

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC74VCX74FT, TC74VCX74FK

Low-Voltage Dual D-Type Flip-Flop with 3.6-V Tolerant Inputs and Outputs

The TC74VCX74FT/FK is a high-performance CMOS D-type flip-flop which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5V, 1.8V, 2.5V or 3.3V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

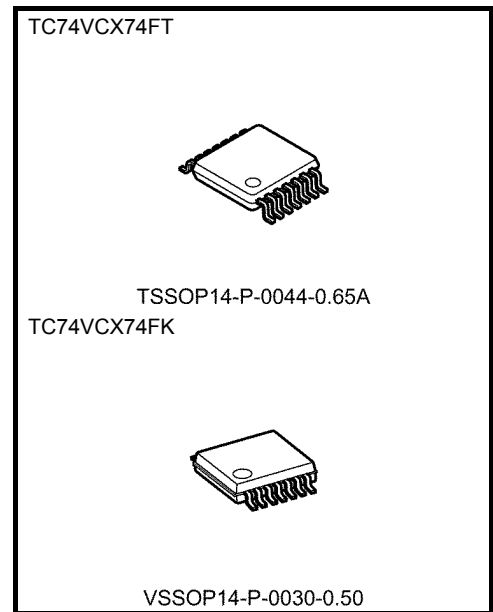
It is also designed with overvoltage tolerant inputs and outputs up to 3.6 V.

The signal level applied to the D INPUT is transferred to Q OUTPUT during the positive going transition of the CK pulse. CLR and PR are independent of the CK and are accomplished by setting the appropriate input low.

All inputs are equipped with protection circuits against static discharge.

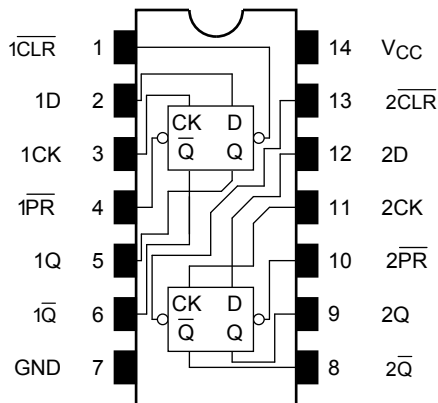
Features

- Low-voltage operation: $V_{CC} = 1.2\sim 3.6\text{ V}$
- High-speed operation: $t_{pd} = 3.5\text{ ns (max) (}V_{CC} = 3.0\sim 3.6\text{ V)}$
 : $t_{pd} = 4.6\text{ ns (max) (}V_{CC} = 2.3\sim 2.7\text{ V)}$
 : $t_{pd} = 9.2\text{ ns (max) (}V_{CC} = 1.65\sim 1.95\text{ V)}$
 : $t_{pd} = 18.4\text{ ns (max) (}V_{CC} = 1.4\sim 1.6\text{ V)}$
 : $t_{pd} = 46.0\text{ ns (max) (}V_{CC} = 1.2\text{ V)}$
- Output current: $I_{OH}/I_{OL} = \pm 24\text{ mA (min) (}V_{CC} = 3.0\text{ V)}$
 : $I_{OH}/I_{OL} = \pm 18\text{ mA (min) (}V_{CC} = 2.3\text{ V)}$
 : $I_{OH}/I_{OL} = \pm 6\text{ mA (min) (}V_{CC} = 1.65\text{ V)}$
 : $I_{OH}/I_{OL} = \pm 2\text{ mA (min) (}V_{CC} = 1.4\text{ V)}$
- Latch-up performance: -300 mA
- ESD performance: Machine model $\geq \pm 200\text{ V}$
 Human body model $\geq \pm 2000\text{ V}$
- Package: TSSOP and VSSOP (US)
- Power-down protection provided on all inputs and outputs

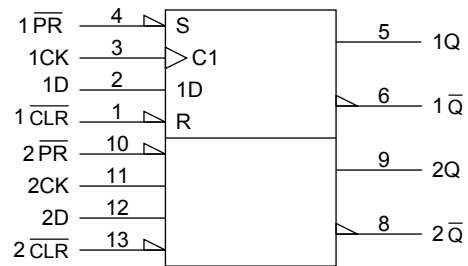


| | |
|----------------------|-----------------|
| Weight | |
| TSSOP14-P-0044-0.65A | : 0.06 g (typ.) |
| VSSOP14-P-0030-0.50 | : 0.02 g (typ.) |

Pin Assignment (top view)



IEC Logic Symbol



Truth Table

| Inputs | | | | Outputs | | Function |
|--------|----|---|----|---------|--------|-----------|
| CLR | PR | D | CK | Q | Q-bar | |
| L | H | X | X | L | H | Clear |
| H | L | X | X | H | L | Preset |
| L | L | X | X | H | H | — |
| H | H | L | ↑ | L | H | — |
| H | H | H | ↑ | H | L | — |
| H | H | X | ↓ | Qn | Qn-bar | No change |

X: Don't care

Absolute Maximum Ratings (Note 1)

| Characteristics | Symbol | Rating | Unit |
|-----------------------------|------------------|-------------------------------|------|
| Power supply voltage | V_{CC} | -0.5~4.6 | V |
| DC input voltage | V_{IN} | -0.5~4.6 | V |
| DC output voltage | V_{OUT} | -0.5~4.6 (Note 2) | V |
| | | -0.5~ $V_{CC} + 0.5$ (Note 3) | |
| Input diode current | I_{IK} | -50 | mA |
| Output diode current | I_{OK} | ±50 (Note 4) | mA |
| DC output current | I_{OUT} | ±50 | mA |
| Power dissipation | P_D | 180 | mW |
| DC V_{CC} /ground current | I_{CC}/I_{GND} | ±100 | mA |
| Storage temperature | T_{stg} | -65~150 | °C |

Note 1: 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 2: $V_{CC} = 0$ V

Note 3: High or low state. I_{OUT} absolute maximum rating must be observed.

Note 4: $V_{OUT} < GND$, $V_{OUT} > V_{CC}$

Operating Ranges (Note 1)

| Characteristics | Symbol | Rating | Unit |
|--------------------------|-----------------|----------------------|------|
| Power supply voltage | V_{CC} | 1.2~3.6 | V |
| Input voltage | V_{IN} | -0.3~3.6 | V |
| Output voltage | V_{OUT} | 0~3.6 (Note 2) | V |
| | | 0~ V_{CC} (Note 3) | |
| Output current | I_{OH}/I_{OL} | ± 24 (Note 4) | mA |
| | | ± 18 (Note 5) | |
| | | ± 6 (Note 6) | |
| | | ± 2 (Note 7) | |
| Operating temperature | T_{opr} | -40~85 | °C |
| Input rise and fall time | dt/dv | 0~10 (Note 8) | ns/V |

Note 1: 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 2: $V_{CC} = 0$ V

Note 3: High or low state

Note 4: $V_{CC} = 3.0\sim 3.6$ V

Note 5: $V_{CC} = 2.3\sim 2.7$ V

Note 6: $V_{CC} = 1.65\sim 1.95$ V

Note 7: $V_{CC} = 1.4\sim 1.6$ V

Note 8: $V_{IN} = 0.8\sim 2.0$ V, $V_{CC} = 3.0$ V

Electrical Characteristics

DC Characteristics ($T_a = -40$ to 85°C , 2.7 V $< V_{CC} \leq 3.6$ V)

| Characteristics | | Symbol | Test Condition | V_{CC} (V) | Min | Max | Unit |
|--------------------------------|---------|-----------------|---------------------------------|-----------------------------|---------|----------------|---------------|
| | | | | | | | |
| Input voltage | H-level | V_{IH} | — | 2.7~3.6 | 2.0 | — | V |
| | L-level | V_{IL} | — | 2.7~3.6 | — | 0.8 | |
| Output voltage | H-level | V_{OH} | $V_{IN} = V_{IH}$ or V_{IL} | $I_{OH} = -100 \mu\text{A}$ | 2.7~3.6 | $V_{CC} - 0.2$ | V |
| | | | | $I_{OH} = -12 \text{ mA}$ | 2.7 | 2.2 | |
| | | | | $I_{OH} = -18 \text{ mA}$ | 3.0 | 2.4 | |
| | | | | $I_{OH} = -24 \text{ mA}$ | 3.0 | 2.2 | |
| | L-level | V_{OL} | $V_{IN} = V_{IH}$ or V_{IL} | $I_{OL} = 100 \mu\text{A}$ | 2.7~3.6 | — | 0.2 |
| | | | | $I_{OL} = 12 \text{ mA}$ | 2.7 | — | 0.4 |
| | | | | $I_{OL} = 18 \text{ mA}$ | 3.0 | — | 0.4 |
| | | | | $I_{OL} = 24 \text{ mA}$ | 3.0 | — | 0.55 |
| Input leakage current | | I_{IN} | $V_{IN} = 0$ to 3.6 V | 2.7~3.6 | — | ± 5.0 | 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 | 2.7~3.6 | — | 20.0 | μA |
| | | | $V_{CC} \leq V_{IN} \leq 3.6$ V | 2.7~3.6 | — | ± 20.0 | |
| Increase in I_{CC} per input | | ΔI_{CC} | $V_{IH} = V_{CC} - 0.6$ V | 2.7~3.6 | — | 750 | |

DC Characteristics (Ta = -40 to 85°C, 2.3 V ≤ VCC ≤ 2.7 V)

| Characteristics | | Symbol | Test Condition | | VCC (V) | Min | Max | Unit |
|---------------------------|---------|------------------|--|---------------------------|---------|-----------------------|-------|------|
| | | | | | | | | |
| Input voltage | H-level | V _{IH} | — | | 2.3~2.7 | 1.6 | — | V |
| | L-level | V _{IL} | — | | 2.3~2.7 | — | 0.7 | |
| Output voltage | H-level | V _{OH} | V _{IN} = V _{IH} or V _{IL} | I _{OH} = -100 μA | 2.3~2.7 | V _{CC} - 0.2 | — | V |
| | | | | I _{OH} = -6 mA | 2.3 | 2.0 | — | |
| | | | | I _{OH} = -12 mA | 2.3 | 1.8 | — | |
| | L-level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 100 μA | 2.3~2.7 | — | 0.2 | |
| | | | | I _{OL} = 12 mA | 2.3 | — | 0.4 | |
| | | | | I _{OL} = 18 mA | 2.3 | — | 0.6 | |
| Input leakage current | | I _{IN} | V _{IN} = 0 to 3.6 V | | 2.3~2.7 | — | ±5.0 | 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 | | 2.3~2.7 | — | 20.0 | μA |
| | | | V _{CC} ≤ V _{IN} ≤ 3.6 V | | 2.3~2.7 | — | ±20.0 | |

DC Characteristics (Ta = -40 to 85°C, 1.65 V ≤ VCC < 2.3 V)

| Characteristics | | Symbol | Test Condition | | VCC (V) | Min | Max | Unit |
|---------------------------|---------|------------------|--|---------------------------|----------|------------------------|-----------------------|------|
| | | | | | | | | |
| Input voltage | H-level | V _{IH} | — | | 1.65~2.3 | 0.65 × V _{CC} | — | V |
| | L-level | V _{IL} | — | | 1.65~2.3 | — | 0.2 × V _{CC} | |
| Output voltage | H-level | V _{OH} | V _{IN} = V _{IH} or V _{IL} | I _{OH} = -100 μA | 1.65~2.3 | V _{CC} - 0.2 | — | V |
| | | | | I _{OH} = -6 mA | 1.65 | 1.25 | — | |
| | L-level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 100 μA | 1.65~2.3 | — | 0.2 | |
| | | | | I _{OL} = 6 mA | 1.65 | — | 0.3 | |
| Input leakage current | | I _{IN} | V _{IN} = 0 to 3.6 V | | 1.65~2.3 | — | ±5.0 | 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 | | 1.65~2.3 | — | 20.0 | μA |
| | | | V _{CC} ≤ V _{IN} ≤ 3.6 V | | 1.65~2.3 | — | ±20.0 | |

DC Characteristics (Ta = -40 to 85°C, 1.4 V ≤ VCC < 1.65 V)

| Characteristics | | Symbol | Test Condition | | VCC (V) | Min | Max | Unit |
|---------------------------|---------|------------------|--|---------------------------|----------|------------------------|------------------------|------|
| | | | | | | | | |
| Input voltage | H-level | V _{IH} | — | | 1.4~1.65 | 0.65 × V _{CC} | — | V |
| | L-level | V _{IL} | — | | 1.4~1.65 | — | 0.05 × V _{CC} | |
| Output voltage | H-level | V _{OH} | V _{IN} = V _{IH} or V _{IL} | I _{OH} = -100 μA | 1.4~1.65 | V _{CC} - 0.2 | — | V |
| | | | | I _{OH} = -2 mA | 1.4 | 1.05 | — | |
| | L-level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 100 μA | 1.4~1.65 | — | 0.05 | |
| | | | | I _{OL} = 2 mA | 1.4 | — | 0.35 | |
| Input leakage current | | I _{IN} | V _{IN} = 0 to 3.6 V | | 1.4~1.65 | — | ±5.0 | 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 | | 1.4~1.65 | — | 20.0 | μA |
| | | | V _{CC} ≤ V _{IN} ≤ 3.6 V | | 1.4~1.65 | — | ±20.0 | |

DC Characteristics (Ta = -40 to 85°C, 1.2 V ≤ VCC < 1.4 V)

| Characteristics | | Symbol | Test Condition | | VCC (V) | Min | Max | Unit |
|---------------------------|---------|------------------|--|---------------------------|---------|-----------------------|------------------------|------|
| | | | | | | | | |
| Input voltage | H-level | V _{IH} | — | | 1.2~1.4 | 0.8 × V _{CC} | — | V |
| | L-level | V _{IL} | — | | 1.2~1.4 | — | 0.05 × V _{CC} | |
| Output voltage | H-level | V _{OH} | V _{IN} = V _{IH} or V _{IL} | I _{OH} = -100 μA | 1.2 | V _{CC} - 0.1 | — | V |
| | L-level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 100 μA | 1.2 | — | 0.05 | |
| Input leakage current | | I _{IN} | V _{IN} = 0 to 3.6 V | | 1.2 | — | ±5.0 | 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 | — | 20.0 | μA |
| | | | V _{CC} ≤ V _{IN} ≤ 3.6 V | | 1.2 | — | ±20.0 | |

AC Characteristics (Ta = -40 to 85°C, input: tr = tf = 2.0 ns) (Note)

| Characteristics | Symbol | Test Condition | V _{CC} (V) | Min | Max | Unit | |
|--|--|--------------------|--|------------|-----|------|-----|
| | | | | | | | |
| Maximum clock frequency | f _{max} | Figure 1, Figure 2 | C _L = 15 pF, R _L = 2 kΩ | 1.2 | 40 | — | MHz |
| | | | | 1.5 ± 0.1 | 80 | — | |
| | | | C _L = 30 pF, R _L = 500 Ω | 1.8 ± 0.15 | 100 | — | |
| | | | | 2.5 ± 0.2 | 200 | — | |
| Propagation delay time (CK-Q, \bar{Q}) | t _{pLH} t _{pHL} | Figure 1, Figure 2 | C _L = 15 pF, R _L = 2 kΩ | 1.2 | 3.0 | 46.0 | ns |
| | | | | 1.5 ± 0.1 | 2.0 | 18.4 | |
| | | | C _L = 30 pF, R _L = 500 Ω | 1.8 ± 0.15 | 1.5 | 9.2 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.6 | |
| Propagation delay time (\bar{CLR} , \bar{PR} -Q, \bar{Q}) | t _{pLH} t _{pHL} | Figure 1, Figure 4 | C _L = 15 pF, R _L = 2 kΩ | 1.2 | 3.0 | 46.0 | ns |
| | | | | 1.5 ± 0.1 | 2.0 | 18.4 | |
| | | | C _L = 30 pF, R _L = 500 Ω | 1.8 ± 0.15 | 1.5 | 9.2 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.6 | |
| Minimum pulse width (CK) | t _w (H) t _w (L) | Figure 1, Figure 2 | C _L = 15 pF, R _L = 2 kΩ | 1.2 | 24 | — | ns |
| | | | | 1.5 ± 0.1 | 8.0 | — | |
| | | | C _L = 30 pF, R _L = 500 Ω | 1.8 ± 0.15 | 4.0 | — | |
| | | | | 2.5 ± 0.2 | 1.5 | — | |
| Minimum pulse width (\bar{CLR} , \bar{PR}) | t _w (L) | Figure 1, Figure 4 | C _L = 15 pF, R _L = 2 kΩ | 1.2 | 24 | — | ns |
| | | | | 1.5 ± 0.1 | 8.0 | — | |
| | | | C _L = 30 pF, R _L = 500 Ω | 1.8 ± 0.15 | 4.0 | — | |
| | | | | 2.5 ± 0.2 | 1.5 | — | |
| Minimum set-up time | t _s | Figure 1, Figure 2 | C _L = 15 pF, R _L = 2 kΩ | 1.2 | 20 | — | ns |
| | | | | 1.5 ± 0.1 | 7.5 | — | |
| | | | C _L = 30 pF, R _L = 500 Ω | 1.8 ± 0.15 | 3.0 | — | |
| | | | | 2.5 ± 0.2 | 1.5 | — | |
| Minimum hold time | t _h | Figure 1, Figure 2 | C _L = 15 pF, R _L = 2 kΩ | 1.2 | 8.0 | — | ns |
| | | | | 1.5 ± 0.1 | 3.0 | — | |
| | | | C _L = 30 pF, R _L = 500 Ω | 1.8 ± 0.15 | 1.0 | — | |
| | | | | 2.5 ± 0.2 | 1.0 | — | |
| Minimum removal time | t _{rem} | Figure 1, Figure 3 | C _L = 15 pF, R _L = 2 kΩ | 1.2 | 24 | — | ns |
| | | | | 1.5 ± 0.1 | 8.0 | — | |
| | | | C _L = 30 pF, R _L = 500 Ω | 1.8 ± 0.15 | 3.0 | — | |
| | | | | 2.5 ± 0.2 | 2.0 | — | |
| | | | | 3.3 ± 0.3 | 1.5 | — | |

Note: For C_L = 50 pF, add approximately 300 ps to the AC maximum specification.

Dynamic Switching Characteristics (Ta = 25°C, input: tr = tf = 2.0 ns, CL = 30 pF)

| Characteristics | Symbol | Test Condition | VCC (V) | Typ. | Unit |
|----------------------------------|--------|-------------------------------|---------|-------|------|
| | | | | | |
| Quiet output maximum dynamic VOL | VOLP | VIH = 1.8 V, VIL = 0 V (Note) | 1.8 | 0.25 | V |
| | | VIH = 2.5 V, VIL = 0 V (Note) | 2.5 | 0.6 | |
| | | VIH = 3.3 V, VIL = 0 V (Note) | 3.3 | 0.8 | |
| Quiet output minimum dynamic VOL | VOLV | VIH = 1.8 V, VIL = 0 V (Note) | 1.8 | -0.25 | V |
| | | VIH = 2.5 V, VIL = 0 V (Note) | 2.5 | -0.6 | |
| | | VIH = 3.3 V, VIL = 0 V (Note) | 3.3 | -0.8 | |
| Quiet output minimum dynamic VOH | VOHV | VIH = 1.8 V, VIL = 0 V (Note) | 1.8 | 1.5 | V |
| | | VIH = 2.5 V, VIL = 0 V (Note) | 2.5 | 1.9 | |
| | | VIH = 3.3 V, VIL = 0 V (Note) | 3.3 | 2.2 | |

Note: Parameter guaranteed by design.

Capacitive Characteristics (Ta = 25°C)

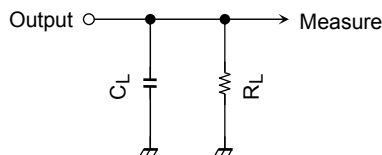
| Characteristics | Symbol | Test Condition | VCC (V) | Typ. | Unit |
|-------------------------------|--------|---------------------|---------------|------|------|
| | | | | | |
| Input capacitance | CIN | — | 1.8, 2.5, 3.3 | 6 | pF |
| Power dissipation capacitance | CPD | fIN = 10 MHz (Note) | 1.8, 2.5, 3.3 | 20 | pF |

Note: CPD 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:

$$I_{CC (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/2 \text{ (per F/F)}$$

AC Test Circuit



| Symbol | VCC | |
|--------|-------|--|
| | | 3.3 ± 0.3 V 2.5 ± 0.2 V 1.8 ± 0.15 V |
| RL | 500 Ω | 2 kΩ |
| CL | 30 pF | 15 pF |

Figure 1

AC Waveform

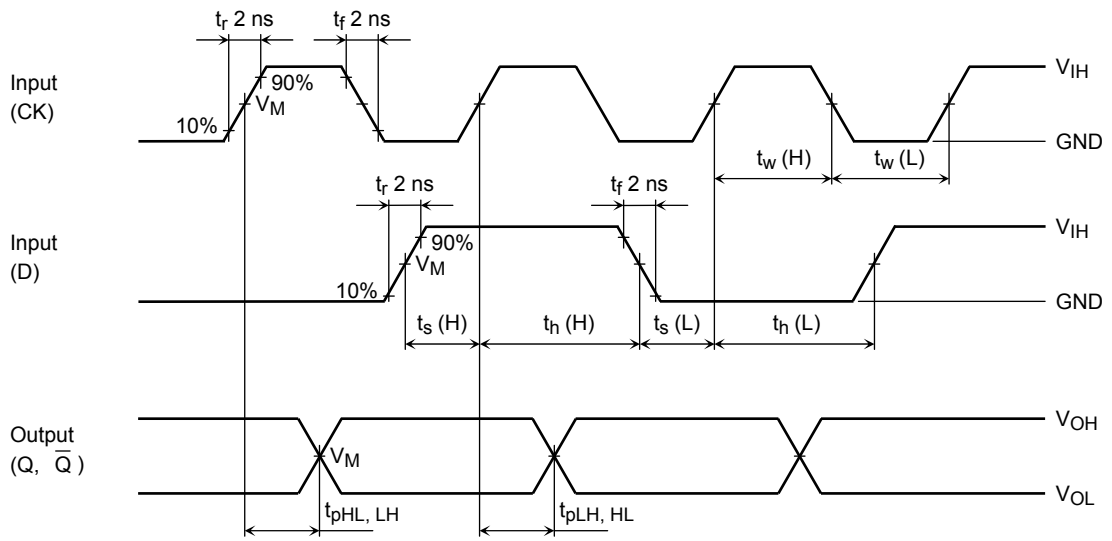


Figure 2 t_{pLH} , t_{pHL} , t_w , t_s , t_h

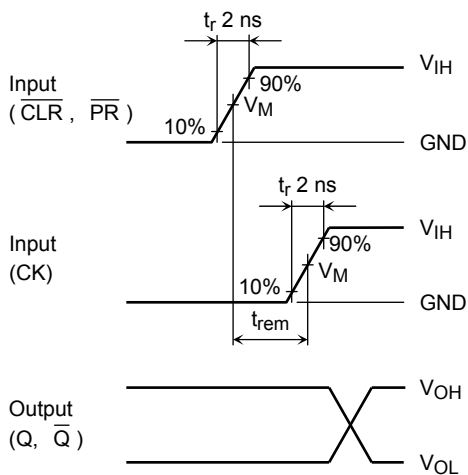


Figure 3 t_{rem}

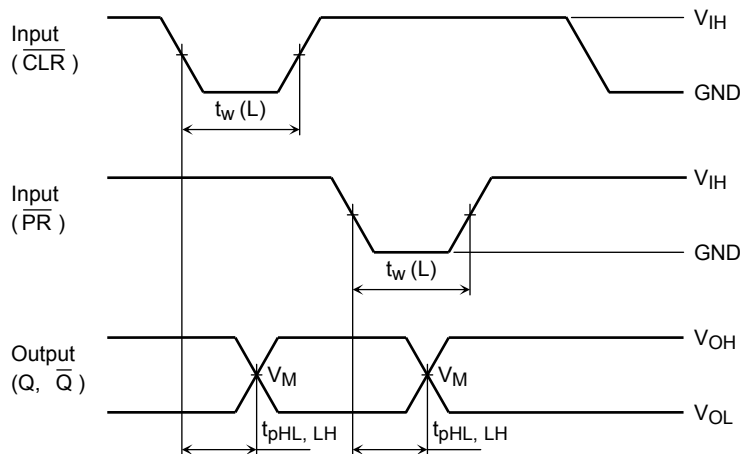


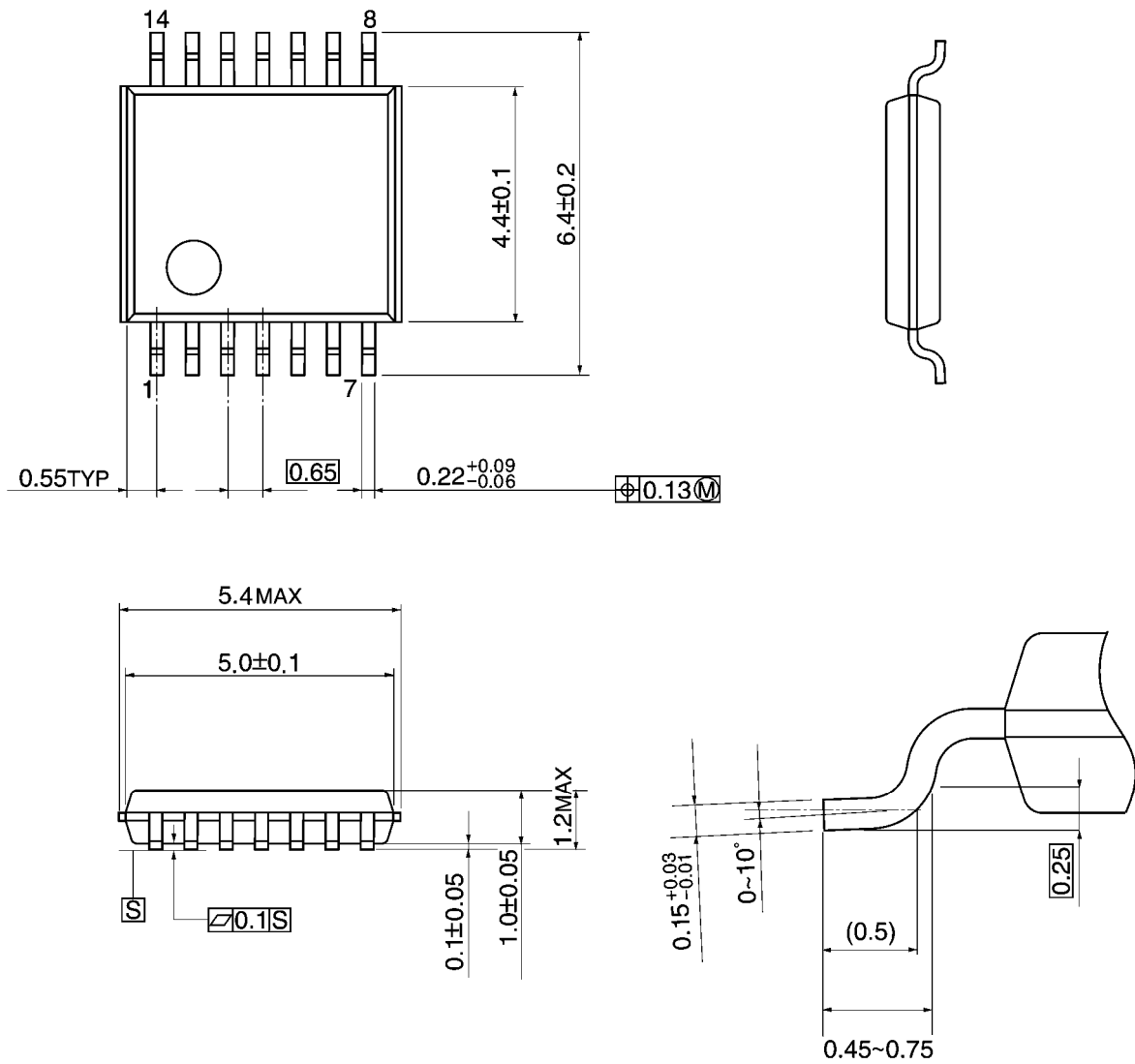
Figure 4 t_{pLH} , t_{pHL} , t_w

| Symbol | V_{CC} | | | | |
|----------|------------------------|------------------------|-------------------------|------------------------|----------------|
| | $3.3 \pm 0.3\text{ V}$ | $2.5 \pm 0.2\text{ V}$ | $1.8 \pm 0.15\text{ V}$ | $1.5 \pm 0.1\text{ V}$ | 1.2 V |
| V_{IH} | 2.7 V | V_{CC} | V_{CC} | V_{CC} | V_{CC} |
| V_M | 1.5 V | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ |

Package Dimensions

TSSOP14-P-0044-0.65A

Unit: mm

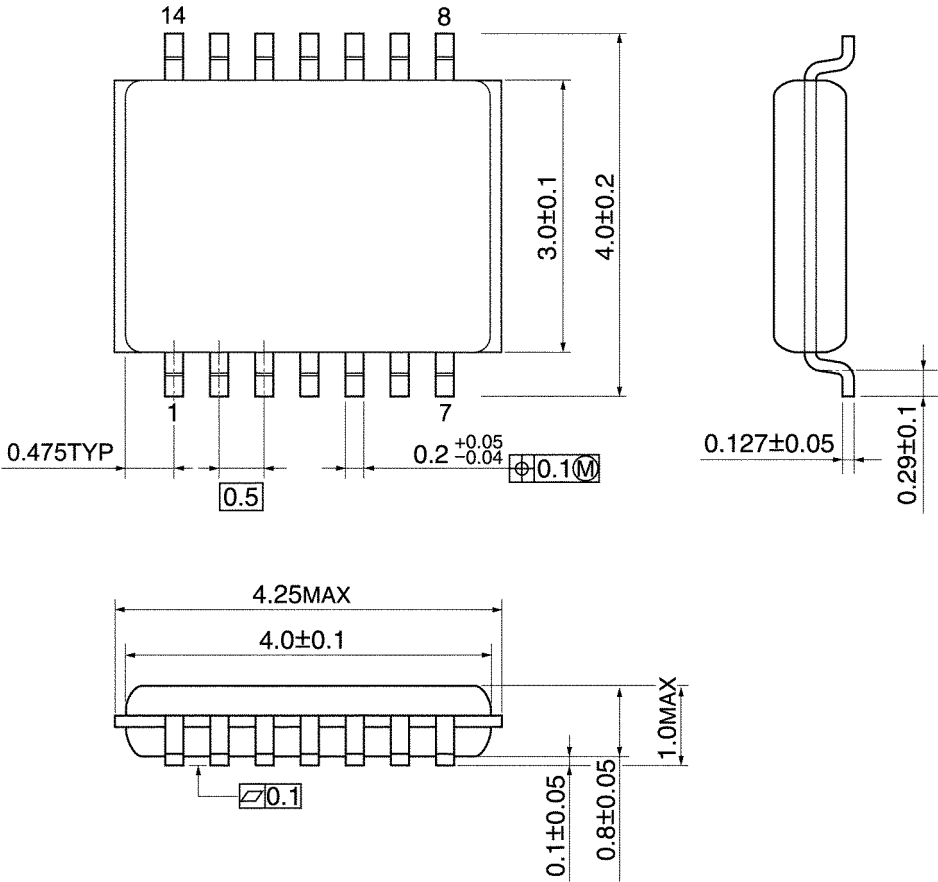


Weight: 0.06 g (typ.)

Package Dimensions

VSSOP14-P-0030-0.50

Unit: mm



Weight: 0.02 g (typ.)

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