

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

## TC74VCX374FT, TC74VCX374FK, TC74VCX374FTG

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

The TC74VCX374 is a high performance CMOS octal D-type flip-flop which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5 V, 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

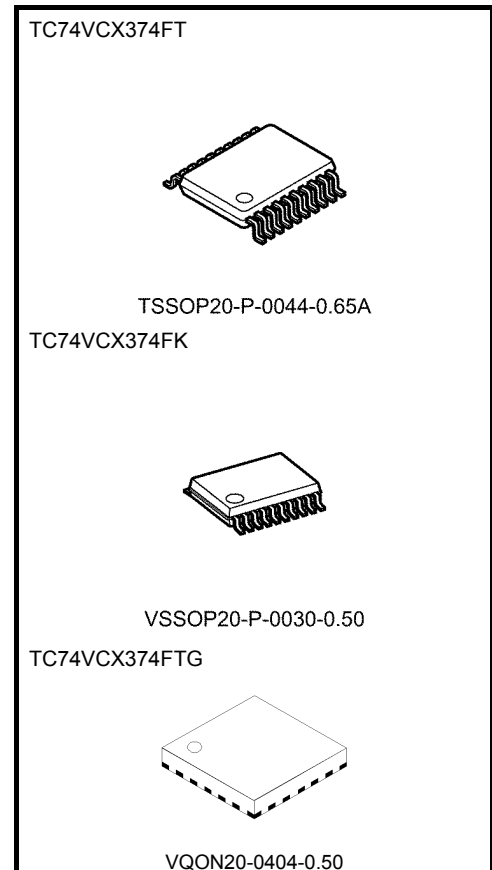
It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

This 8 bit D-type flip-flop is controlled by a clock input (CK) and a output enable input ( $\overline{OE}$ ). When  $\overline{OE}$  input is high, the eight outputs are in a high impedance state.

All inputs are equipped with protection circuits against static discharge.

### Features

- Low voltage operation:  $V_{CC} = 1.2\sim 3.6\text{ V}$
- High speed operation:  $t_{pd} = 4.2\text{ ns (max)} (V_{CC} = 3.0\sim 3.6\text{ V})$   
 $t_{pd} = 4.8\text{ ns (max)} (V_{CC} = 2.3\sim 2.7\text{ V})$   
 $t_{pd} = 9.6\text{ ns (max)} (V_{CC} = 1.65\sim 1.95\text{ V})$   
 $t_{pd} = 19.2\text{ ns (max)} (V_{CC} = 1.4\sim 1.6\text{ V})$   
 $t_{pd} = 48.0\text{ ns (max)} (V_{CC} = 1.2\text{ V})$
- 3.6 V tolerant inputs and outputs.
- Output current:  $I_{OH}/I_{OL} = \pm 24\text{ mA (min)} (V_{CC} = 3.0\text{ V})$   
 $I_{OH}/I_{OL} = \pm 18\text{ mA (min)} (V_{CC} = 2.3\text{ V})$   
 $I_{OH}/I_{OL} = \pm 6\text{ mA (min)} (V_{CC} = 1.65\text{ V})$   
 $I_{OH}/I_{OL} = \pm 2\text{ mA (min)} (V_{CC} = 1.4\text{ V})$
- Latch-up performance:  $-300\text{ mA}$
- ESD performance: Machine model  $\geq \pm 200\text{ V}$   
Human body model  $\geq \pm 2000\text{ V}$
- Package: TSSOP  
VSSOP (US)  
VQON
- Power down protection is provided on all inputs and outputs.

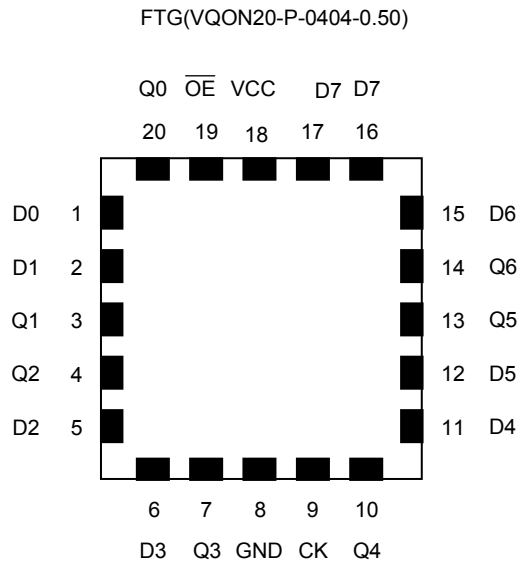
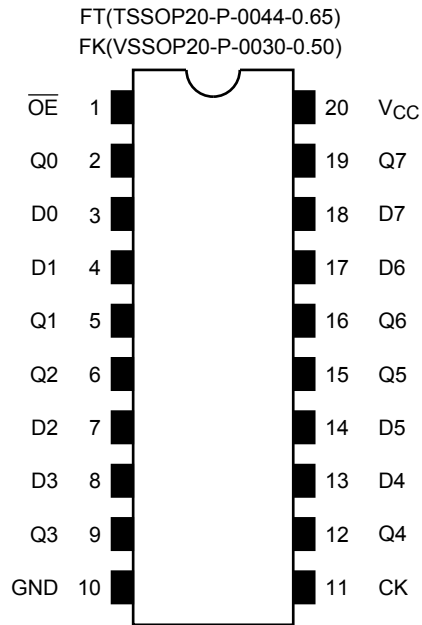


### Weight

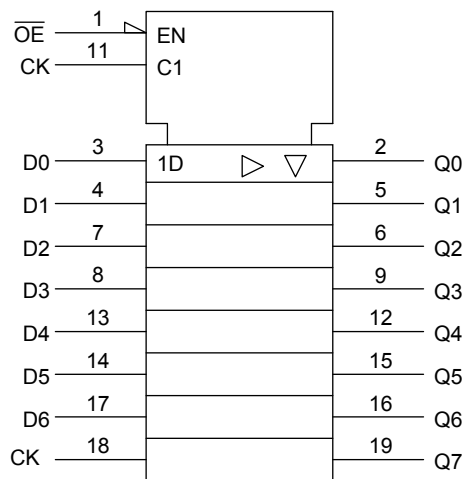
TSSOP20-P-0044-0.65A	: 0.08 g (typ.)
VSSOP20-P-0030-0.50	: 0.03 g (typ.)
VQON20-P-0404-0.50	: 0.0145g (typ.)

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

## Pin Assignment (top view)



## IEC Logic Level



## Truth Table

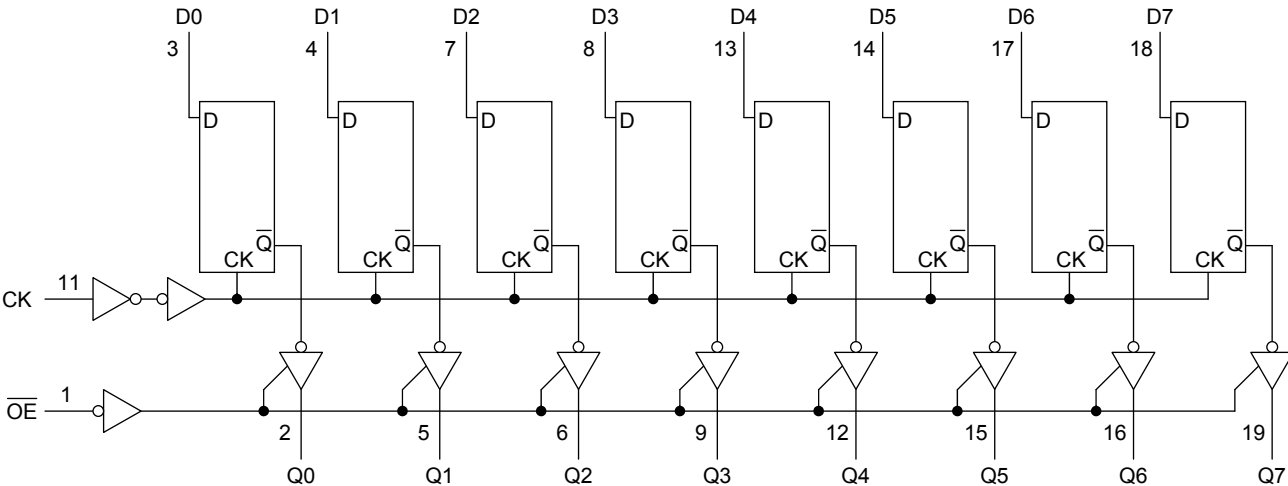
Inputs			Outputs
$\overline{OE}$	CK	D	
H	X	X	Z
L	$\downarrow$	X	$Q_n$
L	$\uparrow$	L	L
L	$\uparrow$	H	H

X: Don't care

Z: High impedance

$Q_n$ : No change

System Diagram



## 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	$V_{CC}$	1.2~3.6	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	$I_{OH}/I_{OL}$	±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 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 (Ta = -40~85°C, 2.7 V < VCC ≤ 3.6 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V <sub>IH</sub>	—		2.7~3.6	2.0	—	V
	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 μA	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 μA	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	—	±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		2.7~3.6	—	±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		2.7~3.6	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		2.7~3.6	—	±20.0	
		ΔI <sub>CC</sub>	V <sub>IH</sub> = V <sub>CC</sub> - 0.6 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> = -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 μA	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	
				Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V	
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, 1.65 V ≤ VCC < 2.3 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V <sub>IH</sub>	—		1.65~2.3	0.65 × V <sub>CC</sub>	—	V
	Low level	V <sub>IL</sub>	—		1.65~2.3	—	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	1.65~2.3	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -6 mA	1.65	1.25	—	
	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	1.65~2.3	—	0.2	
				I <sub>OL</sub> = 6 mA	1.65	—	0.3	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		1.65~2.3	—	±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		1.65~2.3	—	±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		1.65~2.3	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		1.65~2.3	—	±20.0	

## DC Characteristics (Ta = -40~85°C, 1.4 V ≤ VCC < 1.65 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V <sub>IH</sub>	—		1.4~1.65	0.65 × V <sub>CC</sub>	—	V
	Low level	V <sub>IL</sub>	—		1.4~1.65	—	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	1.4~1.65	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -2 mA	1.4	1.05	—	
	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	1.4~1.65	—	0.05	
				I <sub>OL</sub> = 2 mA	1.4	—	0.35	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		1.4~1.65	—	±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		1.4~1.65	—	±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		1.4~1.65	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		1.4~1.65	—	±20.0	

## DC Characteristics (Ta = -40~85°C, 1.2 V ≤ VCC < 1.4 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V <sub>IH</sub>	—		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	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		1.2	—	±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		1.2	—	20.0	μA
			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: tr = tf = 2.0 ns) (Note 1)

Characteristics	Symbol	Test Condition		VCC (V)	Min	Max	Unit			
Maximum clock frequency	f <sub>max</sub>	Figure 1, Figure 2	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	1.2	40	—	MHz			
				1.5 ± 0.1	80	—				
			C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	1.8 ± 0.15	100	—				
				2.5 ± 0.2	200	—				
				3.3 ± 0.3	250	—				
				Propagation delay time (CK-Q)	Figure 1, Figure 2	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	1.2	1.5	48.0	ns
							1.5 ± 0.1	1.0	19.2	
						C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	1.8 ± 0.15	1.5	9.6	
2.5 ± 0.2	0.8	4.8								
				3.3 ± 0.3	0.6	4.2				
				3-state output enable time	Figure 1, Figure 3	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	1.2	1.5	49.0	ns
							1.5 ± 0.1	1.0	19.6	
						C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	1.8 ± 0.15	1.5	9.8	
2.5 ± 0.2	0.8	5.5								
				3.3 ± 0.3	0.6	4.5				
				3-state output disable time	Figure 1, Figure 3	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	1.2	1.5	32.5	ns
							1.5 ± 0.1	1.0	13.0	
						C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	1.8 ± 0.15	1.5	6.5	
2.5 ± 0.2	0.8	3.6								
				3.3 ± 0.3	0.6	3.3				
				Minimum pulse width (CK)	Figure 1, Figure 2	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	1.2	24	—	ns
							1.5 ± 0.1	8.0	—	
						C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	1.8 ± 0.15	4.0	—	
2.5 ± 0.2	1.5	—								
				3.3 ± 0.3	1.5	—				
				Minimum set-up time	Figure 1, Figure 2	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	1.2	20	—	ns
							1.5 ± 0.1	7.5	—	
						C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	1.8 ± 0.15	2.5	—	
2.5 ± 0.2	1.5	—								
				3.3 ± 0.3	1.5	—				
				Minimum hold time	Figure 1, Figure 2	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	1.2	8.0	—	ns
							1.5 ± 0.1	3.0	—	
						C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	1.8 ± 0.15	1.0	—	
2.5 ± 0.2	1.0	—								
				3.3 ± 0.3	1.0	—				
				Output to output skew	(Note 2)	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	1.2	—	1.5	ns
							1.5 ± 0.1	—	1.5	
						C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	1.8 ± 0.15	—	0.5	
2.5 ± 0.2	—	0.5								
				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<sub>osLH</sub> = |t<sub>pLHm</sub> - t<sub>pLHn</sub>|, t<sub>osHL</sub> = |t<sub>pHLm</sub> - t<sub>pHLn</sub>|)

## 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 VOL	VOLP	VIH = 1.8 V, VIL = 0 V (Note)	1.8	0.25	V
		VIH = 2.5 V, VIL = 0 V (Note)	2.5	0.6	
		VIH = 3.3 V, VIL = 0 V (Note)	3.3	0.8	
Quiet output minimum dynamic VOL	VOLV	VIH = 1.8 V, VIL = 0 V (Note)	1.8	-0.25	V
		VIH = 2.5 V, VIL = 0 V (Note)	2.5	-0.6	
		VIH = 3.3 V, VIL = 0 V (Note)	3.3	-0.8	
Quiet output minimum dynamic VOH	VOHV	VIH = 1.8 V, VIL = 0 V (Note)	1.8	1.5	V
		VIH = 2.5 V, VIL = 0 V (Note)	2.5	1.9	
		VIH = 3.3 V, VIL = 0 V (Note)	3.3	2.2	

Note: This parameter is guaranteed by design.

## Capacitive Characteristics (Ta = 25°C)

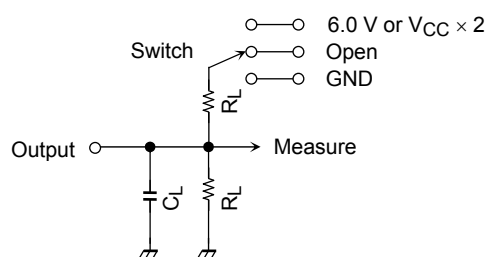
Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Input capacitance	CIN	—	1.8, 2.5, 3.3	6	pF
Output capacitance	CO	—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	CPD	fIN = 10 MHz (Note)	1.8, 2.5, 3.3	20	pF

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:

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

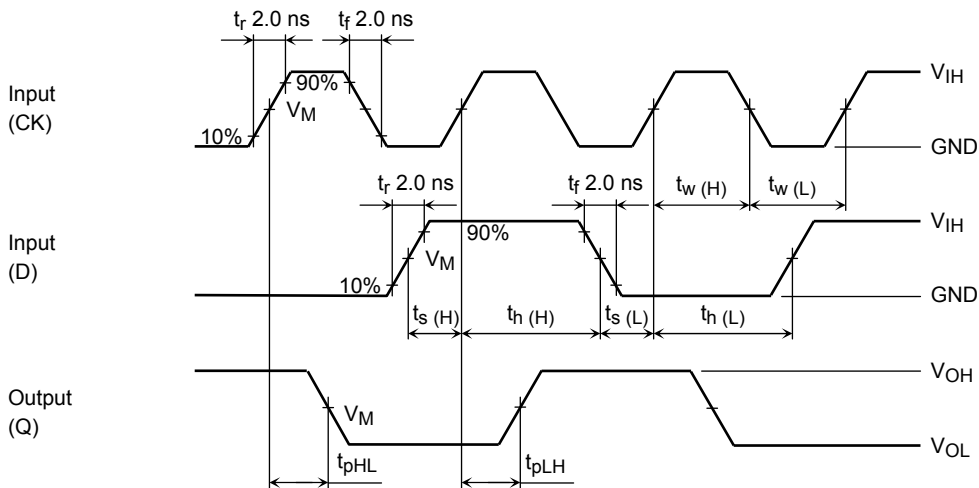
## AC Test Circuit



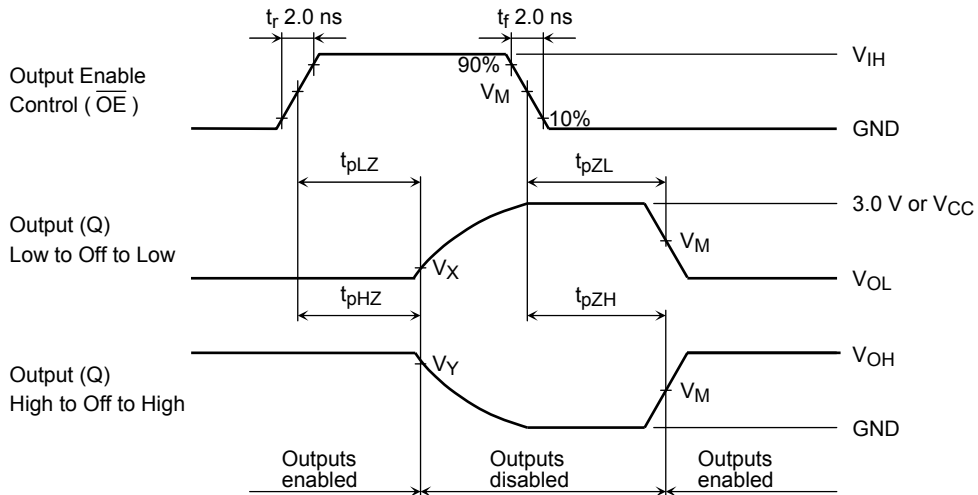
Parameter	Switch	$V_{CC}$	
$t_{pLH}$ , $t_{pHL}$	Open	$3.3 \pm 0.3$ V $2.5 \pm 0.2$ V $1.8 \pm 0.15$ V	$1.5 \pm 0.1$ V $1.2$ V
$t_{pLZ}$ , $t_{pZL}$	6.0 V $V_{CC} \times 2$	@ $V_{CC} = 3.3 \pm 0.3$ V @ $V_{CC} = 2.5 \pm 0.2$ V @ $V_{CC} = 1.8 \pm 0.15$ V @ $V_{CC} = 1.5 \pm 0.1$ V @ $V_{CC} = 1.2$ V	
$t_{pHZ}$ , $t_{pZH}$	GND		
		$R_L$	$500\Omega$ $2k\Omega$
		$C_L$	$30pF$ $15pF$

**Figure 1**

**AC Waveform**



**Figure 2  $t_{pLH}$ ,  $t_{pHL}$ ,  $t_w$ ,  $t_s$ ,  $t_h$**



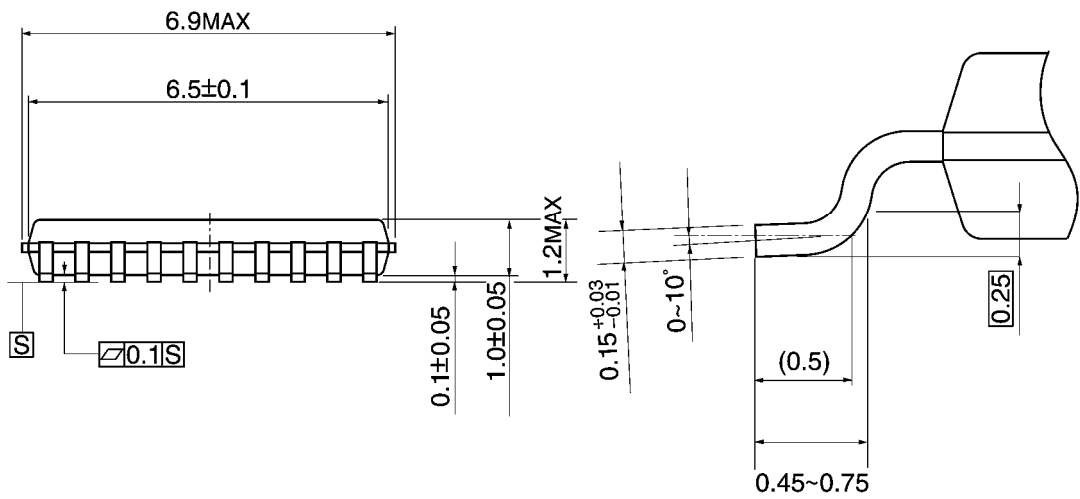
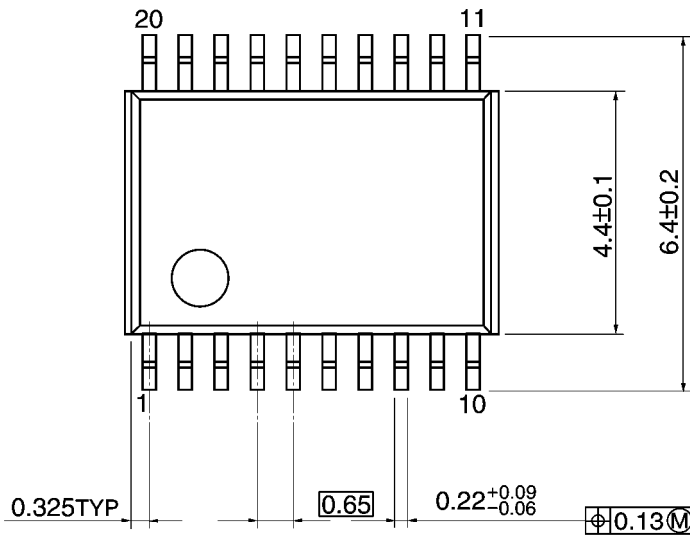
**Figure 3  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$**

Symbol	$V_{CC}$				
	$3.3 \pm 0.3 \text{ V}$	$2.5 \pm 0.2 \text{ V}$	$1.8 \pm 0.15 \text{ V}$	$1.5 \pm 0.1 \text{ V}$	$1.2 \text{ V}$
$V_{IH}$	2.7 V	$V_{CC}$	$V_{CC}$	$V_{CC}$	$V_{CC}$
$V_M$	1.5 V	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$
$V_X$	$V_{OL} + 0.3 \text{ V}$	$V_{OL} + 0.15 \text{ V}$	$V_{OL} + 0.15 \text{ V}$	$V_{OL} + 0.1 \text{ V}$	$V_{OL} + 0.1 \text{ V}$
$V_Y$	$V_{OH} - 0.3 \text{ V}$	$V_{OH} - 0.15 \text{ V}$	$V_{OH} - 0.15 \text{ V}$	$V_{OH} - 0.1 \text{ V}$	$V_{OH} - 0.1 \text{ V}$

**Package Dimensions**

TSSOP20-P-0044-0.65A

Unit: mm

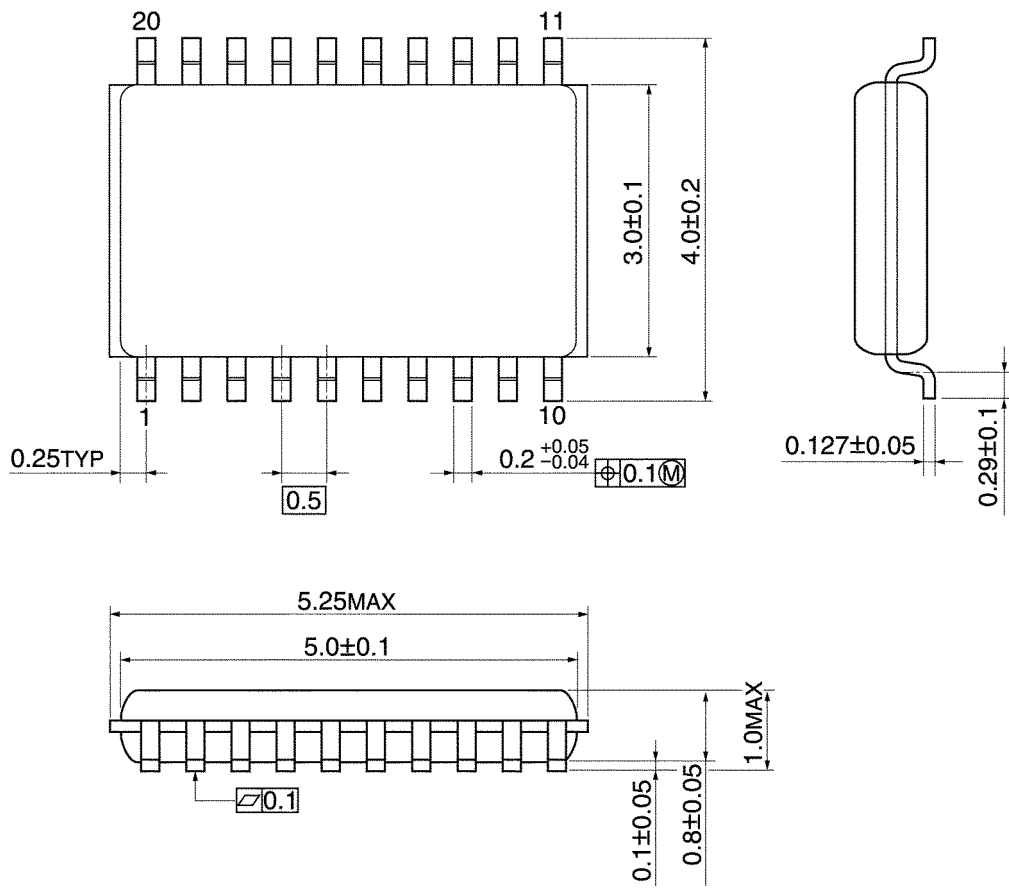


Weight: 0.08 g (typ.)

## Package Dimensions

VSSOP20-P-0030-0.50

Unit: mm

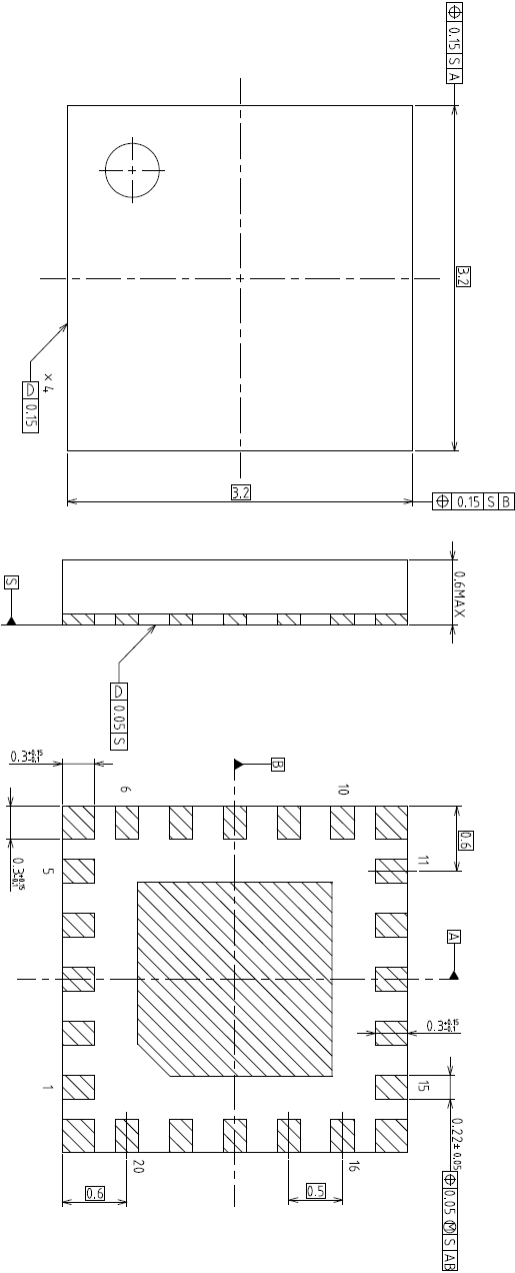


Weight: 0.03 g (typ.)

**Package Dimensions**

VQON20-P-0404-0.50

Unit: mm



Weight: 0.0145g (typ.)

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