TOSHIBA CMOS Digital Integrated Circuit   Silicon Monolithic

TC7MA2574FK

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

The TC7MA2574FK is a high performance CMOS octal 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 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.

The 26 Ω series resistor helps reducing output overshoot and undershoot without external resistor.

All inputs are equipped with protection circuits against static discharge.
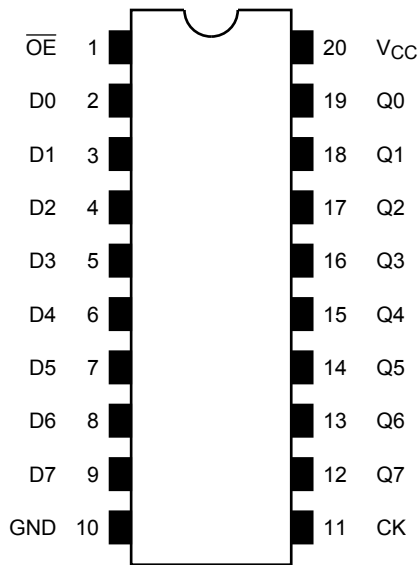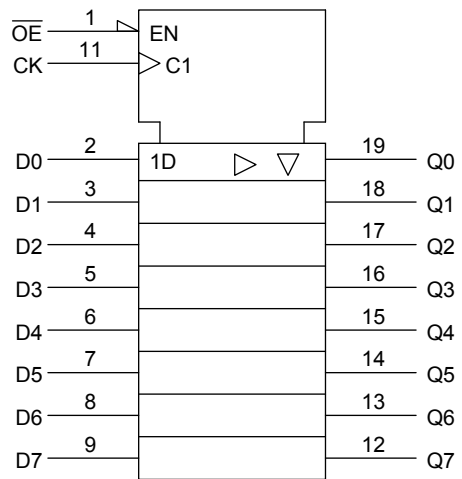
VSSOP20-P-0030-0.50
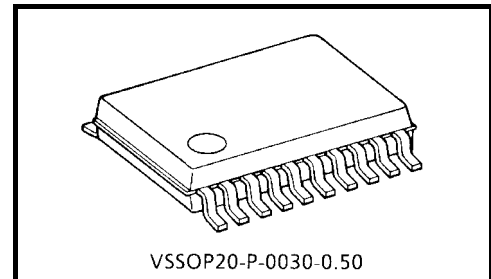
Weight: 0.03 g (typ.)

Features

- 26 Ω series resistors on outputs.
- Low voltage operation: V_{CC} = 1.8~3.6 V
- High speed operation: t_{pd} = 5.1 ns (max) (V_{CC} = 3.0~3.6 V)

    t_{pd} = 6.2 ns (max) (V_{CC} = 2.3~2.7 V)

    t_{pd} = 9.8 ns (max) (V_{CC} = 1.8 V)

- 3.6 V tolerant inputs and outputs.
- 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: VSSOP (US)
- Power down protection is provided on all inputs and outputs.

Pin Assignment (top view)

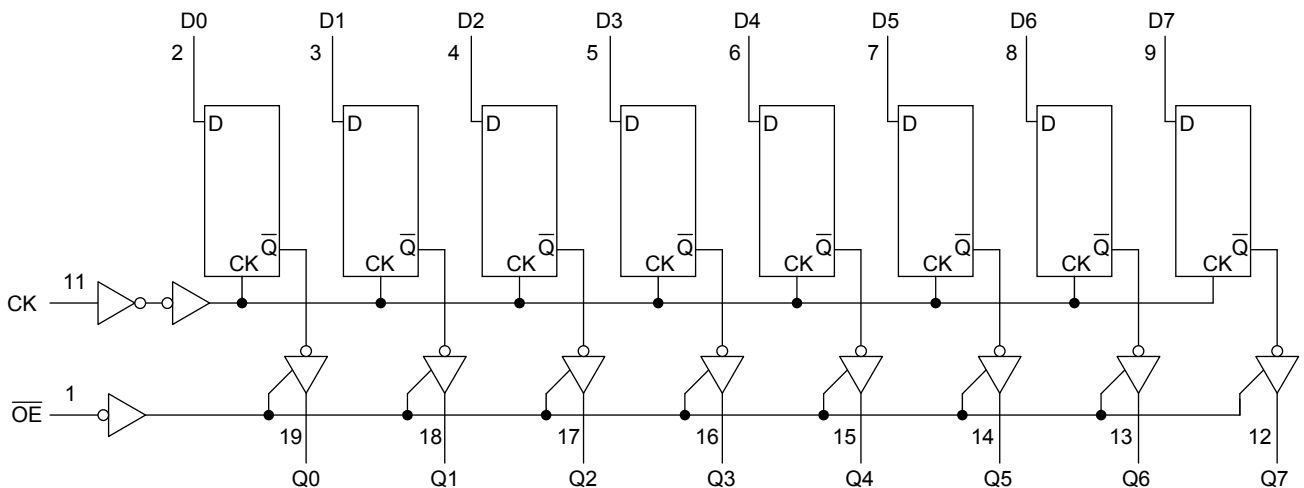|				
$\overline{OE}$	1		20	V_{CC}
D0	2		19	Q0
D1	3		18	Q1
D2	4		17	Q2
D3	5		16	Q3
D4	6		15	Q4
D5	7		14	Q5
D6	8		13	Q6
D7	9		12	Q7
GND	10		11	CK

IEC Logic Level

$\overline{OE}$	1	EN		
CK	11	C1		
D0	2	1D	19	Q0
D1	3		18	Q1
D2	4		17	Q2
D3	5		16	Q3
D4	6		15	Q4
D5	7		14	Q5
D6	8		13	Q6
D7	9		12	Q7

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

2007-10-19

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}	1.8~3.6		V
		1.2~3.6 (Note 2)		
Input voltage	V_{IN}	−0.3~3.6		V
Output voltage	V_{OUT}	0~3.6 (Note 3)		V
		0~V_{CC} (Note 4)		
Output current	I_{OH}/I_{OL}	±12 (Note 5)		mA
		±8 (Note 6)		
		±4 (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 VCC or GND.

Note 2: Data retention only

Note 3: Off-state

Note 4: High or low state

Note 5: V_{CC} = 3.0~3.6 V

Note 6: V_{CC} = 2.3~2.7 V

Note 7: V_{CC} = 1.8 V

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

Electrical Characteristics

DC Characteristics (Ta = −40~85°C, 2.7 V < V$_{CC}$ ≦ 3.6 V)

Characteristics		Symbol	Test Condition		V$_{CC}$ (V)	Min	Max	Unit
Input voltage	High level	V$_{IH}$	—		2.7~3.6	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$_{OH}$ = −6 mA	2.7	2.2	—	
				I$_{OH}$ = −8 mA	3.0	2.4	—	
				I$_{OH}$ = −12 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$_{OL}$ = 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$_{IN}$ = 0~3.6 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	
		Δl$_{CC}$	V$_{IH}$ = V$_{CC}$ − 0.6 V (per input)		2.7~3.6	—	750	

DC Characteristics (Ta = −40~85°C, 2.3 V ≦ V$_{CC}$ ≦ 2.7 V)

Characteristics		Symbol	Test Condition		V$_{CC}$ (V)	Min	Max	Unit
Input voltage	High level	V$_{IH}$	—		2.3~2.7	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$_{OH}$ = −4 mA	2.3	2.0	—	
				I$_{OH}$ = −6 mA	2.3	1.8	—	
				I$_{OH}$ = −8 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$_{OL}$ = 6 mA	2.3	—	0.4	
				I$_{OL}$ = 8 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, 1.8 V ≦ V_{CC} < 2.3 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	High level	V_{IH}	—		1.8~2.3	0.7 × V_{CC}	—	V
	Low level	V_{IL}	—		1.8~2.3	—	0.2 × V_{CC}	
Output voltage	High level	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OH} = -100$ μA	1.8	$V_{CC} - 0.2$	—	V
				$I_{OH} = -4$ mA	1.8	1.4	—	
	Low level	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OL} = 100$ μA	1.8	—	0.2	
				$I_{OL} = 4$ mA	1.8	—	0.3	
Input leakage current		I_{IN}	$V_{IN} = 0~3.6$ V		1.8	—	±5.0	μA
3-state output off-state current		I_{OZ}	$V_{IN} = V_{IH}$ or V_{IL} $V_{OUT} = 0~3.6$ V		1.8	—	±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		1.8	—	20.0	μA
			$V_{CC} ≦ (V_{IN}, V_{OUT}) ≦ 3.6$ V		1.8	—	±20.0	

AC Characteristics (Ta = −40~85°C, Input: $t_r = t_f = 2.0$ ns, $C_L = 30$ pF, $R_L = 500$ Ω)

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	6.2	
			3.3 ± 0.3	0.6	5.1	
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	6.5	
			3.3 ± 0.3	0.6	5.0	
3-state output disable time	t_{pLZ} t_{pHZ}	Figure 1, Figure 3	1.8	1.5	7.7	ns
			2.5 ± 0.2	0.8	4.3	
			3.3 ± 0.3	0.6	3.9	
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 set-up 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)	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: 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		V$_{CC}$ (V)	Typ.	Unit
Quiet output maximum dynamic V$_{OL}$	V$_{OLP}$	V$_{IH}$ = 1.8 V, V$_{IL}$ = 0 V	(Note)	1.8	0.15	V
		V$_{IH}$ = 2.5 V, V$_{IL}$ = 0 V	(Note)	2.5	0.25	
		V$_{IH}$ = 3.3 V, V$_{IL}$ = 0 V	(Note)	3.3	0.35	
Quiet output minimum dynamic V$_{OL}$	V$_{OLV}$	V$_{IH}$ = 1.8 V, V$_{IL}$ = 0 V	(Note)	1.8	−0.15	V
		V$_{IH}$ = 2.5 V, V$_{IL}$ = 0 V	(Note)	2.5	−0.25	
		V$_{IH}$ = 3.3 V, V$_{IL}$ = 0 V	(Note)	3.3	−0.35	
Quiet output minimum dynamic V$_{OH}$	V$_{OHV}$	V$_{IH}$ = 1.8 V, V$_{IL}$ = 0 V	(Note)	1.8	1.55	V
		V$_{IH}$ = 2.5 V, V$_{IL}$ = 0 V	(Note)	2.5	2.05	
		V$_{IH}$ = 3.3 V, V$_{IL}$ = 0 V	(Note)	3.3	2.65	

Note: This parameter is 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$_{OUT}$	—	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
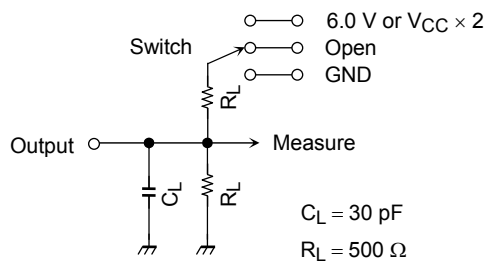
Parameter	Switch	
t_{pLH}, t_{pHL}	Open	
t_{pLZ}, t_{pZL}	6.0 V $V_{CC} \times 2$	@V_{CC} = 3.3 ± 0.3 V @V_{CC} = 2.5 ± 0.2 V @V_{CC} = 1.8 V
t_{pHZ}, t_{pZH}	GND	

Figure 1

AC Waveform
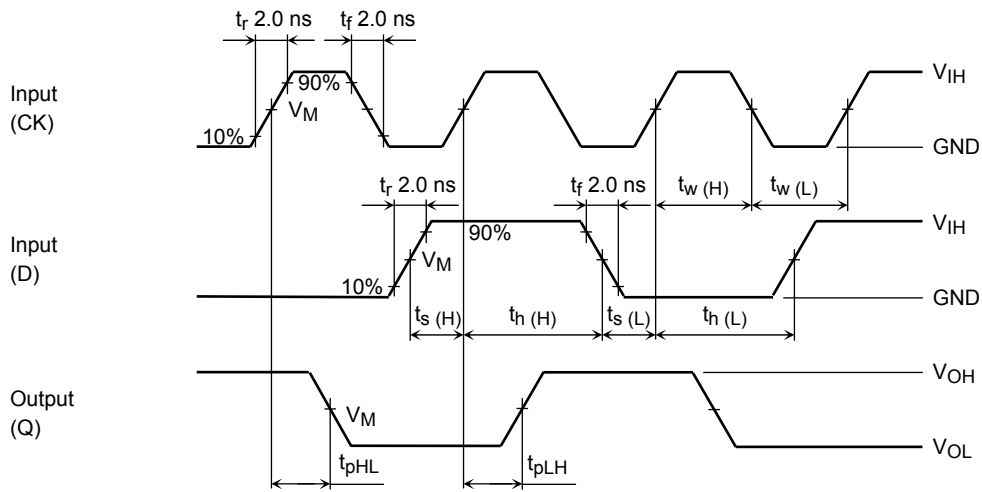
Figure 2 t_{pLH}, t_{pHL}, t_w, t_s, t_h
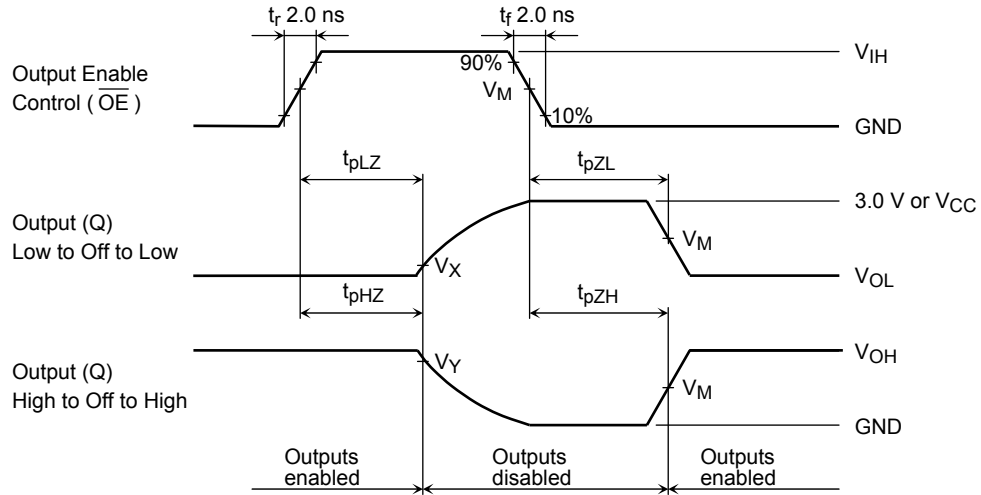
Figure 3 t_{pLZ}, t_{pHZ}, t_{pZL}, t_{pZH}

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

VSSOP20-P-0030-0.50   Unit : mm

No.20   No.11

3.0±0.1
4.0±0.2

No.1   No.10

0.25 TYP.   0.5   0.2 +0.05 −0.04   ⊕ 0.1 Ⓜ

0.127±0.05   0.29±0.1

5.25 MAX
5.0±0.1

1.0 MAX
0.1±0.05   0.8±0.05

▱ 0.1
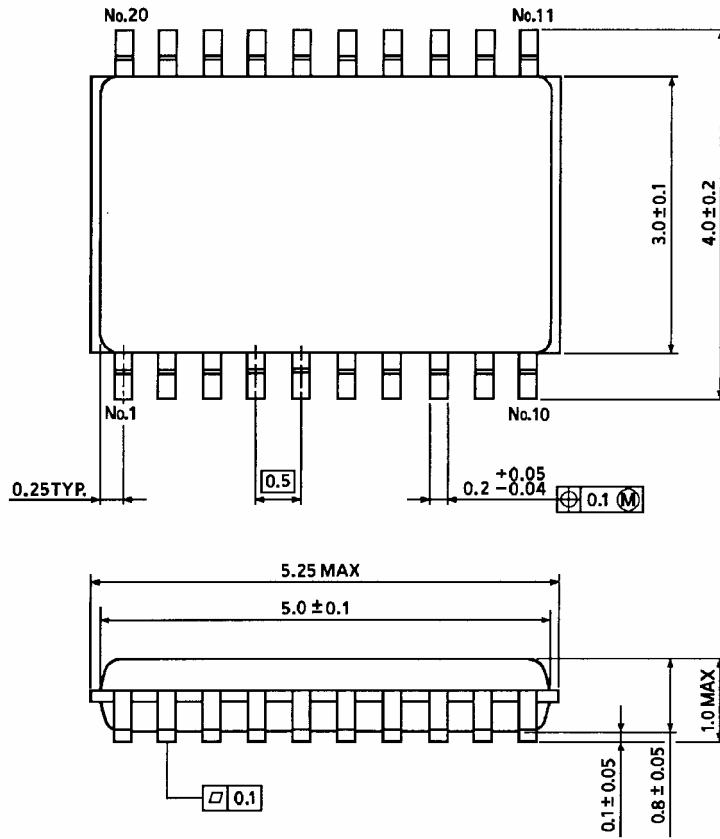
Weight: 0.03 g (typ.)

RESTRICTIONS ON PRODUCT USE