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Understanding 1G EPON Power Budgets in IEEE Formalism

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Testing interfaces:

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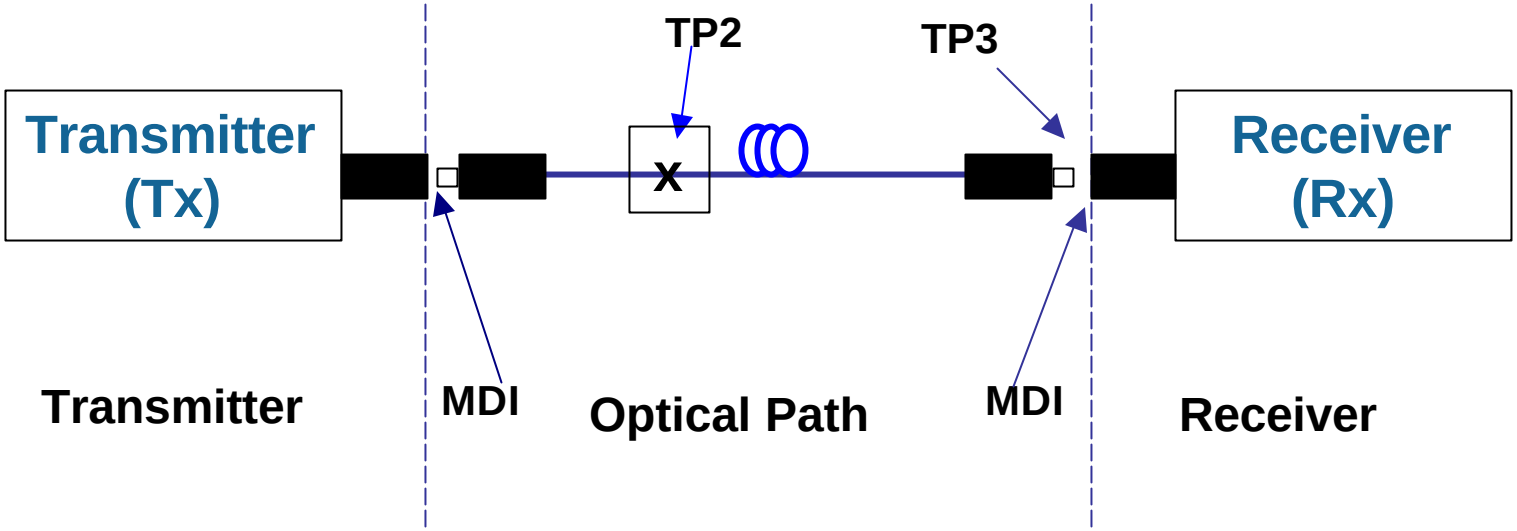
- Transmitter; measured at **TP2**
- Receiver; signals defined at **TP3**; (with stressed eye conformance)
- Optical path; defined as link power budget.



1G EPON power budgets and penalties (802.3ah D3 P.334)

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Table 60–9—Illustrative 1000BASE-PX10 and 1000BASE-PX20 channel insertion loss and penalties

Description	1000BASE-PX10		1000BASE-PX20		Units
	Upstream	Downstream	Upstream	Downstream	
Fiber Type	B1.1, B1.3 SMF				
Measurement wavelength for fibre	1310	1550[a]	1310	1550[a]	nm
Nominal distance	10		20		km
Available power budget[b]	23.0	21.0	26.0	26.0	dB
Channel insertion loss (max)[c]	20	19.5	24	23.5	dB
Channel insertion loss (min)[d]	5		10		dB
Allocation for penalties[e]	3	1.5	2	2.5	dB
Optical return loss of ODN (min)	20				dB

[a]The nominal transmit wavelength is 1490 nm

[b]In an FEC enabled link, when not operating at the dispersion limit, the available power budget is increased by 2.5 dB

[c]The channel insertion loss is based on the cable attenuation at the target distance and nominal measurement wavelength. The channel insertion loss also includes the loss for connectors, splices and other passive components such as splitters

[d]The power budgets for PX10 and PX20 links are such that a minimum insertion loss is assumed between transmitter and receiver. This minimum attenuation is required for PMD testing

[e]The allocation for penalties is the difference between the available power budget and the channel insertion loss; insertion loss difference between nominal and worst case operating wavelength is considered a penalty. This allocation may be used to compensate for transmission related penalties. Further details are given in 60.7.2.

PX10 working budget

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1.25G EPON				
	PX10 DS		PX10 US	
Wavelength	1480 to 1500nm		1260 to 1360nm	
	OMA	**AOP**	**OMA**	**AOP**
Tx launching power (min) - (1)	-2.2	**-3**	-0.22	**-1**
Rx Sensitivity (max.) - (2)	-23.2	**-24**	-23.2	**-24**
SRS senstivity (2)'	-20.7	-21.4	-21.5	-22.3
IL - (3)	19.5	19.5	20	20
ER	6		6	
TWDP	1.3		2.8	
VECP	2.2		1.2	
RX overload		-3		-1
Power budget (4) = (1)-(2)	**21**	**21**	**23.0**	**23**
Path penalty (5) = (4) -(3)	**1.5**	**1.5**	**3.0**	**3**
"SRS Power budget" (4)'=(1) - (2)'	18.5	18.4	21.3	21.3

Note: At ER=6dB, OMA-AOP=0.8dB

PX20 working budget

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1.25G EPON				
	PX20 DS		**PX20 US**	
Wavelength	1480 to 1500nm		1260 to 1360nm	
Tx launching power (min) - (1)	2.8	2	-0.22	-1
Rx Sensitivity (max.) = (2)	-23.2	-24	-26.2	-27
SRS senstivity (max) = (2)'	-21.3	-22.1	-23.6	-24.4
IL - (3)	23.5	23.5	24	24
ER	6		6	
TWDP	2.3		1.8	
VECP	1.5		2.2	
RX overload		-3		-6
Power budget (4) = (1)-(2)	**26**	**26**	**26.0**	**26**
Path penalty (5) = (4) -(3)	**2.5**	**2.5**	**2.0**	**2**
"SRS Power budget" (4)'=(1) - (2)'	24.1	24.1	23.4	23.4

Note: At ER=6dB, OMA-AOP=0.8dB

GPON B+ 2.488G/1.244G working budget (Amendment 1 to G.984.2)

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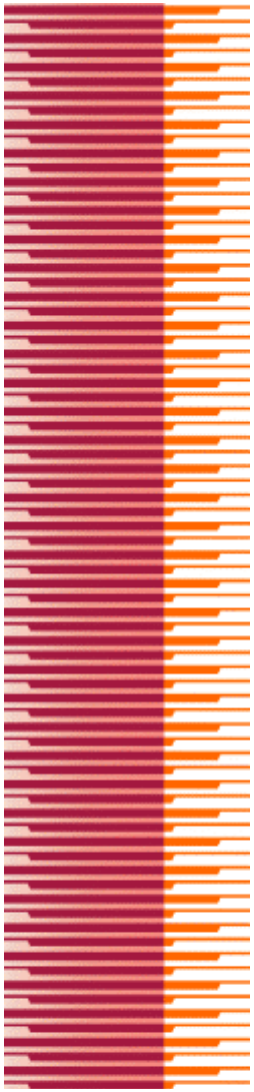
(embedded doc):

Table III.1/G.984.2 – Optical power levels for the 2.4 Gbit/s downstream,1.2 Gbit/s upstream system



International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.984.2

Amendment 1

(02/2006)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Optical line systems for local and access networks

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Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification

Amendment 1: New Appendix III – Industry best practice for 2.488 Gbit/s downstream, 1.244 Gbit/s upstream G-PON

GPON B+ 2.488G/1.244G working budget (Ref to: Amendment 1 to G.984.2)

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2.488/1.244Gb/s GPON (G.984.2Amend)				
	B+ DS		**B+ US**	
Wavelength	1480 to 1500nm		1260 to 1360nm	
Tx launching power (min) = (1)	3.6	**1.5**	2.6	**0.5**
Rx Sensitivity (max.) = (2)	-24.9	**-27**	-25.9	**-28**
SRS senstivity (max) = (2)'				
IL - (3)	28	28	28	28
ER				
TWDP				
VECP				
RX overload		-8		-8
Power budget (4) = (1)-(2)	**28.5**	**28.5**	**28.5**	**28.5**
Path penalty (5) = (4) -(3)	**0.5**	**0.5**	**0.5**	**0.5**
Power budget (4)'=(2)'-1				

Note: GPON assume ER>10dB; At ER=10dB, OMA-AOP=2.1dB

Why TDP (802.3ah 58.7.9 p.272)??

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- For Tx compliance test at TP2 only:
  - Specific conditions and procedures: (Ref Tx, Ref Rx, Test channel;…..)

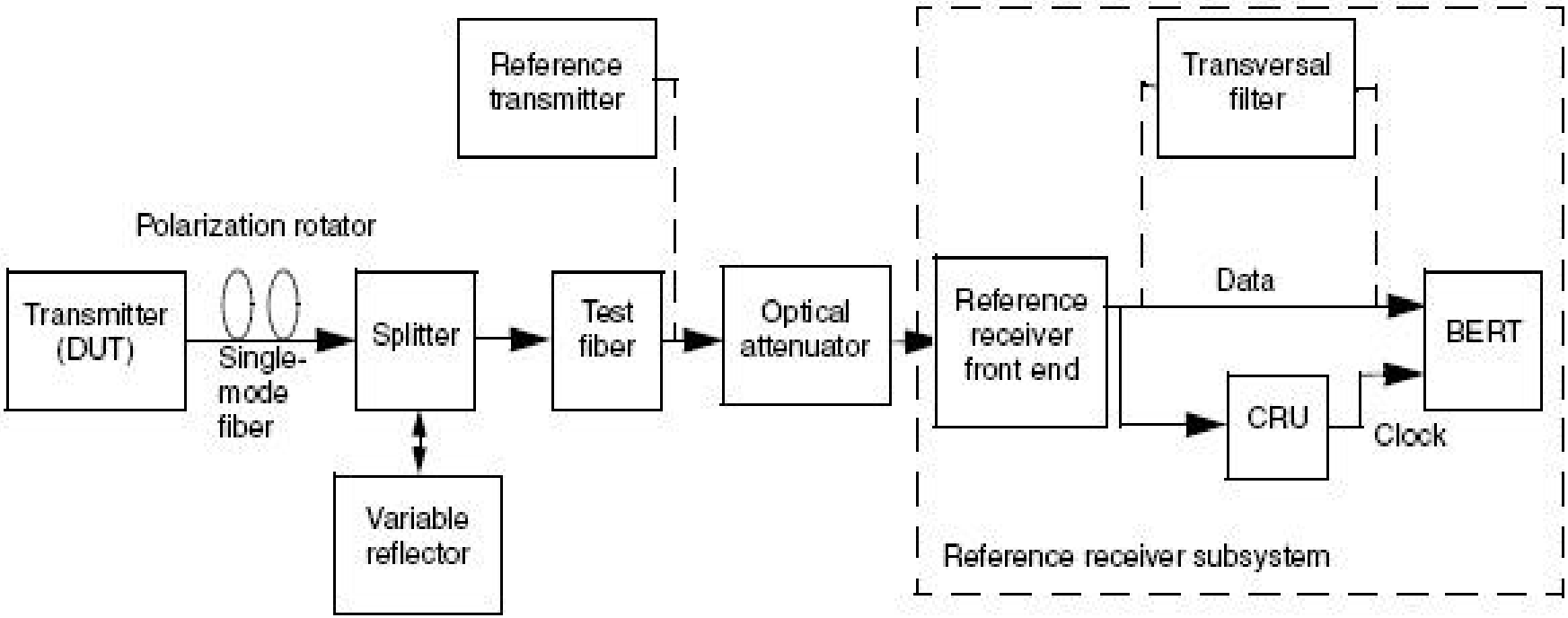

Figure 58–7—Test setup for measurement of transmitter and dispersion penalty

Why SRS (802.3ah 58.7.11 p.275)??

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- For Rx compliance test at TP3 only:
  - Specific SRS conditions and procedures: (VECP, SJ, ….)

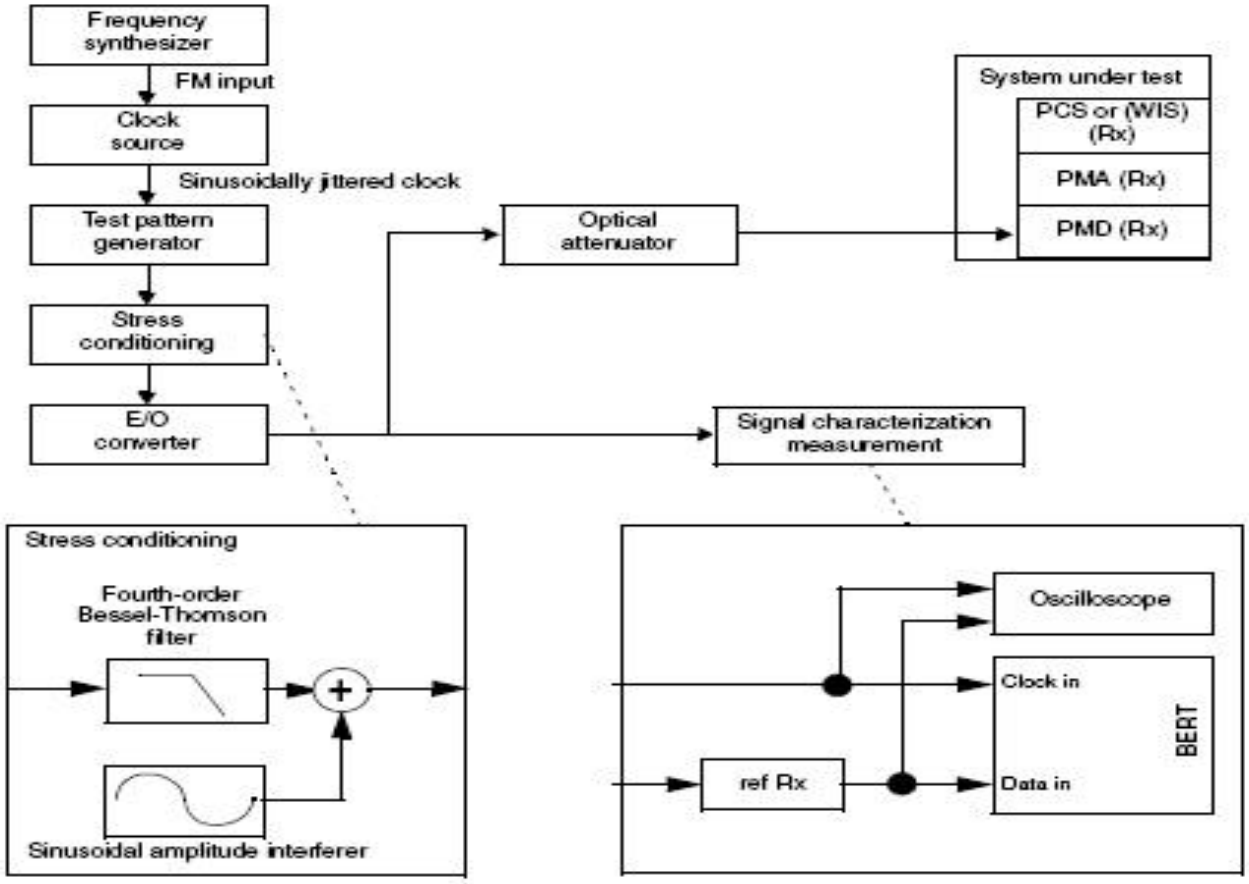

Figure 58–8—Stressed receiver conformance test block diagram

Recommendations:

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- Follow the 1G EPON methodology to define 10G EPON specs
  - 10G EPON group need to specify 10G EPON path penalty
  - Translate AOP into OMA
- Donot confuse TDP for link budget
  - TDP is only for Transmitter compliance test at TP2
  - 10G EPON group need to work out similar Tx test as well
- Donot confuse SRS for link budget
  - SRS is only for Receiver compliance test at TP3
  - 10G EPON group need to work out similar SRS test as well

One example:

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10G EPON B++ (APD@ONU case in 3av_0707_hamano_1.pdf)				
	B++ DS		**B++ US**	
Wavelength	1480 to 1500nm		1260 to 1360nm	
Tx launching power (min) = (1)	3.9	**2**	4.8	**4**
Rx Sensitivity (max.) = (2)	-26.1	**-28**	-25.2	**-26**
SRS senstivity (max) = (2)'				
IL - (3)	29	29	29	29
ER		9		6
TWDP				
VECP				
RX overload		-10		-6
Power budget (4) = (1)-(2)	**30**	**30**	**30**	**30**
Path penalty (5) = (4) -(3)	**1**	**1**	**1**	**1**
Power budget (4)'=(2)'-1				

Note: At ER=9dB, OMA-AOP=1.9dB

At ER=6dB, OMA-AOP=0.8dB

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Backup Slides

10GbE 802.3ae link budget based on link model

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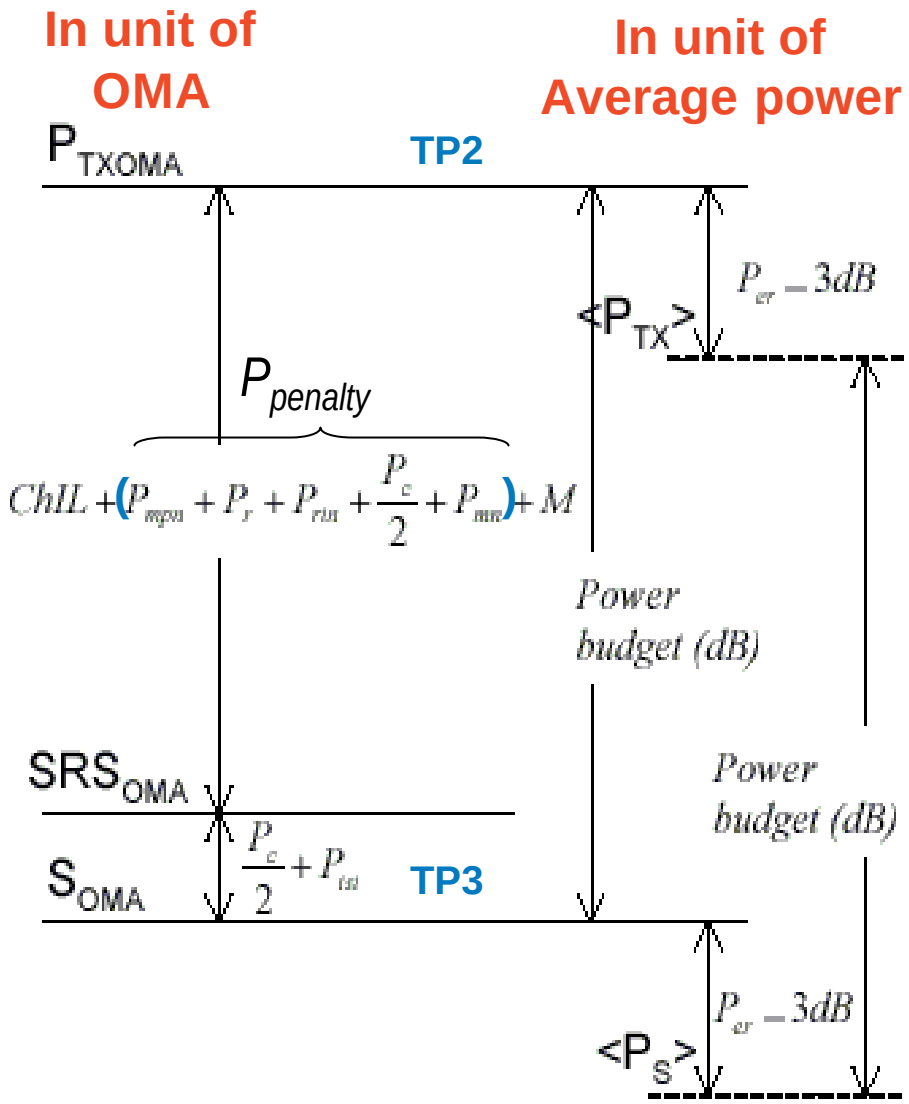

Figure 2. The 10Gigabit Ethernet power budget

- **10GbE link power budget in OMA**

$$SRS_{OMA} = P_{TXOMA} - CHIL - P_{penalty} - M$$

$$S_{OMA} = SRS_{OMA} - P_{ISI} - P_C/2$$

  - SRS_{OMA} : Stressed Rx sensitivity in OMA (dBm)
  - P_{TXOMA} : Transmit power in OMA (dBm)
  - CHIL : Channel loss (dB)
  - M : Link margin (dB)

- **10GbE link power budget in average power**

$$\langle P_S \rangle = \langle P_{TX} \rangle - CHIL - P_{penalty} - M$$

  - $\langle P_S \rangle$: Receiver sensitivity (dBm)
  - $\langle P_{Tx} \rangle$: Average transmit power (dBm)

- **Correlating OMA with average power**

$$S_{OMA} = \langle P_S \rangle + P_{ER} - 3dB$$

$$P_{TXOMA} = \langle P_{TX} \rangle + P_{ER} - 3dB$$

Optical specs of 10GbE standards was developed based on 10GbE link model worst-case analysis.