

► Integrating Spectrum Cards in Dolphin PCIe Expansion Systems

PCIe Expansion with Spectrum Cards

Using PCIe expansion systems in combination with PCIe digitizers, AWGs and Digital I/O card is an easy and flexible approach to overcome the limitations of PC systems.

This whitepaper discussed different combination of Spectrum instrument cards and Dolphin expansion systems and summarizes a number of setups that have been tested in Spectrum lab with hardware.

An expansion system is helpful if free slots are limited in the host PC, for giving the flexibility to update the host system independently, for sharing a bunch of PCIe card throughout different systems, for locating the analog inputs and outputs near the device under test using optical fiber connection or for allowing the usage of synchronized PCIe cards inside a PXIe system.



Spectrum Instrumentation GmbH, Germany

<https://spectrum-instrumentation.com>

Spectrum Instrumentation GmbH specializes in the production of high speed digitizers, arbitrary waveform generators (AWGs), DDS generators and digital I/O products designed for various standards such as PCIe (PCI Express), PXIe or the Ethernet-based LXI. The high-speed digitizer portfolio covers the medium and high-speed ranges with sampling rates between 5 MS/s and 10 GS/s. The bandwidth can reach more than 4 GHz.



Spectrum Instrumentation's arbitrary waveform generators excel with high channel densities that far surpass standard signal generators, all at a very good price/performance ratio. Our AWGs are available with output rates ranging from 40 MS/s to 10 GS/s and bandwidths that can exceed 2 GHz.

All high speed digitizers, AWGs, DDS and digital I/O products are designed for high continuous data throughput and can be used to create streaming systems with continuous, gapless recording in the GHz range

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Dolphin is a leader in PCI Express Software and Hardware for multi-computing systems. Since 1992, Dolphin has developed multi-computing and IO solutions for embedded, scientific, and OEM application.



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► **Integrating Spectrum Cards in Dolphin PCIe Expansion Systems**

Dolphin passive backplane technology

The passive backplanes from Dolphin contain no active components. Each PCIe slot on the backplane is directly routed via PCB traces to a discrete downstream port on the adapter board. The adapter board integrates a Microchip PCIe switch that serves both as the host uplink interface and the downstream switch fabric for all backplane slots.

The host CPU sees a fully transparent PCIe topology; endpoints enumerate identically to locally installed cards with no special software required.



Dolphin PCIe Expansion solutions eBox 4

The eBox 4 is a flexible, standard and cost-effective expansion solution design to host PCIe cards with small to medium speed and power requirement. It can house up to 8 M2p or M4i cards or even 4 M5i cards. Depending on the configuration, M4i and M5i cards may not receive full PCIe performance. The eBox 4 can be configured with any combination of 1 or 2 backplane, to host from 1 to 8 Spectrum Cards.

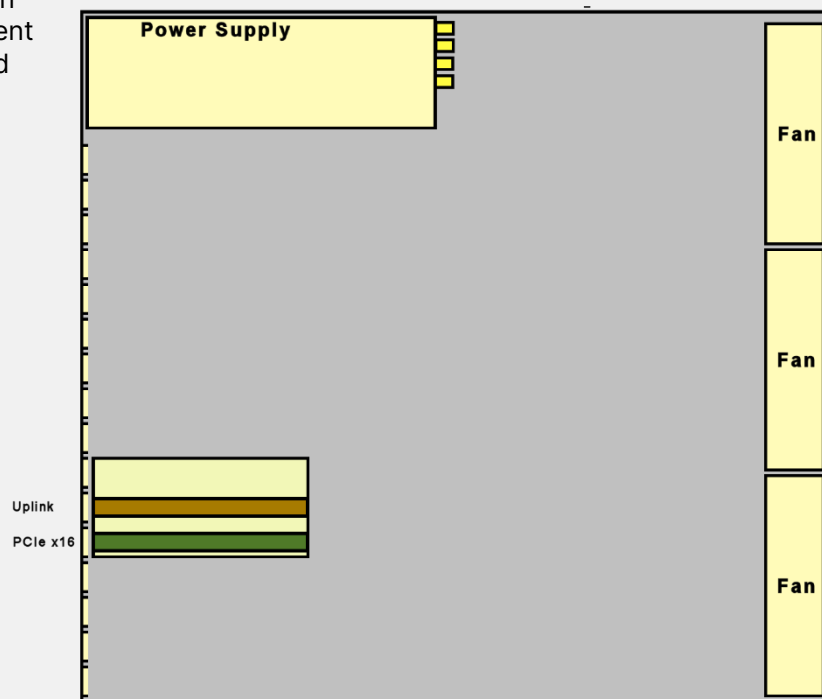
Each backplane requires it to be equipped with the target adapter card and the connection with the computing system is done with host adapter card(s) and a cable set.

The configurations outlined hereafter are some of the standard products from Dolphin, however more configurations can be made available.

eBox with single 2-slot backplane (CONF_A)

Model MXE520A0

One card up to PCIe x16 connector can be used. The solution provides sufficient data throughput to maintain full-speed operation over PCIe x16 interfaces compliant with PCIe standards up to PCIe 5.0.



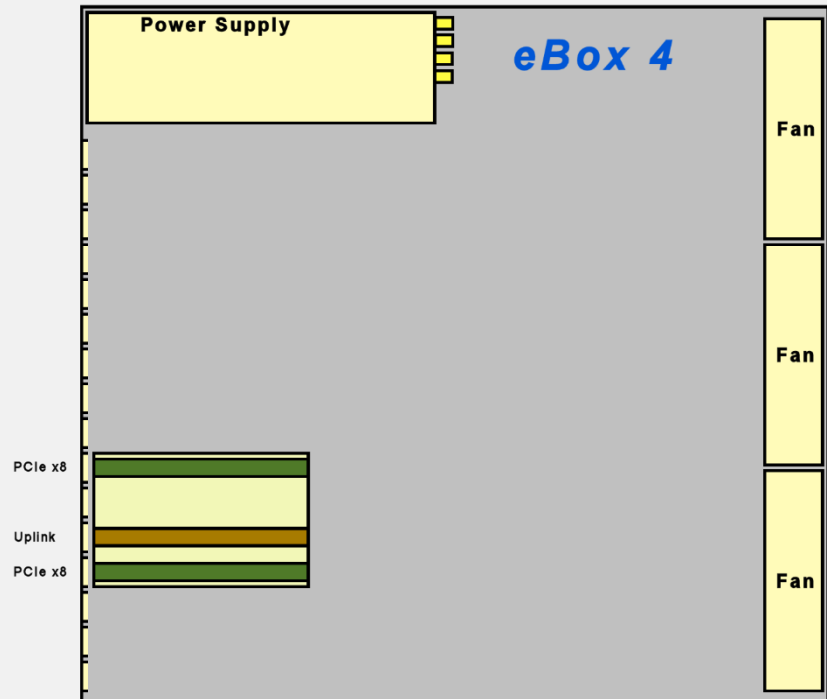


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eBox with single 3-slot backplane (CONF_B)

Model MXE52OC0

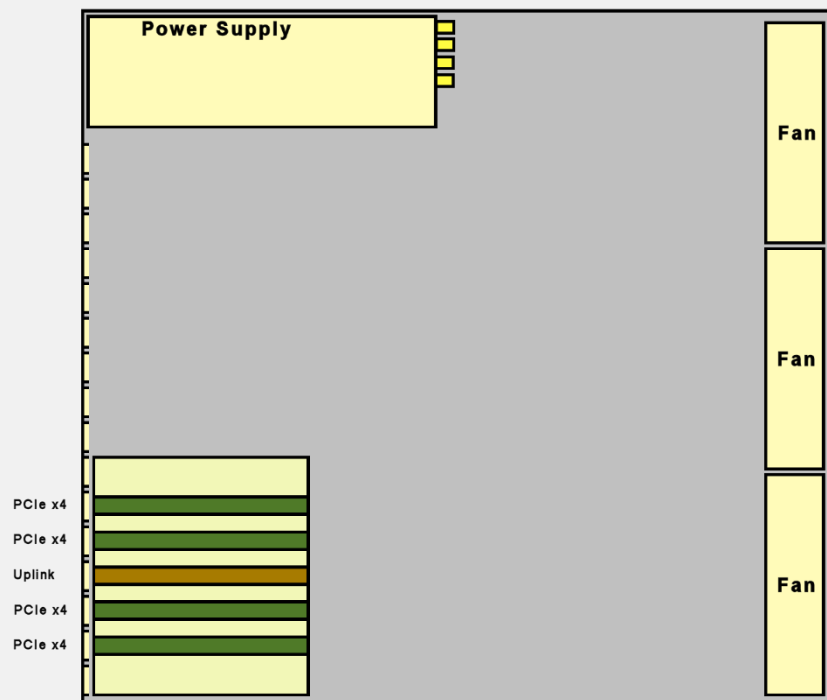
Two cards up to PCIe x16 connector can be used. The solution provides sufficient data throughput to maintain full-speed operation over PCIe x8 interfaces compliant with PCIe standards up to PCIe 5.0.



eBox with single 5-slot backplane (CONF_C)

Model MXE52OD0

Up to 4 cards up to PCIe x16 connector can be used. The solution provides sufficient data throughput to maintain full-speed operation over PCIe x4 interfaces compliant with PCIe standards up to PCIe 5.0.



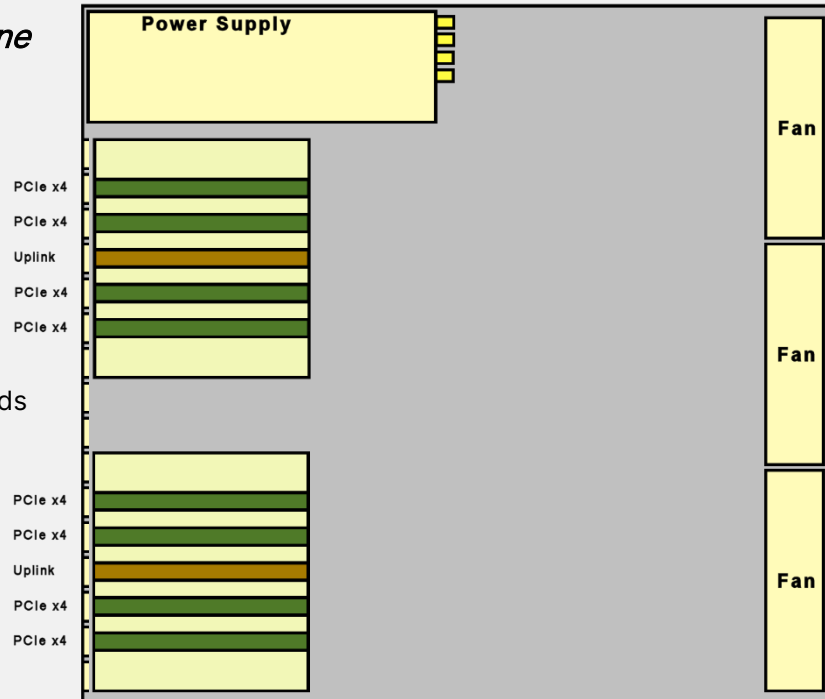


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eBox with dual 5-slot backplane (CONF_D)

Model MXE52DD0

Up to 8 cards up to PCIe x16 connector can be used. The solution provides sufficient data throughput to maintain full-speed operation over PCIe x4 interfaces compliant with PCIe standards up to PCIe 5.0. For full 8x PCIe x4 performance, two host interface cards are needed.



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Dolphin PCIe Expansion eBox 4 Pro

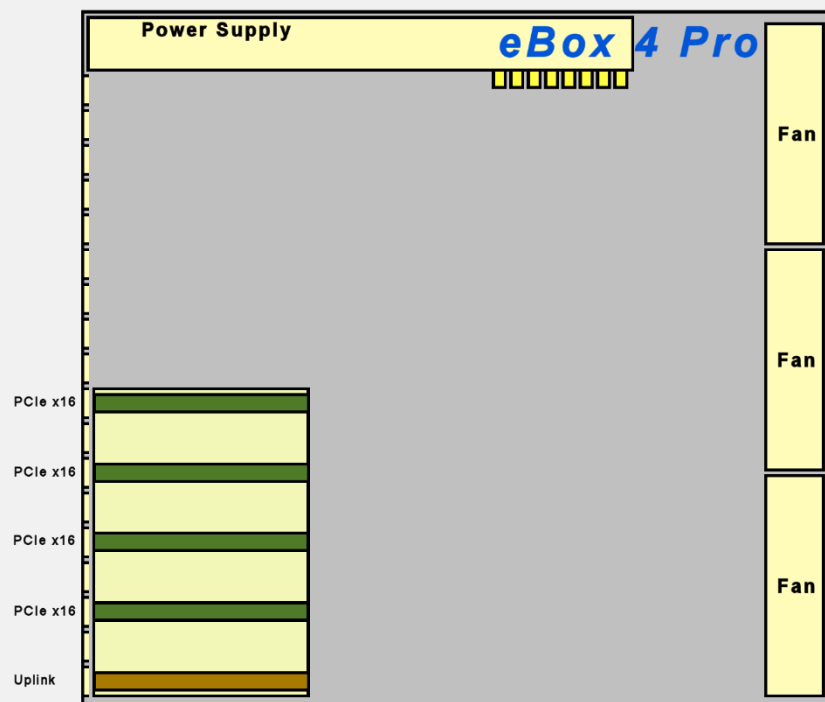
The eBox 4 Pro is the high-end model which can be used for high-demanding applications requiring more power, up to PCIe 5.0 data throughput and double-width slots. It can house up to eight spectrum cards, even eight M5i cards. 3 configuration options are available.

eBox Pro with single 5-slot backplane (CONF_E)

This configuration allows to house up to four Spectrum cards with single-width or double-width.

The M5i star-hub can be mounted on the top-most card, allowing a configuration of 4x M5i cards with star-hub.

The connection allows to run all 4 slots with full PCIe x16 PCIe 3.0 speed.





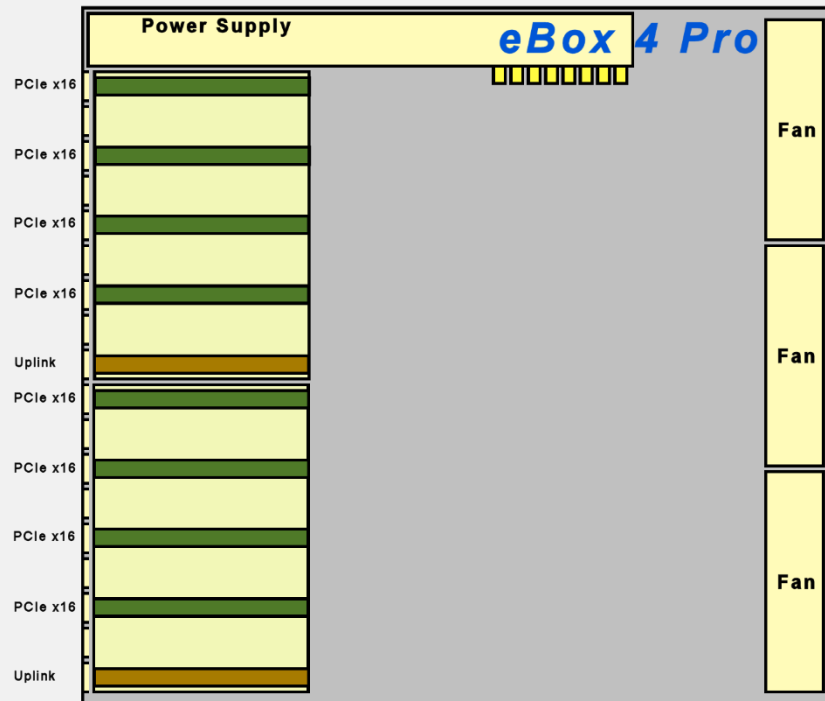
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eBox Pro with dual 5-slot backplane (CONF_F)

This configuration allows to house up to eight Spectrum cards of single-width or dual-width.

When equipped with 8x M5i card, mounting an additional star-hub is NOT possible. Please check the dual 5-slot crosslinked backplane option further below.

This version needs two separate host controllers. The connection allows to run all eight slots with full PCIe x16 PCIe 3.0 speed.

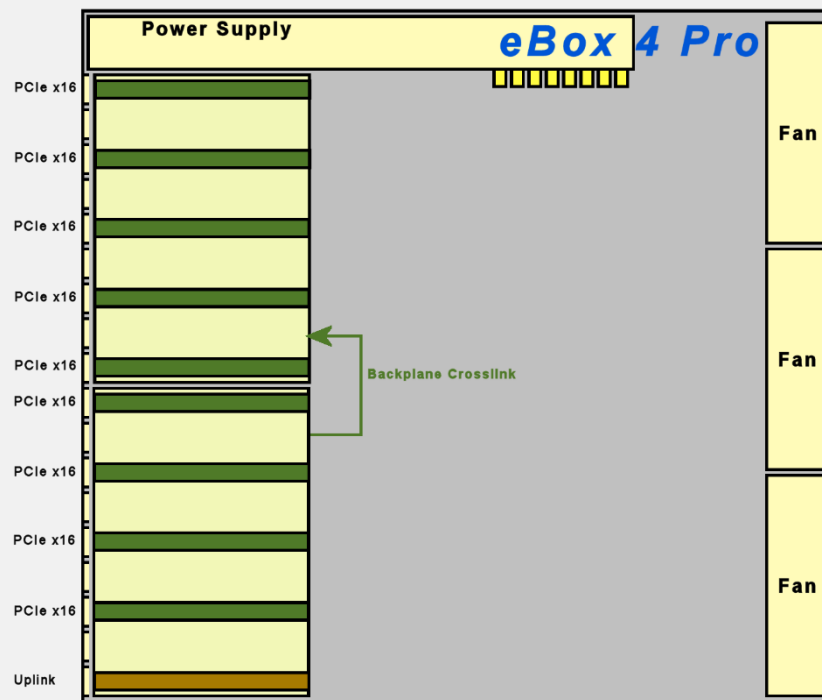


eBox Pro with dual 5-slot backplane and crosslink connection (CONF_G)

This configuration connected the two backplanes internally and only needs a single uplink connections.

This configuration allows to house up to eight Spectrum cards of single-width or dual-width. The additional spare slot allows to mount an M5i card with star-hub in the adjacent slot or an additional single-width card.

This version needs a single host controller. The connection allows to run all eight slots with a maximum of PCIe x16 PCIe 2.0 speed.



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M2p Series with PCIe x4 PCIe 1.0 connector

The Spectrum M2p series consists of several ½ length PCIe Digitizer, AWGs and Digital I/O cards. Each card only draws a neglectable amount of power from the PCIe bus and do not need an additional external power supply.



Card Width

When incorporating the cards into the expansion systems, one needs to check for the width of the card as this varies with the types and options:

- M2p.59xx Digitizer: single-slot width
- M2p.653x AWGs: single-slot width
- M2p.654x AWGs: **double** slot width
- M2p.656x AWGs: single-slot width
- M2p.657x AWGs: **double** slot width
- M2p.75xx Digital I/O: single slot width
- Option M2p.xxxx-DigFX2 digital channel extension: one **additional** slot width
- Option M2p.xxxx-DigSMB digital channel extension: one **additional** slot width
- Option M2p.xxxx-SHxTM star-hub top-mount version: one **additional** slot width
 - Recommendation: using the SHxEX version instead which does not block an additional slot

(CONF_A) One M2p card single or double-width

Dolphin Order Information:

- Chassis: eBox MXE520A0
- Uplink: 1x MXH932
- Host: 1x MXH915
- Cable: 1x SFF8644 Copper Cable up to 5m

Alternative Optical Connection

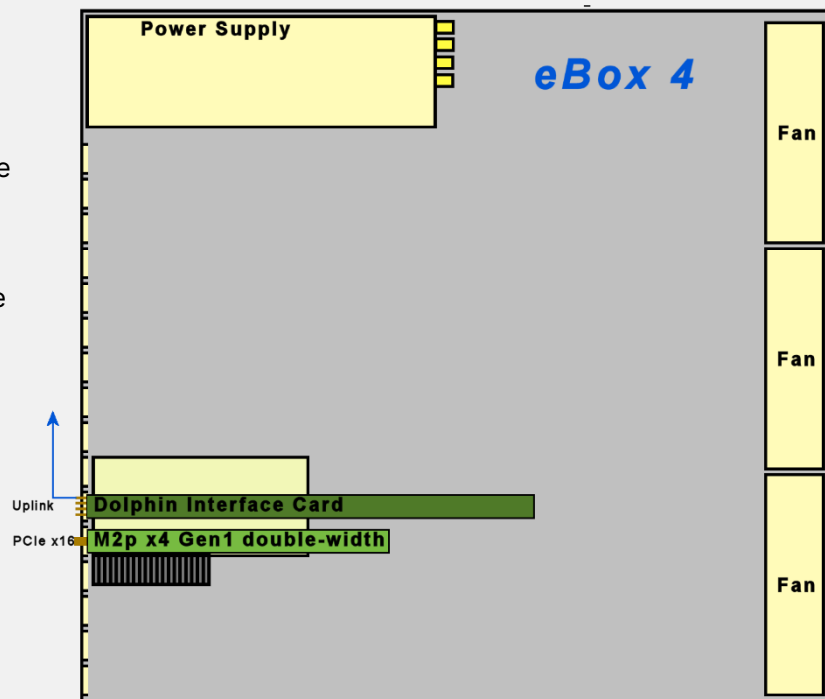
- Cable: 1x SFF8644 Optical Cable up to 100m

Speed

- Full PCIe x4 PCIe 1.0 Speed

Possible Configurations

- 1x M2p single-width
- 1x M2p dual-width



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(CONF_B) Two M2p cards single-width or double-width

Dolphin Order Information:

- Chassis: eBox MXE520C0
- Uplink: 1x MXH932
- Host: 1x MXH915
- Cable: 1x SFF8644 Copper Cable up to 5m

Alternative Optical Connection

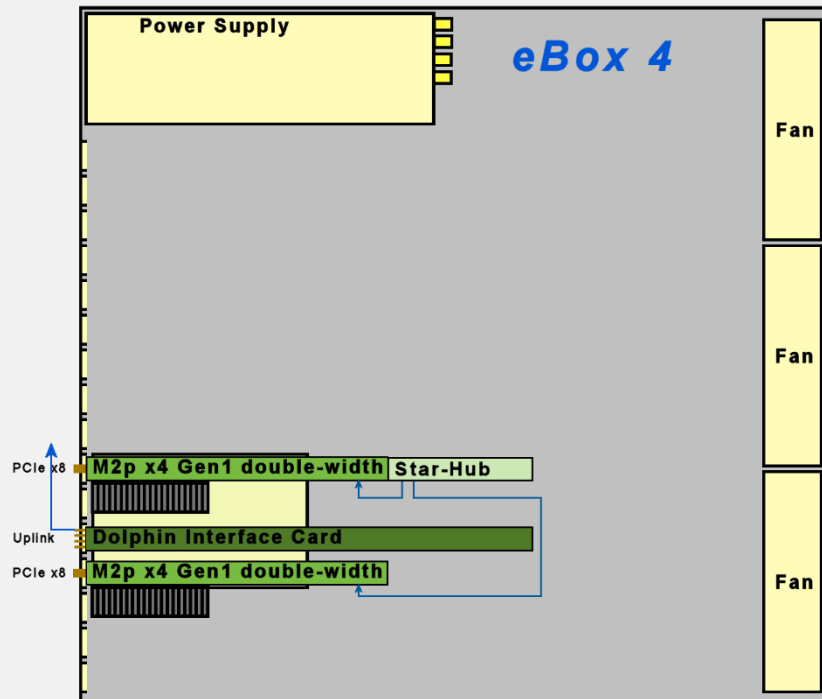
- Cable: 1x SFF8644 Optical Cable up to 100m

Speed (Copper Cable)

- Full PCIe x4 PCIe 1.0 Speed

Possible Configurations

- 2x M2p single-width
- 1x M2p single-width + 1x M2p dual-width
- 2x M2p dual-width



(CONF_C) Three or Four M2p cards

Dolphin Order Information:

- Chassis: eBox MXE520D0
- Uplink: 1x MXH932
- Host: 1x MXH915
- Cable: 1x SFF8644 Copper Cable up to 5m

Alternative Optical Connection

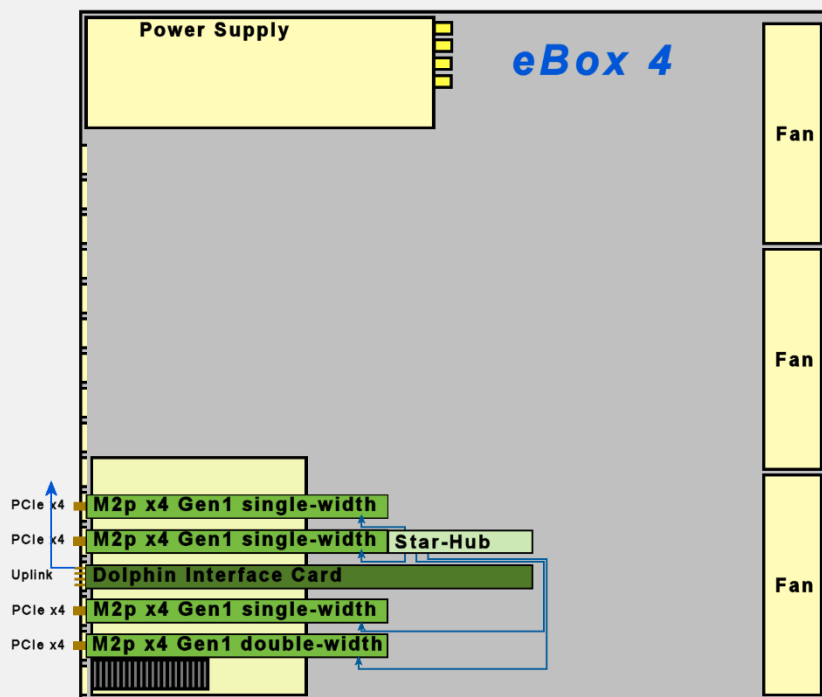
- Cable: 1x SFF8644 Optical Cable up to 100m

Speed (Copper Cable)

- Full PCIe x4 PCIe 1.0 Speed

Possible Configurations

- 3x or 4x M2p single-width
- 3x M2p single-width + 1x M2p dual-width



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(CONF_D) Up to eight M2p cards single-width or 4 cards double-width

Dolphin Order Information:

- Chassis: eBox MXE52DD0
- Uplink: 2x MXH932
- Host: 1x MXH919 (single host card connects with two cables to two different uplink cards)
- Cable: 2x SFF8644 Copper Cable up to 5m

Alternative Optical Connection

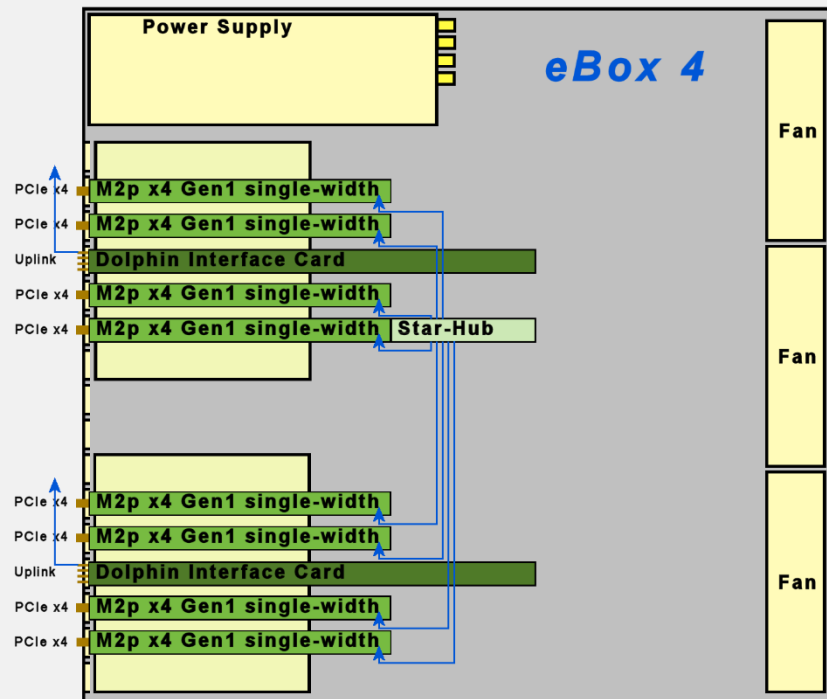
- Cable: 2x SFF8644 Optical Cable up to 100m

Speed (Copper Cable)

- Full PCIe x4 PCIe 1.0 speed

Possible Configurations

- 5x to 8x M2p single-width
- 6x M2p single-width + 2x M2p dual-width



(Conf_G) Up to eight M2p cards double-width

Dolphin Order Information:

- Chassis: eBox Pro Dual MXB585 interconnected
- Uplink: 1x MXH572
- Host: 1x MXH572
- Cable: 1x CDFP CopprLink Copper Cable up to 3m

Alternative Optical Connection

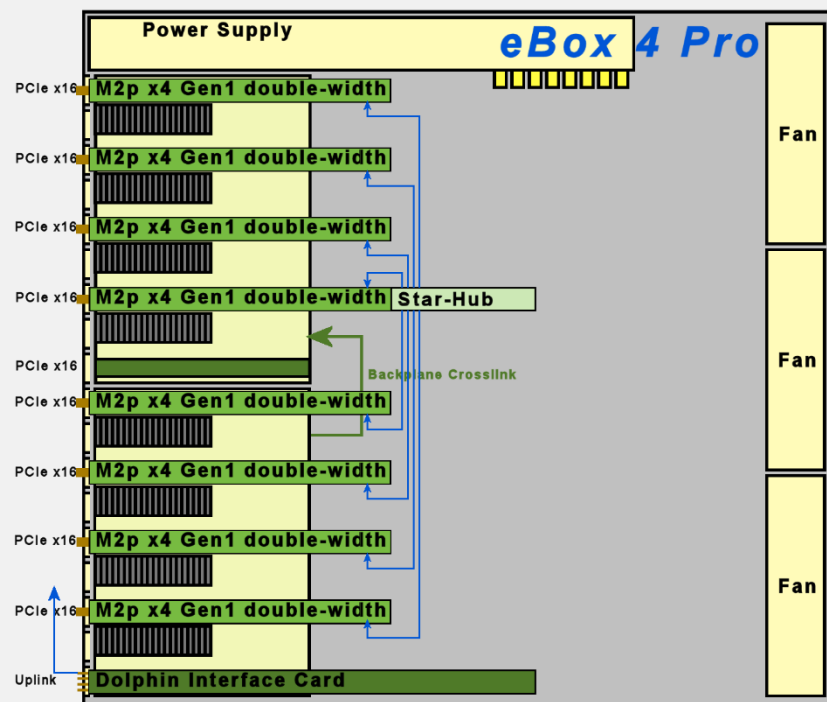
- Uplink: 1x MXH572
- Host: 1x MXH572
- Cable: 1x CopprLink Optical Cable up to 50m

Speed (Copper Cable)

- Full PCIe x4 PCIe 1.0 speed

Possible Configurations

- 8x M2p dual-width
- 8x M2p dual-width + 1x M2p single-width



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M4i Series with PCIe x8 PCIe 2.0 connector

The Spectrum M4i series consists of several 3/4 length PCIe Digitizer, AWGs and Digital Acquisition cards. Each card draws between 27 Watts and 40 Watts of power from the backplane.

The backplane of the Dolphin PCIe expansion systems is designed to provide this amount of power per slot making it possible to mount the M4i cards without separate power connection.



Card Width

All M4i cards are single-width cards. There are two options that need an additional slot:

- Star-hub top mount (M4i.xxxx-SH8TM)
- M4i.44xx Digital Inputs (M4i.44xx-DigSMA)

(CONF_A) One M4i card single -width

Dolphin Order Information:

- Chassis: eBox MXE520A0
- Uplink: 1x MXH932
- Host: 1x MXH915
- Cable: 1x SFF8644 Copper Cable up to 5m

Alternative Optical Connection

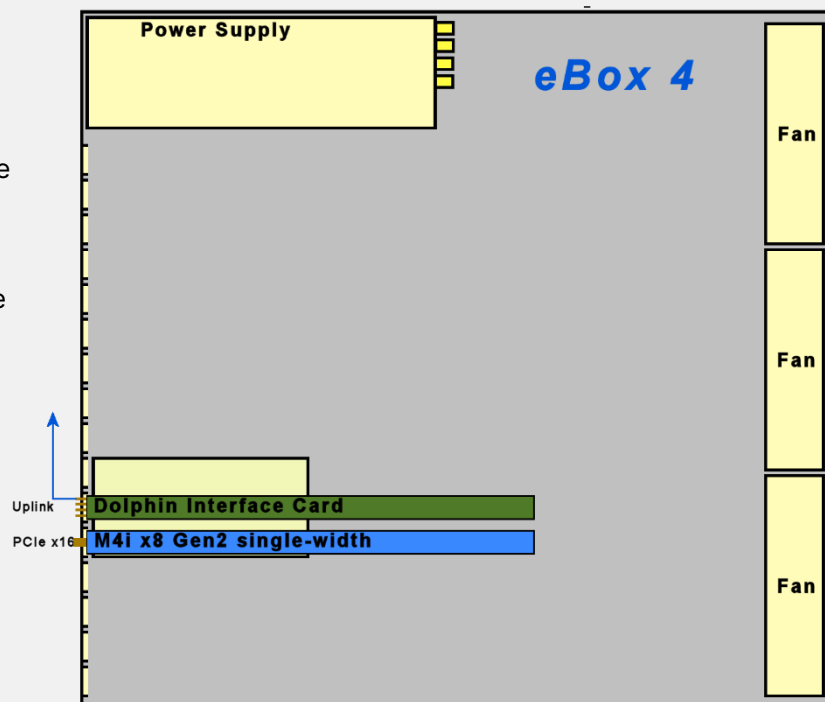
- Cable: 1x SFF8644 Optical Cable up to 100m

Speed (Copper Cable)

- Full PCIe x8 PCIe 2.0 Speed

Possible Configurations

- 1x M4i single-width



► Integrating Spectrum Cards in Dolphin PCIe Expansion Systems

(CONF_B) Two M4i cards single-width

Dolphin Order Information:

- Chassis: eBox MXE520C0
- Uplink: 1x MXH932
- Host: 1x MXH915
- Cable: 1x SFF8644 Copper Cable up to 5m

Alternative Optical Connection

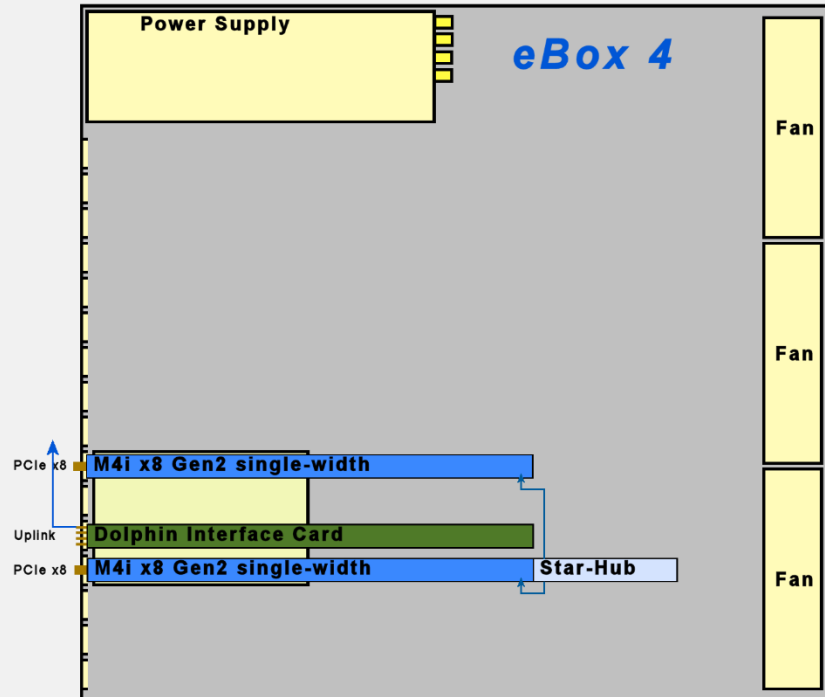
- Cable: 1x SFF8644 Optical Cable up to 100m

Speed (Copper Cable)

- Full PCIe x8 PCIe 2.0 Speed

Possible Configurations

- 2x M4i single-width
- 1x M4i single-width + 1x M4i double-width



(CONF_E) Three or Four M4i cards

Dolphin Order Information:

- Chassis: eBox Pro with single MXB585
- Uplink: 1x MXH932
- Host: 1x MXH917
- Cable: 2x SFF8644 Copper Cable up to 3m

Alternative Optical Connection

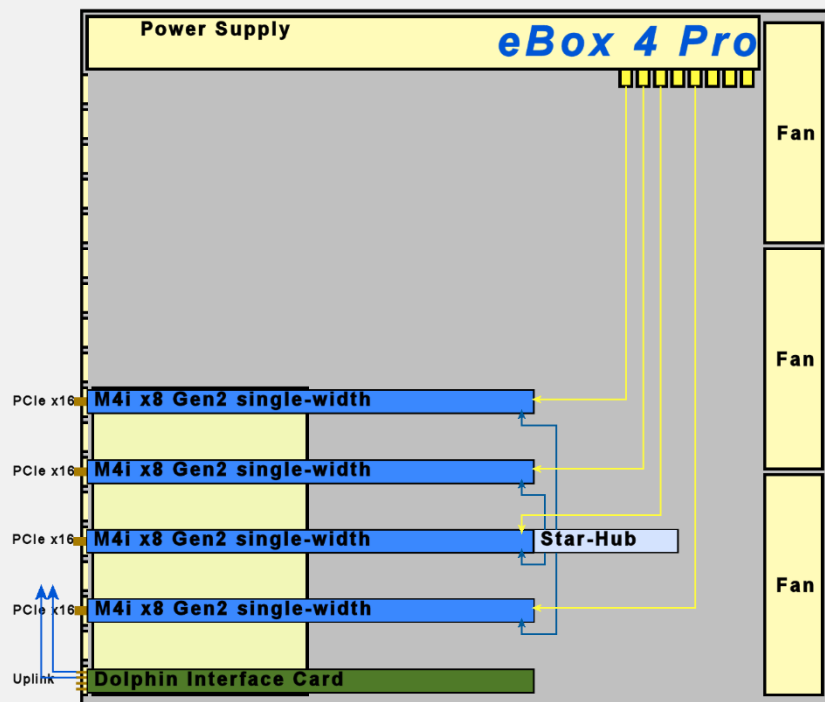
- Cable: 2x SFF8644 Optical Cable up to 100m

Speed (Copper Cable)

- PCIe x8 PCIe 2.0 Speed per slot

Possible Configurations

- 3x or 4x M4i card with any options



► Integrating Spectrum Cards in Dolphin PCIe Expansion Systems

(CONF_G) Up to eight M4i cards

Dolphin Order Information:

- Chassis: eBox Pro Dual MXB585 interconnected
- Uplink: 1x MXH532
- Host: 1x MXH532
- Cable: 2x SFF8614 Copper Cable up to 3m

Alternative Optical Connection

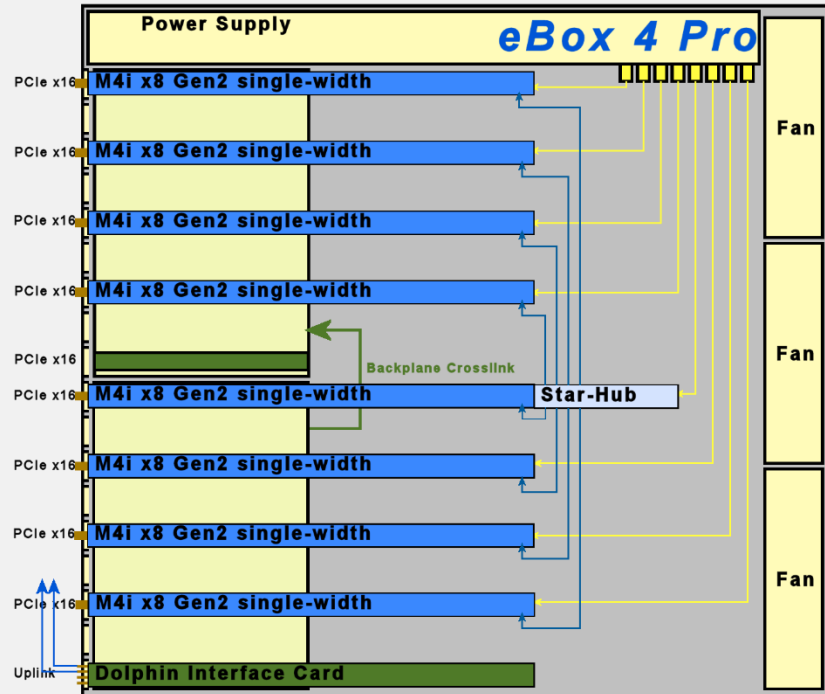
- Uplink: 1x MXH572
- Host: 1x MXH572
- Cable: 1x CopprLink 1.0 Compliant Copper Cable x16 with CDFP connector up to 50m

Speed (Copper Cable)

- Full PCIe x8 PCIe 2.0 speed

Possible Configurations

- 5x to 8x M4i single/dual-width
- 8x M4i synchronized + 1 additional M4i card, non-synchronized



(CONF_C) Alternative solution for up to four M4i cards

Based on the components of CONF_C (eBox 4 with single 5-slot backplane), this solution offers space for up to four single-width M4i cards + star-hub with reduced performance and much reduced system price.

Due to the structure of the interface, the maximum performance per slot is limited to PCIe x4 PCIe 2.0. Data transfer is half the speed as with configuration (CONF_E).

(CONF_D) Alternative solution for up to four M4i cards

Based on the components of CONF_D (eBox 4 with dual 5-slot passive backplane), this solution offers space for up to four single-width M4i cards + star-hub with reduced performance and much reduced system price. The passive backplane solution has a limitation to a PCIe x4 width for the add in cards.

Due to the structure of the interface, the maximum performance per slot is limited to PCIe x4. Data transfer is half the speed of the configuration (CONF_G).

► Integrating Spectrum Cards in Dolphin PCIe Expansion Systems

M5i Series with PCIe x16 PCIe 3.0 connector

The Spectrum M5i series consists of several 3/4 length dual-width PCIe Digitizer and AWGs. Each card draws between 35 Watts and 45 Watts of power and needs an additional power connector.

The Dolphin eBox 4 system supplies four separate power connections and the eBox 4 Pro supplies eight separate power connections that can be used for M5i cards.



Card Width

All M5i cards are double-width cards. Using the star-hub, an additional, third slot is needed.

(CONF_A) One M5i card double-width

Dolphin Order Information:

- Chassis: eBox MXE520A0
- Uplink: 1x MXH932
- Host: 1x MXH919
- Cable: 2x SFF8644 Copper Cable up to 5m

Alternative Optical Connection

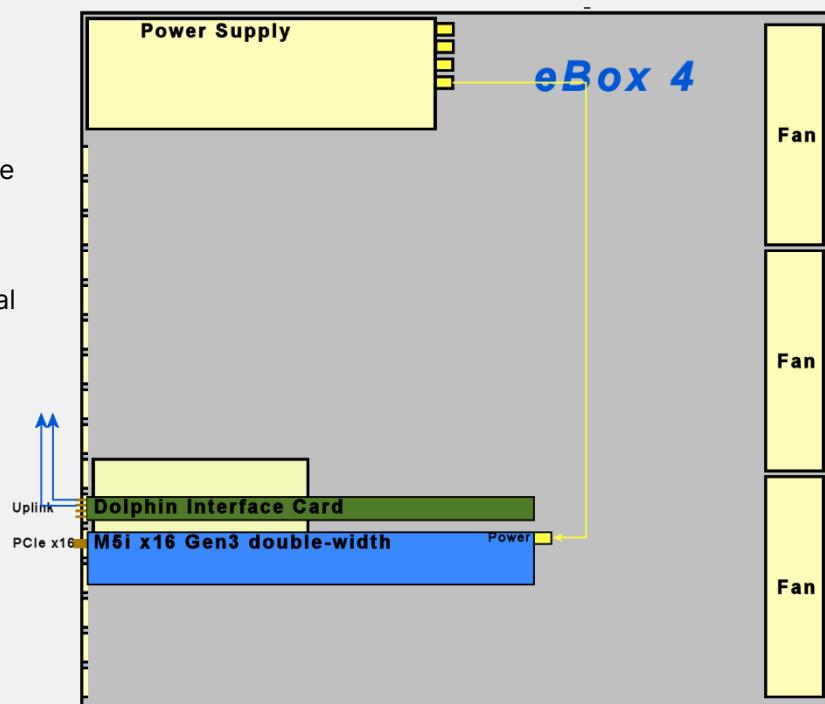
- Cable: 2x SFF8644 Active Optical Cable up to 100m

Speed (Copper Cable)

- Full PCIe x16 PCIe 3.0 Speed

Possible Configurations

- 1x M5i double-width



► Integrating Spectrum Cards in Dolphin PCIe Expansion Systems

(CONF_E) Two to Four M5i cards

Dolphin Order Information:

- Chassis: eBox Pro with single MXB585
- Uplink: 1x MXH572
- Host: 1x MXH572
- Cable: 1x CopprLink 1.0 Compliant Copper Cable x16 with CDFP connector up to 3m

Alternative Optical Connection

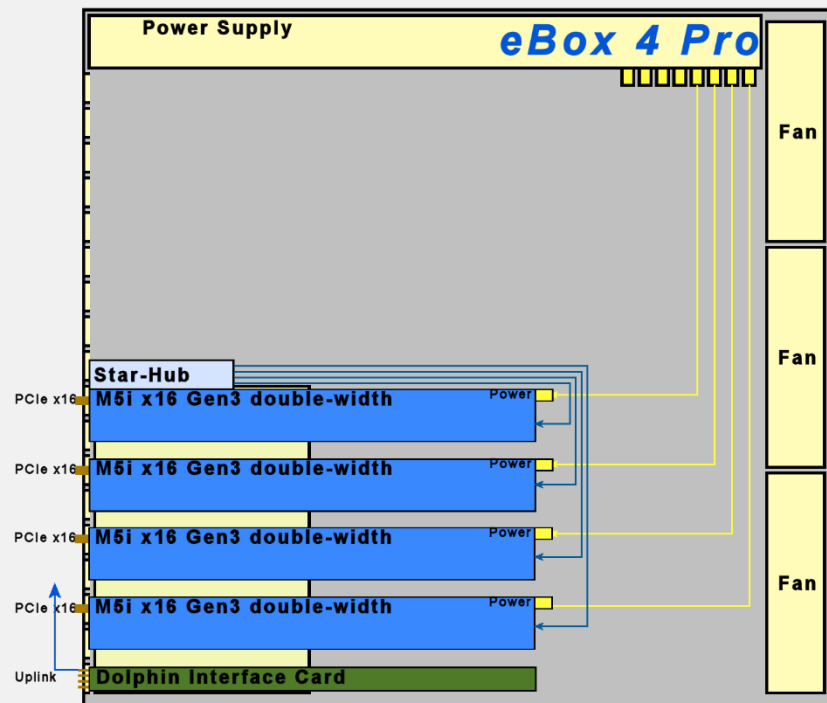
- Cable: 1x CopprLink 1.0 Compliant AOC Fiber Cable x16 CDFP connector up to 50m

Speed (Copper Cable)

- PCIe x16 PCIe 3.0 speed per slot

Possible Configurations

- 2x to 4x M5i card



(CONF_G) Up to eight M5i cards

Dolphin Order Information:

- Chassis: eBox Pro Dual MXB585 interconnected
- Uplink: 1x MXH572
- Host: 1x MXH572
- Cable: 1x CopprLink 1.0 Compliant Copper Cable x16 with CDFP connector up to 3m

Alternative Optical Connection

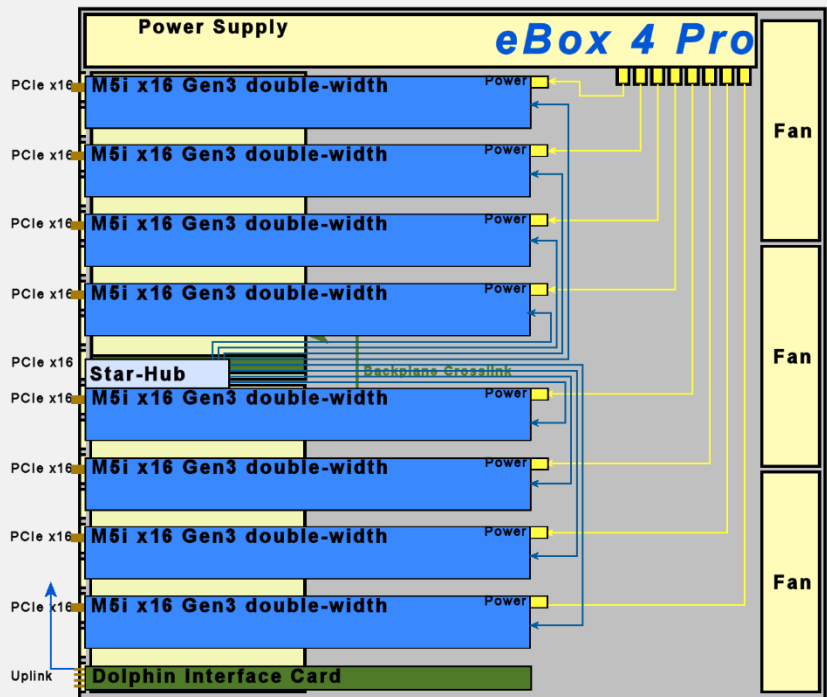
- Uplink: 1x MXH572
- Host: 1x MXH572
- Cable: 1x CopprLink 1.0 Compliant AOC Fiber Cable x16 CDFP connector up to 50m

Speed (Copper Cable)

- PCIe x16 PCIe 2.0 speed on all slots

Possible Configurations

- 5x to 8x M5i dual-width





► Integrating Spectrum Cards in Dolphin PCIe Expansion Systems

(CONF_C) Alternative solution for up to two M5i cards

Based on the components of CONF_C (eBox 4 with single 5-slot backplane), this solution offers space for two double-width M5i cards + star-hub with reduced performance and much reduced system price.

Due to the structure of the interface, the maximum performance per slot is limited to PCIe x4 PCIe 3.0. Data transfer is 1/4 the speed as with configuration (CONF_E)

(CONF_D) Alternative solution for up to four M5i cards

Based on the components of CONF_D (eBox 4 with dual 5-slot backplane), this solution offers space for up to four double-width M5i cards + star-hub with reduced performance and much reduced system price.

Due to the structure of the interface, the maximum performance per slot is limited to PCIe x4 PCIe 3.0. Data transfer is 1/4 the speed as with configuration (CONF_E).

► Integrating Spectrum Cards in Dolphin PCIe Expansion Systems

Speed Test Results

All speed results obtained using the copper cable connection. Due to signal cable run time, the received transfer speed is less when using an optical connection.

(CONF_A) eBox with 2-slot backplane

The single available slot can be configured up to x16 PCIe 5.0 performance. Make sure to get the correct host card and number of cables to reach the desired speed

Single cable. Slot configuration x4 PCIe 4.0

- M2p.5968-x4 (Digitizer): >800 MByte/s
- M2p.6568-x4 (AWG): >750 MByte/s
- M4i.4451-x8 (Digitizer): >1.6 GByte/s
- M5i.3357-x16 (Digitizer): >3.0 GByte/s

Single cable. Slot configuration x8 PCIe 3.0

- M4i.4451-x8 (Digitizer): >3.2 GByte/s
- M4i.6622-x8 (AWG): >2.4 GByte/s

Two cables. Slot configuration x16 PCIe 3.0

- M2p.5968-x4 (Digitizer): >800 MByte/s
- M4i.4451-x8 (Digitizer): >3.2 GByte/s
- M5i.3357-x16 (Digitizer): >12.0 GByte/s
- M5i.6357-x16 (AWG): >9.0 GByte/s

(CONF_C) eBox with 5-slot backplane

Technically, if using all slots of the backplane, the maximum slot configuration that can be reached is four times x4 PCIe 5.0. There is a hardware limitation that limits the expansion slot to PCIe x4.

Four cables Slot configuration: four slots with x4 Gen4

- M2p.5968-x4 (Digitizer): >800 MByte/s
- M2p.6568-x4 (AWG): >750 MByte/s
- M4i.4451-x8 (Digitizer): >1.6 GByte/s
- M5i.3357-x16 (Digitizer): >3.0 GByte/s