TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VCX2125FT,TC74VCX2125FK

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

The TC74VCX2125FT/FK is a high-performance CMOS quad 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 overvoltage tolerant inputs and outputs up to 3.6 V.

This device requires the 3-state control input  $\overline{OE}$  to be set high to place the output into the high-impedance state.

The 26- $\Omega$ -series resistor helps reducing output overshoot and undershoot without external resistor.

All inputs are equipped with protection circuits against static discharge.

#### **Features**

- 26-Ω-series resistos on outputs.
- Low-voltage operation: V<sub>CC</sub> = 1.8 to 3.6 V
- High-speed operation:  $t_{pd} = 3.7 \text{ ns (max)} (V_{CC} = 3.0 \text{ to } 3.6 \text{ V})$

 $t_{pd} = 4.8 \text{ ns (max) (VCC} = 2.3 \text{ to } 2.7 \text{ V)}$ 

 $t_{pd} = 9.6 \text{ ns (max) (VCC} = 1.8 \text{ V)}$ 

• Output current:  $I_{OH}/I_{OL} = \pm 12 \text{ mA (min)} (V_{CC} = 3.0 \text{ V})$ 

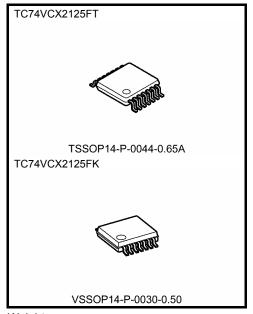
:  $I_{OH}/I_{OL} = \pm 8 \text{ mA (min) (V}_{CC} = 2.3 \text{ V)}$ 

:  $I_{OH}/I_{OL} = \pm 4$  mA (min) ( $V_{CC} = 1.8$  V)

- Latch-up performance: -300 mA
- ESD performance: Machine model  $\geq \pm 200 \text{ V}$

Human body model  $\geq \pm 2000 \text{ V}$ 

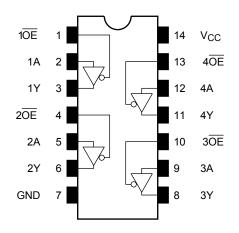
- Package: TSSOP and VSSOP (US)
- 3.6-V tolerant function and power-down protection provided on all inputs and outputs



Weight

TSSOP14-P-0044-0.65A : 0.06 g (typ.) VSSOP14-P-0030-0.50 : 0.02 g (typ.)

#### Pin Assignment (top view)



#### **IEC Logic Symbol**

3OE 10 8 3V	1OE	EN ▷ ♡	3 1Y
3OE 10 8 3			6 2Y
	3 <del>0E</del> 10 ►		8 3Y
3A 9 4OE 13 11 4Y	4 <del>0E</del>		11 4Y

#### **Truth Table**

Inp	uts	Outputs
ŌĒ	Α	Υ
Н	X	Z
L	L	L
L	Н	Н

X: Don't care

Z: High impedance

## **Absolute Maximum Ratings (Note 1)**

Characteristics	Symbol	Rating	Unit
Power supply voltage	V <sub>CC</sub>	-0.5 to 4.6	V
DC input voltage	V <sub>IN</sub>	–0.5 to 4.6	V
		-0.5 to 4.6 (Note 2)	
DC output voltage	Vout	-0.5 to V <sub>CC</sub> + 0.5	
		(Note 3)	
Input diode current	l <sub>IK</sub>	-50	mA
Output diode current	lok	±50 (Note 4)	mA
DC output current	lout	±50	mA
Power dissipation	PD	180	mW
DC V <sub>CC</sub> /ground current	I <sub>CC</sub> /I <sub>GND</sub>	±100	mA
Storage temperature	T <sub>stg</sub>	-65 to 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. IOUT absolute maximum rating must be observed.

Note 4:  $V_{OUT} < GND, V_{OUT} > V_{CC}$ 



## **Operating Ranges (Note 1)**

Characteristics	Symbol	Rating	Unit
Power supply voltage	V <sub>CC</sub>	1.8 to 3.6	V
rower supply voltage	, CC	1.2 to 3.6 (Note 2)	V
Input voltage	V <sub>IN</sub>	-0.3 to 3.6	V
Output voltage	Vout	0 to 3.6 (Note 3)	V
Output voltage	VOUI	0 to V <sub>CC</sub> (Note 4)	V
		±12 (Note 5)	
Output current	I <sub>OH</sub> /I <sub>OL</sub>	±8 (Note 6)	mA
		±4 (Note 7)	
Operating temperature	T <sub>opr</sub>	-40 to 85	°C
Input rise and fall time	dt/dv	0 to 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:  $V_{CC} = 3.0 \text{ to } 3.6 \text{ V}$
- Note 6:  $V_{CC} = 2.3 \text{ to } 2.7 \text{ V}$
- Note 7:  $V_{CC} = 1.8 \text{ V}$
- Note 8:  $V_{IN} = 0.8$  to 2.0 V,  $V_{CC} = 3.0$  V

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## **Electrical Characteristics**

## DC Characteristics (Ta = -40 to 85°C, 2.7 V < $V_{CC} \leq 3.6 \ V)$

Characteristics		Symbol	Test Condition			Min	Max	Unit											
	_		rest condition		V <sub>CC</sub> (V)														
Input voltage	H-level	$V_{IH}$		_	2.7 to 3.6	2.0	_	V											
mpat voltage	L-level	V <sub>IL</sub>		_	2.7 to 3.6	_	0.8	•											
				$I_{OH} = -100 \mu A$	2.7 to 3.6	V <sub>CC</sub> - 0.2													
	H-level	VoH	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	$I_{OH} = -6 \text{ mA}$	2.7	2.2	_												
				$I_{OH} = -8 \text{ mA}$	3.0	2.4	_												
Output voltage				$I_{OH} = -12 \text{ mA}$	3.0	2.2	_	V											
			$V_{IN} = V_{IH}$ or $V_{IL}$	I <sub>OL</sub> = 100 μA	2.7 to 3.6	_	0.2												
	L-level			I <sub>OL</sub> = 6 mA	2.7	_	0.4												
	L-level	V <sub>OL</sub>		VIN - VIH OI VIL	AIN — AIH OI AIL	AIN — AIH OI AIL	AIM — AIH OI AIT	VIN - VIH OI VIL	AIM — AIH OL AIF	VIIN — VIH OI VIL	AIN — AIH OI AIL	VIIV — VIH OI VIL	VIN — VIH OI VIL	VIIV — VIH OI VIL	AIN — AIH OI AIL	I <sub>OL</sub> = 8 mA	3.0	_	0.55
				I <sub>OL</sub> = 12 mA		_	0.8												
Input leakage curre	nt	I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		2.7 to 3.6	_	±5.0	μА											
2 state subsut OFF	-1-1		V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>		0.745.0.0		140.0	^											
3-state output OFF state current		loz	$V_{OUT} = 0$ to 3.6 V		2.7 to 3.6	_	±10.0	μА											
Power-off leakage of	current	I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	_	10.0	μΑ											
Out-out-out-out-out-out-out-out-out-out-o		1	$V_{IN} = V_{CC}$ or GND		2.7 to 3.6	_	20.0												
Quiescent supply co	ui eiit	Icc	$V_{CC} \le (V_{IN}, V_{OUT}) \le 3$	$C \le (V_{IN}, V_{OUT}) \le 3.6 \text{ V}$		_	±20.0	μА											
Increase in I <sub>CC</sub> per	input	Δlcc	V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V		2.7 to 3.6	_	750												

## DC Characteristics (Ta = -40 to 85°C, 2.3 V $\leq$ V<sub>CC</sub> $\leq$ 2.7 V)

Characte	ristics	Symbol	Test	Condition	\/ (\)	Min	Max	Unit							
	H-level	\/			V <sub>CC</sub> (V)	1.6									
Input voltage		V <sub>IH</sub>		_			0.7	V							
	L-level	V <sub>IL</sub>		<u> </u>	2.3 to 2.7		0.7								
				$I_{OH} = -100 \mu A$	2.3 to 2.7	V <sub>CC</sub> - 0.2	_								
	H-level	Voh	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	$I_{OH} = -4 \text{ mA}$	2.3	2.0	_								
			V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>			$I_{OH} = -6 \text{ mA}$	2.3	1.8	_						
Output voltage				$I_{OH} = -8 \text{ mA}$	2.3	1.7	_	V							
				V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	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 to 2.7	_	0.2						
	L-level	V <sub>OL</sub>				$V_{IN} = V_{IH} \ or \ V_{IL}$	$V_{IN} = V_{IH} \ or \ V_{IL}$	$V_{IN} = V_{IH} \ or \ V_{IL}$	$V_{IN} = V_{IH} \text{ or } V_{IL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$V_{IN} = V_{IH} \text{ or } V_{IL}$	$V_{IN} = V_{IH} \ or \ V_{IL}$	$V_{IN} = V_{IH} \ or \ V_{IL}$	I <sub>OL</sub> = 6 mA	2.3
				I <sub>OL</sub> = 8 mA	2.3		0.6								
Input leakage curr	ent	I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V	<u>.</u>	2.3 to 2.7	_	±5.0	μА							
			$V_{IN} = V_{IH}$ or $V_{IL}$		2245 27		140.0	^							
3-state output OFF	- state current	loz	$V_{OUT} = 0$ to 3.6 V		2.3 to 2.7		±10.0	μΑ							
Power-off leakage	current	I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	_	10.0	μА							
Outpoont our also	ourrant	1	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.3 to 2.7		20.0	^							
Quiescent supply	current	Icc	$V_{CC} \le (V_{IN}, V_{OUT}) \le$	3.6 V	2.3 to 2.7		±20.0	μΑ							



## DC Characteristics (Ta = -40 to $85^{\circ}$ C, $1.8 \text{ V} \leq \text{V}_{\text{CC}} < 2.3 \text{ V})$

Characteris	stics	Symbol	Test Co	Test Condition		Test Condition V <sub>CC</sub> (V)		Min	Max	Unit
lanut valtara	H-level	V <sub>IH</sub>	_		1.8 to 2.3	0.7 × V <sub>CC</sub>	_	V		
Input voltage	L-level	V <sub>IL</sub>	_	_	1.8 to 2.3	_	0.2 × V <sub>CC</sub>	V		
	H-level	VoH	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	$I_{OH} = -100 \mu A$	1.8	V <sub>CC</sub> - 0.2				
Output voltage				I <sub>OH</sub> = -4 mA	1.8	1.4	_	V		
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	$I_{OL} = 100 \mu A$	1.8		0.2			
	L-IEVEI	VOL	VIN - VIH OI VIL	I <sub>OL</sub> = 4 mA	1.8		0.3			
Input leakage currer	nt	I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V	V <sub>IN</sub> = 0 to 3.6 V			±5.0	μΑ		
3-state output OFF	state current	I <sub>OZ</sub>	$V_{IN} = V_{IH} \text{ or } V_{IL}$ $V_{OUT} = 0 \text{ to } 3.6 \text{ V}$		1.8		±10.0	μА		
Power-off leakage c	urrent	l <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	_	10.0	μА		
Quiescent supply cu	ırrent	loo	V <sub>IN</sub> = V <sub>CC</sub> or GND		1.8	_	20.0	μА		
Quiescent supply co	III CIII	Icc	$V_{CC} \le (V_{IN}, V_{OUT}) \le 3.6$	S V	1.8	_	±20.0	μΑ		

## AC Characteristics (Ta = -40 to 85°C, input: $t_r = t_f = 2.0$ ns, $C_L = 30$ pF, $R_L = 500$ $\Omega$ ) (Note 1)

Characteristics	Symbol	Test Condition	V <sub>CC</sub> (V)	Min	Max	Unit
	4		1.8	1.0	9.6	
Propagation delay time	t <sub>pLH</sub>	Figure 1, Figure 2	$2.5 \pm 0.2$	8.0	4.8	ns
	t <sub>pHL</sub>		$3.3 \pm 0.3$	0.6	3.7	
			1.8	1.0	9.8	
3-state output enable time	t <sub>pZL</sub>	Figure 1, Figure 3	$2.5 \pm 0.2$	8.0	5.1	ns
	<sup>t</sup> PZH		$3.3 \pm 0.3$	0.6	4.1	
	+		1.8	1.0	8.1	
3-state output disable time	t <sub>pLZ</sub>	Figure 1, Figure 3	$2.5 \pm 0.2$	8.0	4.5	ns
	t <sub>pHZ</sub>		$3.3 \pm 0.3$	0.6	4.1	
	<b>+</b>		1.8		0.5	
Output to output skew	t <sub>osLH</sub>	(Note 2)	$2.5\pm0.2$	_	0.5	ns
	t <sub>osHL</sub>		$3.3 \pm 0.3$	_	0.5	

Note 1: For  $C_L = 50$  pF, add approximately 300 ps to the AC maximum specification.

Note 2: Parameter guaranteed by design.  $(t_{OSLH} = |t_{DLHm} - t_{DLHn}|, \, t_{OSHL} = |t_{DHLm} - t_{DHLn}|)$ 

## Dynamic Switching Characteristics (Ta = 25°C, input: $t_r = t_f = 2.0$ ns, $C_L = 30$ pF)

Characteristics	Symbol	Test Condition		ı	Тур.	Unit
				V <sub>CC</sub> (V)	71	
		$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	1.8	0.15	
Quiet output maximum dynamic $V_{\mbox{OL}}$	V <sub>OLP</sub>	$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	2.5	0.25	V
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	3.3	0.35	
		$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	1.8	-0.15	
Quiet output minimum dynamic $V_{\mbox{OL}}$	V <sub>OLV</sub>	$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	2.5	-0.25	V
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	3.3	-0.35	
		$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	1.8	1.55	
Quiet output minimum dynamic V <sub>OH</sub>	V <sub>OHV</sub>	$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	2.5	2.05	V
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$ (N	Note)	3.3	2.65	

Note: Parameter guaranteed by design.

#### **Capacitive Characteristics (Ta = 25°C)**

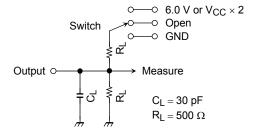
Characteristics	Symbol	Toot Condition		Tun	Unit	
Characteristics	Symbol	Test Condition		V <sub>CC</sub> (V)	Тур.	Offic
Input capacitance	C <sub>IN</sub>	_		1.8, 2.5, 3.3	6	pF
Output capacitance	C <sub>OUT</sub>	_		1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C <sub>PD</sub>	f <sub>IN</sub> = 10 MHz	(Note)	1.8, 2.5, 3.3	20	pF

Note: 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:

 $I_{CC (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/4 \text{ (per bit)}$ 

#### **AC Test Circuit**



Parameter	Switch			
t <sub>pLH</sub> , t <sub>pHL</sub>	Open			
t <sub>pLZ</sub> , t <sub>pZL</sub>				
t <sub>pHZ</sub> , t <sub>pZH</sub>	GND			

Figure 1

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#### **AC Waveform**

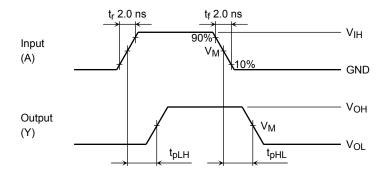


Figure 2 t<sub>pLH</sub>, t<sub>pHL</sub>

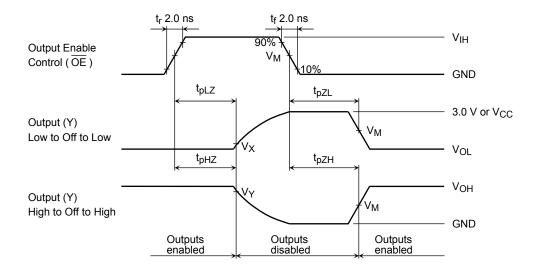
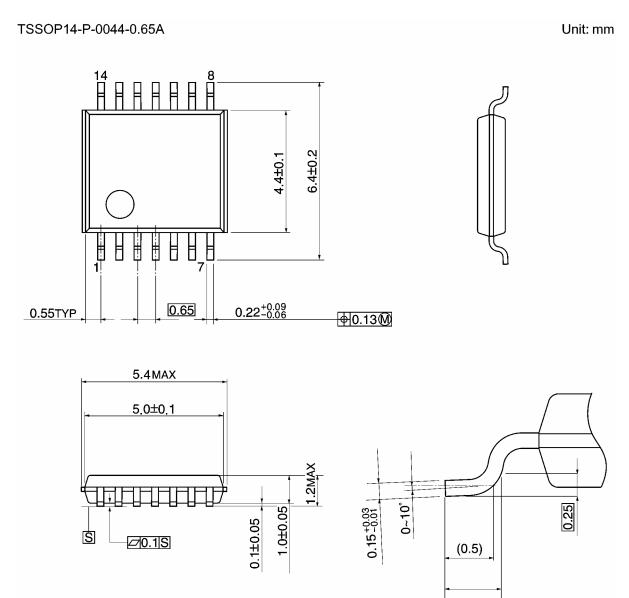


Figure 3  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$ 

Symbol		V <sub>CC</sub>	
Syllibol	$3.3\pm0.3~\textrm{V}$	$2.5\pm0.2\textrm{V}$	1.8 V
V <sub>IH</sub>	2.7 V	V <sub>CC</sub>	V <sub>CC</sub>
V <sub>M</sub>	1.5 V	V <sub>CC</sub> /2	V <sub>CC</sub> /2
VX	V <sub>OL</sub> + 0.3 V	V <sub>OL</sub> + 0.15 V	V <sub>OL</sub> + 0.15 V
VY	V <sub>OH</sub> – 0.3 V	V <sub>OH</sub> – 0.15 V	V <sub>OH</sub> – 0.15 V

## **TOSHIBA**

## **Package Dimensions**

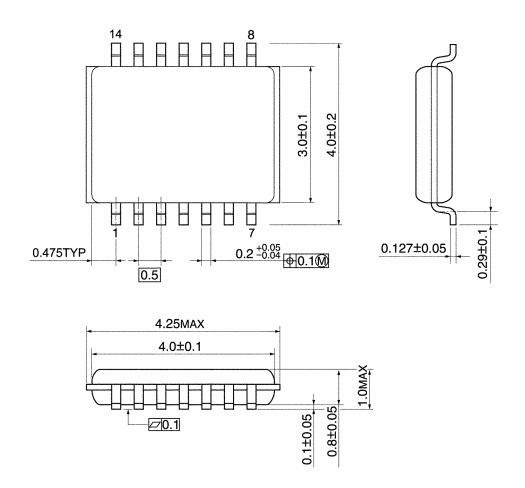


Weight: 0.06 g (typ.)

0.45~0.75

## **Package Dimensions**

VSSOP14-P-0030-0.50 Unit: mm



Weight: 0.02 g (typ.)

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20070701-EN GENERAL

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