

# TC74VCX541FT, TC74VCX541FK, TC74VCX541FTG

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

The TC74VCX541 is a high performance CMOS octal bus buffer which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5V, 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

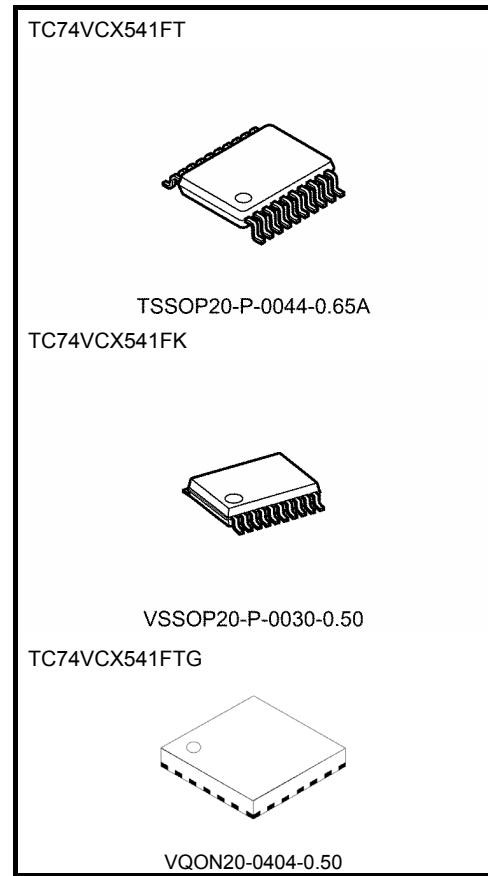
It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

The device is a non-inverting 3-state buffer having two active-low output enables. When either  $\overline{OE}_1$  or  $\overline{OE}_2$  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.

All inputs are equipped with protection circuits against static discharge.

### Features (Note 1)

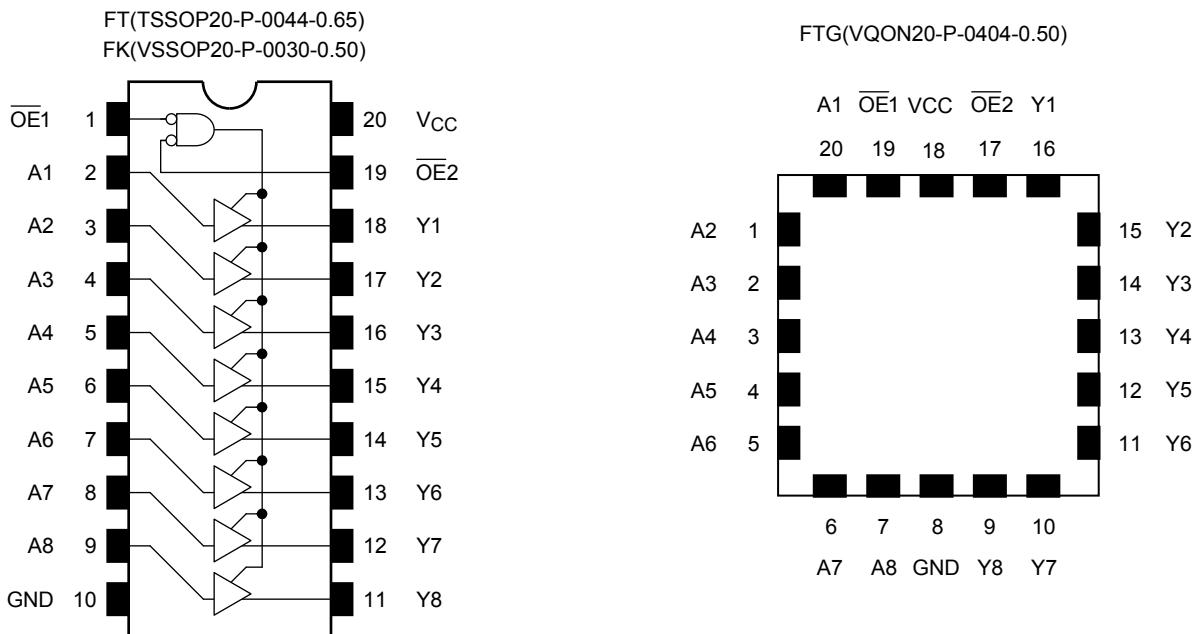
- Low voltage operation:  $V_{CC} = 1.2\sim 3.6$  V
- High speed operation:  $t_{pd} = 3.5$  ns (max) ( $V_{CC} = 3.0\sim 3.6$  V)  
 $t_{pd} = 4.2$  ns (max) ( $V_{CC} = 2.3\sim 2.7$  V)  
 $t_{pd} = 8.4$  ns (max) ( $V_{CC} = 1.65\sim 1.95$  V)  
 $t_{pd} = 16.8$  ns (max) ( $V_{CC} = 1.4\sim 1.6$  V)  
 $t_{pd} = 42.0$  ns (max) ( $V_{CC} = 1.2$  V)
- 3.6 V tolerant inputs and outputs.
- Output current:  $I_{OH}/I_{OL} = \pm 24$  mA (min) ( $V_{CC} = 3.0$  V)  
 $I_{OH}/I_{OL} = \pm 18$  mA (min) ( $V_{CC} = 2.3$  V)  
 $I_{OH}/I_{OL} = \pm 6$  mA (min) ( $V_{CC} = 1.65$  V)  
 $I_{OH}/I_{OL} = \pm 2$  mA (min) ( $V_{CC} = 1.4$  V)
- Latch-up performance:  $-300$  mA
- ESD performance: Machine model  $\geq \pm 200$  V  
Human body model  $\geq \pm 2000$  V
- Package: TSSOP  
VSSOP (US)  
VQON
- Power down protection is provided on all inputs and outputs.



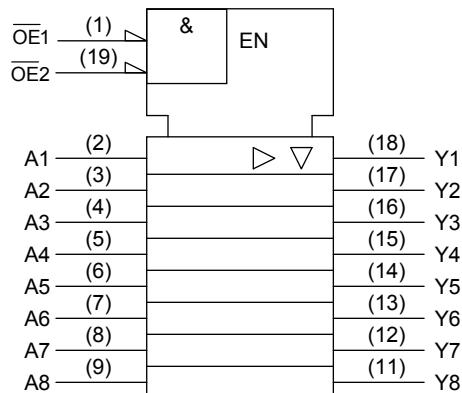
Weight	
TSSOP20-P-0044-0.65A	: 0.08 g (typ.)
VSSOP20-P-0030-0.50	: 0.03 g (typ.)
VQON20-P-0404-0.50	: 0.0145g (typ.)

Note 1: When mounting VQON package, the type of recommended flux is RA or RMA.

## Pin Assignment (top view)



## IEC Logic Level



## Truth Table

Inputs			Outputs
$\overline{OE}_1$	$\overline{OE}_2$	$A_n$	
H	X	X	Z
X	H	X	Z
L	L	H	H
L	L	L	L

X: Don't care

Z: High impedance

**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	$I_{OK}$	$\pm 50$ (Note 4)	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	°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	$I_{OH}/I_{OL}$	$\pm 24$ (Note 4)	mA
		$\pm 18$ (Note 5)	
		$\pm 6$ (Note 6)	
		$\pm 2$ (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: Off-state

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

Characteristics		Symbol	Test Condition		V <sub>CC</sub> (V)	Min	Max	Unit	
Input voltage	High level		—			2.7~3.6	2.0	—	
	Low level	V <sub>IL</sub>	—			2.7~3.6	—	0.8	
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 $\mu$ A	2.7~3.6	V <sub>CC</sub> - 0.2	—	V	
				I <sub>OH</sub> = -12 mA	2.7	2.2	—		
				I <sub>OH</sub> = -18 mA	3.0	2.4	—		
				I <sub>OH</sub> = -24 mA	3.0	2.2	—		
	Low level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 $\mu$ A	2.7~3.6	—	0.2		
				I <sub>OL</sub> = 12 mA	2.7	—	0.4		
				I <sub>OL</sub> = 18 mA	3.0	—	0.4		
				I <sub>OL</sub> = 24 mA	3.0	—	0.55		
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		2.7~3.6	—	$\pm 5.0$	$\mu$ A	
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		2.7~3.6	—	$\pm 10.0$	$\mu$ A	
Power off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V		0	—	10.0	$\mu$ A	
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.7~3.6	—	20.0	$\mu$ A	
			V <sub>CC</sub> $\leq$ (V <sub>IN</sub> , V <sub>OUT</sub> ) $\leq$ 3.6 V		2.7~3.6	—	$\pm 20.0$		
$\Delta I_{CC}$		V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V (per input)		2.7~3.6		—	750		

DC Characteristics ( $T_a = -40\text{~}85^\circ\text{C}$ ,  $2.3\text{ V} \leq V_{CC} \leq 2.7\text{ V}$ )

Characteristics		Symbol	Test Condition		V <sub>CC</sub> (V)	Min	Max	Unit	
Input voltage	High level		—			2.3~2.7	1.6	—	
	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 $\mu$ A	2.3~2.7	V <sub>CC</sub> - 0.2	—	V	
				I <sub>OH</sub> = -6 mA	2.3	2.0	—		
				I <sub>OH</sub> = -12 mA	2.3	1.8	—		
				I <sub>OH</sub> = -18 mA	2.3	1.7	—		
	Low level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 $\mu$ A	2.3~2.7	—	0.2		
				I <sub>OL</sub> = 12 mA	2.3	—	0.4		
				I <sub>OL</sub> = 18 mA	2.3	—	0.6		
				I <sub>OL</sub> = 24 mA	2.3~2.7	—	0.8		
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		2.3~2.7	—	$\pm 5.0$	$\mu$ A	
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	—	$\pm 10.0$	$\mu$ A	
Power off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V		0	—	10.0	$\mu$ A	
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.3~2.7	—	20.0	$\mu$ A	
			V <sub>CC</sub> $\leq$ (V <sub>IN</sub> , V <sub>OUT</sub> ) $\leq$ 3.6 V		2.3~2.7	—	$\pm 20.0$		

DC Characteristics ( $T_a = -40\text{~}85^\circ\text{C}$ ,  $1.65\text{ V} \leq V_{CC} < 2.3\text{ V}$ )

Characteristics		Symbol	Test Condition		$V_{CC} (\text{V})$	Min	Max	Unit	
Input voltage	High level		—			1.65~2.3	$0.65 \times V_{CC}$		
	Low level	$V_{IL}$	—		1.65~2.3	—	$0.2 \times V_{CC}$		
Output voltage	High level	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -100\text{ }\mu\text{A}$	1.65~2.3	$V_{CC} - 0.2$	—	V	
				$I_{OH} = -6\text{ mA}$	1.65	1.25	—		
	Low level	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 100\text{ }\mu\text{A}$	1.65~2.3	—	0.2		
				$I_{OL} = 6\text{ mA}$	1.65	—	0.3		
Input leakage current		$I_{IN}$	$V_{IN} = 0\text{~}3.6\text{ V}$		1.65~2.3	—	$\pm 5.0$	$\mu\text{A}$	
3-state output off-state current		$I_{OZ}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{OUT} = 0\text{~}3.6\text{ V}$		1.65	—	$\pm 10.0$	$\mu\text{A}$	
Power off leakage current		$I_{OFF}$	$V_{IN}, V_{OUT} = 0\text{~}3.6\text{ V}$		0	—	10.0	$\mu\text{A}$	
Quiescent supply current		$I_{CC}$	$V_{IN} = V_{CC}$ or GND		1.65~2.3	—	20.0	$\mu\text{A}$	
			$V_{CC} \leq (V_{IN}, V_{OUT}) \leq 3.6\text{ V}$		1.65~2.3	—	$\pm 20.0$		

DC Characteristics ( $T_a = -40\text{~}85^\circ\text{C}$ ,  $1.4\text{ V} \leq V_{CC} < 1.65\text{ V}$ )

Characteristics		Symbol	Test Condition		$V_{CC} (\text{V})$	Min	Max	Unit	
Input voltage	High level		—			1.4~1.65	$0.65 \times V_{CC}$		
	Low level	$V_{IL}$	—		1.4~1.65	—	$0.05 \times V_{CC}$		
Output voltage	High level	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -100\text{ }\mu\text{A}$	1.4~1.65	$V_{CC} - 0.2$	—	V	
				$I_{OH} = -2\text{ mA}$	1.4	1.05	—		
	Low level	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 100\text{ }\mu\text{A}$	1.4~1.65	—	0.05		
				$I_{OL} = 2\text{ mA}$	1.4	—	0.35		
Input leakage current		$I_{IN}$	$V_{IN} = 0\text{~}3.6\text{ V}$		1.4~1.65	—	$\pm 5.0$	$\mu\text{A}$	
3-state output off-state current		$I_{OZ}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{OUT} = 0\text{~}3.6\text{ V}$		1.4~1.65	—	$\pm 10.0$	$\mu\text{A}$	
Power off leakage current		$I_{OFF}$	$V_{IN}, V_{OUT} = 0\text{~}3.6\text{ V}$		0	—	10.0	$\mu\text{A}$	
Quiescent supply current		$I_{CC}$	$V_{IN} = V_{CC}$ or GND		1.4~1.65	—	20.0	$\mu\text{A}$	
			$V_{CC} \leq (V_{IN}, V_{OUT}) \leq 3.6\text{ V}$		1.4~1.65	—	$\pm 20.0$		

DC Characteristics (Ta = -40~85°C, 1.2 V ≤ V<sub>CC</sub> < 1.4 V)

Characteristics		Symbol	Test Condition		V <sub>CC</sub> (V)	Min	Max	Unit
Input voltage	High level		—		1.2~1.4	0.8 × V <sub>CC</sub>	—	V
	Low level	V <sub>IL</sub>	—		1.2~1.4	—	0.05 × 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	1.2	V <sub>CC</sub> - 0.1	—	V
	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	1.2	—	0.05	
Input leakage current	I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		—		1.2	—	±5.0
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		—		1.2	—	±10.0
Power off leakage current	I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V		—		0	—	10.0
Quiescent supply current	I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		—		1.2	—	20.0
		V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		—		1.2	—	±20.0

AC Characteristics (Ta = -40~85°C, Input: t<sub>r</sub> = t<sub>f</sub> = 2.0 ns) (Note 1)

Characteristics		Symbol	Test Condition		V <sub>CC</sub> (V)	Min	Max	Unit
Propagation delay time	t <sub>PLH</sub> t <sub>PHL</sub>	Figure 1, Figure 2	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ		1.2	1.5	42.0	ns
					1.5 ± 0.1	1.0	16.8	
			C <sub>L</sub> = 30 pF, R <sub>L</sub> = 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	
					1.2	1.5	49.0	
3-state output enable time	t <sub>PZL</sub> t <sub>PZH</sub>	Figure 1, Figure 3	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ		1.5 ± 0.1	1.0	19.6	ns
					1.8 ± 0.15	1.5	9.8	
			C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω		2.5 ± 0.2	0.8	5.5	
					3.3 ± 0.3	0.6	4.5	
					1.2	1.5	32.5	
					1.5 ± 0.1	1.0	13.0	
3-state output disable time	t <sub>PZL</sub> t <sub>PZH</sub>	Figure 1, Figure 3	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ		1.8 ± 0.15	1.5	6.5	ns
					2.5 ± 0.2	0.8	3.6	
			C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω		3.3 ± 0.3	0.6	3.3	
					1.2	—	1.5	
					1.5 ± 0.1	—	1.5	
					1.8 ± 0.15	—	0.5	
Output to output skew	t <sub>osLH</sub> t <sub>osHL</sub>	(Note 2)	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ		2.5 ± 0.2	—	0.5	ns
					3.3 ± 0.3	—	0.5	

Note 1: For C<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

Note 2: This parameter is guaranteed by design.

$$(t_{osLH} = |t_{PLHm} - t_{PLHn}|, t_{osHL} = |t_{PZHm} - t_{PZHn}|)$$

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

Characteristics	Symbol	Test Condition	V <sub>CC</sub> (V)	Typ.	Unit
Quiet output maximum dynamic V <sub>OL</sub>	V <sub>O LP</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note)	1.8	0.25	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note)	2.5	0.6	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note)	3.3	0.8	
Quiet output minimum dynamic V <sub>OL</sub>	V <sub>O LV</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note)	1.8	-0.25	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note)	2.5	-0.6	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note)	3.3	-0.8	
Quiet output minimum dynamic V <sub>OH</sub>	V <sub>O HV</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note)	1.8	1.5	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note)	2.5	1.9	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note)	3.3	2.2	

Note: This parameter is guaranteed by design.

## Capacitive Characteristics (Ta = 25°C)

Characteristics	Symbol	Test Condition	V <sub>CC</sub> (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 (Note)	1.8, 2.5, 3.3	20	pF

Note: CPD 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:

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

## AC Test Circuit

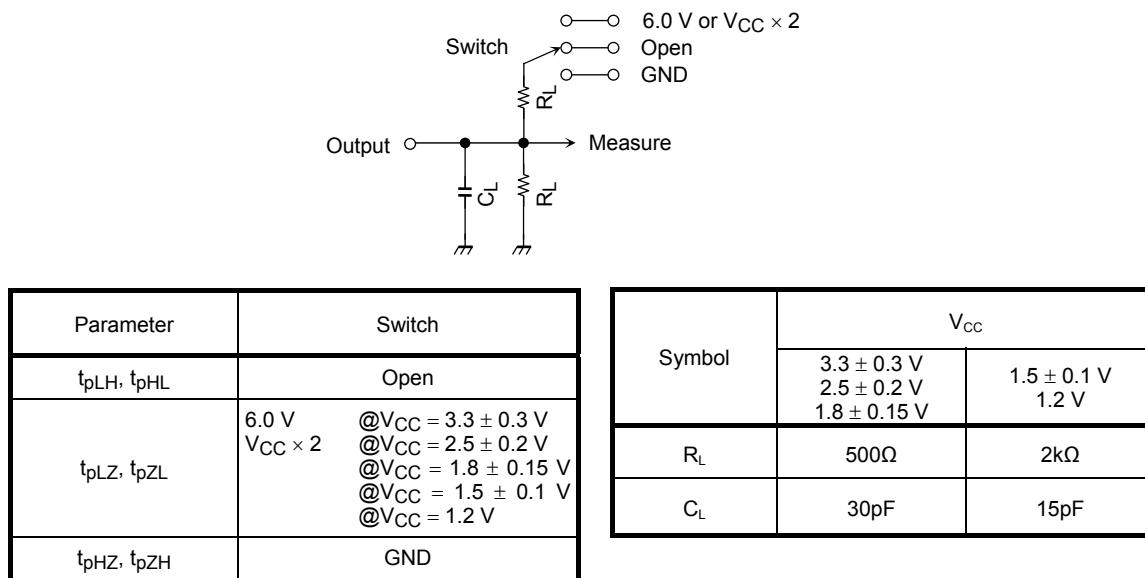
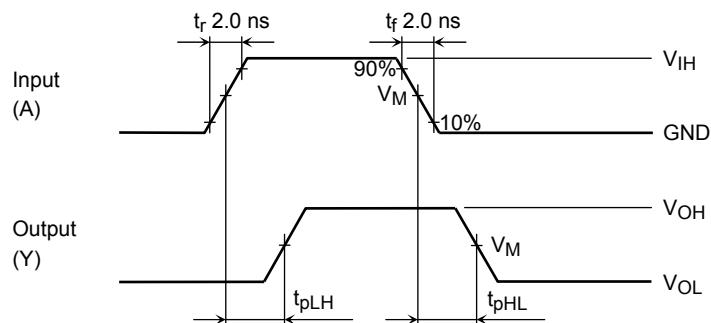


Figure 1

## AC Waveform

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

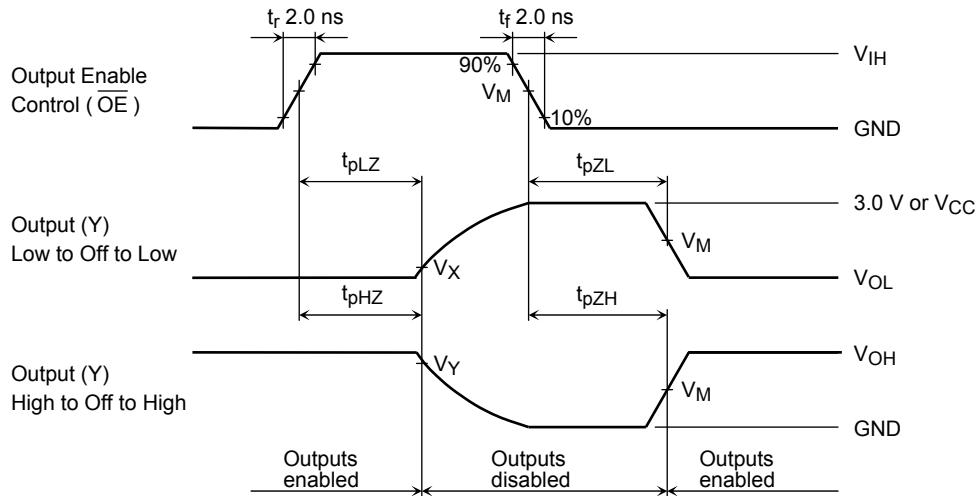


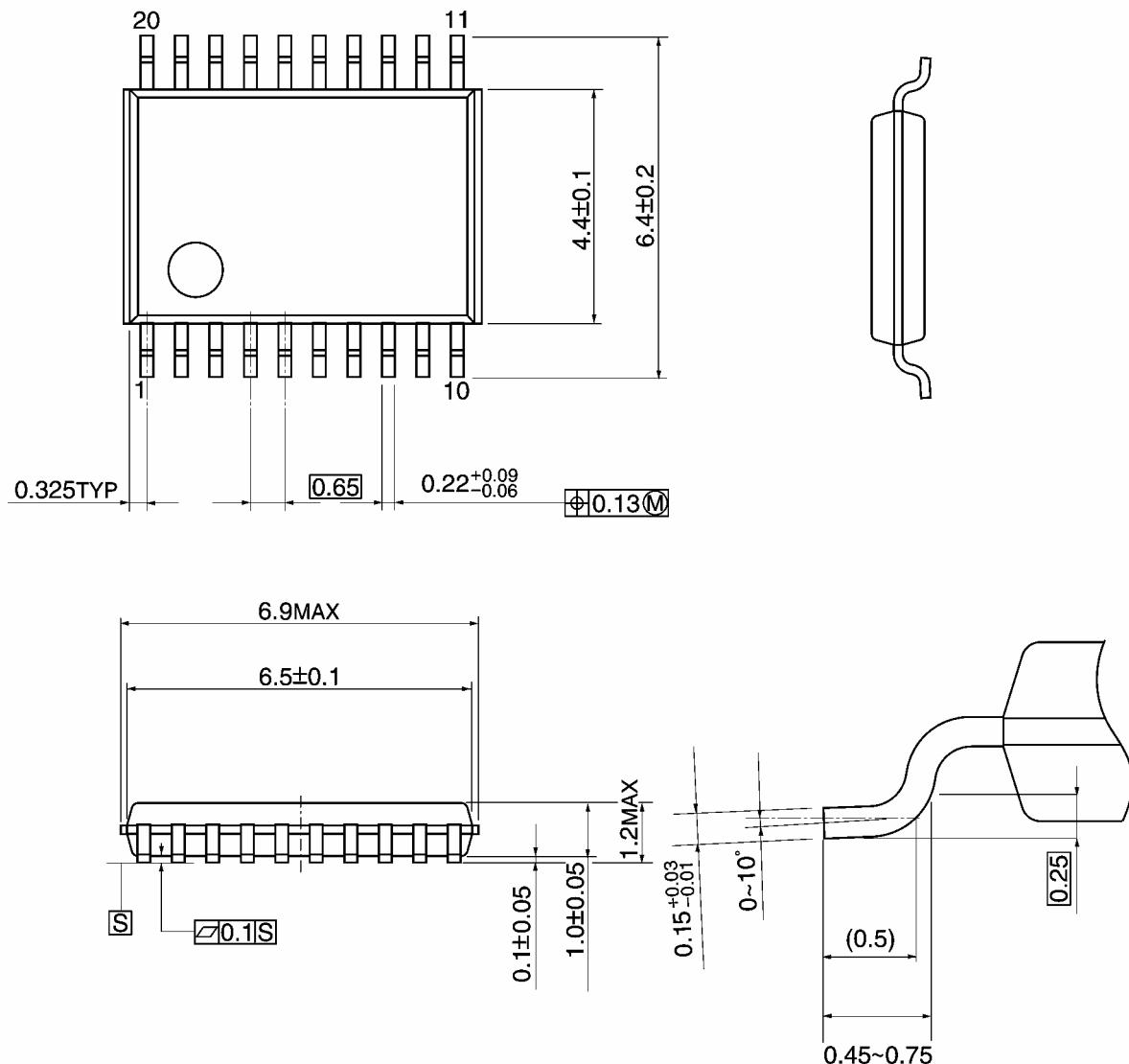
Figure 3  $t_{PLZ}$ ,  $t_{PHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$

Symbol	$V_{CC}$				
	$3.3 \pm 0.3$ V	$2.5 \pm 0.2$ V	$1.8 \pm 0.15$ V	$1.5 \pm 0.1$ 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**

TSSOP20-P-0044-0.65A

Unit: mm

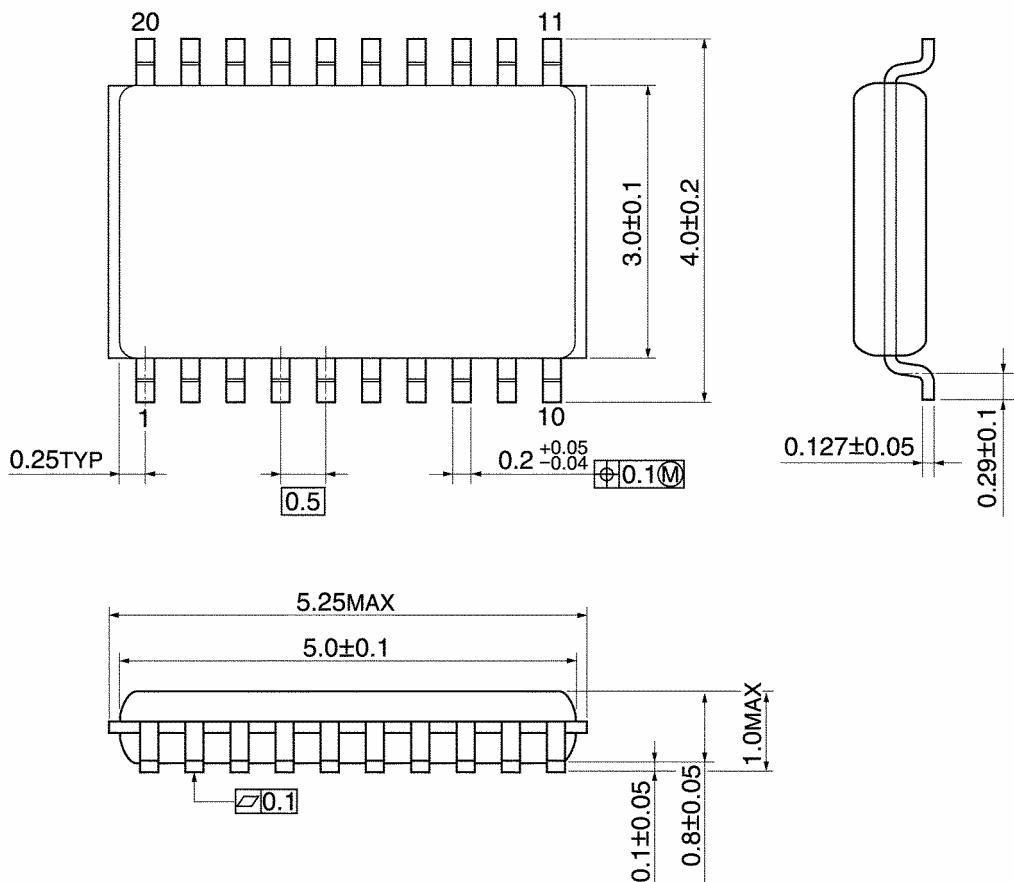


Weight: 0.08 g (typ.)

**Package Dimensions**

VSSOP20-P-0030-0.50

Unit: mm

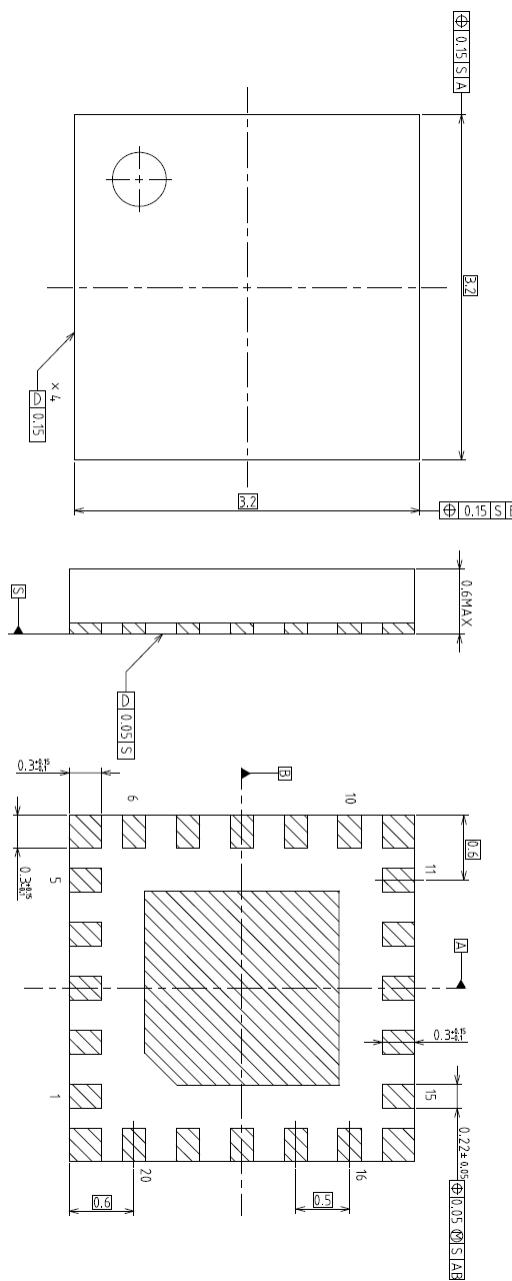


Weight: 0.03 g (typ.)

**Package Dimensions**

VQON20-P-0404-0.50

Unit: mm



Weight: 0.0145 g (typ.)

## RESTRICTIONS ON PRODUCT USE

20070701-EN GENERAL

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