

TMUXHS4612 3.3V 6-Channel 20Gbps Differential 2:1 Mux / 1:2 Demux

1 Features

- Supports HDMI 1.4b/2.0/2.1 up to 12Gbps, USB4 up to 20Gbps, DisplayPort 1.4/2.1 up to UHBR20
- Data rate support up to 20Gbps
- High-speed path supports wide common-mode voltage range (0V to V_{CC})
- Low R_{ON} of 8.8 Ω typical for high-speed data pins
- –3dB differential BW of 13.0GHz for high-speed data pins
- Excellent dynamic characteristics at 10GHz:
 - Insertion loss: –2.5dB
 - Return loss: –13dB
 - Cross talk: –30dB
- All sideband signals can pass-through up to 5V levels and are 5.5V tolerant
- Support 1.8V and 3.3V control logic
- Single supply voltage of 3.3V
- Low active (800 μ A) and standby power (32 μ A)
- I_{OFF} protection that prevents current leakage when supply rail collapsed ($V_{CC} = 0V$)
- Temperature range: –40°C to 125°C
- Package: 40-pin, 3mm × 6mm, 0.4mm pitch WQFN

2 Applications

- [PC and notebooks](#)
- [Gaming, Home theater & entertainment and TV](#)
- [Data center and enterprise computing](#)
- [Medical applications](#)
- [Test and measurements](#)
- [Factory automation and control](#)
- [Aerospace and defense](#)
- [Electronic point of sale \(EPOS\)](#)
- [Wireless infrastructure](#)

3 Description

The TMUXHS4612 is a high-speed bidirectional passive switch in mux or demux configurations. The device is protocol agnostic supporting many applications including HDMI 1.4 / 2.0 / 2.1, and DisplayPort 1.4 / 2.1. The TMUXHS4612 is a generic analog differential passive mux or demux that works for many high-speed differential interfaces with data rates up to 20Gbps. The TMUXHS4612 high-speed channels support differential signaling and single-ended signaling as long as the single-ended signals do not violate $V_{P-N_ABS\text{MAX}}$ parameter. The sideband channels are 5V tolerant and support single-ended and differential signaling such as I²C, UART, DisplayPort AUX, and USB2, just to name a few. The dynamic characteristics of the high-speed channel allows high-speed switching with minimal attenuation to the signal eye diagram and with very little added jitter. The silicon design of the device is optimized for excellent frequency response at higher frequency spectrum of the signals. The device supports differential signaling with common-mode voltage range (CMV) of 0V to 3.6V in the Dxx datapaths.

The TMUXHS4612 consumes very low active power of 800 μ A. The device also offers a power-down mode in which all channels become Hi-Z and the device operates with minimal power of just 32 μ A.

Package Information

PART NUMBER	TEMPERATURE	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
TMUXHS4612	$T_A = 0^\circ\text{C to } 105^\circ\text{C}$	RET (WQFN, 40)	6mm × 3mm
TMUXHS4612I	$T_A = -40^\circ\text{C to } 125^\circ\text{C}$		

- (1) For all available packages, see [Section 11](#).
 (2) The package size (length x width) is a nominal value and includes pins, where applicable.

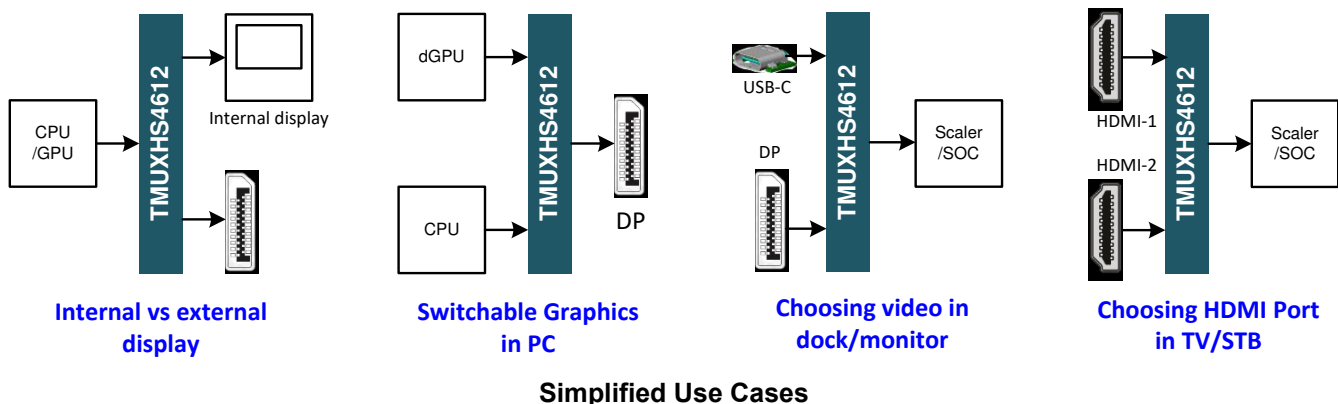


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4 Pin Configuration and Functions

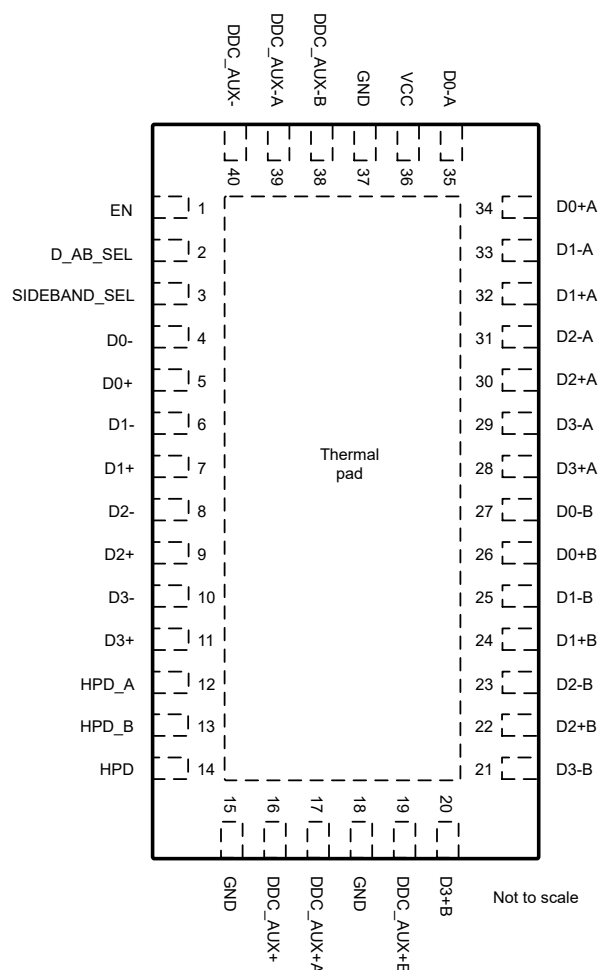


Figure 4-1. RET Package 40-Pin WQFN With Exposed Thermal Pad (Top View)

Table 4-1. Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
EN	1	I	Device Enable L: Device Disabled. All data and sideband signals in Hi-Z. H: Device Enabled. All data and sideband signals selected by D_AB_SEL and SIDEBAND_SEL are enabled.
D_AB_SEL	2	I	Selects between high-speed datapath A and B. L: High-speed datapath A H: High-speed datapath B
SIDEBAND_SEL	3	I	Selects between sideband path A and B L: Sideband path A H: Sideband path B
D0–	4	I/O	Common Port, Channel 0, –ve signal
D0+	5	I/O	Common Port, Channel 0, +ve signal
D1–	6	I/O	Common Port, Channel 1, –ve signal
D1+	7	I/O	Common Port, Channel 1, +ve signal
D2–	8	I/O	Common Port, Channel 2, –ve signal

Table 4-1. Pin Functions (continued)

PIN		TYPE	DESCRIPTION
NAME	NO.		
D2+	9	I/O	Common Port, Channel 2, +ve signal
D3–	10	I/O	Common Port, Channel 3, –ve signal
D3+	11	I/O	Common Port, Channel 3, +ve signal
HPD_A	12	I/O	Port A, Hot Plug Detect sideband signal
HPD_B	13	I/O	Port B, Hot Plug Detect sideband signal
HPD	14	I/O	Common Port, Hot Plug Detect sideband signal
GND	15	GND	Ground
DDC_AUX+	16	I/O	Common Port, DDC or AUX sideband signal
DDC_AUX+A	17	I/O	Port A, DDC or AUX sideband signal
GND	18	GND	Ground
DDC_AUX+B	19	I/O	Port B, DDC or AUX sideband signal
D3+B	20	I/O	Port B, Channel 3, +ve signal
D3–B	21	I/O	Port B, Channel 3, –ve signal
D2+B	22	I/O	Port B, Channel 2, +ve signal
D2–B	23	I/O	Port B, Channel 2, –ve signal
D1+B	24	I/O	Port B, Channel 1, +ve signal
D1–B	25	I/O	Port B, Channel 1, –ve signal
D0+B	26	I/O	Port B, Channel 0, +ve signal
D0–B	27	I/O	Port B, Channel 0, –ve signal
D3+A	28	I/O	Port A, Channel 3, +ve signal
D3–A	29	I/O	Port A, Channel 3, –ve signal
D2+A	30	I/O	Port A, Channel 2, +ve signal
D2–A	31	I/O	Port A, Channel 2, –ve signal
D1+A	32	I/O	Port A, Channel 1, +ve signal
D1–A	33	I/O	Port A, Channel 1, –ve signal
D0+A	34	I/O	Port A, Channel 0, +ve signal
D0–A	35	I/O	Port A, Channel 0, –ve signal
VCC	36	Power	Supply Voltage
GND	37	GND	Ground
DDC_AUX-B	38	I/O	Port B, DDC or AUX sideband signal
DDC_AUX-A	39	I/O	Port A, DDC or AUX sideband signal
DDC_AUX–	40	I/O	Common Port, DDC or AUX sideband signal
GND	PowerPad	GND	Ground

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

		MIN	MAX	UNIT
V _{CC} _{ABSM} AX	Supply voltage range	–0.5	4.0	V
V _{I/O} - ABSMAX	Analog voltage range ^{(2) (3) (4)} All high-speed data I/O pins	–0.5	4.0	V
V _{I/O} - ABSMAX	Analog voltage range ^{(2) (3) (4)} All sideband ⁽⁵⁾ pins	–0.5	6.0	V
V _{IN} - ABSMAX	Digital input voltage range ^{(2) (3)} All control pins ⁽⁶⁾	–0.5	5.0	V
V _P - N _{ABSMAX}	Absolute value of positive pin minus negative pin All high-speed data I/O pins		0.8	V
T _{Jmax}	Maximum junction temperature TMUXHS4612	0	105	°C
T _{Jmax}	Maximum junction temperature TMUXHS4612I	–40	125	°C
T _{stg}	Storage temperature range	–65	150	°C

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2) All voltages are with respect to ground, unless otherwise specified.
- (3) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (4) V_I and V_O are used to denote specific conditions for V_{I/O}.
- (5) Sideband pins: DDC_AUX+A, DDC_AUX-A, HPD_A, DDC_AUX+B, DDC_AUX-B, HPD_B, DDC_AUX+, DDC_AUX-, HPD
- (6) Control pins: D_AB_SEL, SIDEBAND_SEL, EN

5.2 ESD Ratings

		VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, ⁽¹⁾	±1500
		Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002, ⁽²⁾	±750

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

		MIN	TYP	MAX	UNIT
V _{CC}	Supply voltage	3.0	3.3	3.6	V
V _{I/O,CM}	Input/Output common mode voltage (data pins)	0		3.6	V
V _{I/O}	Input/Output voltage data pins	0		3.6	V
V _{I/O}	Input/Output voltage sideband ⁽²⁾ pins	0		5	V
V _{IN}	Digital input voltage (control ⁽³⁾ pins)	0		V _{CC}	V
DR	Data rate for differential signals			20	Gbps
T _A	Operating ambient temperature TMUXHS4612	0		105	°C
T _A	Operating ambient temperature TMUXHS4612I	–40		125	°C
T _J	Operating junction temperature TMUXHS4612	0		110	°C
T _J	Operating junction temperature TMUXHS4612I	–40		125	°C

- (1) All unused control inputs of the device must be held at VCC or GND to ensure proper device operation. For more information, see [Implications of Slow or Floating CMOS Inputs](#) application note.
- (2) Sideband pins: DDC_AUX+A, DDC_AUX-A, HPD_A, DDC_AUX+B, DDC_AUX-B, HPD_B, DDC_AUX+, DDC_AUX-, HPD
- (3) Control pins: D_AB_SEL, SIDEBAND_SEL, EN

5.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TMUXHS4612	UNIT
		RET	
		40 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	33.0	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	25.4	°C/W
R _{θJB}	Junction-to-board thermal resistance	12.2	°C/W
ψ _{JT}	Junction-to-top characterization parameter	0.8	°C/W
ψ _{JB}	Junction-to-board characterization parameter	12.2	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	3.1	°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application note.

5.5 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER ^{(3) (4)}			TEST CONDITIONS ⁽¹⁾	MIN	TYP ⁽²⁾	MAX	UNIT
DC Characteristics (data and sideband)							
R _{ON-D}	ON-state resistance	All data pins;	V _{I/O} = 0V to VCC; I _{I/O} = −10mA; VCC = 3.3V ±10%; 0 to 85°C;		8.8	11	Ω
			V _{I/O} = 0V to VCC; I _{I/O} = −10mA; VCC = 3.3V ±10%; −40 to 125°C;		8.8	12	Ω
R _{ON-SB}	ON-state resistance	All sideband pins;	V _{I/O} = 0V to VCC; I _{I/O} = −10mA; VCC = 3.3V ±10%; 0 to 85°C;		8.2	15	Ω
			V _{I/O} = 0V to VCC; I _{I/O} = −10mA; VCC = 3.3V ±10%; −40 to 125°C;		8.2	16	Ω
R _{ON-SB-5V}	ON-state resistance	All sideband pins;	V _{I/O} = 5V; I _{I/O} = −10 mA; VCC = 3.3V ±10%; −40 to 125°C;		65	110	Ω
C _{ON-SB-100K}	Sideband ON capacitance to GND		f = 100kHz;			8	pF
C _{OFF-SB-100K}	Sideband Off capacitance to GND		f = 100kHz;			5	pF
C _{ON-SB-1M}	Sideband ON capacitance to GND		f = 1MHz;			7	pF
C _{OFF-SB-1M}	Sideband Off capacitance to GND		f = 1MHz;			4.5	pF
I _{IH-D}	Input current for high-speed data pair	All selected data pins.	EN = H; V _{I/O} = 3.3V; VCC = 3.3V ±10%;			4	μA
		All non-selected data pins.	EN = H; V _{I/O} = 3.3V; VCC = 3.3V ±10%;			70	μA
I _{IH-SB}	Input current for sideband	All selected sideband pins.	EN = H; V _{I/O} = 3.3V; VCC = 3.3V ±10%;			5	μA
		All non-selected sideband pins.	EN = H; V _{I/O} = 3.3V; VCC = 3.3V ±10%;			1	μA
I _{OFF-DAB}	Leakage under power off (failsafe current)	All data pins	VCC = 0V; V _{I/O} = 0V to 3.3V; All common pins are pulled up to 3.3V and A side and B side are at GND.		−20	100	μA
I _{OFF-SB}	Leakage under power off (failsafe current)	All sideband pins	VCC = 0V; V _{I/O} = 0V to 5.5V;		−1	5	μA
Control Inputs (SIDEBAND_SEL, D_AB_SEL, EN)							
V _{IH-CTRL}	High-level input voltage for control pins	Per pin for all control pins.	VCC = 3.3V ±10%;		1.4		V
V _{IL-CTRL}	Low-level input voltage for control pins	Per pin for all control pins.	VCC = 3.3V ±10%;			0.5	V
I _{IH-CTRL}	Input high leakage current for control pins	Per pin for all control pins.	VCC = 3.6V; V _{IN} = 3.6V;		−0.1	0.1	μA
I _{IL-CTRL}	Input low leakage current for control pins	Per pin for all control pins.	VCC = 3.6V; V _{IN} = 0V;		−0.1	0.1	μA
I _{OFF-CTRL}	Leakage under power off (failsafe current)	Per pin for all control pins.	VCC = 0V; V _{IN} = 0V or 3.6V;		−0.1	0.1	μA
C _{IN-CTRL}	Input capacitance	Per pin for all control pins.	f = 1MHz;			5	pF
Power Supply							

over operating free-air temperature range (unless otherwise noted)

PARAMETER ^{(3) (4)}		TEST CONDITIONS ⁽¹⁾	MIN	TYP ⁽²⁾	MAX	UNIT
I _{CC}	VCC supply current in active mode	EN = H; V _{I/O} = 0V or VCC;			800	μA
I _{CC-PD}	VCC supply current in power-down mode	EN = L; V _{I/O} = 0V or VCC;		0.04	32	μA

(1) V_I, V_O, I_I, and I_O refer to data and sideband I/O pins. V_{IN} refers to the control inputs.

(2) All typical values are at V_{CC} = 3.3V (unless otherwise noted), T_A = 25°C.

(3) Sideband pins: DDC_AUX+A, DDC_AUX-A, HPD_A, DDC_AUX+B, DDC_AUX-B, HPD_B, DDC_AUX+, DDC_AUX-, HPD

(4) Control pins: D_AB_SEL, SIDEBAND_SEL, EN

5.6 High-Speed Performance Parameters

over recommended operation free-air temperature range, (unless otherwise noted). For all data pins. R_L = 50Ω where applicable.

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
BW _{SB}	Sideband pins differential bandwidth (–3dB from DC)			2.0		GHz
BW _{HS}	High-speed pins differential bandwidth (–3dB from DC)			13		GHz
IL _{DAB}	Differential insertion loss	At 100MHz; VCM = 0V;		–0.7		dB
		At 1.7GHz; VCM = 0V;		–1.0		dB
		At 2.7GHz; VCM = 0V;		–1.1		dB
		At 4.0GHz; VCM = 0V;		–1.2		dB
		At 6.0GHz; VCM = 0V;		–1.6		dB
		At 10.0GHz; VCM = 0V;		–2.5		dB
RL _{DAB}	Differential return loss	At 100MHz; VCM = 0V;		–23		dB
		At 1.7GHz; VCM = 0V;		–22		dB
		At 2.7GHz; VCM = 0V;		–20		dB
		At 4.0GHz; VCM = 0V;		–19		dB
		At 6.0GHz; VCM = 0V;		–18		dB
		At 10.0GHz; VCM = 0V;		–13		dB
Xtalk	Differential crosstalk	At 100MHz; VCM = 0V;		–66		dB
		At 1.7GHz; VCM = 0V;		–40		dB
		At 2.7GHz; VCM = 0V;		–37		dB
		At 4.0GHz; VCM = 0V;		–44		dB
		At 6.0GHz; VCM = 0V;		–45		dB
		At 10.0GHz; VCM = 0V;		–30		dB
OISO	Differential off isolation	At 100MHz; VCM = 0V;		–65		dB
		At 1.7GHz; VCM = 0V;		–37		dB
		At 2.7GHz; VCM = 0V;		–33		dB
		At 4.0GHz; VCM = 0V;		–30		dB
		At 6.0GHz; VCM = 0V;		–27		dB
		At 10.0GHz; VCM = 0V;		–23		dB

(1) All Typical Values are at V_{CC} = 3.3V (unless otherwise noted), T_A = 25°C.

5.7 Switching Characteristics

PARAMETER			MIN	TYP	MAX	UNIT
Device Switching Time						
t _{SW_POWER_ON}	Device power ON time	EN pin from L to H;			200	μs
t _{SW_POWER_OFF}	Device power OFF time	EN pin from H to L;			400	ns
High Speed Pins						
t _{PD}	Switch differential propagation delay	f = 1GHz		60		ps
t _{SW_AB}	Switching time from A to B	Measured from 50% of select to 50% of VOH/VOL			40	μs
t _{SW_BA}	Switching time from B to A	Measured from 50% of select to 50% of VOH/VOL			40	μs
t _{SK_INTRA}	Intra-pair output skew between + and - pins for same channel	f = 1GHz		1.8	6	ps
t _{SK_INTER}	Inter-pair output skew between channels	f = 1GHz			8	ps
Sideband Pins						
t _{PD-SB}	Switch single-ended propagation delay	f = 1MHz			250	ps
t _{SW-SB_AB}	Switching time from A to B	Measured from 50% of select to 50% of VOH/VOL			20	μs
t _{SW-SB_BA}	Switching time from B to A	Measured from 50% of select to 50% of VOH/VOL			20	μs
t _{SK-SB}	Output skew between DDC_AUX+ and DDC_AUX- pins	f = 1MHz			8	ps

5.8 Typical Characteristics

Data taken from a single unit under nominal power supply and temperature conditions with $V_{I/O,CM}$ at 0V.

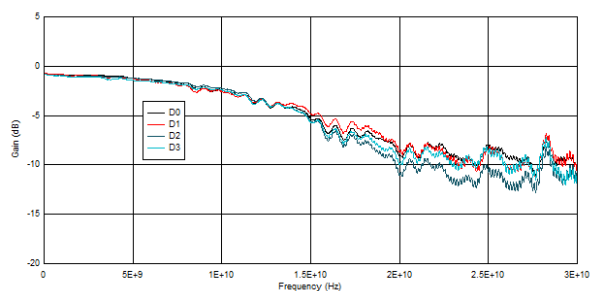


Figure 5-1. Differential Insertion Loss for port A

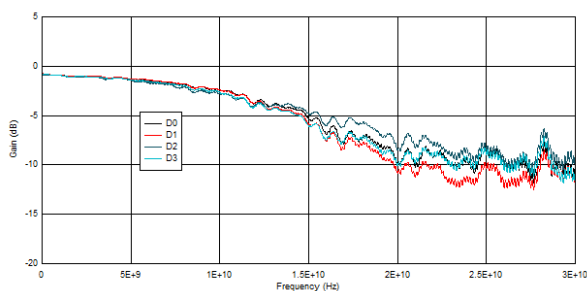


Figure 5-2. Differential Insertion Loss for port B

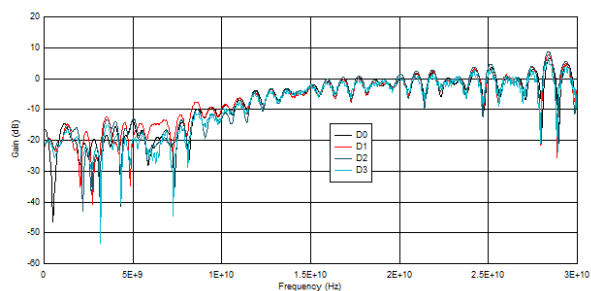


Figure 5-3. Input Differential Return Loss when port A is selected

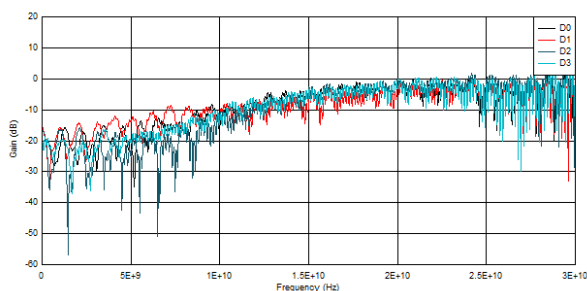


Figure 5-4. Output Differential Return Loss when port A is selected

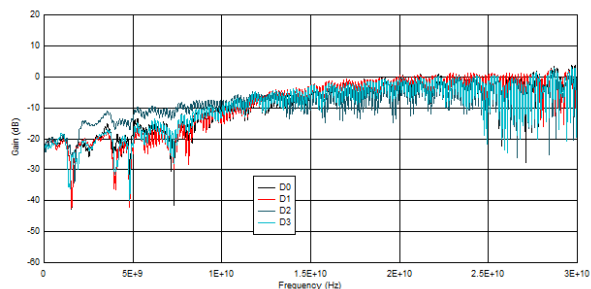


Figure 5-5. Output Differential Return Loss when port B is selected

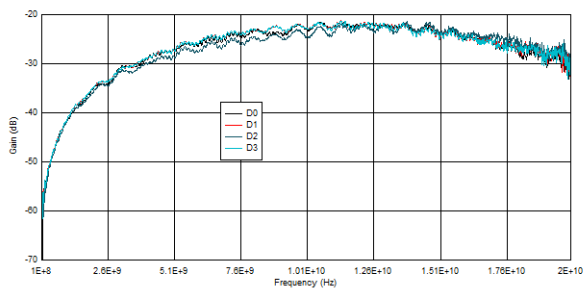


Figure 5-6. Off-State Isolation (OISO) for port A

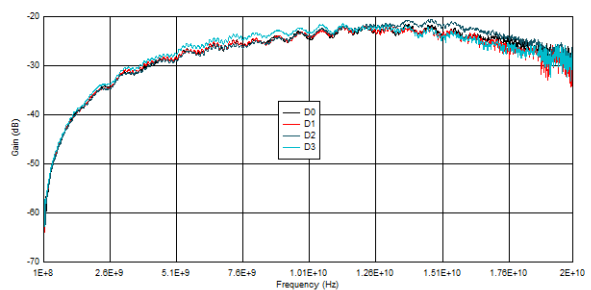


Figure 5-7. Off-State Isolation (OISO) for port B

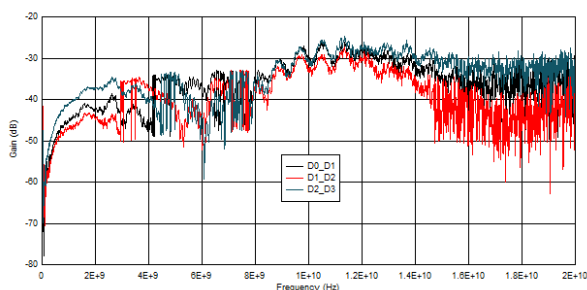
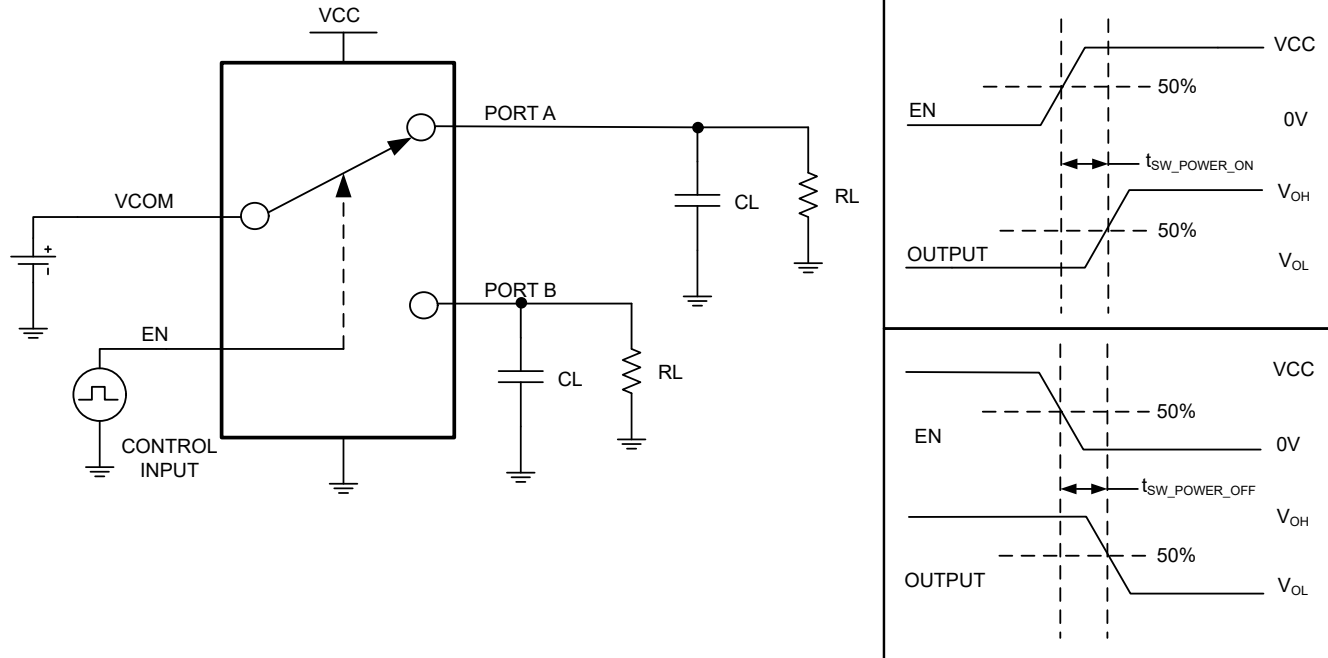


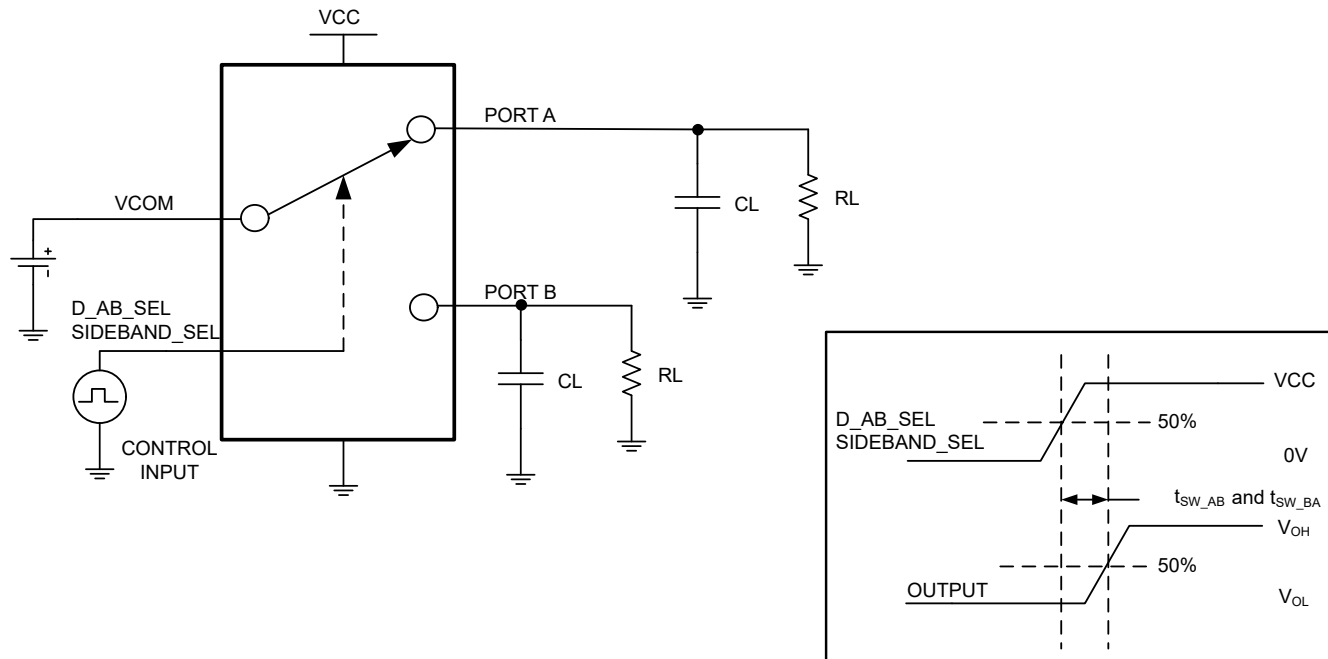
Figure 5-8. Crosstalk (Xtalk) between channels on common port side

6 Parameter Measurement Information



NOTE: $R_L = 10k\Omega$; $V_{COM} = V_{CC}$; $C_L = 1pF$

Figure 6-1. Switch Turn-On Time ($t_{SW_POWER_ON}$ and $t_{SW_POWER_OFF}$)



$R_L = 10k\Omega$; $V_{COM} = V_{CC}$; $C_L = 1pF$

Figure 6-2. Switching Time Between Channels (t_{SW_AB} and t_{SW_BA})

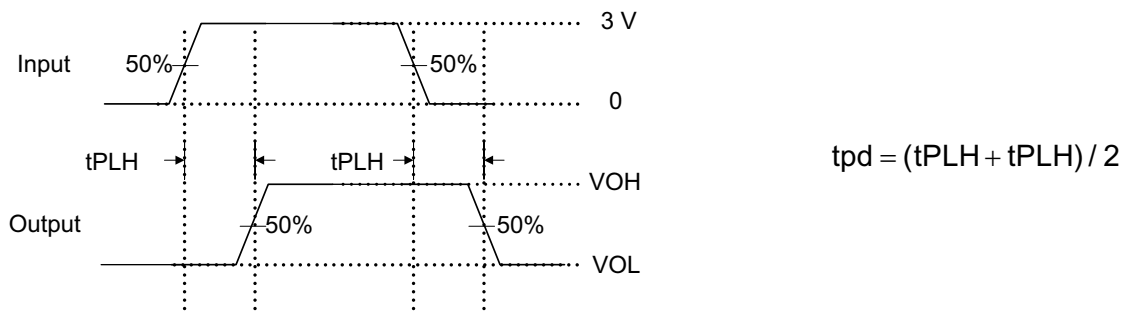


Figure 6-3. Propagation Delay (t_{pd})

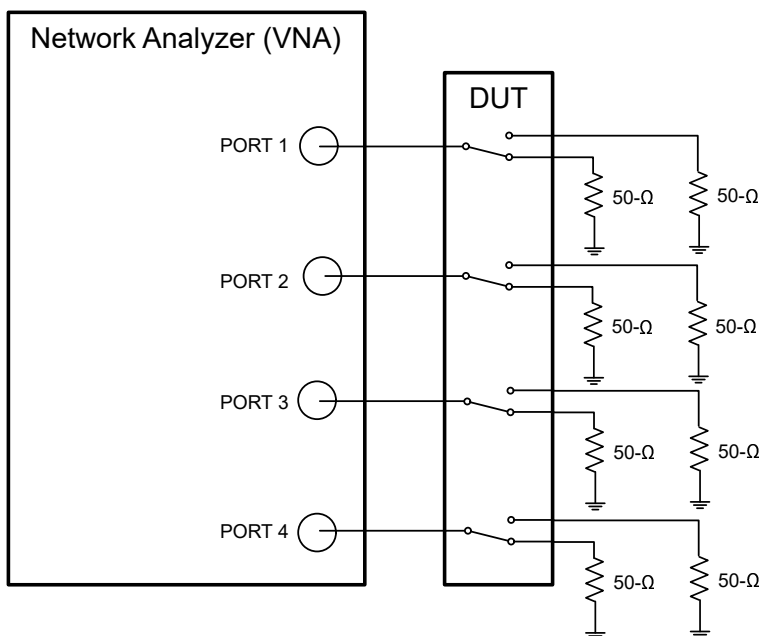


Figure 6-4. Crosstalk (Xtalk)

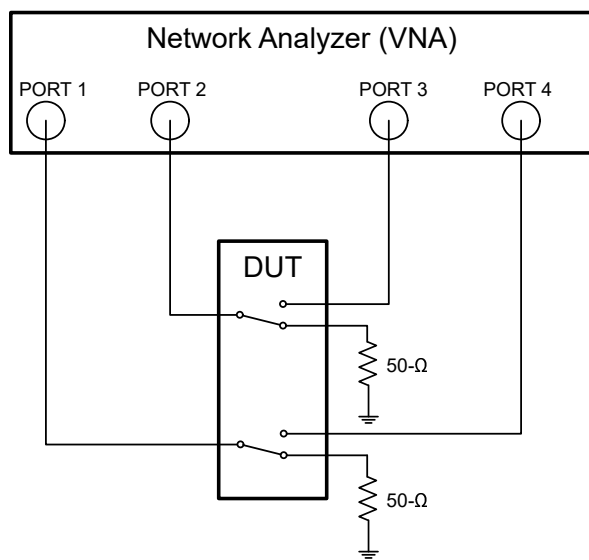


Figure 6-5. Differential Off-Isolation (OISO)

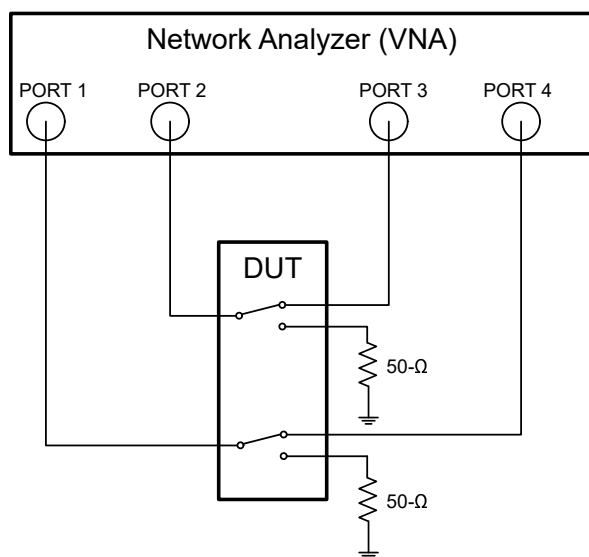


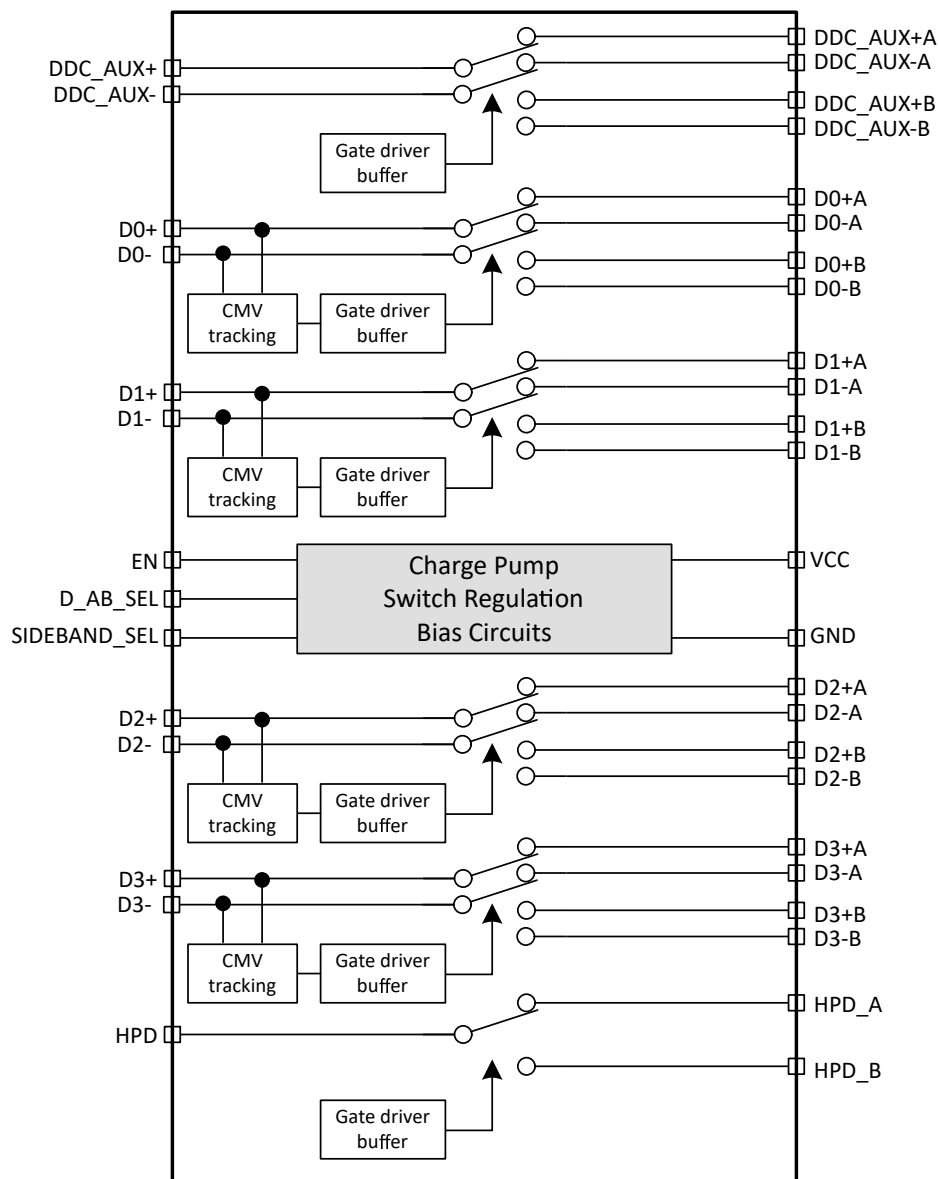
Figure 6-6. Differential Bandwidth (BW), Insertion Loss, and Return Loss

7 Detailed Description

7.1 Overview

The TMUXHS4612 is a protocol agnostic bidirectional multiplexer/demultiplexer that offers low on-state resistance as well as low I/O capacitance, which allows the device to achieve a high bandwidth of 13.0GHz typical for differential channels. The TMUXHS4612 is a passive mux that is recommended for data rates up to 20Gbps. However, the device can be used for interfaces with higher data rates if overall electrical link loss permits. The high-speed data channels of the device provide the high bandwidth necessary for many interfaces to handle differential as well as single-ended signals as long as the single-ended signals do not violate V_{P-N_ABSMAX} . The high-speed channels of the device support differential signaling with common-mode voltage range (CMV) of 0V to 3.6V that can be used in high common-mode interfaces such as HDMI. The sideband channels are 5V tolerant. The sideband channels support 0V to 3.6V CMOS signals with a typical R_{ON} of 8.5Ω and 5V CMOS signals with a typical R_{ON} of 65Ω.

7.2 Functional Block Diagram



7.3 Feature Description

The TMUXHS4612 is based on proprietary TI technology which uses FET switches driven by a high-voltage generated from an integrated charge-pump to achieve a low on-state resistance. The TMUXHS4612's low power technology uses only 800µA in active and just 32µA in powerdown (EN = L) mode. The device has integrated ESD that can support up to 1.5kV Human-Body Model (HBM) and 750V Charge Device Model (CDM). The TMUXHS4612 also has a special feature that prevents the device from back-powering when the V_{CC} supply is not available and an analog signal is applied on the I/O pin. In this situation this special feature prevents leakage current in the device. The TMUXHS4612 is not designed for passing signals with negative swings.

7.4 Device Functional Modes

Table 7-1 lists the device functions for the TMUXHS4612 device.

Table 7-1. Functional Table

EN	D_AB_SEL	SIDEHAND_SEL	FUNCTION
L	X	X	Switch disabled. All channels are Hi-Z.
H	L	L	All A channels are enabled. All B channels are Hi-Z.
H	L	H	All A data high-speed channels are enabled and B sideband channels are enabled. All other channels are Hi-Z.
H	H	L	All B data high-speed channels are enabled and A sideband channels are enabled. All other channels are Hi-Z.
H	H	H	All B channels are enabled. All A channels are Hi-Z.

8 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The TMUXHS4612 is a generic analog differential passive mux or demux that works for many high-speed differential interfaces with data rates up to 20Gbps. The TMUXHS4612 supports differential signaling with common-mode voltage range (CMV) of 0V to 3.6V and with differential amplitude up to 1600mVpp in Dxx channels. The device can be also used for single-ended CMOS signals with swing limited to 0V to 3.6V in sideband channels. The TMUXHS4612 can be used as mux or demux switch for:

- HDMI 1.4 up to 3.4Gbps, HDMI 2.0 up to 6Gbps and HDMI 2.1 up to 12Gbps
- DisplayPort (DP) for up to UHBR20 for data rates up to 20Gbps
- USB4 and Thunderbolt (TBT) 3 or 4 for data rates up to 20Gbps

8.2 Typical Application - HDMI

The TMUXHS4612 can be used to switch HDMI signals in both source and sink applications. In source applications HDMI port from a graphics processor can be demultiplexed into one of the two HDMI connectors. In a PC the TMUXHS4612 can be used to switch integrated graphics versus discrete graphics to a connector. In a sink application the device also can be used to select between two HDMI connectors to provide HDMI signals into a scaler (SOC) in HDMI sink application. This section provides detailed design implementation for a sink application where TMUXHS4612 provides 2:1 demultiplexing function.

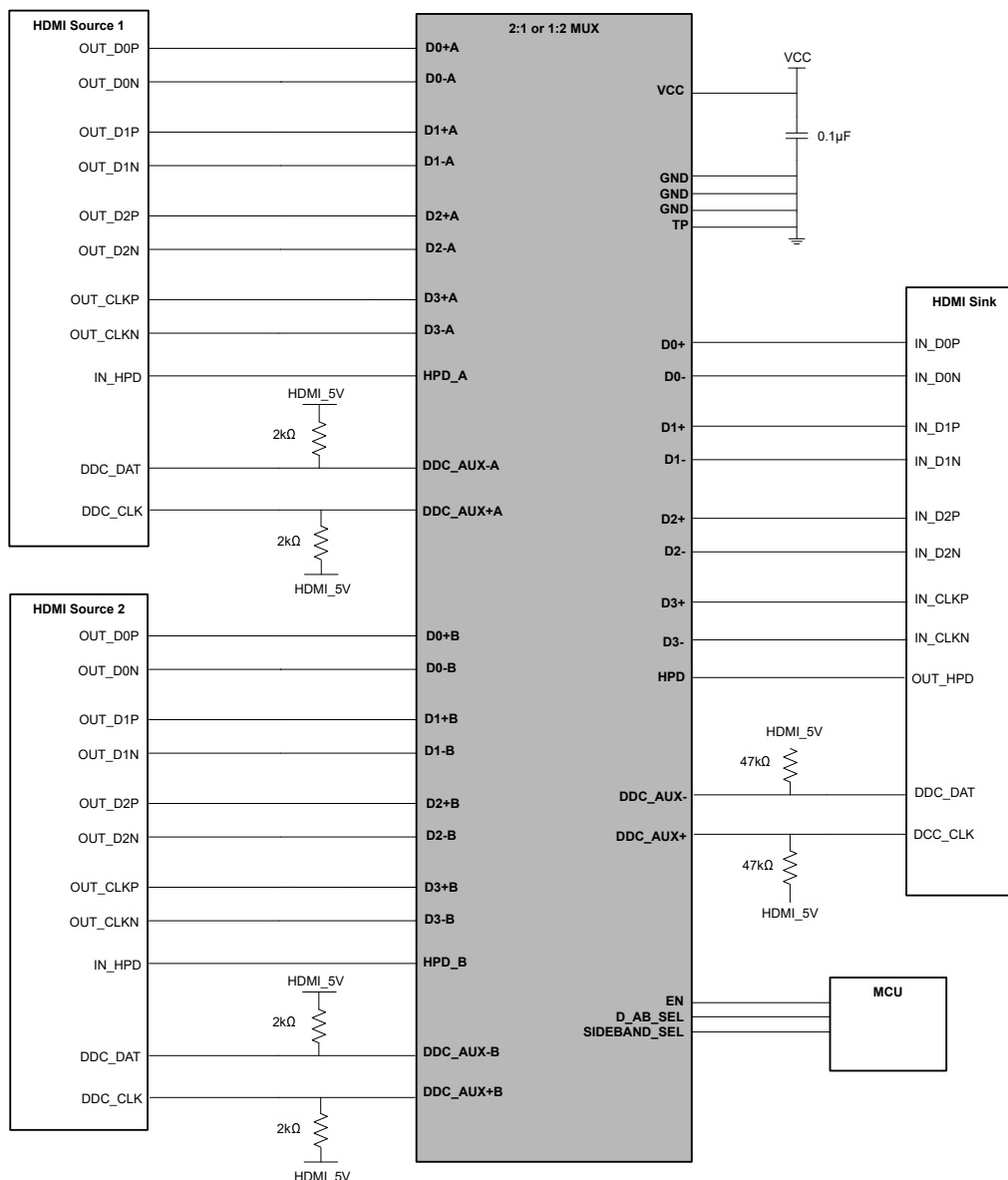


Figure 8-1. Choosing One of Two HDMI Port - Application Schematic

8.2.1 Design Requirements

Table 8-1 lists the design parameters for this HDMI example.

Table 8-1. Design Parameters for HDMI Application

Design parameter	Example value
V _{CC}	3V to 3.6V
VCC decoupling capacitor	0.1µF
DDC Pullup resistors	Sink Side: 47kΩ to 5V Source Side: 2kΩ to 5V

8.2.2 Detailed Design Procedure

The TMUXHS4612 is designed to operate with 3.0V to 3.6V power supply. Decoupling capacitors can be used to reduce noise and improve power supply integrity. Pullup resistors to 5V must be placed on the source side DDC clock and data lines according to the HDMI standard.

In the HDMI standard the DDC clock, DDC data, and HPD lines are at 5V levels. In some use cases the HDMI source or sink may not be able to handle 5V levels. If this is the case, then an external level shifter must be deployed in order to level shift the HDMI signals to an acceptable level. Figure 8-2 shows an example implementation of an I²C level shifter such as Texas Instruments TCA9517. In this example the HDMI sources are subjected to HDMI levels up to VCC_A (such as 3.3V) instead of HDMI 5V.

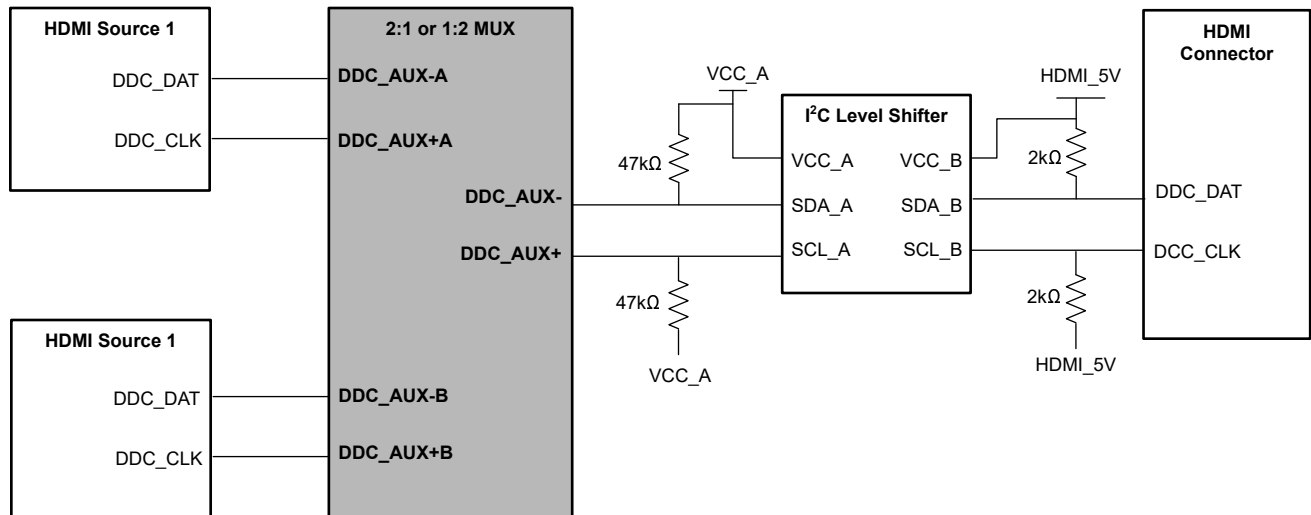


Figure 8-2. DDC level shifter source side example

8.2.3 Application Curves

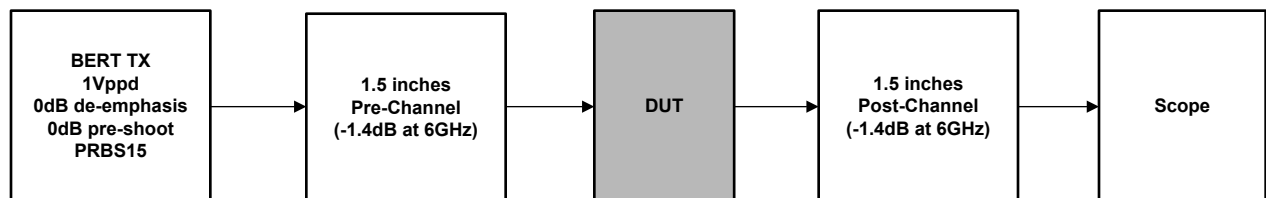


Figure 8-3. Test Setup

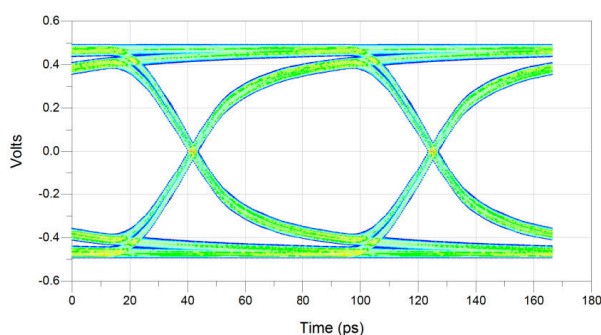


Figure 8-4. Eye Pattern: 12Gbps, No Device Through Path (Only One Channel Measured at a Time)

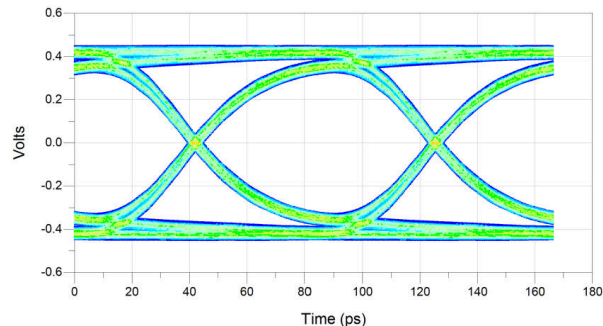


Figure 8-5. Eye Pattern: 12Gbps Port B, D0+ to D0+B, D0- to D0-B (Only One Channel Measured at a Time)

8.3 Power Supply Recommendations

Keep the V_{CC} in the range of 3.0V to 3.6V. Do not use voltage levels above those listed in the *Absolute Maximum Ratings* table. Use decoupling capacitors to reduce noise and improve power supply integrity. There are no power sequence requirements for the TMUXHS4612.

8.4 Layout Guidelines

To ensure reliability of the device, the following commonly used printed circuit board layout guidelines are recommended:

- Use decoupling capacitors between power supply pin and ground pin to ensure low impedance to reduce noise. To achieve a low impedance over a wide frequency range use capacitors with a high self-resonance frequency.
- Place ESD and EMI protection devices (if used) as close as possible to the connector.
- Use short trace lengths to avoid excessive loading.
- Keep traces at least two times the trace width apart to minimize the effects of crosstalk on adjacent traces.
- Separate high-speed signals from low-speed signals and digital from analog signals
- Avoid right-angle bends in a trace and try to route them at least with two 45° corners.
- Route the high-speed differential signal traces parallel to each other as much as possible. The traces are recommended to be symmetrical.
- Place a solid ground plane next to the high-speed signal layer. This also provides an excellent low-inductance path for the return current flow.

8.4.1 Layout Example

The TMUXHS4612 application with a single controller interfacing between a common port and two separate ports.

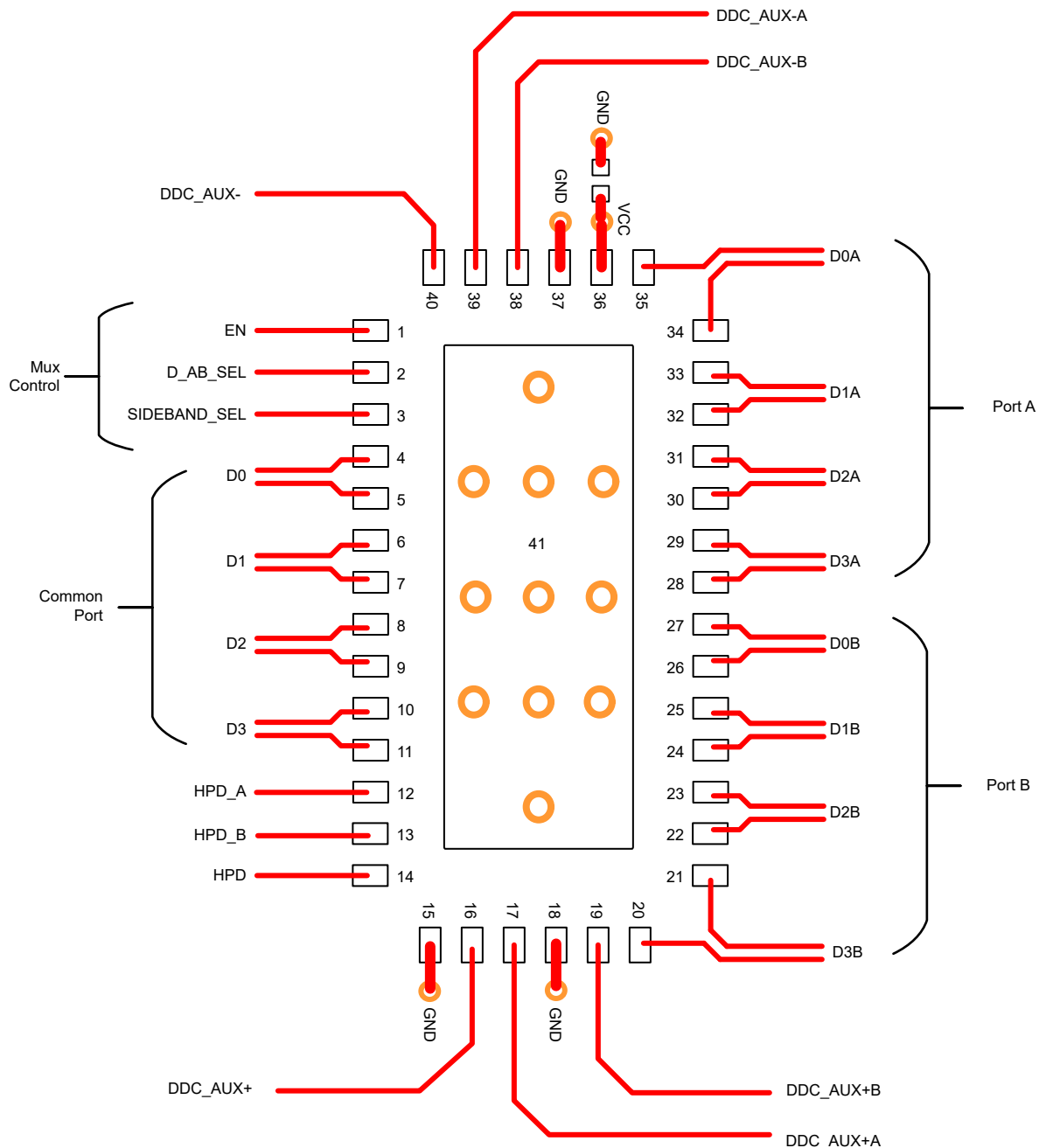


Figure 8-6. Layout Example

8.5 Component Placement Guidelines

The external components need to be placed as close as possible to the device to minimize signal loss. For larger trace lengths, the signal loss may lead to the protocol compliance failure. [Table 8-2](#) summarizes the maximum values of trace length (assuming FR4 dielectric) that TMUXHS4612 can support to meet the protocol compliance without any additional equalization.

Table 8-2. Maximum trace length TMUXHS4612 can support

Protocol	Signal source assumption	Maximum trace length supported
HDMI1.4	+/- 400mV PRBS 15 sequence	8"
HDMI2.0	+/- 300mV PRBS 15 sequence	6"
HDMI2.1	+/- 300mV PRBS 15 sequence	8"
DP2.1	+/- 300mV PRBS 15 sequence	5"

8.6 Systems Examples

8.6.1 DisplayPort 2:1 Multitplexing

The TMUXHS4612 supports AC-coupled interfaces such as DisplayPort. External ac-coupling capacitors must be used on either the common side or the non-common side of the device. In this particular example, the external AC-coupling capacitors are placed on the non-common side. The common side is DC-coupled to the DP sink. The choice of DC-coupling the non-common side or the common side is based on which DP source or DP sink meets the $V_{IO,CM}$ requirement of the device. If the DP source does not comply to the $V_{IO,CM}$ requirement, then place the AC-coupling capacitors between the DP source and TMUXHS4612. If the DP sink does not comply to the $V_{IO,CM}$ requirement, then place the AC-coupling capacitors between the DP sink and TMUXHS4612.

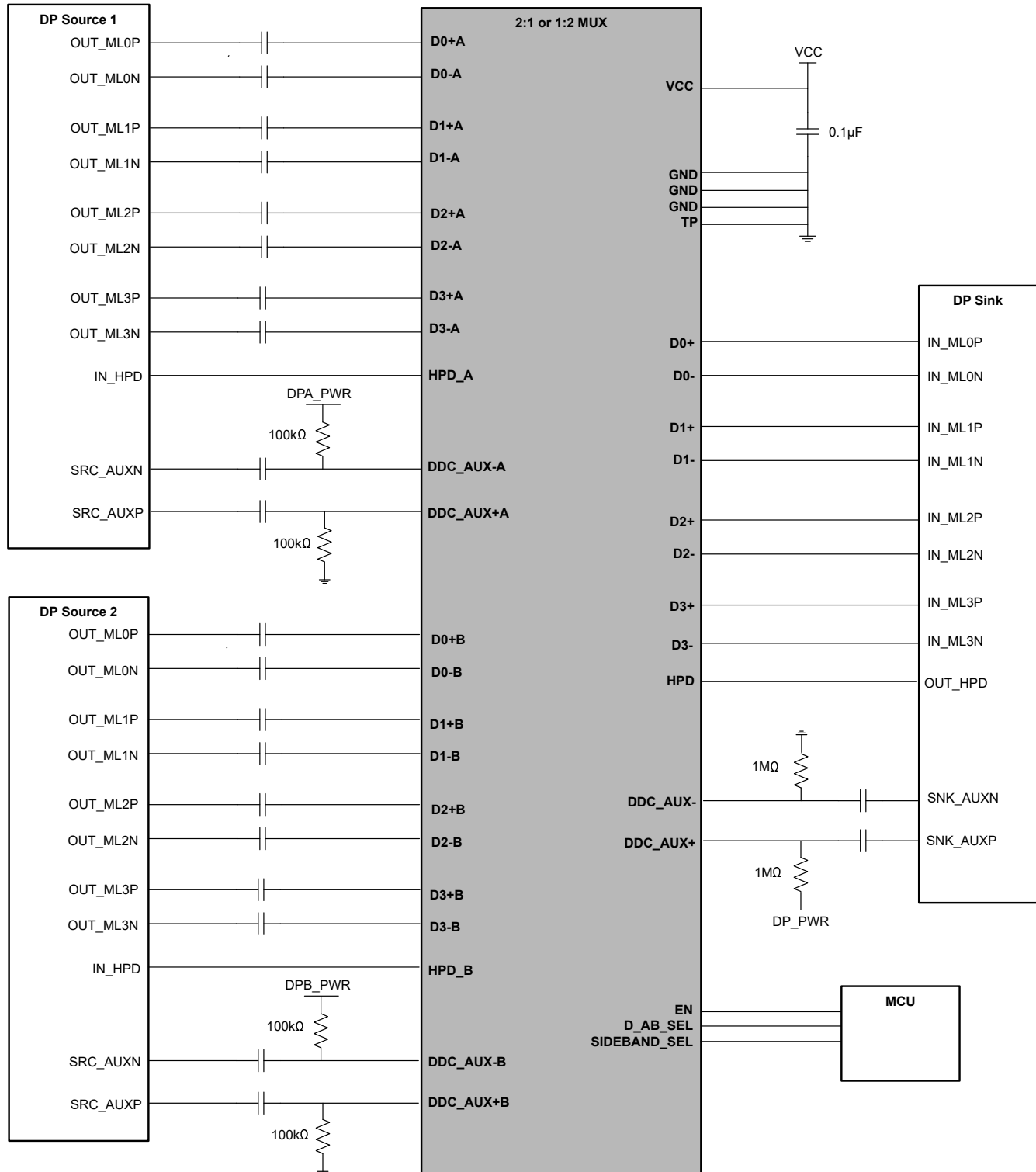


Figure 8-7. DisplayPort 2:1 Switching

8.6.2 DisplayPort 1:2 Multiplexing

The TMUXHS4612 supports AC-coupled interfaces such as DisplayPort. External AC-coupling capacitors must be used on either the common side or the non-common side of the device. In this particular example, the external AC-coupling capacitors are placed on the common side. The non-common side is DC-coupled to the

DP sinks. The choice of DC-coupling the non-common side or the common side is based on which DP source or DP sink meets the $V_{IO,CM}$ requirements of the device. If the DP source does not comply to the $V_{IO,CM}$ requirement, then place the AC-coupling capacitors between the DP source and TMUXHS4612. If the DP sink does not comply to the $V_{IO,CM}$ requirement, then place the AC-coupling capacitors between the DP sink and TMUXHS4612.

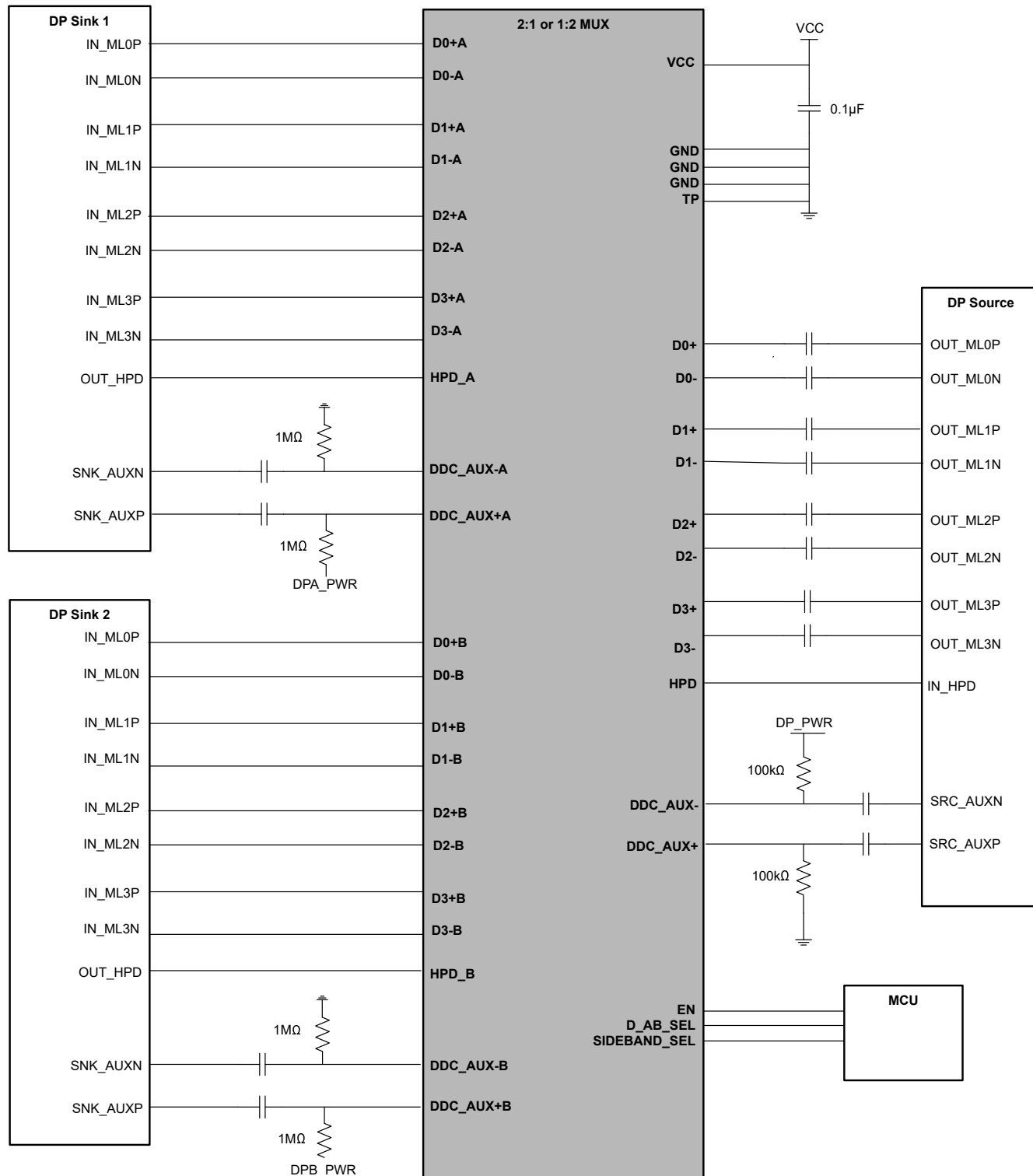


Figure 8-8. DisplayPort 1:2 Switching

9 Device and Documentation Support

9.1 Third-Party Products Disclaimer

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9.2 Documentation Support

9.2.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [Implications of Slow or Floating CMOS Inputs application note](#).

9.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](#). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.4 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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9.6 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.7 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (November 2024) to Revision B (January 2025)	Page
• Updated Simplified Use Cases figure.....	1
• Added Component Placement Guidelines.....	19

Changes from Revision * (June 2024) to Revision A (November 2024)	Page
• Changed data sheet status from: Advanced Information to: Production Data.....	1

11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TMUXHS4612IRETR	Active	Production	WQFN (RET) 40	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TMX412
TMUXHS4612IRETR.A	Active	Production	WQFN (RET) 40	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TMX412
TMUXHS4612IRETT	Active	Production	WQFN (RET) 40	250 SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TMX412
TMUXHS4612IRETT.A	Active	Production	WQFN (RET) 40	250 SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TMX412
TMUXHS4612RETR	Active	Production	WQFN (RET) 40	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	0 to 105	TMX412
TMUXHS4612RETR.A	Active	Production	WQFN (RET) 40	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	0 to 105	TMX412
TMUXHS4612RETT	Active	Production	WQFN (RET) 40	250 SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	0 to 105	TMX412
TMUXHS4612RETT.A	Active	Production	WQFN (RET) 40	250 SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	0 to 105	TMX412

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMUXHS4612IRETR	WQFN	RET	40	3000	330.0	16.4	3.3	6.3	1.0	8.0	16.0	Q1
TMUXHS4612IRETT	WQFN	RET	40	250	180.0	16.4	3.3	6.3	1.0	8.0	16.0	Q1
TMUXHS4612RETR	WQFN	RET	40	3000	330.0	16.4	3.3	6.3	1.0	8.0	16.0	Q1
TMUXHS4612RETT	WQFN	RET	40	250	180.0	16.4	3.3	6.3	1.0	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMUXHS4612IRETR	WQFN	RET	40	3000	367.0	367.0	38.0
TMUXHS4612IRETT	WQFN	RET	40	250	213.0	191.0	35.0
TMUXHS4612RETR	WQFN	RET	40	3000	367.0	367.0	38.0
TMUXHS4612RETT	WQFN	RET	40	250	213.0	191.0	35.0

WQFN - 0.8 mm max height

[illegible]

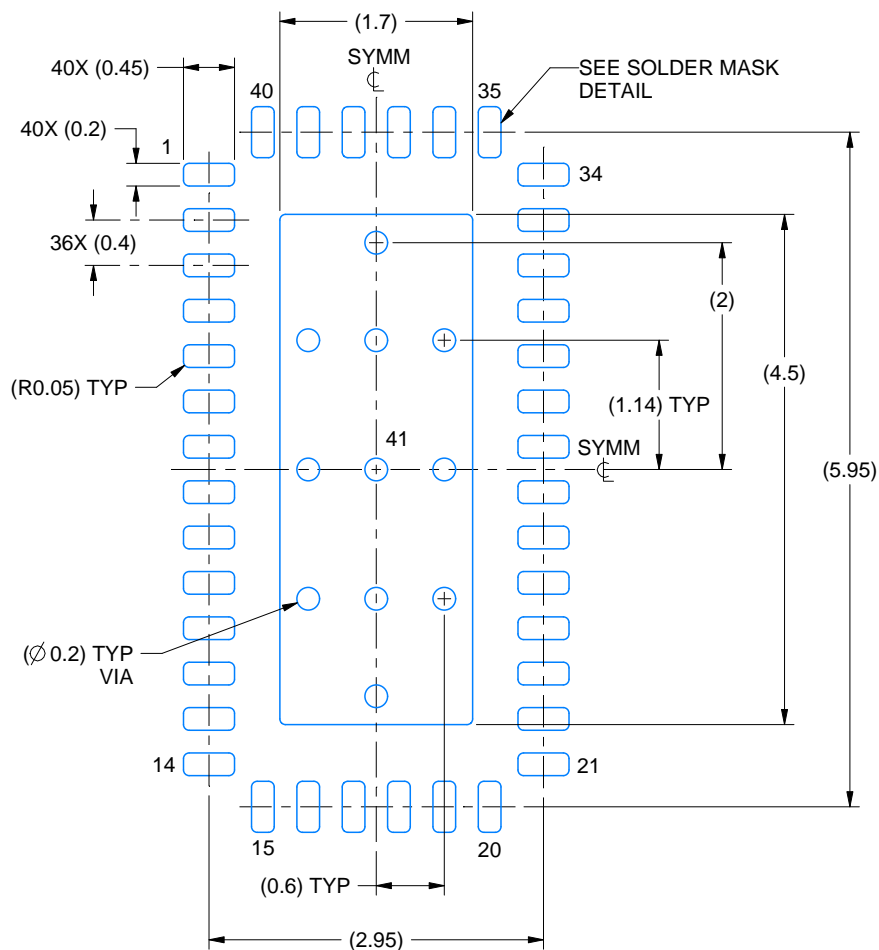
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

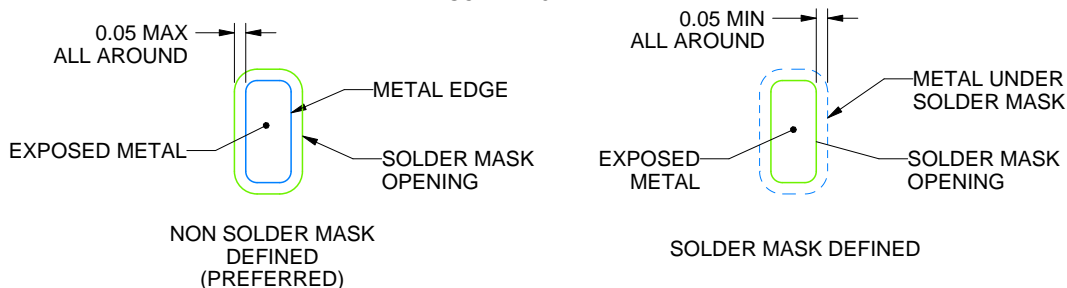
RET0040A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X



SOLDER MASK DETAILS

4229203/A 11/2022

NOTES: (continued)

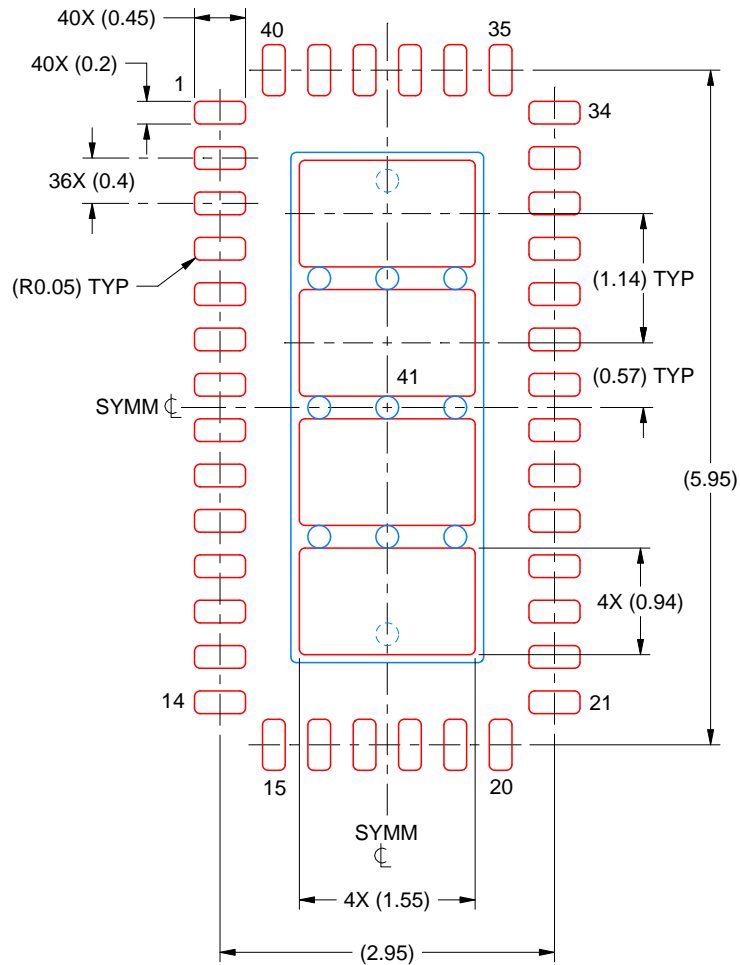
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

RET0040A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 15X

EXPOSED PAD 41
76% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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