TOSHIBA CMOS Digital Integrated Circuit   Silicon Monolithic

TC7MA245FK

Low-Voltage Octal Bus Transceiver with 3.6 V Tolerant Inputs and Outputs

The TC7MA245FK is a high performance CMOS octal bus transceiver which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5V, 1.8V, 2.5V 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 direction of data transmission is determined by the level of the DIR inputs. The $\overline{\text{OE}}$ inputs can be used to disable the device so that the busses are effectively isolated.

All inputs are equipped with protection circuits against static discharge.
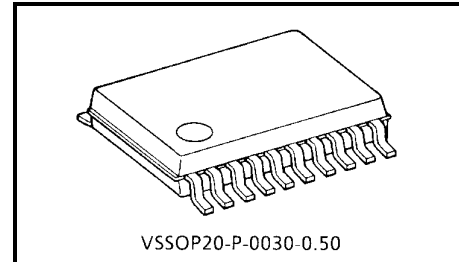
VSSOP20-P-0030-0.50

Weight: 0.03 g (typ.)

Features

- Low voltage operation: V_{CC} = 1.2~3.6 V
- High speed operation: t_{pd} = 3.5 ns (max) (V_{CC} = 3.0~3.6 V)

    t_{pd} = 4.2 ns (max) (V_{CC} = 2.3~2.7 V)

    t_{pd} = 8.4 ns (max) (V_{CC} = 1.65~1.95 V)

    t_{pd} = 16.8 ns (max) (V_{CC} = 1.4~1.6 V)

    t_{pd} = 42.0 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: VSSOP(US)
- Bidirectional interface between 2.5 V and 3.3 V signals. (*1)
- Power down protection is provided on all inputs and outputs. (*2)

*1: Do not apply a signal to any bus terminal when it is in the output mode. Damage may result.

*2: All floating (high impedance) bus terminal must have their input level fixed by means of pull up or pull down resistors.

Pin Assignment (top view)

IEC Logic Symbol

DIR	1	20	V_{CC}
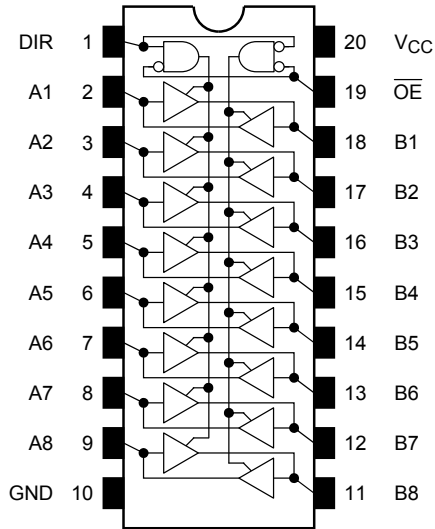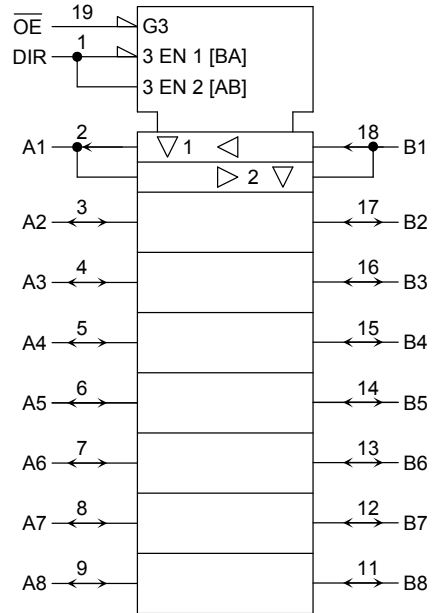
Truth Table

Inputs		Outputs	Function	
$\overline{OE}$	DIR		A-Bus	B-Bus
L	L	A = B	Output	Input
L	H	B = A	Input	Output
H	X	Z	Z	

X: Don't care

Z: High impedance

Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating		Unit
Power supply voltage	V_{CC}	−0.5~4.6		V
DC input voltage (DIR, $\overline{OE}$)	V_{IN}	−0.5~4.6		V
DC bus I/O voltage	$V_{I/O}$	−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: $V_{CC} = 0$ V

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 (DIR, $\overline{OE}$)	V_{IN}	−0.3~3.6		V
Bus I/O voltage	$V_{I/O}$	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 and bus inputs must be tied to either VCC or GND. Please connect both bus inputs and the bus outputs with VCC or GND when the I/O of the bus terminal changes by the function. In this case, please note that the output is not short-circuited.

Note 2: Off-state

Note 3: High or low state

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

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

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

Note 7: $V_{CC} = 1.4$~1.6 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
				$I_{OH} = -12$ 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	
Increase in I_{CC} per input		ΔI_{CC}	$V_{IH} = V_{CC} - 0.6$ V		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
				$I_{OH} = -6$ 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	
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	

2007-10-19

DC Characteristics (Ta = −40~85°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}	—		1.65~2.3	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 ≤ V_{CC} < 1.65 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
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 $\leq$ V$_{CC}$ < 1.4 V)

Characteristics		Symbol	Test Condition		V$_{CC}$ (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$_{CC}$ $\leq$ (V$_{IN}$, V$_{OUT}$) $\leq$ 3.6 V		1.2	—	±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
Propagation delay time	t$_{pLH}$ t$_{pHL}$	Figure 1, Figure 2	C$_L$ = 15 pF, R$_L$ = 2 kΩ	1.2	1.5	42.0	ns
				1.5 ± 0.1	1.0	16.8	
			C$_L$ = 30 pF, R$_L$ = 500 Ω	1.8 ± 0.15	1.5	8.4	
				2.5 ± 0.2	0.8	4.2	
				3.3 ± 0.3	0.6	3.5	
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	5.6	
				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	36.0	ns
				1.5 ± 0.1	1.0	14.4	
			C$_L$ = 30 pF, R$_L$ = 500 Ω	1.8 ± 0.15	1.5	7.2	
				2.5 ± 0.2	0.8	4.0	
				3.3 ± 0.3	0.6	3.6	
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: $t_r = t_f = 2.0$ 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	0.25	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		V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}	—		1.8, 2.5, 3.3	6	pF
Bus I/O capacitance	$C_{I/O}$	—		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

Figure 1
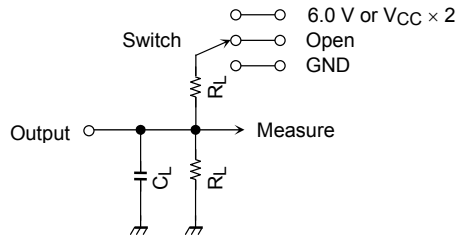
Parameter	Switch	
t_{pLH}, t_{pHL}	Open	
t_{pLZ}, t_{pZL}	6.0 V $V_{CC} \times 2$	@V_{CC} = 3.3 ± 0.3 V @V_{CC} = 2.5 ± 0.2 V @V_{CC} = 1.8 ± 0.15 V @V_{CC} = 1.5 ± 0.1 V @V_{CC} = 1.2 V
t_{pHZ}, t_{pZH}	GND	

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

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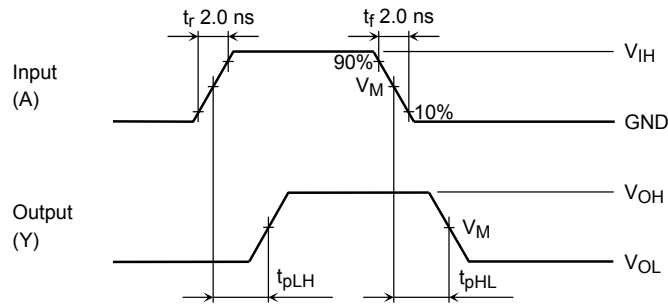
Figure 2 t_{pLH}, t_{pHL}
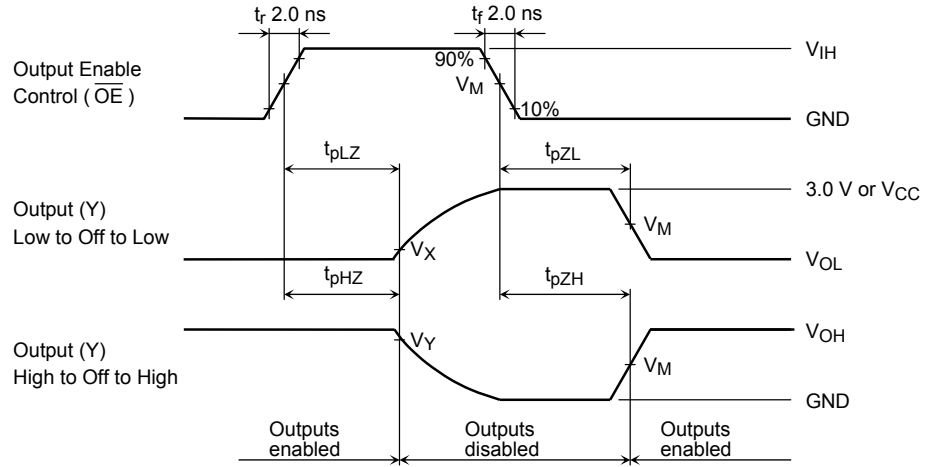
Figure 3 t_{pLZ}, t_{pHZ}, t_{pZL}, t_{pZH}

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

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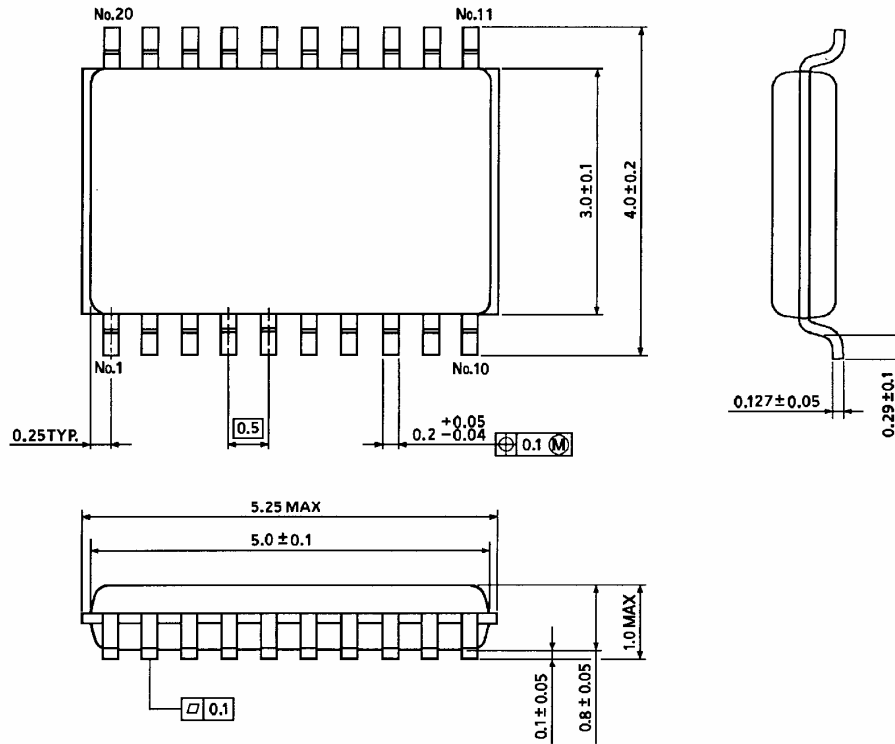
Weight: 0.03 g (typ.)

RESTRICTIONS ON PRODUCT USE

20070701-EN

- The information contained herein is subject to change without notice.

- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
  In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc.

- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.).These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in his document shall be made at the customer's own risk.

- The products described in this document shall not be used or embedded to any downstream products of which manufacture, use and/or sale are prohibited under any applicable laws and regulations.

- Please contact your sales representative for product-by-product details in this document regarding RoHS compatibility. Please use these products in this document in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances. Toshiba assumes no liability for damage or losses occurring as a result of noncompliance with applicable laws and regulations.