Extended EPON Study Group

Overview of IEEE, ITU-T and regional PON power budgets

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Contents

- Terminology
- Channel model
- 1G-EPON power budgets
- 10G-EPON power budgets
- GPON power budgets
- XGPON power budgets
- CCSA defined power budgets for EPON
- Other PON power budgets (??)

Purpose

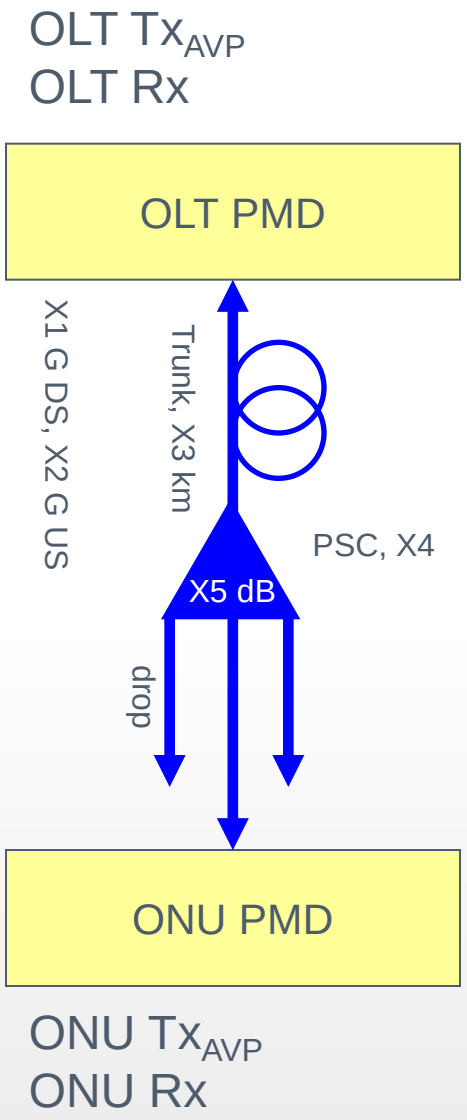
- Present the current state of the art for various IEEE and ITU-T PON systems in terms of power budget support
- Look at specifications added by national standardization bodies e.g. CCSA in China
- Create a reference for further discussion within the Study Group on technical feasibility of extended power budget PMDs

Terms

- **PMD** = Physical Medium Dependent layer, as defined in Clause 60 for 1G-EPON and Clause 75 for 10G-EPON
- **ChIL** = Channel Insertion Loss, per 802.3, 1.4.95, the static loss of light through a link between a transmitter and receiver. It includes the loss of the fiber, connectors, and splices and, for EPON links, optional power splitter/combiner. Also referred to as "loss budget"
- **Power budget** = the total of the ChIL and any transmission penalties associated with the non-ideal characteristics of the transmitter, receiver and transmission channel. Typically, *power budget > loss budget*.
- **ODN** = Optical Distribution Network, the structure made of fiber, splitters and optional connectors, spanning between the OLT MDI and ONU MDI interfaces

Channel Model

- OLT PMD and ONU PMD operating at X1 Gb/s in downstream and X2 Gb/s in upstream direction
- ODN with nominal distance of X3 km, with the nominal PSC split of X4, with the minimum ChIL of X5_1 and maximum ChIL of X5_2 dB
- OLT PMD and ONU PMD parameters defined as Rx sensitivity and Tx average launch power. The OLT Tx operates at a specific central wavelength X6, with the tolerance of X6t. The ONU Tx operates at a specific central wavelength X7, with the tolerance of X7t.



1G-EPON (IEEE Std 802.3ah-2004)

Description	Low power budget	Medium power budget	Unit
	PX10	PX20	
Downstream rate (X1)	1.25		GBd
Upstream rate (X2)	1.25		GBd
Downstream wavelength (X6)	1490		nm
Downstream wavelength band (X6t)	20		nm
Upstream wavelength (X7)	1310		nm
Upstream wavelength band (X7t)	100		nm
Nominal maximum reach (X3)	10	20	km
Nominal split (X4)	1:16	1:16	-
Maximum ChIL (X5_2)	20	24	dB
Minimum ChIL (X5_1)	5	10	dB

Note:

- Nominal maximum reach is informative – PMDs may support longer reach and remain standard compliant;
- 1 Gb/s link parameters with ChIL = 29 dB were not included in IEEE Std 802.3ah-2004 and were added in IEEE Std 802.3av-2009 for upstream direction only

1G-EPON devices types

	OLT Tx	OLT Rx	ONU Tx	ONU Rx
PX10	DML	PIN	DML	PIN
PX20	DML	PIN	DML	PIN

NOTES:

- These are typical types of devices expected to meet launch power / sensitivity requirements set forth in 802.3ah-2004, in existing products available on the market
- Other device types are certainly possible, as long as launch power / sensitivity requirements set forth in 802.3ah-2004 can be met

10G-EPON (IEEE Std 802.3av-2009)

Description	Low power budget		Medium power budget		High power budget		Unit
	PRX10	PR10	PRX20	PR20	PRX30	PR30	
Downstream rate (X1)	10.3125						GBd
Upstream rate (X2)	1.25	10.3125	1.25	10.3125	1.25	10.3125	GBd
Downstream wavelength (X6)	1577						nm
Downstream wavelength band (X6t)	+3 / -2						nm
Upstream wavelength (X7)	1310	1270	1310	1270	1310	1270	nm
Upstream wavelength band (X7t)	100	20	100	20	100	20	nm
Nominal maximum reach (X3)	10		20		20		km
Nominal split (X4)	1:16		1:16		1:32		-
Maximum ChIL (X5_2)	20		24		29		dB
Minimum ChIL (X5_1)	5		10		15		dB

Note:

- Nominal maximum reach is informative – PMDs may support longer reach and remain standard compliant;
- PRX30 uses 1 Gb/s link parameters which were not included in IEEE Std 802.3ah specifications (29 dB ChIL)

10G-EPON devices types

	OLT Tx	OLT Rx	ONU Tx	ONU Rx
PR10	EML	PIN + FEC	DML	PIN + FEC
PR20	EML + AMP	APD + FEC	DML	PIN + FEC
PR30	EML	APD + FEC	High power DML	APD + FEC
PRX10	EML	PIN	DML	PIN + FEC
PRX20	EML + AMP	APD	DML	PIN + FEC
PRX30	EML	PIN / APD + FEC	DML	APD + FEC

NOTES:

- These are typical types of devices expected to meet launch power / sensitivity requirements set forth in 802.3av-2009, as discussed at the time when 802.3av was under development
- Other device types are certainly possible, as long as launch power / sensitivity requirements set forth in 802.3av-2009 can be met

GPON (G.984 series)

Description	Low power budget	Medium power budget		High power budget		Unit
	A	B	B+	C	C+	
Downstream rate (X1)	2.5					GBd
Upstream rate (X2)	1.25					GBd
Downstream wavelength (X6)	1490					nm
Downstream wavelength band (X6t)	20					nm
Upstream wavelength (X7)	1310					nm
Upstream wavelength band (X7t)	100 / 40 / 20, depending on selected G.984.5 spec					nm
Nominal maximum reach (X3)	20					km
Nominal split (X4)	undefined					-
Maximum ChIL (X5_2)	20	25	26.5	30	32	dB
Minimum ChIL (X5_1)	5	10	10	15	15	dB

Note:

- Nominal maximum reach is informative – PMDs may support longer reach and remain standard compliant; nominal split is undefined
- Downstream link assumes 1dB margin, upstream link assumes 0.5dB margin.

XGPON (G.987 series)

Description	Nominal power budgets		Unit
	N1	N2	
Downstream rate (X1)	9.95328		GBd
Upstream rate (X2)	2.48832		GBd
Downstream wavelength (X6)	1575 – 1580		nm
Downstream wavelength band (X6t)	5		nm
Upstream wavelength (X7)	1260 – 1280		nm
Upstream wavelength band (X7t)	20		nm
Nominal maximum reach (X3)	20		km
Nominal split (X4)	undefined		-
Maximum ChIL (X5_2)	29	31	dB
Minimum ChIL (X5_1)	14	16	dB

Note:

- Nominal maximum reach is informative – PMDs may support longer reach and remain standard compliant; nominal split is undefined
- Downstream link assumes 1dB margin, upstream link assumes 0.5dB margin.

CCSA EPON specifications

Description	1G-EPON	10G-EPON				Unit
	PX20+	PRX40	PR40	PRX50	PR50	
Downstream rate (X1)	1.25	10.3125				GBd
Upstream rate (X2)	1.25	1.25	10.3125	1.25	10.3125	GBd
Downstream wavelength (X6)	1490	1577				nm
Downstream wavelength band (X6t)	+10 / -10	+3 / -2				nm
Upstream wavelength (X7)	1310	1310	1270	1310	1270	nm
Upstream wavelength band (X7t)	+50 / -50	+50 / -50	+10 / -10	+50 / -50	+10 / -10	nm
Nominal maximum reach (X3)	20	20+		20+		km
Nominal split (X4)	1:32	1:16		1:32		-
Maximum ChIL (X5_2)	28	33		37		dB
Minimum ChIL (X5_1)	10	18		21		dB

Note:

- PX20+ class devices are available commercially today and deployed en mass
- PR(X)40 devices are sampling