CMOS Digital Integrated Circuits Silicon Monolithic

# TDS4A212MX,TDS4B212MX

## 1. Functional Description

- 1-32Gbps 1-Lane Two Differential Channel, 2:1 Mux/1:2 De-Mux

## 2. General

TDS4A212MX, TDS4B212MX are high-speed differential channel multiplexer(Mux)/demultiplexer(De-Mux) switches. These devices are designed to support up to 32Gbps high-speed differential interfaces such as PCIe® 5.0, CXL 2.0, USB4® Version 2.0, Thunderbolt™ 4, DisplayPort™ 2.0.

TDS4A212MX and TDS4B212MX have different pin assignment. TDS4B212MX has an optimized pin assignment to achieve high frequency performance, while TDS4A212MX's pin assignment is easy to use for board layout.

The A Port (An+, An-) is connected to either the B Port (Bn+, Bn-) or C Port (Cn+, Cn-), which is determined by the combination of both the select (SEL) and output enable ($\overline{OE}$).When the output enable ($\overline{OE}$) is held at a high-level, the switches are open (high-impedance state), regardless of the state of the select, thus these devices have lower consumption current.

The devices are designed to operate in temperatures from -40 ℃ to 105 ℃ and can be used for application including industrial use cases.

## 3. Features

(1) Operating voltage: $V_{CC}$ = 1.6 to 3.6 V

(2) Operating temperature : $T_{opr}$ = -40 to 105 ℃

(3) Low current consumption For active mode (Typ.) : $I_{ope}$ = 60 μA,
For standby mode (Max) : $I_{STB}$ = 10 μA

(4) -3-dB Bandwidth (differential) $BW_{(Diff)}$ (Typ.) : TDS4B212MX = 27.5 GHz
TDS4A212MX = 26.2 GHz

(5) Differential insertion Loss DDIL (Typ.) : TDS4B212MX = -1.4 dB @ f = 16 GHz
TDS4A212MX = -1.9 dB @ f = 16 GHz

(6) Differential return Loss DDRL (Typ.) : TDS4B212MX = -16 dB @ f = 16 GHz
TDS4A212MX = -18 dB @ f = 16 GHz

(7) Differential Off Isolation DDOIRR (Typ.) : TDS4B212MX = -14 dB @ f = 16 GHz
TDS4A212MX = -11 dB @ f = 16 GHz

(8) Differential Crosstalk DDXT (Typ.) : TDS4B212MX = -36 dB @ f = 16 GHz
TDS4A212MX = -30 dB @ f = 16 GHz

(9) Package: XQFN16

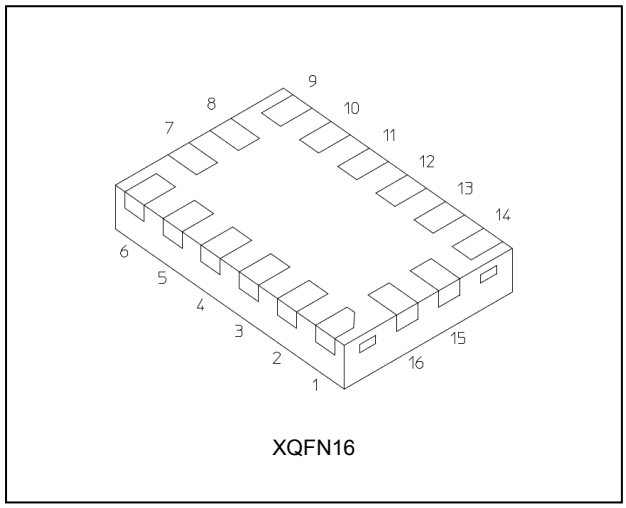
## 4. Interfaces

- PCIe 5.0/4.0
- CXL 2.0/1.0
- USB4 Version 2.0, Gen3/Gen2
- SAS 3.0
- Thunderbolt 4/3
- DisplayPort 2.0/1.4
- USB 3.2 Gen 2/Gen 1



Start of commercial production
2024-05

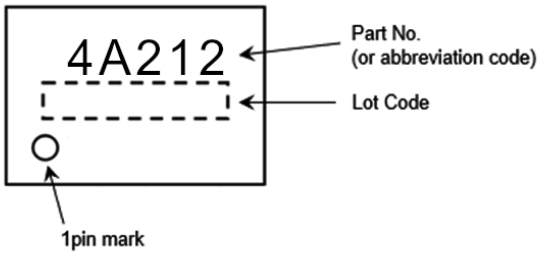
## 5. Packaging



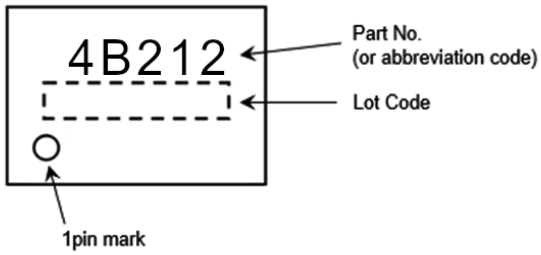

XQFN16

## 6. Marking

TDS4A212MX

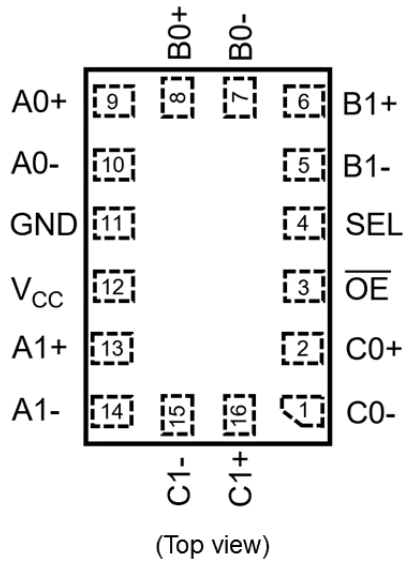



TDS4B212MX



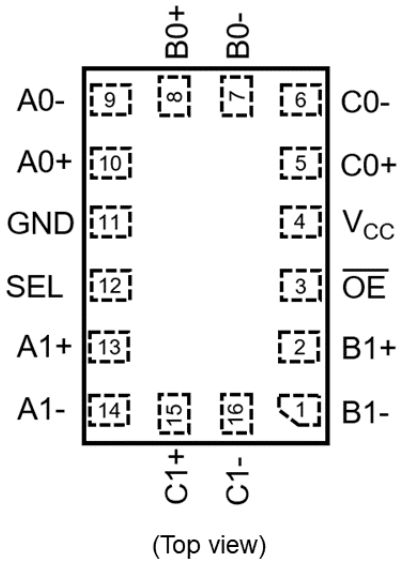
## 7. Pin Assignment

TDS4A212MX



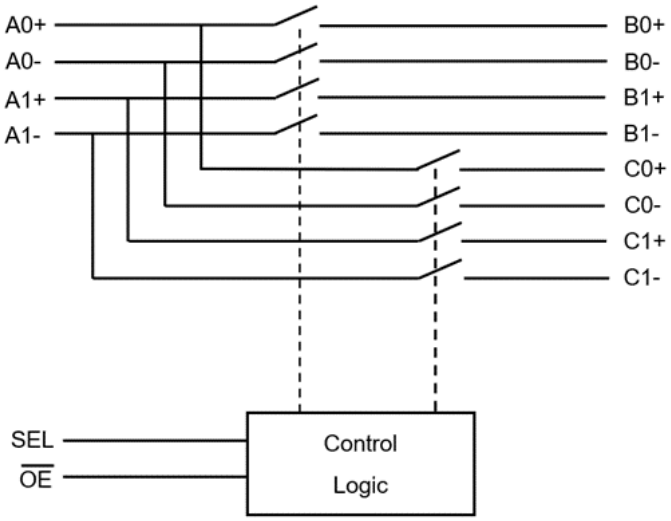

(Top view)

TDS4B212MX




(Top view)

## 8. Block Diagram




## 9. Truth Table

| Inputs $\overline{OE}$ | Inputs SEL | Function | |
|---|---|---|---|
| L | L | An+ port = Bn+ port, An- port = Bn- port | (n=0,1) |
| L | H | An+ port = Cn+ port, An- port = Cn- port | (n=0,1) |
| H | — | An, Bn, Cn port Disconnect | (n=0,1) |

—: Don't care

## 10. Absolute Maximum Ratings (Note)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ | -0.5 to 4.0 | V |
| Input voltage ($\overline{OE}$, SEL) | $V_{IN}$ | -0.5 to 4.0 | V |
| Switch I/O voltage | $V_S$ | -0.5 to 2.5 | V |
| Switch I/O current | $I_S$ | 32 | mA |
| Power dissipation | $P_D$ | 180 | mW |
| $V_{CC}$/ground current | $I_{CC}/I_{GND}$ | ±50 | mA |
| Storage temperature | $T_{stg}$ | -65 to 150 | ℃ |

Note: 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).

## 11. Operating Ranges (Note)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ | 1.6 to 3.6 | V |
| Input voltage ($\overline{OE}$, SEL) | $V_{IN}$ | 0 to 3.6 | V |
| Signal pins differential voltage. | $V_{I/O(Diff)}$ | 0 to 1.8 | V |
| Signal pins common mode voltage. | $V_{I/O(Com)}$ | 0 to 2.0 | V |
| Operating temperature | $T_{opr}$ | -40 to 105 | ℃ |
| Input rise and fall times | dt/dv | 0 to 10 | ns/V |

Note: The operating ranges must be maintained to ensure the normal operation of the device.
Unused control inputs must be tied to either $V_{CC}$ or GND.

# 12. Electrical Characteristics

## 12.1. DC Characteristics

### 12.1.1. DC Characteristics (Note) (Unless otherwise specified, $T_a$ = -40 to 85 °C)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-level input voltage ($\overline{OE}$, SEL) | $V_{IH}$ | — | 1.65 to 3.6 | 0.65 × $V_{CC}$ | — | — | V |
| Low-level input voltage ($\overline{OE}$, SEL) | $V_{IL}$ | — | 1.65 to 3.6 | — | — | 0.35 × $V_{CC}$ | V |
| Input leakage current ($\overline{OE}$, SEL) | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | 1.65 to 3.6 | — | — | ±1 | μA |
| Switch OFF-state leakage current | $I_{SZ}$ | $V_{IS}$ = 0 to 2.5 V, $\overline{OE}$ = $V_{CC}$ | 1.65 to 3.6 | — | — | ±3 | μA |
| ON-resistance | $R_{ON}$ | $V_{IS}$ = 0 V, $I_{IS}$ = 8 mA (TDS4A212) | 3.0 | — | — | 8.4 | Ω |
| | | $V_{IS}$ = 0 V, $I_{IS}$ = 8 mA (TDS4B212) | 3.0 | — | — | 7.9 | |
| | | $V_{IS}$ = 2 V, $I_{IS}$ = 8 mA | 3.0 | — | — | 15 | |
| Standby current | $I_{STB}$ | $V_{IN}$ = $V_{CC}$ or GND, $\overline{OE}$ = $V_{CC}$ | 3.6 | — | — | 10 | μA |
| Current consumption | $I_{ope}$ | $V_{IN}$ = $V_{CC}$ or GND, $\overline{OE}$ = GND | 3.6 | — | 60 | 150 | μA |

Note : All typical values are at $T_a$ = 25 °C.

### 12.1.2. DC Characteristics (Note) (Unless otherwise specified, $T_a$ = -40 to 105 °C)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-level input voltage ($\overline{OE}$, SEL) | $V_{IH}$ | — | 1.65 to 3.6 | 0.65 × $V_{CC}$ | — | — | V |
| Low-level input voltage ($\overline{OE}$, SEL) | $V_{IL}$ | — | 1.65 to 3.6 | — | — | 0.35 × $V_{CC}$ | V |
| Input leakage current ($\overline{OE}$, SEL) | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | 1.65 to 3.6 | — | — | ±1 | μA |
| Switch OFF-state leakage current | $I_{SZ}$ | $V_{IS}$ = 0 to 2.5 V, $\overline{OE}$ = $V_{CC}$ | 1.65 to 3.6 | — | — | ±4 | μA |
| ON-resistance | $R_{ON}$ | $V_{IS}$ = 0 V, $I_{IS}$ = 8 mA (TDS4A212) | 3.0 | — | — | 8.9 | Ω |
| | | $V_{IS}$ = 0 V, $I_{IS}$ = 8 mA (TDS4B212) | 3.0 | — | — | 8.4 | |
| | | $V_{IS}$ = 2 V, $I_{IS}$ = 8 mA | 3.0 | — | — | 16 | |
| Standby current | $I_{STB}$ | $V_{IN}$ = $V_{CC}$ or GND, $\overline{OE}$ = $V_{CC}$ | 3.6 | — | — | 10 | μA |
| Current consumption | $I_{ope}$ | $V_{IN}$ = $V_{CC}$ or GND, $\overline{OE}$ = GND | 3.6 | — | 60 | 150 | μA |

Note: All typical values are at $T_a$ = 25 °C.

## 12.2. High frequency characteristics (Note) (Unless otherwise specified, $V_{CC}$ = 1.6 to 3.6 V)

### 12.2.1. TDS4A212MX

| Characteristics | Symbol | Note | Test Condition | | Typ. | Unit |
|---|---|---|---|---|---|---|
| -3-dB Bandwidth (differential) | $BW_{(Diff)}$ | (Note 1) | $R_L$ = 50 Ω, See Fig. 13.1 | | 26.2 | GHz |
| Differential insertion loss | DDIL | (Note 1) | $R_L$ = 50 Ω<br>See Fig. 13.1 | f = 2.5 GHz | -0.7 | dB |
| | | | | f = 4.0 GHz | -0.8 | |
| | | | | f = 5.0 GHz | -0.9 | |
| | | | | f = 8.0 GHz | -1.0 | |
| | | | | f = 10.0 GHz | -1.1 | |
| | | | | f = 12.8 GHz | -1.4 | |
| | | | | f = 16.0 GHz | -1.9 | |
| Differential return loss | DDRL | (Note 1) | $R_L$ = 50 Ω<br>See Fig. 13.1 | f = 2.5 GHz | -18 | dB |
| | | | | f = 4.0 GHz | -19 | |
| | | | | f = 5.0 GHz | -15 | |
| | | | | f = 8.0 GHz | -14 | |
| | | | | f = 10.0 GHz | -17 | |
| | | | | f = 12.8 GHz | -17 | |
| | | | | f = 16.0 GHz | -18 | |
| Differential OFF isolation | DDOIRR | (Note 1) | $R_L$ = 50 Ω<br>See Fig. 13.2 | f = 2.5 GHz | -25 | dB |
| | | | | f = 4.0 GHz | -22 | |
| | | | | f = 5.0 GHz | -20 | |
| | | | | f = 8.0 GHz | -19 | |
| | | | | f = 10.0 GHz | -17 | |
| | | | | f = 12.8 GHz | -12 | |
| | | | | f = 16.0 GHz | -11 | |
| Differential Crosstalk | DDXT | (Note 1) | $R_L$ = 50 Ω<br>See Fig. 13.3, 13.4 | f = 2.5 GHz | -40 | dB |
| | | | | f = 4.0 GHz | -37 | |
| | | | | f = 5.0 GHz | -36 | |
| | | | | f = 8.0 GHz | -34 | |
| | | | | f = 10.0 GHz | -32 | |
| | | | | f = 12.8 GHz | -31 | |
| | | | | f = 16.0 GHz | -30 | |

Note: All typical values are at $T_a$ = 25 °C.
Note 1: Parameter guaranteed by design.

### 12.2.2. TDS4B212MX

| Characteristics | Symbol | Note | Test Condition | | Typ. | Unit |
|---|---|---|---|---|---|---|
| -3-dB Bandwidth (differential) | $BW_{(Diff)}$ | (Note 1) | $R_L$ = 50 Ω, See Fig. 13.1 | | 27.5 | GHz |
| Differential insertion loss | DDIL | (Note 1) | $R_L$ = 50 Ω<br>See Fig. 13.1 | f = 2.5 GHz | -0.7 | dB |
| | | | | f = 4.0 GHz | -0.8 | |
| | | | | f = 5.0 GHz | -0.8 | |
| | | | | f = 8.0 GHz | -0.9 | |
| | | | | f = 10.0 GHz | -0.9 | |
| | | | | f = 12.8 GHz | -1.2 | |
| | | | | f = 16.0 GHz | -1.4 | |
| Differential return loss | DDRL | (Note 1) | $R_L$ = 50 Ω<br>See Fig. 13.1 | f = 2.5 GHz | -20 | dB |
| | | | | f = 4.0 GHz | -18 | |
| | | | | f = 5.0 GHz | -17 | |
| | | | | f = 8.0 GHz | -15 | |
| | | | | f = 10.0 GHz | -20 | |
| | | | | f = 12.8 GHz | -17 | |
| | | | | f = 16.0 GHz | -16 | |
| Differential OFF isolation | DDOIRR | (Note 1) | $R_L$ = 50 Ω<br>See Fig. 13.2 | f = 2.5 GHz | -25 | dB |
| | | | | f = 4.0 GHz | -21 | |
| | | | | f = 5.0 GHz | -20 | |
| | | | | f = 8.0 GHz | -17 | |
| | | | | f = 10.0 GHz | -16 | |
| | | | | f = 12.8 GHz | -17 | |
| | | | | f = 16.0 GHz | -14 | |
| Differential Crosstalk | DDXT | (Note 1) | $R_L$ = 50 Ω<br>See Fig. 13.3, 13.4 | f = 2.5 GHz | -68 | dB |
| | | | | f = 4.0 GHz | -60 | |
| | | | | f = 5.0 GHz | -56 | |
| | | | | f = 8.0 GHz | -48 | |
| | | | | f = 10.0 GHz | -44 | |
| | | | | f = 12.8 GHz | -39 | |
| | | | | f = 16.0 GHz | -36 | |

Note: All typical values are at $T_a$ = 25 °C.
Note 1: Parameter guaranteed by design.

## 12.3. Switching Characteristics (Unless otherwise specified, Ta = 25 °C)

### 12.3.1. TDS4A212MX

| Characteristics | Symbol | Note | Test Condition | $V_{CC}$ (V) | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Propagation delay time | $t_{PLH}/t_{PHL}$ | (Note 1) | $R_L$ = 50 Ω, f = 10 GHz<br>See Fig. 13.1, 13.7 | 3.3 | 33 | — | ps |
| Output skew (bit to bit) | $t_{SK(b)}$ | (Note 1) | $R_L$ = 50 Ω, f = 10 GHz<br>See Fig. 13.1, 13.8 | 3.3 | 6 | — | ps |
| Output skew (channel to channel) | $t_{SK(CH)}$ | (Note 1) | $R_L$ = 50 Ω, f = 10 GHz<br>See Fig. 13.1, 13.7 | 3.3 | 6 | — | ps |

Note 1: Parameter guaranteed by design.

### 12.3.2. TDS4B212MX

| Characteristics | Symbol | Note | Test Condition | $V_{CC}$ (V) | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Propagation delay time | $t_{PLH}/t_{PHL}$ | (Note 1) | $R_L$ = 50 Ω, f = 10 GHz<br>See Fig. 13.1, 13.7 | 3.3 | 30 | — | ps |
| Output skew (bit to bit) | $t_{SK(b)}$ | (Note 1) | $R_L$ = 50 Ω, f = 10 GHz<br>See Fig. 13.1, 13.8 | 3.3 | 4 | — | ps |
| Output skew (channel to channel) | $t_{SK(CH)}$ | (Note 1) | $R_L$ = 50 Ω, f = 10 GHz<br>See Fig. 13.1, 13.7 | 3.3 | 2 | — | ps |

Note 1: Parameter guaranteed by design.

## 12.4. Timing characteristics

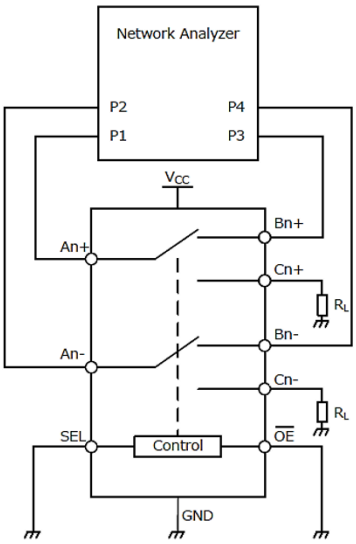
### 12.4.1. Timing characteristics (Unless otherwise specified, $T_a$ = -40 to 85 °C)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Start-up time. | $t_{sup}$ | See Fig. 13.5 | 1.65 to 3.6 | — | — | 100 | μs |
| Turn-ON time (SEL to Output) | $t_{on}$ | $R_L$ = 50 Ω, $C_L$ = 5 pF<br>See Fig. 13.5 | 1.65 to 3.6 | — | — | 180 | ns |
| Turn-ON time ($\overline{OE}$ to Output) | | | 1.65 to 3.6 | — | — | 100 | μs |
| Turn-OFF time (SEL to Output) | $t_{off}$ | $R_L$ = 50 Ω, $C_L$ = 5 pF<br>See Fig. 13.5 | 1.65 to 3.6 | — | — | 18 | ns |
| Turn-OFF time ($\overline{OE}$ to Output) | | | 1.65 to 3.6 | — | — | 21 | |
| Break before make | TBBM | $R_L$ = 50 Ω, $C_L$ = 5 pF<br>See Fig. 13.6 | 1.65 to 3.6 | 55 | — | 160 | ns |

### 12.4.2. Timing characteristics (Unless otherwise specified, $T_a$ = -40 to 105 °C)

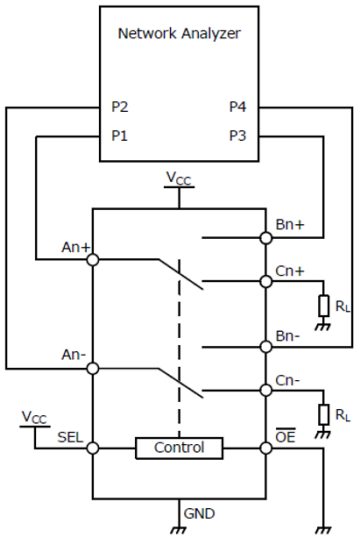
| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Start-up time. | $t_{sup}$ | See Fig. 13.5 | 1.65 to 3.6 | — | — | 110 | μs |
| Turn-ON time (SEL to Output) | $t_{on}$ | $R_L$ = 50 Ω, $C_L$ = 5 pF<br>See Fig. 13.5 | 1.65 to 3.6 | — | — | 180 | ns |
| Turn-ON time ($\overline{OE}$ to Output) | | | 1.65 to 3.6 | — | — | 110 | μs |
| Turn-OFF time (SEL to Output) | $t_{off}$ | $R_L$ = 50 Ω, $C_L$ = 5 pF<br>See Fig. 13.5 | 1.65 to 3.6 | — | — | 20 | ns |
| Turn-OFF time ($\overline{OE}$ to Output) | | | 1.65 to 3.6 | — | — | 25 | |
| Break before make | TBBM | $R_L$ = 50 Ω, $C_L$ = 5 pF<br>See Fig. 13.6 | 1.65 to 3.6 | 55 | — | 160 | ns |

## 13. AC Electrical Test Circuit (Fig)



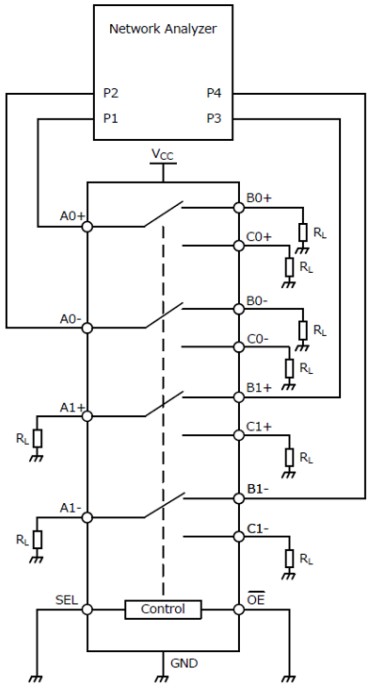

$R_L$ = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure An and Bn.

**Fig. 13.1 -3-dB Bandwidth(differential), Differential insertion loss,Differential return loss, Propagation delay time, Output skew (channel to channel, bit to bit)**



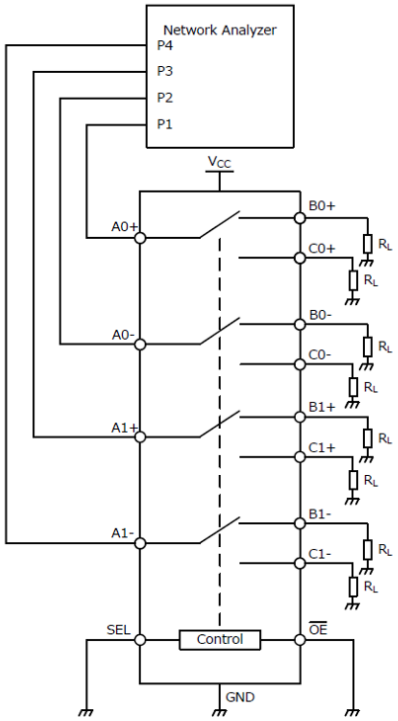

$R_L$ = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure An and Bn.

**Fig. 13.2 Differential OFF isolation**



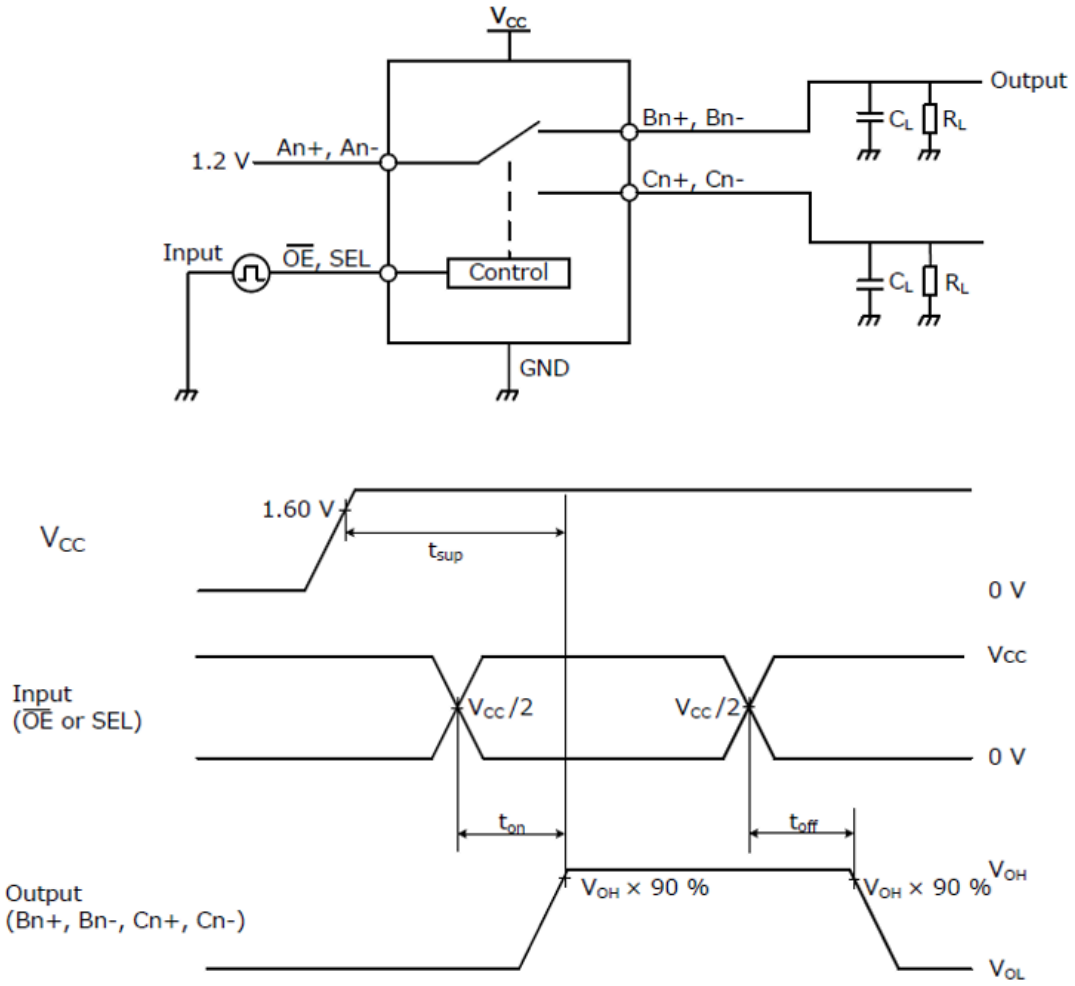

$R_L$ = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure A0 and B1.

**Fig. 13.3 Differential Far-end crosstalk**




$R_L$ = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure A0 and A1.

**Fig. 13.4 Differential Near-end crosstalk**




$R_L$ = 50 Ω, $C_L$ = 5 pF

**Fig. 13.5 Start-up, Turn-ON and Turn-OFF time**

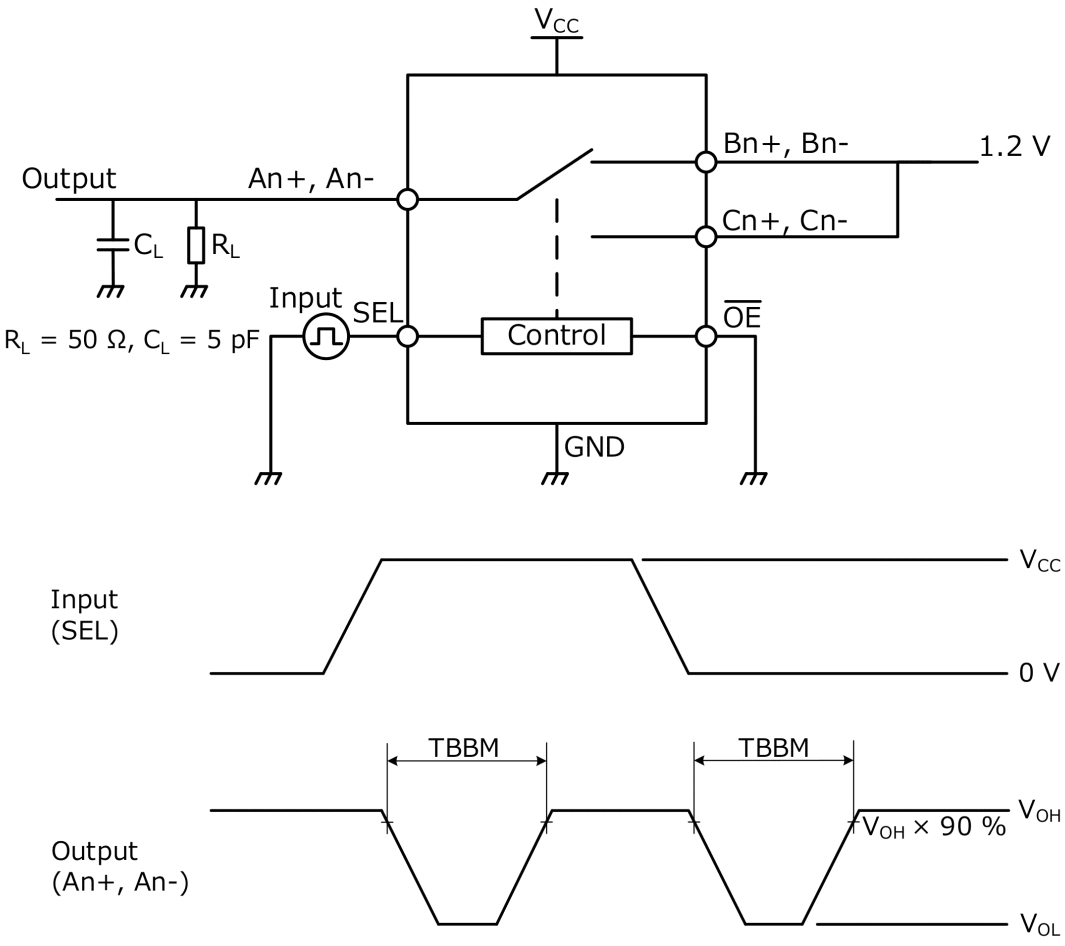



**Fig. 13.6 Break before make**

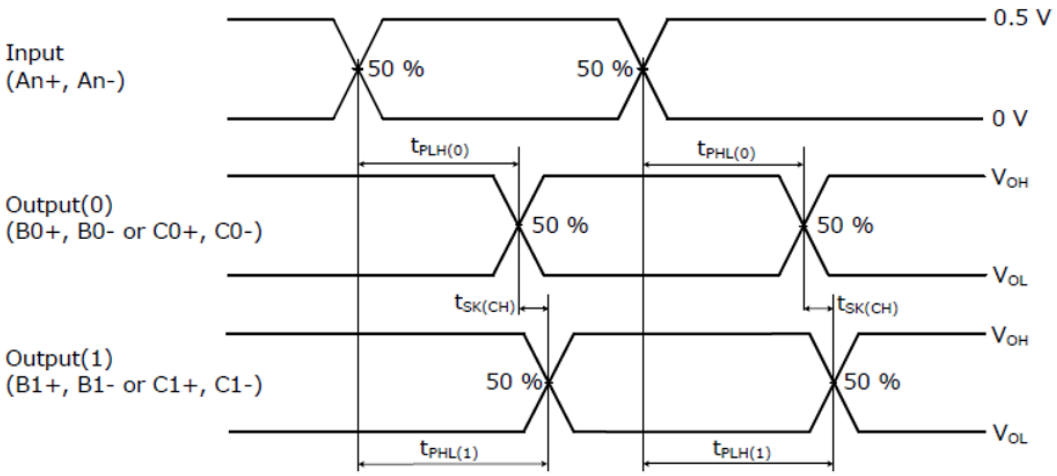



**Fig. 13.7 Output skew (channel to channel), Propagation delay time**

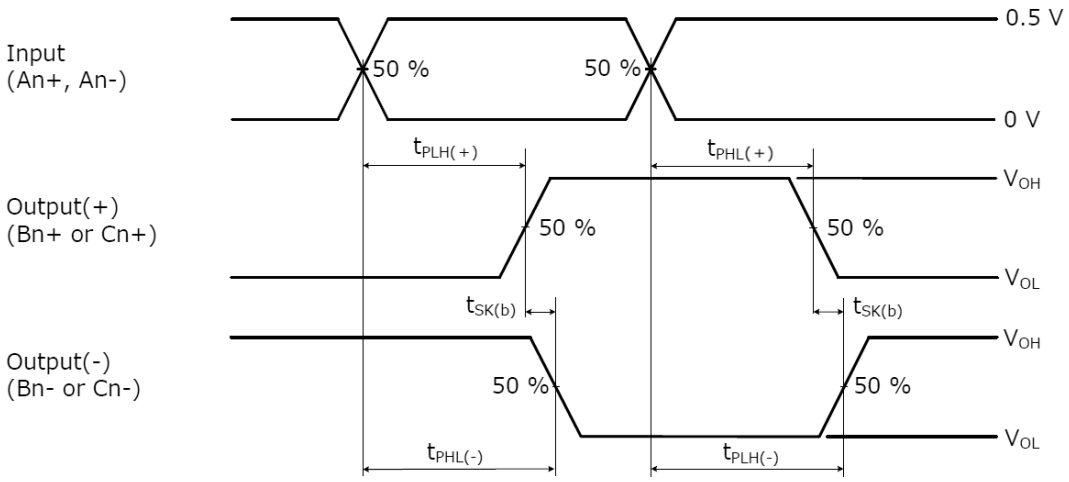
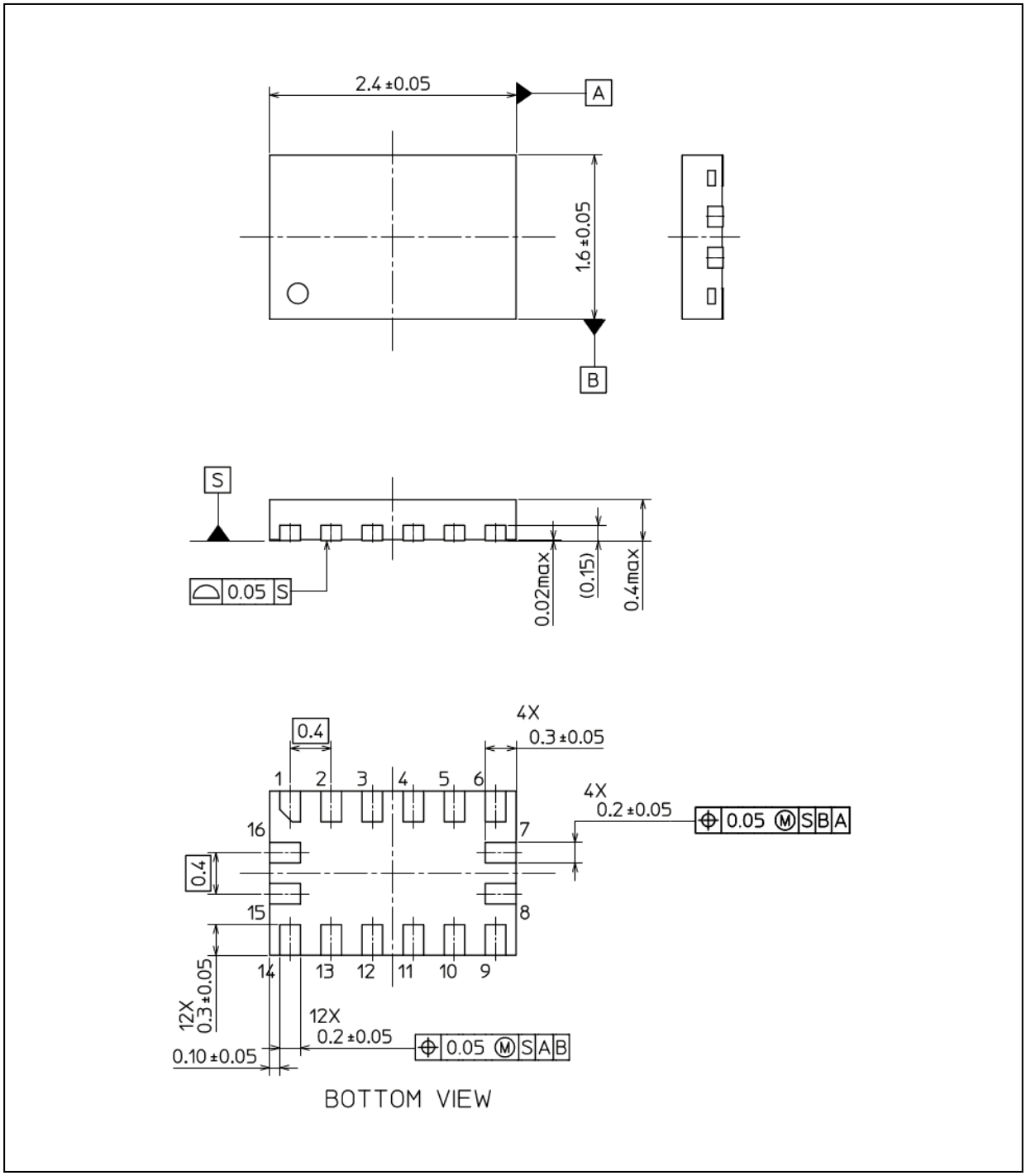



**Fig. 13.8 Output skew (bit to bit)**

## Package Dimensions

Unit: mm




Weight: 3.9 mg (typ.)

| Package Name(s) |
| --- |
| Nickname: XQFN16 |

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