

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

## TC7MA2541FK

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

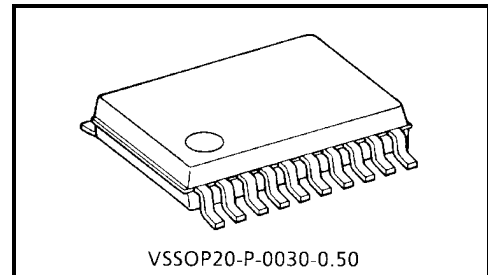
The TC7MA2541FK is a high performance CMOS octal bus buffer. Designed for use in 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

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

This device is non-inverting 3-state buffer having two active-low output enables. When either the  $\overline{OE}1$ ,  $\overline{OE}2$  are high, the terminal outputs are in the high-impedance state. This device is designed to be used with 3-state memory address drivers, etc.

The 26  $\Omega$  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

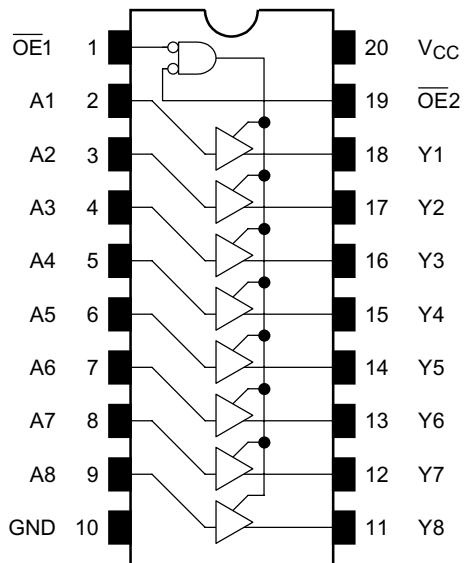
- 26  $\Omega$  series resistor on outputs.
- Low voltage operation:  $V_{CC} = 1.8\sim 3.6$  V
- High speed operation:  $t_{pd} = 4.4$  ns (max) ( $V_{CC} = 3.0\sim 3.6$  V)  
 $t_{pd} = 5.6$  ns (max) ( $V_{CC} = 2.3\sim 2.7$  V)  
 $t_{pd} = 9.8$  ns (max) ( $V_{CC} = 1.8$  V)
- 3.6 V tolerant inputs and outputs.
- Output current:  $I_{OH}/I_{OL} = \pm 12$  mA (min) ( $V_{CC} = 3.0$  V)  
 $I_{OH}/I_{OL} = \pm 8$  mA (min) ( $V_{CC} = 2.3$  V)  
 $I_{OH}/I_{OL} = \pm 4$  mA (min) ( $V_{CC} = 1.8$  V)
- Latch-up performance:  $\pm 300$  mA
- ESD performance: Machine model  $> \pm 200$  V  
Human body model  $> \pm 2000$  V
- Package: VSSOP (US20)
- Power down protection is provided on all inputs and outputs.
- Supports live insertion/withdrawal (\*)

\*: To ensure the high-impedance state during power up or power down,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pullup resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

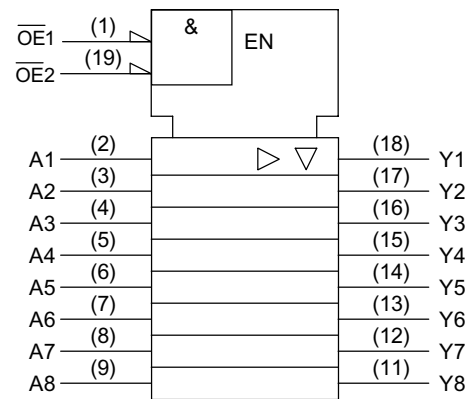
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## Pin Assignment (top view)



## IEC Logic Level



## Truth Table

Inputs			Outputs
$\overline{OE1}$	$\overline{OE2}$	$A_n$	
H	X	X	Z
X	H	X	Z
L	L	H	H
L	L	L	L

X: Don't care

Z: High impedance

## Maximum Ratings

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 (Note1)	V
		-0.5~ $V_{CC} + 0.5$ (Note2)	
Input diode current	$I_{IK}$	-50	mA
Output diode current	$I_{OK}$	$\pm 50$ (Note3)	mA
DC output current	$I_{OUT}$	$\pm 50$	mA
Power dissipation	$P_D$	180	mW
DC $V_{CC}$ /ground current	$I_{CC}/I_{GND}$	$\pm 100$	mA
Storage temperature	$T_{stg}$	-65~150	$^{\circ}C$

Note1: Off-state

Note2: High or low state.  $I_{OUT}$  absolute maximum rating must be observed.

Note3:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## Recommended Operating Range

Characteristics	Symbol	Rating	Unit
Supply voltage	$V_{CC}$	1.8~3.6	V
		1.2~3.6 (Note4)	
Input voltage	$V_{IN}$	-0.3~3.6	V
Output voltage	$V_{OUT}$	0~3.6 (Note5)	V
		0~ $V_{CC}$ (Note6)	
Output current	$I_{OH}/I_{OL}$	$\pm 12$ (Note7)	mA
		$\pm 8$ (Note8)	
		$\pm 4$ (Note9)	
Operating temperature	$T_{opr}$	-40~85	°C
Input rise and fall time	dt/dv	0~10 (Note10)	ns/V

Note4: Data retention only

Note5: Off-state

Note6: High or low state

Note7:  $V_{CC} = 3.0\sim 3.6$  V

Note8:  $V_{CC} = 2.3\sim 2.7$  V

Note9:  $V_{CC} = 1.8$  V

Note10:  $V_{IN} = 0.8\sim 2.0$  V,  $V_{CC} = 3.0$  V

## Electrical Characteristics

### DC Characteristics ( $T_a = -40\sim 85^\circ\text{C}$ , $2.7\text{ V} < V_{CC} \leq 3.6\text{ V}$ )

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 $V_{IL}$	$I_{OH} = -100\ \mu\text{A}$	2.7~3.6	$V_{CC} - 0.2$	—	V
				$I_{OH} = -6\ \text{mA}$	2.7	2.2	—	
				$I_{OH} = -8\ \text{mA}$	3.0	2.4	—	
				$I_{OH} = -12\ \text{mA}$	3.0	2.2	—	
	Low level	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 100\ \mu\text{A}$	2.7~3.6	—	0.2	
				$I_{OL} = 6\ \text{mA}$	2.7	—	0.4	
				$I_{OL} = 8\ \text{mA}$	3.0	—	0.55	
				$I_{OL} = 12\ \text{mA}$	3.0	—	0.8	
Input leakage current		$I_{IN}$	$V_{IN} = 0\sim 3.6\text{ V}$	2.7~3.6	—	$\pm 5.0$	$\mu\text{A}$	
3-state output off-state current		$I_{OZ}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{OUT} = 0\sim 3.6\text{ V}$	2.7~3.6	—	$\pm 10.0$	$\mu\text{A}$	
Power off leakage current		$I_{OFF}$	$V_{IN}, V_{OUT} = 0\sim 3.6\text{ V}$	0	—	10.0	$\mu\text{A}$	
Quiescent supply current		$I_{CC}$	$V_{IN} = V_{CC}$ or GND	2.7~3.6	—	20.0	$\mu\text{A}$	
			$V_{CC} \leq (V_{IN}, V_{OUT}) \leq 3.6\text{ V}$	2.7~3.6	—	$\pm 20.0$		
		$\Delta I_{CC}$	$V_{IH} = V_{CC} - 0.6\text{ V}$ (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 <sub>IH</sub>	—		2.3~2.7	1.6	—	V
	Low level	V <sub>IL</sub>	—		2.3~2.7	—	0.7	
Output voltage	High level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.3~2.7	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -4 mA	2.3	2.0	—	
				I <sub>OH</sub> = -6 mA	2.3	1.8	—	
	Low level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	2.3~2.7	—	0.2	
				I <sub>OL</sub> = 6 mA	2.3	—	0.4	
				I <sub>OL</sub> = 8 mA	2.3	—	0.6	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		2.3~2.7	—	±5.0	μA
3-state output off-state current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0~3.6 V		2.3~2.7	—	±10.0	μA
Power off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.3~2.7	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		2.3~2.7	—	±20.0	

## DC Characteristics (Ta = -40~85°C, 1.8 V ≤ VCC < 2.3 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V <sub>IH</sub>	—		1.8~2.3	0.7 × V <sub>CC</sub>	—	V
	Low level	V <sub>IL</sub>	—		1.8~2.3	—	0.2 × V <sub>CC</sub>	
Output voltage	High level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	1.8	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -4 mA	1.8	1.4	—	
	Low level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	1.8	—	0.2	
				I <sub>OL</sub> = 4 mA	1.8	—	0.3	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		1.8	—	±5.0	μA
3-state output off-state current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0~3.6 V		1.8	—	±10.0	μA
Power off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		1.8	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		1.8	—	±20.0	

## AC Characteristics (Ta = -40~85°C, Input: tr = tf = 2.0 ns, CL = 30 pF, RL = 500 Ω)

Characteristics	Symbol	Test Condition	VCC (V)	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	5.6	
			3.3 ± 0.3	0.6	4.4	
3-state output enable time	t <sub>pZL</sub> t <sub>pZH</sub>	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 <sub>pLZ</sub> t <sub>pHZ</sub>	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	
Output to output skew	t <sub>osLH</sub> t <sub>osHL</sub>	(Note11)	1.8	—	0.5	ns
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

For C<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

Note11: 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 V <sub>OL</sub>	V <sub>OLP</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note12)	1.8	0.15	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12)	2.5	0.25	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12)	3.3	0.35	
Quiet output minimum dynamic V <sub>OL</sub>	V <sub>OLV</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note12)	1.8	-0.15	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12)	2.5	-0.25	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12)	3.3	-0.35	
Quiet output minimum dynamic V <sub>OH</sub>	V <sub>OHV</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note12)	1.8	1.55	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note12)	2.5	2.05	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note12)	3.3	2.65	

Note12: This parameter is guaranteed by design.

## Capacitive Characteristics (Ta = 25°C)

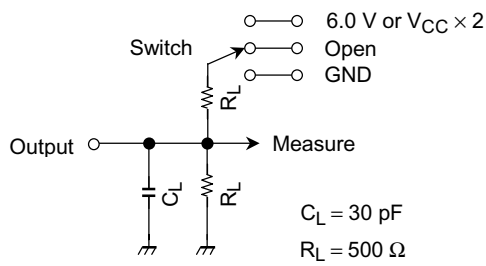
Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Input capacitance	C <sub>IN</sub>	—	1.8, 2.5, 3.3	6	pF
Output capacitance	C <sub>O</sub>	—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C <sub>PD</sub>	f <sub>IN</sub> = 10 MHz (Note13)	1.8, 2.5, 3.3	20	pF

Note13: C<sub>PD</sub> 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:

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

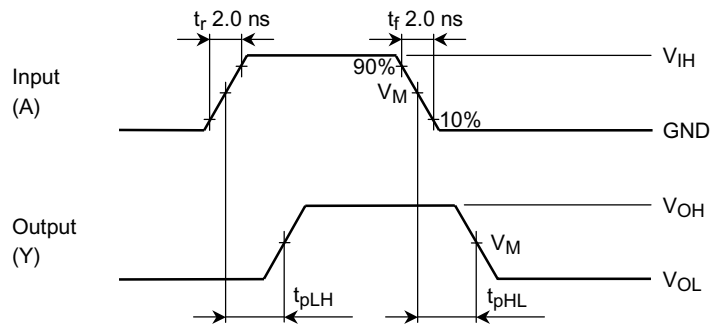
**AC Test Circuit**



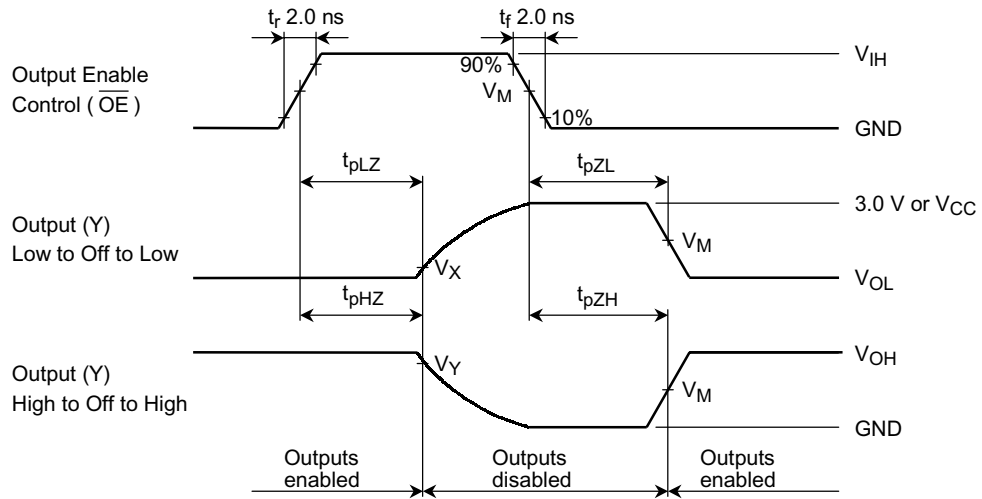
Parameter	Switch
$t_{pLH}, t_{pHL}$	Open
$t_{pLZ}, t_{pZL}$	6.0 V @ $V_{CC} = 3.3 \pm 0.3 \text{ V}$ $V_{CC} \times 2$ @ $V_{CC} = 2.5 \pm 0.2 \text{ V}$ @ $V_{CC} = 1.8 \text{ V}$
$t_{pHZ}, t_{pZH}$	GND

**Figure 1**

**AC Waveform**



**Figure 2  $t_{pLH}, t_{pHL}$**



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

Symbol	$V_{CC}$		
	$3.3 \pm 0.3$ V	$2.5 \pm 0.2$ 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

