

CMOS Digital Integrated Circuits Silicon Monolithic

# TC74VCX02FK

## 1. Functional Description

- Low-Voltage Quad 2-Input NOR Gate with 3.6-V Tolerant Inputs and Outputs

## 2. General

The TC74VCX02FK is a high-performance CMOS 2-input NOR gate 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.

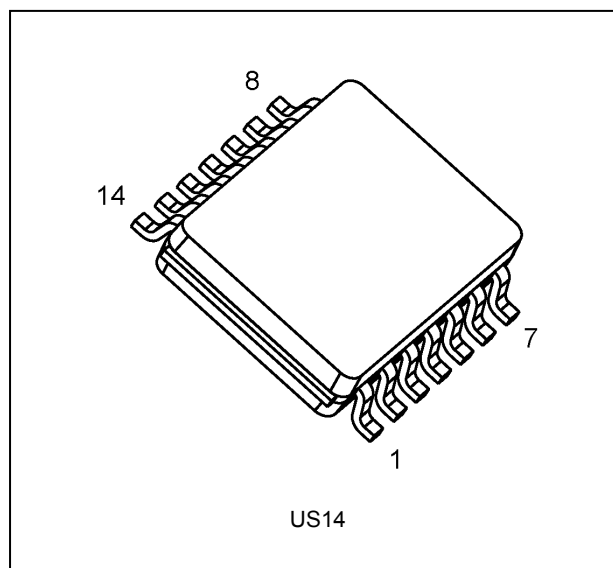
It is also designed with overvoltage tolerant inputs and outputs up to 3.6 V.

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:  $t_{pd} = 2.8$  ns (max) ( $V_{CC} = 3.0$  to  $3.6$  V)  
 $t_{pd} = 3.7$  ns (max) ( $V_{CC} = 2.3$  to  $2.7$  V)  
 $t_{pd} = 7.4$  ns (max) ( $V_{CC} = 1.65$  to  $1.95$  V)  
 $t_{pd} = 14.8$  ns (max) ( $V_{CC} = 1.4$  to  $1.6$  V)  
 $t_{pd} = 37.0$  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) Latch-up performance:  $-300$  mA
- (5) ESD performance: Human Body Model  $\geq \pm 2000$  V
- (6) 3.6 V tolerant function and power-down protection provided on all inputs and outputs.

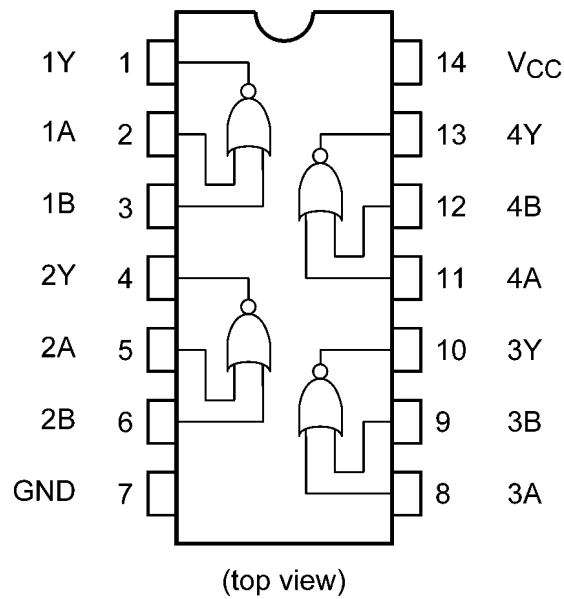
## 4. Packaging



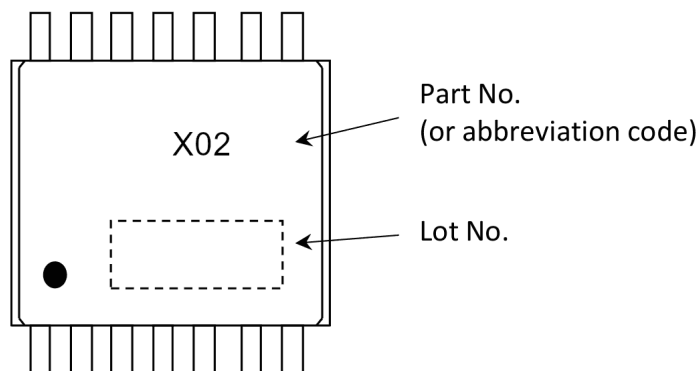
Start of commercial production

2005-12

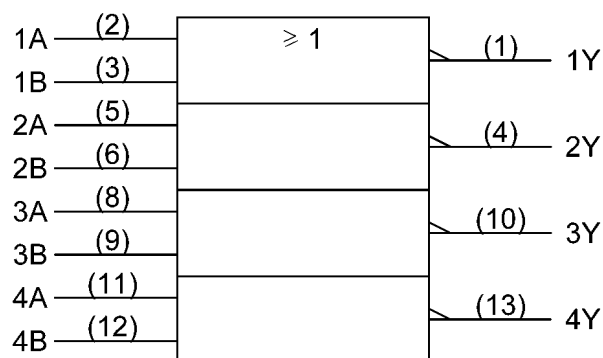
### 5. Pin Assignment



### 6. Marking



### 7. IEC Logic Symbol



### 8. Truth Table

| Inputs<br>A | Inputs<br>B | Outputs<br>Y |
|-------------|-------------|--------------|
| L           | L           | H            |
| L           | H           | L            |
| H           | L           | L            |
| H           | H           | L            |

### 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             | $^{\circ}C$ |

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:  $V_{CC} = 0$  V

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     | $^{\circ}C$ |
| 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:  $V_{CC} = 0$  V

Note 2: High or low 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 $85$ °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 | $V_{OH}$        | $V_{IN} = V_{IL}$                                | $I_{OH} = -100 \mu A$     | 1.2                  | $V_{CC} - 0.1$       | —       | V |
|                           |                 |  |                           | 1.4 to 1.65          | $V_{CC} - 0.2$       | —       |   |
|                           |                 |  |                           | 1.65 to 3.6          | $V_{CC} - 0.2$       | —       |   |
|                           |                 |  | $I_{OH} = -2 \text{ mA}$  | 1.4                  | 1.05                 | —       |   |
|                           |                 |  |                           | 1.65                 | 1.25                 | —       |   |
|                           |                 |  | $I_{OH} = -6 \text{ mA}$  | 2.3                  | 2.0                  | —       |   |
|                           |                 |  |                           | 2.7                  | 2.2                  | —       |   |
|                           |                 |  | $I_{OH} = -12 \text{ mA}$ | 2.3                  | 1.8                  | —       |   |
|                           |                 |  |                           | 2.7                  | 2.2                  | —       |   |
|                           |                 |  | $I_{OH} = -18 \text{ mA}$ | 2.3                  | 1.7                  | —       |   |
| 3.0                       | 2.4             | —  |                           |                      |                      |         |   |
| $I_{OH} = -24 \text{ mA}$ | 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     |   |
|                           |                 |  | $I_{OL} = 2 \text{ mA}$   | 1.4                  | —                    | 0.35    |   |
|                           |                 |  |                           | 1.65                 | —                    | 0.3     |   |
|                           |                 |  | $I_{OL} = 6 \text{ mA}$   | 2.3                  | —                    | 0.4     |   |
|                           |                 |  |                           | 2.7                  | —                    | 0.4     |   |
|                           |                 |  | $I_{OL} = 12 \text{ mA}$  | 2.3                  | —                    | 0.6     |   |
|                           |                 |  |                           | 3.0                  | —                    | 0.4     |   |
|                           |                 |  | $I_{OL} = 18 \text{ mA}$  | 2.3                  | —                    | 0.6     |   |
| 3.0                       | —               | 0.4  |                           |                      |                      |         |   |
| $I_{OL} = 24 \text{ mA}$  | 2.3             | —  | 0.6                       |                      |                      |         |   |
|                           | 3.0             | —  | 0.55                      |                      |                      |         |   |
| Input leakage current     | $I_{IN}$        | $V_{IN} = 0$ to $3.6 \text{ V}$                  | 1.2 to 3.6                | —                    | $\pm 5.0$            | $\mu A$ |   |
| Power-OFF leakage current | $I_{OFF}$       | $V_{IN}/V_{OUT} = 0$ to $3.6 \text{ V}$          | 0                         | —                    | 10.0                 | $\mu A$ |   |
| Quiescent supply current  | $I_{CC}$        | $V_{IN} = V_{CC}$ or GND                         | 1.2 to 3.6                | —                    | 20.0                 | $\mu A$ |   |
|                           |                 | $V_{CC} \leq V_{IN} \leq 3.6 \text{ V}$          | 1.2 to 3.6                | —                    | $\pm 20.0$           |         |   |
|                           | $\Delta I_{CC}$ | $V_{IH} = V_{CC} - 0.6 \text{ V}$<br>(per input) | 2.7 to 3.6                | —                    | 750                  | $\mu A$ |   |

### 11.2. 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 11.5 AC Test Circuit, Fig. 11.6.1, Table 11.6.1 | 1.2            | 3.0 | 37.0 | ns   |
|                        |                      |          |   | $1.5 \pm 0.1$  | 2.0 | 14.8 |      |
|                        |                      |          |   | $1.8 \pm 0.15$ | 1.5 | 7.4  |      |
|                        |                      |          |   | $2.5 \pm 0.2$  | 0.8 | 3.7  |      |
|                        |                      |          |   | $3.3 \pm 0.3$  | 0.6 | 2.8  |      |
| 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, $T_a = 25$ °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.

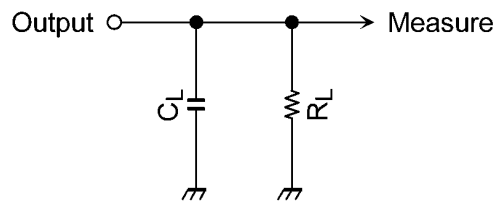
### 11.4. Capacitive Characteristics (Unless otherwise specified, $T_a = 25$ °C)

| Characteristics               | Symbol   | Note     | Test Condition    | $V_{CC}$ (V)  | Typ. | Unit |
|-------------------------------|----------|----------|-------------------|---------------|------|------|
| Input capacitance             | $C_{IN}$ |          | —                 | 1.8, 2.5, 3.3 | 6    | 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.

$$I_{CC(opr)} = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}/4 \text{ (per gate)}$$

### 11.5. AC Test Circuit



### 11.6. AC Waveform

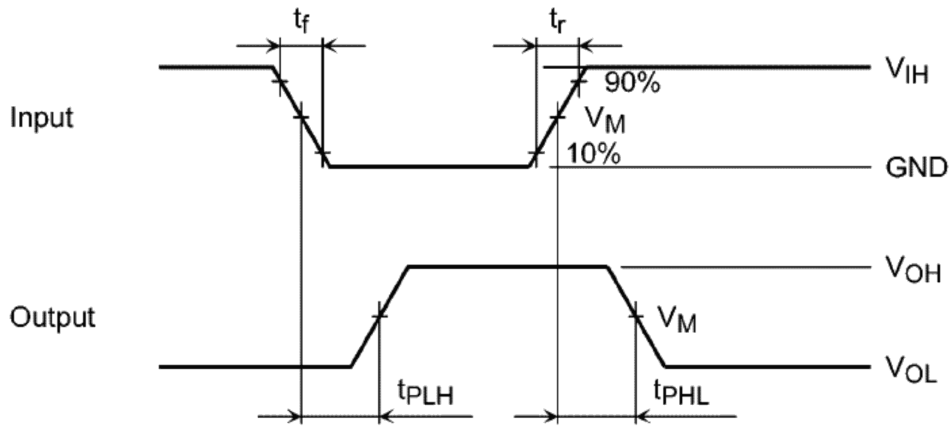


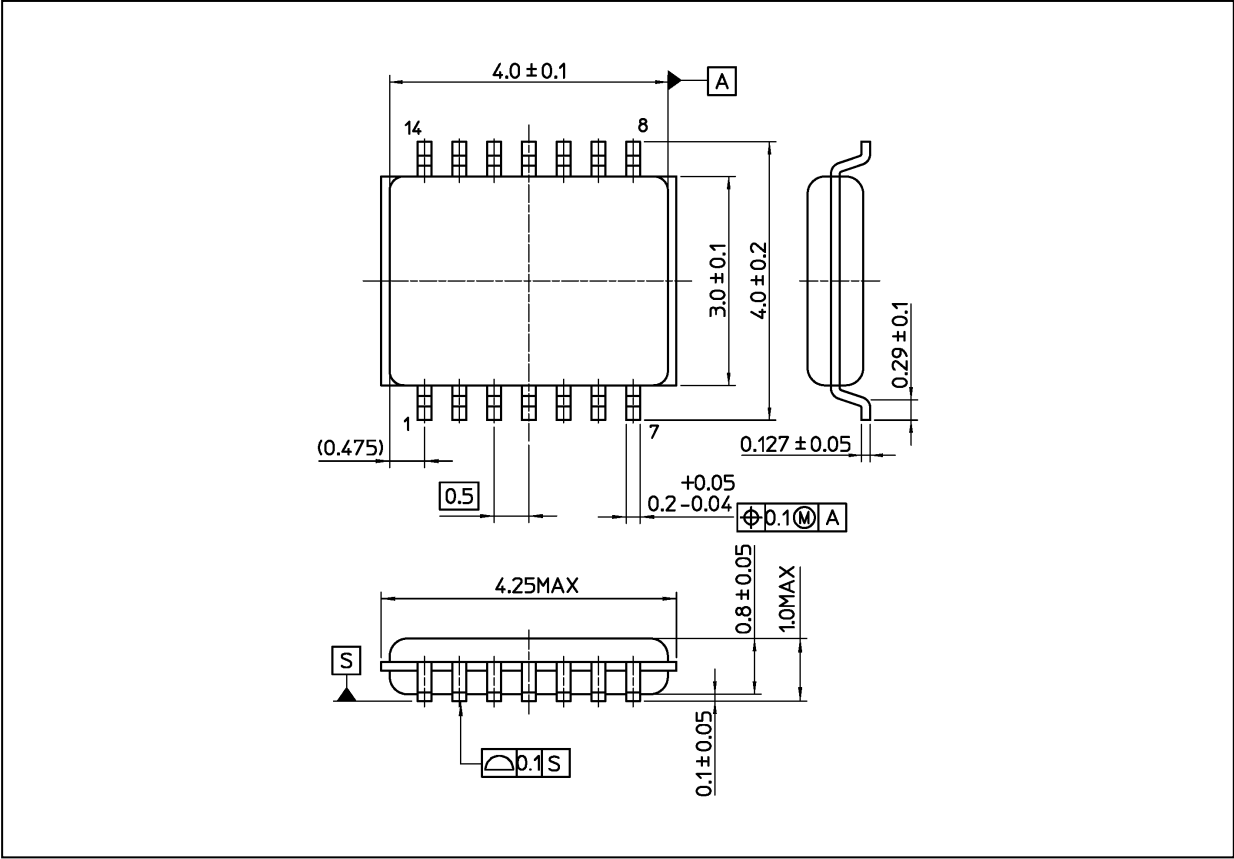
Fig. 11.6.1  $T_{PLH}, T_{PHL}$

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                            | $V_{CC}/2$  | $V_{CC}/2$   |
| Load   | $C_L$      | 30 pF                            | 30 pF   | 15 pF  |
|        | $R_L$      | 500 $\Omega$                     | 500 $\Omega$  | 2 k $\Omega$   |

Package Dimensions

Unit: mm



Weight: 0.02 g (typ.)

|                 |
|-----------------|
| Package Name(s) |
| Nickname: US14  |



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