TENTATIVE TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VCXH162374FT

Low-Voltage 16-Bit D-Type Flip-Flop with Bushold

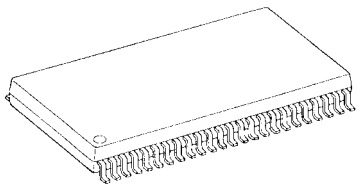
The TC74VCXH162374FT is a high-performance CMOS 16-bit D-type flip-flop. Designed for use in 1.8-V, 2.5-V or 3.3-V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

This 16-bit D-type flip-flop is controlled by a clock input (CK) and a output enable input ($\overline{OE}$) which are common to each byte. It can be used as two 8-bit flip-flops or one 16-bit flip-flop. When the $\overline{OE}$ input is high, the outputs are in a high impedance state.

The 26-Ω series resistor helps reducing output overshoot and undershoot without external resistor.

The D data inputs include active bushold circuitry, eliminating the need for external pull-up resisisors to hold unused or floating data inputs at a valid logic level.

All inputs are equipped with protection circuits against static discharge.



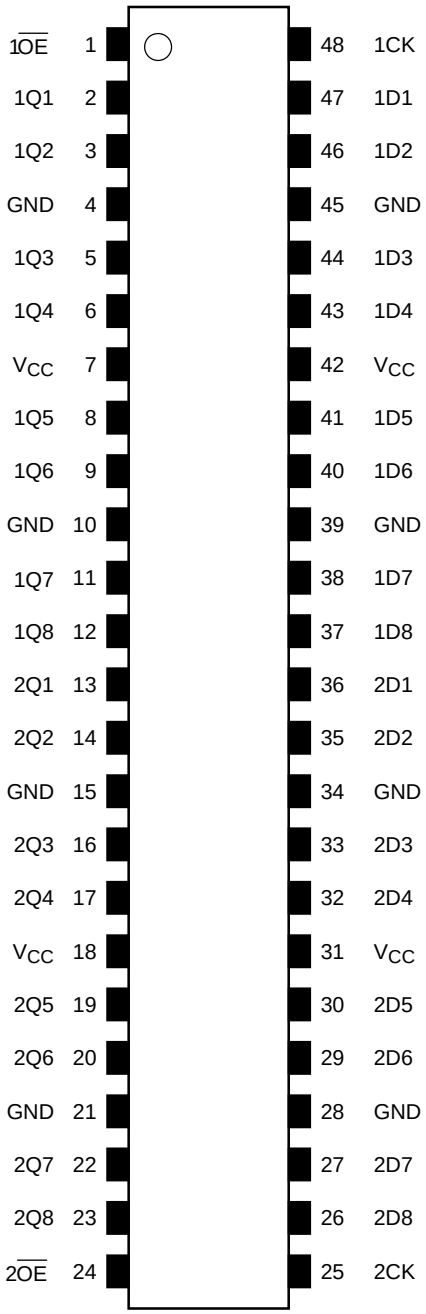
TSSOP48-P-0061-0.50

Weight: 0.25 g (typ.)

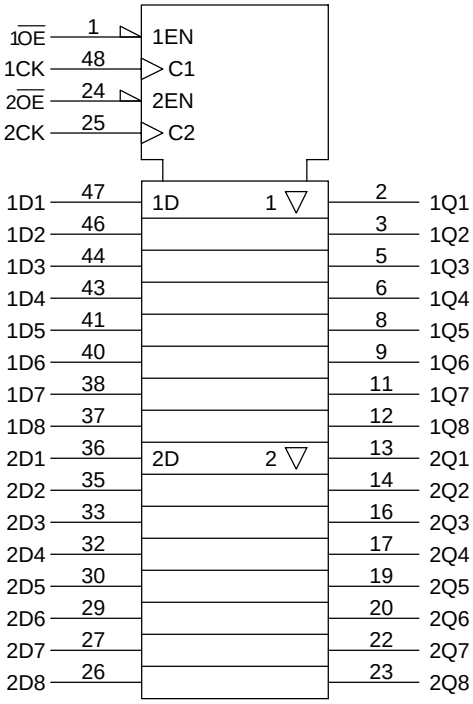
## Features

- 26-Ω series resistors on outputs
- Low-voltage operation: $V_{CC}$ = 1.8 to 3.6 V
- Bushold on data inputs eliminating the need for external pull-up/pull-down resistors
- High-speed operation: $t_{pd}$ = 3.4 ns (max) ($V_{CC}$ = 3.0 to 3.6 V)
  : $t_{pd}$ = 4.8 ns (max) ($V_{CC}$ = 2.3 to 2.7 V)
  : $t_{pd}$ = 6.0 ns (max) ($V_{CC}$ = 1.8 V)
- Output current: $I_{OH}/I_{OL}$ = ±12 mA (min) ($V_{CC}$ = 3.0 V)
  : $I_{OH}/I_{OL}$ = ±8 mA (min) ($V_{CC}$ = 2.3 V)
  : $I_{OH}/I_{OL}$ = ±4 mA (min) ($V_{CC}$ = 1.8 V)
- Latch-up performance: ±300 mA
- ESD performance: Machine model > ±200 V
  : Human body model > ±2000 V
- Package: TSSOP (thin shrink small outline package)
- 3.6-V tolerant function and power-down protection control inputs and outputs

## Pin Assignment (top view)




## IEC Logic Symbol



## Truth Table

| Inputs | | | Outputs |
|---|---|---|---|
| $1\overline{OE}$ | 1CK | 1D1-1D8 | 1Q1-1Q8 |
| H | X | X | Z |
| L | ↓ | X | Qn |
| L | ↑ | L | L |
| L | ↑ | H | H |

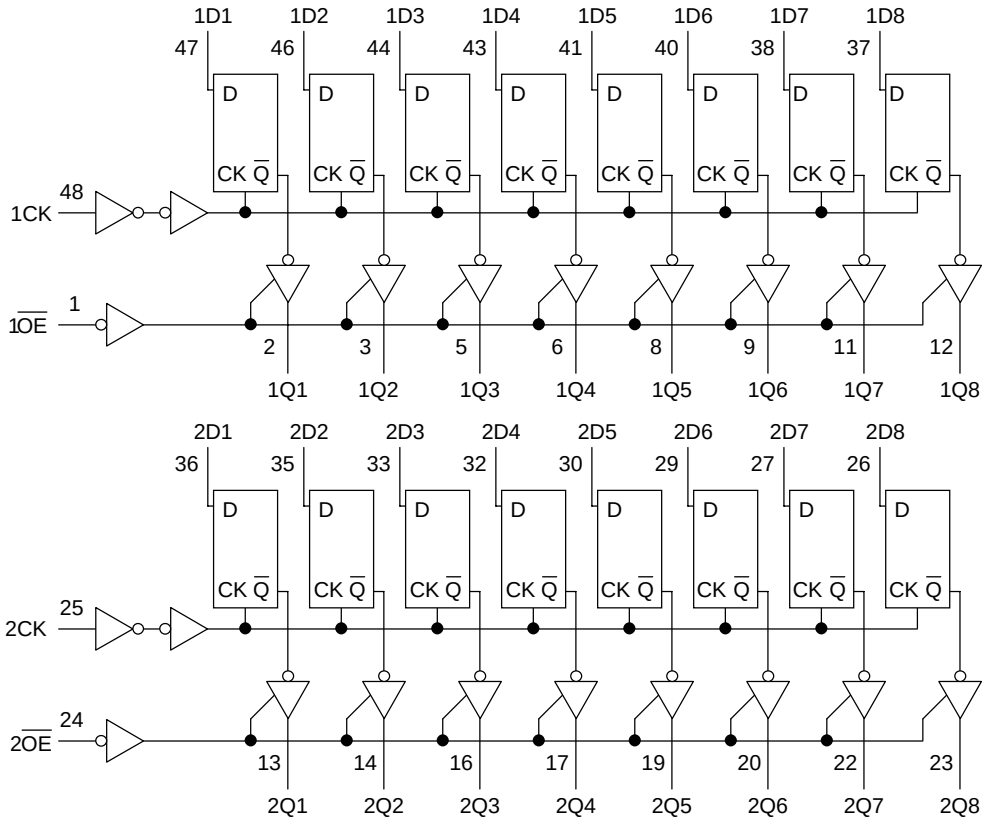
| Inputs | | | Outputs |
|---|---|---|---|
| $2\overline{OE}$ | 2CK | 2D1-2D8 | 2Q1-2Q8 |
| H | X | X | Z |
| L | ↓ | X | Qn |
| L | ↑ | L | L |
| L | ↑ | H | H |

X: Don't care

Z: High impedance

Qn: No change

## System Diagram



## Maximum Ratings

| Characteristics | | Symbol | Rating | Unit |
|---|---|---|---|---|
| Power supply voltage | | $V_{CC}$ | −0.5 to 4.6 | V |
| DC input voltage | ( $\overline{OE}$ , CK) | $V_{IN}$ | −0.5 to 4.6 | V |
| | (An) | | −0.5 to $V_{CC}$ + 0.5 | |
| DC output voltage | | $V_{OUT}$ | −0.5 to 4.6 (Note 1) | V |
| | | | −0.5 to $V_{CC}$ + 0.5 (Note 2) | |
| Input diode current | | $I_{IK}$ | −50 | mA |
| Output diode current | | $I_{OK}$ | ±50 (Note 3) | mA |
| Output current | | $I_{OUT}$ | ±50 | mA |
| Power dissipation | | $P_D$ | 400 | mW |
| DC $V_{CC}$/ground current per supply pin | | $I_{CC}/I_{GND}$ | ±100 | mA |
| Storage temperature | | $T_{stg}$ | −65 to 150 | °C |

Note 1: OFF state

Note 2: High or low state. $I_{OUT}$ absolute maximum rating must be observed.

Note 3: $V_{OUT} < GND$, $V_{OUT} > V_{CC}$

## Recommended Operating Range (Note 4)

| Characteristics | | Symbol | Rating | Unit |
|---|---|---|---|---|
| Power supply voltage | | $V_{CC}$ | 1.8 to 3.6 | V |
| | | | 1.2 to 3.6 (Note 5) | |
| Input voltage | ( $\overline{OE}$ , CK) | $V_{IN}$ | −0.3 to 3.6 | V |
| | (An) | | 0 to $V_{CC}$ | |
| Output voltage | | $V_{OUT}$ | 0 to 3.6 (Note 6) | V |
| | | | 0 to $V_{CC}$ (Note 7) | |
| Output current | | $I_{OH}/I_{OL}$ | ±12 (Note 8) | mA |
| | | | ±8 (Note 9) | |
| | | | ±4 (Note 10) | |
| Operating temperature | | $T_{opr}$ | −40 to 85 | °C |
| Input rise and fall time | | dt/dv | 0 to 10 (Note 11) | ns/V |

Note 4: Floating or unused control inputs must be held high or low.

Note 5: Data retention

Note 6: OFF state

Note 7: High or low state

Note 8: $V_{CC}$ = 3.0 to 3.6 V

Note 9: $V_{CC}$ = 2.3 to 2.7 V

Note 10: $V_{CC}$ = 1.8 V

Note 11: $V_{IN}$ = 0.8 to 2.0 V, $V_{CC}$ = 3.0 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 | $V_{IH}$ | — | | 2.7 to 3.6 | 2.0 | — | V |
| | L-level | $V_{IL}$ | — | | 2.7 to 3.6 | — | 0.8 | |
| Output voltage | H-level | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = –100 μA | 2.7 to 3.6 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –6 mA | 2.7 | 2.2 | — | |
| | | | | $I_{OH}$ = –8 mA | 3.0 | 2.4 | — | |
| | | | | $I_{OH}$ = –12 mA | 3.0 | 2.2 | — | |
| | L-level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 100 μA | 2.7 to 3.6 | — | 0.2 | |
| | | | | $I_{OL}$ = 6 mA | 2.7 | — | 0.4 | |
| | | | | $I_{OL}$ = 8 mA | 3.0 | — | 0.5 | |
| | | | | $I_{OL}$ = 12 mA | 3.0 | — | 0.8 | |
| Input leakage current | ( $\overline{OE}$ , CK) | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 2.7 to 3.6 | — | ±5.0 | μA |
| | (An) | | $V_{IN}$ = $V_{CC}$ or GND | | 2.7 to 3.6 | — | ±5.0 | |
| Bushold input minimum drive hold current | | $I_{I (HOLD)}$ | $V_{IN}$ = 0.8 V | | 3.0 | 75 | — | μA |
| | | | $V_{IN}$ = 2.0 V | | 3.0 | –75 | — | |
| Bushold input over-drive current to change state | | $I_{I (OD)}$ | (Note 12) | | 3.6 | — | 450 | μA |
| | | | (Note 13) | | 3.6 | — | –450 | |
| 3-state output OFF state current | | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = 0 to 3.6 V | | 2.7 to 3.6 | — | ±10.0 | μA |
| Power-off leakage current | | $I_{OFF}$ | $V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 2.7 to 3.6 | — | 20.0 | μA |
| | | | $V_{CC}$ ≦ $V_{OUT}$ ≦ 3.6 V | (Note 14) | 2.7 to 3.6 | — | ±20.0 | |
| Increase in $I_{CC}$ per input | | $\Delta I_{CC}$ | $V_{IH}$ = $V_{CC}$ – 0.6 V | | 2.7 to 3.6 | — | 750 | μA |

Note 12: An external driver must source at least the specified current to switch LOW-to-HIGH.

Note 13: An external driver must sink at least the specified current to switch HIGH-to-LOW.

Note 14: Outputs high impedance only.

## 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 | $V_{IH}$ | — | | 2.3 to 2.7 | 1.6 | — | V |
| | L-level | $V_{IL}$ | — | | 2.3 to 2.7 | — | 0.7 | |
| Output voltage | H-level | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = –100 μA | 2.3 to 2.7 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –4 mA | 2.3 | 2.0 | — | |
| | | | | $I_{OH}$ = –6 mA | 2.3 | 1.8 | — | |
| | | | | $I_{OH}$ = –8 mA | 2.3 | 1.7 | — | |
| | L-level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 100 μA | 2.3 to 2.7 | — | 0.2 | |
| | | | | $I_{OL}$ = 6 mA | 2.3 | — | 0.4 | |
| | | | | $I_{OL}$ = 8 mA | 2.3 | — | 0.6 | |
| Input leakage current | ( $\overline{OE}$ , CK) | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 2.3 to 2.7 | — | ±5.0 | μA |
| | (An) | | $V_{IN}$ = $V_{CC}$ or GND | | 2.3 to 2.7 | — | ±5.0 | |
| Bushold input minimum drive hold current | | $I_{I (HOLD)}$ | $V_{IN}$ = 0.7 V | | 2.3 | 45 | — | μA |
| | | | $V_{IN}$ = 1.6 V | | 2.3 | –45 | — | |
| Bushold input over-drive current to change state | | $I_{I (OD)}$ | (Note 12) | | 2.7 | — | 300 | μA |
| | | | (Note 13) | | 2.7 | — | –300 | |
| 3-state output OFF state current | | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = 0 to 3.6 V | | 2.3 to 2.7 | — | ±10.0 | μA |
| Power-off leakage current | | $I_{OFF}$ | $V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 2.3 to 2.7 | — | 20.0 | μA |
| | | | $V_{CC}$ ≦ $V_{OUT}$ ≦ 3.6 V | (Note 14) | 2.3 to 2.7 | — | ±20.0 | |

Note 12: An external driver must source at least the specified current to switch LOW-to-HIGH.

Note 13: An external driver must sink at least the specified current to switch HIGH-to-LOW.

Note 14: Outputs high impedance only.

## DC Characteristics (Ta = –40 to 85°C, 1.8 V ≦ $V_{CC}$ < 2.3 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | H-level | $V_{IH}$ | — | | 1.8 to 2.3 | 0.7 × $V_{CC}$ | — | V |
| | L-level | $V_{IL}$ | — | | 1.8 to 2.3 | — | 0.2 × $V_{CC}$ | |
| Output voltage | H-level | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = –100 μA | 1.8 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –4 mA | 1.8 | 1.4 | — | |
| | L-level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 100 μA | 1.8 | — | 0.2 | |
| | | | | $I_{OL}$ = 4 mA | 1.8 | — | 0.3 | |
| Input leakage current | ( $\overline{OE}$ , CK) | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 1.8 | — | ±5.0 | μA |
| | (An) | | $V_{IN}$ = $V_{CC}$ or GND | | 1.8 | — | ±5.0 | |
| Bushold input minimum drive hold current | | $I_{I (HOLD)}$ | $V_{IN}$ = 0.36 V | | 1.8 | 25 | — | μA |
| | | | $V_{IN}$ = 1.26 V | | 1.8 | –25 | — | |
| Bushold input over-drive current to change state | | $I_{I (OD)}$ | (Note 12) | | 1.8 | — | 200 | μA |
| | | | (Note 13) | | 1.8 | — | –200 | |
| 3-state output OFF state current | | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = 0 to 3.6 V | | 1.8 | — | ±10.0 | μA |
| Power-off leakage current | | $I_{OFF}$ | $V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 1.8 | — | 20.0 | μA |
| | | | $V_{CC}$ ≦ $V_{OUT}$ ≦ 3.6 V | (Note 14) | 1.8 | — | ±20.0 | |

Note 12: An external driver must source at least the specified current to switch LOW-to-HIGH.

Note 13: An external driver must sink at least the specified current to switch HIGH-to-LOW.

Note 14: Outputs high impedance only.

## AC Characteristics (Ta = –40 to 85°C, input: $t_r = t_f = 2.0$ ns, $C_L = 30$ pF, $R_L = 500\ \Omega$)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|
| Maximum clock frequency | $f_{max}$ | Figure 1, Figure 2 | 1.8 | 125 | — | MHz |
| | | | 2.5 ± 0.2 | 200 | — | |
| | | | 3.3 ± 0.3 | 250 | — | |
| Propagation delay time (CK-Q) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | 1.8 | 1.5 | 6.0 | ns |
| | | | 2.5 ± 0.2 | 1.0 | 4.8 | |
| | | | 3.3 ± 0.3 | 0.8 | 3.4 | |
| 3-state output enable time | $t_{pZL}$ $t_{pZH}$ | Figure 1, Figure 3 | 1.8 | 1.5 | 7.6 | ns |
| | | | 2.5 ± 0.2 | 1.0 | 5.4 | |
| | | | 3.3 ± 0.3 | 0.8 | 3.9 | |
| 3-state output disable time | $t_{pLZ}$ $t_{pHZ}$ | Figure 1, Figure 3 | 1.8 | 1.5 | 5.3 | ns |
| | | | 2.5 ± 0.2 | 1.0 | 4.4 | |
| | | | 3.3 ± 0.3 | 0.8 | 4.0 | |
| Minimum pulse width (CK) | $t_{w\ (H)}$ $t_{w\ (L)}$ | Figure 1, Figure 2 | 1.8 | 3.0 | — | ns |
| | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum set-up time | $t_s$ | Figure 1, Figure 2 | 1.8 | 2.5 | — | ns |
| | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum hold time | $t_h$ | Figure 1, Figure 2 | 1.8 | 1.0 | — | ns |
| | | | 2.5 ± 0.2 | 1.0 | — | |
| | | | 3.3 ± 0.3 | 1.0 | — | |
| Output to output skew | $t_{osLH}$ $t_{osHL}$ | (Note 15) | 1.8 | — | 0.5 | ns |
| | | | 2.5 ± 0.2 | — | 0.5 | |
| | | | 3.3 ± 0.3 | — | 0.5 | |

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

Note 15: 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 16) | 1.8 | 0.15 | V |
| | | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note 16) | 2.5 | 0.25 | |
| | | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note 16) | 3.3 | 0.35 | |
| Quiet output minimum dynamic | $V_{OL}$ | $V_{OLV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note 16) | 1.8 | −0.15 | V |
| | | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note 16) | 2.5 | −0.25 | |
| | | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note 16) | 3.3 | −0.35 | |
| Quiet output minimum dynamic | $V_{OH}$ | $V_{OHV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note 16) | 1.8 | 1.55 | V |
| | | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note 16) | 2.5 | 2.05 | |
| | | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note 16) | 3.3 | 2.65 | |

Note 16: Parameter guaranteed by design.

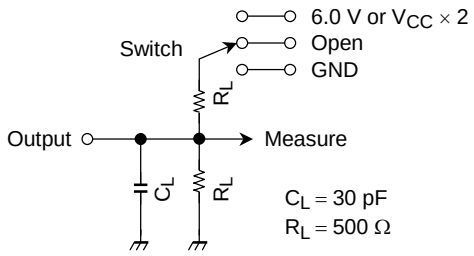
## Capacitive Characteristics (Ta = 25°C)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|
| Input capacitance | $C_{IN}$ | — | 1.8, 2.5, 3.3 | 6 | pF |
| Output capacitance | $C_O$ | — | 1.8, 2.5, 3.3 | 7 | pF |
| Power dissipation capacitance | $C_{PD}$ | $f_{IN}$ = 10 MHz (Note 17) | 1.8, 2.5, 3.3 | 20 | pF |

Note 17: $C_{PD}$ 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:

$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/16$ (per bit)

## AC Test Circuit




| Parameter | Switch | |
|---|---|---|
| $t_{pLH}$, $t_{pHL}$ | Open | |
| $t_{pLZ}$, $t_{pZL}$ | 6.0 V<br>$V_{CC} \times 2$ | @$V_{CC}$ = 3.3 ± 0.3 V<br>@$V_{CC}$ = 2.5 ± 0.2 V<br>@$V_{CC}$ = 1.8 V |
| $t_{pHZ}$, $t_{pZH}$ | GND | |

**Figure 1**

## AC Waveform

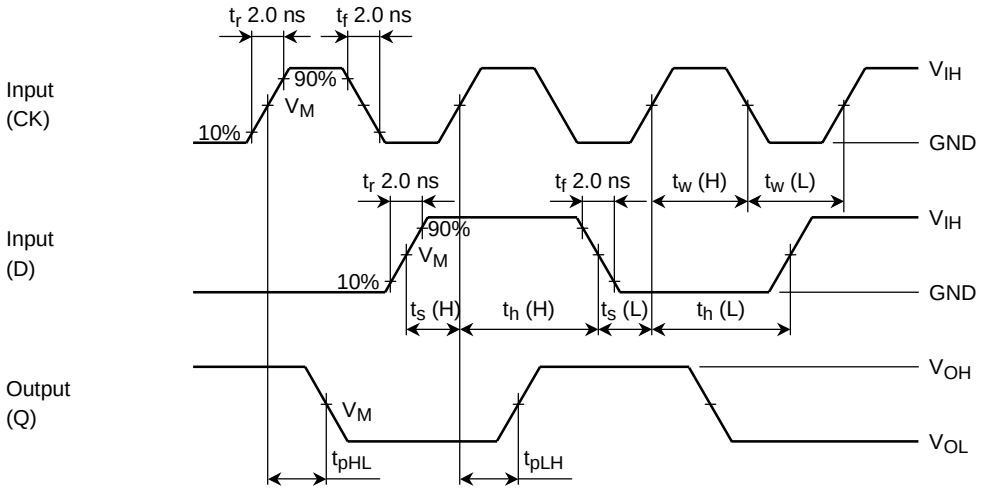



**Figure 2 $t_{pLH}$, $t_{pHL}$, $t_w$, $t_s$, $t_h$**

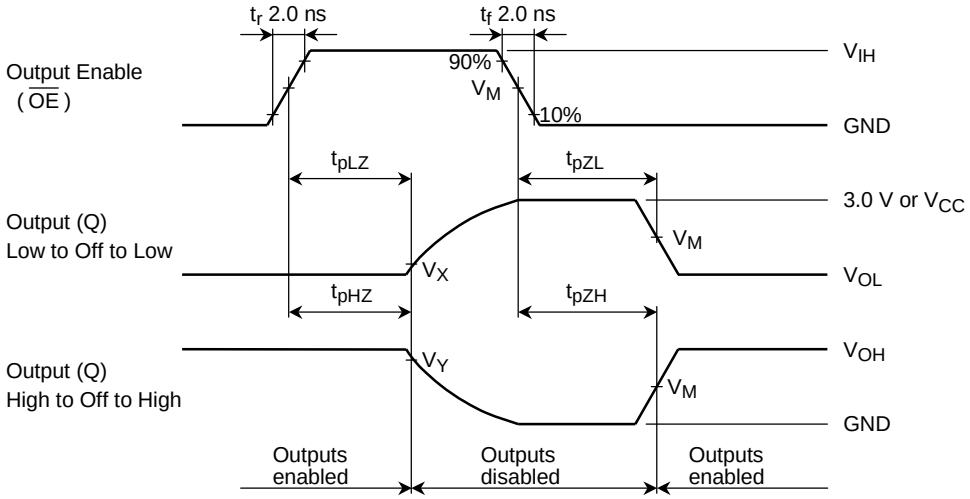
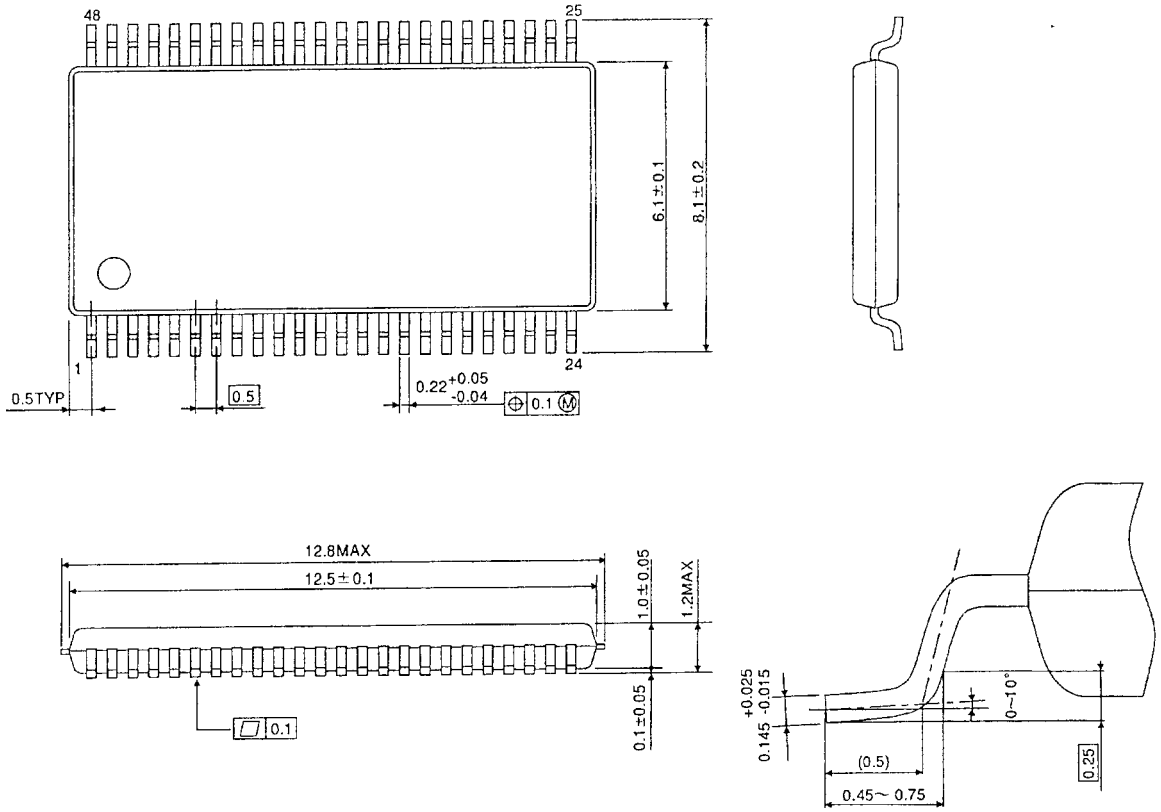



**Figure 3 $t_{pLZ}$, $t_{pHZ}$, $t_{pZL}$, $t_{pZH}$**

| Symbol | $V_{CC}$ | | |
|---|---|---|---|
| | 3.3 ± 0.3 V | 2.5 ± 0.2 V | 1.8 V |
| $V_{IH}$ | 2.7 V | $V_{CC}$ | $V_{CC}$ |
| $V_M$ | 1.5 V | $V_{CC}/2$ | $V_{CC}/2$ |
| $V_X$ | $V_{OL}$ + 0.3 V | $V_{OL}$ + 0.15 V | $V_{OL}$ + 0.15 V |
| $V_Y$ | $V_{OH}$ − 0.3 V | $V_{OH}$ − 0.15 V | $V_{OH}$ − 0.15 V |

## Package Dimensions

TSSOP48-P-0061-0.50 Unit : mm




Weight: 0.25 g (typ.)

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