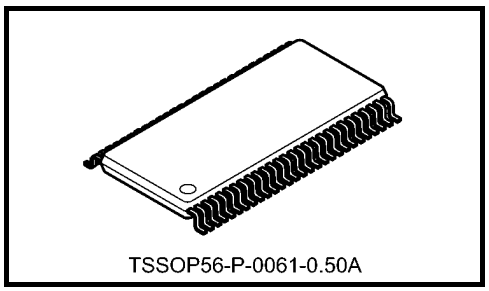
TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VCXR162501FT

## Low-Voltage 18-Bit Universal Bus Transceiver with 3.6-V Tolerant Inputs and Outputs




Weight: 0.25 g (typ.)

The TC74VCXR162501FT is a high-performance CMOS 18-bit universal 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.

Data flow in each direction is controlled by output-enable ($\overline{OEAB}$ and $\overline{OEBA}$), latch-enable (LEAB and LEBA), and clock (CKAB and CKBA) inputs.

For A-to-B data flow, the device operates in the transparent mode when LEAB is high. When LEAB is low, the A data is latched if CKAB is held at a high or low logic level. If LEAB is low, the A bus data is stored in the latch/flip-flop on the low-to-high transition of CKAB.

Data flow for B to A is similar to that of A to B but uses $\overline{OEBA}$, LEBA, and CKBA.

When the $\overline{OE}$ input is high, the outputs are in a high-impedance state. This device is designed to be used with 3-state memory address drivers, etc.

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

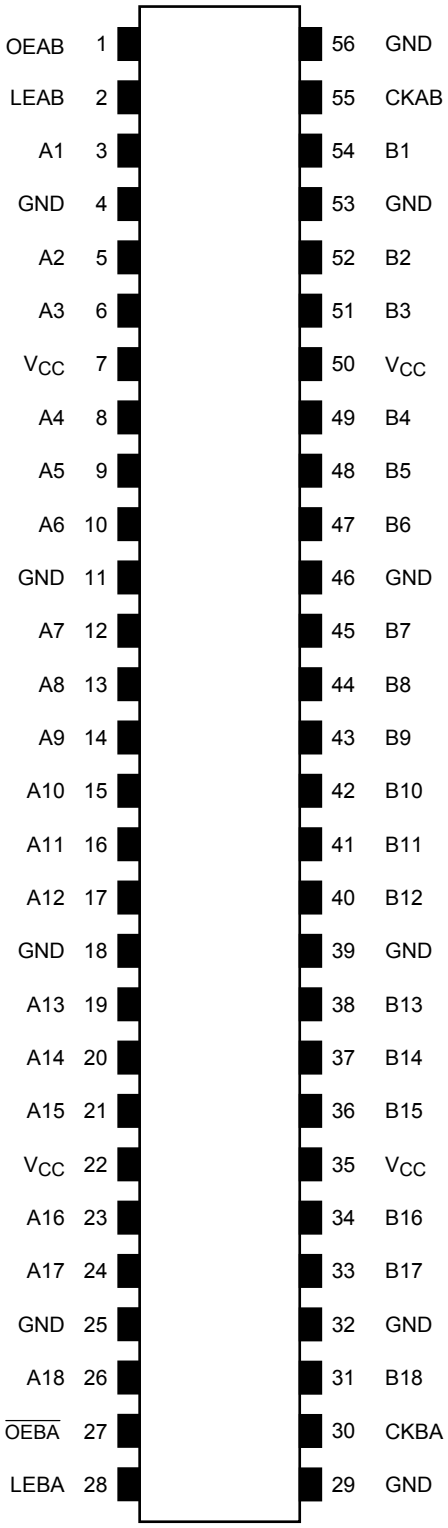
All inputs are equipped with protection circuits against static discharge.

## Features (Note)

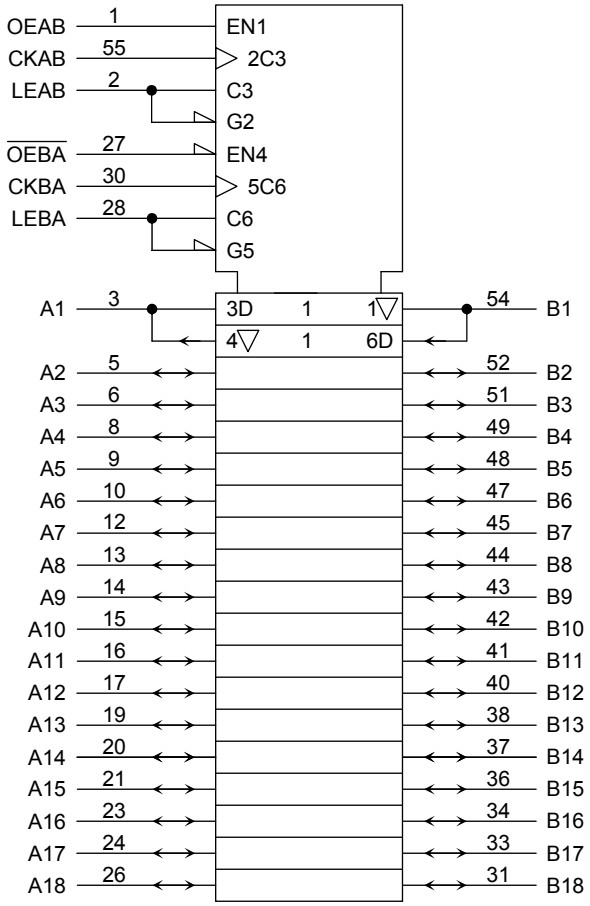
- 26-Ω series resistors on outputs
- Low-voltage operation: $V_{CC}$ = 1.8 to 3.6 V
- High-speed operation: $t_{pd}$ = 3.8 ns (max) ($V_{CC}$ = 3.0 to 3.6 V)
  : $t_{pd}$ = 4.9 ns (max) ($V_{CC}$ = 2.3 to 2.7 V)
  : $t_{pd}$ = 9.8 ns (max) ($V_{CC}$ = 1.8 V)
- Output current: $I_{OH}/I_{OL}$ = ±12 mA (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 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 (A bus → B bus)

| Inputs | | | | Outputs |
|---|---|---|---|---|
| OEAB | LEAB | CKAB | A | B |
| L | X | X | X | Z |
| H | H | X | L | L |
| H | H | X | H | H |
| H | L | ↑ | L | L |
| H | L | ↑ | H | H |
| H | L | H | X | B0 (Note) |
| H | L | L | X | B0 (Note) |

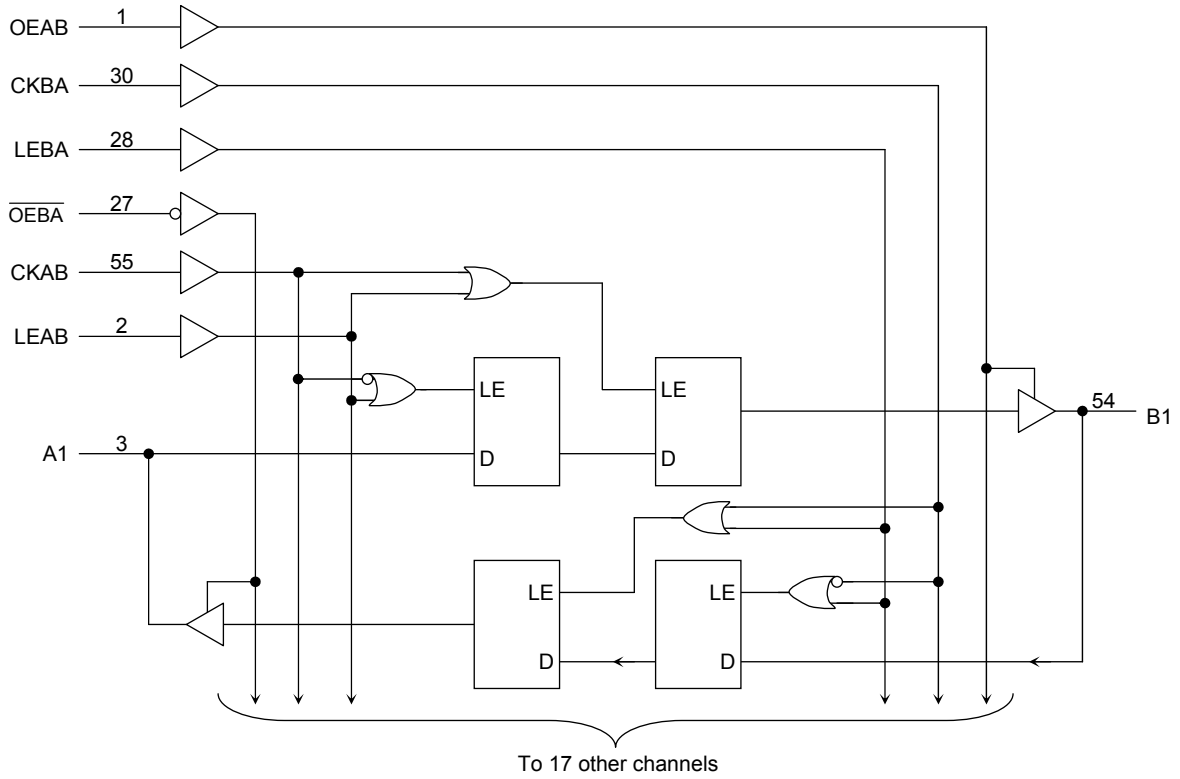
Note: Output level before the indicated steady-state input conditions were established, provided that CKAB was low or high before LEAB went low.

### Truth Table (B bus → A bus)

| Inputs | | | | Outputs |
|---|---|---|---|---|
| $\overline{\text{OEBA}}$ | LEBA | CKBA | B | A |
| H | X | X | X | Z |
| L | H | X | L | L |
| L | H | X | H | H |
| L | L | ↑ | L | L |
| L | L | ↑ | H | H |
| L | L | H | X | A0 (Note) |
| L | L | L | X | A0 (Note) |

Note: Output level before the indicated steady-state input conditions were established, provided that CKBA was low or high before LEBA went low.

## 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 (OEAB, $\overline{OEBA}$, LEAB, LEBA, CKAB, CKBA) | $V_{IN}$ | −0.5 to 4.6 | V |
| DC bus I/O voltage | $V_{I/O}$ | −0.5 to 4.6 (Note 2)<br>−0.5 to $V_{CC}$ + 0.5 (Note 3) | V |
| 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 (OEAB, $\overline{OEBA}$, LEAB, LEBA, CKAB, CKBA) | $V_{IN}$ | −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 must be tied to either VCC or GND.

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, $R_L = 500\ \Omega$) (Note 1)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|
| Maximum clock frequency | $f_{max}$ | Figure 1, Figure 3 | 1.8 | 100 | — | MHz |
| | | | 2.5 ± 0.2 | 200 | — | |
| | | | 3.3 ± 0.3 | 250 | — | |
| Propagation delay time (An, Bn-Bn, An) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | 1.8 | 1.5 | 9.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.9 | |
| | | | 3.3 ± 0.3 | 0.6 | 3.8 | |
| Propagation delay time (CKAB, CLKBA-Bn, An) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 3 | 1.8 | 1.5 | 9.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 5.8 | |
| | | | 3.3 ± 0.3 | 0.6 | 4.4 | |
| Propagation delay time (LEAB, LEBA-Bn, An) | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 4 | 1.8 | 1.5 | 9.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 6.3 | |
| | | | 3.3 ± 0.3 | 0.6 | 4.7 | |
| Output enable time (OEAB, $\overline{OEBA}$ -Bn, An) | $t_{pZL}$ $t_{pZH}$ | Figure 1, Figure 5, Figure 6 | 1.8 | 1.5 | 9.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 5.9 | |
| | | | 3.3 ± 0.3 | 0.6 | 4.3 | |
| Output disable time (OEAB, $\overline{OEBA}$ -Bn, An) | $t_{pLZ}$ $t_{pHZ}$ | Figure 1, Figure 5, Figure 6 | 1.8 | 1.5 | 8.8 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.9 | |
| | | | 3.3 ± 0.3 | 0.6 | 4.3 | |
| Minimum pulse width | $t_{W\ (H)}$ $t_{W\ (L)}$ | Figure 1, Figure 3, Figure 4 | 1.8 | 4.0 | — | ns |
| | | | 2.5 ± 0.2 | 1.5 | — | |
| | | | 3.3 ± 0.3 | 1.5 | — | |
| Minimum setup time | $t_s$ | Figure 1, Figure 3, Figure 4 | 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 3, Figure 4 | 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 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, $R_L = 500\ \Omega$)**

| 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.

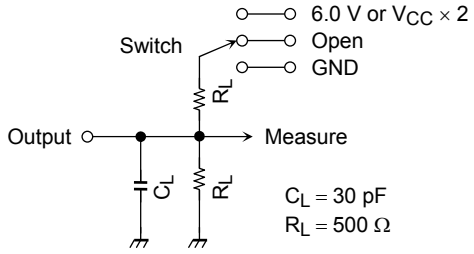
## Capacitive Characteristics (Ta = 25°C)

| 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:

$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/18$ (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

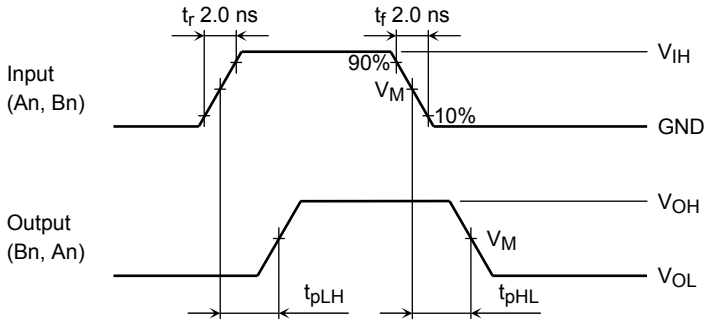



**Figure 2 $t_{pLH}$, $t_{pHL}$**

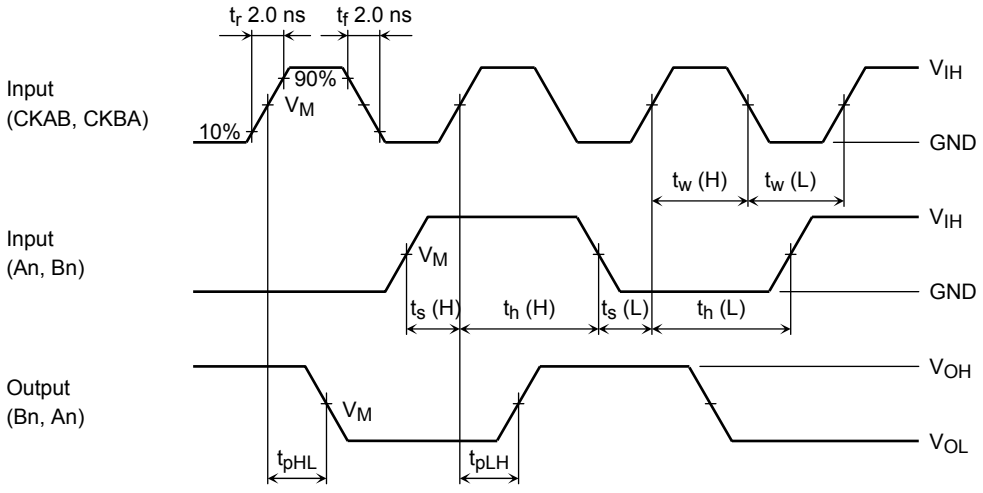



**Figure 3 $t_{pLH}$, $t_{pHL}$, $t_w$, $t_s$, $t_h$**

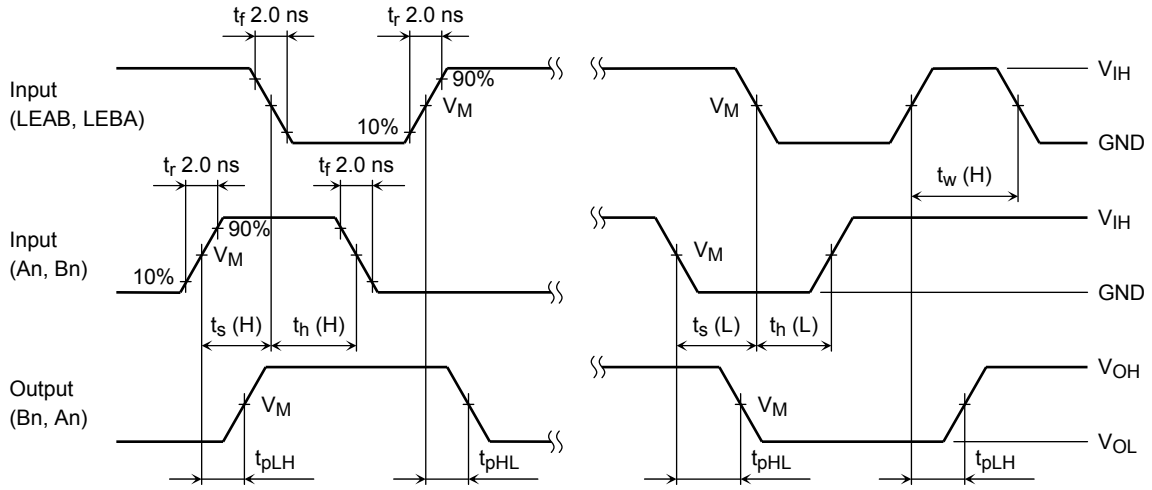



**Figure 4 $t_{pLH}$, $t_{pHL}$, $t_w$, $t_s$, $t_h$**

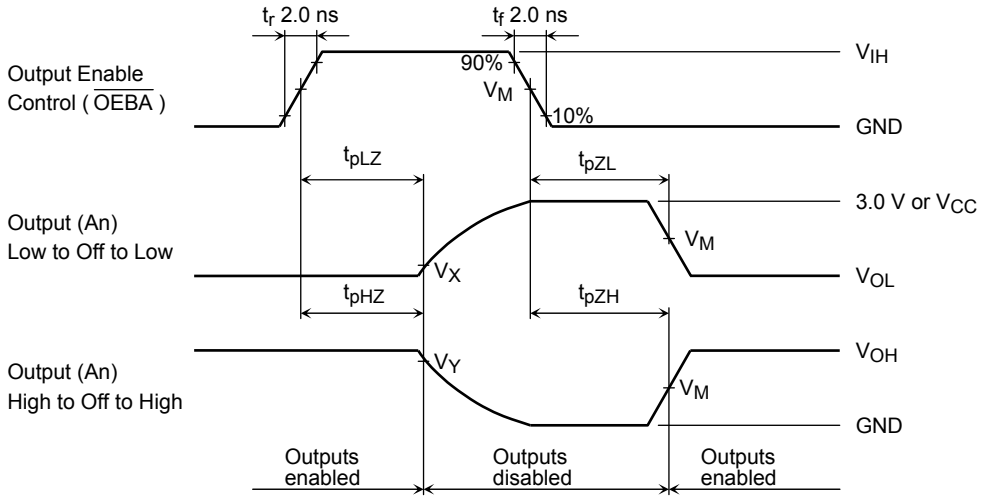



**Figure 5 $t_{pLZ}$, $t_{pHZ}$, $t_{pZL}$, $t_{pZH}$**

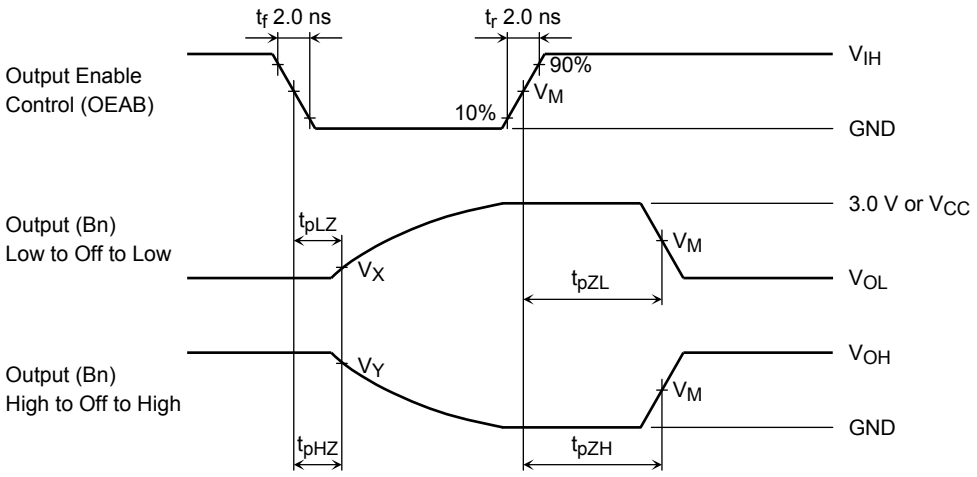
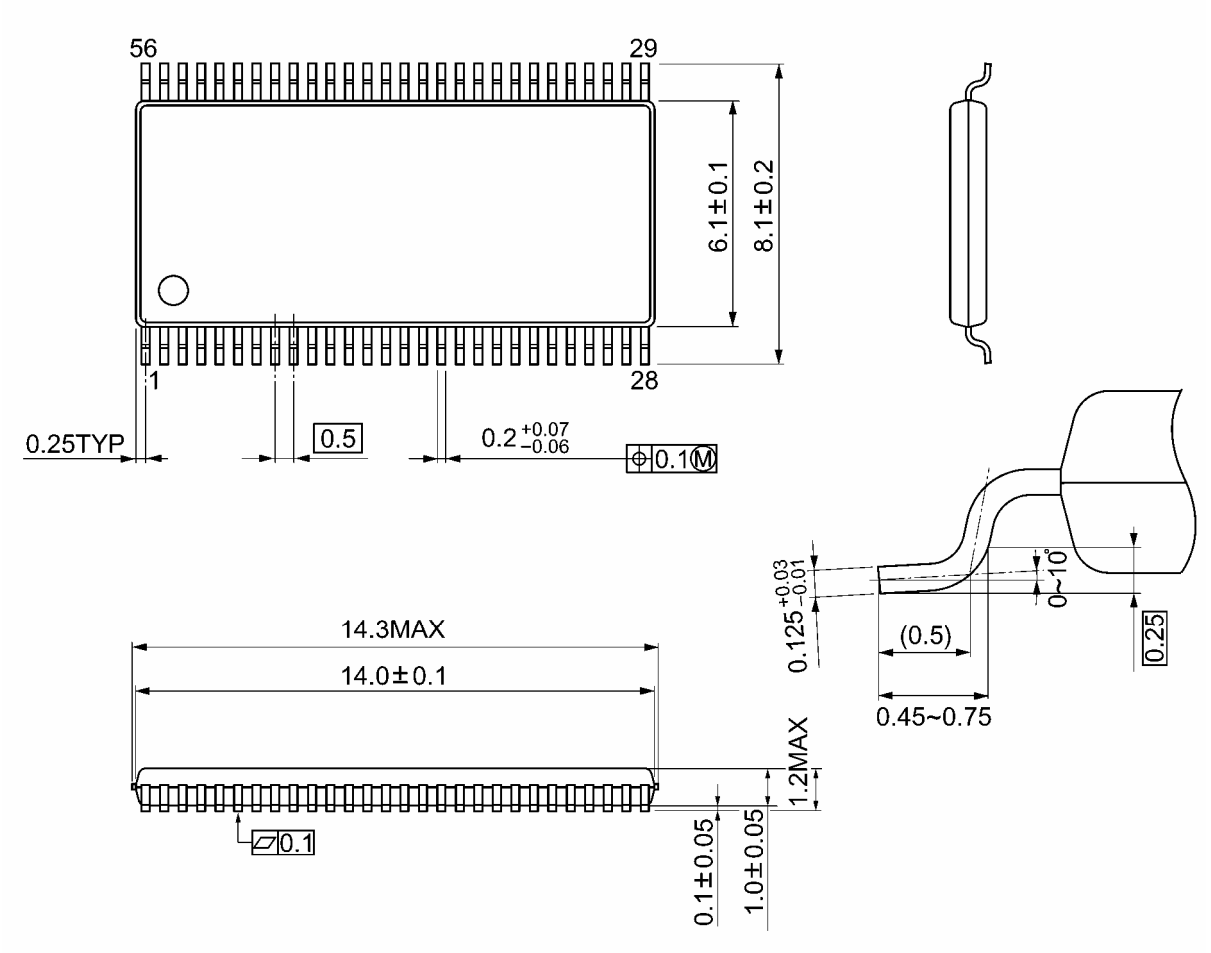



**Figure 6 $t_{pLZ}$, $t_{pHZ}$, $t_{pZL}$, $t_{pZH}$**

| 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

TSSOP56-P-0061-0.50A Unit: mm




Weight: 0.25 g (typ.)

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20070701-EN GENERAL

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