

# TC74VCX244FK

## 1. Functional Description

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

## 2. General

The TC74VCX244FK 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.

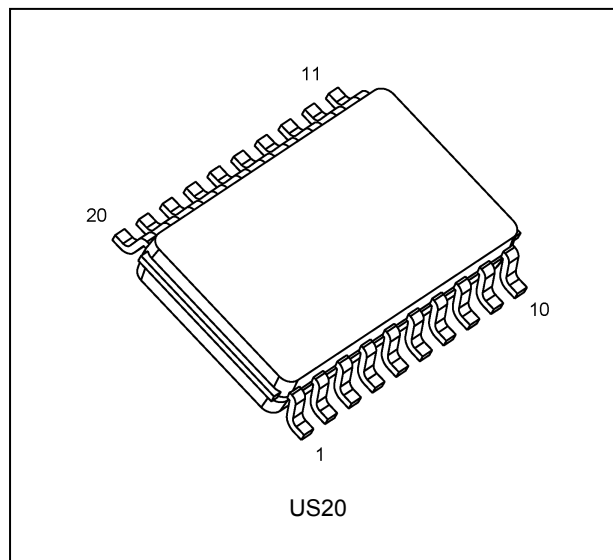
It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

This device is non-inverting 3-state buffer having two active-low output enables. When the  $\overline{OE}$  input is high, the outputs are in a 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

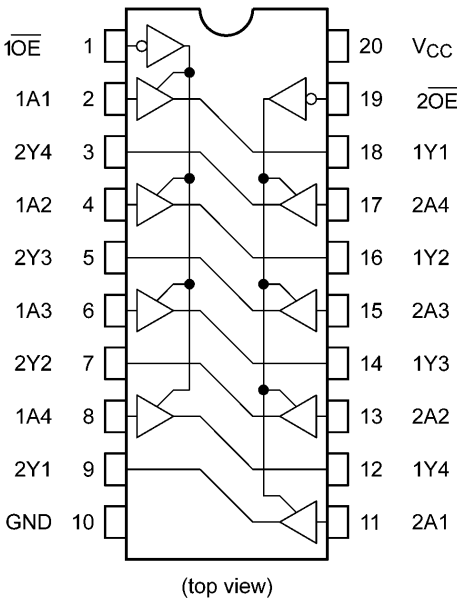
- (1) Low-voltage operation:  $V_{CC} = 1.2$  to  $3.6$  V
- (2) High-speed operation:  $t_{pd} = 3.5$  ns (max) ( $V_{CC} = 3.0$  to  $3.6$  V)  
 $t_{pd} = 4.2$  ns (max) ( $V_{CC} = 2.3$  to  $2.7$  V)  
 $t_{pd} = 8.4$  ns (max) ( $V_{CC} = 1.65$  to  $1.95$  V)  
 $t_{pd} = 16.8$  ns (max) ( $V_{CC}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

## 4. Packaging

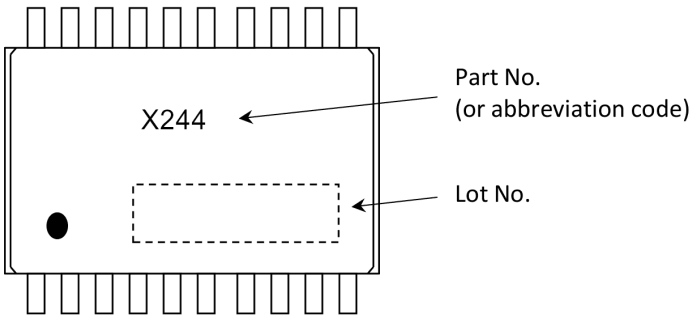


Start of commercial production  
2006-04

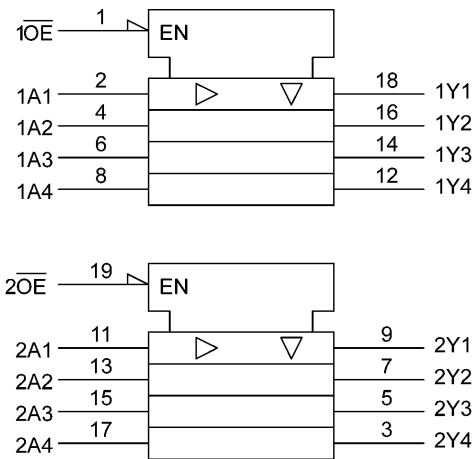
5. Pin Assignment



6. Marking



7. IEC Logic Symbol



### 8. Truth Table

| Inputs $\overline{OE}$ | Inputs $A_n$ | Outputs |
|------------------------|--------------|---------|
| L                      | L            | L       |
| L                      | H            | H       |
| H                      | X            | 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            | $V_{IN}$         |          | -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        | $P_D$            |          | 180                    | mW   |
| $V_{CC}$ /ground current | $I_{CC}/I_{GND}$ |          | $\pm 100$              | 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:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

### 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     | $T_{opr}$        |          | -40 to 85     | °C   |
| Input rise and fall times | $dt/dv$          | (Note 7) | 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:  $V_{IN} = 0.8$  to  $2.0$  V ,  $V_{CC} = 3.0$  V

## 11. Electrical Characteristics

11.1. DC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $85^\circ\text{C}$ )

| Characteristics                          | Symbol           | Test Condition                                                                        |                           | V <sub>CC</sub> (V)      | Min                    | Max                    | Unit |
|------------------------------------------|------------------|---------------------------------------------------------------------------------------|---------------------------|--------------------------|------------------------|------------------------|------|
| High-level input voltage                 | V <sub>IH</sub>  | —                                                                                     |                           | 1.2 to 1.4               | V <sub>CC</sub> × 0.8  | —                      | V    |
|                                          |                  |                                                                                       |                           | 1.4 to 1.65              | V <sub>CC</sub> × 0.65 | —                      |      |
|                                          |                  |                                                                                       |                           | 1.65 to 2.3              | V <sub>CC</sub> × 0.65 | —                      |      |
|                                          |                  |                                                                                       |                           | 2.3 to 2.7               | 1.6                    | —                      |      |
|                                          |                  |                                                                                       |                           | 2.7 to 3.6               | 2.0                    | —                      |      |
| Low-level input voltage                  | V <sub>IL</sub>  | —                                                                                     |                           | 1.2 to 1.4               | —                      | V <sub>CC</sub> × 0.05 | V    |
|                                          |                  |                                                                                       |                           | 1.4 to 1.65              | —                      | V <sub>CC</sub> × 0.05 |      |
|                                          |                  |                                                                                       |                           | 1.65 to 2.3              | —                      | V <sub>CC</sub> × 0.2  |      |
|                                          |                  |                                                                                       |                           | 2.3 to 2.7               | —                      | 0.7                    |      |
|                                          |                  |                                                                                       |                           | 2.7 to 3.6               | —                      | 0.8                    |      |
| High-level output voltage                | 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    |
|                                          |                  |                                                                                       |                           | 1.4 to 1.65              | V <sub>CC</sub> - 0.2  | —                      |      |
|                                          |                  |                                                                                       |                           | 1.65 to 3.6              | V <sub>CC</sub> - 0.2  | —                      |      |
|                                          |                  |                                                                                       | I <sub>OH</sub> = -2 mA   | 1.4                      | 1.05                   | —                      |      |
|                                          |                  |                                                                                       |                           | I <sub>OH</sub> = -6 mA  | 1.65                   | 1.25                   |      |
|                                          |                  |                                                                                       | 2.3                       |                          | 2.0                    | —                      |      |
|                                          |                  |                                                                                       |                           | I <sub>OH</sub> = -12 mA | 2.3                    | 1.8                    |      |
|                                          |                  |                                                                                       | 2.7                       |                          | 2.2                    | —                      |      |
|                                          |                  |                                                                                       |                           | I <sub>OH</sub> = -18 mA | 2.3                    | 1.7                    |      |
|                                          |                  |                                                                                       | 3.0                       |                          | 2.4                    | —                      |      |
| I <sub>OH</sub> = -24 mA                 | 3.0              | 2.2                                                                                   |                           | —                        |                        |                        |      |
| Low-level output voltage                 | 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                   | V    |
|                                          |                  |                                                                                       |                           | 1.4 to 1.65              | —                      | 0.05                   |      |
|                                          |                  |                                                                                       |                           | 1.65 to 3.6              | —                      | 0.2                    |      |
|                                          |                  |                                                                                       | I <sub>OL</sub> = 2 mA    | 1.4                      | —                      | 0.35                   |      |
|                                          |                  |                                                                                       | I <sub>OL</sub> = 6 mA    | 1.65                     | —                      | 0.3                    |      |
|                                          |                  |                                                                                       |                           | I <sub>OL</sub> = 12 mA  | 2.3                    | —                      |      |
|                                          |                  |                                                                                       | 2.7                       |                          | —                      | 0.4                    |      |
|                                          |                  |                                                                                       |                           | I <sub>OL</sub> = 18 mA  | 2.3                    | —                      |      |
|                                          |                  |                                                                                       | 3.0                       |                          | —                      | 0.4                    |      |
|                                          |                  |                                                                                       |                           | I <sub>OL</sub> = 24 mA  | 3.0                    | —                      |      |
| Input leakage current                    | I <sub>IN</sub>  | V <sub>IN</sub> = 0 to 3.6 V                                                          |                           | 1.2 to 3.6               | —                      | ±5.0                   | μA   |
| 3-state output OFF-state leakage current | I <sub>OZ</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0 to 3.6 V |                           | 1.2 to 3.6               | —                      | ±10.0                  | μA   |
| Power-OFF leakage current                | I <sub>OFF</sub> | V <sub>IN</sub> /V <sub>OUT</sub> = 0 to 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 to 3.6               | —                      | 20.0                   | μA   |
|                                          |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> /V <sub>OUT</sub> ) ≤ 3.6 V                        |                           | 1.2 to 3.6               | —                      | ±20.0                  |      |
|                                          | ΔI <sub>CC</sub> | V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V<br>(per input)                              |                           | 2.7 to 3.6               | —                      | 750                    | μA   |

11.2. AC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $85^\circ\text{C}$ )

| Characteristics             | Symbol               | Note     | Test Condition                                                    | $V_{CC}$ (V)   | Min | Max  | Unit |
|-----------------------------|----------------------|----------|-------------------------------------------------------------------|----------------|-----|------|------|
| Propagation delay time      | $t_{PLH}, t_{PHL}$   |          | See 11.5 AC Test Circuit, Table 11.5.1, Fig. 11.6.1, Table 11.6.1 | 1.2            | 3.0 | 42.0 | ns   |
|                             |                      |          |                                                                   | $1.5 \pm 0.1$  | 2.0 | 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 11.5 AC Test Circuit, Table 11.5.1, Fig. 11.6.2, Table 11.6.1 | 1.2            | 3.0 | 49.0 | ns   |
|                             |                      |          |                                                                   | $1.5 \pm 0.1$  | 2.0 | 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 11.5 AC Test Circuit, Table 11.5.1, Fig. 11.6.2, Table 11.6.1 | 1.2            | 3.0 | 29.0 | ns   |
|                             |                      |          |                                                                   | $1.5 \pm 0.1$  | 2.0 | 11.6 |      |
|                             |                      |          |                                                                   | $1.8 \pm 0.15$ | 1.5 | 5.8  |      |
|                             |                      |          |                                                                   | $2.5 \pm 0.2$  | 0.8 | 3.2  |      |
|                             |                      |          |                                                                   | $3.3 \pm 0.3$  | 0.6 | 3.0  |      |
| Output skew                 | $t_{osLH}, t_{osHL}$ | (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. ( $t_{osLH} = |t_{PLHm} - t_{PLHn}|$ ,  $t_{osHL} = |t_{PHLm} - t_{PHLn}|$ )

## 11.3. Dynamic Switching Characteristics (Note)

(Unless otherwise specified,  $T_a = 25^\circ\text{C}$ , 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.

11.4. 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) | $f_{IN} = 10$ 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.

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

11.5. AC Test Circuit

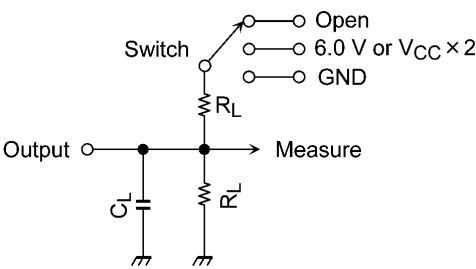


Table 11.5.1 Parameter for AC Test Circuit

| 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               | —                                 |

11.6. AC Waveform

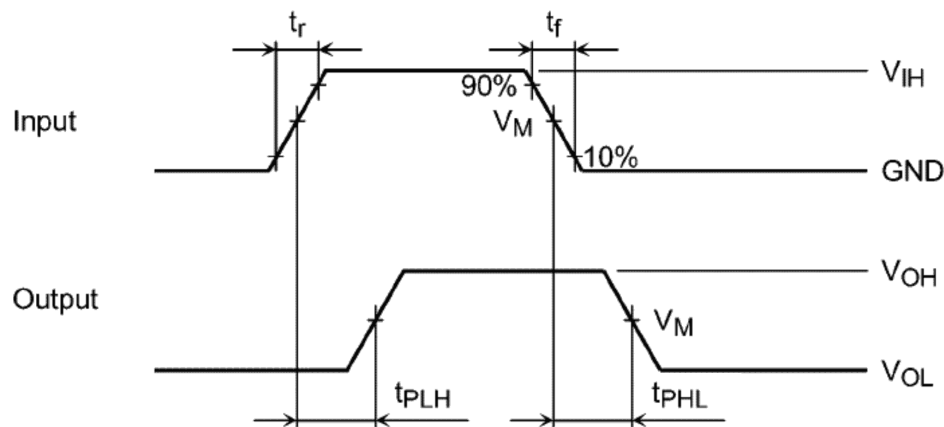


Fig. 11.6.1 t<sub>PLH</sub>, t<sub>PHL</sub>

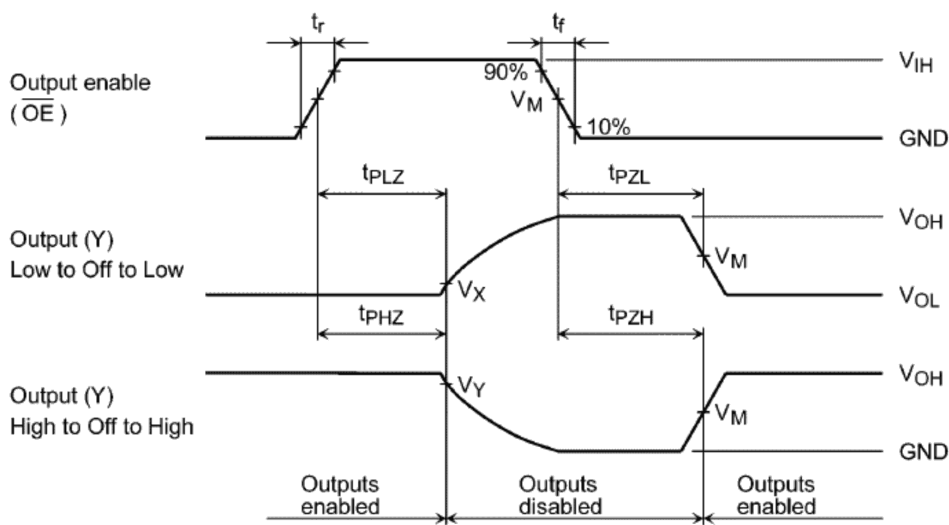


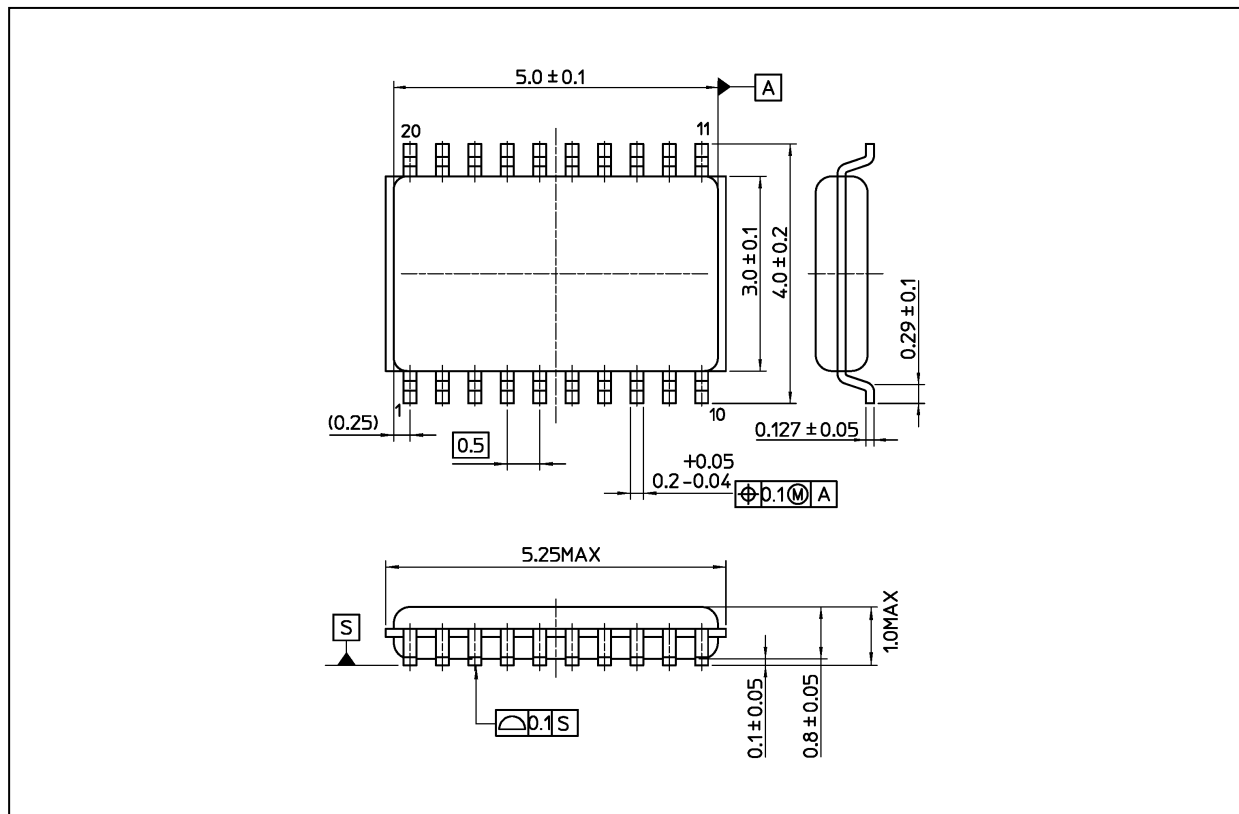
Fig. 11.6.2 t<sub>PLZ</sub>, t<sub>PHZ</sub>, t<sub>PZL</sub>, t<sub>PZH</sub>

Table 11.6.1 AC Waveform Symbols

|        | Symbol     | $V_{CC} = 3.3 \pm 0.3 \text{ V}$ | $V_{CC} = 2.5 \pm 0.2 \text{ V}$<br>$V_{CC} = 1.8 \pm 0.15 \text{ V}$ | $V_{CC} = 1.5 \pm 0.1 \text{ V}$<br>$V_{CC} = 1.2 \text{ V}$ |
|--------|------------|----------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------|
| 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: 0.03 g (typ.)

| Package Name(s) |
|-----------------|
| Nickname: US20  |

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