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

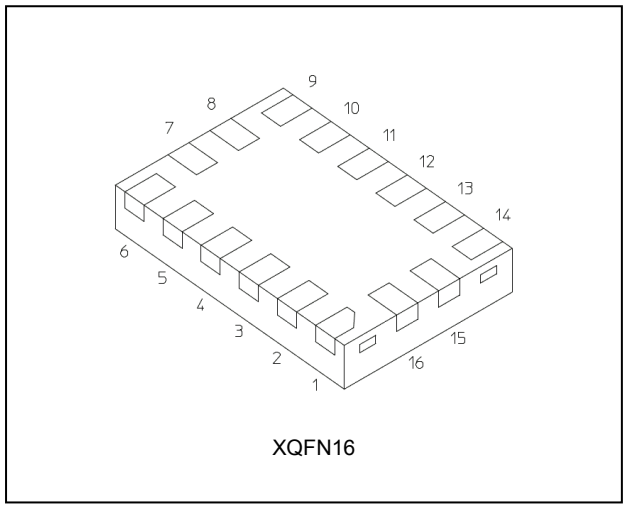
(9) Package: XQFN16

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

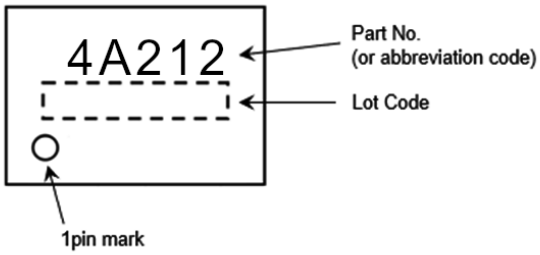
5. Packaging



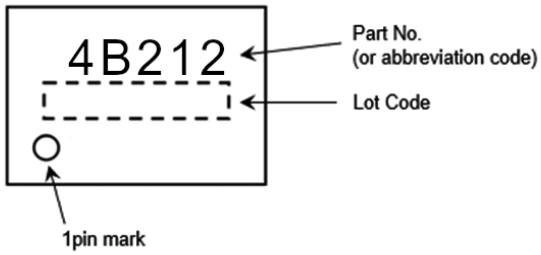
XQFN16

6. Marking

TDS4A212MX

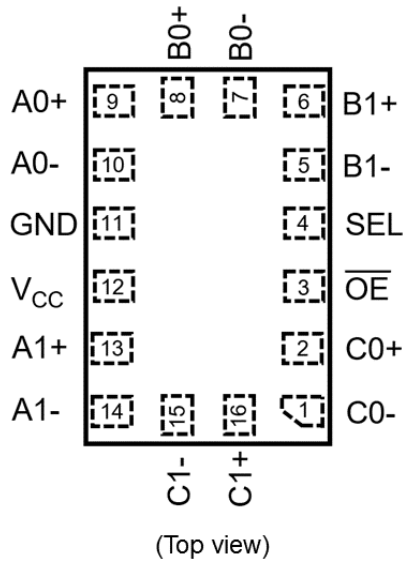


TDS4B212MX



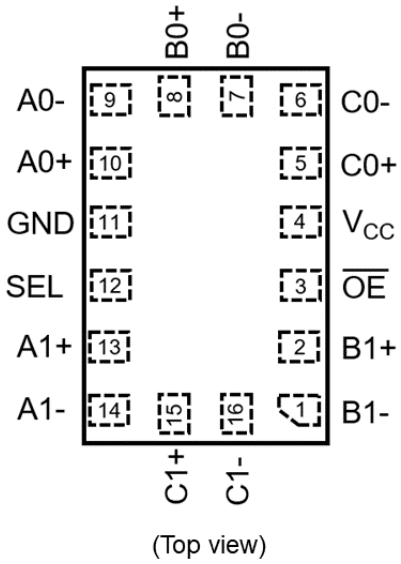
7. Pin Assignment

TDS4A212MX



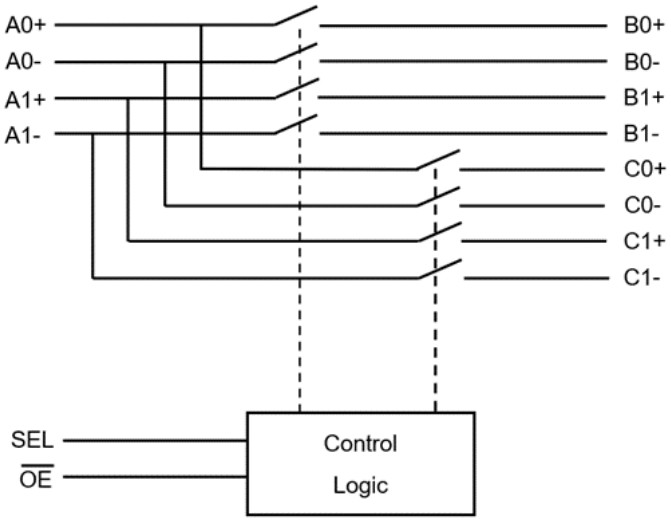
(Top view)

TDS4B212MX



(Top view)

8. Block Diagram



9. 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 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 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_L = 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

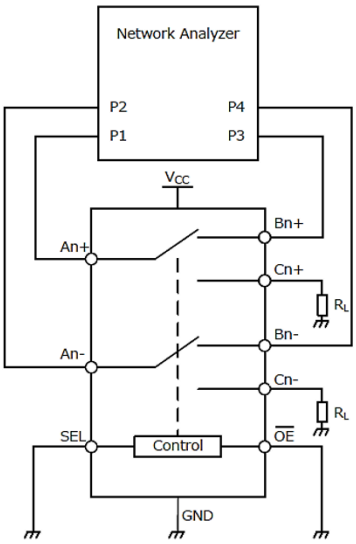
12.4.1. Timing characteristics (Unless otherwise specified, T_a = -45 to 85 °C)

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 ($\overline{OE}$ 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 ($\overline{OE}$ 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

12.4.2. Timing characteristics (Unless otherwise specified, T_a = -45 to 105 °C)

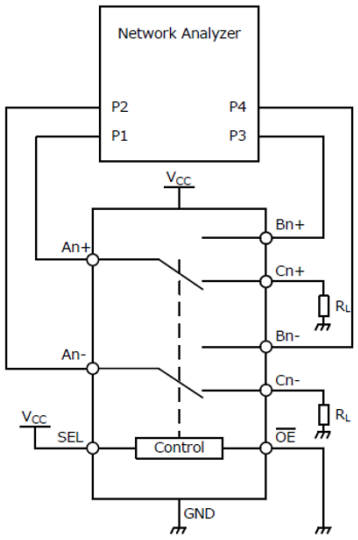
Characteristics	Symbol	Test Condition	V_{CC} (V)	Min	Typ.	Max	Unit
Start-up time.	t_{sup}	See Fig. 13.5	1.65 to 3.6	—	—	110	μs
Turn-ON time (SEL to Output)	t_{on}	R_L = 50 Ω, C_L = 5 pF See Fig. 13.5	1.65 to 3.6	—	—	180	ns
Turn-ON time ($\overline{OE}$ to Output)			1.65 to 3.6	—	—	110	μs
Turn-OFF time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

13. AC Electrical Test Circuit (Fig)



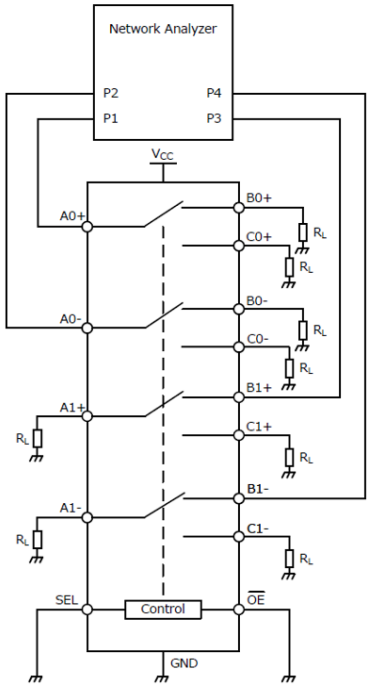
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure An and Bn.

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



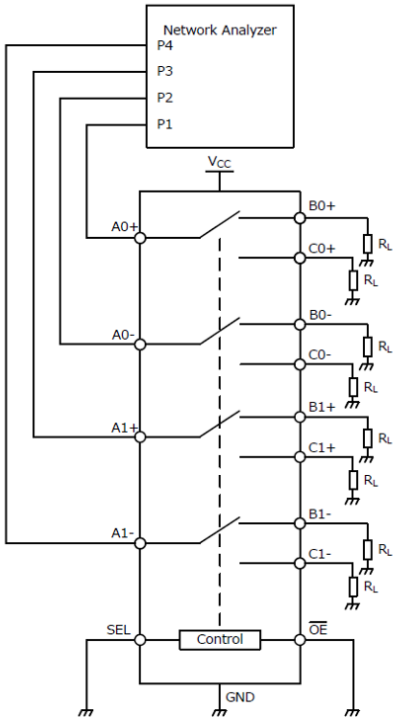
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure An and Bn.

Fig. 13.2 Differential OFF isolation



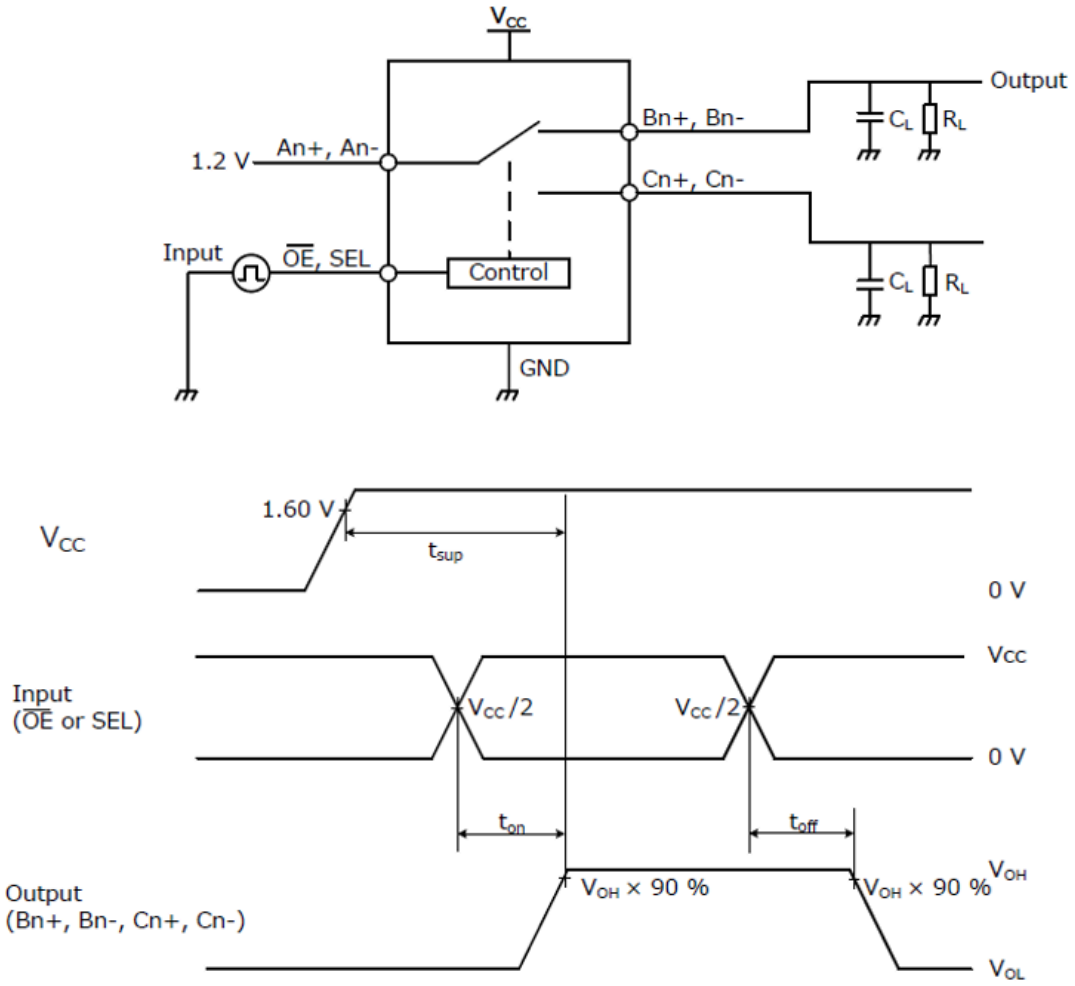
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure A0 and B1.

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

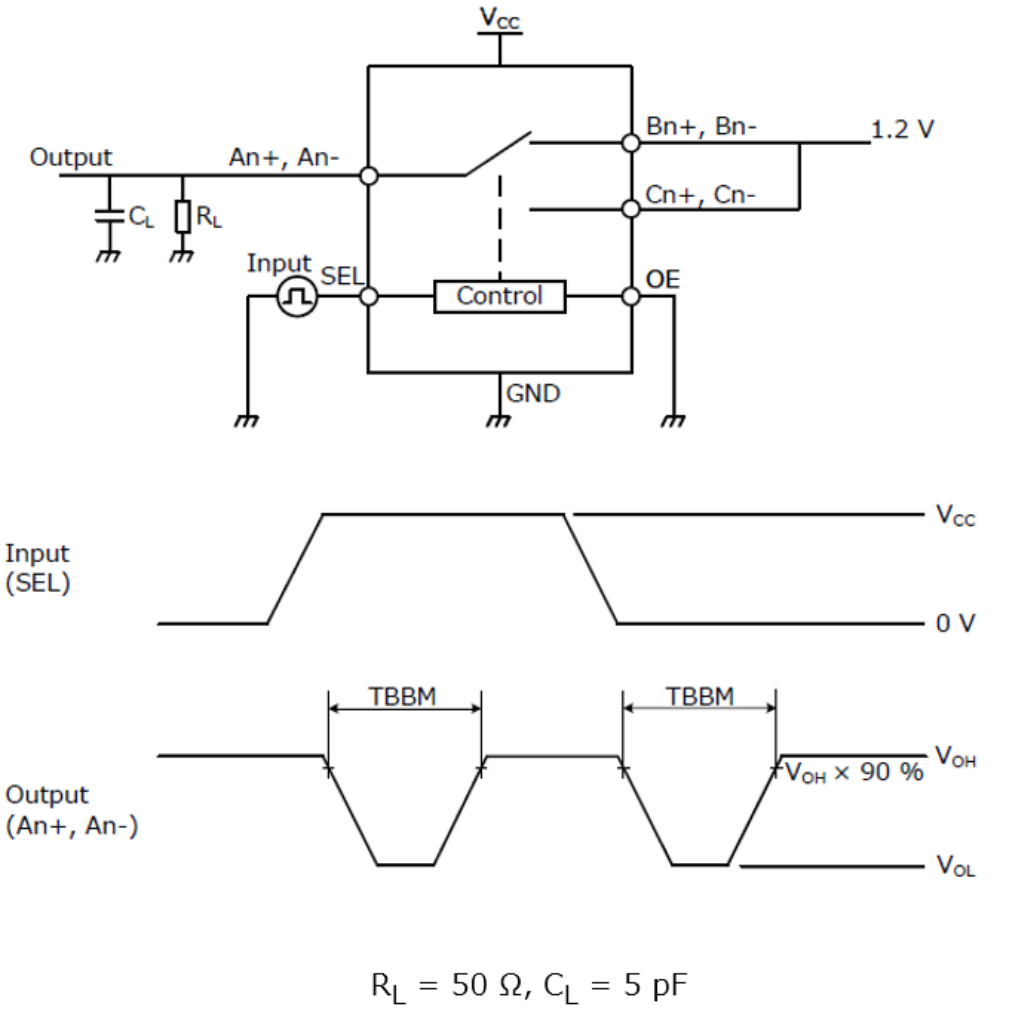


Fig. 13.6 Break before make

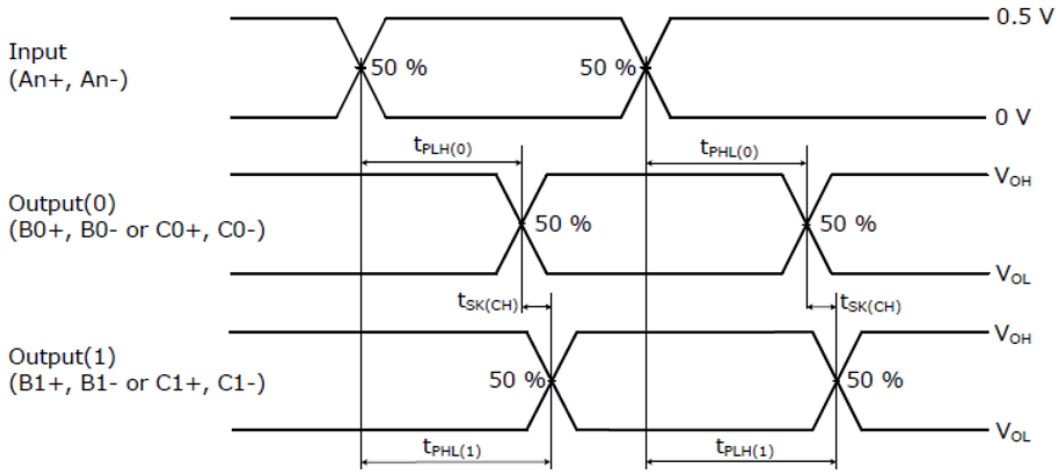


Fig. 13.7 Output skew (channel to channel), Propagation delay time

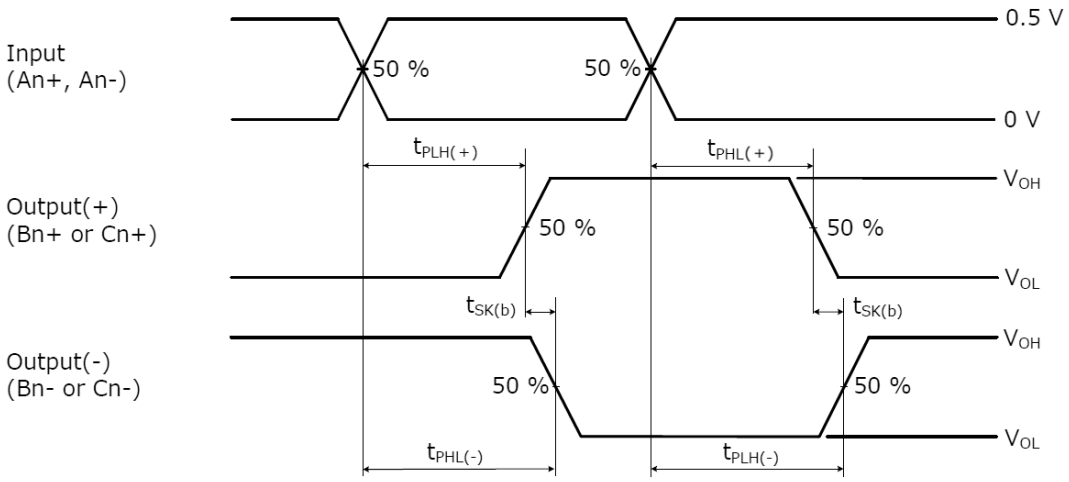
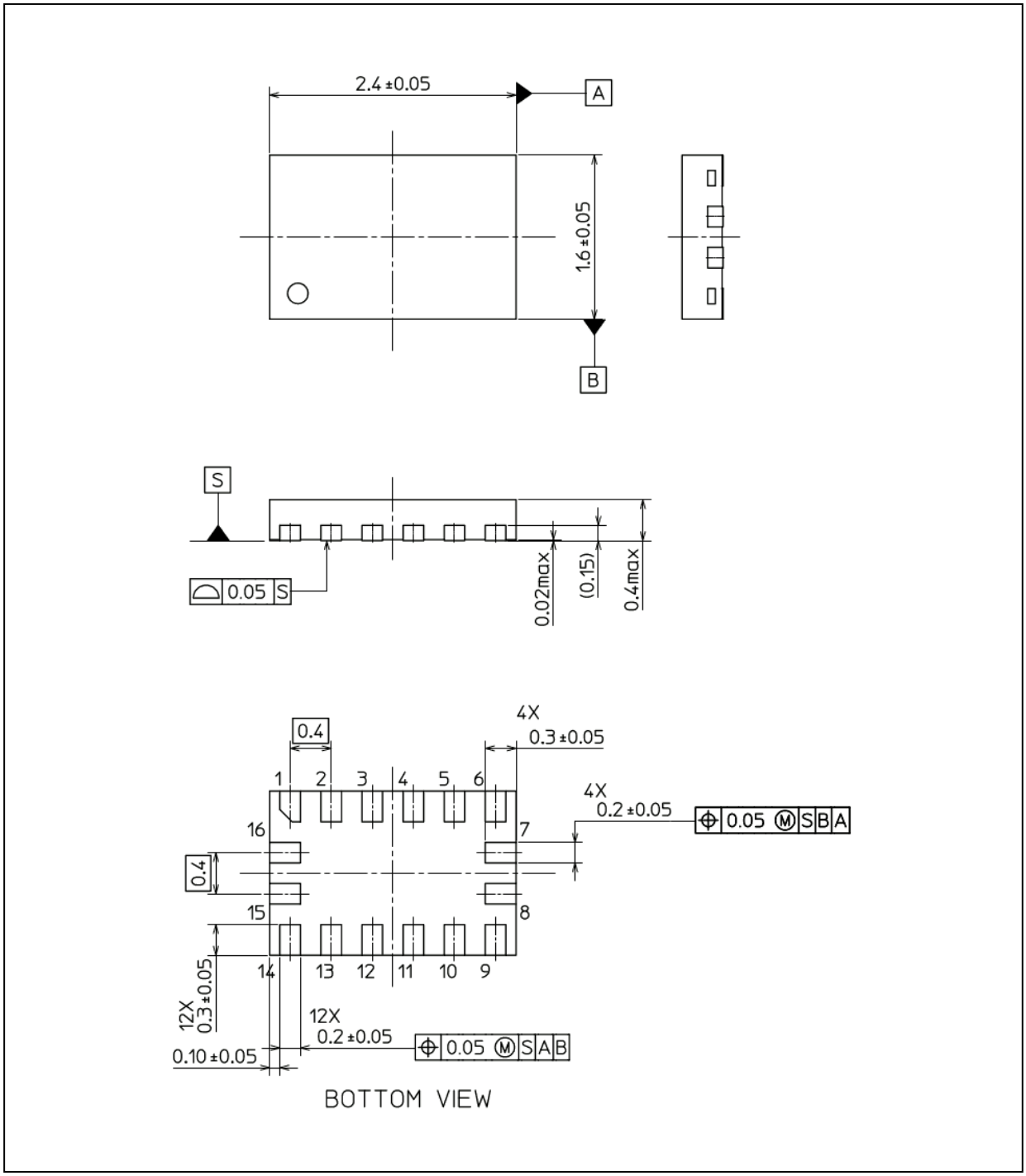


Fig. 13.8 Output skew (bit to bit)

Package Dimensions

Unit: mm



Weight: 3.9 mg (typ.)

Package Name(s)
Nickname: XQFN16

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