congatec Application Note

Affected Products	All products
Subject	U.2 Introduction
Confidential/Public	Public
Author	GMX

Revision History

Revision	Date (yyyy-mm-dd)	Author	Changes
1.0	2020-05-04	GMX	Initial Revision

Preface

This Application Note introduces the SFF-8639 (U.2) interface. The goal is to give an overview of the technology and hint on how to design-in this technology for customer carrier boards.

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Symbols

The following are symbols used in this application note.

Note

Notes call attention to important information that should be observed.

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Cautions warn the user about how to prevent damage to hardware or loss of data.

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Terminology

Term	Description
NVMe	Non-Volatile Memory Express
SSD	Solid State Drive
SAS	Serial-Attached SCSI
SATA	Serial ATA
SFF	Small Form Factor
OD	Open-Drain

1 U.2 / SFF-8639 Introduction

1.1 Introduction

The U.2 specification (initially SFF-8639), which is released by the PCI-SIG group, describes a hardware interface that supports several SSD interface technologies.

This specification is used mostly for connecting high performance NVMe SSDs. For overview of the NVMe protocol, visit www.congatec.com and view the technote "NVMe support on congatec COMs and SBCs" in the restricted area of the website.

To enable NVMe SSDs, the U.2 pinout features up to four PCIe lanes for inter-connection. Most often, this specification is used for SSDs in 2.5" form factor. This makes implementing the U.2 form factor a good method of scaling up the system speed while still being able to keep the same physical form factor for existing SATA-based SSDs.

In addition to PCIe-based SSDs, the interface also supports SAS and SATA. This enables the connector to work with different SSD technologies.

This application note is concerned with U.2 specification pinout as well as topologies that can be used to design-in the interface.

1.2 Backward Compatibility

One of the advantages of this specification is that it allows SATA, SAS and U.2 NVMe SSDs to be used on the same U.2 connector. This means that systems can be equipped with different types of SSD, depending on the demands of the system. In that way, the system can be scaled to perform different tasks, thereby improving the overall price efficiency of the design.

1.3 Advantages

U.2 SSDs are often used in data centers and server-related ecosystems. The SSD housing of a U.2 SSD is bigger and more ruggedized when compared to the bare PCB M.2 SSDs. This also allows U.2 devices to feature a bigger overall capacity.

U.2 devices can support hot-plug and hot-swap features. This capability allows new devices to be connected to the platform (hot-plug) or devices of the same type can be swapped out (hot-swap) while the system is up and running. The following conditions need to be met to support these features:

1. The target SSD needs to support unplanned power loss.
2. The BIOS of the congatec module you want to use needs PCIe hot-plug support.

U.2 SSDs often feature advanced power loss protection. This means that in a surprise power loss event, mandatory data transactions that have been cached can still be completed, making the SSD more robust to corruption in unstable power environments.

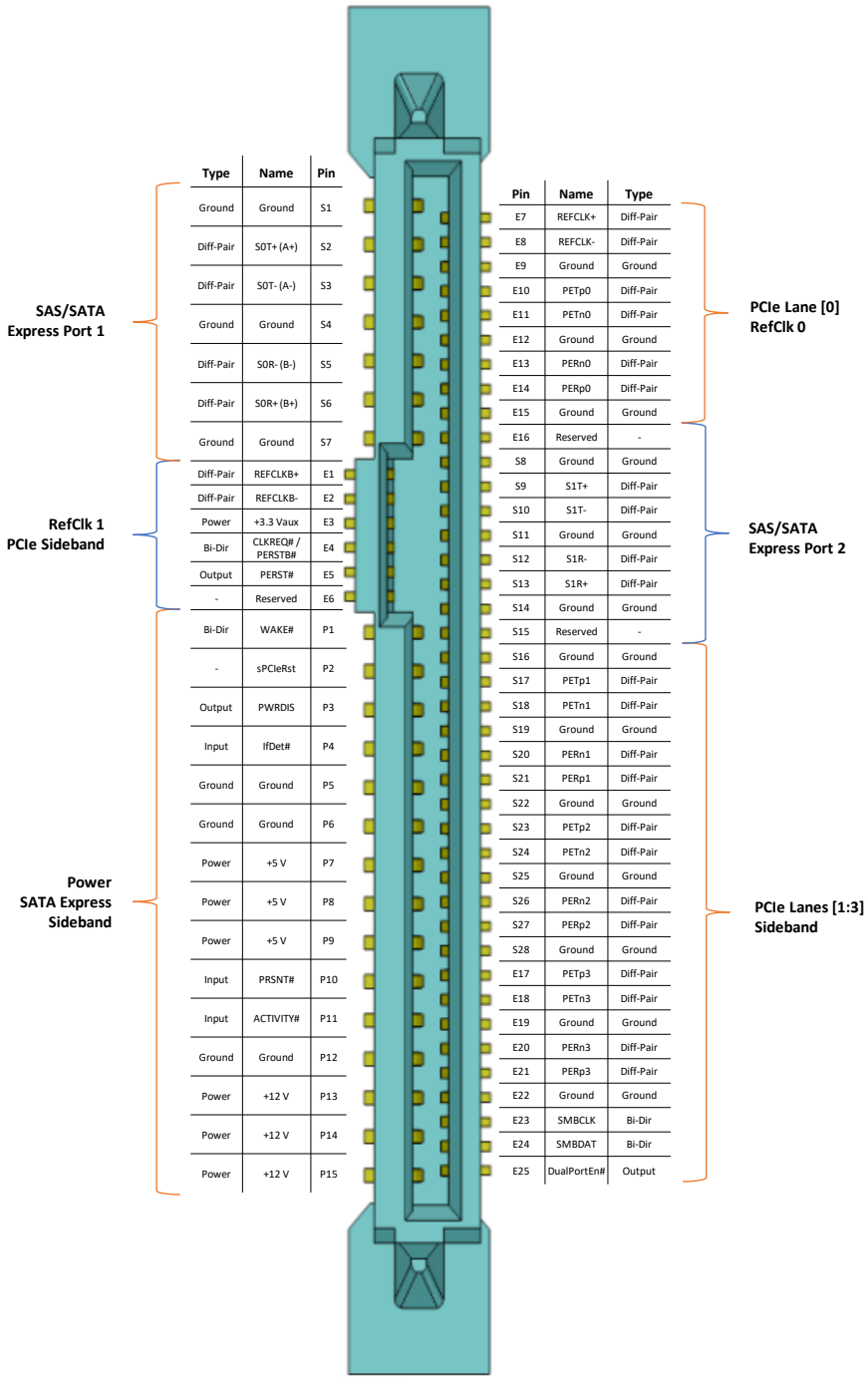
Note

If you are unsure about hot-plug support on your congatec module, contact your FAE.

2 Connector Overview

This chapter gives a general overview of the U.2 connector. Sub-section 2.1 highlights the overall U.2 connector while sub-section 2.2 lists the pinout of all supported interfaces.

2.1 U.2 Connector Overview



Type	Name	Pin
Ground	Ground	S1
Diff-Pair	S0T+ (A+)	S2
Diff-Pair	S0T- (A-)	S3
Ground	Ground	S4
Diff-Pair	S0R- (B-)	S5
Diff-Pair	S0R+ (B+)	S6
Ground	Ground	S7
Diff-Pair	REFCLKB+	E1
Diff-Pair	REFCLKB-	E2
Power	+3.3 Vaux	E3
Bi-Dir	CLKREQ# / PERSTB#	E4
Output	PERST#	E5
-	Reserved	E6
Bi-Dir	WAKE#	P1
-	sPCIeRst	P2
Output	PWRDIS	P3
Input	IfDet#	P4
Ground	Ground	P5
Ground	Ground	P6
Power	+5 V	P7
Power	+5 V	P8
Power	+5 V	P9
Input	PRSNT#	P10
Input	ACTIVITY#	P11
Ground	Ground	P12
Power	+12 V	P13
Power	+12 V	P14
Power	+12 V	P15

Pin	Name	Type
E7	REFCLK+	Diff-Pair
E8	REFCLK-	Diff-Pair
E9	Ground	Ground
E10	PETp0	Diff-Pair
E11	PETn0	Diff-Pair
E12	Ground	Ground
E13	PERn0	Diff-Pair
E14	PERp0	Diff-Pair
E15	Ground	Ground
E16	Reserved	-
S8	Ground	Ground
S9	S1T+	Diff-Pair
S10	S1T-	Diff-Pair
S11	Ground	Ground
S12	S1R-	Diff-Pair
S13	S1R+	Diff-Pair
S14	Ground	Ground
S15	Reserved	-
S16	Ground	Ground
S17	PETp1	Diff-Pair
S18	PETn1	Diff-Pair
S19	Ground	Ground
S20	PERn1	Diff-Pair
S21	PERp1	Diff-Pair
S22	Ground	Ground
S23	PETp2	Diff-Pair
S24	PETn2	Diff-Pair
S25	Ground	Ground
S26	PERn2	Diff-Pair
S27	PERp2	Diff-Pair
S28	Ground	Ground
E17	PETp3	Diff-Pair
E18	PETn3	Diff-Pair
E19	Ground	Ground
E20	PERn3	Diff-Pair
E21	PERp3	Diff-Pair
E22	Ground	Ground
E23	SMBCLK	Bi-Dir
E24	SMBDAT	Bi-Dir
E25	DualPortEn#	Output

2.2 General U.2 Connector Pinout

The table below lists the pinout of interfaces that are supported with U.2.

Please note that for SATA and SATA Express implementations on U.2, the below signal names do not match the SATA specification exactly.

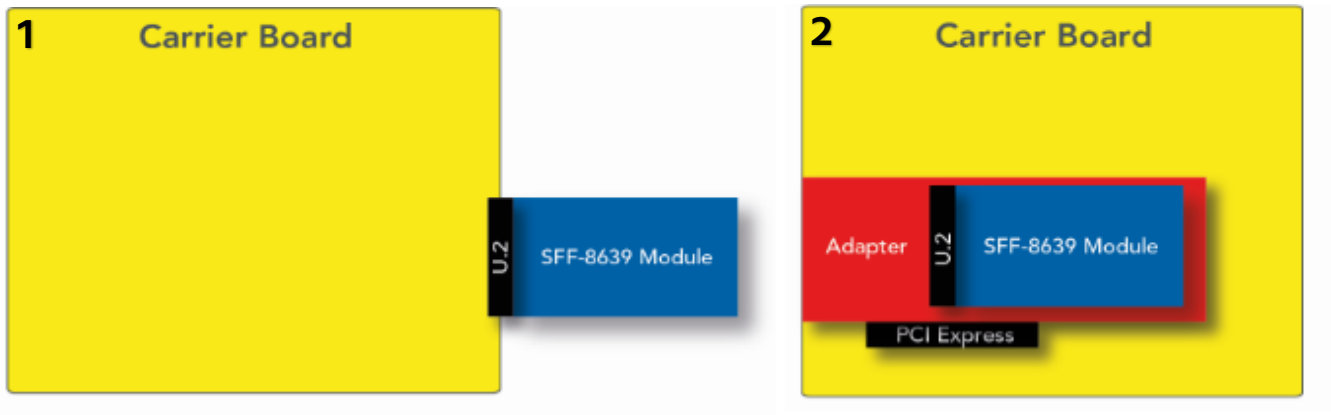
Pin	Name	Type	PCIe NVMe	SATA	SATA Express	SAS x4
P1	WAKE#	Bi-Dir			Optional	
P2	sPCIeRst	-				
P3	PWRDIS	Output			Optional	
P4	IfDet#	Input	Optional		Optional	Optional
P5	Ground	Ground				
P6	Ground	Ground				
P7	+5 V	Power				
P8	+5 V	Power				
P9	+5 V	Power				
P10	PRSNT#	Input		Optional	Optional	
P11	ACTIVITY#	Input		Optional	Optional	
P12	Ground	Ground		Optional	Optional	
P13	+12 V	Power				
P14	+12 V	Power				
P15	+12 V	Power				
S1	Ground	Ground				
S2	S0T+ (A+)	Diff-Pair				
S3	S0T- (A-)	Diff-Pair				
S4	Ground	Ground				
S5	S0R- (B-)	Diff-Pair				
S6	S0R+ (B+)	Diff-Pair				
S7	Ground	Ground				
S8	Ground	Ground				
S9	S1T+	Diff-Pair				
S10	S1T-	Diff-Pair				

S11	Ground	Ground				
S12	S1R-	Diff-Pair				
S13	S1R+	Diff-Pair				
S14	Ground	Ground				
S15	Reserved	-				
S16	Ground	Ground				
S17	PETp1	Diff-Pair				
S18	PETn1	Diff-Pair				
S19	Ground	Ground				
S20	PERn1	Diff-Pair				
S21	PERp1	Diff-Pair				
S22	Ground	Ground				
S23	PETp2	Diff-Pair				
S24	PETn2	Diff-Pair				
S25	Ground	Ground				
S26	PERn2	Diff-Pair				
S27	PERp2	Diff-Pair				
S28	Ground	Ground				
E1	REFCLKB+	Diff-Pair	DualPort Only			
E2	REFCLKB-	Diff-Pair	DualPort Only			
E3	+3.3 Vaux	Power	Optional			
E4	CLKREQ#/ PERSTB#	CLKREQ# is SSD OD-Output				
E5	PERST#	Output				
E6	Reserved	-				
E7	REFCLK+	Diff-Pair			Optional	
E8	REFCLK-	Diff-Pair			Optional	
E9	Ground	Ground			Optional	
E10	PETp0	Diff-Pair				
E11	PETn0	Diff-Pair				
E12	Ground	Ground				

E13	PERn0	Diff-Pair				
E14	PERp0	Diff-Pair				
E15	Ground	Ground				
E16	Reserved	-				
E17	PETp3	Diff-Pair				
E18	PETn3	Diff-Pair				
E19	Ground	Ground				
E20	PERn3	Diff-Pair				
E21	PERp3	Diff-Pair				
E22	Ground	Ground				
E23	SMBCLK	Bi-Dir	Optional			
E24	SMBDAT	Bi-Dir	Optional			
E25	DualPortEn#	Output	DualPort Only			

3 Topologies

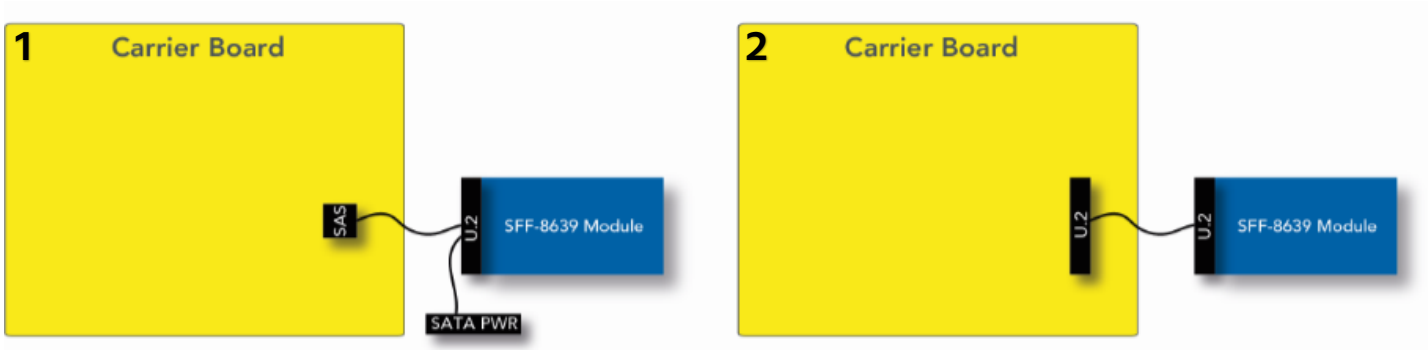
3.1 Direct Connect Topologies



Topology 1 (left) connects a U.2 module directly to the standard connector. In this topology, SATA, SAS and U.2 NVMe modules can be connected if the carrier board connector supports all U.2 interfaces.

Topology 2 (right) uses a PCI Express to U.2 adapter to connect a U.2 NVMe module. This topology can be useful for testing SFF-8639 modules on existing carrier boards that have PCIe slots. The adapters currently on the market feature a PCIe x4 lane configuration to utilize the full capacity of the device.

3.2 Topologies with Cabling

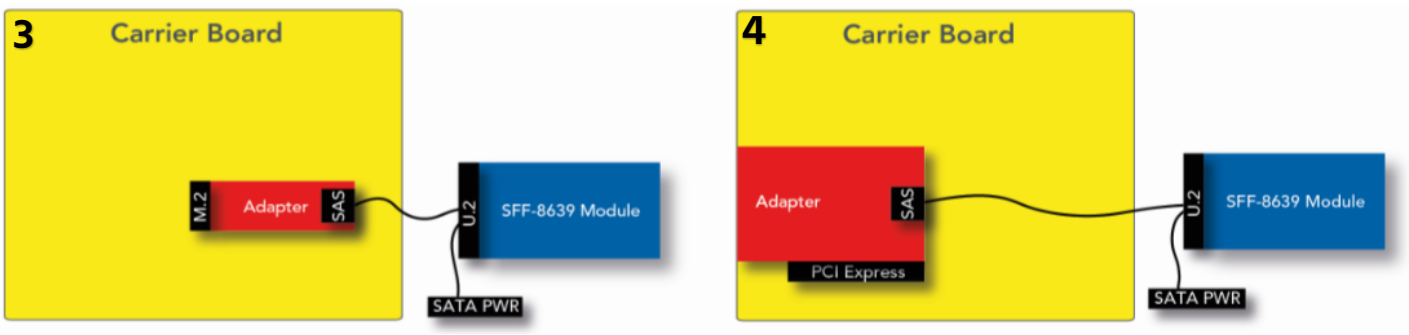


Cabling sets on the market right now focus on reusing existing SFF-8643 cables and connectors. These Mini-SAS HD cables are capable of carrying PCIe signals necessary for operating U.2 NVMe modules. Topology 1 depicts this setup. The carrier board features the SFF-8643 connector. An SFF-8643 to U.2 cable is used to connect the device. In addition, power is supplied to the U.2 module via a SATA power connector.

The second topology depicts a direct connection via U.2 cable.

Note

Direct-connect U.2 cables are currently in development.



Topologies 3 and 4 use the HD Mini-SAS to U.2 cable as described in the first topology. Both setups can be used to determine the function of your U.2 module in existing carriers by using adapters on existing interfaces.
Adapters exist for M.2 as well as PCI Express interfaces.

Note

Cabling and adapter solutions can negatively impact signal quality.