

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Features

- Two Bidirectional Differential Channels, 2:1 Multiplexer/Demultiplexer
- High-Speed Signal Switching up to 16 Gbps
- High Bandwidth: 12 GHz @ -3 dB
- Low Insertion Loss: -2.1 dB @ 8 GHz
- Low Return Loss: -12 dB @ 8 GHz
- Low Off-Isolation: -10 dB @ 8 GHz
- Low Intra/Inter Channel Skew: 10/15 ps max
- Support anti-backflow to power on control signals (OE / SEL) and high speed data channels
- Single Supply Voltage: 3.3 V
- Industrial Temperature Range: -40°C to +85°C
- Packaging (Pb-Free & Green): QFN2.5x4.5-20

Applications

- Notebook, Tablets, PC, Server
- Switch, Router
- OTN Transport
- Medical Equipment
- Wireless Infrastructure
- Test and Measurements

Description

The TPD160221 is a dual differential channel 2:1 multiplexer/demultiplexer switch for PCIe Gen3.0, Gen4.0, DP1.3, DP1.4, USB3.1, USB3.2, or other high-speed serial interface signals.

Typical Application Circuit

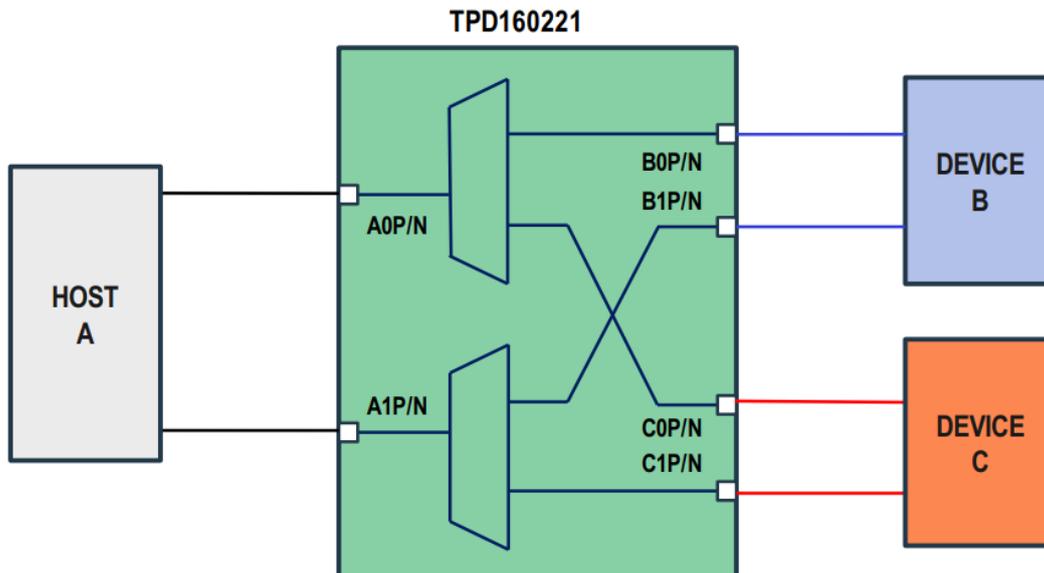


Table of Contents

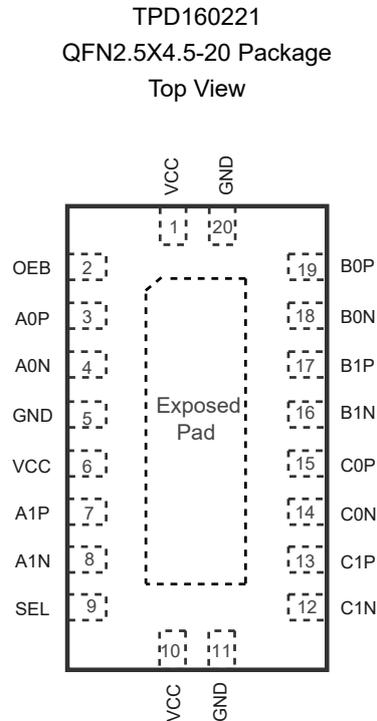
Features	1
Applications	1
Description	1
Typical Application Circuit	1
Product Family Table	3
Revision History	3
Pin Configuration and Functions	4
Specifications	6
Absolute Maximum Ratings ⁽¹⁾	6
ESD, Electrostatic Discharge Protection.....	6
Recommended Operating Conditions.....	6
Thermal Information.....	6
Electrical Characteristics.....	7
Typical Performance Characteristics.....	9
Detailed Description	12
Overview.....	12
Functional Block Diagram.....	12
Feature Description.....	12
Application and Implementation	13
Application Information.....	13
Typical Application.....	14
Layout	19
Layout Guideline.....	19
Layout Example.....	19
Tape and Reel Information	20
Package Outline Dimensions	21
QFN2.5X4.5-20.....	21
Order Information	22
IMPORTANT NOTICE AND DISCLAIMER	23

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch**Product Family Table**

Order Number	Maximum Data Rate	Package
TPD160221-QF3R-S	16 Gbps	QFN2.5X4.5-20

Revision History

Date	Revision	Notes
2023-03-01	Rev.A.0	Initial version.
2023-10-09	Rev.A.1	Changed P0 in Tape and Reel Information.
2023-11-01	Rev.A.2	Added feature: anti-backflow to power on control signals and high speed data channels. Changed Ron typical value.

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch
Pin Configuration and Functions

Table 1. Pin Functions: TPD160221

Pin		I/O	Description
No.	Name		
1	VCC	Power	
2	OEB	Input	Active low Output Enable L: normal operation H: shut down
3	A0P	Input/Output	Port A, channel 0, high speed positive signal
4	A0N	Input/Output	Port A, channel 0, high speed negative signal
5	GND	GND	Ground
6	VCC	Power	3.3-V power supply
7	A1P	Input/Output	Port A, channel 1, high speed positive signal
8	A1N	Input/Output	Port A, channel 1, high speed negative signal
9	SEL	Input	Port select pin L: Port A to Port B H: Port A to Port C
10	VCC	Power	
11	GND	GND	Ground
12	C1N	Input/Output	Port C, channel 1, high speed negative signal
13	C1P	Input/Output	Port C, channel 1, high speed positive signal
14	C0N	Input/Output	Port C, channel 0, high speed negative signal
15	C0P	Input/Output	Port C, channel 0, high speed positive signal
16	B1N	Input/Output	Port B, channel 1, high speed negative signal

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Pin		I/O	Description
No.	Name		
17	B1P	Input/Output	Port B, channel 1, high speed positive signal
18	B0N	Input/Output	Port B, channel 0, high speed negative signal
19	B0P	Input/Output	Port B, channel 0, high speed positive signal
20	GND	GND	Ground
	Exposed Pad	GND	Thermal pad of QFN package, for enhanced thermal and electrical performance, it is required to solder the exposed pad to Ground.

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Specifications

Absolute Maximum Ratings ⁽¹⁾

Parameter		Min	Max	Unit
V _{CC-ABSMAX}	Power Supply Voltage	-0.5	4.6	V
V _{CTL-ABSMAX}	Control voltage (OEB, SEL)	-0.5	4.6	V
V _{HS-ABSMAX}	High Speed Switch I/O Voltage	-0.5	min (4.6, V _{CC} +0.5)	V
T _{STG}	Storage Temperature Range	-55	125	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

(2) This data was taken with the JEDEC low effective thermal conductivity test board.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Minimum Value	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±2000	V
CDM	Charged Device Model ESD	JEDEC specification JESD22-C101 ⁽²⁾	±1500	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

Parameter			Min	Nom	Max	Unit
V _{CC}	Supply Voltage	Normal	3	3.3	3.6	V
V _{IH}	Input Logic High Voltage	SEL/OEB pin	0.8*V _{CC}			V
V _{IL}	Input Logic Low Voltage	SEL/OEB pin			0.2*V _{CC}	V
V _{DIFF}	Differential-Mode Input Voltage	Recommended op. condition	0	0.8	1.8	V
V _{CM}	Common-Mode Input Voltage	Recommended op. condition	0	1.6	2.0	V
T _{AMB}	Operating Ambient Temperature	None	-40	27	85	°C

Thermal Information

Package Type	θ _{JA}	θ _{JB}	θ _{JC}	Unit
QFN4.5X4.5-20	53.0	27.2	52.4	°C/W

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch
Electrical Characteristics

Parameter		Conditions	Min	Typ	Max	Units
Electrical Charateristics						
I _{CC_OP}	Supply Active Current	Operating mode, OEB = GND		172	300	uA
I _{CC_DOWN}	Supply Shutdown Current	Shutdown mode, OEB = V _{CC}		0.6	1	uA
V _{HS}	High-Speed Switch I/O Voltage	Input/output voltage range of the switch (AN, BN, CN)	0		V _{CC} ⁽²⁾	V
I _{HIZ,HS}	Switch OFF-state Leakage Current	V _{HS} = 0 to V _{CC} , OEB = V _{CC}			1	uA
C _{HSOFF_A}	High-Speed Switch Terminal OFF-Capacitance	OEB = V _{CC} , V _{HS} = 0 V		0.8		pF
C _{HSOFF_BC}	High-Speed Switch Terminal OFF-Capacitance	OEB = V _{CC} , V _{HS} = 0 V		0.5		pF
C _{HSON}	High-Speed Switch Terminal ON-Capacitance	OEB = GND, V _{HS} = 0V		1.5		pF
R _{ON}	ON Resistance	V _{HS} = 0 V, I _{HS} = 30 mA ⁽¹⁾		7.5	11.5	Ω
R _{ON}	ON Resistance	V _{HS} = 1.2 V, I _{HS} = 30 mA ⁽¹⁾		8.5	13.5	Ω
R _{ON_FLAT}	ON Resistance Flatness	V _{HS} = 0 V-1.2 V, I _{HS} = 15 mA ⁽¹⁾		0.8	-	Ω
ΔR _{ON}	Difference of ON-resistance between Switches	V _{HS} = 0 V, 1.2 V, I _{HS} = 15 mA ⁽¹⁾		0.1	-	Ω
V _{CTRL}	Control Input Voltage (SEL / OEB)		0		V _{CC}	V
I _{IH,CTRL}	Control Input High Current (SEL / OEB)	V _{CTRL} = 3.6 V			1	uA
I _{IL,CTRL}	Control Input Low Current (SEL / OEB)	V _{CTRL} = 0 V			1	uA
C _{CTRL}	Control Input Capacitance (SEL / OEB)	V _{HS} = 0 V		3		pF
Switching Charactoristics						
t _{PLH} /t _{PHL}	Propagation Delay Time	C _L = 5 pF		80	-	ps
t _{ON}	Turn-ON Time (SEL to Output)	R _L = 50 Ω, C _L = 5 pF		14	20	ns
t _{ON}	Turn-ON Time (OEB to Output)	R _L = 50 Ω, C _L = 5 pF		21.5	50	us
t _{OFF}	Turn-OFF Time (SEL to Output)	R _L = 50 Ω, C _L = 5 pF		5.5	7.0	ns
t _{OFF}	Turn-OFF Time (OEB to Output)	R _L = 50 Ω, C _L = 5 pF		6.7	8.0	ns
t _{BBM}	Break before Make	R _L = 50 Ω, C _L = 5 pF		10.3		ns
t _{SKEW_INTRA}	Intra Pair Output Skew between P and N for the same channel	C _L = 5 pF		6.2		ps
t _{SKEW_INTER}	Inter Pair Output Skew between Channels	C _L = 5 pF		5.7		ps
High Speed Performance Parameters						

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Parameter		Conditions	Min	Typ	Max	Units
DOFFISO	Differential OFF Isolation	$R_L = 50 \Omega, f = 2.7 \text{ GHz}$		-17		dB
		$R_L = 50 \Omega, f = 4 \text{ GHz}$		-14		dB
		$R_L = 50 \Omega, f = 8 \text{ GHz}$		-10		dB
DXT	Differential Crosstalk	$R_L = 50 \Omega, f = 2.7 \text{ GHz}$		-48		dB
		$R_L = 50 \Omega, f = 4 \text{ GHz}$		-46		dB
		$R_L = 50 \Omega, f = 8 \text{ GHz}$		-38		dB
DRL	Differential Return Loss	$R_L = 50 \Omega, f = 2.7 \text{ GHz}$		-19		dB
		$R_L = 50 \Omega, f = 4 \text{ GHz}$		-16		dB
		$R_L = 50 \Omega, f = 8 \text{ GHz}$		-12		dB
DIL	Differential Insertion Loss	$R_L = 50 \Omega, f = 2.7 \text{ GHz}$		-0.8		dB
		$R_L = 50 \Omega, f = 4 \text{ GHz}$		-1.0		dB
		$R_L = 50 \Omega, f = 8 \text{ GHz}$		-2.1		dB
BW	-3dB Bandwidth	$R_L = 50 \Omega, C_L = 0 \text{ pF}$		12.0		GHz
BR	Signal Bit Rate	AN - BN / CN			16 ⁽²⁾	Gbps

(1) ON-resistance is measured by measuring the voltage drop across the switch at the indicated current

(2) Design Guarantee Spec

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Typical Performance Characteristics

All test conditions: $V_{CC} = 3.3\text{ V}$, $T_A = +27^\circ\text{C}$, unless otherwise noted.

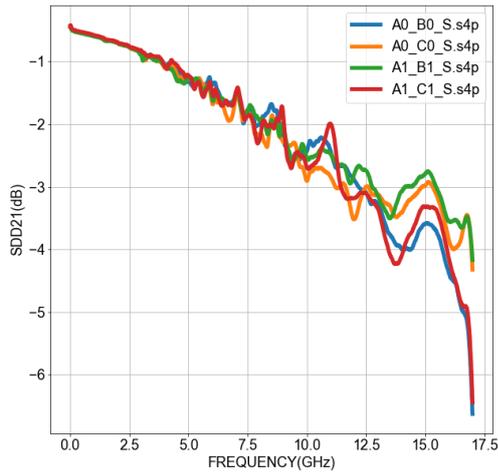


Figure 1. Differential Insertion Loss

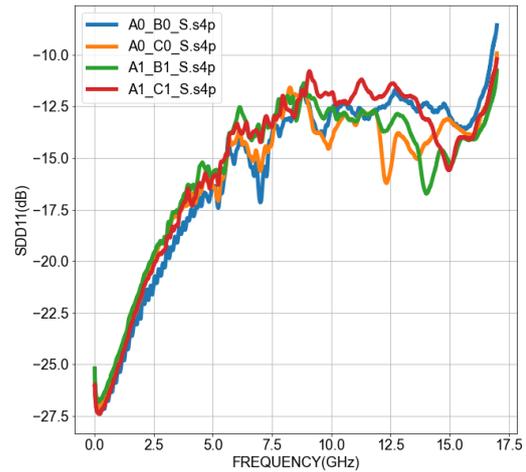


Figure 2. Differential Return Loss

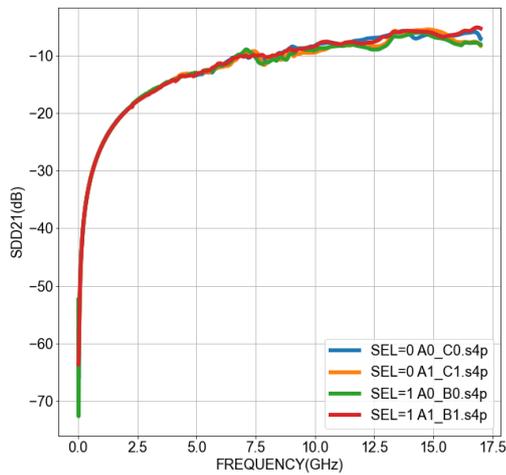


Figure 3. Differential Off Isolation

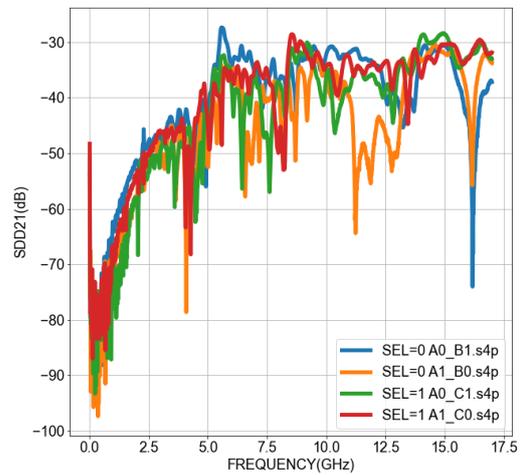


Figure 4. Differential Near End Crosstalk

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch



Figure 5. 5.4GBPS Eye Diagram



Figure 6. 5.4 GBPS Jitter



Figure 7. 8.1 GBPS Eye Diagram



Figure 8. 8.1 GBPS Jitter



Figure 9. 10.0 GBPS Eye Diagram



Figure 10. 10.0 GBPS Jitter

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

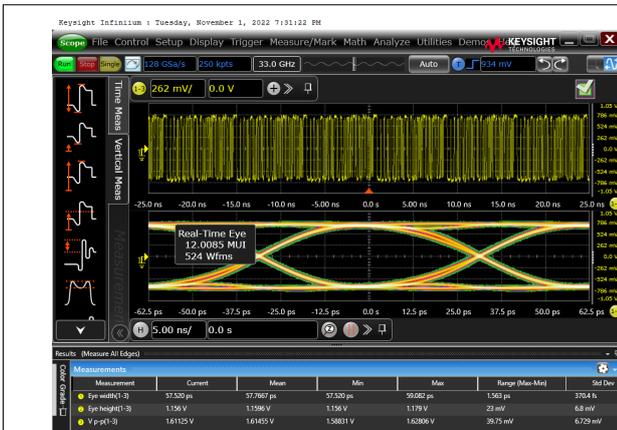


Figure 11. 16.0 GBPS Eye Diagram



Figure 12. 16.0 GBPS Jitter

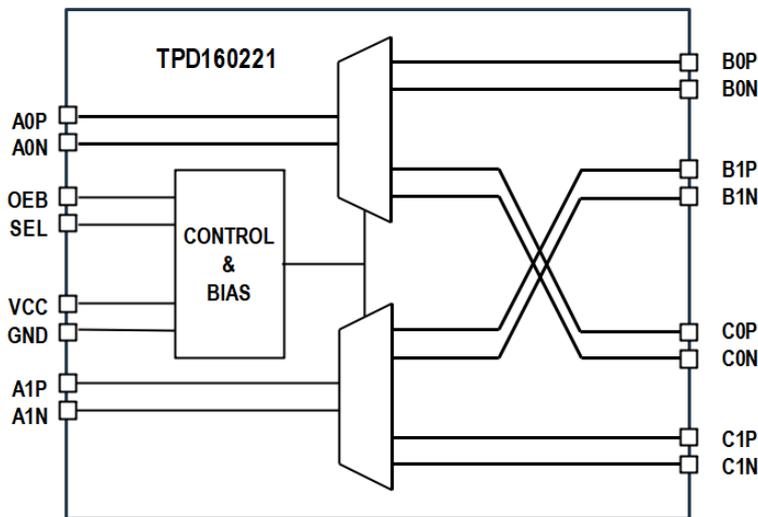
2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Detailed Description

Overview

The TPD160221 is a two differential channel 2:1 multiplexer/demultiplexer switch for PCIe Gen3, Gen4 and other high-speed serial link applications, the maximum data rate can be up to 16 Gbps.

Functional Block Diagram



Feature Description

PORT A	PORT B / C CONNECTED TO PORT A LOGIC	
	SEL = L	SEL = H
A0P	B0P	C0P
A0N	B0N	C0N
A1P	B1P	C1P
A1N	B1N	C1N

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Application and Implementation

Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Application Information

The TPD160221 is a pure passive 2:1 multiplexer without any signal conditioning circuits, such as equalizer or pre-emphasis. It can support various high speed data signals provided that the differential amplitude is within 1.8 Vpp. In order to keep RON within a relatively small value (eg. < 10 ohm), the common mode voltage should be less than 2.5 V. The TPD160221 is suitable for the following applications: USB 3.2 Gen1.0/2.0, 2.0, USB Type-C, PCIe Gen 1.0/2.0/3.0/4.0, SATA, SAS, DP 1.4, TBT 3.0, MIPI DSI, MIPI CSI-2, LVDS, GE/10GE, etc

The MUX/DEMUX channel selection is controlled by the SEL pin. When SEL = L, MUX is placed to port B. When SEL = H, MUX is placed to port C.

Typical high speed mux application requires ac coupling capacitors to avoid different common-mode voltages between port A and port B/C.

Several options can be used for ac-coupling capacitors. Option 1, the ac-coupling capacitors are placed to the connector side on the TX link, refer to Figure 13. Option 2, place the ac-coupling capacitor close to HOST TX, refer to Figure 14. If both sides of TPD160221 are using ac-coupling capacitors, proper bias must be provided, refer to option 3 in Figure 15.

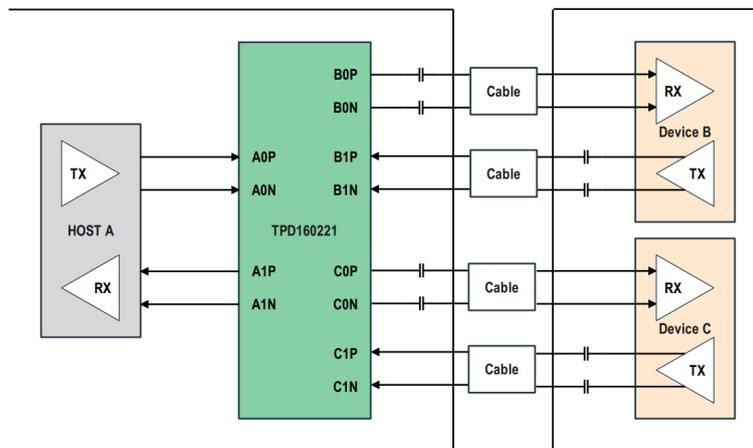


Figure 13. AC Coupling Capacitor Placement Option 1

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

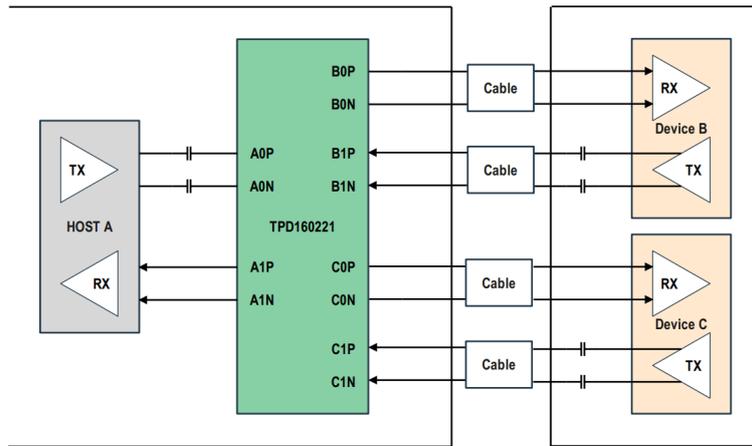


Figure 14. AC Coupling Capacitor Placement Option 2

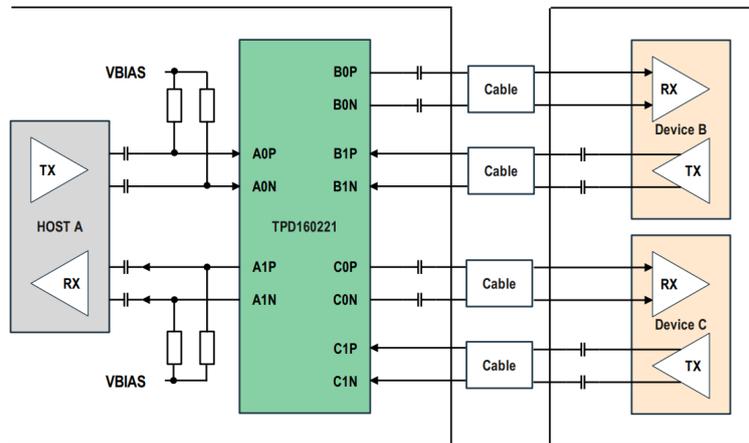


Figure 15. AC Coupling Capacitor Placement Option 3

Typical Application

Figure 16 shows the typical simplified application block diagram.

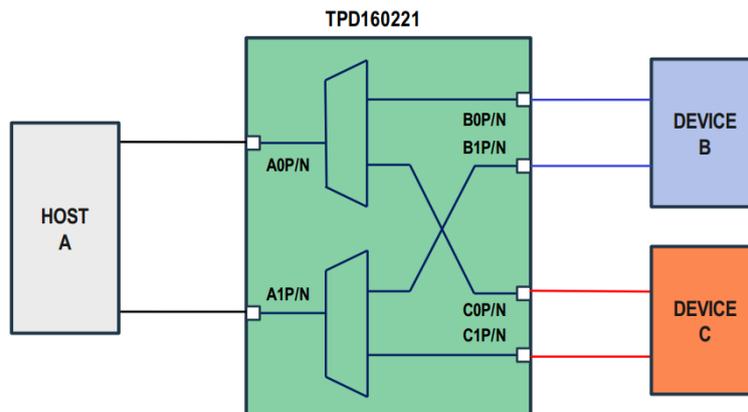


Figure 16. Typical Application Circuit

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Multiplex dual channel DP1.4

In multiple channel mux/demux application, low inter-skew performance is required, Figure 17 shows the block diagram of using 2x TPD160221 to build a 8:4 mux application for DP1.4.

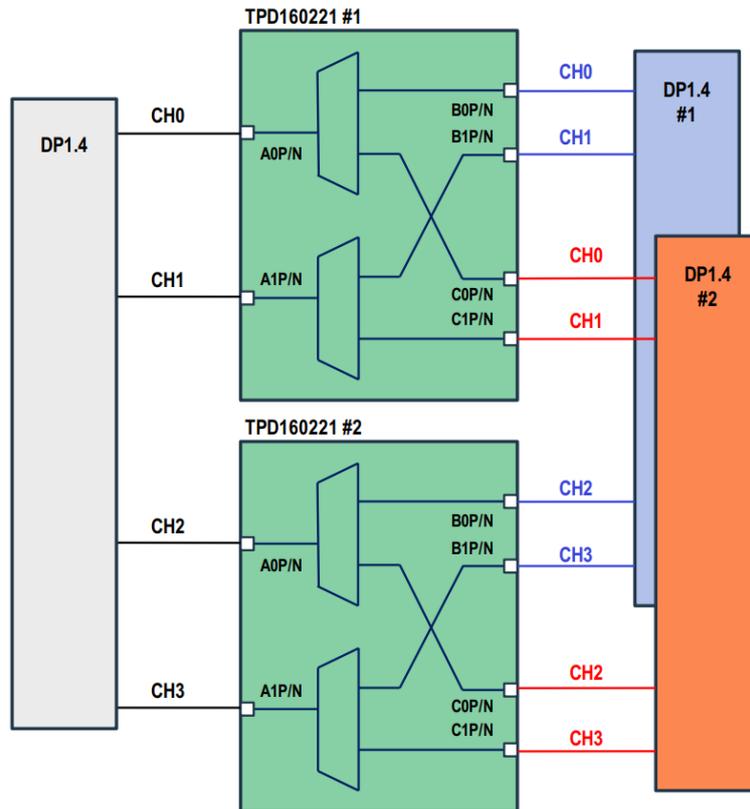


Figure 17. Multiplex Dual Channel DP1.4

AC Parameter Measurement Setup

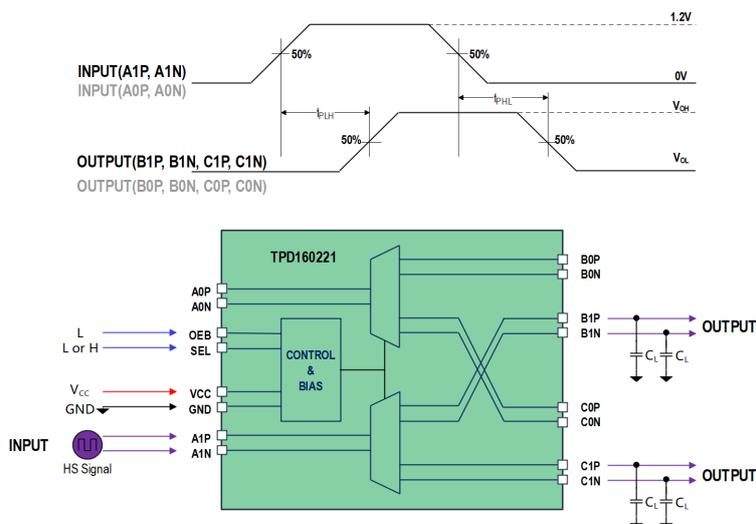


Figure 18. Propagation Delay Measurement

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

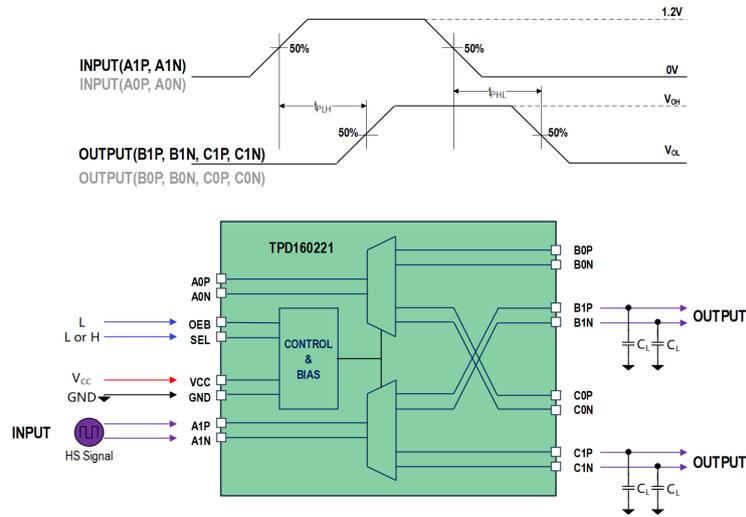


Figure 19. Intra Pair Skew Measurement

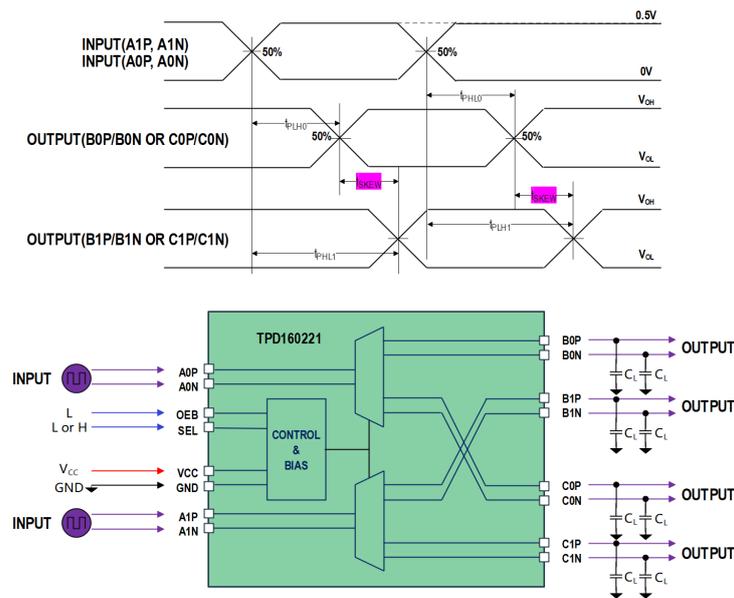


Figure 20. Inter Pair Skew Measurement

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

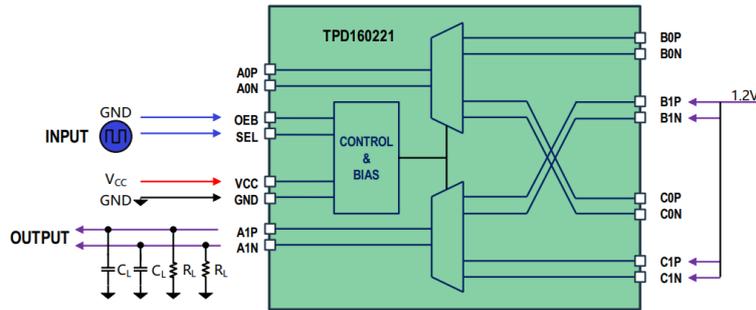
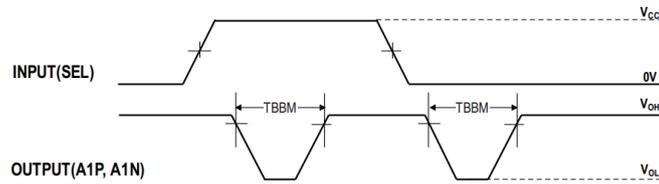


Figure 21. Break Before Make Measurement

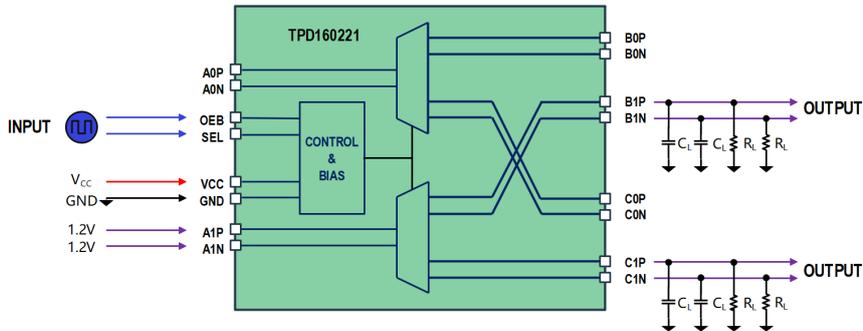
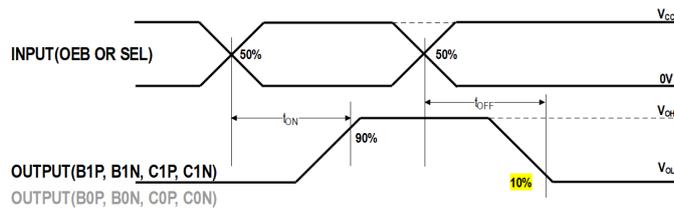


Figure 22. Turn-On/Off Measurement

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

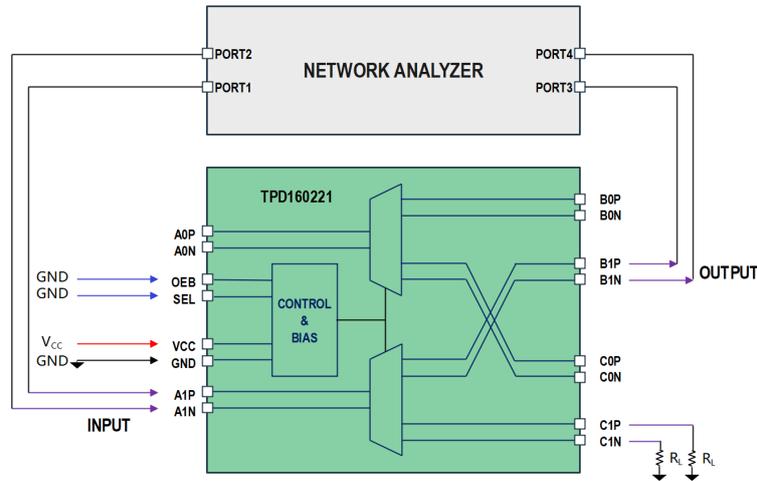


Figure 23. Insertion/Return Loss Measurement

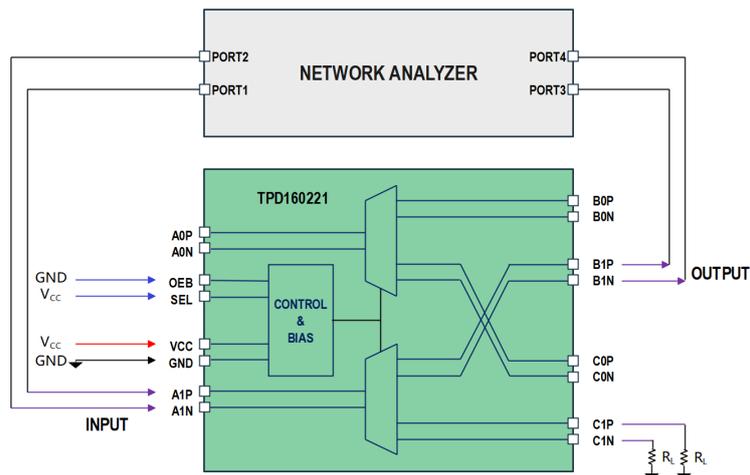


Figure 24. Off Isolation Measurement

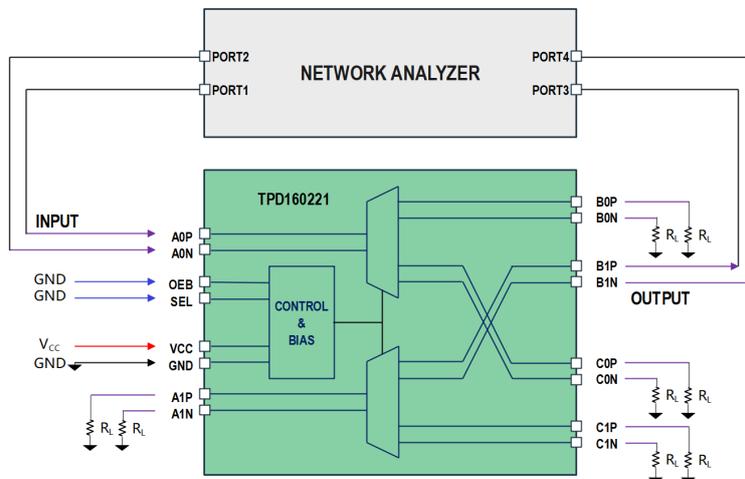


Figure 25. Near End Crstalk Measurement

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Layout

Layout Guideline

- Impedance matching (eg. $50\ \Omega \pm 10\%$) is recommended for high-speed signals to reduce the reflection of the trace.
- Try to control the length of high-speed traces to be the same.
- Exposed pads are recommended to be directly connected to PCB grounding plane, and the copper area to be as large as possible.

Layout Example

Figure 26 shows the location of external components as they appear on the PCB.

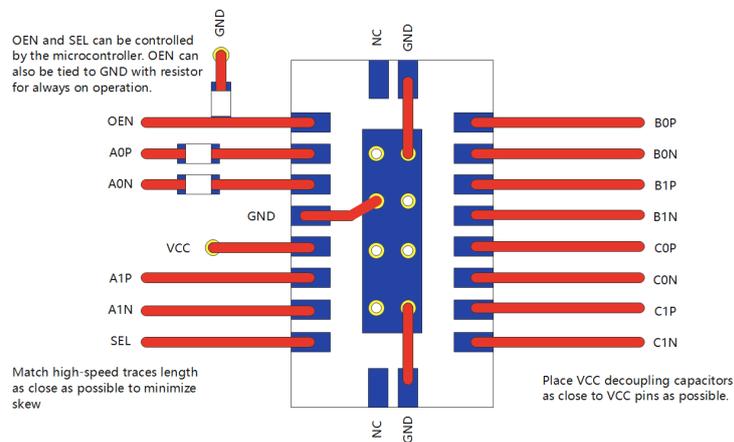
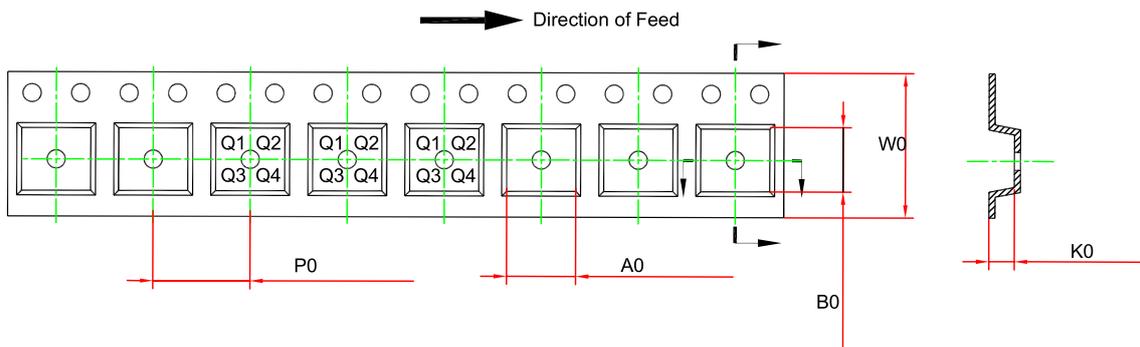
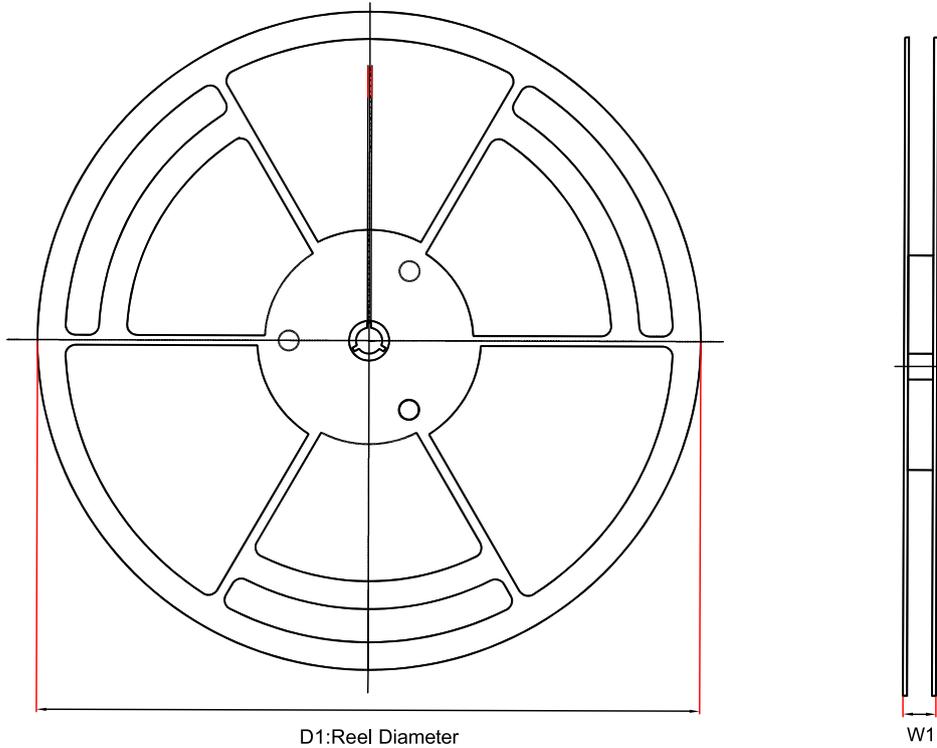


Figure 26. TPD160221 Layout Example

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Tape and Reel Information

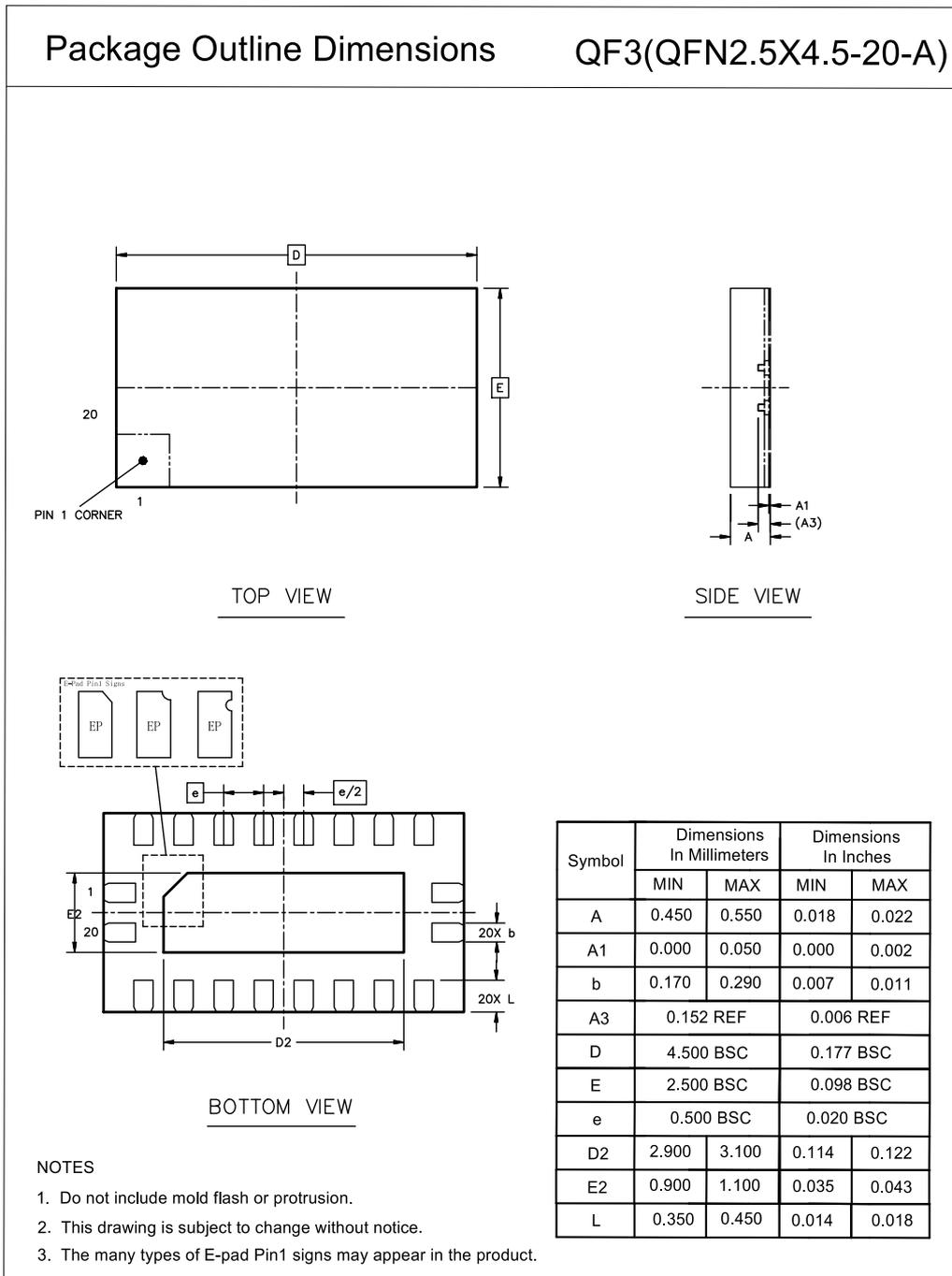


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPD160221-QF3R-S	QFN2.5X4.5-20	330.0	17.6	2.75	4.75	0.75	4.0	12.0	Q1

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

Package Outline Dimensions

QFN2.5X4.5-20



2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch**Order Information**

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPD160221-QF3R-S	-40 to 85°C	QFN2.5X4.5-20	MUX	3	Tape and Reel, 6000	Green

(1) For future products, contact the 3PEAK factory for more information and samples.

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

2 Differential Channels 2:1 Multiplexer/Demultiplexer Switch

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