CMOS Digital Integrated Circuits Silicon Monolithic

TC74VCX245FT

1. Functional Description

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

2. General

The TC74VCX245FT is a high performance CMOS octal bus transceiver 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 direction of data transmission is determined by the level of the DIR inputs. The $\overline{OE}$ inputs can be used to disable the device so that the busses are effectively isolated.

All inputs are equipped with protection circuits against static discharge.

3. Features (Note)

(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} = ±24 mA (min) (V_{CC} = 3.0 V)
I_{OH}/I_{OL} = ±18 mA (min) (V_{CC} = 2.3 V)
I_{OH}/I_{OL} = ±6 mA (min) (V_{CC} = 1.65 V)
I_{OH}/I_{OL} = ±2 mA (min) (V_{CC} = 1.4 V)

(5) Bidirectional interface between 2.5 V and 3.3 V signals

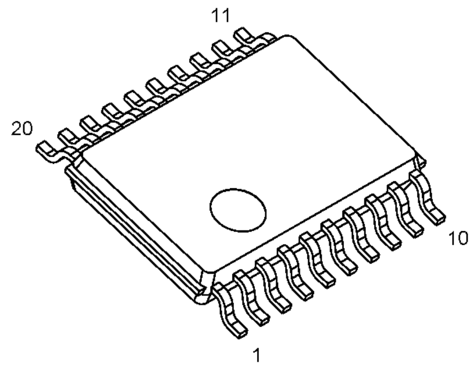
(6) 3.6 V tolerant function and power-down protection provided on all inputs and outputs.

Note: Do not apply a signal to any bus pins when it is in the output mode. Damage may result.
All floating (high impedance) bus pins must have their input levels fixed by means of pull-up or pull-down resistors.

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

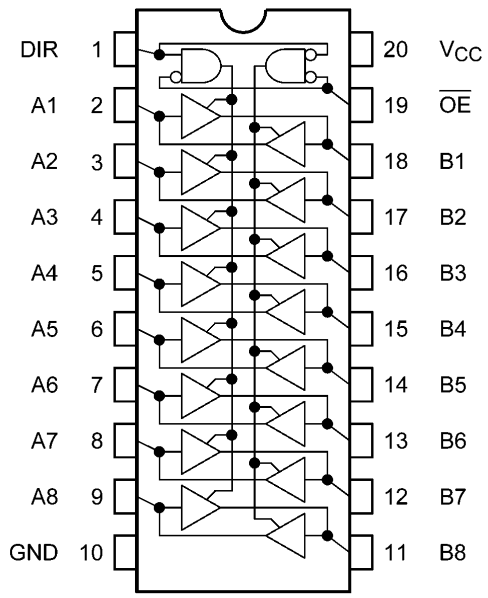
Start of commercial production
2020-04

4. Packaging



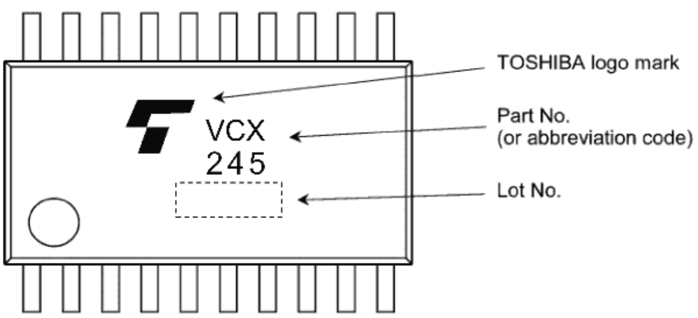
TSSOP20

5. Pin Assignment

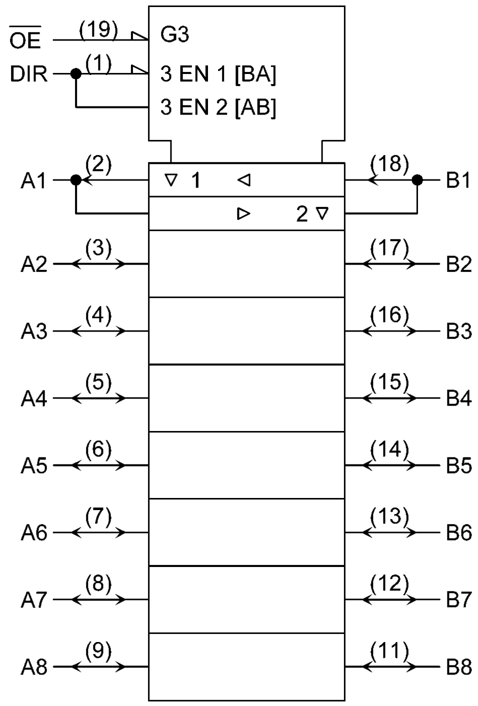


(top view)

6. Marking



7. IEC Logic Symbol



8. Truth Table

Input $\overline{OE}$	Input DIR	Outputs	Function A-Bus	Function B-Bus
L	L	A = B	Output	Input
L	H	B = A	Input	Output
H	X	Z	Z	Z

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(DIR/$\overline{OE}$)	V_{IN}		-0.5 to 4.6	V
Bus I/O voltage	$V_{I/O}$	(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)	±50	mA
Output current	I_{OUT}		±50	mA
Power dissipation	P_D	(Note 4)	180	mW
V_{CC}/ground current	I_{CC}/I_{GND}		±100	mA
Storage temperature	T_{stg}		-65 to 150	°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 °C. From T_a = 85 to 125 °C a derating factor of -3.25 mW/°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(DIR/$\overline{OE}$)	V_{IN}		-0.3 to 3.6	V
Bus I/O voltage	$V_{I/O}$	(Note 1)	0 to 3.6	V
		(Note 2)	0 to V_{CC}	
Output current	I_{OH},I_{OL}	(Note 3)	±24	mA
		(Note 4)	±18	
		(Note 5)	±6	
		(Note 6)	±2	
Operating temperature	T_{opr}	(Note 7)	-40 to 125	°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 and bus inputs must be tied to either V_{CC} or GND. Please connect both bus inputs and the bus outputs with V_{CC} or GND when the I/O of the bus terminal changes by the function. In this case, please note that the output is not short-circuited.

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 °C to 125 °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℃)

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 μA	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	—	
			I_{OH} = -6 mA	1.65	1.25	—	
				2.3	2.0	—	
			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	3.0	2.2	—	
Low-level output voltage	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}	I_{OL} = 100 μA	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	
			I_{OL} = 6 mA	1.65	—	0.3	
			I_{OL} = 12 mA	2.3	—	0.4	
				2.7	—	0.4	
			I_{OL} = 18 mA	2.3	—	0.6	
				3.0	—	0.4	
			I_{OL} = 24 mA	3.0	—	0.55	
Input leakage current	I_{IN}	V_{IN} = 0 to 3.6 V		1.2 to 3.6	—	±5.0	μA
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	—	±10.0	μA
Power-OFF leakage current	I_{OFF}	V_{IN}/V_{OUT} = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current	I_{CC}	$V_{IN} = V_{CC}$ or GND		1.2 to 3.6	—	20.0	μA
		$V_{CC} \leq (V_{IN}/V_{OUT}) \leq 3.6$ V		1.2 to 3.6	—	±20.0	
	ΔI_{CC}	$V_{IH} = V_{CC}$ - 0.6 V (per input)		2.7 to 3.6	—	750	μA

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} × 0.8	—	V
				1.4 to 1.65	V_{CC} × 0.65	—	
				1.65 to 2.3	V_{CC} × 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} × 0.05	V
				1.4 to 1.65	—	V_{CC} × 0.05	
				1.65 to 2.3	—	V_{CC} × 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 μA	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	—	
			I_{OH} = -6 mA	1.65	1.25	—	
				2.3	2.0	—	
			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	—	
Low-level output voltage	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 100 μA	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	
			I_{OL} = 6 mA	1.65	—	0.3	
			I_{OL} = 12 mA	2.3	—	0.4	
				2.7	—	0.4	
			I_{OL} = 18 mA	2.3	—	0.8	
				3.0	—	0.4	
			I_{OL} = 24 mA	3.0	—	0.55	
Input leakage current	I_{IN}	V_{IN} = 0 to 3.6 V		1.2 to 3.6	—	±20.0	μA
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	—	±40.0	μA
Power-OFF leakage current	I_{OFF}	V_{IN}/V_{OUT} = 0 to 3.6 V		0	—	40.0	μA
Quiescent supply current	I_{CC}	V_{IN} = V_{CC} or GND		1.2 to 3.6	—	80.0	μA
		V_{CC} ≤ (V_{IN}/V_{OUT}) ≤ 3.6 V		1.2 to 3.6	—	±80.0	
	ΔI_{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 ± 0.1	1.0	16.8	
				1.8 ± 0.15	1.5	8.4	
				2.5 ± 0.2	0.8	4.2	
				3.3 ± 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 ± 0.1	1.0	19.6	
				1.8 ± 0.15	1.5	9.8	
				2.5 ± 0.2	0.8	5.6	
				3.3 ± 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	36.0	ns
				1.5 ± 0.1	1.0	14.4	
				1.8 ± 0.15	1.5	7.2	
				2.5 ± 0.2	0.8	4.0	
				3.3 ± 0.3	0.6	3.6	
Output skew	t_{osLH},t_{osHL}	(Note 1)	—	1.2	—	1.5	ns
				1.5 ± 0.1	—	1.5	
				1.8 ± 0.15	—	0.5	
				2.5 ± 0.2	—	0.5	
				3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design. (t_{osLH} = |t_{PLH}m-t_{PLH}n|, t_{osHL} = |t_{PHL}m-t_{PHL}n|)

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 ± 0.1	1.0	21.4	
				1.8 ± 0.15	1.5	10.0	
				2.5 ± 0.2	0.8	5.0	
				3.3 ± 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 ± 0.1	1.0	23.2	
				1.8 ± 0.15	1.5	11.6	
				2.5 ± 0.2	0.8	6.5	
				3.3 ± 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	45.0	ns
				1.5 ± 0.1	1.0	17.9	
				1.8 ± 0.15	1.5	9.0	
				2.5 ± 0.2	0.8	5.0	
				3.3 ± 0.3	0.6	4.5	
Output skew	t_{osLH},t_{osHL}	(Note 1)	—	1.2	—	2.0	ns
				1.5 ± 0.1	—	2.0	
				1.8 ± 0.15	—	1.0	
				2.5 ± 0.2	—	1.0	
				3.3 ± 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_{osLH} = |t_{PLH}m-t_{PLH}n|, t_{osHL} = |t_{PHL}m-t_{PHL}n|)

11.5. Dynamic Switching Characteristics (Note)
(Unless otherwise specified, T_a = 25°C, Input: t_r = t_f = 2.0 ns, C_L = 30 pF)

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

Note: Parameter guaranteed by design.

11.6. Capacitive Characteristics (Unless otherwise specified, T_a = 25°C)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}		—	1.8, 2.5, 3.3	6	pF
Bus I/O capacitance	$C_{I/O}$		—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C_{PD}	(Note 1)	f_{IN} = 10 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.

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

11.7. AC Test Circuit

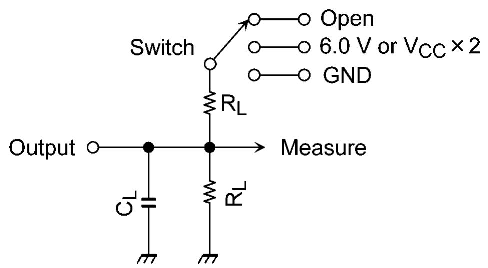


Table 11.7.1 Parameter for AC Test Circuit

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

11.8. AC Waveform

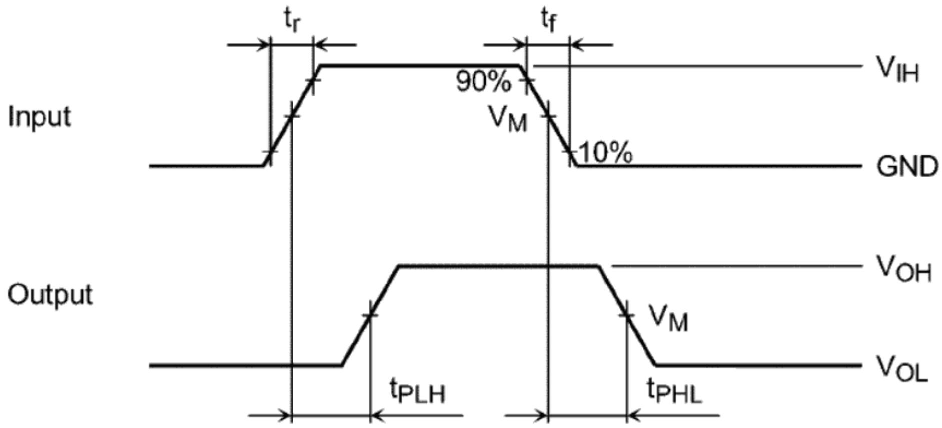


Fig. 11.8.1 t_{PLH}, t_{PHL}

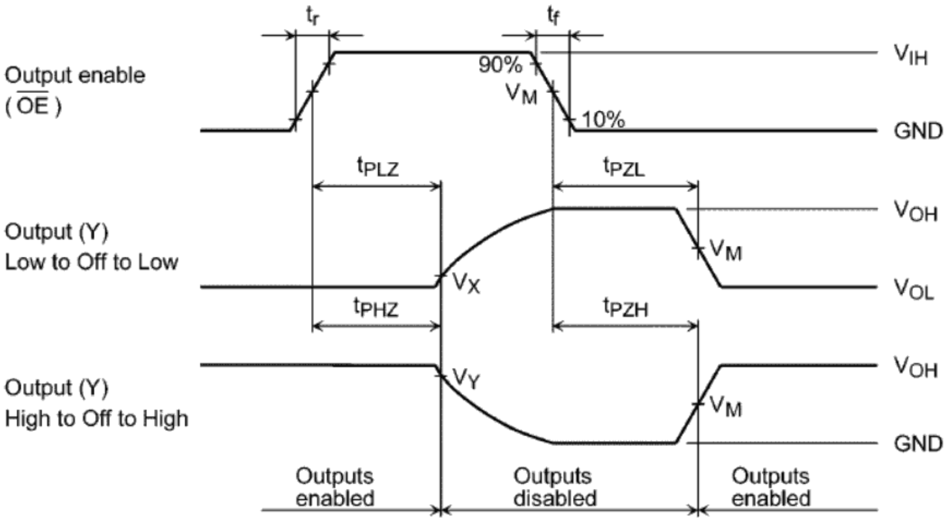


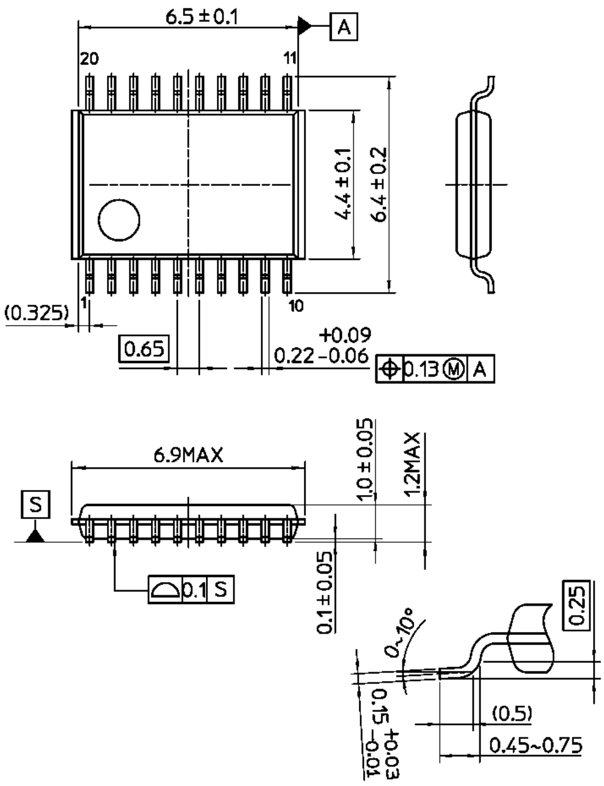
Fig. 11.8.2 t_{PLZ}, t_{PHZ}, t_{PZL}, t_{PZH}

Table 11.8.1 AC Waveform Symbols

	Symbol	V_{CC} = 3.3 ± 0.3 V	V_{CC} = 2.5 ± 0.2 V V_{CC} = 1.8 ± 0.15 V	V_{CC} = 1.5 ± 0.1 V V_{CC} = 1.2 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 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
Load	C_L	30 pF	30 pF	30 pF
	R_L	500 Ω	500 Ω	2 kΩ

Package Dimensions

Unit: mm



Weight: 0.08 g (typ.)

Package Name(s)
Nickname: TSSOP20

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