800 Gb/s PMD Implementation Agreement

800 Gb/s PMD Implementation Agreement

Version 1.0

April 13, 2023

800 Gb/s PMD Implementation Agreement

Implementation Agreement created and approved by IPEC

www.ipec-org.org

The International Photonics & Electronics Committee (IPEC) is an international standards organization that is committed to developing open optoelectronic standards and delivering strategic roadmap reports. IPEC focuses on standardizing solutions in optical chips, optical/electrical components, and optical modules. Markets addressed by IPEC include 5G, IoT and AI. The gradual digitalization of these industries and the construction of new infrastructure require standardization. However, current optoelectronic standards are reactive, do not pro-actively motivate strategic investments, and do not address all market segments. Therefore, IPEC will look beyond the work of other standards organizations. IPEC will support the optoelectronic industry for the long term, and address un-met needs of its members.

IPEC is open to any interested party who wishes to join. All members have the opportunity to participate in developing all IPEC standards and reports on a non-discriminatory basis. The process of developing these standards and reports is transparent to all members. IPEC is registered in Switzerland.

800 Gb/s PMD Implementation Agreement

Summary

The objective of the document is to define two 800 Gb/s PMDs for operation over single mode fibers (SMF) with lengths up to at least 500m and 2km.

The 2023 edition of this IA specifies eight lanes in each direction with a nominal signaling rate of 106.25 Gbps per lane. A future IA is planned to specify four lanes in each direction with a nominal signaling rate of 200G.

Keywords

800G, PMD, DR, FR, PAM4

Working Group: **PMD**

TITLE: **800 Gb/s PMD Implementation Agreement**

SOURCE: TECHNICAL EDITOR

Name: Xiang YUN

Company Name: Fiberhome Telecommunication Technologies Co.,LTD

Email: yunxig@fiberhome.com

SOURCE: TECHNICAL EDITOR

Name: Limin Geng

Company Name: Huawei Technologies Co., Ltd

Email: genglimin@huawei.com

WORKING GROUP CHAIR

Name: Tom Issenhuth

Company Name: Huawei Technologies Co., Ltd

Email: tissenhuth@outlook.com

List of Members

The following companies were members of this project at the release of this specification:

Company	
Accelink Technologies Co., Ltd.	Marvell
Acon Optics	Meituan
Advanced Fiber Resources (Zhuhai), Ltd.	National Optoelectronics Innovation Center (NOEIC)
Amphenol Corporation	New H3C Technologies Co., Ltd.
Applied Optoelectronics, Inc.	O-Net Communications (Shenzhen) Limited
ATOP Corporation	Semtech Semiconductor (Shenzhen) Company Limited
AVIC Jonhon Optronic Technology Co., Ltd.	Senko (Shenzhen)
Broadex Technologies Co., Ltd.	Shanghai Jiao Tong University
China Academy of Information and Communications Technology	SiFotonics Technologies
China Telecommunications Corporation	Sitrus Technology
CIG Shanghai Co., Ltd.	Source Photonics
FiberHome Telecommunication Technologies Co., Ltd.	Suzhou GL Foresight Electronics Technology Co., Ltd.
Fujin Precision Industrial (Jincheng) Co., Ltd.	VIAVI
Fujitsu Optical Components, Ltd.	Wenzhou Yihua Connector Co., Ltd.

HG Genuine Optics Tech Co., Ltd.	WuHan Aroptics-tech Co., Ltd.
Hisense Broadband Multimedia Technologies Co., Ltd.	Wuhan Mindsemi Company Limited
Huawei Technologies Co., Ltd.	Yamaichi Electronics Co., Ltd.
InnoLight Technology (Suzhou) Ltd.	Yangtze Optical Fibre and Cable Joint Stock Ltd.
Intel Corporation	Yuanjie
Liobate Technologies Limited	ZTE Corporation
LuxshareTech	

Document Revision History

Rev	**Date**	**Description**
1.0	2023-4-13	Publication of this IA.

Table of Contents

Table of Contents

List of Figures

List of Tables

800 Gb/s PMD Implementation Agreement

1 Introduction

This IA specifies Physical Layer specifications and parameters for 800 Gb/s optical interfaces.

The objective of the document is to define two 800 Gb/s PMDs for operation over single mode fibers (SMF) with lengths up to at least 500 m and 2 km.

1.1 Scope

This Implementation Agreement (IA) defines two optical interfaces for 800 Gbps optical transceivers for Ethernet applications. Forward error correction (FEC) is required to be implemented by the host to ensure reliable system operation. One transceiver communicates over single mode fibers (SMF) of lengths from 2 meters up to at least 500 meters and one transceiver communicates over single mode fibers (SMF) of lengths from 2 meters up to at least 2 kilometers. The transceiver electrical interface is not specified by this IA but can have, for example, eight lanes in each direction with a nominal signaling rate of 106.25 Gbps per lane.

A variety of form factors for the transceivers are possible and none are precluded by this IA.

1.2 Hardware Signaling Pins

Hardware signaling pins are specified in the respective module form factor MSAs.

1.3 Module Management Interface

The contents of the various ID registers shall comply with the requirements of the module MSA and the respective standards.

1.4 High Speed Electrical Characteristics

The detailed high speed electrical characteristics are not defined by this IA. 800GE modules should be implemented in compliance with applicable electrical interface specifications.

1.5 FEC Requirements

800Gb links rely on the host system implementing the 800GBASE-R PCS layer in accordance with the Ethernet Technology Consortium 800G Specification along with clauses from the IEEE Std 802.3-2022™ and IEEE Std 802.3ck-2022™.

1.6 Mechanical Dimensions

Mechanical dimensions are defined in module form factor MSA specifications. This IA does not specify the use of a specific form factor.

Figure 1 shows 800G DR8 module block diagram. It has basic features: eight optical transmitters and eight optical receivers.

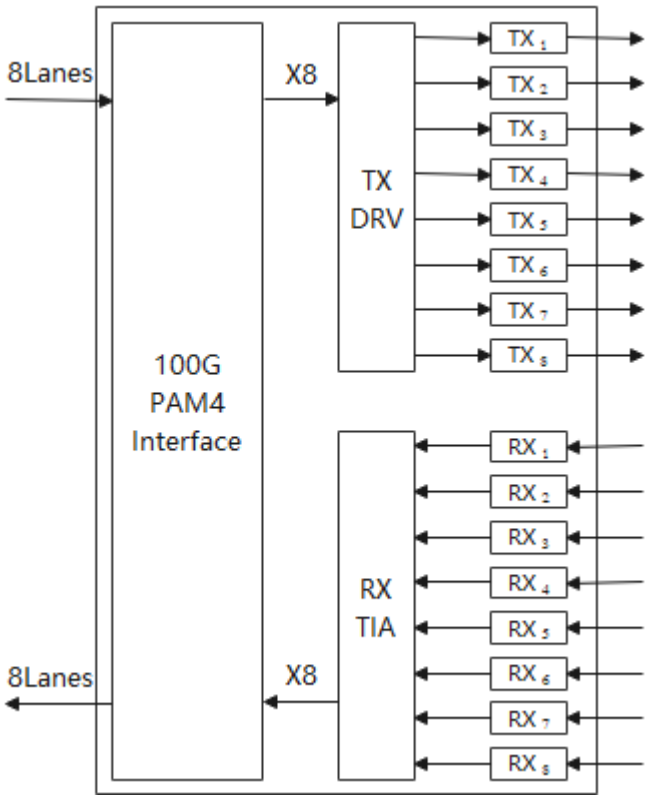

Figure 1 800G DR8 Module Block Diagram

Figure 2 shows 2×400G FR4 Module Block Diagram. It has basic features: eight optical transmitters, eight optical receivers and wavelength division multiplexer and demultiplexer.

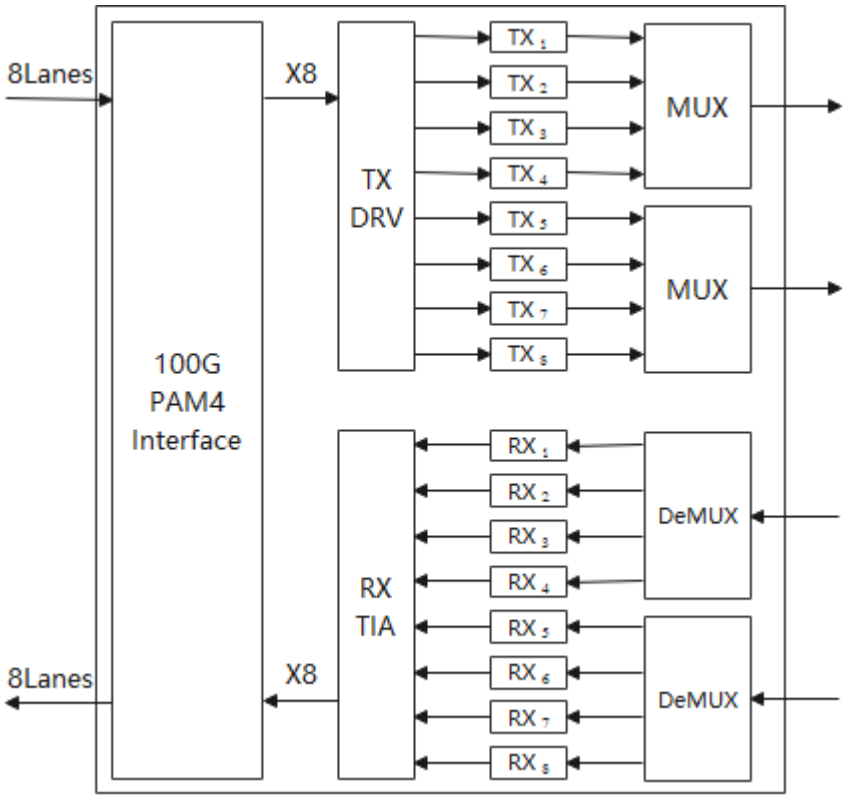

Figure 2 2×400G FR4 Module Block Diagram

2 800G-DR8 Optical Specifications

This IA defines 800G-DR8 optical interface for 800 Gbps optical transceiver. The following tables show the common parameters: operating range, optical transmit characteristics, 800G-DR8 optical receive characteristics and optical link budget.

TABLE 1 800G-DR8 OPERATING RANGE

PMD type	Required operating range
800G-DR8	500 m

TABLE 2 800G-DR8 OPTICAL TRANSMIT CHARACTERISTICS

Description	Value	Unit
Signaling rate (range)	53.125±100 ppm	GBd

Modulation format	PAM4	-
Wavelength (range)	1304.5 to 1317.5	nm
Side-mode suppression ratio (SMSR), (min)	30	dB
Average launch power, each lane (max)	4	dBm
Average launch power, each lane (min)	-2.9	dBm
Outer Optical Modulation Amplitude (OAMouter) (max)	4.2	dBm
Outer Optical Modulation Amplitude (OMAouter) (min) for TDECQ<1.4dB for 1.4 dB ≤TDECQ ≤3.4 dB	-0.8 -2.2+TDECQ	dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	3.4	dB
Average launch power of OFF transmitter (max)	-15	dBm
Extinction ratio (min)	3.5	dB
Transmitter transition time (max)	17	ps
$RIN_{21.4}OMA$ (max)	-136	dB/hz
Optical return loss tolerance (max)	21.4	dB
Transmitter reflectance (max)	-26	dB

TABLE 3 800G-DR8 OPTICAL RECEIVE CHARACTERISTICS

Description	**Value**	**Unit**
Signaling rate (range)	53.125±100 ppm	GBd
Modulation format	PAM4	-
Wavelengths (range)	1304.5 to 1317.5	nm
Damage threshold, each lane	5	dBm
Average receive power, each lane(max)	4	dBm
Average receive power, each lane (min)	-5.9	dBm

Receive power (OMAouter), each lane (max)	4.2	dBm
Receiver reflectance (max)	-26	dB
Receiver sensitivity (OMAouter) (max)	RS = max (-3.9, SECQ - 5.3)	dBm
Stressed receiver sensitivity (OMAouter) (max)	-1.9	dBm
Conditions of stressed receiver sensitivity test:		
Stressed eye closure for PAM4 (SECQ)	3.4	dB
OMAouter of each aggressor lane	4.2	dBm

TABLE 4 800G-DR8 OPTICAL LINK BUDGET

Description	Value	Unit
Power budget (for max TDECQ):	6.5	dB
Operating distance	500	m
Channel insertion loss	3	dB
Maximum discrete reflectance	-35	dB
Allocation for penalties (for max TDECQ):	3.5	dB
Additional insertion loss allowed	0	dB

2.1 800Gb DR8 illustrative link power budget

Figure 3 shows 800G DR8 optical link budget and sensitivity mask.

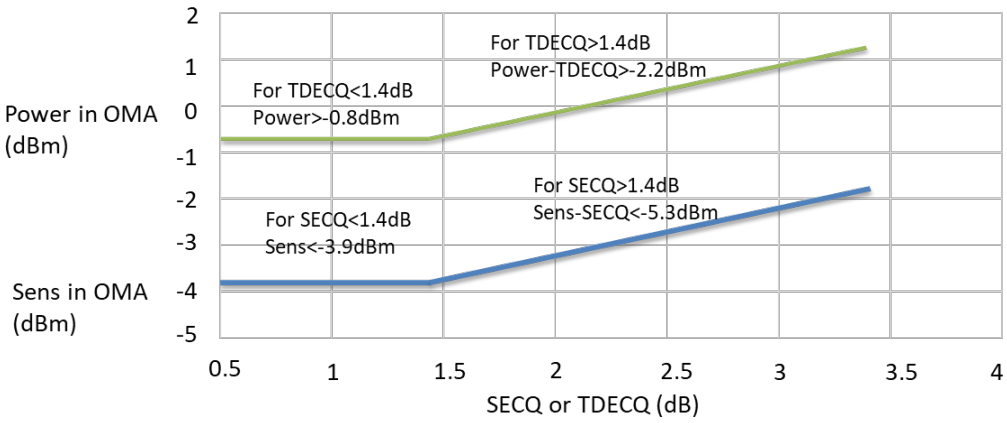

Figure 3 800G DR8 optical link budget and sensitivity mask

3 2×400G FR4 Optical Specification

This IA defines 2×400G FR4 optical interface for 800 Gbps optical transceiver. The following tables show the common parameters: operating range, optical transmit characteristics, 2×400G FR4 optical receive characteristics and optical link budget.

TABLE 5 2×400G FR4 OPERATING RANGE

PMD type	Required operating range
2×400G FR4 operating range	2 km

TABLE 6 2×400G FR4 WAVELENGTH GRID

2×400G FR4 CWDM Lane	Center Wavelength (nm)	Wavelength range (nm)
L0	1271	1264.5 to 1277.5
L1	1291	1284.5 to 1297.5
L2	1311	1304.5 to 1317.5
L3	1331	1324.5 to 1337.5

TABLE 7 2×400G FR4 OPTICAL TRANSMIT CHARACTERISTICS

Description	Value	Unit
Signaling rate, each lane (range)	53.125 ± 100 ppm	GBd
Modulation format	PAM4	-
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Side-mode suppression ratio (SMSR), (min)	30	dB
Total average launch power, each fiber (max.)	10.4	dBm
Average launch power, each lane (max)	4.4	dBm
Average launch power, each lane (min)	-3.2	dBm
Outer Optical Modulation Amplitude (OMAouter), each lane (max)	3.7	dBm
Outer Optical Modulation Amplitude (OMAouter), each lane (min) for TDECQ <1.4dB for 1.4 dB ≤TDECQ ≤3.4 dB	-0.2 -1.6 + TDECQ	dBm
Difference in launch power between any two lanes (OMAouter) (max)	3.9	dB
Transmitter & dispersion eye closure for PAM4 (TDECQ), each lane (max)	3.4	dB
Average launch power of Off transmitter, each lane (max)	-16	dBm
Extinction ratio, each lane (min)	3.5	dB
Transmitter transition time (ps)	17	ps
$RIN_{17.1}$OMA (max)	-136	dB/Hz
Optical return loss tolerance (max)	17.1	dB

Transmitter reflectance (max)	-26	dB

TABLE 8 2×400G FR4 OPTICAL RECEIVE CHARACTERISTICS

Description	Value	Unit
Signaling rate, each lane (range)	53.125 ± 100 ppm	GBd
Modulation format	PAM4	-
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Damage threshold, each lane	5.4	dBm
Average receive power, each lane (max)	4.4	dBm
Average receive power, each lane (min)	-7.2	dBm
Receive power (OMAouter), each lane (max)	3.7	dBm
Difference in receive power between any two lanes (OMAouter) (max)	4.1	dB
Receiver reflectance (max)	-26	dB
Receiver sensitivity (OMAouter), each lane (max)	Max (-4.6,SECQ - 6.0)	dBm
Stressed receiver sensitivity (OMAouter) (max)	-2.6	dBm
Conditions of stressed receiver sensitivity test:		
Stressed eye closure for PAM4 (SECQ), lane under test	3.4	dB
OMAouter of each aggressor lane	1.4	dBm

TABLE 9 2×400G FR4 OPTICAL LINK BUDGET

Description	Value	Unit
Power budget (for maximum TDECQ):	7.8	dB
Operating distance	2	km
Channel insertion loss	4	dB
Maximum discrete reflectance	-35	dB
Allocation for penalties (for maximum TDECQ):	3.8	dB
Additional insertion loss allowed	0	dB

3.1 2x400Gb FR4 illustrative link power budget

Figure 4 illustrates 2×400Gb FR4 optical link budget and sensitivity mask.

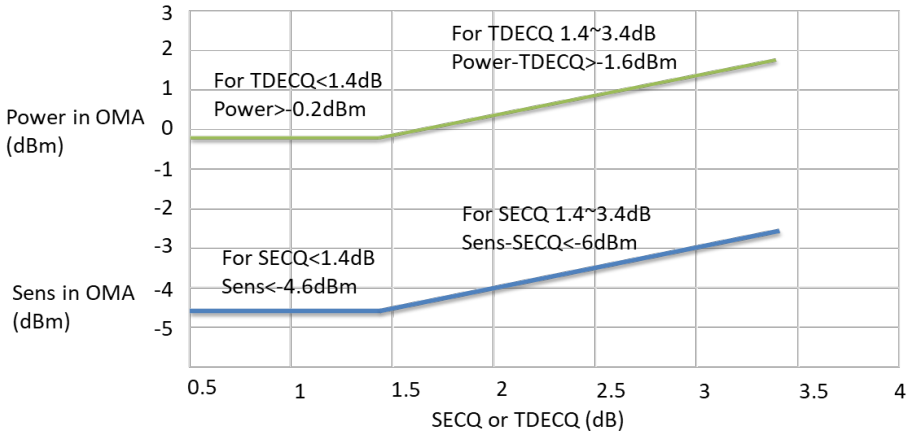

Figure 4 2x400Gb FR4 optical link budget and sensitivity mask

4 Definition of Optical Parameters and Measurement Methods

The specific test patterns are defined in Clause 3 of 400G-FR4 Technical Specification [2].

4.1 Test patterns for optical parameters

Detailed information on the test patterns for optical parameters is available in Clause 3.1 of 400G-FR4 Technical Specification [2].

4.2 Skew and skew variation

The skew and skew variation are available in Clause 3.2 of 400G-FR4 Technical Specification [2].

4.3 Wavelength

The wavelengths of each optical lane are available in Clause 3.3 of 400G-FR4 Technical Specification [2].

4.4 Average Optical power

The specific average optical power is defined in Clause 3.4 of 400G-FR4 Technical Specification [2].

4.5 Optical modulation amplitude (OMAouter)

The specific OMAouter are defined in Clause 3.5 of 400G-FR4 Technical Specification [2].

4.6 Transmitter and dispersion eye closure for PAM4 (TDECQ)

The specific TDECQ is defined in Clause 3.6 of 400G-FR4 Technical Specification [2].

4.6.1 TDECQ reference equalizer

The specific TDECQ reference equalizer defined in Clause 3.6.1 of 400G-FR4 Technical Specification [2].

4.7 Extinction ratio

See Clause 3.7 of 400G-FR4 Technical Specification [2].

4.8 Transmitter transition time

See Clause 3.8 of 400G-FR4 Technical Specification [2].

4.9 Relative Intensity Noise (RIN)

See Clause 3.9 of 400G-FR4 Technical Specification [2].

4.10 Receiver sensitivity

See Clause 3.10 of 400G-FR4 Technical Specification [2].

4.11 Stressed receiver sensitivity

See Clause 3.11 of 400G-FR4 Technical Specification [2].

5 Fiber Optic Cabling Model

The fiber optic cabling model of 800G DR8 and 2×400G FR4 is shown in Figure 5.

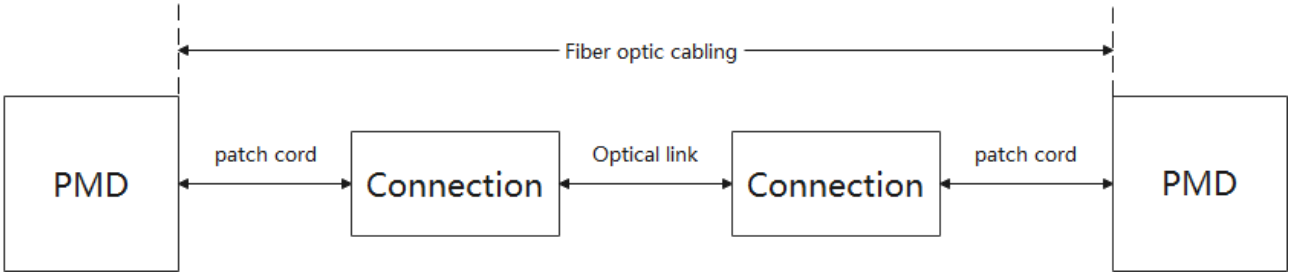

Figure 5 Fiber optic cabling model

6 Characteristics of the fiber optic cabling (Channel)

The link loss related specs are given in Clause 5 of 400G-FR4 Technical Specification [2].

The fiber optic cabling requirements for 800G DR8 and 2×400G FR4 are specified in Table 10 and Table 11.

TABLE 10 FIBER OPTIC CABLING CHARACTERISTICS FOR 800G DR8

Description	800G DR8	Unit
Operating distance(max)	500	m
Channel insertion loss[a](max)	3	dB
Positive dispersion[b](max)	0	ps/nm
Negative dispersion[b](min)	0.8	ps/nm
DGD_max	2.24	ps
Optical return loss	27	dB

[a] The channel insertion loss includes connectors, splices etc.

[b] The wavelength range is from 1304.5nm to 1317.5nm

TABLE 11 FIBER OPTIC CABLING CHARACTERISTICS FOR 2×400G FR4

Description	2×400G FR4	Unit
Operating distance(max)	2	km
Channel insertion loss(max)	4	dB
Channel insertion loss(min)	0	dB
Positive dispersion(max)	6.6	ps/nm
Negative dispersion(min)	-11.7	ps/nm
DGD_max	2.3	ps
Optical return loss(min)	25	dB

[a] The channel insertion loss includes connectors, splices etc.

[b] The wavelength range is from 1264.5nm to 1337.5nm

7 References

7.1 Normative references

1. IEEE Std 802.3-2022: IEEE Standard for Ethernet

2. 400G-FR4 Technical Specification (Rev 2.0 December 9, 2020), 100G Lambda MSA Group

3. IEEE Std 802.3ck-2022™ IEEE Standard for Ethernet Amendment 4: Physical Layer Specifications and Management Parameters for 100 Gb/s, 200 Gb/s, and 400 Gb/s Electrical Interfaces Based on 100 Gb/s Signaling

7.2 Informative references

8 Appendix A: Abbreviations and acronyms

The following abbreviations and acronyms are used in this IA:

DeMUX	Demultiplexer
DGD	Differential Group Delay
DRV	Driver
FEC	Forward Error Correction
IA	Implementation Agreement
MSA	Multisource Agreement
MUX	Multiplexer
OMA	Optical Modulation Amplitude
OMAouter	Outer Optical Modulation Amplitude
PCS	Physical Coding Sublayer
PMA	Physical Medium Attachment
PMD	Physical Medium Dependent
PRBS	Pseudo-Random Bit Sequence
QSFP	Quad Small Form Factor Pluggable
RIN	Relative Intensity Noise
RX	Receiver
SECQ	Stressed Eye Closure for PAM4
SMF	Single Mode Fiber
SMSR	Side-mode Suppression Ratio
SSPRQ	Short Stress Pattern Random Quaternary
TDECQ	Transmitter and Dispersion Eye Closure for PAM4
TIA	Transimpedance Amplifier
TX	Transmitter