

7UL1G04FU

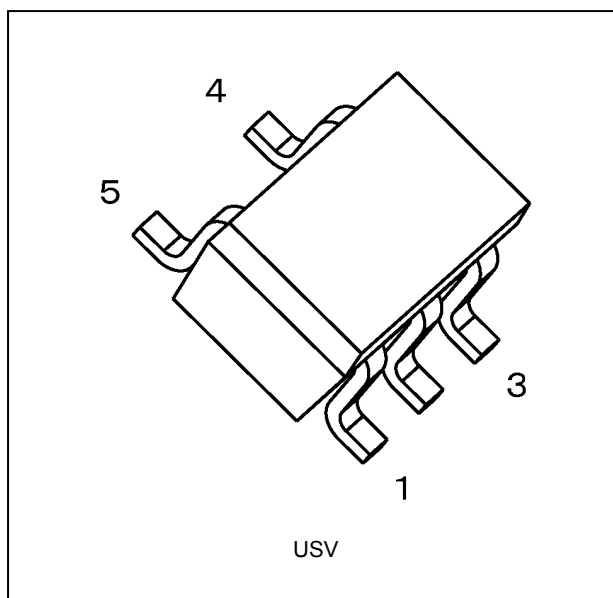
1. Functional Description

- Inverter

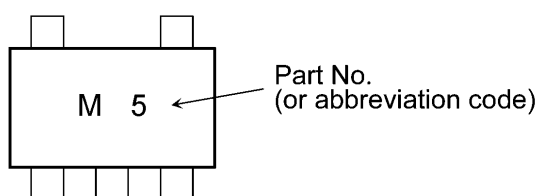
2. Features

- (1) Wide operating temperature range: $T_{opr} = -40$ to 125°C
- (2) High output current: ± 8.0 mA (min) at $V_{CC} = 3.0$ V
- (3) Super high speed operation: $t_{pd} = 2.5$ ns (typ.) at $V_{CC} = 3.3$ V, $C_L = 15$ pF
- (4) Operation voltage range: $V_{CC} = 0.9$ to 3.6 V
- (5) 3.6 V tolerant inputs
- (6) 3.6 V power down protection output

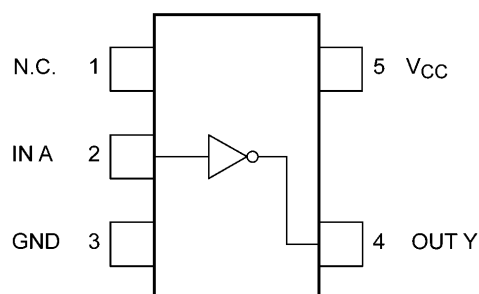
3. Packaging



4. Marking and Pin Assignment



Marking



Pin Assignment (Top view)

Start of commercial production

2018-08

5. IEC Logic Symbol



6. Truth Table

| Input A | Output Y |
|------------|-------------|
| L | H |
| H | L |

7. Absolute Maximum Ratings (Note) (Unless otherwise specified, $T_a = 25\text{ }^{\circ}\text{C}$)

| 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 |
| DC 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} | | -20 | mA |
| Output diode current | I_{OK} | (Note 3) | -20 | mA |
| DC output current | I_{OUT} | | ± 25 | mA |
| V_{CC} /ground current | I_{CC} | | ± 50 | mA |
| Power dissipation | P_D | | 200 | mW |
| Storage temperature | T_{stg} | | -65 to 150 | $^{\circ}\text{C}$ |

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: $V_{CC} = 0\text{ V}$

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

Note 3: $V_{OUT} < \text{GND}$

8. Operating Ranges (Note)

| Characteristics | Symbol | Note | Test Condition | Rating | Unit |
|--------------------------|------------------|----------|---|---------------|------|
| Supply voltage | V_{CC} | | — | 0.9 to 3.6 | V |
| Input voltage | V_{IN} | | — | 0 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} | | $V_{CC} = 3.0$ to 3.6 V | ± 8.0 | mA |
| | | | $V_{CC} = 2.3$ to 2.7 V | ± 4.0 | |
| | | | $V_{CC} = 1.65$ to 1.95 V | ± 3.0 | |
| | | | $V_{CC} = 1.4$ to 1.6 V | ± 1.7 | |
| | | | $V_{CC} = 1.1$ to 1.3 V | ± 0.3 | |
| | | | $V_{CC} = 0.9$ V | ± 0.02 | |
| Operating temperature | T_{opr} | | — | -40 to 125 | °C |
| Input rise and fall time | dt/dv | | $V_{IN} = 0.8$ to 2.0 V, $V_{CC} = 3.0$ V | 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 (H) or Low (L) state.

9. Electrical Characteristics

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

| Characteristics | Symbol | Test Condition | | V_{CC} (V) | Min | Typ. | Max | Unit |
|---------------------------|-----------|---|----------------------------|--------------|----------------------|------|----------------------|---------------|
| High-level input voltage | V_{IH} | — | | 0.9 | V_{CC} | — | — | V |
| | | | | 1.1 to 1.3 | $V_{CC} \times 0.70$ | — | — | |
| | | | | 1.4 to 1.6 | $V_{CC} \times 0.65$ | — | — | |
| | | | | 1.65 to 1.95 | $V_{CC} \times 0.65$ | — | — | |
| | | | | 2.3 to 2.7 | 1.7 | — | — | |
| | | | | 3.0 to 3.6 | 2.0 | — | — | |
| Low-level input voltage | V_{IL} | — | | 0.9 | — | — | GND | V |
| | | | | 1.1 to 1.3 | — | — | $V_{CC} \times 0.30$ | |
| | | | | 1.4 to 1.6 | — | — | $V_{CC} \times 0.35$ | |
| | | | | 1.65 to 1.95 | — | — | $V_{CC} \times 0.35$ | |
| | | | | 2.3 to 2.7 | — | — | 0.7 | |
| | | | | 3.0 to 3.6 | — | — | 0.8 | |
| High-level output voltage | V_{OH} | $V_{IN} = V_{IL}$ | $I_{OH} = -0.02\text{ mA}$ | 0.9 | 0.75 | — | — | V |
| | | | $I_{OH} = -0.3\text{ mA}$ | 1.1 to 1.3 | $V_{CC} \times 0.75$ | — | — | |
| | | | $I_{OH} = -1.7\text{ mA}$ | 1.4 to 1.6 | $V_{CC} \times 0.75$ | — | — | |
| | | | $I_{OH} = -3.0\text{ mA}$ | 1.65 to 1.95 | $V_{CC} - 0.45$ | — | — | |
| | | | $I_{OH} = -4.0\text{ mA}$ | 2.3 to 2.7 | 2.0 | — | — | |
| | | | $I_{OH} = -8.0\text{ mA}$ | 3.0 to 3.6 | 2.48 | — | — | |
| Low-level output voltage | V_{OL} | $V_{IN} = V_{IH}$ | $I_{OL} = 0.02\text{ mA}$ | 0.9 | — | — | 0.1 | V |
| | | | $I_{OL} = 0.3\text{ mA}$ | 1.1 to 1.3 | — | — | $V_{CC} \times 0.25$ | |
| | | | $I_{OL} = 1.7\text{ mA}$ | 1.4 to 1.6 | — | — | $V_{CC} \times 0.25$ | |
| | | | $I_{OL} = 3.0\text{ mA}$ | 1.65 to 1.95 | — | — | 0.45 | |
| | | | $I_{OL} = 4.0\text{ mA}$ | 2.3 to 2.7 | — | — | 0.4 | |
| | | | $I_{OL} = 8.0\text{ mA}$ | 3.0 to 3.6 | — | — | 0.4 | |
| Input leakage current | I_{IN} | $V_{IN} = 0\text{ to }3.6\text{ V}$ | | 0 to 3.6 | — | — | ± 0.1 | μA |
| Power-OFF leakage current | I_{OFF} | $V_{IN} = 0\text{ to }3.6\text{ V}$, $V_{OUT} = 0\text{ to }3.6\text{ V}$ | | 0 | — | — | 1.0 | μA |
| Quiescent supply current | I_{CC} | $V_{IN} = V_{CC}\text{ or GND}$ | | 3.6 | — | — | 1.0 | μA |

9.2. 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} | — | | 0.9 | V_{CC} | — | V |
| | | | | 1.1 to 1.3 | $V_{CC} \times 0.70$ | — | |
| | | | | 1.4 to 1.6 | $V_{CC} \times 0.65$ | — | |
| | | | | 1.65 to 1.95 | $V_{CC} \times 0.65$ | — | |
| | | | | 2.3 to 2.7 | 1.7 | — | |
| | | | | 3.0 to 3.6 | 2.0 | — | |
| Low-level input voltage | V_{IL} | — | | 0.9 | — | GND | V |
| | | | | 1.1 to 1.3 | — | $V_{CC} \times 0.30$ | |
| | | | | 1.4 to 1.6 | — | $V_{CC} \times 0.35$ | |
| | | | | 1.65 to 1.95 | — | $V_{CC} \times 0.35$ | |
| | | | | 2.3 to 2.7 | — | 0.7 | |
| | | | | 3.0 to 3.6 | — | 0.8 | |
| High-level output voltage | V_{OH} | $V_{IN} = V_{IL}$ | $I_{OH} = -0.02$ mA | 0.9 | 0.75 | — | V |
| | | | $I_{OH} = -0.3$ mA | 1.1 to 1.3 | $V_{CC} \times 0.75$ | — | |
| | | | $I_{OH} = -1.7$ mA | 1.4 to 1.6 | $V_{CC} \times 0.75$ | — | |
| | | | $I_{OH} = -3.0$ mA | 1.65 to 1.95 | $V_{CC} - 0.45$ | — | |
| | | | $I_{OH} = -4.0$ mA | 2.3 to 2.7 | 2.0 | — | |
| | | | $I_{OH} = -8.0$ mA | 3.0 to 3.6 | 2.48 | — | |
| Low-level output voltage | V_{OL} | $V_{IN} = V_{IH}$ | $I_{OL} = 0.02$ mA | 0.9 | — | 0.1 | V |
| | | | $I_{OL} = 0.3$ mA | 1.1 to 1.3 | — | $V_{CC} \times 0.25$ | |
| | | | $I_{OL} = 1.7$ mA | 1.4 to 1.6 | — | $V_{CC} \times 0.25$ | |
| | | | $I_{OL} = 3.0$ mA | 1.65 to 1.95 | — | 0.45 | |
| | | | $I_{OL} = 4.0$ mA | 2.3 to 2.7 | — | 0.4 | |
| | | | $I_{OL} = 8.0$ mA | 3.0 to 3.6 | — | 0.4 | |
| Input leakage current | I_{IN} | $V_{IN} = 0$ to 3.6 V | | 0 to 3.6 | — | ± 0.5 | μ A |
| Power-OFF leakage current | I_{OFF} | $V_{IN} = 0$ to 3.6 V, $V_{OUT} = 0$ to 3.6 V | | 0 | — | 10.0 | μ A |
| Quiescent supply current | I_{CC} | $V_{IN} = V_{CC}$ or GND | | 3.6 | — | 10.0 | μ A |

9.3. DC Characteristics (Unless otherwise specified, $T_a = -40$ to $125\text{ }^{\circ}\text{C}$)

| Characteristics | Symbol | Test Condition | | V_{CC} (V) | Min | Max | Unit |
|---------------------------|-----------|---|----------------------------|--------------|----------------------|----------------------|---------------|
| High-level input voltage | V_{IH} | — | | 0.9 | V_{CC} | — | V |
| | | | | 1.1 to 1.3 | $V_{CC} \times 0.70$ | — | |
| | | | | 1.4 to 1.6 | $V_{CC} \times 0.65$ | — | |
| | | | | 1.65 to 1.95 | $V_{CC} \times 0.65$ | — | |
| | | | | 2.3 to 2.7 | 1.7 | — | |
| | | | | 3.0 to 3.6 | 2.0 | — | |
| Low-level input voltage | V_{IL} | — | | 0.9 | — | GND | V |
| | | | | 1.1 to 1.3 | — | $V_{CC} \times 0.30$ | |
| | | | | 1.4 to 1.6 | — | $V_{CC} \times 0.35$ | |
| | | | | 1.65 to 1.95 | — | $V_{CC} \times 0.35$ | |
| | | | | 2.3 to 2.7 | — | 0.7 | |
| | | | | 3.0 to 3.6 | — | 0.8 | |
| High-level output voltage | V_{OH} | $V_{IN} = V_{IL}$ | $I_{OH} = -0.02\text{ mA}$ | 0.9 | 0.75 | — | V |
| | | | $I_{OH} = -0.3\text{ mA}$ | 1.1 to 1.3 | $V_{CC} \times 0.73$ | — | |
| | | | $I_{OH} = -1.7\text{ mA}$ | 1.4 to 1.6 | $V_{CC} \times 0.73$ | — | |
| | | | $I_{OH} = -3.0\text{ mA}$ | 1.65 to 1.95 | $V_{CC} - 0.5$ | — | |
| | | | $I_{OH} = -4.0\text{ mA}$ | 2.3 to 2.7 | 1.95 | — | |
| | | | $I_{OH} = -8.0\text{ mA}$ | 3.0 to 3.6 | 2.4 | — | |
| Low-level output voltage | V_{OL} | $V_{IN} = V_{IH}$ | $I_{OL} = 0.02\text{ mA}$ | 0.9 | — | 0.1 | V |
| | | | $I_{OL} = 0.3\text{ mA}$ | 1.1 to 1.3 | — | $V_{CC} \times 0.27$ | |
| | | | $I_{OL} = 1.7\text{ mA}$ | 1.4 to 1.6 | — | $V_{CC} \times 0.27$ | |
| | | | $I_{OL} = 3.0\text{ mA}$ | 1.65 to 1.95 | — | 0.5 | |
| | | | $I_{OL} = 4.0\text{ mA}$ | 2.3 to 2.7 | — | 0.45 | |
| | | | $I_{OL} = 8.0\text{ mA}$ | 3.0 to 3.6 | — | 0.45 | |
| Input leakage current | I_{IN} | $V_{IN} = 0$ to 3.6 V | | 0 to 3.6 | — | ± 2.0 | μA |
| Power-OFF leakage current | I_{OFF} | $V_{IN} = 0$ to 3.6 V , $V_{OUT} = 0$ to 3.6 V | | 0 | — | 80.0 | μA |
| Quiescent supply current | I_{CC} | $V_{IN} = V_{CC}$ or GND | | 3.6 | — | 80.0 | μA |

9.4. AC Characteristics (Unless otherwise specified, $T_a = 25\text{ }^{\circ}\text{C}$, Input: $t_r = t_f = 3\text{ ns}$)

| Characteristics | Symbol | Note | Test Condition | V_{CC} (V) | C_L (pF) | Min | Typ. | Max | Unit |
|-------------------------------|--------------------|----------|--|--------------|------------|-----|------|------|------|
| Propagation delay time | t_{PLH}, t_{PHL} | | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 10 | — | 20.7 | — | ns |
| | | | | 1.1 to 1.3 | | — | 10.5 | 18.4 | |
| | | | | 1.4 to 1.6 | | — | 6.1 | 8.5 | |
| | | | | 1.65 to 1.95 | | — | 4.5 | 6.2 | |
| | | | | 2.3 to 2.7 | | — | 3.0 | 3.9 | |
| | | | | 3.0 to 3.6 | | — | 2.3 | 3.1 | |
| Propagation delay time | t_{PLH}, t_{PHL} | | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 15 | — | 22.9 | — | ns |
| | | | | 1.1 to 1.3 | | — | 11.5 | 21.5 | |
| | | | | 1.4 to 1.6 | | — | 6.7 | 9.3 | |
| | | | | 1.65 to 1.95 | | — | 4.9 | 6.9 | |
| | | | | 2.3 to 2.7 | | — | 3.2 | 4.4 | |
| | | | | 3.0 to 3.6 | | — | 2.5 | 3.4 | |
| Propagation delay time | t_{PLH}, t_{PHL} | | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 30 | — | 30.6 | — | ns |
| | | | | 1.1 to 1.3 | | — | 14.8 | 29.6 | |
| | | | | 1.4 to 1.6 | | — | 8.5 | 13.1 | |
| | | | | 1.65 to 1.95 | | — | 6.3 | 9.2 | |
| | | | | 2.3 to 2.7 | | — | 4.3 | 5.7 | |
| | | | | 3.0 to 3.6 | | — | 3.3 | 4.4 | |
| Input capacitance | C_{IN} | | — | 3.6 | — | — | 3 | — | pF |
| Power dissipation capacitance | C_{PD} | (Note 1) | — | 0.9 to 3.6 | — | — | 9 | — | 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.

$$I_{CC(opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}$$

9.5. AC Characteristics

(Unless otherwise specified, $T_a = -40\text{ to }85\text{ }^{\circ}\text{C}$, Input: $t_r = t_f = 3\text{ ns}$)

| Characteristics | Symbol | Test Condition | V_{CC} (V) | C_L (pF) | Min | Max | Unit |
|------------------------|--------------------|--|--------------|------------|-----|------|------|
| Propagation delay time | t_{PLH}, t_{PHL} | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 10 | — | — | ns |
| | | | 1.1 to 1.3 | | 1.0 | 34.2 | |
| | | | 1.4 to 1.6 | | 1.0 | 10.0 | |
| | | | 1.65 to 1.95 | | 1.0 | 6.7 | |
| | | | 2.3 to 2.7 | | 1.0 | 4.4 | |
| | | | 3.0 to 3.6 | | 1.0 | 3.7 | |
| Propagation delay time | t_{PLH}, t_{PHL} | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 15 | — | — | ns |
| | | | 1.1 to 1.3 | | 1.0 | 37.2 | |
| | | | 1.4 to 1.6 | | 1.0 | 11.2 | |
| | | | 1.65 to 1.95 | | 1.0 | 7.1 | |
| | | | 2.3 to 2.7 | | 1.0 | 5.0 | |
| | | | 3.0 to 3.6 | | 1.0 | 3.9 | |
| Propagation delay time | t_{PLH}, t_{PHL} | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 30 | — | — | ns |
| | | | 1.1 to 1.3 | | 1.0 | 56.0 | |
| | | | 1.4 to 1.6 | | 1.0 | 15.9 | |
| | | | 1.65 to 1.95 | | 1.0 | 9.6 | |
| | | | 2.3 to 2.7 | | 1.0 | 6.1 | |
| | | | 3.0 to 3.6 | | 1.0 | 4.8 | |

9.6. AC Characteristics

(Unless otherwise specified, $T_a = -40$ to 125 °C, Input: $t_r = t_f = 3$ ns)

| Characteristics | Symbol | Test Condition | V_{CC} (V) | C_L (pF) | Min | Max | Unit |
|------------------------|--------------------|--|--------------|------------|-----|------|------|
| Propagation delay time | t_{PLH}, t_{PHL} | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 10 | — | — | ns |
| | | | 1.1 to 1.3 | | 1.0 | 44.8 | |
| | | | 1.4 to 1.6 | | 1.0 | 11.0 | |
| | | | 1.65 to 1.95 | | 1.0 | 7.1 | |
| | | | 2.3 to 2.7 | | 1.0 | 4.8 | |
| | | | 3.0 to 3.6 | | 1.0 | 4.1 | |
| Propagation delay time | t_{PLH}, t_{PHL} | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 15 | — | — | ns |
| | | | 1.1 to 1.3 | | 1.0 | 47.7 | |
| | | | 1.4 to 1.6 | | 1.0 | 12.5 | |
| | | | 1.65 to 1.95 | | 1.0 | 7.6 | |
| | | | 2.3 to 2.7 | | 1.0 | 5.4 | |
| | | | 3.0 to 3.6 | | 1.0 | 4.3 | |
| Propagation delay time | t_{PLH}, t_{PHL} | $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1 | 0.9 | 30 | — | — | ns |
| | | | 1.1 to 1.3 | | 1.0 | 73.6 | |
| | | | 1.4 to 1.6 | | 1.0 | 17.8 | |
| | | | 1.65 to 1.95 | | 1.0 | 10.2 | |
| | | | 2.3 to 2.7 | | 1.0 | 6.6 | |
| | | | 3.0 to 3.6 | | 1.0 | 5.2 | |

9.7. AC Waveform

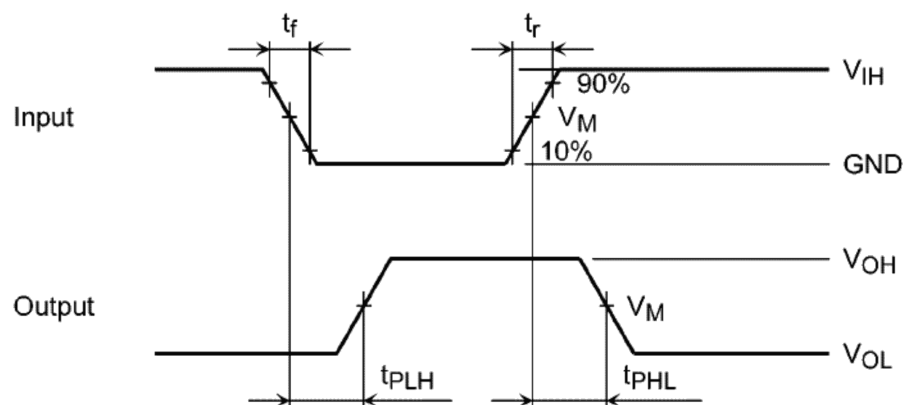


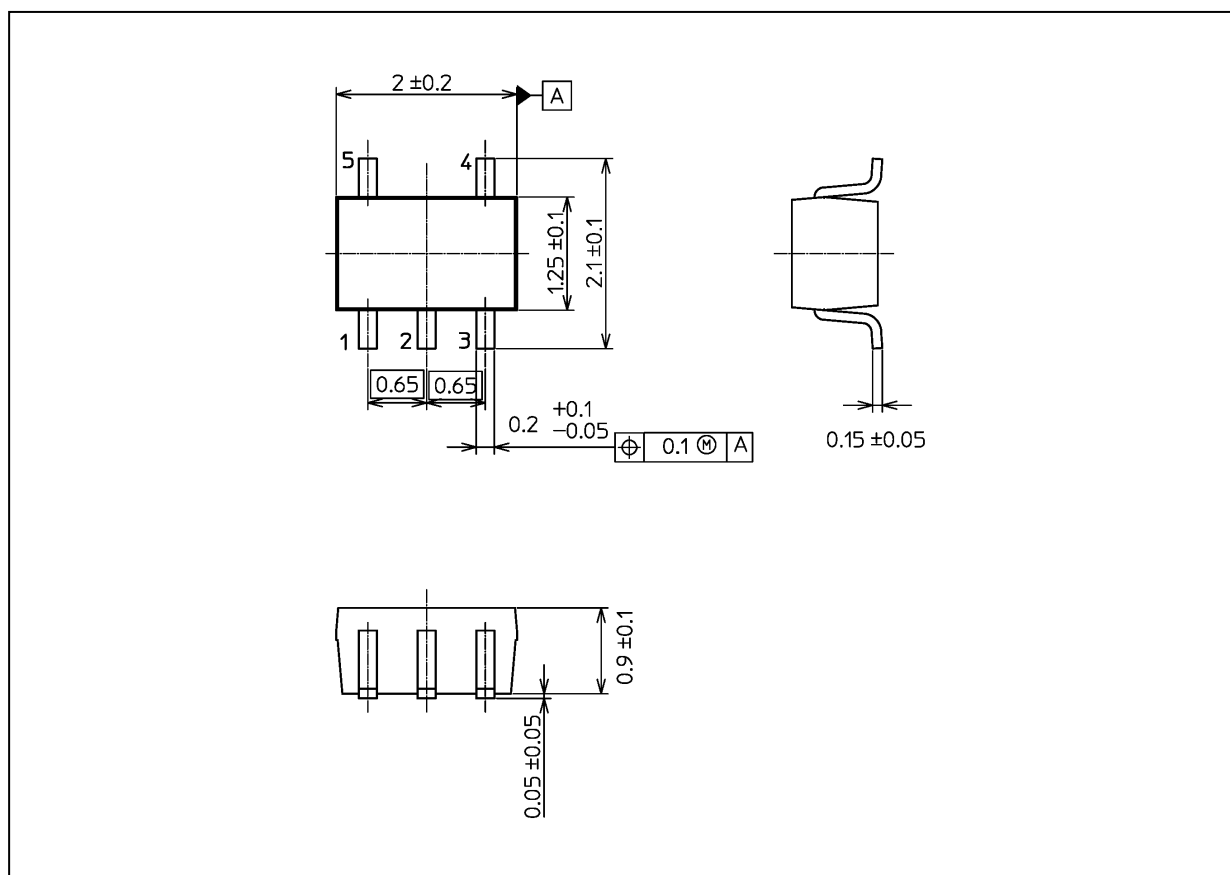
Fig. 9.7.1 t_{PLH} , t_{PHL}

Table 9.7.1 AC Waveform Symbols

| | Symbol | $V_{CC} = 3.3 \pm 0.3\text{ V}$ | $V_{CC} = 2.5 \pm 0.2\text{ V}$ | $V_{CC} = 1.8 \pm 0.15\text{ V}$ | $V_{CC} = 1.5 \pm 0.1\text{ V}$ | $V_{CC} = 1.2 \pm 0.1\text{ V}$ | $V_{CC} = 0.9\text{ V}$ |
|--------|----------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|---------------------------------|-------------------------|
| Input | V_{IH} | V_{CC} | V_{CC} | V_{CC} | V_{CC} | V_{CC} | V_{CC} |
| | V_M | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ |
| Output | V_M | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ |

Package Dimensions

Unit: mm



Weight: 6.2 mg (typ.)

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

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