

CMOS Digital Integrated Circuits Silicon Monolithic

# TC74VCX541FT

## 1. Functional Description

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

## 2. General

The TC74VCX541FT 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 1.5 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.

The device is a non-inverting 3-state buffer having two active-low output enables. When either  $\overline{OE1}$  or  $\overline{OE2}$  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.

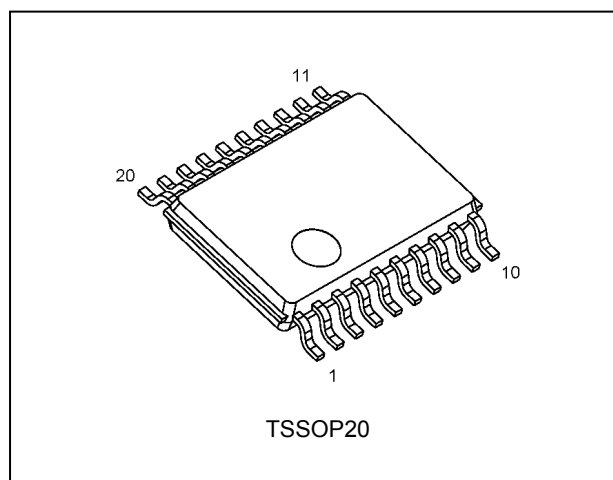
All inputs are equipped with protection circuits against static discharge.

## 3. Features

- (1) Wide operating temperature range:  $T_{opr} = -40$  to  $125$  °C (Note 1)
- (2) Low-voltage operation:  $V_{CC} = 1.2$  to  $3.6$  V
- (3) High-speed operation:  $t_{pd} = 3.5$  ns (max) ( $V_{CC} = 3.0$  to  $3.6$  V)  
 $t_{pd} = 4.2$  ns (max) ( $V_{CC} = 2.3$  to  $2.7$  V)  
 $t_{pd} = 8.4$  ns (max) ( $V_{CC} = 1.65$  to  $1.95$  V)  
 $t_{pd} = 16.8$  ns (max) ( $V_{CC} = 1.4$  to  $1.6$  V)  
 $t_{pd} = 42.0$  ns (max) ( $V_{CC} = 1.2$  V)
- (4) 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)
- (5) 3.6 V tolerant function and power-down protection provided on all inputs and outputs.

Note 1: Operating Range spec of  $T_{opr} = -40$  °C to  $125$  °C is applicable only for the products which manufactured after April 2020.

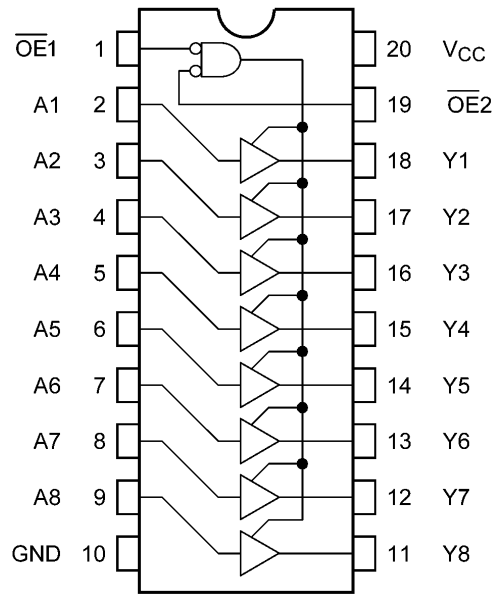
## 4. Packaging



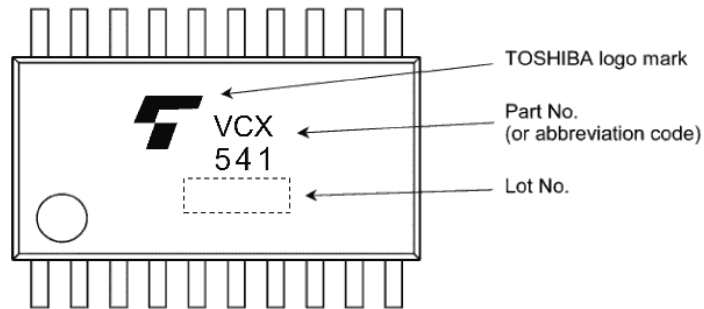
Start of commercial production

2020-04

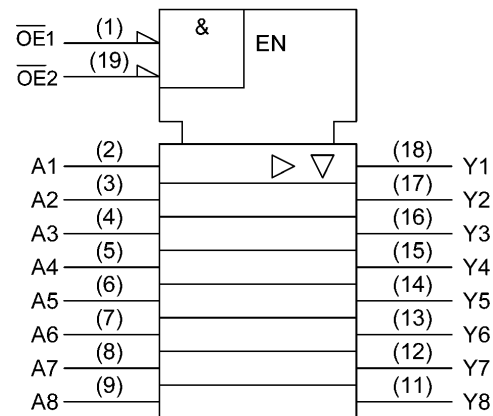
### 5. Pin Assignment



### 6. Marking



### 7. IEC Logic Symbol



### 8. Truth Table

Input OE1	Input OE2	Inputs An	Outputs
H	X	X	Z
X	H	X	Z
L	L	H	H
L	L	L	L

X: Don't care

Z: High impedance

### 9. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	$V_{CC}$		-0.5 to 4.6	V
Input voltage	$V_{IN}$		-0.5 to 4.6	V
Output voltage	$V_{OUT}$	(Note 1)	-0.5 to 4.6	V
		(Note 2)	-0.5 to $V_{CC} + 0.5$	
Input diode current	$I_{IK}$		-50	mA
Output diode current	$I_{OK}$	(Note 3)	$\pm 50$	mA
Output current	$I_{OUT}$		$\pm 50$	mA
Power dissipation	$P_D$	(Note 4)	180	mW
$V_{CC}$ /ground current	$I_{CC}/I_{GND}$		$\pm 100$	mA
Storage temperature	$T_{stg}$		-65 to 150	$^{\circ}C$

Note: 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 1: Output in OFF state.

Note 2: High (H) or Low (L) state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 3:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

Note 4: 180 mW in the range of  $T_a = -40$  to  $85^{\circ}C$ . From  $T_a = 85$  to  $125^{\circ}C$  a derating factor of  $-3.25$  mW/ $^{\circ}C$  shall be applied until 50 mW.

### 10. Operating Ranges (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	$V_{CC}$		1.2 to 3.6	V
Input voltage	$V_{IN}$		-0.3 to 3.6	V
Output voltage	$V_{OUT}$	(Note 1)	0 to 3.6	V
		(Note 2)	0 to $V_{CC}$	
Output current	$I_{OH}, I_{OL}$	(Note 3)	$\pm 24$	mA
		(Note 4)	$\pm 18$	
		(Note 5)	$\pm 6$	
		(Note 6)	$\pm 2$	
Operating temperature	$T_{opr}$	(Note 7)	-40 to 125	$^{\circ}C$
Input rise and fall times	$dt/dv$	(Note 8)	0 to 10	ns/V

Note: 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 1: Output in OFF state.

Note 2: High (H) or Low (L) state.

Note 3:  $V_{CC} = 3.0$  to  $3.6$  V

Note 4:  $V_{CC} = 2.3$  to  $2.7$  V

Note 5:  $V_{CC} = 1.65$  to  $1.95$  V

Note 6:  $V_{CC} = 1.4$  to  $1.6$  V

Note 7: Operating Range spec of  $T_{opr} = -40$   $^{\circ}C$  to  $125$   $^{\circ}C$  is applicable only for the products which manufactured after April 2020.

Note 8:  $V_{IN} = 0.8$  to  $2.0$  V,  $V_{CC} = 3.0$  V

### 11. Electrical Characteristics

#### 11.1. DC Characteristics (Unless otherwise specified, $T_a = -40$ to $85$ °C)

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit	
High-level input voltage	$V_{IH}$	—	1.2 to 1.4	$V_{CC} \times 0.8$	—	V	
			1.4 to 1.65	$V_{CC} \times 0.65$	—		
			1.65 to 2.3	$V_{CC} \times 0.65$	—		
			2.3 to 2.7	1.6	—		
			2.7 to 3.6	2.0	—		
Low-level input voltage	$V_{IL}$	—	1.2 to 1.4	—	$V_{CC} \times 0.05$	V	
			1.4 to 1.65	—	$V_{CC} \times 0.05$		
			1.65 to 2.3	—	$V_{CC} \times 0.2$		
			2.3 to 2.7	—	0.7		
			2.7 to 3.6	—	0.8		
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -100 \mu A$	1.2	$V_{CC} - 0.1$	—	V
				1.4 to 1.65	$V_{CC} - 0.2$	—	
				1.65 to 3.6	$V_{CC} - 0.2$	—	
			$I_{OH} = -2$ mA	1.4	1.05	—	
				1.65	1.25	—	
			$I_{OH} = -6$ mA	2.3	2.0	—	
				2.7	2.2	—	
			$I_{OH} = -12$ mA	2.3	1.8	—	
				2.7	2.2	—	
			$I_{OH} = -18$ mA	2.3	1.7	—	
3.0	2.4	—					
$I_{OH} = -24$ mA	2.3	1.7	—				
	3.0	2.4	—				
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 100 \mu A$	1.2	—	0.05	V
				1.4 to 1.65	—	0.05	
				1.65 to 3.6	—	0.2	
			$I_{OL} = 2$ mA	1.4	—	0.35	
				1.65	—	0.3	
			$I_{OL} = 6$ mA	2.3	—	0.4	
				2.7	—	0.4	
			$I_{OL} = 12$ mA	2.3	—	0.6	
				3.0	—	0.4	
			$I_{OL} = 18$ mA	2.3	—	0.6	
3.0	—	0.4					
$I_{OL} = 24$ mA	2.3	—	0.6				
	3.0	—	0.55				
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $3.6$ V	1.2 to 3.6	—	$\pm 5.0$	$\mu A$	
3-state output OFF-state leakage current	$I_{OZ}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{OUT} = 0$ to $3.6$ V	1.2 to 3.6	—	$\pm 10.0$	$\mu A$	
Power-OFF leakage current	$I_{OFF}$	$V_{IN}/V_{OUT} = 0$ to $3.6$ V	0	—	10.0	$\mu A$	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	1.2 to 3.6	—	20.0	$\mu A$	
		$V_{CC} \leq (V_{IN}/V_{OUT}) \leq 3.6$ V	1.2 to 3.6	—	$\pm 20.0$		
	$\Delta I_{CC}$	$V_{IH} = V_{CC} - 0.6$ V (per input)	2.7 to 3.6	—	750	$\mu A$	

### 11.2. DC Characteristics (Note) (Unless otherwise specified, $T_a = -40$ to $125$ °C)

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit	
High-level input voltage	$V_{IH}$	—	1.2 to 1.4	$V_{CC} \times 0.8$	—	V	
			1.4 to 1.65	$V_{CC} \times 0.65$	—		
			1.65 to 2.3	$V_{CC} \times 0.65$	—		
			2.3 to 2.7	1.6	—		
			2.7 to 3.6	2.0	—		
Low-level input voltage	$V_{IL}$	—	1.2 to 1.4	—	$V_{CC} \times 0.05$	V	
			1.4 to 1.65	—	$V_{CC} \times 0.05$		
			1.65 to 2.3	—	$V_{CC} \times 0.2$		
			2.3 to 2.7	—	0.7		
			2.7 to 3.6	—	0.8		
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -100 \mu A$	1.2	$V_{CC} - 0.1$	—	V
				1.4 to 1.65	$V_{CC} - 0.2$	—	
				1.65 to 3.6	$V_{CC} - 0.2$	—	
			$I_{OH} = -2$ mA	1.4	1.05	—	
				1.65	1.25	—	
			$I_{OH} = -6$ mA	2.3	2.0	—	
				2.7	2.2	—	
			$I_{OH} = -12$ mA	2.3	1.8	—	
				2.7	2.2	—	
			$I_{OH} = -18$ mA	2.3	1.6	—	
3.0	2.4	—					
$I_{OH} = -24$ mA	3.0	2.2	—				
	3.0	2.2	—				
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 100 \mu A$	1.2	—	0.05	V
				1.4 to 1.65	—	0.05	
				1.65 to 3.6	—	0.2	
			$I_{OL} = 2$ mA	1.4	—	0.35	
				1.65	—	0.3	
			$I_{OL} = 6$ mA	2.3	—	0.4	
				2.7	—	0.4	
			$I_{OL} = 12$ mA	2.3	—	0.8	
				3.0	—	0.4	
			$I_{OL} = 18$ mA	2.3	—	0.8	
3.0	—	0.4					
$I_{OL} = 24$ mA	3.0	—	0.55				
	3.0	—	0.55				
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $3.6$ V	1.2 to 3.6	—	$\pm 20.0$	$\mu A$	
3-state output OFF-state leakage current	$I_{OZ}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{OUT} = 0$ to $3.6$ V	1.2 to 3.6	—	$\pm 40.0$	$\mu A$	
Power-OFF leakage current	$I_{OFF}$	$V_{IN}/V_{OUT} = 0$ to $3.6$ V	0	—	40.0	$\mu A$	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	1.2 to 3.6	—	80.0	$\mu A$	
		$V_{CC} \leq (V_{IN}/V_{OUT}) \leq 3.6$ V	1.2 to 3.6	—	$\pm 80.0$		
	$\Delta I_{CC}$	$V_{IH} = V_{CC} - 0.6$ V (per input)	2.7 to 3.6	—	1.5	mA	

Note: Operating Range spec of  $T_{opr} = -40$  °C to  $125$  °C is applicable only for the products which manufactured after April 2020.

### 11.3. AC Characteristics (Unless otherwise specified, $T_a = -40$ to $85$ °C)

Characteristics	Symbol	Note	Test Condition	$V_{CC}$ (V)	Min	Max	Unit
Propagation delay time	$t_{PLH}, t_{PHL}$		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.1, Table 11.8.1	1.2	1.5	42.0	ns
				$1.5 \pm 0.1$	1.0	16.8	
				$1.8 \pm 0.15$	1.5	8.4	
				$2.5 \pm 0.2$	0.8	4.2	
				$3.3 \pm 0.3$	0.6	3.5	
3-state output enable time	$t_{PZL}, t_{PZH}$		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.2, Table 11.8.1	1.2	1.5	49.0	ns
				$1.5 \pm 0.1$	1.0	19.6	
				$1.8 \pm 0.15$	1.5	9.8	
				$2.5 \pm 0.2$	0.8	5.5	
				$3.3 \pm 0.3$	0.6	4.5	
3-state output disable time	$t_{PLZ}, t_{PHZ}$		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.2, Table 11.8.1	1.2	1.5	32.5	ns
				$1.5 \pm 0.1$	1.0	13.0	
				$1.8 \pm 0.15$	1.5	6.5	
				$2.5 \pm 0.2$	0.8	3.6	
				$3.3 \pm 0.3$	0.6	3.3	
Output skew	$t_{oS LH}, t_{oS HL}$	(Note 1)	—	1.2	—	1.5	ns
				$1.5 \pm 0.1$	—	1.5	
				$1.8 \pm 0.15$	—	0.5	
				$2.5 \pm 0.2$	—	0.5	
				$3.3 \pm 0.3$	—	0.5	

Note 1: Parameter guaranteed by design. ( $t_{oS LH} = |t_{PLHm} - t_{PLHn}|$ ,  $t_{oS HL} = |t_{PHLm} - t_{PHLn}|$ )

### 11.4. AC Characteristics (Note) (Unless otherwise specified, $T_a = -40$ to $125$ °C)

Characteristics	Symbol	Note	Test Condition	$V_{CC}$ (V)	Min	Max	Unit
Propagation delay time	$t_{PLH}, t_{PHL}$		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.1, Table 11.8.1	1.2	1.5	55.0	ns
				$1.5 \pm 0.1$	1.0	21.4	
				$1.8 \pm 0.15$	1.5	10.0	
				$2.5 \pm 0.2$	0.8	5.0	
				$3.3 \pm 0.3$	0.6	4.2	
3-state output enable time	$t_{PZL}, t_{PZH}$		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.2, Table 11.8.1	1.2	1.5	60.0	ns
				$1.5 \pm 0.1$	1.0	23.2	
				$1.8 \pm 0.15$	1.5	11.6	
				$2.5 \pm 0.2$	0.8	6.5	
				$3.3 \pm 0.3$	0.6	5.4	
3-state output disable time	$t_{PLZ}, t_{PHZ}$		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.2, Table 11.8.1	1.2	1.5	41.0	ns
				$1.5 \pm 0.1$	1.0	16.2	
				$1.8 \pm 0.15$	1.5	8.1	
				$2.5 \pm 0.2$	0.8	4.5	
				$3.3 \pm 0.3$	0.6	4.1	
Output skew	$t_{oS LH}, t_{oS HL}$	(Note 1)	—	1.2	—	2.0	ns
				$1.5 \pm 0.1$	—	2.0	
				$1.8 \pm 0.15$	—	1.0	
				$2.5 \pm 0.2$	—	1.0	
				$3.3 \pm 0.3$	—	1.0	

Note: Operating Range spec of  $T_{opr} = -40$  °C to  $125$  °C is applicable only for the products which manufactured after April 2020.

Note 1: Parameter guaranteed by design. ( $t_{oS LH} = |t_{PLHm} - t_{PLHn}|$ ,  $t_{oS HL} = |t_{PHLm} - t_{PHLn}|$ )

### 11.5. Dynamic Switching Characteristics (Note)

(Unless otherwise specified,  $T_a = 25^\circ\text{C}$ , Input:  $t_r = t_f = 2.0 \text{ ns}$ ,  $C_L = 30 \text{ pF}$ )

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Typ.	Unit
Quiet output maximum dynamic $V_{OL}$	$V_{OLP}$	$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$	1.8	0.25	V
		$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$	2.5	0.6	
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$	3.3	0.8	
Quiet output minimum dynamic $V_{OL}$	$V_{OLV}$	$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$	1.8	-0.25	V
		$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$	2.5	-0.6	
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$	3.3	-0.8	
Quiet output minimum dynamic $V_{OH}$	$V_{OHV}$	$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$	1.8	1.5	V
		$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$	2.5	1.9	
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$	3.3	2.2	

Note: Parameter guaranteed by design.

### 11.6. Capacitive Characteristics (Unless otherwise specified, $T_a = 25^\circ\text{C}$ )

Characteristics	Symbol	Note	Test Condition	$V_{CC}$ (V)	Typ.	Unit
Input capacitance	$C_{IN}$		—	1.8, 2.5, 3.3	6	pF
Output capacitance	$C_{OUT}$		—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	$C_{PD}$	(Note 1)	$f_{IN} = 10 \text{ MHz}$	1.8, 2.5, 3.3	20	pF

Note 1:  $C_{PD}$  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.

$$I_{CC(opr)} = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}/8 \text{ (per 1 gate)}$$

### 11.7. AC Test Circuit

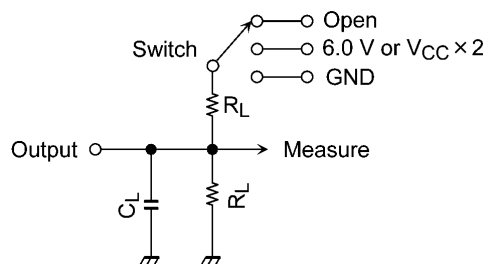


Table 11.7.1 Parameter for AC Test Circuit

Parameter	Switch	Test Condition
$t_{PLH}, t_{PHL}$	OPEN	—
$t_{PLZ}, t_{PZL}$	6.0 V	$V_{CC} = 3.3 \pm 0.3 \text{ V}$
	$V_{CC} \times 2$	$V_{CC} = 2.5 \pm 0.2 \text{ V}$
		$V_{CC} = 1.8 \pm 0.15 \text{ V}$
		$V_{CC} = 1.5 \pm 0.1 \text{ V}$
$V_{CC} = 1.2 \text{ V}$		
$t_{PHZ}, t_{PZH}$	GND	—



### 11.8. AC Waveform

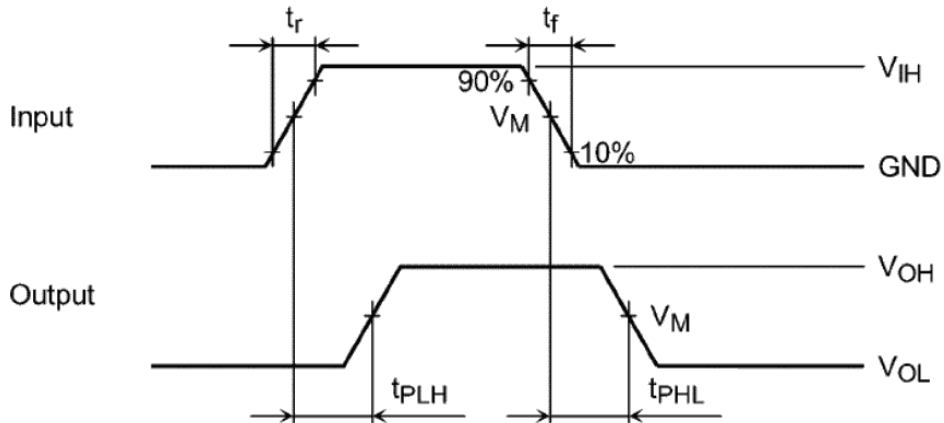


Fig. 11.8.1  $t_{PLH}$ ,  $t_{PHL}$

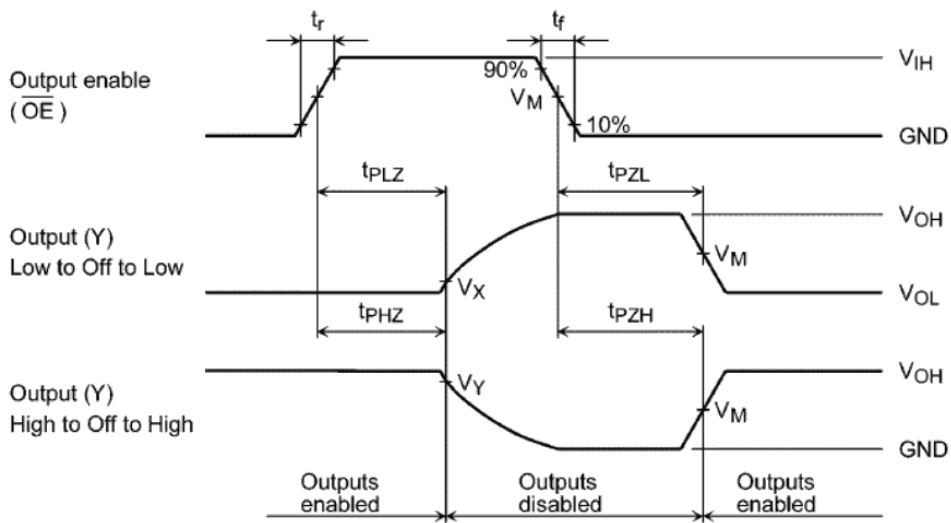


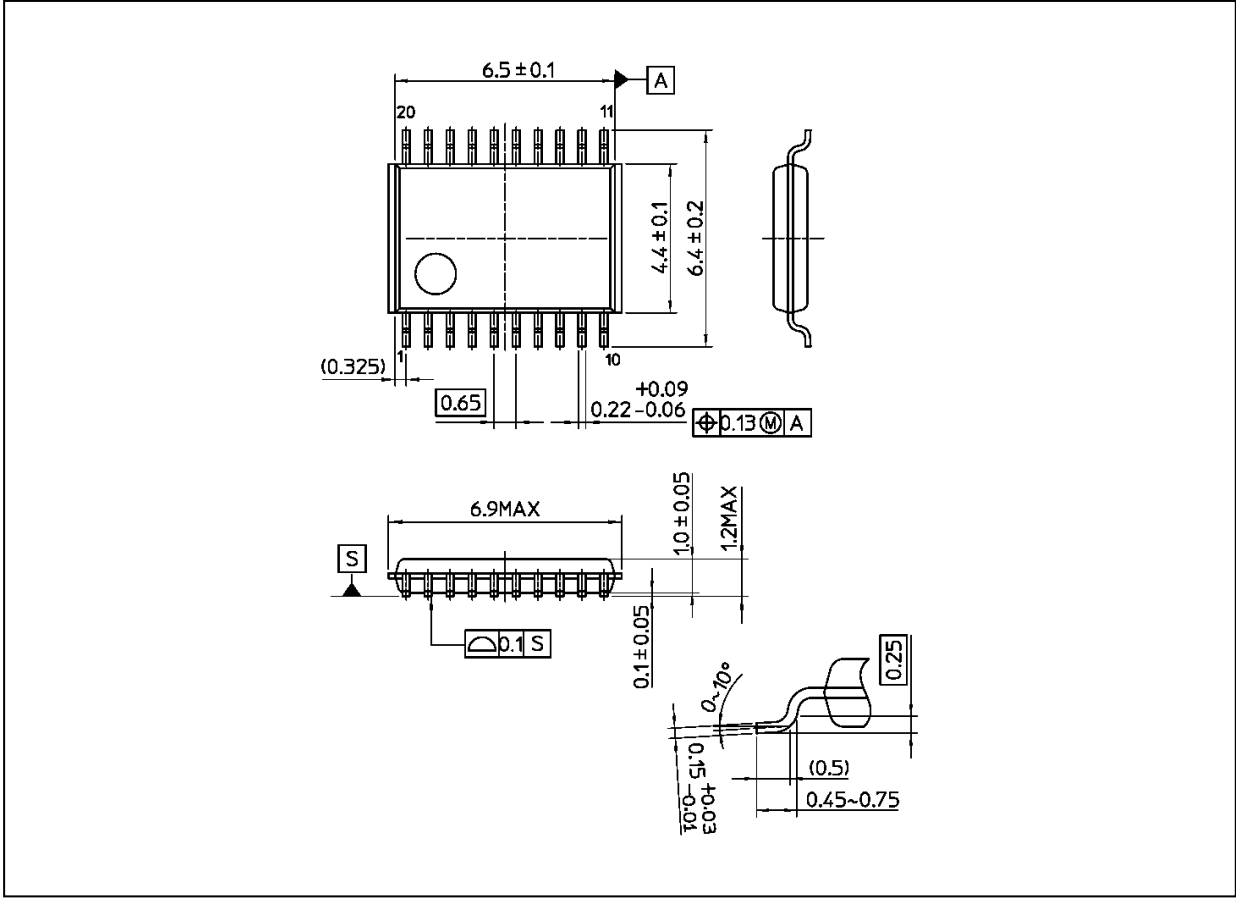
Fig. 11.8.2  $t_{PLZ}$ ,  $t_{PHZ}$ ,  $t_{PZL}$ ,  $t_{PZH}$

Table 11.8.1 AC Waveform Symbols

	Symbol	$V_{CC} = 3.3 \pm 0.3 \text{ V}$	$V_{CC} = 2.5 \pm 0.2 \text{ V}$ $V_{CC} = 1.8 \pm 0.15 \text{ V}$	$V_{CC} = 1.5 \pm 0.1 \text{ V}$ $V_{CC} = 1.2 \text{ V}$
Input	$V_{IH}$	2.7 V	$V_{CC}$	$V_{CC}$
	$V_M$	1.5 V	$V_{CC}/2$	$V_{CC}/2$
	$t_r, t_f$	2.0 ns	2.0 ns	2.0 ns
Output	$V_M$	1.5 V	$V_{CC}/2$	$V_{CC}/2$
	$V_X$	$V_{OL} + 0.3 \text{ V}$	$V_{OL} + 0.15 \text{ V}$	$V_{OL} + 0.15 \text{ V}$
	$V_Y$	$V_{OH} - 0.3 \text{ V}$	$V_{OH} - 0.15 \text{ V}$	$V_{OH} - 0.15 \text{ V}$
Load	$C_L$	30 pF	30 pF	15 pF
	$R_L$	500 $\Omega$	500 $\Omega$	2 k $\Omega$

Package Dimensions

Unit: mm



Weight: 0.08 g (typ.)

Package Name(s)
Nickname: TSSOP20

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