

Eco-system Considerations in Defining Beyond 10km PHYs

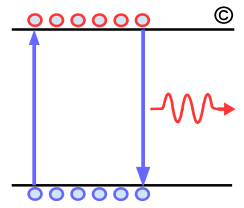
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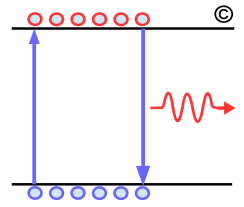
Sept 15th, 2017

Overview



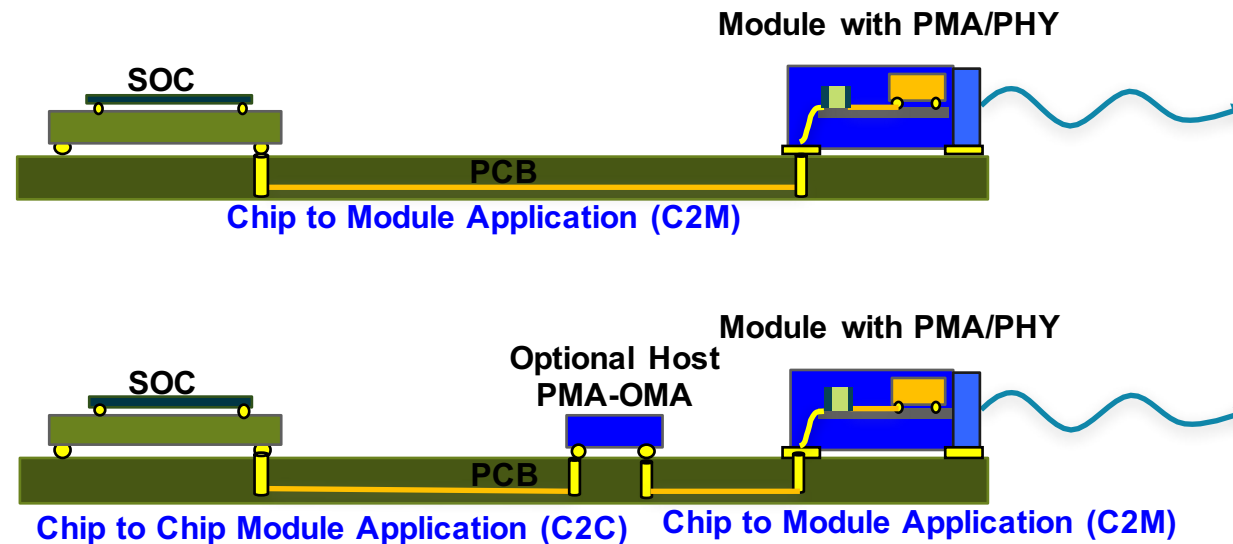
- ❑ **Our project scope is to define beyond 10 km PHYs for 50 GbE, 200 GbE, and 400 GbE**
 - The project goal should be to supplement the eco-system of 50 GbE, 200 GbE, and 400 GbE with > 10 km PHYs
- ❑ **Previously in IEEE P802.3 following PMDs with >10 km reach were defined**
 - P802.3ae defined 10GBASE-ER with 40 km reach
 - P802.3cc defined 25GBASE-ER with 30 km reach and engineered link up to 40 km
 - P802.3bm defined 40GBASE-ER4 with with 30 km reach and engineered link up to 40 km
 - P802.3ba defined 100GBASE-ER4 with 30 km reach and engineered link up to 40 km
 - 4WDM-20/40 MSA has defines 100GbE PMD respectively for 20 km and 40 km
- ❑ **All of the above >10 km PMDs use existing PCS and FEC instead of creating a full PHY**
 - The study group need to determine if existing PCS/FEC can be reused
 - Only if necessary the study group should define a more complex PMA and/or higher gain FEC
 - There is no doubt reusing existing PCS/FEC would be advantages, synergistic with existing PCS/FEC/PMA, and without the complexity of segmented PCS/FEC
- ❑ **The scope of this project allows defining a new PHY for > 10 km reach**
 - This study group also should consider an objective based on nominal reach of 30 km, where the engineered link can be up to 40 km
- ❑ **This contribution looks at Ethernet layers, compatibility, and AUI interfaces.**

Application Reference Model

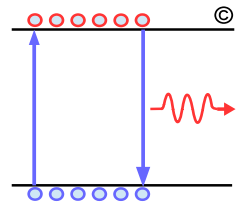


□ This project should consider reuse existing C2C and C2M AUI interfaces

- Need to support 25Gbps/lane NRZ with no-FEC and RS(514, 528)
- Need to support 50 Gbps/lane PAM4 with RS (514, 544)
- This project should monitor 100 Gbps/lane AUI interface in OIF and future IEEE project
- Given that this project is completing the PMD set for 802.3bs/cd the required AUI interfaces are 25 Gbps/lane NRZ and 50 Gbps/lane PAM4.



From Lower Complexity to Higher Complexity

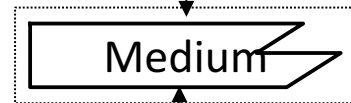
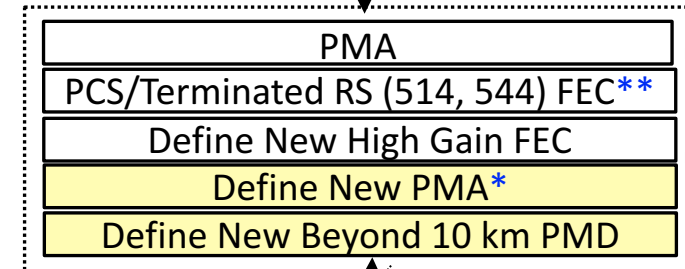
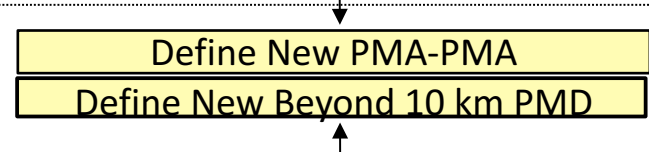
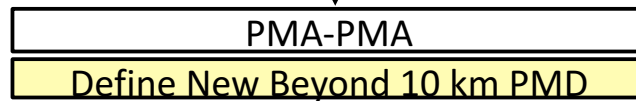
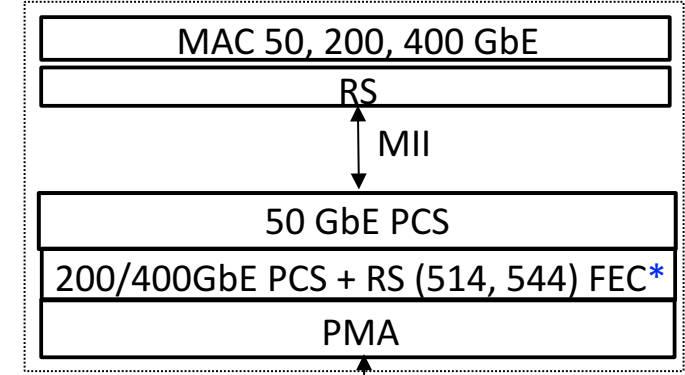
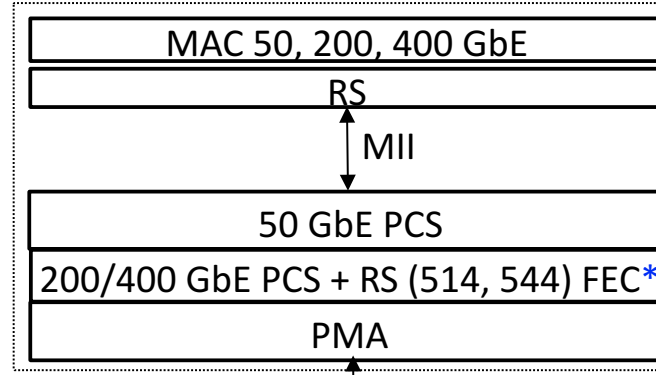
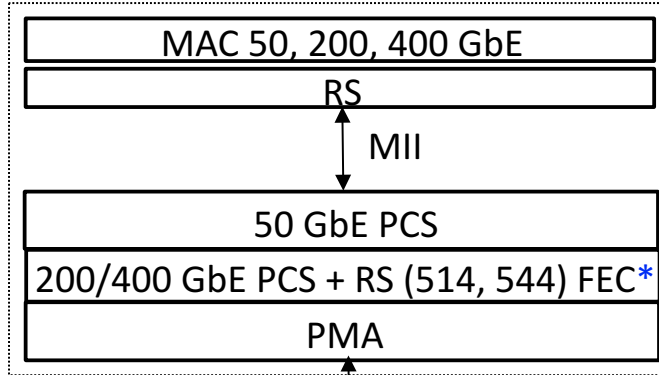


Reuse PCS/FEC/PMA

Reuse PCS/FEC with New PMA

Define a Full New PHY

Pluggable Module



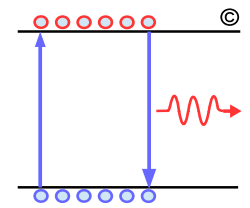
50 GbE, 200 GbE, 400 GbE

50 GbE, 200 GbE, 400 GbE

50 GbE, 200 GbE, 400 GbE

*In case of 200/400 GbE PCS and FEC function are in one common block.
But 50 GbE LAUI-2 can operate with/without FEC RS(514, 544).

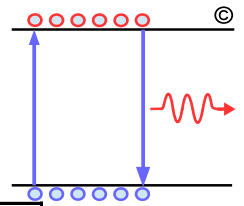
Relation of Study Group to Relevant Ethernet Standards



Standard	Designation	Modulation	Baudrate GBaud	Reach (m)	#Lanes or #λ	PCS/PMA Clause	FEC Clause	PMD Clause
50 GbE	50GBASE-SR	PAM4	26.5625	100	1	CL 133/CL 135 4 PCS Lanes	CL 134 RS (514, 544) FEC	CL 138
	50GBASE-FR			2000				CL 139
	50GBASE-LR			1,000				CL139
	50GBASE-ER	TBD	TBD	40000?	1?	TBD	TBD	TBD
100 GbE	100GBASE-SR4	NRZ	25.78125	100	4	CL 82 20 PCS Lanes	CL 91 RS (514, 528) FEC	CL 95
	100GBASE-LR4			10000				CL 88
	100GBASE-ER4			40000 ^a				CL 88
	100GBASE-SR2	PAM4	26.5625	100	2	CL 82/CL 135	CL 91	CL 138
	100GBASE-DR		53.125	500	1	20 PCS Lanes	RS (514, 544) FEC	CL 140
200 GbE	200GBASE-SR4	PAM4	26.5625	100	4	CL 119/CL 118 8 PCS Lanes	CL 119 RS (514, 544) FEC	CL 138
	200GBASE-DR4			500				CL 121
	200GBASE-FR4			2000				CL 122
	200GBASE-LR4			10000				CL 122
	200GBASE-ERx	TBD	TBD	40000?	TBD	TBD	TBD	TBD
400 GbE	400GBASE-SR16	NRZ	13.28125	100	16	CL 119/CL 118 16 PCS Lanes	CL 119 RS (514, 544) FEC	CL 123
	400GBASE-DR4	NRZ	53.125	500	4			CL 124
	400GBASE-FR8		26.5625	2000	CL 122			
	400GBASE-LR8		10000	8	CL 122			
	400GBASE-ERx	TBD	TBD	40000?	TBD	TBD	TBD	TBD

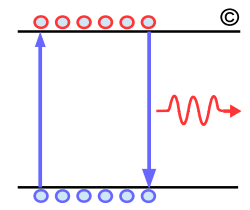
^a . 100GBASE-ER4 support 30 km but link reaches up to 40 km maybe supported with an engineered link.

Relation of Study Group to Relevant Ethernet AUIs



Standard	Designation	Modulation	Baudrate GBaud	#Lanes	PCS/PMA Clause	FEC Clause	AUI Clauses
50 GbE	LAUI-2 C2C	NRZ	25.78125	2	CL 133/135 4 PCS Lanes	NA	CL 135B
	LAUI-2 C2M						CL 135C
	50GAUI-2 C2C 50GAUI-2 C2M	NRZ	26.5625	2		CL 134 RS (514, 544) FEC	CL 135D CL 135E
	50GAUI-1 C2C 50GAUI-1 C2M						PAM4
100 GbE	CAUI-4 C2C	NRZ	25.78125	4	CL 82/CL 135 20 PCS Lanes	NA	CL 83D
	CAUI-4 C2M						CL 83E
	100GAUI-4 C2C 100GAUI-4 C2M	NRZ	26.5625	4		CL 91 RS (514, 544) FEC	CL 135D CL 135E
	100GAUI-2 C2C 100GAUI-2 C2M						PAM4
200 GbE	200GAUI-8 C2C 200GAUI-8 C2M	NRZ	26.5625	8	CL 119/CL 118 8 PCS Lanes	CL 119 RS (514, 544) FEC	CL 120B CL 120C
	200GAUI-4 C2C 200GAUI-4 C2M			PAM4			4
400 GbE	400GAUI-16 C2C 400GAUI-16 C2M	NRZ	26.5625	16	CL 119/CL 118 16 PCS Lanes	CL 119 RS (514, 544) FEC	CL 120B CL 120C
	400GAUI-8 C2C 400GAUI-8 C2M			PAM4			8

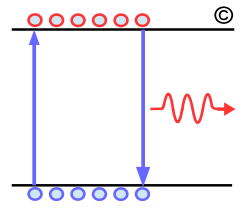
FEC in the module can be supported if required



Standard	Module Interface	Host FEC	Module FEC	PMDs
50 GbE	LAUI-2 C2M	NA	RS (514, 544) FEC	50GBBASE-SR 50GBASE-FR 50GBASE-LR
	50GAUI-1 C2M	RS (514, 544) FEC	NA	
	50GAUI-2 C2M			
100 GbE	CAUI-4 C2M	NA	NA	100GBASE-LR4 100GBASE-ER4
		Optional RS (514, 528) FEC	NA ^a	100GBASE-SR4
	100GAUI-2 C2M	RS (514, 544) FEC	NA	100GBASE-SR2 100GBASE-DR
	100GAUI-4 C2M			
200 GbE	200GAUI-4 C2M	RS (514, 544) FEC	NA	200GBASE-SR4 200GBASE-DR4 200GBASE-FR4 200GBASE-LR4
	200GAUI-8 C2M			
400 GbE	400GAUI-8 C2M	RS (514, 544) FEC	NA	400GBASE-SR16 400GBASE-DR4 400GBASE-FR8 400GBASE-LR8
	400GAUI-16 C2M			

^a If Optional host FEC not available then RS (514, 528) FEC in the module is required. PSM4 MSA, CLR4 MSA, CWDM4 MSA, and 4WDM-10/20/40 MSA also require RS(514, 528) FEC.

Summary



- ❑ **The simplest approach that needs to be explored foremost instead of defining full PHY, “can the beyond 10 km objective be met by defining a set of PMDs for 50, 200, and 400 GbE and reuse 802.3bs/cd (PCS, FEC, and PMA) instead of defining full new PHY?”**
 - The objective for >10 km PMDs should be 30 km where engineered link may support up to 40 km
 - In line with definition in 25GBASE-ER, 40GBASE-ER4, and 100GBASE-ER4
 - If we have to define a full PHY (PCS/FEC/PMA) then all options are on the table including stronger FEC with PAM4, stronger FEC with another modulation code, or stronger FEC with coherent
- ❑ **There is no reason to duplicate OIF ZR project in IEEE where 80-120 km amplified single λ and DWDM currently being defined**
- ❑ **If we choose to define a new PHY (coherent, new modulation format, or stronger FEC) the AUI interface must remain compatible with 50, 200, and 400 GbE AUIs**
 - The FEC carried over AUI must be terminated in the module with exception of LAUI-2 which operates without FEC
 - Stronger FEC or a new PMA/modulation format will reside inside the module and operate as segmented FEC using DTE XS and PHY XS layers
 - If new stronger FEC is required then need to consider reusing OIF ZR FEC instead of defining another FEC
 - The decision to define a new FEC and/or PMA should not be taken lightly given the investment it requires and complexity it brings
 - It is unlikely that high gain FEC including OIF ZR FEC will be integrated into superset host ASIC due to core size, FEC latency, and pushing the host interface to >29 GBd!