

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC7MA373FK

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

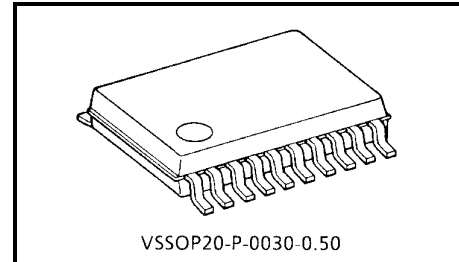
The TC7MA373FK is a high performance CMOS octal D-type latch which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5 V, 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

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

The 8 bit D-type latch is controlled by a latch enable input (LE) and a 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.

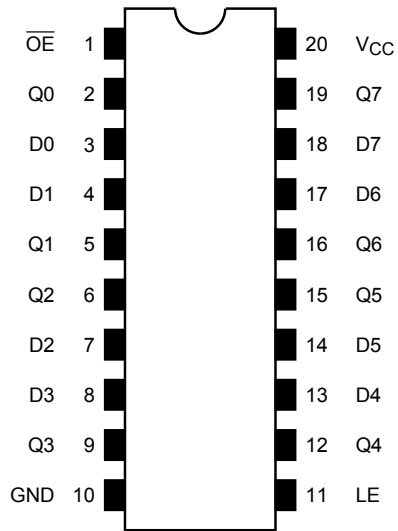


Weight: 0.03 g (typ.)

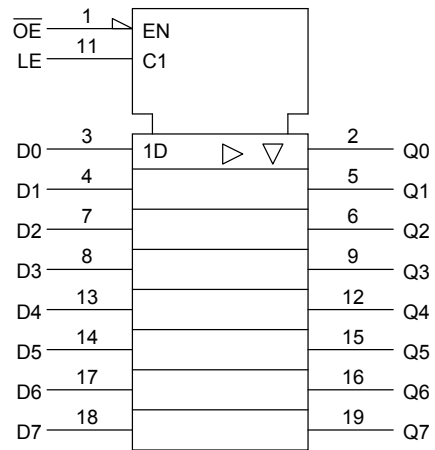
Features

- Low voltage operation: $V_{CC} = 1.2\sim 3.6\text{ V}$
- High speed operation: $t_{pd} = 4.2\text{ ns (max) (}V_{CC} = 3.0\sim 3.6\text{ V)}$
 $t_{pd} = 4.7\text{ ns (max) (}V_{CC} = 2.3\sim 2.7\text{ V)}$
 $t_{pd} = 9.4\text{ ns (max) (}V_{CC} = 1.65\sim 1.95\text{ V)}$
 $t_{pd} = 18.8\text{ ns (max) (}V_{CC} = 1.4\sim 1.6\text{ V)}$
 $t_{pd} = 47.0\text{ ns (max) (}V_{CC} = 1.2\text{ V)}$
- 3.6 V tolerant inputs and outputs.
- Output current: $I_{OH}/I_{OL} = \pm 24\text{ mA (min) (}V_{CC} = 3.0\text{ V)}$
 $I_{OH}/I_{OL} = \pm 18\text{ mA (min) (}V_{CC} = 2.3\text{ V)}$
 $I_{OH}/I_{OL} = \pm 6\text{ mA (min) (}V_{CC} = 1.65\text{ V)}$
 $I_{OH}/I_{OL} = \pm 2\text{ mA (min) (}V_{CC} = 1.4\text{ V)}$
- Latch-up performance: -300 mA
- ESD performance: Machine model $\geq \pm 200\text{ V}$
Human body model $\geq \pm 2000\text{ V}$
- Package: VSSOP (US)
- Power down protection is provided on all inputs and outputs.

Pin Assignment (top view)



IEC Logic Level



Truth Table

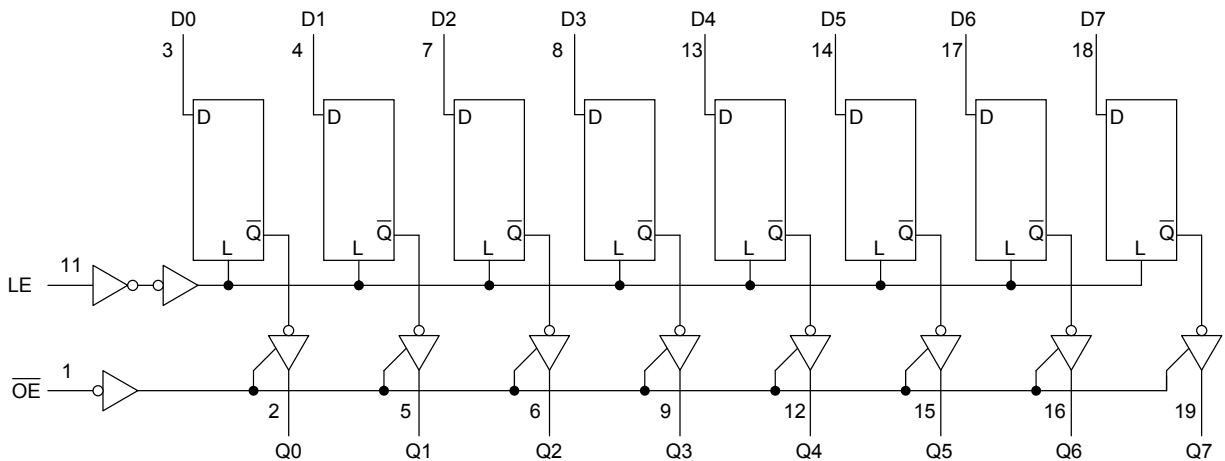
Inputs			Outputs
\overline{OE}	LE	D	
H	X	X	Z
L	L	X	Q_n
L	H	L	L
L	H	H	H

X: Don't care

Z: High impedance

Q_n : Q outputs are latched at the time when the LE input is taken to a low logic level.

System Diagram



Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{CC}	-0.5~4.6	V
DC input voltage	V_{IN}	-0.5~4.6	V
DC output voltage	V_{OUT}	-0.5~4.6 (Note 2)	V
		-0.5~ $V_{CC} + 0.5$ (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}	-65~150	°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}	1.2~3.6	V
Input voltage	V_{IN}	-0.3~3.6	V
Output voltage	V_{OUT}	0~3.6 (Note 2)	V
		0~ 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}	-40~85	°C
Input rise and fall time	dt/dv	0~10 (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: $V_{CC} = 0$ V

Note 3: High or low state

Note 4: $V_{CC} = 3.0\sim 3.6$ V

Note 5: $V_{CC} = 2.3\sim 2.7$ V

Note 6: $V_{CC} = 1.65\sim 1.95$ V

Note 7: $V_{CC} = 1.4\sim 1.6$ V

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

Electrical Characteristics

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

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V _{IH}	—		2.7~3.6	2.0	—	V
	Low level	V _{IL}	—		2.7~3.6	—	0.8	
Output voltage	High level	V _{OH}	V _{IN} = V _{IH} or V _{IL}	I _{OH} = -100 μA	2.7~3.6	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	2.7~3.6	—	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} = 0~3.6 V		2.7~3.6	—	±5.0	μA
3-state output off-state current		I _{OZ}	V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V		2.7~3.6	—	±10.0	μA
Power off leakage current		I _{OFF}	V _{IN} , V _{OUT} = 0~3.6 V		0	—	10.0	μA
Quiescent supply current		I _{CC}	V _{IN} = V _{CC} or GND		2.7~3.6	—	20.0	μA
			V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V		2.7~3.6	—	±20.0	
		ΔI _{CC}	V _{IH} = V _{CC} - 0.6 V (per input)		2.7~3.6	—	750	

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

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V _{IH}	—		2.3~2.7	1.6	—	V
	Low level	V _{IL}	—		2.3~2.7	—	0.7	
Output voltage	High level	V _{OH}	V _{IN} = V _{IH} or V _{IL}	I _{OH} = -100 μA	2.3~2.7	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	2.3~2.7	—	0.2	
				I _{OL} = 12 mA	2.3	—	0.4	
				I _{OL} = 18 mA	2.3	—	0.6	
				I _{OL} = 18 mA	2.3	—	0.6	
Input leakage current		I _{IN}	V _{IN} = 0~3.6 V		2.3~2.7	—	±5.0	μA
3-state output off-state current		I _{OZ}	V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V		2.3~2.7	—	±10.0	μA
Power off leakage current		I _{OFF}	V _{IN} , V _{OUT} = 0~3.6 V		0	—	10.0	μA
Quiescent supply current		I _{CC}	V _{IN} = V _{CC} or GND		2.3~2.7	—	20.0	μA
			V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V		2.3~2.7	—	±20.0	

DC Characteristics (Ta = -40~85°C, 1.65 V ≤ VCC < 2.3 V)

Characteristics		Symbol	Test Condition		Min	Max	Unit
				VCC (V)			
Input voltage	High level	V _{IH}	—		1.65~2.3	0.65 × V _{CC}	V
	Low level	V _{IL}	—		1.65~2.3	0.2 × V _{CC}	
Output voltage	High level	V _{OH}	V _{IN} = V _{IH} or V _{IL}	I _{OH} = -100 μA	1.65~2.3	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	1.65~2.3	0.2	
				I _{OL} = 6 mA	1.65	0.3	
Input leakage current		I _{IN}	V _{IN} = 0~3.6 V		1.65~2.3	±5.0	μA
3-state output off-state current		I _{OZ}	V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V		1.65~2.3	±10.0	μA
Power off leakage current		I _{OFF}	V _{IN} , V _{OUT} = 0~3.6 V		0	10.0	μA
Quiescent supply current		I _{CC}	V _{IN} = V _{CC} or GND		1.65~2.3	20.0	μA
			V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V		1.65~2.3	±20.0	

DC Characteristics (Ta = -40~85°C, 1.4 V ≤ VCC < 1.65 V)

Characteristics		Symbol	Test Condition		Min	Max	Unit
				VCC (V)			
Input voltage	High level	V _{IH}	—		1.4~1.65	0.65 × V _{CC}	V
	Low level	V _{IL}	—		1.4~1.65	0.05 × V _{CC}	
Output voltage	High level	V _{OH}	V _{IN} = V _{IH} or V _{IL}	I _{OH} = -100 μA	1.4~1.65	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	1.4~1.65	0.05	
				I _{OL} = 2 mA	1.4	0.35	
Input leakage current		I _{IN}	V _{IN} = 0~3.6 V		1.4~1.65	±5.0	μA
3-state output off-state current		I _{OZ}	V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V		1.4~1.65	±10.0	μA
Power off leakage current		I _{OFF}	V _{IN} , V _{OUT} = 0~3.6 V		0	10.0	μA
Quiescent supply current		I _{CC}	V _{IN} = V _{CC} or GND		1.4~1.65	20.0	μA
			V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V		1.4~1.65	±20.0	

DC Characteristics (Ta = -40~85°C, 1.2 V ≤ VCC <1.4 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V _{IH}	—		1.2~1.4	0.8 × V _{CC}	—	V
	Low level	V _{IL}	—		1.2~1.4	—	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} = 0~3.6 V		1.2	—	±5.0	μA
3-state output off-state current		I _{OZ}	V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0~3.6 V		1.2	—	±10.0	μA
Power off leakage current		I _{OFF}	V _{IN} , V _{OUT} = 0~3.6 V		0	—	10.0	μA
Quiescent supply current		I _{CC}	V _{IN} = V _{CC} or GND		1.2	—	20.0	μA
			V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V		1.2	—	±20.0	

AC Characteristics (Ta = -40~85°C, Input: tr = tf = 2.0 ns)

Characteristics	Symbol	Test Condition		VCC (V)	Min	Max	Unit
Propagation delay time (D-Q)	t _{pLH} t _{pHL}	Figure 1, Figure 2	C _L = 15 pF, R _L = 2 kΩ	1.2	1.5	47.0	ns
				1.5 ± 0.1	1.0	18.8	
	C _L = 30 pF, R _L = 500 Ω	1.8 ± 0.15	1.5	9.4			
		2.5 ± 0.2	0.8	4.7			
Propagation delay time (LE-Q)	t _{pLH} t _{pHL}	Figure 1, Figure 2	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	4.9			
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-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			
Minimum pulse width (LE)	t _{w(H)}	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	—			
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	—			
Minimum hold time	t _h	Figure 1, Figure 2	C _L = 15 pF, R _L = 2 kΩ	1.2	8.0	—	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	—			
Output to output skew	t _{osLH} t _{osHL}	(Note)	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	

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

Note: 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: tr = tf = 2.0 ns, CL = 30 pF)

Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Quiet output maximum dynamic VOL	VOLP	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 VOL	VOLV	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 VOH	VOHV	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)

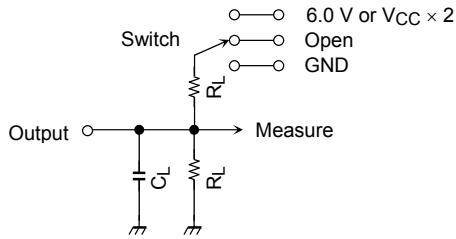
Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Input capacitance	C _{IN}	—	1.8, 2.5, 3.3	6	pF
Output capacitance	C _O	—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C _{PD}	f _{IN} = 10 MHz (Note)	1.8, 2.5, 3.3	20	pF

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:

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

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 @ $V_{CC} = 1.8 \pm 0.15$ V @ $V_{CC} = 1.5 \pm 0.1$ 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
R_L	500Ω	2kΩ
C_L	30pF	15pF

Figure 1

AC Waveform

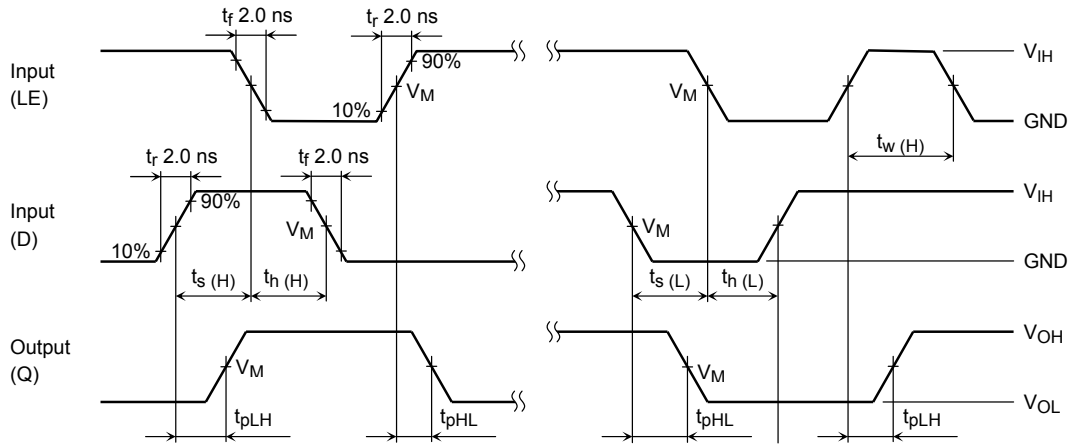
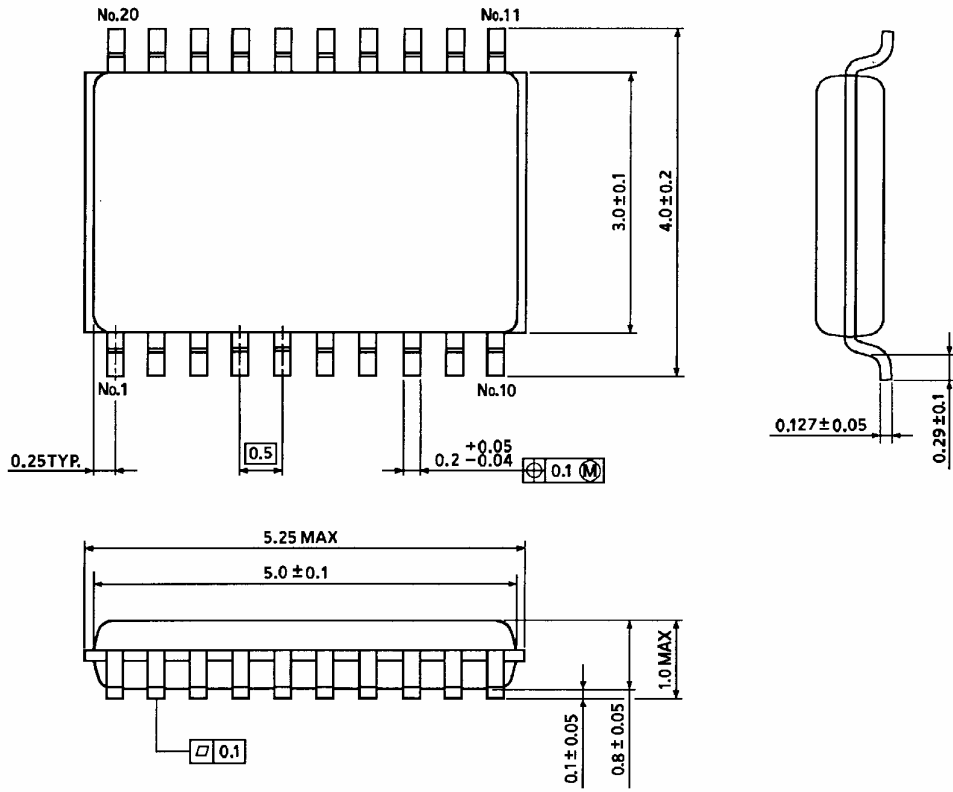


Figure 2 t_{pLH} , t_{pHL} , t_w , t_s , t_h

Package Dimensions

VSSOP20-P-0030-0.50

Unit : mm



Weight: 0.03 g (typ.)

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20070701-EN GENERAL

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