12.6.2, Table 12.6.1	1.2	1.5	32.5	ns
				1.5 ± 0.1	1.0	13.0	
				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)	$t_{w(L)}$,$t_{w(H)}$		See 12.5 AC Test Circuit, Table 12.5.1, Fig. 12.6.1, Table 12.6.1	1.2	24.0	—	ns
				1.5 ± 0.1	8.0	—	
				1.8 ± 0.15	4.0	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum setup time	t_s		See 12.5 AC Test Circuit, Table 12.5.1, Fig. 12.6.1, Table 12.6.1	1.2	20.0	—	ns
				1.5 ± 0.1	7.5	—	
				1.8 ± 0.15	2.5	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum hold time	t_h		See 12.5 AC Test Circuit, Table 12.5.1, Fig. 12.6.1, Table 12.6.1	1.2	8.0	—	ns
				1.5 ± 0.5	3.0	—	
				1.8 ± 0.15	1.0	—	
				2.5 ± 0.2	1.0	—	
				3.3 ± 0.3	1.0	—	
Output skew	t_{osLH},t_{osHL}	(Note 1)	—	1.2	—	1.5	ns
				1.5 ± 0.1	—	1.5	
				1.8 ± 0.15	—	0.5	
				2.5 ± 0.2	—	0.5	
				3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design. (t_{osLH} = $|t_{PLH}m-t_{PLH}n|$, t_{osHL} = $|t_{PHL}m-t_{PHL}n|$)

12.3. Dynamic Switching Characteristics (Note) (Unless otherwise specified, T_a = 25°C, Input: $t_r = t_f$ = 2.0 ns, C_L = 30 pF)

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	1.8	0.25	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	0.6	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	0.8	
Quiet output minimum dynamic V_{OL}	V_{OLV}	V_{IH} = 1.8 V, V_{IL} = 0 V	1.8	-0.25	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	-0.6	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	-0.8	
Quiet output minimum dynamic V_{OH}	V_{OHV}	V_{IH} = 1.8 V, V_{IL} = 0 V	1.8	1.5	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	1.9	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	2.2	

Note: Parameter guaranteed by design.

12.4. Capacitive Characteristics (Unless otherwise specified, T_a = 25 °C)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}		—	1.8, 2.5, 3.3	6	pF
Output capacitance	C_{OUT}		—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C_{PD}	(Note 1)	f_{IN} = 10 MHz	1.8, 2.5, 3.3	20	pF

Note 1: 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.

$I_{CC}(opr) = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}/8$ (per gate)

12.5. AC Test Circuit

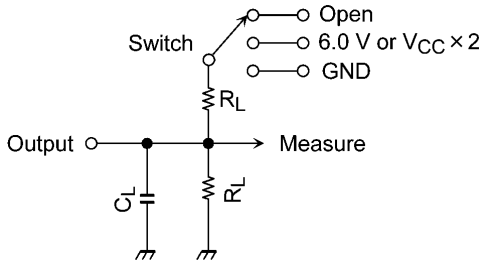


Table 12.5.1 Parameter for AC Test Circuit

Parameter	Switch	Test Condition
t_{PLH}, t_{PHL}	OPEN	—
t_{PLZ}, t_{PZL}	6.0 V	V_{CC} = 3.3 ± 0.3 V
	V_{CC} × 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	—

12.6. AC Waveform

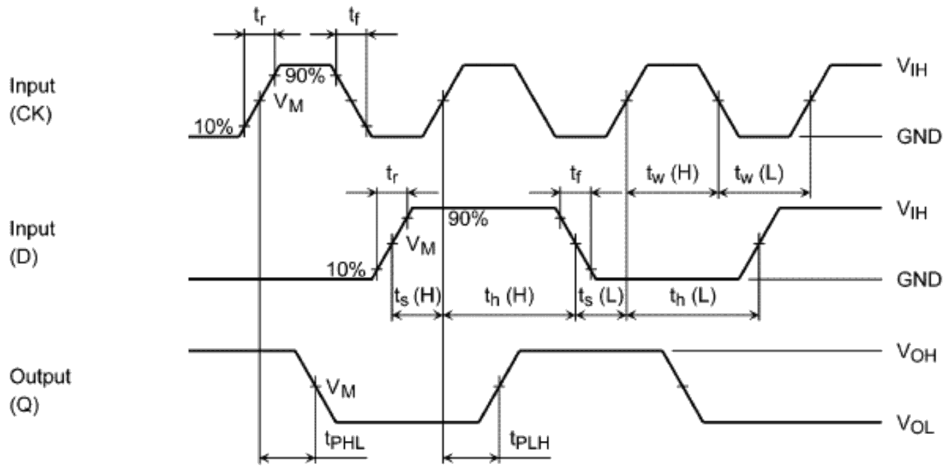


Fig. 12.6.1 t_{PLH}, t_{PHL}, t_w, t_s, t_h

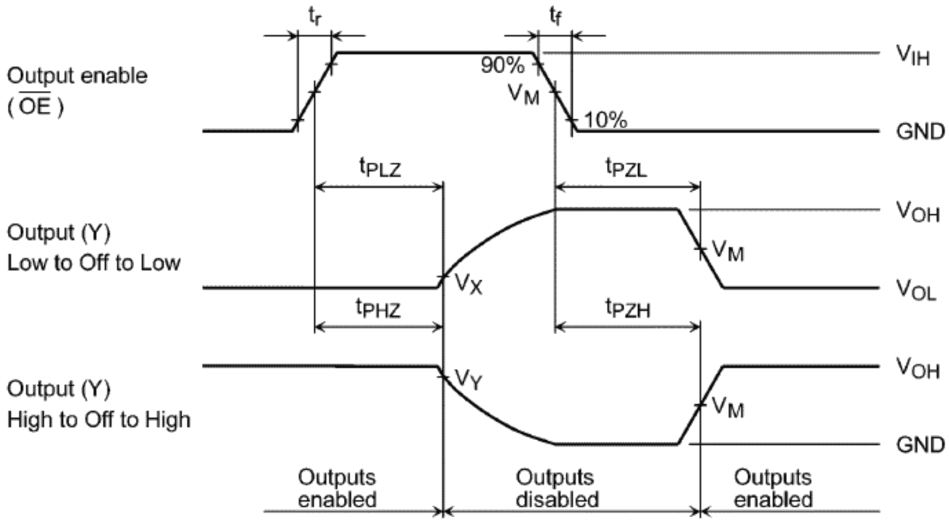


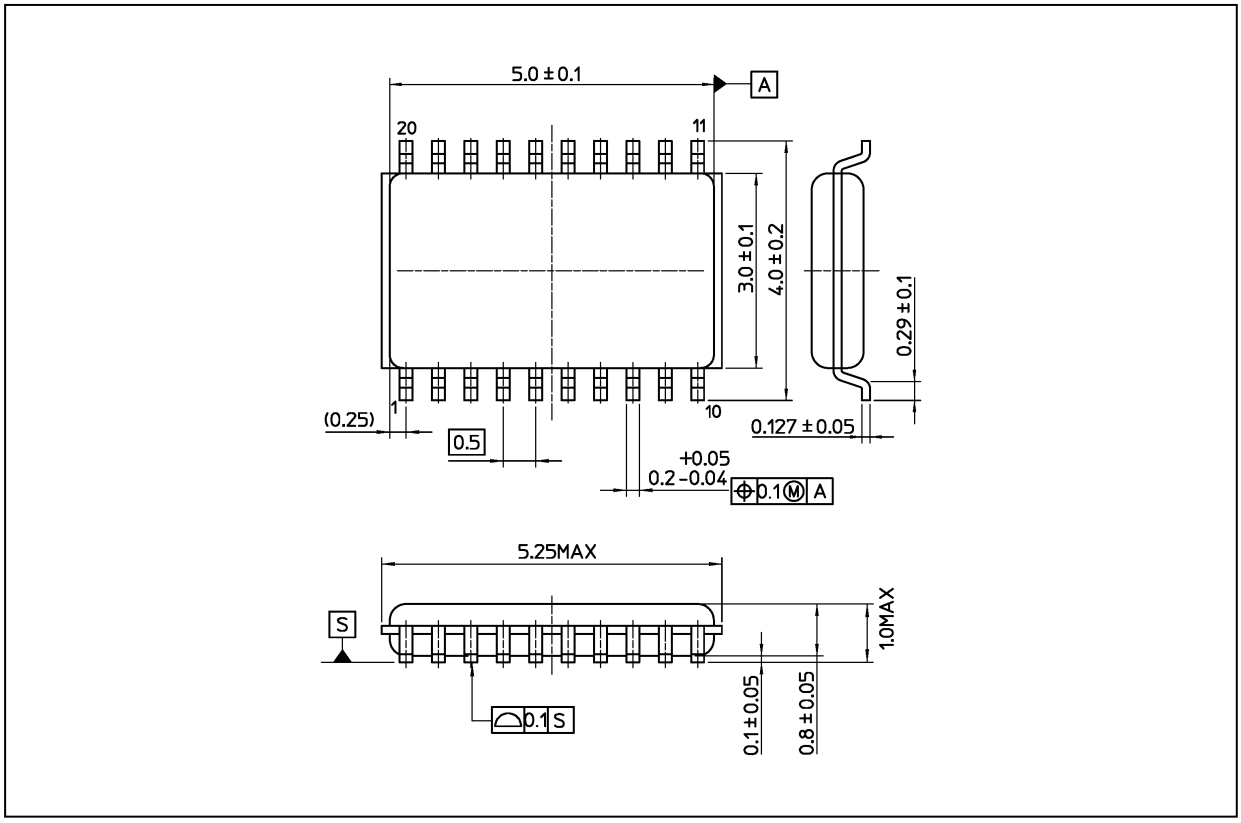
Fig. 12.6.2 t_{PLZ}, t_{PHZ}, t_{PZL}, t_{PZH}

Table 12.6.1 AC Waveform Symbols

	Symbol	V_{CC} = 3.3 ± 0.3 V	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
Input	V_{IH}	2.7 V	V_{CC}	V_{CC}
	V_M	1.5 V	V_{CC}/2	V_{CC}/2
	t_r, t_f	2.0 ns	2.0 ns	2.0 ns
Output	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
Load	C_L	30 pF	30 pF	15 pF
	R_L	500 Ω	500 Ω	2 kΩ

Package Dimensions

Unit: mm



Weight: 0.03 g (typ.)

Package Name(s)
Nickname: US20

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