

TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

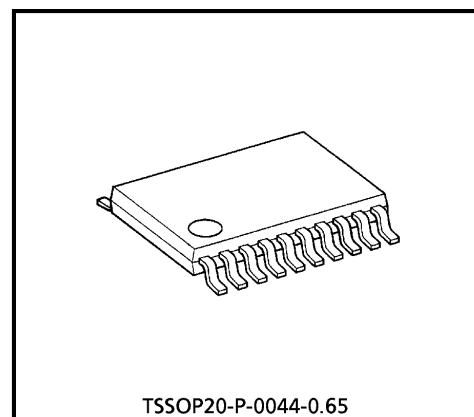
# TC74VCX541FT

## LOW-VOLTAGE OCTAL BUS BUFFER WITH 3.6 V TOLERANT INPUTS AND OUTPUTS

The TC74VCX541FT is a high performance CMOS OCTAL BUS BUFFER. Designed for use in 1.8, 2.5 or 3.3 Volt 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 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.



Weight : 0.08 g (Typ.)

### FEATURES

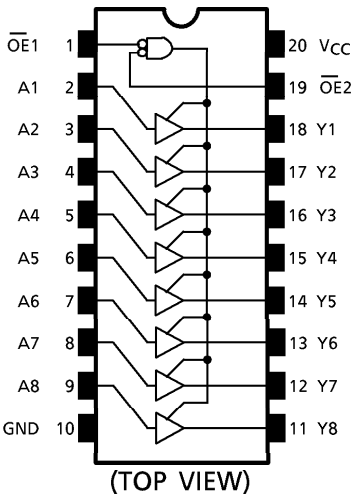
- Low Voltage Operation :  $V_{CC} = 1.8 \sim 3.6$  V
- High Speed Operation :  $t_{pd} = 3.5$  ns (max) at  $V_{CC} = 3.0 \sim 3.6$  V  
 $t_{pd} = 4.2$  ns (max) at  $V_{CC} = 2.3 \sim 2.7$  V  
 $t_{pd} = 8.4$  ns (max) at  $V_{CC} = 1.8$  V
- 3.6 V Tolerant inputs and outputs.
- Output Current :  $I_{OH}/I_{OL} = \pm 24$  mA (min) at  $V_{CC} = 3.0$  V  
 $I_{OH}/I_{OL} = \pm 18$  mA (min) at  $V_{CC} = 2.3$  V  
 $I_{OH}/I_{OL} = \pm 6$  mA (min) at  $V_{CC} = 1.8$  V
- Latch-up Performance :  $\pm 300$  mA
- ESD Performance : Human Body Model  $> \pm 2000$  V  
Machine Model  $> \pm 200$  V
- Package : TSSOP  
(Thin Shrink Small Outline Package)
- Power Down Protection is provided on all inputs and outputs.
- Supports live insertion / withdrawal (Note 1)

(Note 1): To ensure the high-impedance state during power up or power down,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pullup resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

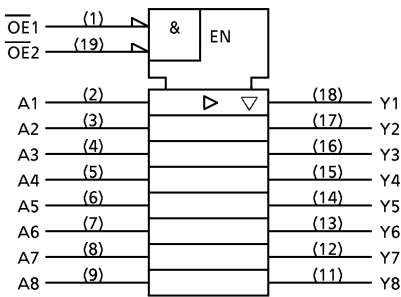
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PIN ASSIGNMENT



IEC LOGIC SYMBOL



TRUTH TABLE

| INPUTS |     |    | OUTPUTS |
|--------|-----|----|---------|
| OE1    | OE2 | An |         |
| H      | X   | X  | Z       |
| X      | H   | X  | Z       |
| L      | L   | H  | H       |
| L      | L   | L  | L       |

X : Don't Care  
Z : High Impedance

MAXIMUM RATINGS

| PARAMETER                           | SYMBOL                             | RATING                               | UNIT |
|-------------------------------------|------------------------------------|--------------------------------------|------|
| Power Supply Voltage                | V <sub>CC</sub>                    | − 0.5~4.6                            | V    |
| DC Input Voltage                    | V <sub>IN</sub>                    | − 0.5~4.6                            | V    |
| DC Output Voltage                   | V <sub>OUT</sub>                   | − 0.5~4.6 (Note 1)                   | V    |
|                                     |                                    | − 0.5~V <sub>CC</sub> + 0.5 (Note 2) |      |
| Input Diode Current                 | I <sub>IK</sub>                    | − 50                                 | mA   |
| Output Diode Current                | I <sub>OK</sub>                    | ± 50 (Note 3)                        | mA   |
| DC Output Current                   | I <sub>OUT</sub>                   | ± 50                                 | mA   |
| Power Dissipation                   | P <sub>D</sub>                     | 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>                   | − 65~150                             | °C   |

(Note 1): Off-State  
(Note 2): High or Low State. I<sub>OUT</sub> absolute maximum rating must be observed.  
(Note 3): V<sub>OUT</sub> < GND, V<sub>OUT</sub> > V<sub>CC</sub>

## RECOMMENDED OPERATING RANGE

| PARAMETER                | SYMBOL          | RATING               | UNIT |
|--------------------------|-----------------|----------------------|------|
| Supply Voltage           | $V_{CC}$        | 1.8~3.6              | V    |
|                          |                 | 1.2~3.6 (Note 4)     |      |
| Input Voltage            | $V_{IN}$        | -0.3~3.6             | V    |
| Output Voltage           | $V_{OUT}$       | 0~3.6 (Note 5)       | V    |
|                          |                 | 0~ $V_{CC}$ (Note 6) |      |
| Output Current           | $I_{OH}/I_{OL}$ | $\pm 24$ (Note 7)    | mA   |
|                          |                 | $\pm 18$ (Note 8)    |      |
|                          |                 | $\pm 6$ (Note 9)     |      |
| Operating Temperature    | $T_{opr}$       | -40~85               | °C   |
| Input Rise And Fall Time | $dt/dv$         | 0~10 (Note 10)       | ns/V |

(Note 4): Data Retention Only

(Note 5): Off-State

(Note 6): High or Low State

(Note 7):  $V_{CC} = 3.0\sim 3.6\text{ V}$ (Note 8):  $V_{CC} = 2.3\sim 2.7\text{ V}$ (Note 9):  $V_{CC} = 1.8\text{ V}$ (Note 10):  $V_{IN} = 0.8\sim 2.0\text{ V}$ ,  $V_{CC} = 3.0\text{ V}$ 

## ELECTRICAL CHARACTERISTICS

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

| PARAMETER                             |           | SYMBOL           | TEST CONDITION                                                                     |                            | V <sub>CC</sub> (V) | MIN                   | MAX    | UNIT |
|---------------------------------------|-----------|------------------|------------------------------------------------------------------------------------|----------------------------|---------------------|-----------------------|--------|------|
| Input Voltage                         | "H" Level | V <sub>IH</sub>  |                                                                                    |                            | 2.7~3.6             | 2.0                   | —      | V    |
|                                       | "L" Level | V <sub>IL</sub>  |                                                                                    |                            | 2.7~3.6             | —                     | 0.8    |      |
| Output Voltage                        | "H" 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                   | —      |      |
|                                       | "L" 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><br>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 |      |
| Increase In I <sub>CC</sub> Per Input |           | ΔI <sub>CC</sub> | V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V                                          |                            | 2.7~3.6             | —                     | 750    | μA   |

## ELECTRICAL CHARACTERISTICS

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

| PARAMETER                        |           | SYMBOL           | TEST CONDITION                                                                     |                           |         |                       | MIN    | MAX | UNIT |
|----------------------------------|-----------|------------------|------------------------------------------------------------------------------------|---------------------------|---------|-----------------------|--------|-----|------|
|                                  |           |                  |                                                                                    |                           |         | V <sub>CC</sub> (V)   |        |     |      |
| Input Voltage                    | "H" Level | V <sub>IH</sub>  |                                                                                    |                           |         | 2.3~2.7               | 1.6    | —   | V    |
|                                  | "L" Level | V <sub>IL</sub>  |                                                                                    |                           |         | 2.3~2.7               | —      | 0.7 |      |
| Output Voltage                   | "H" 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                   | —      |     |      |
|                                  | "L" 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                                                          |                           | 2.3~2.7 | —                     | ± 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><br>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 |     |      |

## ELECTRICAL CHARACTERISTICS

DC characteristics (Ta = -40~85°C, 1.8 V ≤ V<sub>CC</sub> < 2.3 V)

| PARAMETER                        |           | SYMBOL           | TEST CONDITION                                                                     |                            |     | MIN                   | MAX                   | UNIT   |    |
|----------------------------------|-----------|------------------|------------------------------------------------------------------------------------|----------------------------|-----|-----------------------|-----------------------|--------|----|
|                                  |           |                  | V <sub>CC</sub> (V)                                                                |                            |     |                       |                       |        |    |
| Input Voltage                    | “H” Level | V <sub>IH</sub>  | 1.8~2.3                                                                            |                            |     | 0.7 × V <sub>CC</sub> | —                     | V      |    |
|                                  | “L” Level | V <sub>IL</sub>  | 1.8~2.3                                                                            |                            |     | —                     | 0.2 × V <sub>CC</sub> |        |    |
| Output Voltage                   | “H” Level | V <sub>OH</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OH</sub> = − 100 μA | 1.8 | V <sub>CC</sub> − 0.2 | —                     | V      |    |
|                                  |           |                  |                                                                                    | I <sub>OH</sub> = − 6 mA   | 1.8 | 1.4                   | —                     |        |    |
|                                  | “L” Level | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                               | I <sub>OL</sub> = 100 μA   | 1.8 | —                     | 0.2                   |        |    |
|                                  |           |                  |                                                                                    | I <sub>OL</sub> = 6 mA     | 1.8 | —                     | 0.3                   |        |    |
| Input Leakage Current            |           | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                                          |                            |     | 1.8                   | —                     | ± 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><br>V <sub>OUT</sub> = 0~3.6 V |                            |     | 1.8                   | —                     | ± 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                                           |                            |     | 1.8                   | —                     | 20.0   | μA |
|                                  |           |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V                    |                            |     | 1.8                   | —                     | ± 20.0 |    |

AC characteristics (Ta = -40~85°C, Input t<sub>r</sub> = t<sub>f</sub> = 2.0 ns, C<sub>L</sub> = 30 pF, R<sub>L</sub> = 500 Ω)

| PARAMETER                   |                                        | SYMBOL     | TEST CONDITION |  | V <sub>CC</sub> (V) | MIN | MAX | UNIT |
|-----------------------------|----------------------------------------|------------|----------------|--|---------------------|-----|-----|------|
| Propagation Delay Time      | t <sub>pLH</sub><br>t <sub>pHL</sub>   | (Fig.1, 2) |                |  | 1.8                 | 1.5 | 8.4 | ns   |
|                             |                                        |            |                |  | 2.5 ± 0.2           | 0.8 | 4.2 |      |
|                             |                                        |            |                |  | 3.3 ± 0.3           | 0.6 | 3.5 |      |
| 3-State Output Enable Time  | t <sub>pZL</sub><br>t <sub>pZH</sub>   | (Fig.1, 3) |                |  | 1.8                 | 1.5 | 9.8 | ns   |
|                             |                                        |            |                |  | 2.5 ± 0.2           | 0.8 | 5.5 |      |
|                             |                                        |            |                |  | 3.3 ± 0.3           | 0.6 | 4.5 |      |
| 3-State Output Disable Time | t <sub>pLZ</sub><br>t <sub>pHZ</sub>   | (Fig.1, 3) |                |  | 1.8                 | 1.5 | 6.5 | ns   |
|                             |                                        |            |                |  | 2.5 ± 0.2           | 0.8 | 3.6 |      |
|                             |                                        |            |                |  | 3.3 ± 0.3           | 0.6 | 3.3 |      |
| Output To Output Skew       | t <sub>osLH</sub><br>t <sub>osHL</sub> | (Note 11)  |                |  | 1.8                 | —   | 0.5 | ns   |
|                             |                                        |            |                |  | 2.5 ± 0.2           | —   | 0.5 |      |
|                             |                                        |            |                |  | 3.3 ± 0.3           | —   | 0.5 |      |

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

(Note 11): Parameter guaranteed by design.

$$(t_{osLH} = |t_{pLHm} - t_{pLHn}|, t_{osHL} = |t_{pHLm} - t_{pHLn}|)$$

Dynamic switching characteristics ( $T_a = 25^\circ\text{C}$ , Input  $t_r = t_f = 2.0\text{ ns}$ ,  $C_L = 30\text{ pF}$ )

| PARAMETER                                | SYMBOL    | TEST CONDITION                                            | $V_{CC}$ (V) | TYP.  | UNIT |
|------------------------------------------|-----------|-----------------------------------------------------------|--------------|-------|------|
|                                          |           |                                                           |              |       |      |
| Quiet Output Maximum<br>Dynamic $V_{OL}$ | $V_{OLP}$ | $V_{IH} = 1.8\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 1.8          | 0.25  | V    |
|                                          |           | $V_{IH} = 2.5\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 2.5          | 0.6   |      |
|                                          |           | $V_{IH} = 3.3\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 3.3          | 0.8   |      |
| Quiet Output Minimum<br>Dynamic $V_{OL}$ | $V_{OLV}$ | $V_{IH} = 1.8\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 1.8          | -0.25 | V    |
|                                          |           | $V_{IH} = 2.5\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 2.5          | -0.6  |      |
|                                          |           | $V_{IH} = 3.3\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 3.3          | -0.8  |      |
| Quiet Output Minimum<br>Dynamic $V_{OH}$ | $V_{OHV}$ | $V_{IH} = 1.8\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 1.8          | 1.5   | V    |
|                                          |           | $V_{IH} = 2.5\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 2.5          | 1.9   |      |
|                                          |           | $V_{IH} = 3.3\text{ V}$ , $V_{IL} = 0\text{ V}$ (Note 12) | 3.3          | 2.2   |      |

(Note 12): Parameter guaranteed by design.

Capacitive characteristics ( $T_a = 25^\circ\text{C}$ )

| PARAMETER                     | SYMBOL    | 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 | $C_{PD}$  | $f_{IN} = 10\text{ MHz}$ (Note 13) | 1.8, 2.5, 3.3 | 20   | pF   |

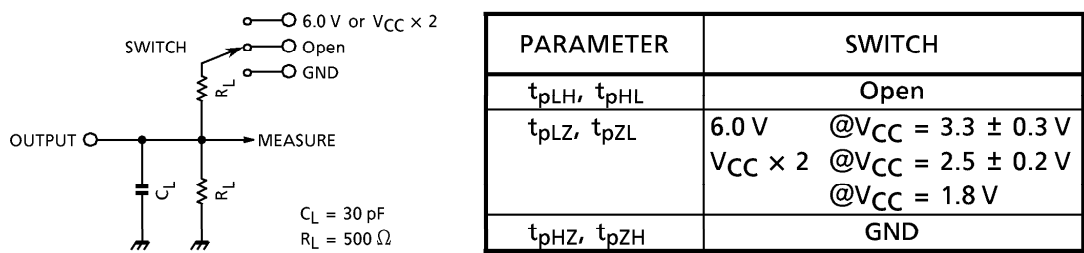
(Note 13):  $C_{PD}$  is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation :

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

TEST CIRCUIT

Fig.1



AC WAVEFORM

Fig.2  $t_{pLH}, t_{pHL}$

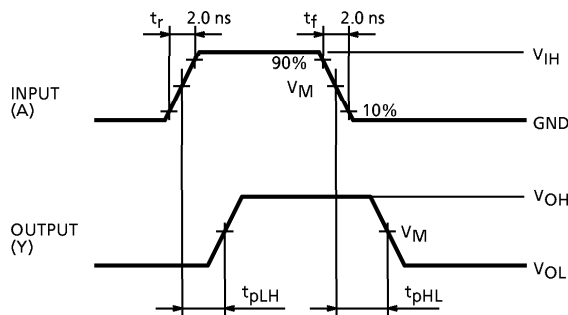
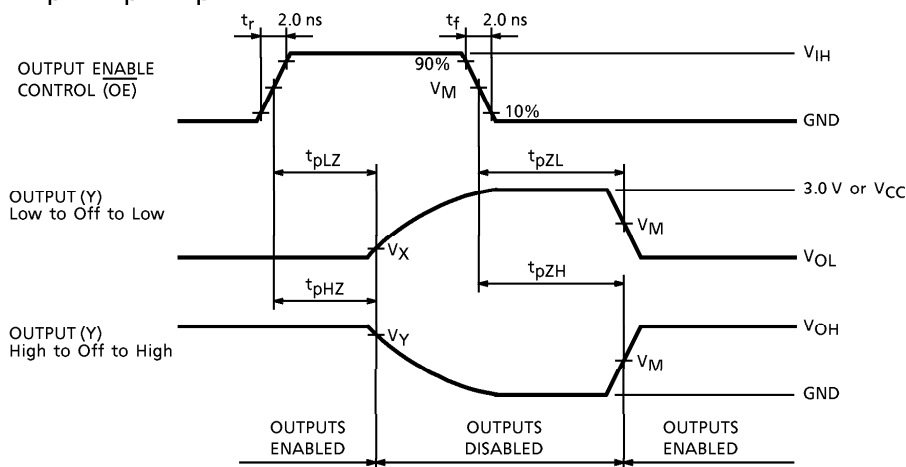


Fig.3  $t_{pLZ}, t_{pHZ}, t_{pZL}, t_{pZH}$

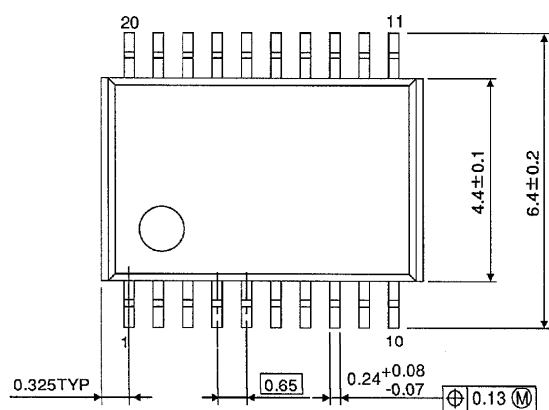
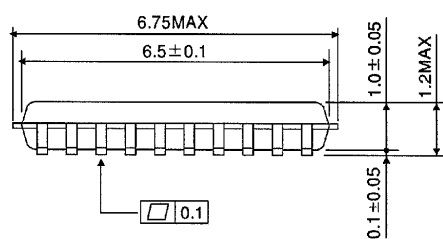
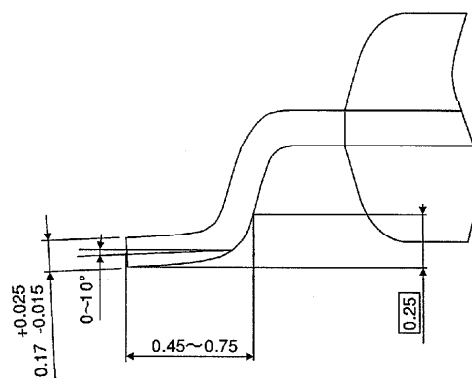


| SYMBOL   | $V_{CC}$                 |                           |                           |
|----------|--------------------------|---------------------------|---------------------------|
|          | $3.3 \pm 0.3 \text{ V}$  | $2.5 \pm 0.2 \text{ V}$   | $1.8 \text{ V}$           |
| $V_{IH}$ |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

**OUTLINE DRAWING**

TSSOP20-P-0044-0.65

Unit : mm



Weight : 0.08 g (Typ.)