TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VCX14FT,TC74VCX14FK

Low-Voltage Hex Schmitt Inverter with 3.6-V Tolerant Inputs and Outputs

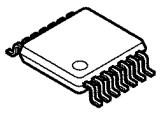
The TC74VCX14FT/FK is a high-performance CMOS schmitt inverter which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5V, 1.8V, 2.5V or 3.3V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

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

Pin configuration and function are the same as the TC74VCX04 but the inputs have hysteresis and with its schmitt trigger function, the TC74VCX14 can be used as a line receivers which will receive slow input signals.

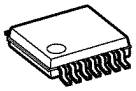
All inputs are equipped with protection circuits against static discharge.

TC74VCX14FT



TSSOP14-P-0044-0.65A

TC74VCX14FK



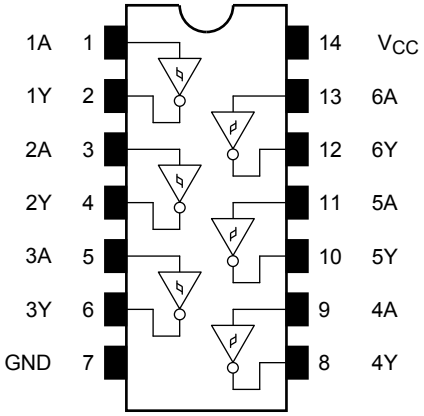
VSSOP14-P-0030-0.50

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

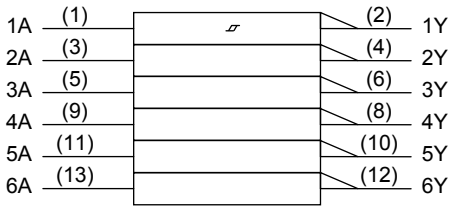
## Features

- Low-voltage operation: $V_{CC}$ = 1.2~3.6 V
- High-speed operation: $t_{pd}$ = 4.0 ns (max) ($V_{CC}$ = 3.0~3.6 V)
  : $t_{pd}$ = 4.3 ns (max) ($V_{CC}$ = 2.3~2.7 V)
  : $t_{pd}$ = 8.6 ns (max) ($V_{CC}$ = 1.65~1.95 V)
  : $t_{pd}$ = 17.2 ns (max) ($V_{CC}$ = 1.4~1.6 V)
  : $t_{pd}$ = 43.0 ns (max) ($V_{CC}$ = 1.2 V)
- Output current: $I_{OH}/I_{OL}$ = ±24 mA (min) ($V_{CC}$ = 3.0 V)
  : $I_{OH}/I_{OL}$ = ±18 mA (min) ($V_{CC}$ = 2.3 V)
  : $I_{OH}/I_{OL}$ = ±6 mA (min) ($V_{CC}$ = 1.65 V)
  : $I_{OH}/I_{OL}$ = ±2 mA (min) ($V_{CC}$ = 1.4 V)
- Latch-up performance: –300 mA
- ESD performance: Machine model ≥ ±200 V
  Human body model ≥ ±2000 V
- Package: TSSOP and VSSOP (US)
- Power-down protection provided on all inputs and outputs

## Pin Assignment (top view)



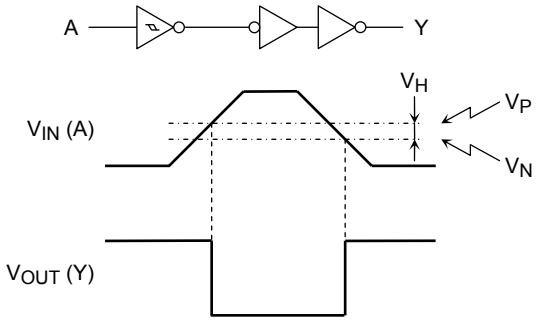

## IEC Logic Symbol




## Truth Table

| Inputs | Outputs |
|---|---|
| A | Y |
| L | H |
| H | L |

## System Diagram and Waveforms



## 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 |

Note 1: The operating ranges must be maintained to ensure the normal operation of the device.
Unused inputs must be tied to either VCC or GND.

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

Note 3: High or low state

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

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

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

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

## Electrical Characteristics

### DC Characteristics (Ta = –40 to 85°C, 2.7 V < $V_{CC}$ ≦ 3.6 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | H-level | $V_P$ | — | | 3.6 | — | 2.2 | V |
| | | | | | 3.0 | — | 2.0 | |
| | L-level | $V_N$ | — | | 3.6 | 0.8 | — | V |
| | | | | | 3.0 | 0.7 | — | |
| Hysteresis voltage | | $V_H$ | — | | 3.6 | 0.3 | 1.2 | V |
| | | | | | 3.0 | 0.3 | 1.2 | |
| Output voltage | H-level | $V_{OH}$ | $V_{IN}$ = $V_{IL}$ | $I_{OH}$ = –100 μA | 2.7~3.6 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –12 mA | 2.7 | 2.2 | — | |
| | | | | $I_{OH}$ = –18 mA | 3.0 | 2.4 | — | |
| | | | | $I_{OH}$ = –24 mA | 3.0 | 2.2 | — | |
| | L-level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 2.7~3.6 | — | 0.2 | V |
| | | | | $I_{OL}$ = 12 mA | 2.7 | — | 0.4 | |
| | | | | $I_{OL}$ = 18 mA | 3.0 | — | 0.4 | |
| | | | | $I_{OL}$ = 24 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 |
| | | | $V_{CC}$ ≦ $V_{IN}$ ≦ 3.6 V | | 2.7~3.6 | — | ±20.0 | |
| Increase in $I_{CC}$ per input | | $\Delta I_{CC}$ | $V_{IH}$ = $V_{CC}$ – 0.6 V | | 2.7~3.6 | — | 750 | |

### DC Characteristics (Ta = –40 to 85°C, 2.3 V ≦ $V_{CC}$ ≦ 2.7 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | H-level | $V_P$ | — | | 2.3 | — | 1.6 | V |
| | L-level | $V_N$ | — | | 2.3 | 0.5 | — | V |
| Hysteresis voltage | | $V_H$ | — | | 2.3 | 0.3 | 1.0 | V |
| Output voltage | H-level | $V_{OH}$ | $V_{IN}$ = $V_{IL}$ | $I_{OH}$ = –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 | — | |
| | | | | $I_{OH}$ = –18 mA | 2.3 | 1.7 | — | |
| | L-level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 2.3~2.7 | — | 0.2 | V |
| | | | | $I_{OL}$ = 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 ≦ $V_{CC}$ < 2.3 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | H-level | $V_P$ | — | | 1.65 | — | 1.4 | V |
| | L-level | $V_N$ | — | | 1.65 | 0.25 | — | V |
| Hysteresis voltage | | $V_H$ | — | | 1.65 | 0.2 | 0.95 | V |
| Output voltage | H-level | $V_{OH}$ | $V_{IN}$ = $V_{IL}$ | $I_{OH}$ = –100 μA | 1.65~2.3 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –6 mA | 1.65 | 1.25 | — | |
| | L-level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 1.65~2.3 | — | 0.2 | V |
| | | | | $I_{OL}$ = 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 ≦ $V_{CC}$< 1.65 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | H-level | $V_P$ | — | | 1.4 | — | 1.2 | V |
| | L-level | $V_N$ | — | | 1.4 | 0.2 | — | V |
| Hysteresis voltage | | $V_H$ | — | | 1.4 | 0.2 | 0.9 | V |
| Output voltage | H-level | $V_{OH}$ | $V_{IN}$ = $V_{IL}$ | $I_{OH}$ = –100 μA | 1.4~1.65 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –2 mA | 1.4 | 1.05 | — | |
| | L-level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 1.4~1.65 | — | 0.05 | V |
| | | | | $I_{OL}$ = 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 ≦ $V_{CC}$ < 1.4 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | H-level | $V_P$ | — | | 1.2 | — | 1.1 | V |
| | L-level | $V_N$ | — | | 1.2 | 0.05 | — | V |
| Hysteresis voltage | | $V_H$ | — | | 1.2 | 0.2 | 0.9 | V |
| Output voltage | H-level | $V_{OH}$ | $V_{IN}$ = $V_{IL}$ | $I_{OH}$ = –100 μA | 1.2 | $V_{CC}$ – 0.1 | — | V |
| | L-level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 1.2 | — | 0.05 | V |
| 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: $t_r$ = $t_f$ = 2.0 ns) (Note 1)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Propagation delay time | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | $C_L$ = 15 pF, $R_L$ = 2 kΩ | 1.2 | 3.0 | 43.0 | ns |
| | | | | 1.5 ± 0.1 | 2.0 | 17.2 | |
| | | | $C_L$ = 30 pF, $R_L$ = 500 Ω | 1.8 ± 0.15 | 1.5 | 8.6 | |
| | | | | 2.5 ± 0.2 | 0.8 | 4.3 | |
| | | | | 3.3 ± 0.3 | 0.6 | 4.0 | |
| Output to output skew | $t_{osLH}$ $t_{osHL}$ | (Note 2) | $C_L$ = 15 pF, $R_L$ = 2 kΩ | 1.2 | — | 1.5 | ns |
| | | | | 1.5 ± 0.1 | — | 1.5 | |
| | | | $C_L$ = 30 pF, $R_L$ = 500 Ω | 1.8 ± 0.15 | — | 0.5 | |
| | | | | 2.5 ± 0.2 | — | 0.5 | |
| | | | | 3.3 ± 0.3 | — | 0.5 | |

Note 1: For $C_L$ = 50 pF, add approximately 300 ps to the AC maximum specification.

Note 2: Parameter guaranteed by design.
($t_{osLH}$ = $|t_{pLHm} - t_{pLHn}|$, $t_{osHL}$ = $|t_{pHLm} - t_{pHLn}|$)

## Dynamic Switching Characteristics ($Ta = 25°C$, 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 (Note) | 1.8 | 0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | 0.6 | V |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | 0.8 | V |
| Quiet output minimum dynamic $V_{OL}$ | $V_{OLV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note) | 1.8 | −0.25 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | −0.6 | V |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | −0.8 | V |
| Quiet output minimum dynamic $V_{OH}$ | $V_{OHV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note) | 1.8 | 1.5 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | 1.9 | V |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | 2.2 | V |

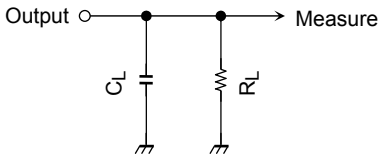
Note: Parameter guaranteed by design.

## Capacitive Characteristics ($Ta = 25°C$)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|
| Input capacitance | $C_{IN}$ | — | 1.8, 2.5, 3.3 | 6 | pF |
| Power dissipation capacitance | $C_{PD}$ | $f_{IN}$ = 10 MHz (Note) | 1.8, 2.5, 3.3 | 20 | pF |

Note: $C_{PD}$ 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:
$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/6$ (per gate)

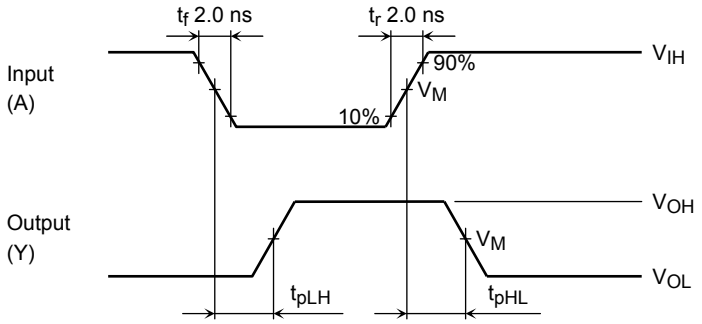
## AC Test Circuit




| Symbol | $V_{CC}$ | |
|---|---|---|
| | 3.3 ± 0.3 V<br>2.5 ± 0.2 V<br>1.8 ± 0.15 V | 1.5 ± 0.1 V<br>1.2V |
| $R_L$ | 500 Ω | 2 kΩ |
| $C_L$ | 30 pF | 15 pF |

**Figure 1**

## AC Waveform

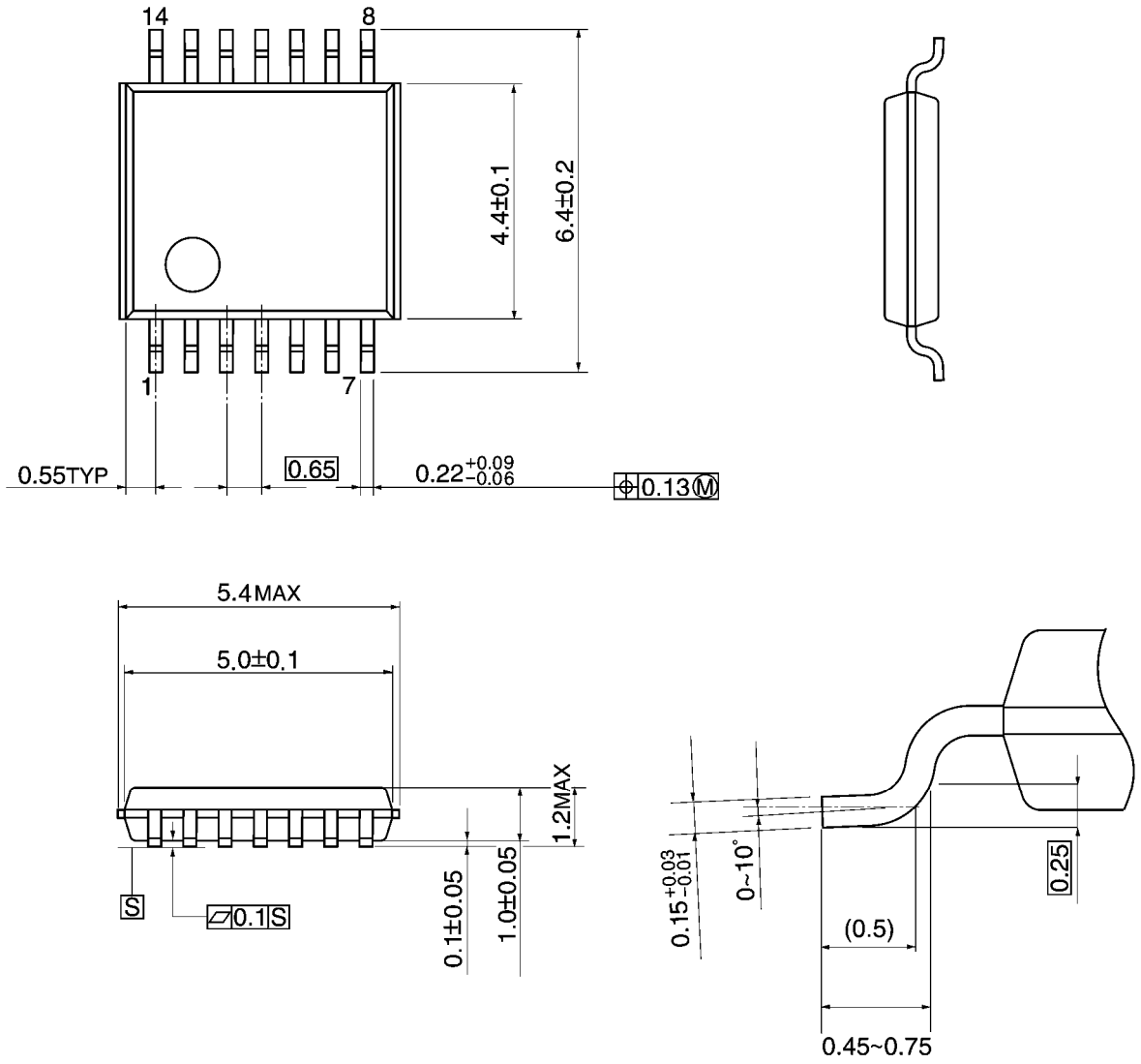



| Symbol | $V_{CC}$ | | | | |
|---|---|---|---|---|---|
| | 3.3 ± 0.3 V | 2.5 ± 0.2 V | 1.8 ± 0.15 V | 1.5 ± 0.1 V | 1.2 V |
| $V_{IH}$ | 2.7 V | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ |
| $V_M$ | 1.5 V | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ | $V_{CC}/2$ |

**Figure 2 $t_{pLH}$, $t_{pHL}$**

## Package Dimensions

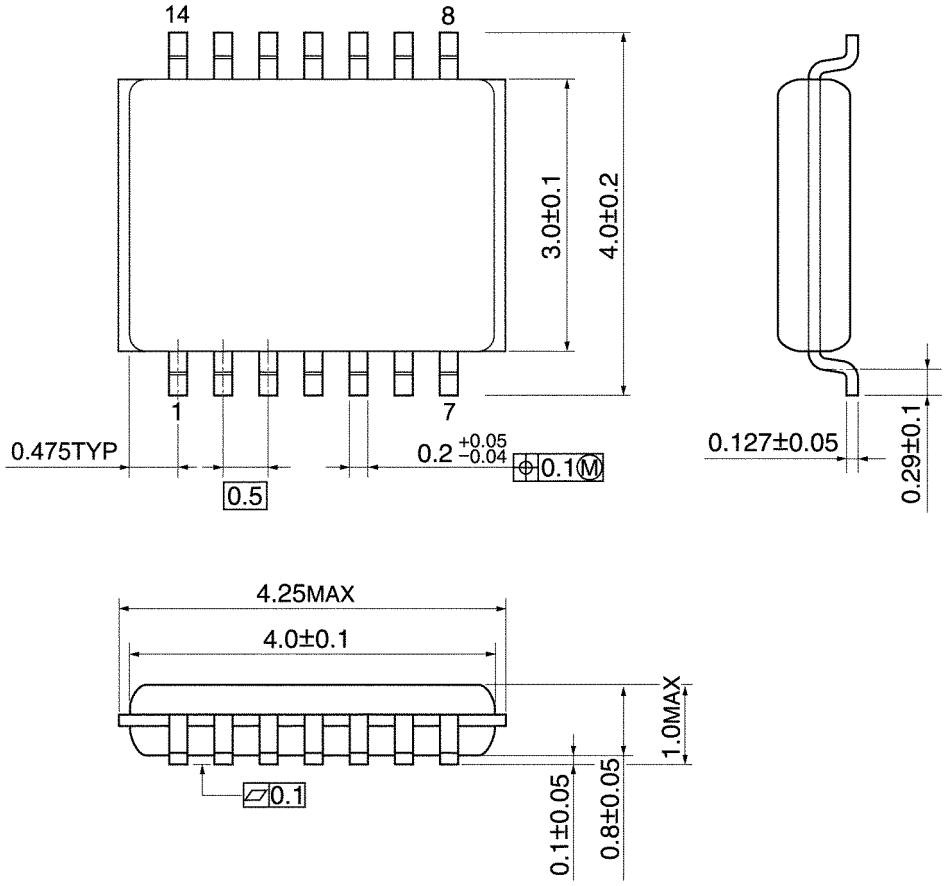
TSSOP14-P-0044-0.65A Unit: mm




Weight: 0.06 g (typ.)

## Package Dimensions

VSSOP14-P-0030-0.50 Unit: mm




Weight: 0.02 g (typ.)

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