CMOS Digital Integrated Circuits Silicon Monolithic

TDS5B212MX,TDS5C212MX

1. Functional Description

- 1-64GT/s 1-Lane Two Differential Channel, 2:1 Mux/1:2 De-Mux

2. General

TDS5B212MX, TDS5C212MX are high-speed differential channel multiplexer(Mux)/demultiplexer(De-mux) switches. These devices are designed to support up to 64GT/s high-speed differential interface such as PCIe® 6.0, CXL 3.x, USB4®Version 2.0, Thunderbolt™ 5, DisplayPort™ 2.0.

TDS5C212MX and TDS5B212MX have different pin layout.TDS5C212MX has an optimized pin assignment to achieve high frequency performance, while TDS5B212MX uses the same pin layout as conventional products.

The A Port(An+/An-) is conneceted 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 pins ($\overline{OE}$). 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.

For device switch adjustment operations, Port A (An+, An-) has a weak differential resistance of 20 kΩ between the positive and negative terminals (An+, An-), and a weak pull-down resistance of approximately 1 MΩ from the An+ and An- terminals to GND.

The devices are designed to operate in temperatures from -40 to 125 ℃ 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 temputure: T_{ope} = -40 to 125 ℃

(3) Low current consumption, For active mode(Typ.) : I_{ope} = 70μA

(4) -3-dB Bandwidth (differential) $BW_{(Diff)}$ (Typ.) : TDS5C212MX = 34 GHz
TDS5B212MX = 29 GHz

(5) Differential insertion Loss DDIL (Typ.) : TDS5C212MX = -1.2 dB @ f = 16 GHz
TDS5B212MX = -1.2 dB @ f = 16 GHz

(6) Differential return Loss DDRL (Typ.) : TDS5C212MX = -14 dB @ f = 16 GHz
TDS5B212MX = -15 dB @ f = 16 GHz

(7) Differential Off Isolation DDOIRR (Typ.) : TDS5C212MX = -24 dB @ f = 16 GHz
TDS5B212MX = -27 dB @ f = 16 GHz

(8) Differential Crosstalk DDXT (Typ.) : TDS5C212MX = -31 dB @ f = 16 GHz
TDS5B212MX = -31 dB @ f = 16 GHz

(9) Package: XQFN16

4. Interfaces

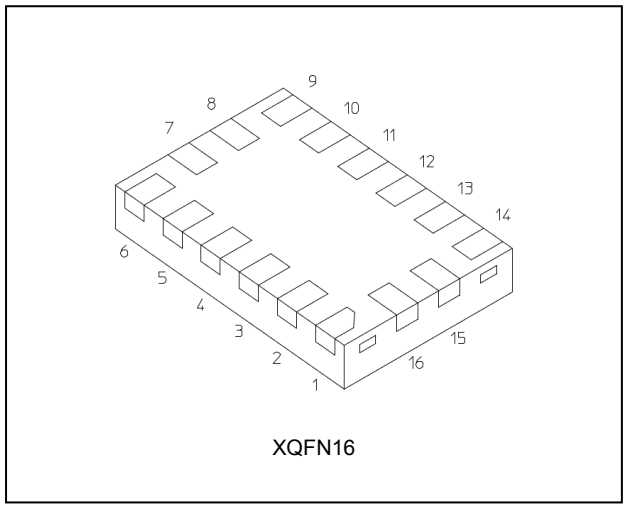
- PCIe 6.0 (PAM4) / 5.0 / 4.0
- CXL 3.x / 2.x / 1.x
- USB4 Version 2.0 , Gen3/Gen2 (PAM3)
- Thunderbolt 5 / 4 / 3
- DisplayPort 2.0 / 1.4
- SAS 3.0
- USB 3.2 Gen 2/Gen 1

- PCIe® is a registered trademark of PCI-SIG.
- USB4® is a registered trademark of USB Implementers Forum.
- Thunderbolt is a trademark of Intel Corporation or its subsidiaries.
- DisplayPort™ is a trademark owned by the Video Electronics Standards Association (VESA®) in the United States and other countries.
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Start of commercial production
2025-11

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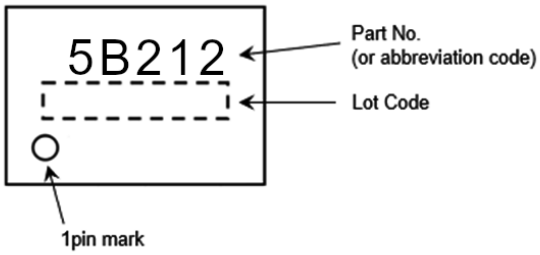
5. Packaging



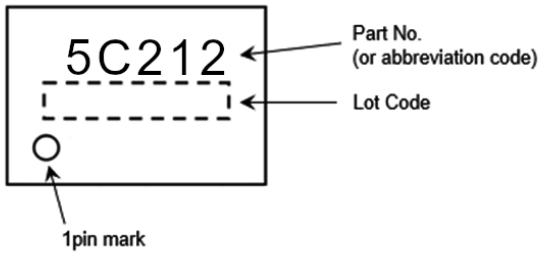
XQFN16

6. Marking

TDS5B212MX



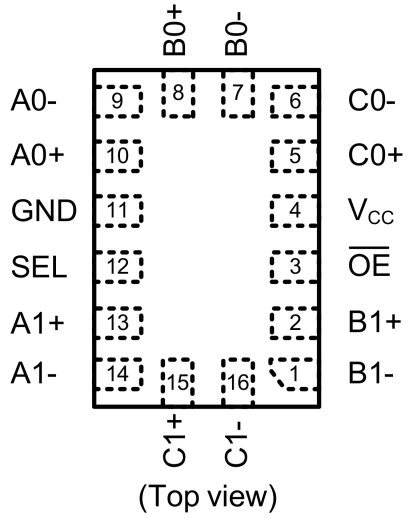
TDS5C212MX



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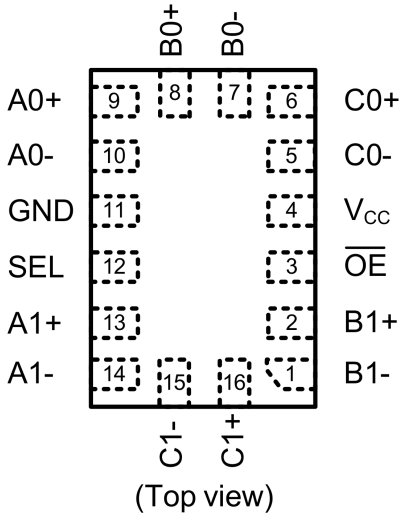
7. Pin Assignment

TDS5B212MX



(Top view)

TDS5C212MX



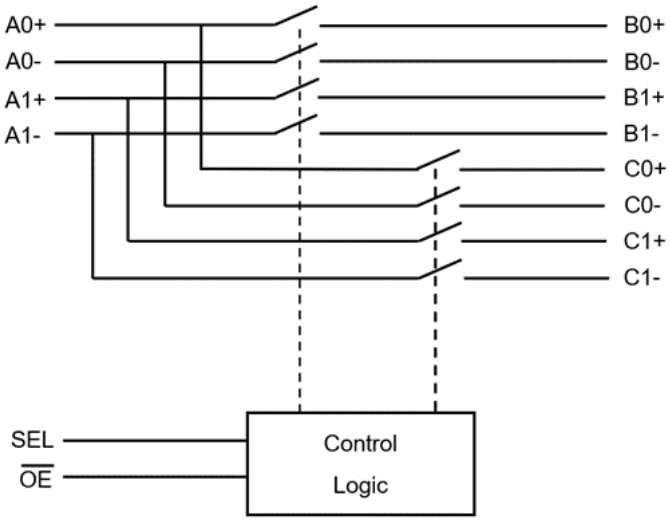
(Top view)

8. Pin functions

Pin name	TDS5B212MX Pin No.	TDS5C212MX Pin No.	Pin Type	Description
A0+	10	9	I/O	A-port channel 0 differential I/O pin
A0-	9	10	I/O	A-port channel 0 differential I/O pin
A1+	13	13	I/O	A-port channel 1 differential I/O pin
A1-	14	14	I/O	A-port channel 1 differential I/O pin
B0+	8	8	I/O	B-port channel 0 differential I/O pin
B0-	7	7	I/O	B-port channel 0 differential I/O pin
B1+	2	2	I/O	B-port channel 1 differential I/O pin
B1-	1	1	I/O	B-port channel 1 differential I/O pin
C0+	5	5	I/O	C-port channel 0 differential I/O pin
C0-	6	6	I/O	C-port channel 0 differential I/O pin
C1+	15	16	I/O	C-port channel 1 differential I/O pin
C1-	16	15	I/O	C-port channel 1 differential I/O pin
$\overline{OE}$	3	3	Input	Output enable pin (L: Enable, H: Disable)
SEL	12	12	Input	Select pin (L: A = B port, H: A = C port)
V_{CC}	4	4	Power supply	—
GND	11	11	Ground	—

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9. Block Diagram



10. 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 (Standby mode)	(n=0,1)

—: Don't care

11. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	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	(Note 1)	180	mW
V_{CC}/ground current	I_{CC}/I_{GND}		±50	mA
Storage temperature	T_{stg}		-65 to 150	°C

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).

Note 1: 180 mW in the range of T_a = -40 to 105 °C. From T_a = 105 to 125 °C a derating factor of -8.5 mW/°C shall be applied until 10 mW.

12. 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 125	°C
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.

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13. Electrical Characteristics

13.1. DC Characteristics

13.1.1. 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_S = 0 to 2.0V, $\overline{OE}$ = V_{CC}	3.6	—	—	±1	μA
ON-resistance	R_{ON}	V_S = 0 V, I_S = 8 mA	3.0	—	—	8.5	Ω
		V_S = 2 V, I_S = 8 mA	3.0	—	—	10	
Current consumption	I_{ope}	V_S = 0 V, $\overline{OE}$ = V_{CC} or GND	3.6	—	70	150	μA
		V_S = 2 V, $\overline{OE}$ = V_{CC} or GND	3.6	—	140	300	

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

13.1.2. DC Characteristics (Note) (Unless otherwise specified, T_a = -40 to 125 °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_S = 0 to 2.0 V, $\overline{OE}$ = V_{CC}	1.65 to 3.6	—	—	±1	μA
ON-resistance	R_{ON}	V_S = 0 V, I_S = 8 mA	3.0	—	—	9.0	Ω
		V_S = 2 V, I_S = 8 mA	3.0	—	—	12	
Current consumption	I_{ope}	V_S = 0 V, $\overline{OE}$ = V_{CC} or GND	3.6	—	70	150	μA
		V_S = 2 V, $\overline{OE}$ = V_{CC} or GND	3.6	—	140	300	

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

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

13.2.1. TDS5B212MX

Characteristics	Symbol	Note	Test Condition		Typ.	Unit
-3-dB Bandwidth (differential)	$BW_{(Diff)}$	(Note 1)	R_L = 50 Ω, See Fig. 14.1		29	GHz
Differential insertion loss	DDIL	(Note 1)	R_L = 50 Ω See Fig. 14.1	f = 2.5 GHz	-0.6	dB
				f = 4.0 GHz	-0.7	
				f = 5.0 GHz	-0.7	
				f = 8.0 GHz	-0.8	
				f = 10.0 GHz	-0.9	
				f = 12.8 GHz	-1.1	
				f = 16.0 GHz	-1.2	
Differential return loss	DDRL	(Note 1)	R_L = 50 Ω See Fig. 14.1	f = 2.5 GHz	-21	dB
				f = 4.0 GHz	-23	
				f = 5.0 GHz	-20	
				f = 8.0 GHz	-20	
				f = 10.0 GHz	-19	
				f = 12.8 GHz	-20	
				f = 16.0 GHz	-15	
Differential OFF isolation	DDOIRR	(Note 1)	R_L = 50 Ω See Fig. 14.2	f = 2.5 GHz	-43	dB
				f = 4.0 GHz	-38	
				f = 5.0 GHz	-36	
				f = 8.0 GHz	-29	
				f = 10.0 GHz	-26	
				f = 12.8 GHz	-26	
				f = 16.0 GHz	-27	
Differential Crosstalk	DDXT	(Note 1)	R_L = 50 Ω See Fig. 14.3, 14.4	f = 2.5 GHz	-47	dB
				f = 4.0 GHz	-43	
				f = 5.0 GHz	-41	
				f = 8.0 GHz	-37	
				f = 10.0 GHz	-35	
				f = 12.8 GHz	-33	
				f = 16.0 GHz	-31	

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

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13.2.2. TDS5C212MX

Characteristics	Symbol	Note	Test Condition		Typ.	Unit
-3-dB Bandwidth (differential)	$BW_{(Diff)}$	(Note 1)	R_L = 50 Ω, See Fig. 14.1		34	GHz
Differential insertion loss	DDIL	(Note 1)	R_L = 50 Ω See Fig. 14.1	f = 2.5 GHz	-0.6	dB
				f = 4.0 GHz	-0.7	
				f = 5.0 GHz	-0.7	
				f = 8.0 GHz	-0.8	
				f = 10.0 GHz	-0.9	
				f = 12.8 GHz	-1.1	
				f = 16.0 GHz	-1.2	
Differential return loss	DDRL	(Note 1)	R_L = 50 Ω See Fig. 14.1	f = 2.5 GHz	-21	dB
				f = 4.0 GHz	-23	
				f = 5.0 GHz	-21	
				f = 8.0 GHz	-24	
				f = 10.0 GHz	-21	
				f = 12.8 GHz	-20	
				f = 16.0 GHz	-14	
Differential OFF isolation	DDOIRR	(Note 1)	R_L = 50 Ω See Fig. 14.2	f = 2.5 GHz	-43	dB
				f = 4.0 GHz	-37	
				f = 5.0 GHz	-33	
				f = 8.0 GHz	-27	
				f = 10.0 GHz	-25	
				f = 12.8 GHz	-24	
				f = 16.0 GHz	-24	
Differential Crosstalk	DDXT	(Note 1)	R_L = 50 Ω See Fig. 14.3, 14.4	f = 2.5 GHz	-47	dB
				f = 4.0 GHz	-43	
				f = 5.0 GHz	-41	
				f = 8.0 GHz	-37	
				f = 10.0 GHz	-35	
				f = 12.8 GHz	-33	
				f = 16.0 GHz	-31	

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

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

13.3.1. TDS5B212MX

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Typ.	Unit
Propagation delay time	t_{PLH}/t_{PHL}	(Note 1)	R_L = 50 Ω, f = 16 GHz See Fig. 14.1, 14.7	3.3	26	ps
Output skew (bit to bit)	$t_{SK(b)}$	(Note 1)	R_L = 50 Ω, f = 16 GHz See Fig. 14.1, 14.8	3.3	2	ps
Output skew (channel to channel)	$t_{SK(CH)}$	(Note 1)	R_L = 50 Ω, f = 16 GHz See Fig. 14.1, 14.7	3.3	2	ps

Note 1: Parameter guaranteed by design.

13.3.2. TDS5C212MX

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Typ.	Unit
Propagation delay time	t_{PLH}/t_{PHL}	(Note 1)	R_L = 50 Ω, f = 16 GHz See Fig. 14.1, 14.7	3.3	26	ps
Output skew (bit to bit)	$t_{SK(b)}$	(Note 1)	R_L = 50 Ω, f = 16 GHz See Fig. 14.1, 14.8	3.3	3	ps
Output skew (channel to channel)	$t_{SK(CH)}$	(Note 1)	R_L = 50 Ω, f = 16 GHz See Fig. 14.1, 14.7	3.3	2	ps

Note 1: Parameter guaranteed by design.

13.4. Timing characteristics

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

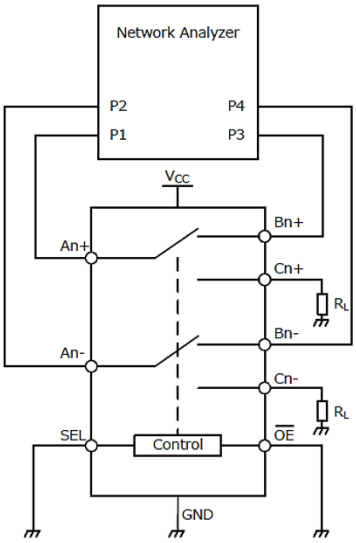
Characteristics	Symbol	Test Condition	V_{CC} (V)	Min	Typ.	Max	Unit
Start-up time.	t_{sup}	R_L = 50 Ω, C_L = 5 pF See Fig. 14.5	1.65 to 3.6	—	—	100	μs
Turn-ON time (SEL to Output)	t_{on}	R_L = 50 Ω, C_L = 5 pF See Fig. 14.5	1.65 to 3.6	—	—	400	ns
Turn-ON time ($\overline{OE}$ to Output)			1.65 to 3.6	—	—	400	
Turn-OFF time (SEL to Output)	t_{off}	R_L = 50 Ω, C_L = 5 pF See Fig. 14.5	1.65 to 3.6	—	—	100	ns
Turn-OFF time ($\overline{OE}$ to Output)			1.65 to 3.6	—	—	100	
Break before make	TBBM	R_L = 50 Ω, C_L = 5 pF See Fig. 14.6	1.65 to 3.6	55	—	400	ns

13.4.2. Timing characteristics (Unless otherwise specified, T_a = -40 to 125 °C)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Min	Typ.	Max	Unit
Start-up time.	t_{sup}	R_L = 50 Ω, C_L = 5 pF See Fig. 14.5	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. 14.5	1.65 to 3.6	—	—	450	ns
Turn-ON time ($\overline{OE}$ to Output)			1.65 to 3.6	—	—	450	
Turn-OFF time (SEL to Output)	t_{off}	R_L = 50 Ω, C_L = 5 pF See Fig. 14.5	1.65 to 3.6	—	—	110	ns
Turn-OFF time ($\overline{OE}$ to Output)			1.65 to 3.6	—	—	110	
Break before make	TBBM	R_L = 50 Ω, C_L = 5 pF See Fig. 14.6	1.65 to 3.6	55	—	450	ns

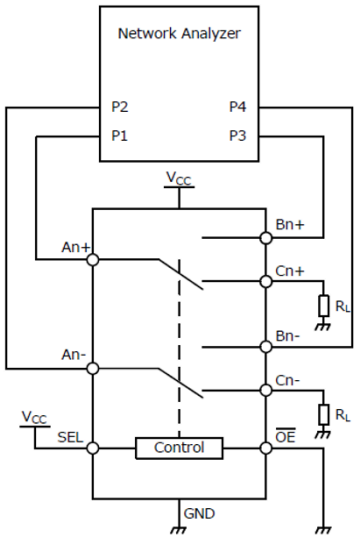
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14. Electrical Test Circuit (Fig)



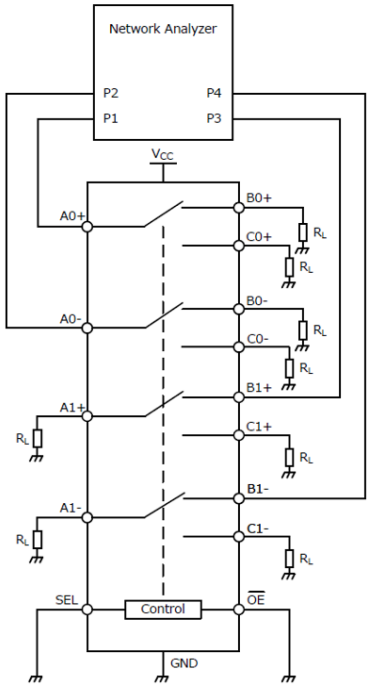
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure An and Bn.

Fig. 14.1 -3-dB Bandwidth(differential), Differential insertion loss,Differential return loss, Propagation delay time, Output skew (channel to channel, bit to bit)



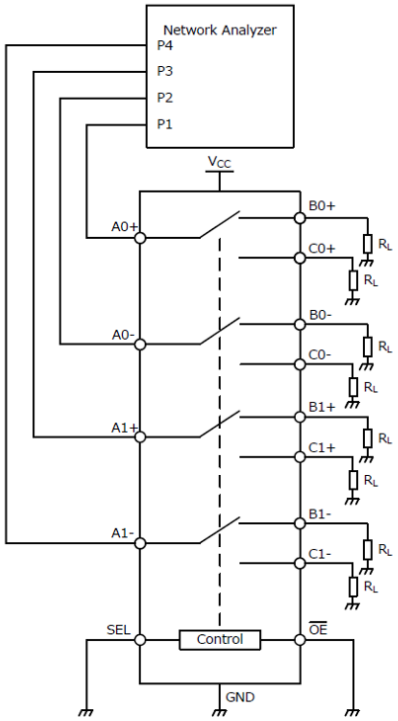
R_L = 50 Ω
All unused ports are connected to GND through 50 Ω pull-down resistors.
This figure is an example showing how to measure An and Bn.

Fig. 14.2 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. 14.3 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. 14.4 Differential Near-end crosstalk

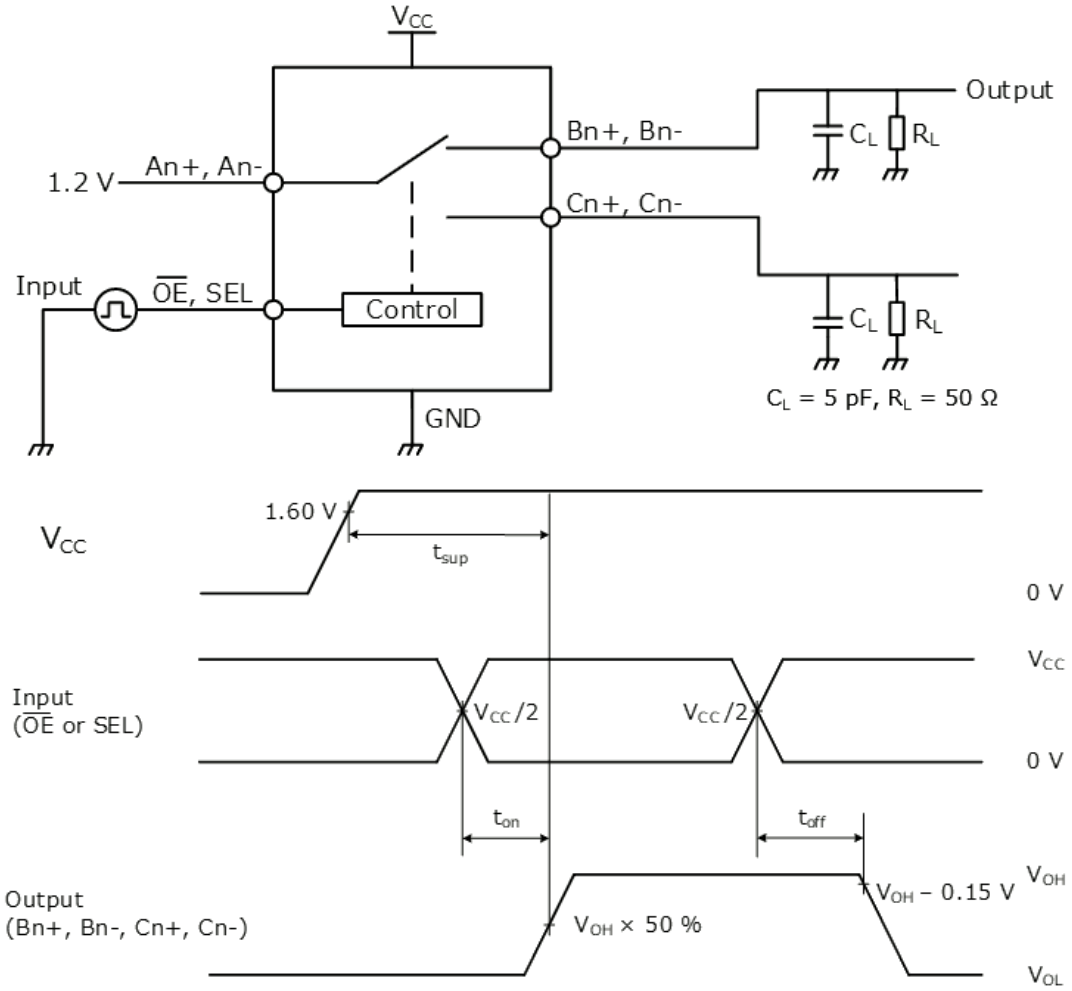


Fig. 14.5 Start-up time, Turn-ON time and Turn-OFF time

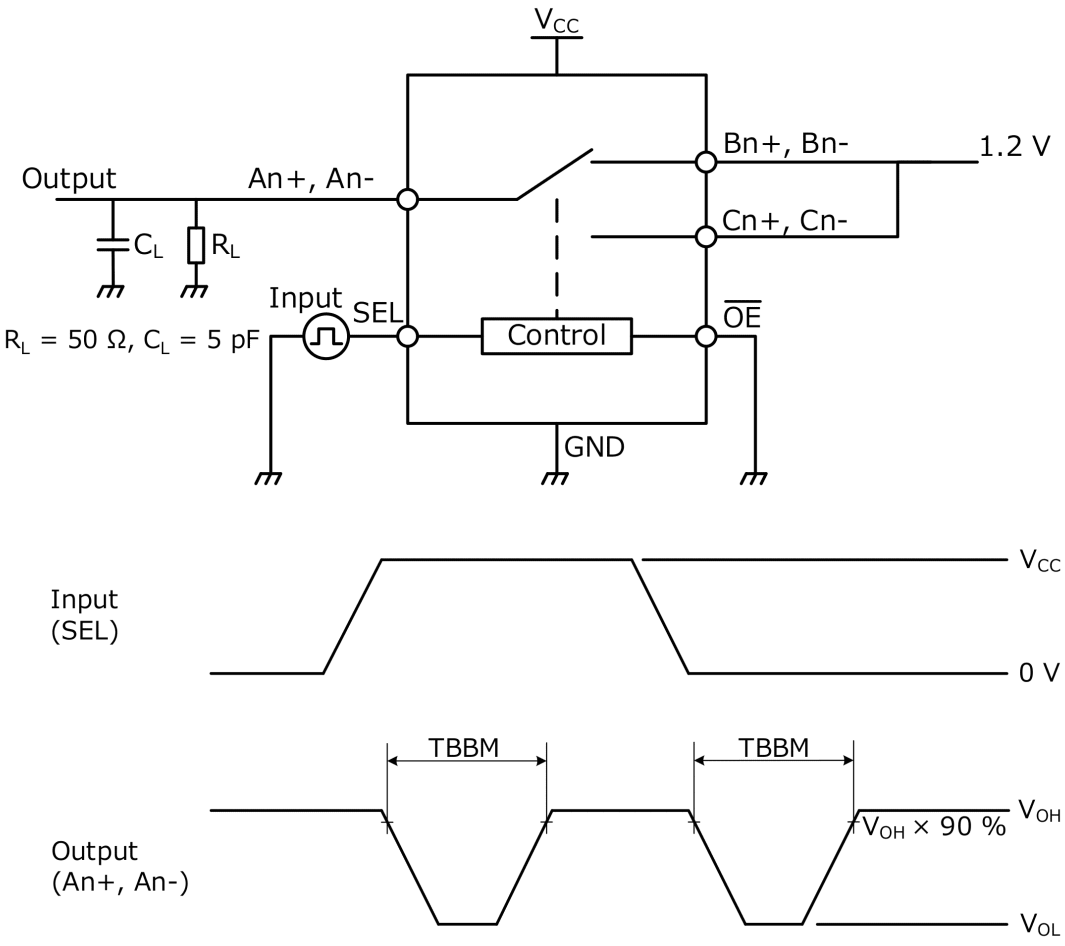


Fig. 14.6 Break before make

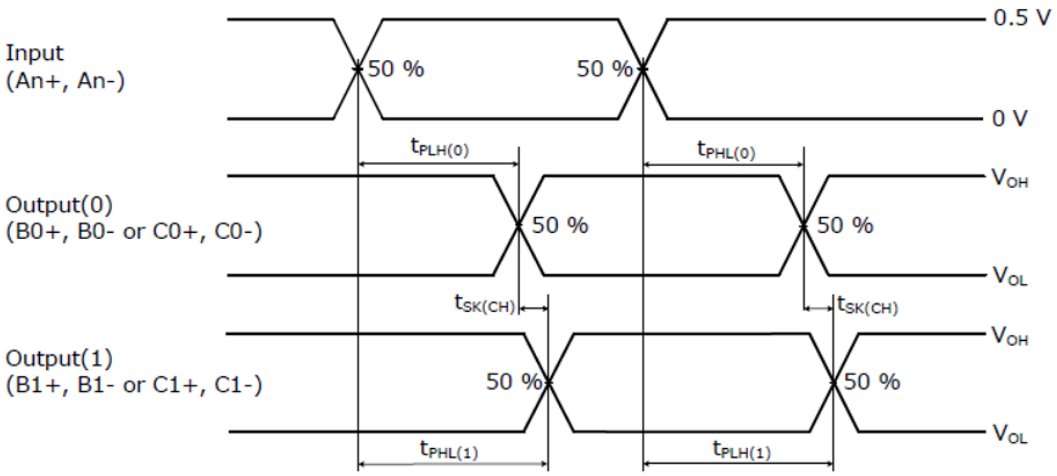


Fig. 14.7 Output skew (channel to channel), Propagation delay time

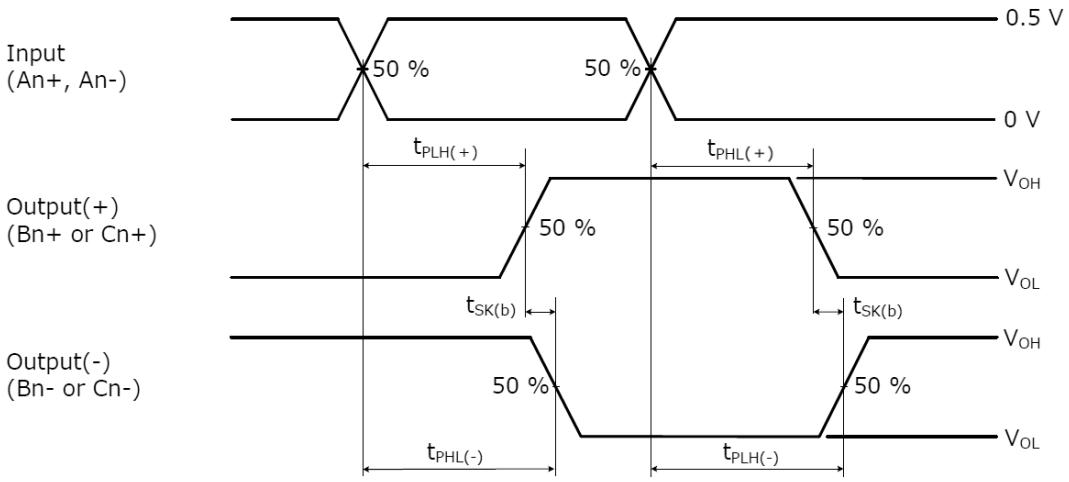
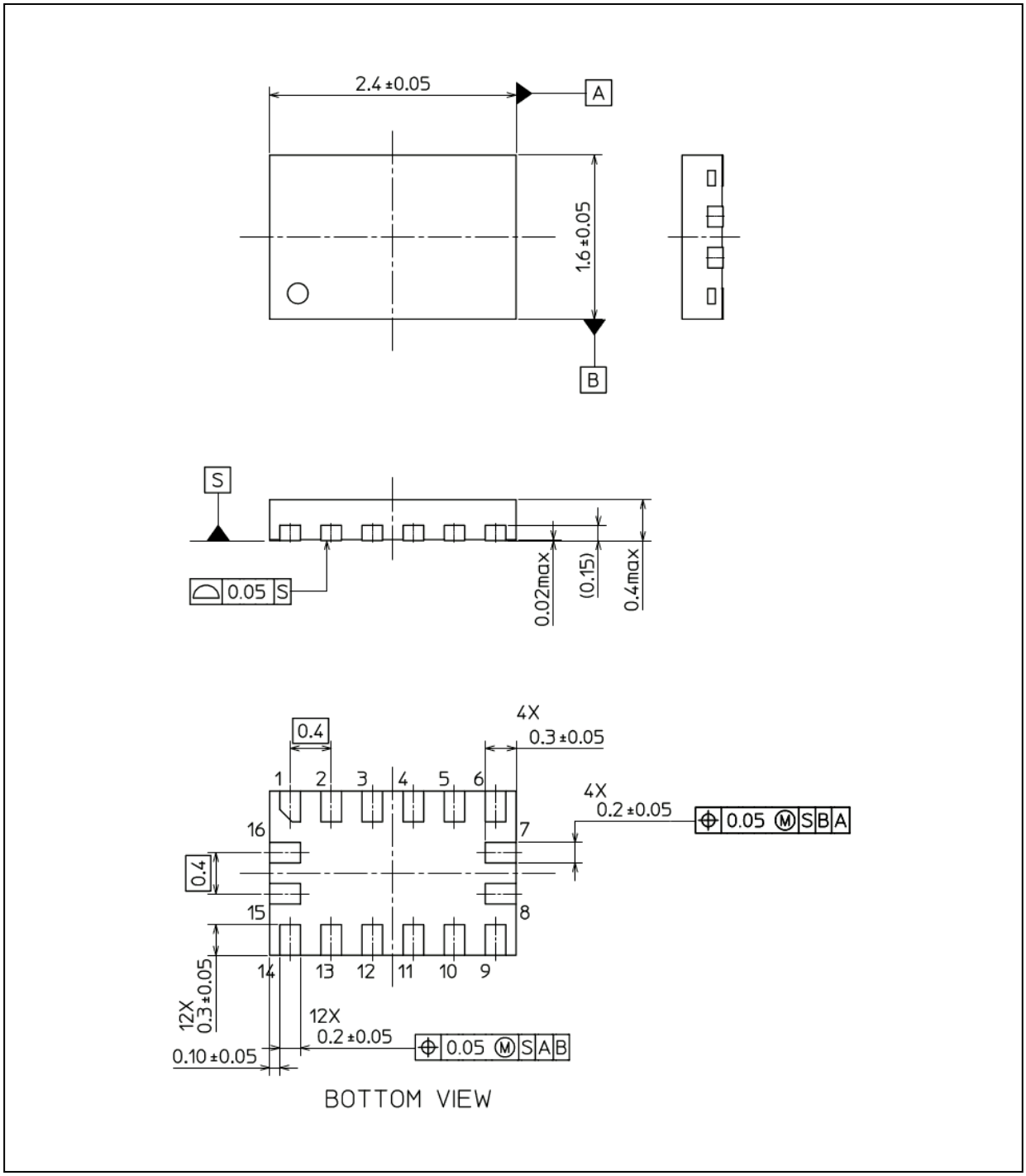


Fig. 14.8 Output skew (bit to bit)

Package Dimensions

Unit: mm



Weight: 3.9 mg (typ.)

Package Name(s)
Nickname: XQFN16

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