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 interface such as PCIe® 5.0, CXL 2.0, USB4® Version 2.0, Thunderbolt™ 4, DisplayPort™ 2.0.
TDS4A212MX and TDS4B212MX have different pinout. TDS4B212MX has an optimized pinout to achieve high frequency performance, on the other hand TDS4A212MX's pinout 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.
All pins are equipped with protection circuits to protect from electrostatic discharge damage.

3. Features

(1) Operating voltage: V_{CC} = 1.6 to 3.6 V
(2) Low current consumption For active mode (Typ.) : I_{ope} = 60 μA, For standby mode (Max) : I_{STB} = 10 μA
(3) -3-dB Bandwidth (differential) BW (Typ.) : TDS4B212MX = 27.5 GHz
TDS4A212MX = 26.2 GHz
(4) Differential insertion Loss DDIL (Typ.): TDS4B212MX = -0.9 dB @ f = 10 GHz, -1.4 dB @ f = 16 GHz
TDS4A212MX = -1.1 dB @ f = 10 GHz, -1.9 dB @ f = 16 GHz
(5) Differential return Loss DDRL (Typ.) : TDS4B212MX = -20 dB @ f = 10 GHz, -16 dB @ f = 16 GHz
TDS4A212MX = -17 dB @ f = 10 GHz, -18 dB @ f = 16 GHz
(6) Differential Off Isolation DDOIRR (Typ.) : TDS4B212MX = -16 dB @ f = 10 GHz, -14 dB @ f = 16 GHz
TDS4A212MX = -17 dB @ f = 10 GHz, -11 dB @ f = 16 GHz
(7) Differential Crosstalk DDXT (Typ.) : TDS4B212MX = -44 dB @ f = 10 GHz, -36 dB @ f = 16 GHz
TDS4A212MX = -32 dB @ f = 10 GHz, -30 dB @ f = 16 GHz
(8) Package: XQFN16

4. Applications

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

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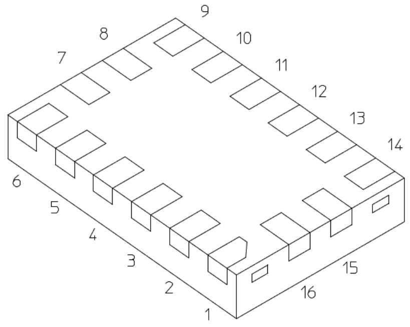
Start of commercial production
2024-05

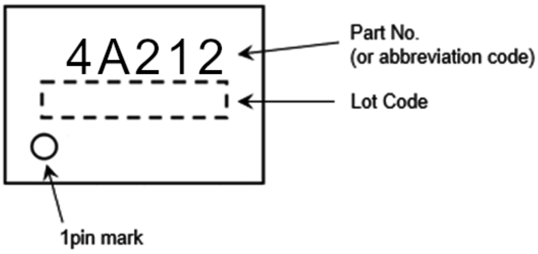
5. Packaging



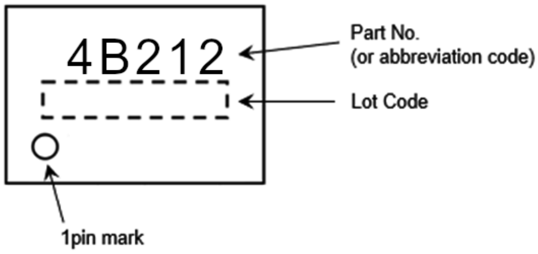
XQFN16

6. Marking

TDS4A212MX

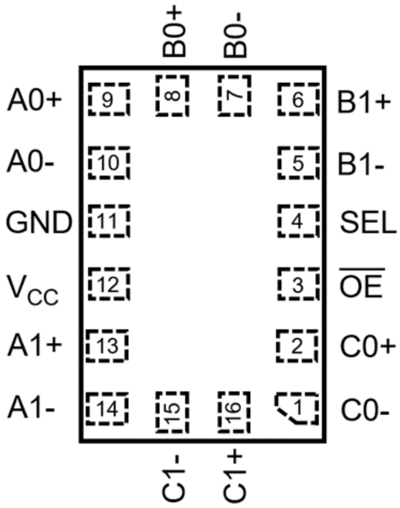


TDS4B212MX



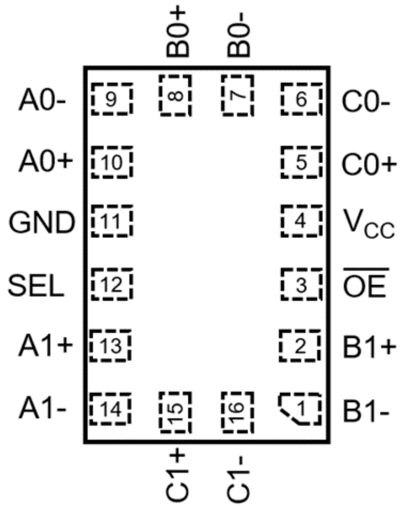
7. Pin Assignment

TDS4A212MX



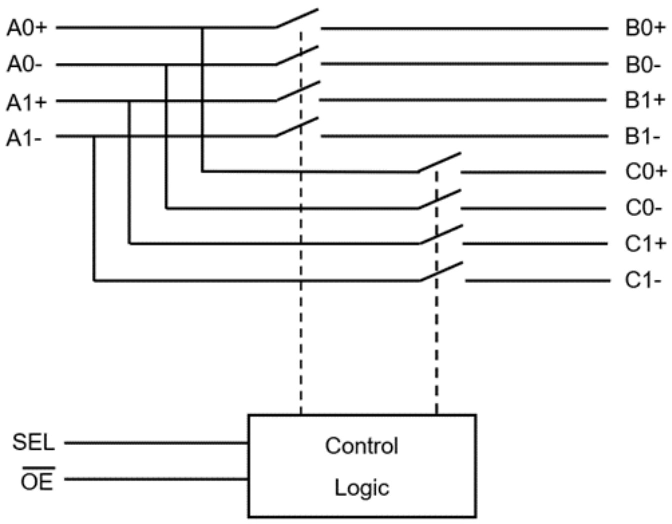
(Top view)

TDS4B212MX



(Top view)

8. Block Diagram



9. Principle of Operation

9.1. 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 85	℃
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 (Note) (Unless otherwise specified, T_a = -40 to 85 ℃)

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	—	—	±20	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 ℃.

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_T = 50 Ω, See Fig. 13.1		26.2	GHz
Differential insertion loss	DDIL	(Note 1)	R_L = 50 Ω 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 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 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 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_T = 50 Ω, See Fig. 13.1		27.5	GHz
Differential insertion loss	DDIL	(Note 1)	R_L = 50 Ω 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 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 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 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 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 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 See Fig. 13.1, 13.7	3.3	6	—	ps

Note 1: Parameter guaranteed by design.

12.3.2. TDS4B212MX

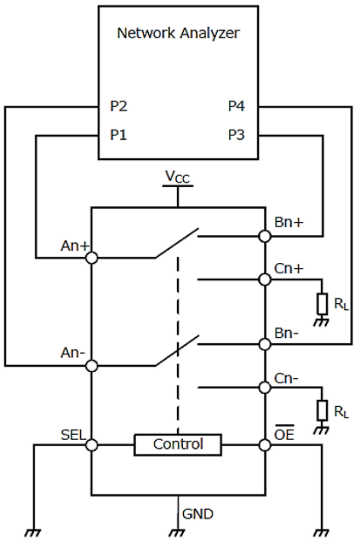
Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Typ.	Max	Unit
Propagation delay time	t_{PLH}/t_{PHL}	(Note 1)	R_L = 50 Ω, f = 10 GHz See Fig. 13.1, 13.7	3.3	30	—	ps
Output skew (bit to bit)	$t_{SK(b)}$	(Note 1)	R_L = 50 Ω, f = 10 GHz See Fig. 13.1, 13.8	3.3	4	—	ps
Output skew (channel to channel)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

Note 1: Parameter guaranteed by design.

12.4. Timing characteristics (Unless otherwise specified, T_a = -45 to 85 °C)

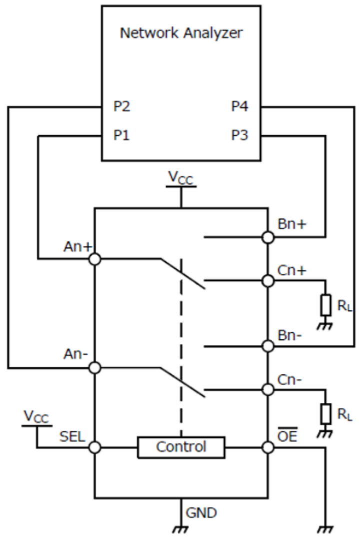
Characteristics	Symbol	Test Condition	V_{CC} (V)	Min	Typ.	Max	Unit
Start-up time.	t_{sup}	See Fig. 13.5	1.65 to 3.6	—	—	100	µs
Turn-ON time (SEL to Output)	t_{on}	R_L = 50 Ω, C_L = 5 pF See Fig. 13.5	1.65 to 3.6	—	—	180	ns
Turn-ON time ($\overline{\text{OE}}$ to Output)			1.65 to 3.6	—	—	100	µs
Turn-OFF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

13. AC Electrical Test Circuit (Fig)



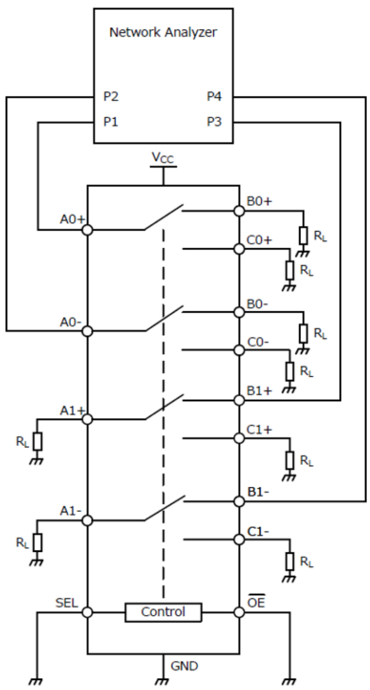
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure An and Bn.

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



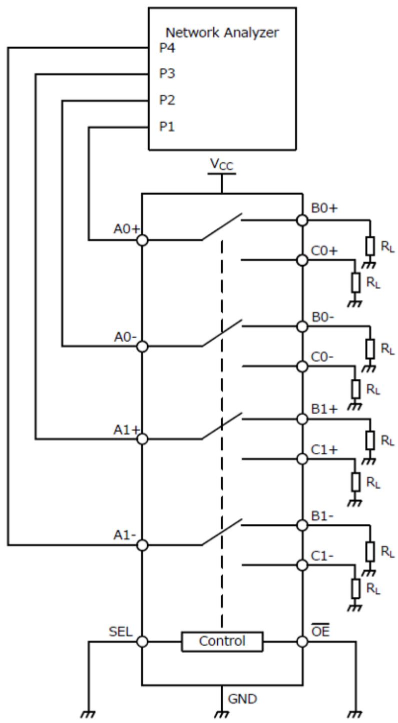
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure An and Bn.

Fig. 13.2 Differential OFF isolation



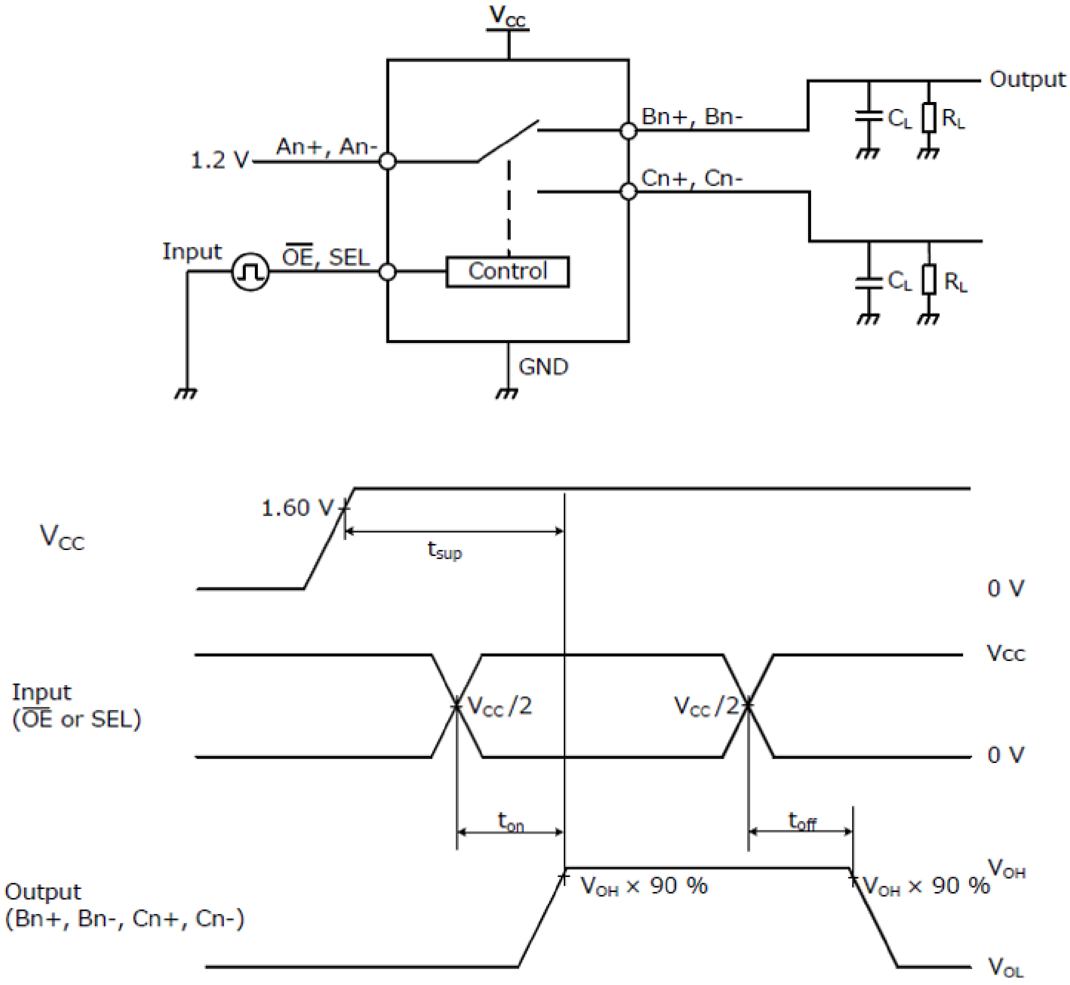
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure A0 and B1.

Fig. 13.3 Differential Far-end crosstalk



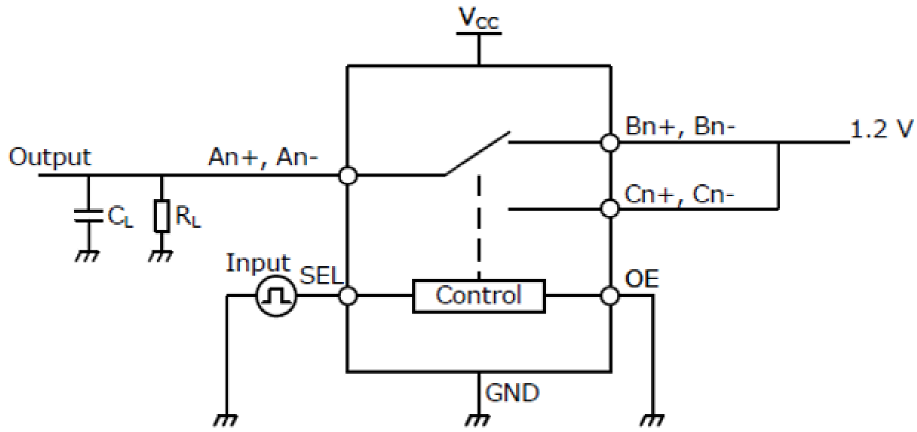
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure A0 and A1.

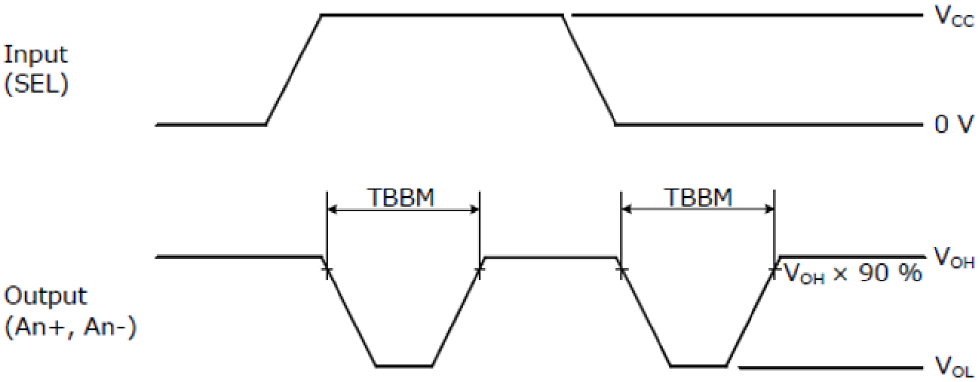
Fig. 13.4 Differential Near-end crosstalk



$R_L = 50\ \Omega$, $C_L = 5$ pF

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





$R_L = 50\ \Omega$, $C_L = 5$ pF

Fig. 13.6 Break before make

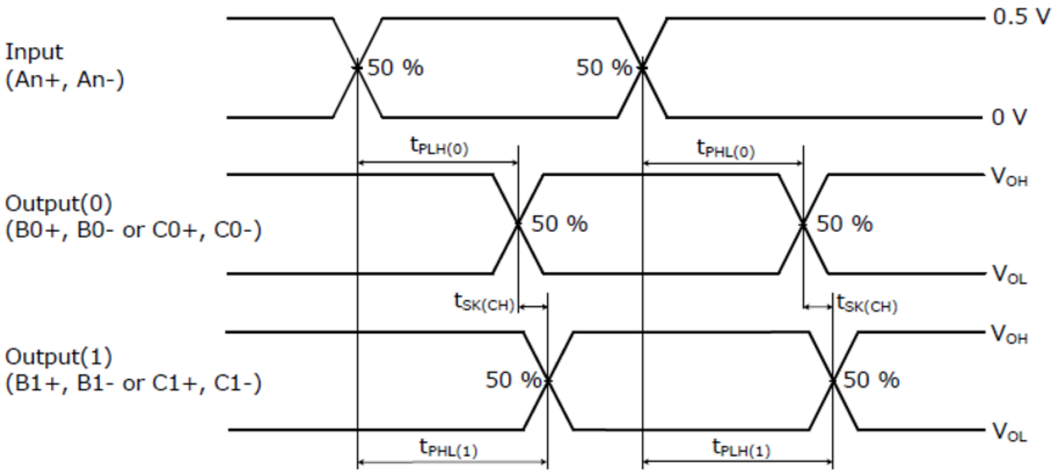


Fig. 13.7 Output skew (channel to channel), Propagation delay time

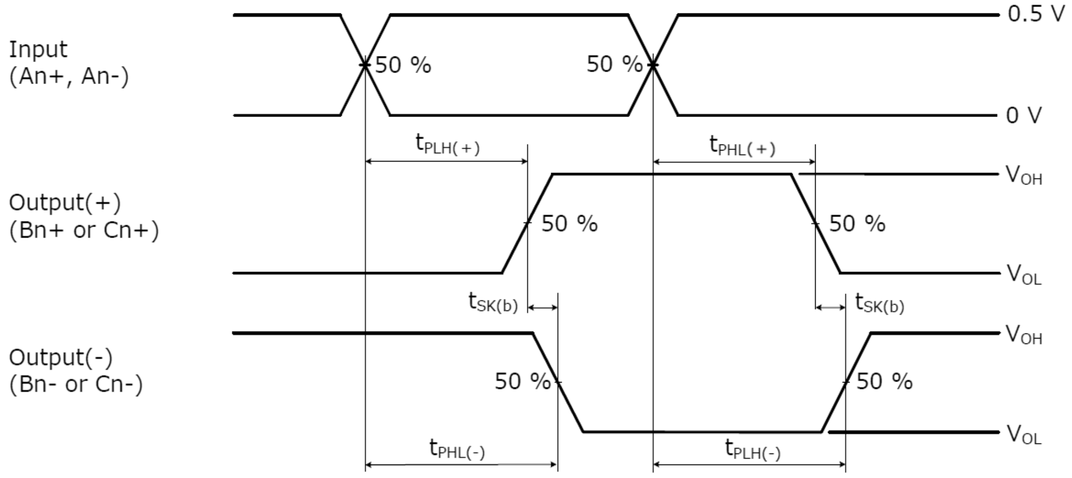
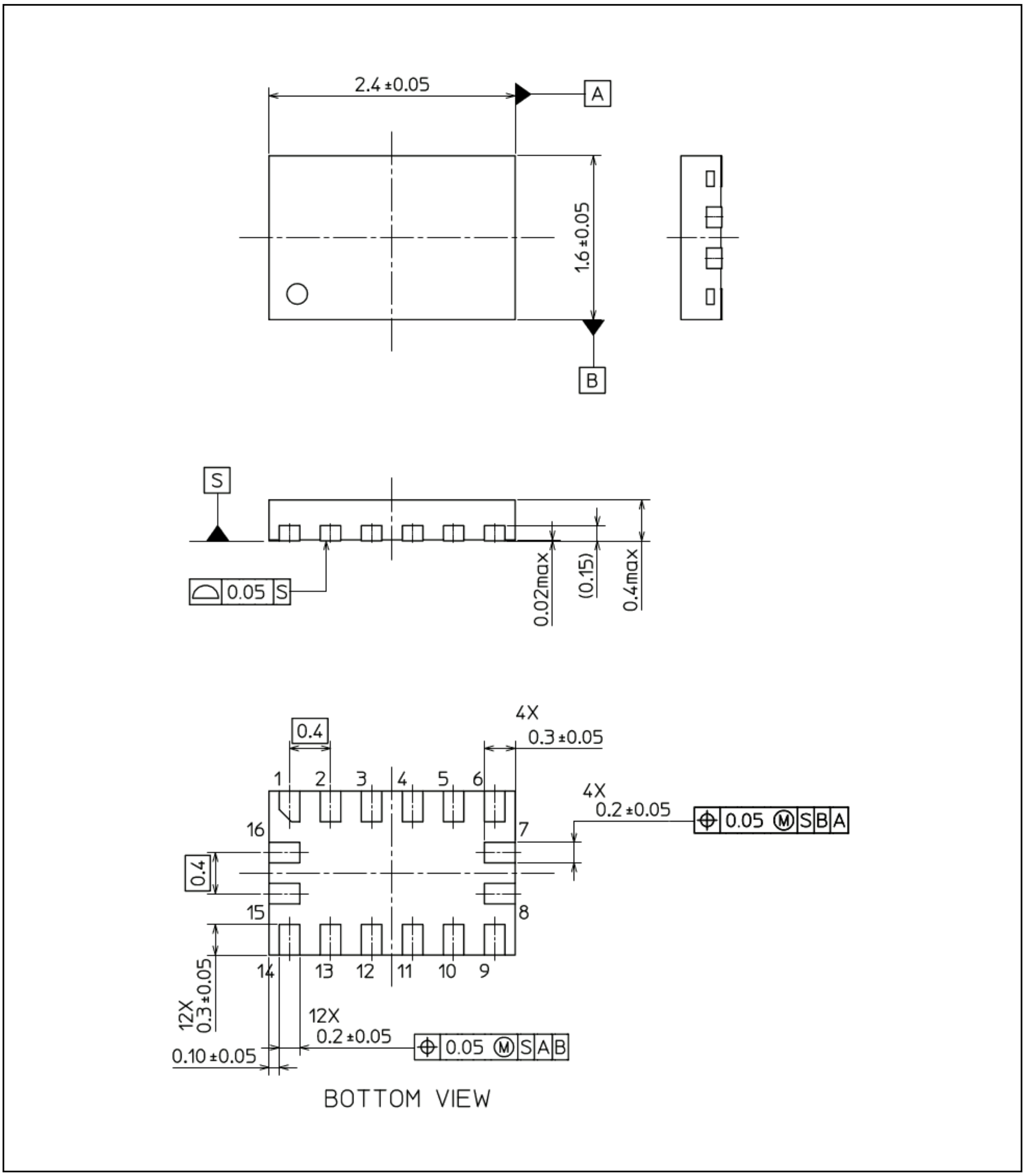


Fig. 13.8 Output skew (bit to bit)

Package Dimensions

Unit: mm



Weight: 3.9 mg (typ.)

Package Name(s)
Nickname: XQFN16

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