TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

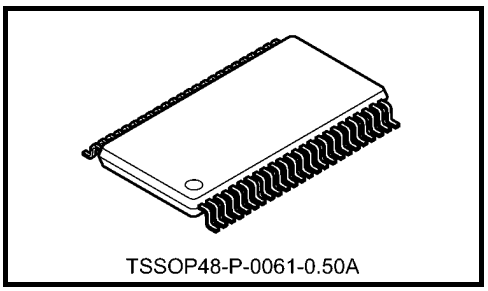
# TC74VCXR162245FT

Low-Voltage 16-Bit Bus Transceiver with 3.6-V Tolerant Inputs and Outputs

The TC74VCXR162245FT is a high-performance CMOS 16-bit bus transceiver. 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.

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

This 16 bit bus transceiver is controlled by direction control (DIR) inputs and output enable ($\overline{OE}$) inputs which are common to each byte. It can be used as two 8-bit transceivers or one 16-bit transceiver. The direction of data transmission is determined by the level of the DIR inputs. The $\overline{OE}$ inputs can be used to disable the device so that the busses are effectively isolated.



TSSOP48-P-0061-0.50A

Weight: 0.25 g (typ.)

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

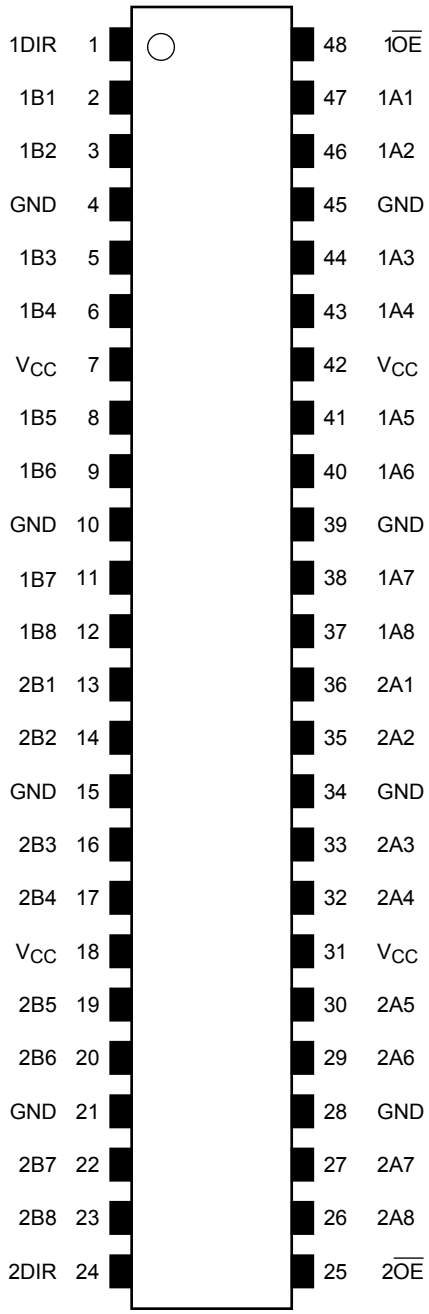
All inputs are equipped with protection circuits against static discharge.

## Features (Note)

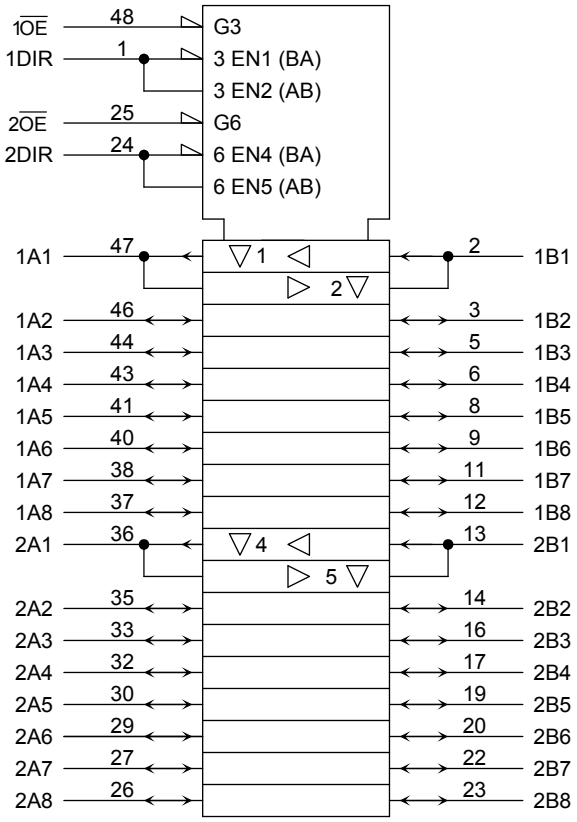
- 26-Ω series resistors on all outputs
- Low-voltage operation: $V_{CC}$ = 1.8 to 3.6 V
- High-speed operation: $t_{pd}$ = 3.4 ns (max) ($V_{CC}$ = 3.0 to 3.6 V)
  : $t_{pd}$ = 4.3 ns (max) ($V_{CC}$ = 2.3 to 2.7 V)
  : $t_{pd}$ = 5.7 ns (max) ($V_{CC}$ = 1.8 V)
- output current: $I_{OH}/I_{OL}$ = ±12 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
- Bidirectional interface between 2.5 V and 3.3 V signals.
- 3.6-V tolerant function and power-down protection is provided on all inputs and outputs

Note: Do not apply a signal to any bus pins when it is in the output mode. Damage may result.
All floating (high impedance) bus pins must have their input level fixed by means of pull-up or pull-down resistors.

## Pin Assignment (top view)




## IEC Logic Symbol



## Truth Table

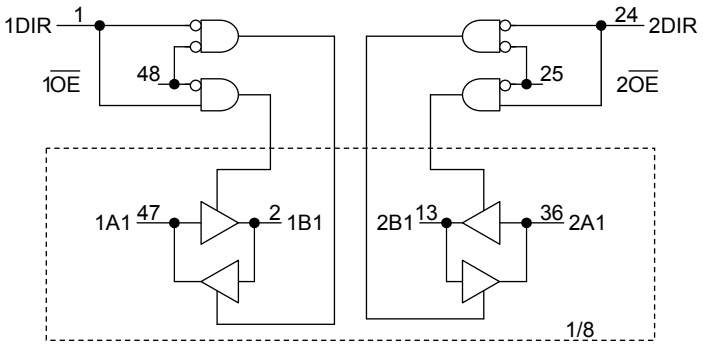
| Inputs | | Function | | Outputs |
|---|---|---|---|---|
| $1\overline{OE}$ | 1DIR | Bus 1A1-1A8 | Bus 1B1-1B8 | |
| L | L | Output | Input | A = B |
| L | H | Input | Output | B = A |
| H | X | Z | | Z |

| Inputs | | Function | | Outputs |
|---|---|---|---|---|
| $2\overline{OE}$ | 2DIR | BUS 2A1-2A8 | BUS 2B1-2B8 | |
| L | L | Output | Input | A = B |
| L | H | Input | Output | B = A |
| H | X | Z | | Z |

X: Don't care

Z: High impedance

## System Diagram



## Absolute Maximum Ratings (Note 1)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Power supply voltage | $V_{CC}$ | −0.5 to 4.6 | V |
| DC input voltage (DIR, $\overline{OE}$) | $V_{IN}$ | −0.5 to 4.6 | V |
| DC bus I/O voltage | $V_{I/O}$ | −0.5 to 4.6 (Note 2) | V |
| | | −0.5 to $V_{CC}$ + 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 | $P_D$ | 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: 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: OFF state

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 | $V_{CC}$ | 1.8 to 3.6 | V |
| | | 1.2 to 3.6 (Note 2) | |
| Input voltage (DIR, $\overline{OE}$) | $V_{IN}$ | −0.3 to 3.6 | V |
| Bus I/O voltage | $V_{I/O}$ | 0 to 3.6 (Note 3) | V |
| | | 0 to $V_{CC}$ (Note 4) | |
| Output current | $I_{OH}/I_{OL}$ | ±12 (Note 5) | mA |
| | | ±8 (Note 6) | |
| | | ±4 (Note 7) | |
| Operating temperature | $T_{opr}$ | −40 to 85 | °C |
| Input rise and fall time | dt/dv | 0 to 10 (Note 8) | ns/V |

Note 1: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs and bus inputs must be tied to either VCC or GND. Please connect both bus inputs and the bus outputs with VCC or GND when the I/O of the bus terminal changes by the function. In this case, please note that the output is not short-circuited.

Note 2: Data retention only

Note 3: OFF state

Note 4: High or low state

Note 5: $V_{CC}$ = 3.0 to 3.6 V

Note 6: $V_{CC}$ = 2.3 to 2.7 V

Note 7: $V_{CC}$ = 1.8 V

Note 8: $V_{IN}$ = 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 | — | 0.55 | |
| | | | | $I_{OL}$ = 12 mA | 3.0 | — | 0.8 | |
| Input leakage current | | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 2.7 to 3.6 | — | ±5.0 | μA |
| 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 | | $I_{OFF}$ | $V_{IN}$, $V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 2.7 to 3.6 | — | 20.0 | μA |
| | | | $V_{CC}$ ≦ ($V_{IN}$, $V_{OUT}$) ≦ 3.6 V | | 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 | |

### 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 | | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 2.3 to 2.7 | — | ±5.0 | μA |
| 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 | | $I_{OFF}$ | $V_{IN}$, $V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 2.3 to 2.7 | — | 20.0 | μA |
| | | | $V_{CC}$ ≦ ($V_{IN}$, $V_{OUT}$) ≦ 3.6 V | | 2.3 to 2.7 | — | ±20.0 | |

## 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 | | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 1.8 | — | ±5.0 | μA |
| 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 | | $I_{OFF}$ | $V_{IN}$, $V_{OUT}$ = 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 |
| | | | $V_{CC}$ ≦ ($V_{IN}$, $V_{OUT}$) ≦ 3.6 V | | 1.8 | — | ±20.0 | |

## AC Characteristics (Ta = –40 to 85°C, input: $t_r$ = $t_f$ = 2.0 ns, $C_L$ = 30 pF, $R_L$ = 500 Ω) (Note 1)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|
| Propagation delay time | $t_{pLH}$<br>$t_{pHL}$ | Figure 1, Figure 2 | 1.8 | 1.5 | 5.7 | ns |
| | | | 2.5 ± 0.2 | 1.0 | 4.3 | |
| | | | 3.3 ± 0.3 | 0.8 | 3.4 | |
| 3-state output enable time | $t_{pZL}$<br>$t_{pZH}$ | Figure 1, Figure 3 | 1.8 | 1.5 | 7.6 | ns |
| | | | 2.5 ± 0.2 | 1.0 | 5.7 | |
| | | | 3.3 ± 0.3 | 0.8 | 4.2 | |
| 3-state output disable time | $t_{pLZ}$<br>$t_{pHZ}$ | Figure 1, Figure 3 | 1.8 | 1.5 | 5.7 | ns |
| | | | 2.5 ± 0.2 | 1.0 | 4.8 | |
| | | | 3.3 ± 0.3 | 0.8 | 4.1 | |
| Output to output skew | $t_{osLH}$<br>$t_{osHL}$ | (Note 2) | 1.8 | — | 0.5 | ns |
| | | | 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 | 0.15 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | 0.25 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | 0.35 | |
| Quiet output minimum dynamic $V_{OL}$ | $V_{OLV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note) | 1.8 | −0.15 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | −0.25 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | −0.35 | |
| Quiet output minimum dynamic $V_{OH}$ | $V_{OHV}$ | $V_{IH}$ = 1.8 V, $V_{IL}$ = 0 V (Note) | 1.8 | 1.55 | V |
| | | $V_{IH}$ = 2.5 V, $V_{IL}$ = 0 V (Note) | 2.5 | 2.05 | |
| | | $V_{IH}$ = 3.3 V, $V_{IL}$ = 0 V (Note) | 3.3 | 2.65 | |

Note: Parameter guaranteed by design.

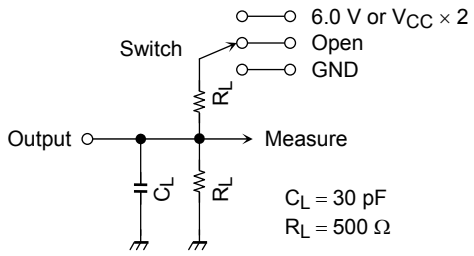
## Capacitive Characteristics (Ta = 25°C)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|
| Input capacitance | $C_{IN}$ | — | 1.8, 2.5, 3.3 | 6 | pF |
| Bus I/O capacitance | $C_{I/O}$ | — | 1.8, 2.5, 3.3 | 7 | 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:

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

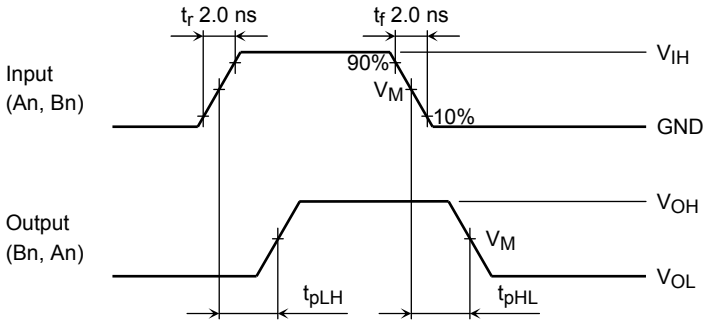



**Figure 2 $t_{pLH}$, $t_{pHL}$**

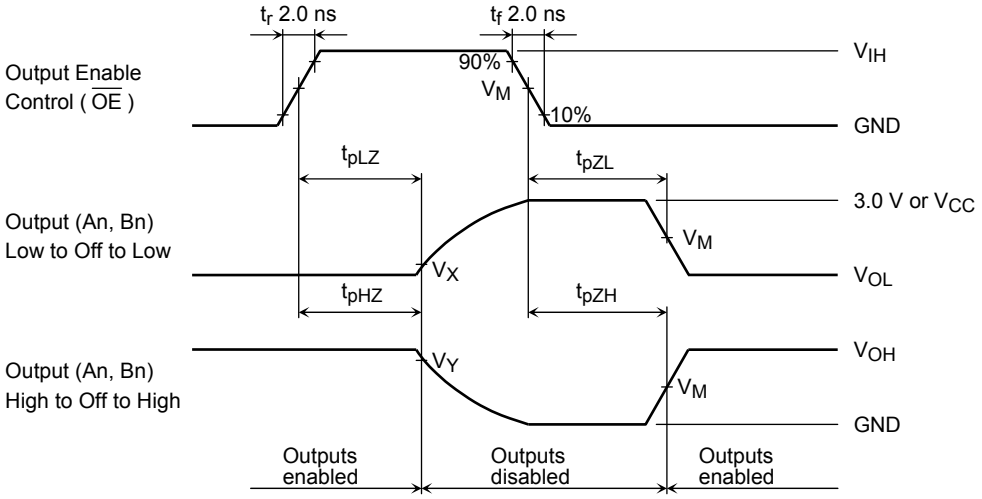
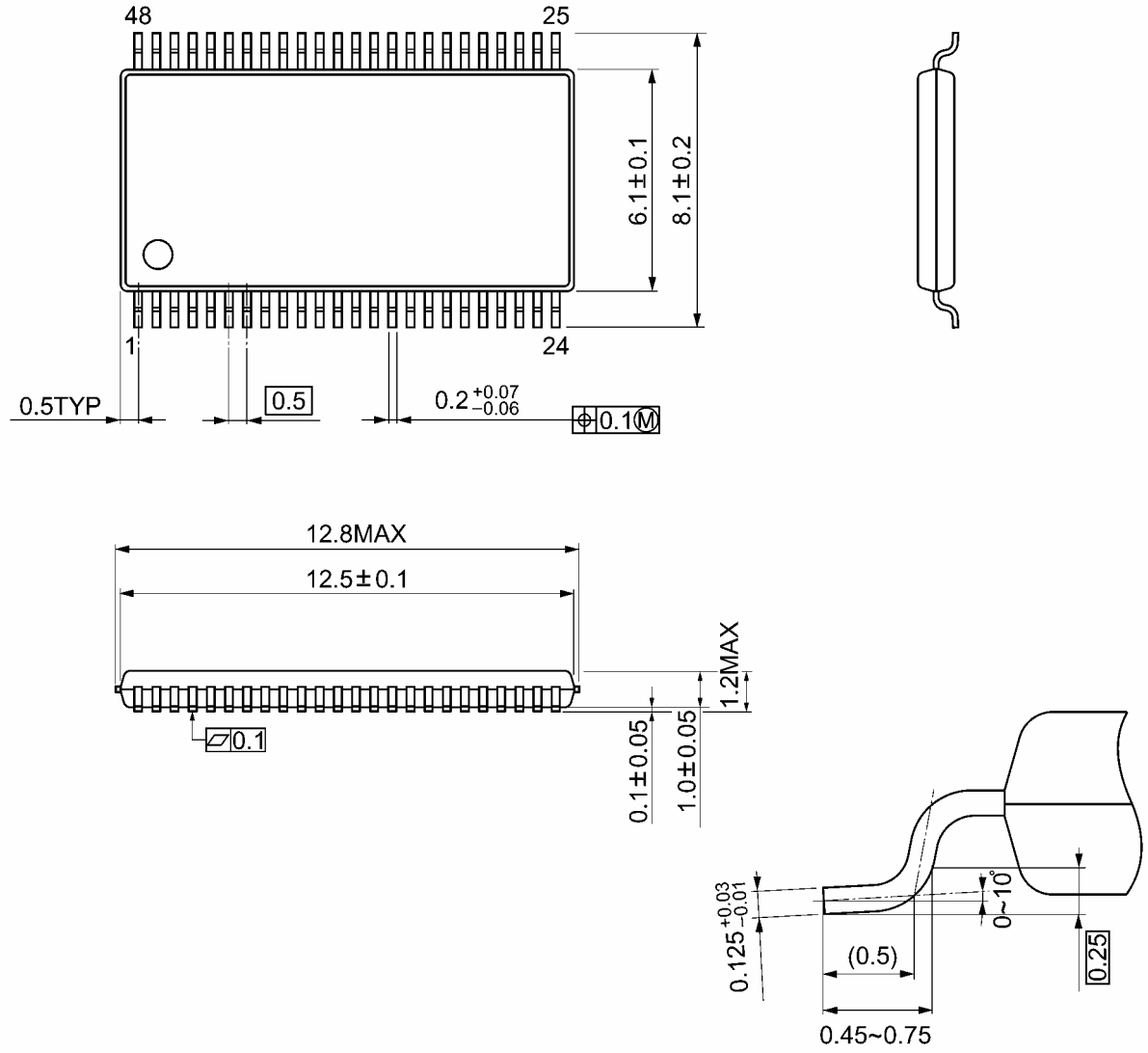



**Figure 3 $t_{pLZ}$, $t_{pHZ}$, $t_{pZL}$, $t_{pZH}$**

| 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-0061-0.50A Unit: mm




Weight: 0.25 g (typ.)

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20070701-EN GENERAL

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