Joint ITU-T / IEEE Workshop on Next Generation Optical Access Systems

Introduction to 10G-EPON PMDs

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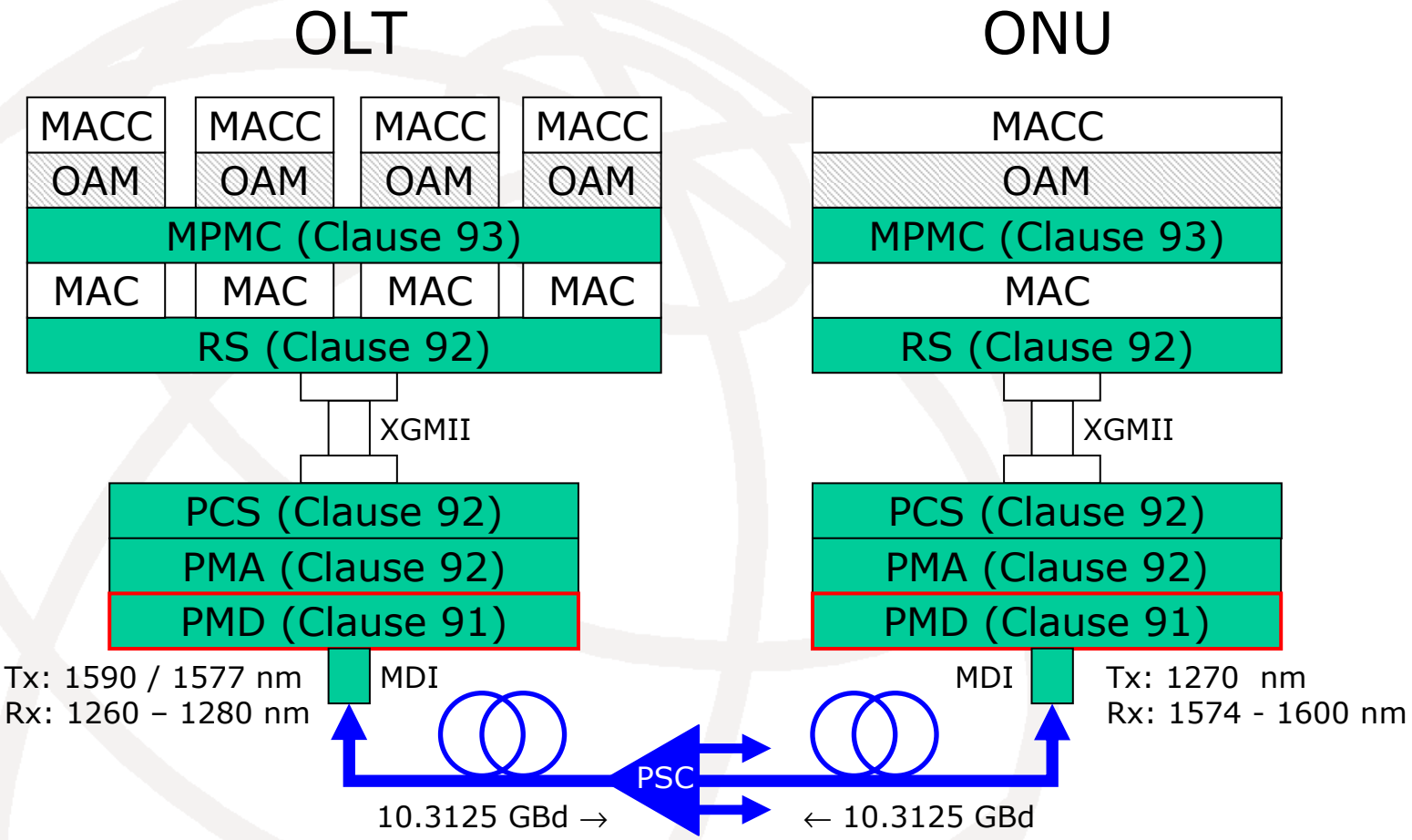
PMD definitions [1]

Some definitions used in Clause 91 802.3av:

- Channel Insertion Loss (ChIL) – total attenuation introduced by the optical channel (fibre, splitter/s/, splices etc.), excluding penalties
- Power budget – total difference between minimum AVP launch power and Rx sensitivity = ChIL + penalties, including:
  - PRX type – asymmetric, backward compatible with EPON
    - **PRX10** – ChIL ≤ 20 dB, compatible with PX10
    - **PRX20** – ChIL ≤ 24 dB, compatible with PX20
    - **PRX30** – ChIL ≤ 29 dB, no EPON PMD for compatibility
  - PR type – symmetric
    - **PR10** – ChIL ≤ 20 dB, compatible with PX10
    - **PR20** – ChIL ≤ 24 dB, compatible with PX20
    - **PR30** – ChIL ≤ 29 dB, no EPON PMD for compatibility
- Power budget class – comprises PMDs with the same ChIL, represented by a symmetric (PR) and asymmetric (PRX) PMD e.g. low power budget with PR10 and PRX10 power budgets

PR-type PMD in IEEE stack

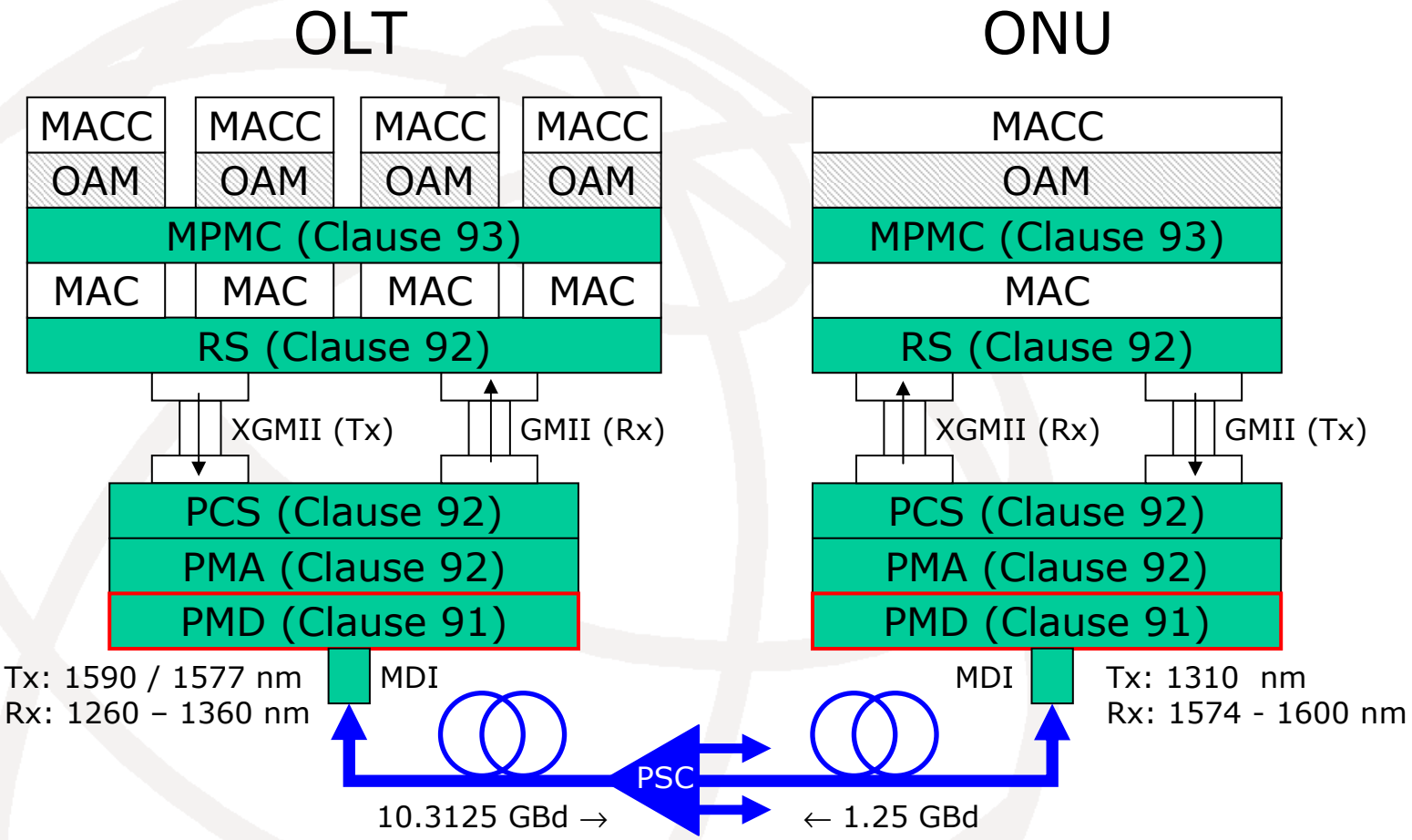


Notes:
- OAM is optional
- Green layers in scope of 802.3av

Layers:
MACC – MAC Client
OAM – Operation And Maintenance
MPMC – Multipoint MAC Control
MAC – Media Access Control

Layers:
RS – Reconciliation Sublayer
PCS – Physical Coding Sublayer
PMA – Physical Medium Attachment
PMD – Physical Medium Dependent
MDI – Medium Dependent Interface

PRX-type PMD in IEEE stack



Notes:
- OAM is optional
- Green layers in scope of 802.3av
- XGMII and GMII interfaces are used in single direction only e.g. Tx path in XGMII in OLT

Layers:
MACC – MAC Client
OAM – Operation And Maintenance
MPMC – Multipoint MAC Control
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Layers:
RS – Reconciliation Sublayer
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PMA – Physical Medium Attachment
PMD – Physical Medium Dependent
MDI – Medium Dependent Interface

Power budgets in Clause 91

Power budgets defined in 802.3av 10G-EPON (symmetric and asymmetric)

Description	Low power budget		Medium power budget		High power budget		Unit
	PRX10	PR10	PRX20	PR20	PRX30	PR30	
Downstream rate	10.3125						GBd
Upstream rate	1.25	10.3125	1.25	10.3125	1.25	10.3125	GBd
Downstream wavelength	1590				1577		nm
Downstream wavelength band	20				6		nm
Upstream wavelength	1310	1270	1310	1270	1310	1270	nm
Upstream wavelength band	100	20	100	20	100	20	nm
Nominal maximum reach (min)	10		20		20		km
Nominal split	1:16		1:16		1:32		-
Maximum ChIL	20		24		29		dB
Minimum ChIL	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 802.3ah specifications (29 ChIL)

Mapping of PMDs to Power Budgets

PMD – power budget mapping for asymmetric PRX–type power budgets

PRX-type power budgets		OLT PMD		
		10/1GBASE-PRX-D1	10/1GBASE-PRX-D2	10/1GBASE-PRX-D3
ONU PMD	10/1GBASE-PRX-U1	PRX10	N/A	N/A
	10/1GBASE-PRX-U2	N/A	PRX20	N/A
	10/1GBASE-PRX-U3	N/A	N/A	PRX30

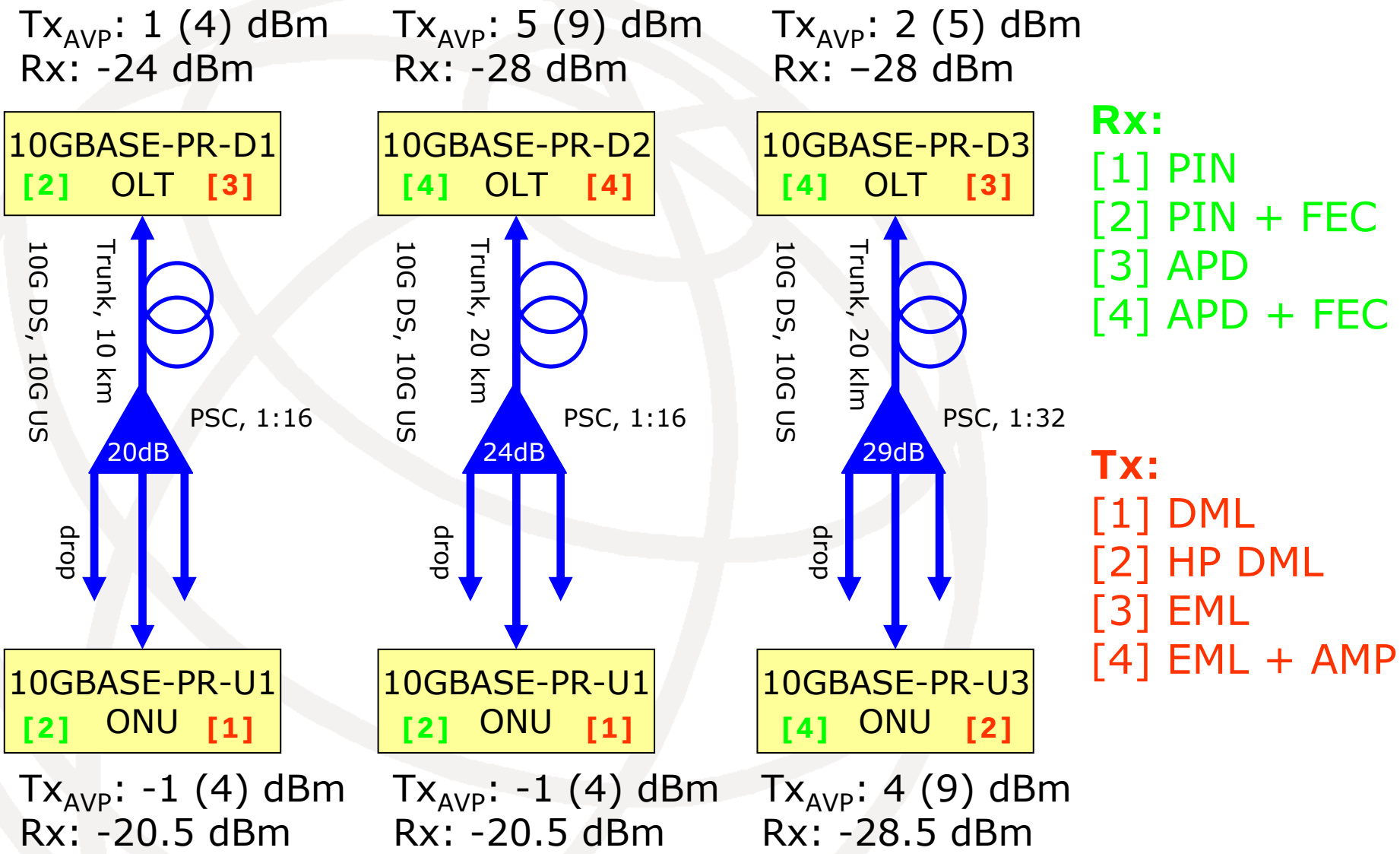
PMD – power budget mapping for symmetric PR–type power budgets

PR-type power budgets		OLT PMD		
		10GBASE-PR-D1	10GBASE-PR-D2	10GBASE-PR-D3
ONU PMD	10GBASE-PR-U1	PR10	PR20	N/A
	10GBASE-PR-U3	N/A	N/A	PR30

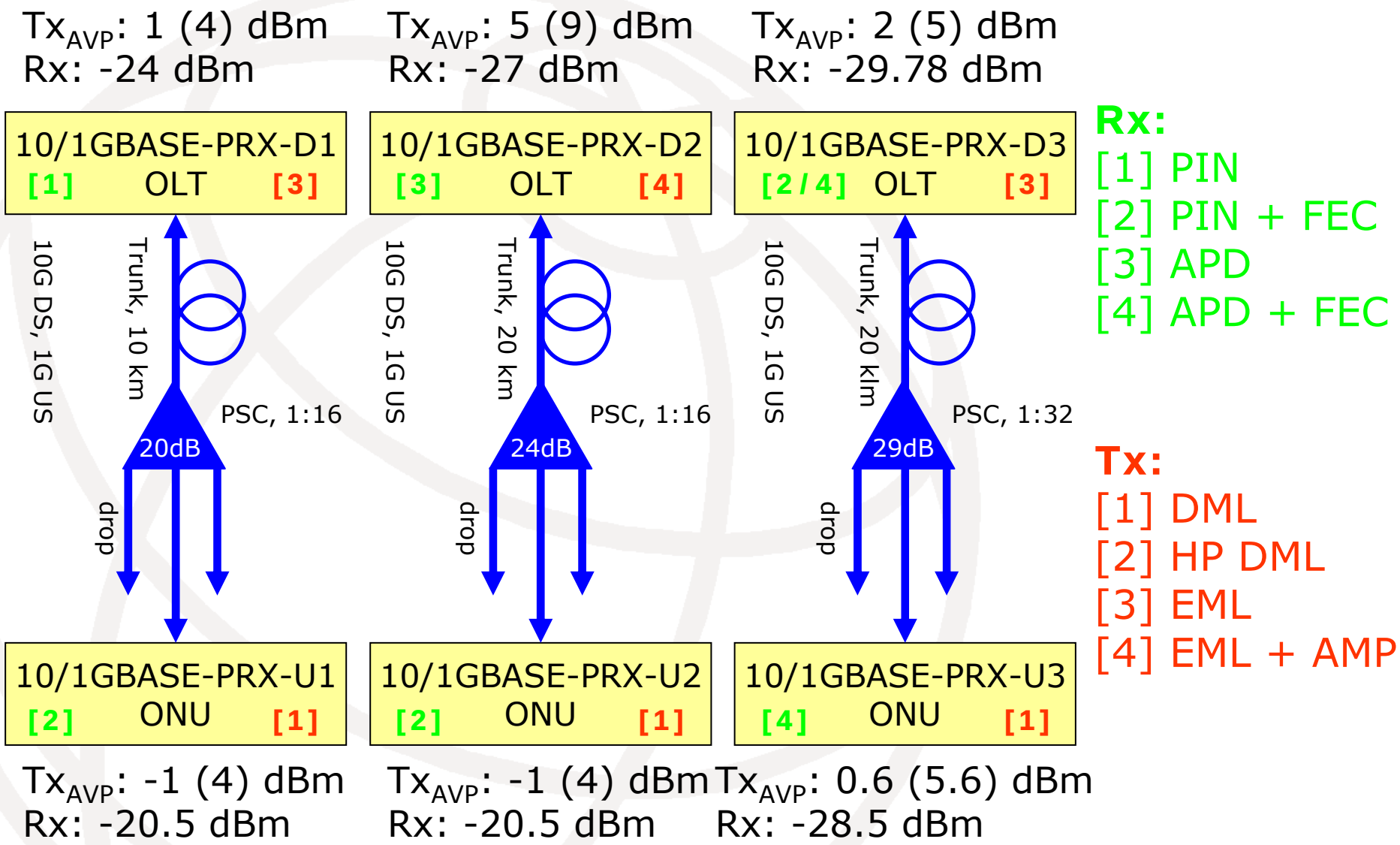
Note:

- number of PMDs < number of power budgets
- one of ONU PMDs (10GBASE-PR-U1) is used in two power budgets:
  - 10GBASE-PR-D1 uses PIN Rx and 10GBASE-PR-D2 uses APD Rx

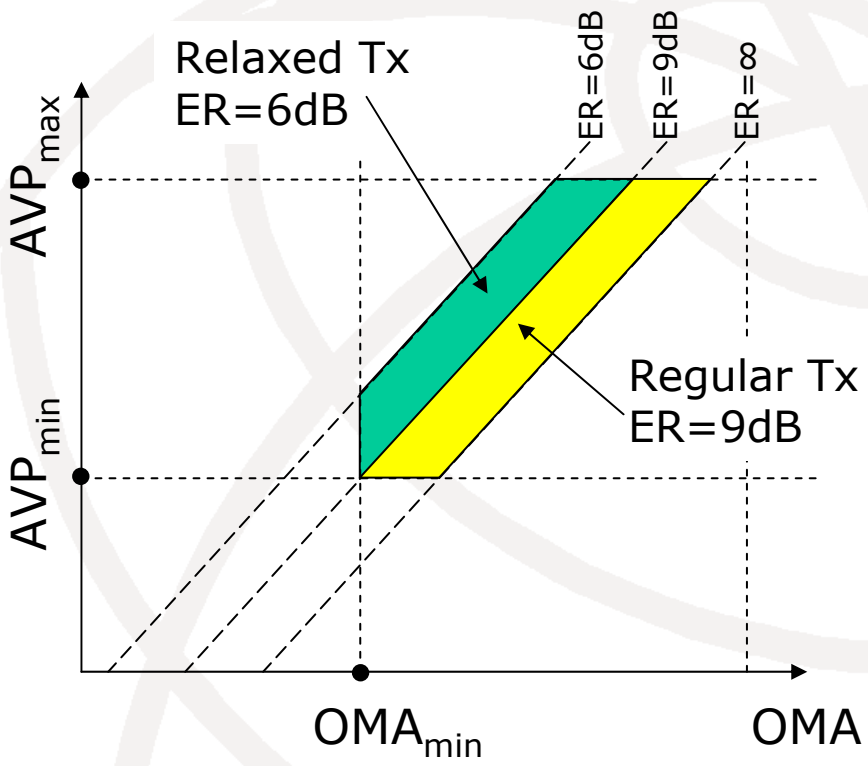
PR10/PR20/PR30 (10G/10G)



PRX10 / PRX20 / PRX30 (10G / 1G)



Transmitter relaxation for 10G OLT



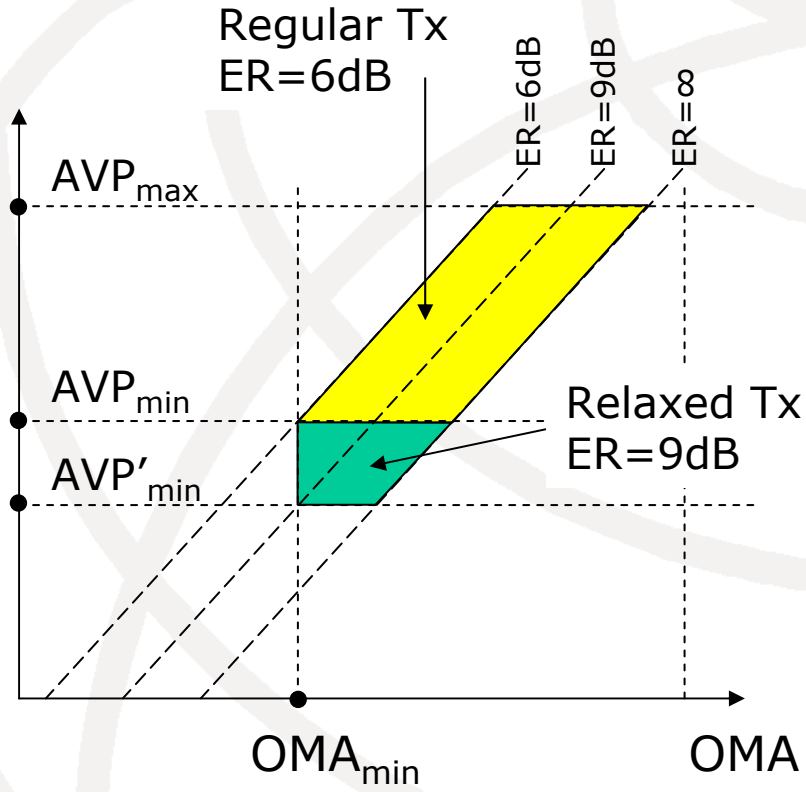
Motivation for Tx relaxation:

- Tx is simpler to manufacture
- lower ER can be traded-off with higher AVP
- OLT Tx can use:
  - DML: lower ER, higher AVP, constant OMA$_{min}$
  - EML: higher ER, lower AVP, constant OMA$_{min}$

Impact on PMD specs:

- OMA$_{min}$ calculated for ER=9dB and AVP$_{min}$
- OLT Tx is required to meet OMA$_{min}$, AVP$_{min}$ and ER=6dB

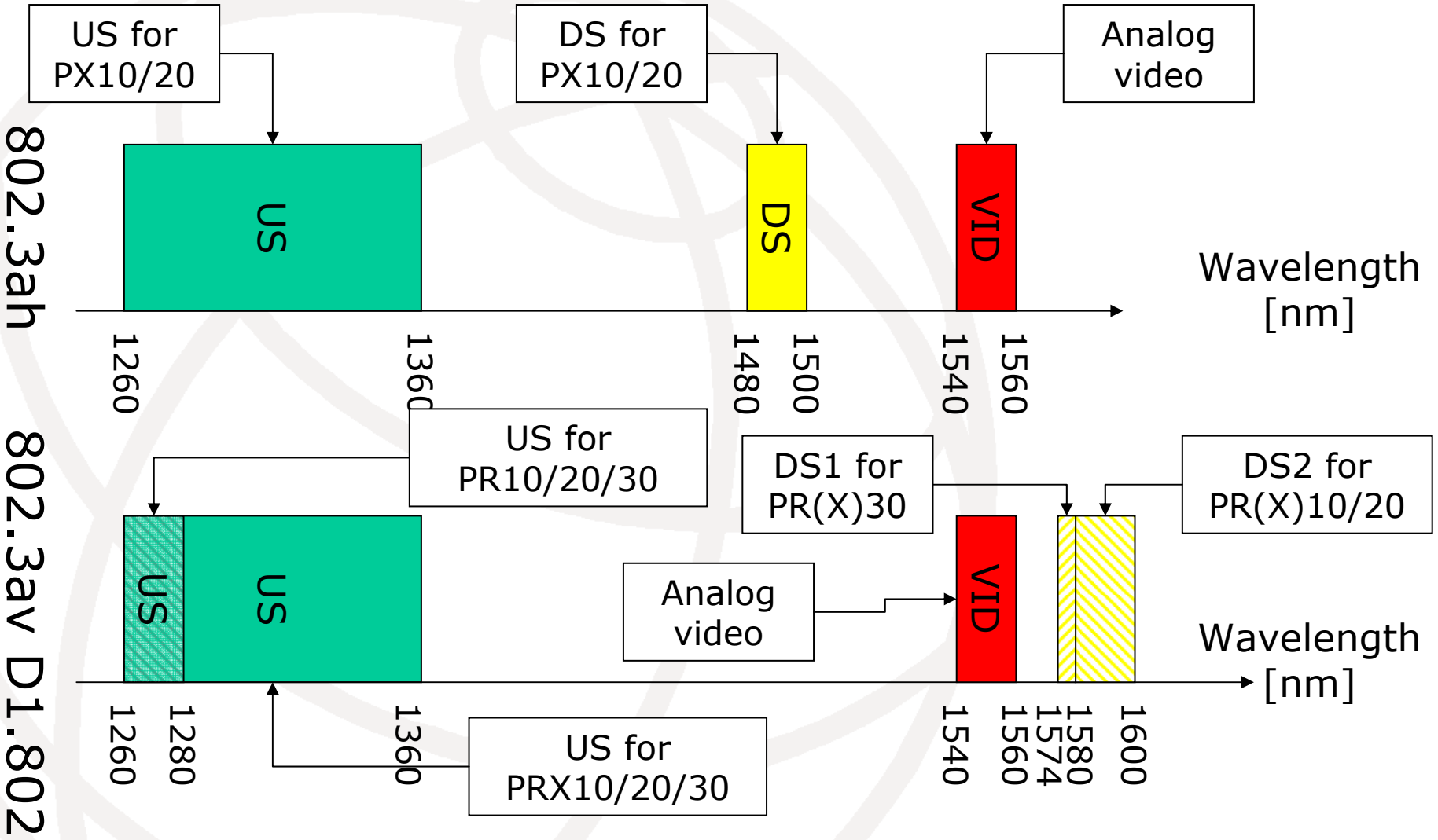
Transmitter relaxation for 10G ONU



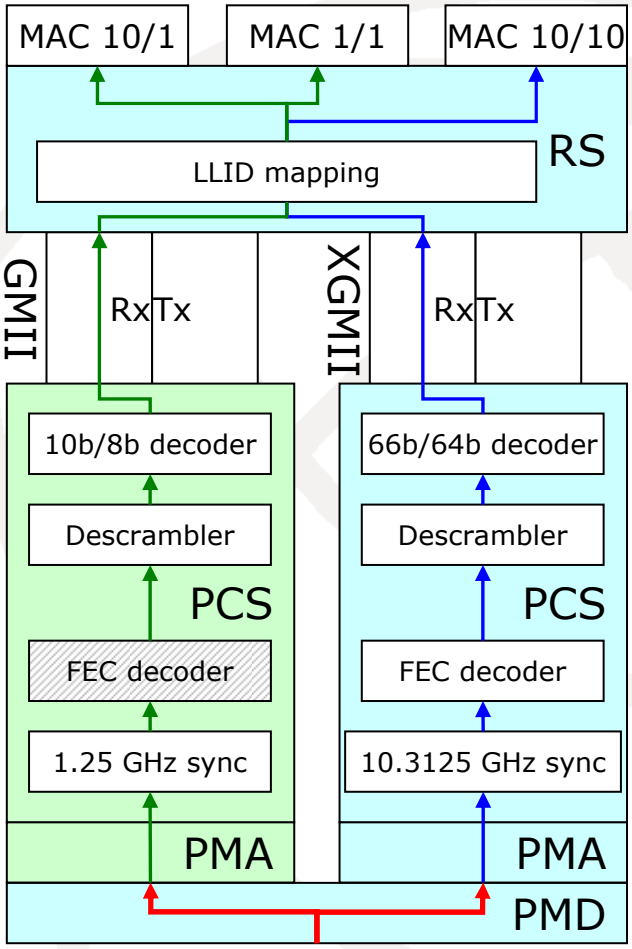
Motivation for Tx relaxation:

- currently High Power DML is assumed to be used in ONU
  - high TDP of 3dB
- TDP can be relaxed if EML is employed
  - smaller TDP means that AVP can be relaxed
- ONU Tx can use:
  - DML: lower ER, higher AVP, constant OMA$_{min}$
  - EML: higher ER, lower AVP, constant OMA$_{min}$

Wavelength allocation plan for 10G-EPON

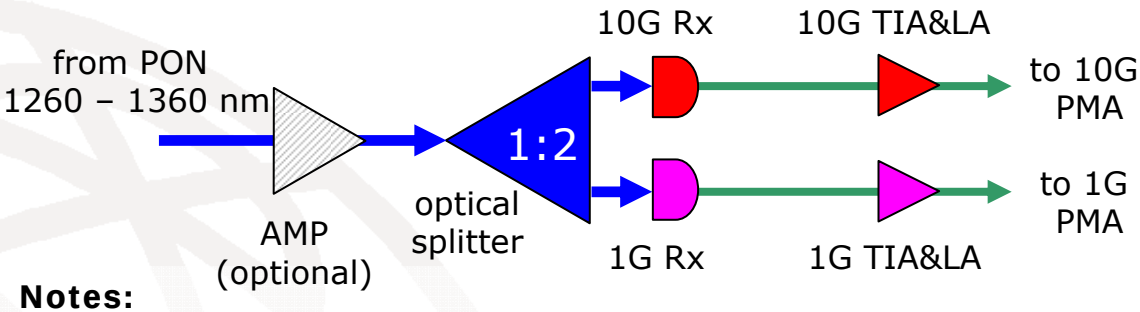


Dual-rate, burst-mode OLT Rx [1]



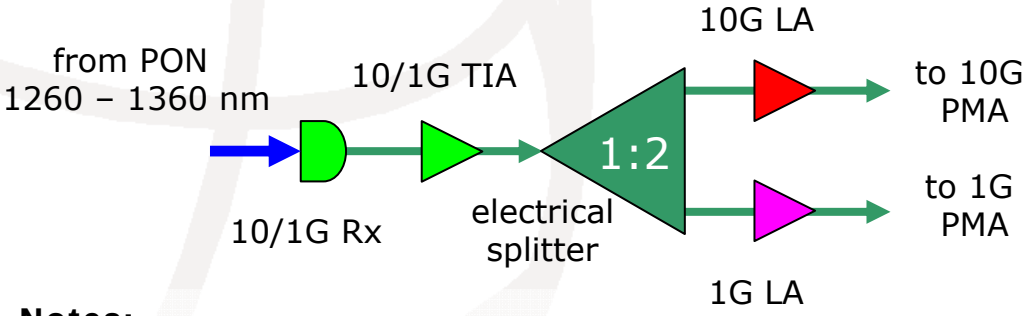
802.3ah sublayers

802.3av sublayers



Notes:

- signal split in optical domain, +3dB loss in 1:2 splitter
  - acceptable in PR(X)10 and PR(X)20 power budgets
  - technically challenging in PR(X)30 power budgets
- two dedicated Rx circuits, optimum sensitivity to 10G / 1G signals
- optional AMP may compensate additional loss of 1:2 splitter

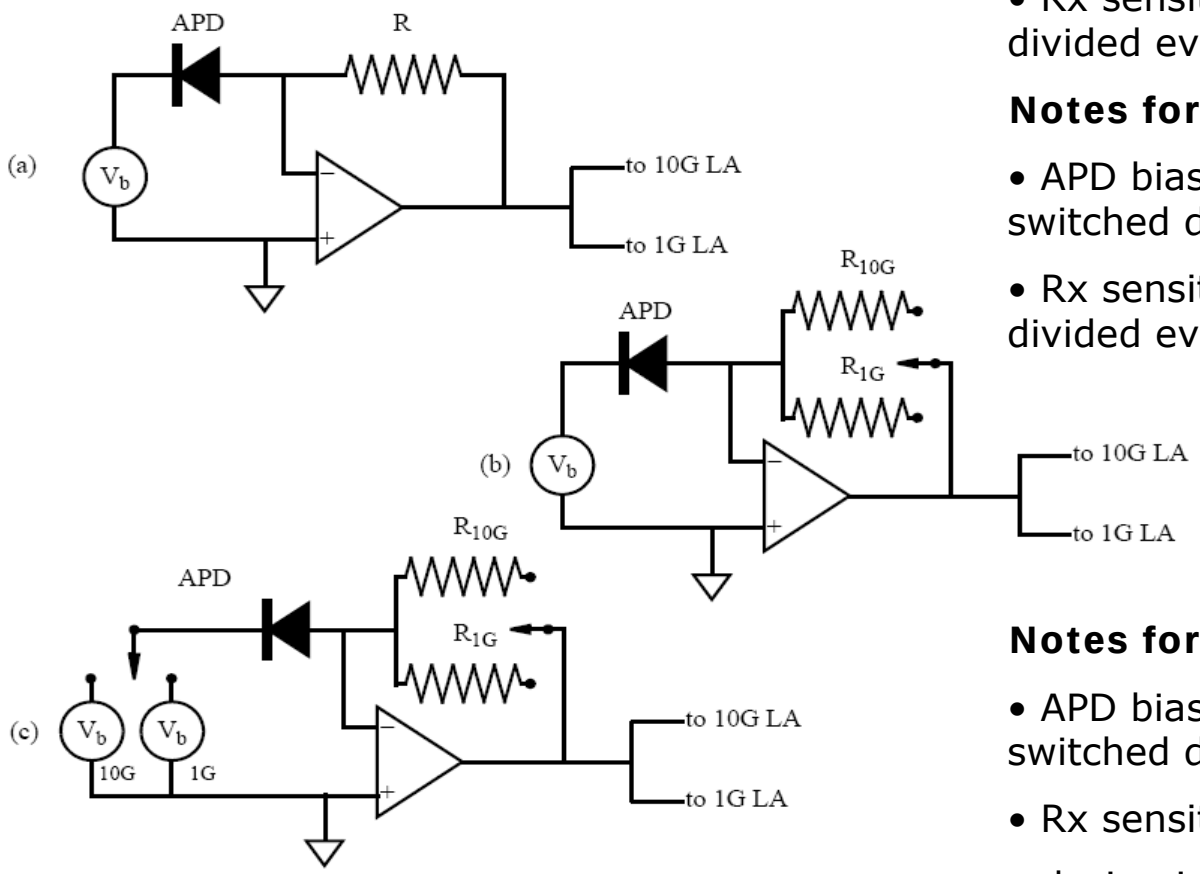


Notes:

- one one PD and TIA is required – need to cope with fast switching between optimum 10G/1G gain
- with no adjustable gain, sensitivity penalty will be observed
- several ways to adjust PD and TIA gain exist (see next slide)

Dual-rate, burst-mode OLT Rx [2]

Options for dual-rate OLT Rx



Notes for (a):

- PD parametric values are fixed;
- Rx sensitivity has 2 dB penalty – can be divided evenly into 10G and 1G path;

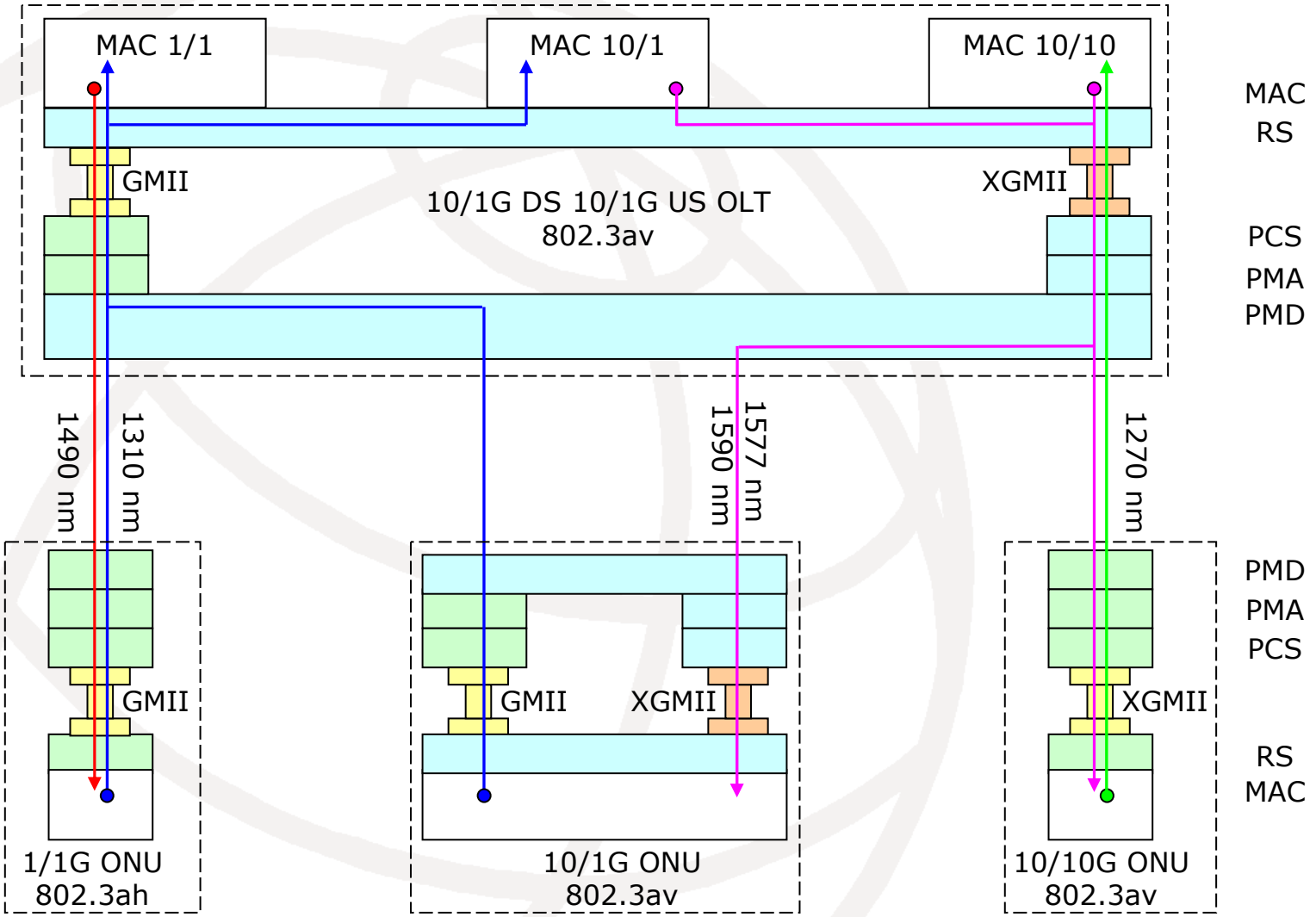
Notes for (b):

- APD bias is fixed, TIA transimpedance is switched depending on target data rate;
- Rx sensitivity has 1 dB penalty – can be divided evenly into 10G and 1G path;

Notes for (c):

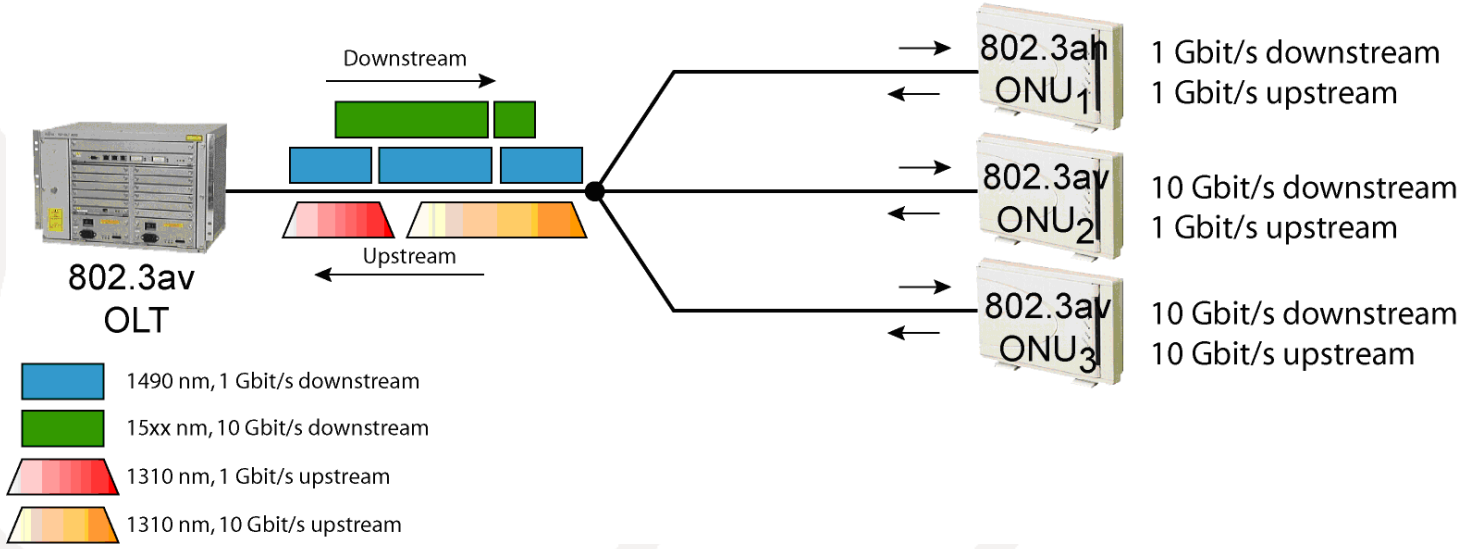
- APD bias and TIA transimpedance are switched depending on target data rate;
- Rx sensitivity has no penalty (ideally);
- design is complex and expensive in terms of control circutry;

Dual-rate EPON stack



Coexistence of EPON and 10G-EPON

- 1/10G downstream using WDM (coexistence with 802.3ah)
- 1/10G upstream using TDMA (dual rate, burst mode transmission, with coexistence with 802.3ah)
- supported configurations:
  - [1/10G DS, 1G US]; [1/10G DS, 1/10G US];
  - [10G DS, 1G US]; [10G DS, 1/10G US]; [10G DS, 10G US];



Conclusions

- Clause 91 PMDs support symmetric and asymmetric operation:
  - WDM separation for downstream
  - dual-rate, burst-mode transmission for upstream
- Three power budget classes defined: 20, 24 and 29 dB ChIL
  - RS (255,223) FEC is always enabled
  - some PMDs may have to use optical post/preamplifier
- Backward compatible with existing 802.3ah equipment
  - evolutionary system upgrade supported
  - 802.3ah ONUs do not need to be replaced