EPON Link Model

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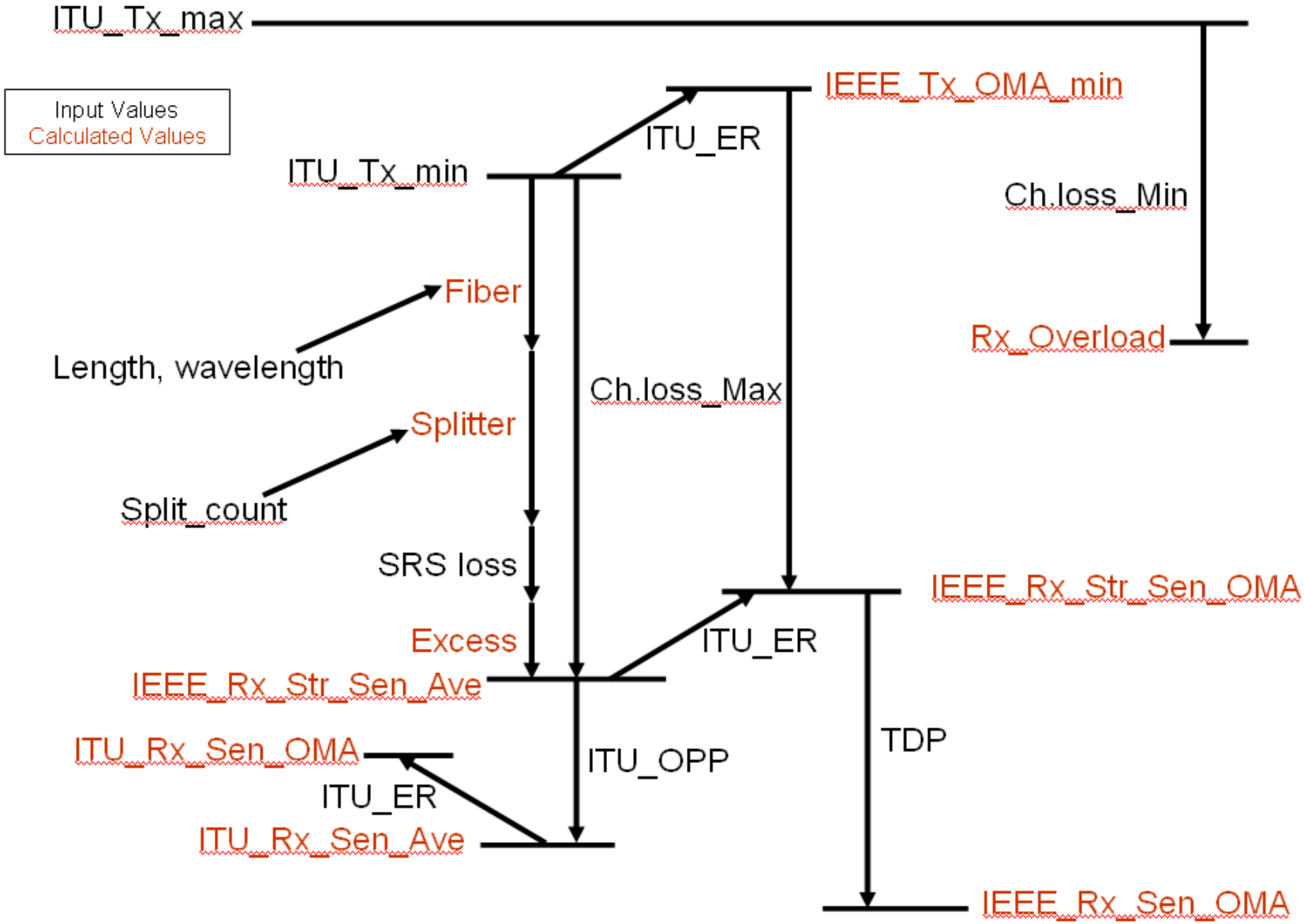
Summary

- The P802.3bk ExEPON Task Force needs an EPON link model to assess the technical feasibility of the proposed link parameters
- This contribution provides the summary of the EPON link model developed by P802.3av 10G-EPON Task Force and references work done by the Link Model adhoc.
- Examples of populated PR(X)-40, PX-30 and PX-40 power budgets are also shown for reference

EPON link model parameters (I)



EPON link model parameters (II)

- Link model features:
  - number of fiber loss models based on G.652AB, G.652CD and λ^4 model (selectable), with minimum and maximum fibre loss curves available for selection;
  - for λ^4 model, the base fiber loss attenuation is provided as a parameter;
  - aggregate PSC loss for 1:2 … 1:128 splitters, using synthetic curves for minimum, average and maximum loss derived from a large data base of commercial products and synthetic model for PSC loss
  - set of calculation macros (Visual Basic) for calculating fibre loss, dispersion, group delay and penalties, including calculation between dB and uW.

Link model spreadsheet

Parameter name	Value	Unit	Description	Value min	Value max
Transmitter parameters					
ITU_ERnom	9.00	dB	Nominal Extinction Ratio used to convert average power values to OMA values - for a test procedure, see 802.3, clause 52.9.5; for relation between OMA, ER and average power, see 802.3, clause 58.7.6	0.00	9.00
ITU_Tx_Ave_Min	-3.00	dBm	Average Tx launch power (minimum) equal to the minimum OMA at the maximum ER	-99.00	99.00
ITU_Tx_Ave_Max	-1.00	dBm	Average Tx launch power (maximum) equal to the maximum OMA at the nominal ER	-99.00	99.00
IEEE_Tx_OMA_Min	-1.09	dBm	Minimum OMA Tx launch power		
IEEE_Tx_OMA_Min	0.78	mW	Minimum OMA Tx launch power		
IEEE_Tx_OMA_Max	0.91	dBm	Maximum OMA Tx launch power		
IEEE_Tx_OMA_Max	1.23	mW	Maximum OMA Tx launch power		
Tx_Wavelength_Min	1580.00	nm	Transmitter wavelength (min)	1200.00	1600.00
Tx_Wavelength_Max	1600.00	nm	Transmitter wavelength (max)	1200.00	1600.00
Tx_Wavelength_Uc	1590.00	nm	Transmitter wavelength (central wavelength), calculated based on Tx_Wavelength_Min and	1580.00	1600.00
Tx_Chirp_Parameter_Max	0.00	-	The maximum (worst case) value of Chirp parameter used in the calculation of the dispersion		
Tx_Data_Rate	10312.50	MBd	The effective data rate at the PMD level after encoding, scrambling i.e. fed to the PMA interface	9500	11500
Link parameters					
Fibre_Attenuation_Curve	lambda^-4	-	Defines the type of the fibre attenuation curve which will be used for calculation of the fibre attenuation for the given operating wavelength. 3 types of curves are available i.e. lambda^-		
Fibre_Attenuation_Curve_Type	min	-	Defines the variant of the fibre attenuation curve for G.652 SMF. Maximum and minimum attenuation curves are available only for G652AB and G652CD type of fibre.		
Fibre_Attenuation_Base_Value	0.35	dB/km	Base wavelength for fibre attenuation estimation - only applicable to the lambda^-4 model.	0	1
Fibre_Attenuation_Base_Wavelength	1550.00	nm	Base wavelength for fibre attenuation estimation		
Fibre_Attenuation_Value	0.34	dB/km	Calculated nominal attenuation of fibre in dB/km of ideal channel (no connectors, splices etc. i.e. the medium is considered to be continous)		
Channel_Length_Max	10	km	The length of the fibre channel between the OLT and the most distant ONU	0.5	20
Fibre_Loss	3.44	dB	Calculated total attenuation of an ideal fibre channel (no connectors, splices etc. i.e. the medium		
PSC_Split_count	16.00	-	The maximum number of ports on the Passive Splitter Combiner (powers of 2 are acceptable)	2	64
PSC_Loss_Curve	max	-	Defines the type of the PSC loss curve (best case [min], average [avg] and worst case [max]) for the FBT type PSC devices, based on the collected device loss data and approximated curves.		
PSC_Loss	14.93	dB	The total loss of the PSC device with the particular number of ports (PSC_Split_count) for the given loss curve (PSC_Loss_Curve), accounting for the ideal and excess loss		
SRS_Loss	1.00	dB	SRS induced nonlinear penalty (as resulting from the nonlinear interaction with any other transmission system e.g. 1550nm Analog video overlay operated on the PON fiber).		10
Excess_Loss	0.63	dB	The additional loss resulting from the non-ideal fibre channel elements i.e. connectors, splices		
ITU_Optical_Path_Penalty	1.00	dB	The penalty attributable to the optical path. Given a fixed set of transmitter and receiver, the optical path penalty is equal to the link margin measured with pure attenuation less the link	0	5
Channel_Loss_Min	8.00	dB	Minimum channel insertion loss (user defined) to prevent the overload of the receiver on the	0	20.00
Channel_Loss_Max	20.00	dB	Maximum channel insertion loss (user defined), limited by the Tx power and Rx sensitivity		29
Power_Budget	21.00	dB	Available power budget		
Dispersion_Uo_Min	1300.00	nm	Minimum value of the zero dispersion wavelength		
Dispersion_Uo_Max	1300.00	nm	Maximum value of the zero dispersion wavelength		
Dispersion_So	0.09	ps/nm^2·km	Value of the dispersion curvature parameter		
Dispersion_D_Max	20.99	ps/(nm·km)	Maximum calculated dispersion "D" parameter		
Dispersion_D_Min	19.90	ps/(nm·km)	Minimum calculated dispersion "D" parameter		
Dispersion_Penalty	0.11	dB	Dispersion penalty, calculated for the worst case transmission wavelength in the allocated window (Tx_Wavelength_Min, Tx_Wavelength_Max), based on the dispersion penalty estimation model presented		
TDP	1.00	dB	Transmitter and Dispersion Penalty (maximum) is equal to the link margin, measured with an ideal Tx and pure attenuation less the link margin measured with a worst case Tx and worst case optical	0	10
Receiver parameters					
ITU_Rx_Sensitivity_Ave	-24.00	dBm	Average Rx sensitivity in ITU formalism, calculated as the difference between the minimum, average Tx launch power (ITU_Tx_Ave_Min) and the total power budget (Channel_Loss_Max +		
ITU_Rx_Sensitivity_Ave_OMA	-22.09	dBm	Average Rx sensitivity (ITU_Rx_Sensitivity_Ave) in OMA, for the given nominal ER (ITU_Ernom) @ BER		
ITU_Rx_Sensitivity_Ave_OMA	6.18	uW	Average Rx sensitivity (ITU_Rx_Sensitivity_Ave) in OMA, for the given nominal ER (ITU_Ernom) @ BER		
IEEE_Rx_Stressed_Sensitivity_Ave	-23.00	dBm	Stressed Rx sensitivity in average power form @ BER 1e-3		
IEEE_Rx_Stressed_Sensitivity_OMA	-21.09	dBm	OMA stressed Rx sensitivity in average power form @ BER 1e-3		
IEEE_Rx_Stressed_Sensitivity_OMA	7.78	uW	OMA stressed Rx sensitivity in average power form @ BER 1e-3		
IEEE_Rx_Sen_Ave	-24.00	dBm	Ideal Rx sensitivity in IEEE formalism in average power taking the TDP into account.		
IEEE_Rx_Sen_Ave	3.98	uW	Ideal Rx sensitivity in IEEE formalism in average power taking the TDP into account.		
IEEE_Rx_Sen_OMA	-22.09	dBm	Ideal Rx sensitivity in IEEE formalism in OMA taking the TDP into account.		
IEEE_Rx_Sen_OMA	6.18	uW	Ideal Rx sensitivity in IEEE formalism in OMA taking the TDP into account.		
Rx_Overload	-9.00	dBm	The Rx overload value for the given link		
Check Conditions					
Dispersion_Penalty <= ITU_Optical_Path_Penalty			PASSED		

Colour Code Key
User input field (unlocked)
Introduced value is OK
Introduced / Calculated value is outside of expected range
Locked fields, not accessible to a user
Comments
Newly added fields

Changes needed in the P802.3av link model

- Fibre model remains the same - λ^4 curve and maximum loss curve will be used for calculations
- PSC loss model remains unchanged – improvements in PSC manufacturing have been primarily limited to the long-term parameter stability and repeatability, but improvement in the PSC loss is marginal
- Model of additional penalties in 10G-EPON and 1G-EPON link remain the same (unmodified) from the analysis done in the times of P802.3av
- Conclusions: no changes to the model implemented in the existing link model spreadsheet are needed

Examples of P802.3bk power budgets

- The examples on three (3) following slides are inline with the latest proposal and baseline parameters as adopted at the last meeting
- Some parameters are calculated that were not present in the adopted baseline – these were either left blank or marked as TBD in the baseline
- There are some parameters which were calculated incorrectly (mainly conversion between dBm and uW/mW parameters – easily fixable).
- The next three slides are for overview only – we still need to discuss and examine individual parameters at the next meeting

PR40-D / PRX40-D

Transmitter parameters	
ITU_ERnom	9.00
ITU_Tx_Ave_Min	5.00
ITU_Tx_Ave_Max	9.00
IEEE_Tx_OMA_Min	6.91
IEEE_Tx_OMA_Min	4.91
IEEE_Tx_OMA_Max	10.91
IEEE_Tx_OMA_Max	12.33
Tx_Wavelength_Min	1574.00
Tx_Wavelength_Max	1580.00
Tx_Wavelength_Uc	1577.00
Tx_Chirp_Parameter_Max	0.00
Tx_Data_Rate	10312.50

Link parameters	
Fibre_Attenuation_Curve	lambda^-4
Fibre_Attenuation_Curve_Type	min
Fibre_Attenuation_Base_Value	0.35
Fibre_Attenuation_Base_Wavelength	1550.00
Fibre_Attenuation_Value	0.35
Channel_Length_Max	20
Fibre_Loss	6.92
PSC_Split_count	64.00
PSC_Loss_Curve	max
PSC_Loss	21.87
SRS_Loss	1.00
Excess_Loss	3.21
ITU_Optical_Path_Penalty	1.00
Channel_Loss_Min	18.00
Channel_Loss_Max	33.00
Power Budget	34.50
Dispersion_Uo_Min	1300.00
Dispersion_Uo_Max	1300.00
Dispersion_So	0.09
Dispersion_D_Max	19.90
Dispersion_D_Min	19.57
Dispersion_Penalty	0.38
TDP	1.50

Receiver parameters	
ITU_Rx_Sensitivity_Ave	-29.00
ITU_Rx_Sensitivity_Ave_OMA	-27.09
ITU_Rx_Sensitivity_Ave_OMA	1.95
IEEE_Rx_Stressed_Sensitivity_Ave	-28.00
IEEE_Rx_Stressed_Sensitivity_OMA	-26.09
IEEE_Rx_Stressed_Sensitivity_OMA	2.46
IEEE_Rx_Sen_Ave	-29.50
IEEE_Rx_Sen_Ave	1.12
IEEE_Rx_Sen_OMA	-27.59
IEEE_Rx_Sen_OMA	1.74
Rx_Overload	-9.00

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PR40-U

Transmitter parameters	
ITU_ERnom	6.00
ITU_Tx_Ave_Min	6.00
ITU_Tx_Ave_Max	10.00
IEEE_Tx_OMA_Min	6.78
IEEE_Tx_OMA_Min	4.77
IEEE_Tx_OMA_Max	10.78
IEEE_Tx_OMA_Max	11.97
Tx_Wavelength_Min	1260.00
Tx_Wavelength_Max	1280.00
Tx_Wavelength_Uc	1270.00
Tx_Chirp_Parameter_Max	0.00
Tx_Data_Rate	10312.50

Link parameters	
Fibre_Attenuation_Curve	lambda^-4
Fibre_Attenuation_Curve_Type	min
Fibre_Attenuation_Base_Value	0.35
Fibre_Attenuation_Base_Wavelength	1310.00
Fibre_Attenuation_Value	0.36
Channel_Length_Max	20
Fibre_Loss	7.27
PSC_Split_count	64.00
PSC_Loss_Curve	max
PSC_Loss	21.87
SRS_Loss	1.00
Excess_Loss	2.86
ITU_Optical_Path_Penalty	1.00
Channel_Loss_Min	18.00
Channel_Loss_Max	33.00
Power Budget	35.00
Dispersion_Uo_Min	1300.00
Dispersion_Uo_Max	1324.00
Dispersion_So	0.09
Dispersion_D_Max	-1.90
Dispersion_D_Min	-6.42
Dispersion_Penalty	0.02
TDP	2.00

Receiver parameters	
ITU_Rx_Sensitivity_Ave	-28.00
ITU_Rx_Sensitivity_Ave_OMA	-27.22
ITU_Rx_Sensitivity_Ave_OMA	1.90
IEEE_Rx_Stressed_Sensitivity_Ave	-27.00
IEEE_Rx_Stressed_Sensitivity_OMA	-26.22
IEEE_Rx_Stressed_Sensitivity_OMA	2.39
IEEE_Rx_Sen_Ave	-29.00
IEEE_Rx_Sen_Ave	1.26
IEEE_Rx_Sen_OMA	-28.22
IEEE_Rx_Sen_OMA	1.51
Rx_Overload	-8.00

OR

PRX40-U

Transmitter parameters	
ITU_ERnom	6.00
ITU_Tx_Ave_Min	2.00
ITU_Tx_Ave_Max	7.00
IEEE_Tx_OMA_Min	2.78
IEEE_Tx_OMA_Min	1.90
IEEE_Tx_OMA_Max	7.78
IEEE_Tx_OMA_Max	6.00
Tx_Wavelength_Min	1290.00
Tx_Wavelength_Max	1330.00
Tx_Wavelength_Uc	1310.00
Tx_Chirp_Parameter_Max	-2.00
Tx_Data_Rate	1250.00

Link parameters	
Fibre_Attenuation_Curve	lambda^-4
Fibre_Attenuation_Curve_Type	min
Fibre_Attenuation_Base_Value	0.35
Fibre_Attenuation_Base_Wavelength	1310.00
Fibre_Attenuation_Value	0.35
Channel_Length_Max	20
Fibre_Loss	7.00
PSC_Split_count	32.00
PSC_Loss_Curve	max
PSC_Loss	18.40
SRS_Loss	1.00
Excess_Loss	6.60
ITU_Optical_Path_Penalty	1.00
Channel_Loss_Min	18.00
Channel_Loss_Max	33.00
Power Budget	34.00
Dispersion_Uo_Min	1300.00
Dispersion_Uo_Max	1324.00
Dispersion_So	0.09
Dispersion_D_Max	2.70
Dispersion_D_Min	-3.29
Dispersion_Penalty	-0.01
TDP	1.00

Receiver parameters	
ITU_Rx_Sensitivity_Ave	-32.00
ITU_Rx_Sensitivity_Ave_OMA	-31.22
ITU_Rx_Sensitivity_Ave_OMA	0.76
IEEE_Rx_Stressed_Sensitivity_Ave	-31.00
IEEE_Rx_Stressed_Sensitivity_OMA	-30.22
IEEE_Rx_Stressed_Sensitivity_OMA	0.95
IEEE_Rx_Sen_Ave	-32.00
IEEE_Rx_Sen_Ave	0.63
IEEE_Rx_Sen_OMA	-31.22
IEEE_Rx_Sen_OMA	0.76
Rx_Overload	-11.00

PX30-D

Transmitter parameters	
ITU_ERnom	6.00
ITU_Tx_Ave_Min	3.00
ITU_Tx_Ave_Max	7.00
IEEE_Tx_OMA_Min	3.78
IEEE_Tx_OMA_Min	2.39
IEEE_Tx_OMA_Max	7.78
IEEE_Tx_OMA_Max	6.00
Tx_Wavelength_Min	1480.00
Tx_Wavelength_Max	1500.00
Tx_Wavelength_Uc	1490.00
Tx_Chirp_Parameter_Max	-2.00
Tx Data Rate	1250.00

Link parameters	
Fibre_Attenuation_Curve	lambda^-4
Fibre_Attenuation_Curve_Type	min
Fibre_Attenuation_Base_Value	0.35
Fibre_Attenuation_Base_Wavelength	1550.00
Fibre_Attenuation_Value	0.36
Channel_Length_Max	20
Fibre_Loss	7.21
PSC_Split_count	32.00
PSC_Loss_Curve	max
PSC_Loss	18.40
SRS_Loss	1.00
Excess_Loss	2.39
ITU_Optical_Path_Penalty	1.00
Channel_Loss_Min	15.00
Channel_Loss_Max	29.00
Power Budget	30.00
Dispersion_Uo_Min	1300.00
Dispersion_Uo_Max	1300.00
Dispersion_So	0.09
Dispersion_D_Max	15.20
Dispersion_D_Min	13.93
Dispersion_Penalty	0.04
TDP	1.00

Receiver parameters	
ITU_Rx_Sensitivity_Ave	-27.00
ITU_Rx_Sensitivity_Ave_OMA	-26.22
ITU_Rx_Sensitivity_Ave_OMA	2.39
IEEE_Rx_Stressed_Sensitivity_Ave	-26.00
IEEE_Rx_Stressed_Sensitivity_OMA	-25.22
IEEE_Rx_Stressed_Sensitivity_OMA	3.01
IEEE_Rx_Sen_Ave	-27.00
IEEE_Rx_Sen_Ave	2.00
IEEE_Rx_Sen_OMA	-26.22
IEEE_Rx_Sen_OMA	2.39
Rx_Overload	-8.00

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PX30-U

Transmitter parameters	
ITU_ERnom	6.00
ITU_Tx_Ave_Min	0.62
ITU_Tx_Ave_Max	5.62
IEEE_Tx_OMA_Min	1.40
IEEE_Tx_OMA_Min	1.38
IEEE_Tx_OMA_Max	6.40
IEEE_Tx_OMA_Max	4.37
Tx_Wavelength_Min	1260.00
Tx_Wavelength_Max	1360.00
Tx_Wavelength_Uc	1310.00
Tx_Chirp_Parameter_Max	-2.00
Tx Data Rate	1250.00

Link parameters	
Fibre_Attenuation_Curve	lambda^-4
Fibre_Attenuation_Curve_Type	min
Fibre_Attenuation_Base_Value	0.35
Fibre_Attenuation_Base_Wavelength	1310.00
Fibre_Attenuation_Value	0.35
Channel_Length_Max	20
Fibre_Loss	7.00
PSC_Split_count	32.00
PSC_Loss_Curve	max
PSC_Loss	18.40
SRS_Loss	1.00
Excess_Loss	2.60
ITU_Optical_Path_Penalty	1.00
Channel_Loss_Min	15.00
Channel_Loss_Max	29.00
Power Budget	30.40
Dispersion_Uo_Min	1300.00
Dispersion_Uo_Max	1324.00
Dispersion_So	0.09
Dispersion_D_Max	5.22
Dispersion_D_Min	-6.42
Dispersion_Penalty	-0.01
TDP	1.40

Receiver parameters	
ITU_Rx_Sensitivity_Ave	-29.38
ITU_Rx_Sensitivity_Ave_OMA	-28.60
ITU_Rx_Sensitivity_Ave_OMA	1.38
IEEE_Rx_Stressed_Sensitivity_Ave	-28.38
IEEE_Rx_Stressed_Sensitivity_OMA	-27.60
IEEE_Rx_Stressed_Sensitivity_OMA	1.74
IEEE_Rx_Sen_Ave	-29.78
IEEE_Rx_Sen_Ave	1.05
IEEE_Rx_Sen_OMA	-29.00
IEEE_Rx_Sen_OMA	1.26
Rx_Overload	-9.38

PX40-D

Transmitter parameters	
ITU_ERnom	6.00
ITU_Tx_Ave_Min	4.00
ITU_Tx_Ave_Max	7.00
IEEE_Tx_OMA_Min	4.78
IEEE_Tx_OMA_Min	3.01
IEEE_Tx_OMA_Max	7.78
IEEE_Tx_OMA_Max	6.00
Tx_Wavelength_Min	1480.00
Tx_Wavelength_Max	1500.00
Tx_Wavelength_Uc	1490.00
Tx_Chirp_Parameter_Max	-2.00
Tx Data Rate	1250.00

Link parameters	
Fibre_Attenuation_Curve	lambda^-4
Fibre_Attenuation_Curve_Type	min
Fibre_Attenuation_Base_Value	0.35
Fibre_Attenuation_Base_Wavelength	1550.00
Fibre_Attenuation_Value	0.36
Channel_Length_Max	20
Fibre_Loss	7.21
PSC_Split_count	32.00
PSC_Loss_Curve	max
PSC_Loss	18.40
SRS_Loss	1.00
Excess_Loss	6.39
ITU_Optical_Path_Penalty	1.00
Channel_Loss_Min	18.00
Channel_Loss_Max	33.00
Power Budget	34.00
Dispersion_Uo_Min	1300.00
Dispersion_Uo_Max	1300.00
Dispersion_So	0.09
Dispersion_D_Max	15.20
Dispersion_D_Min	13.93
Dispersion_Penalty	0.04
TDP	1.00

Receiver parameters	
ITU_Rx_Sensitivity_Ave	-30.00
ITU_Rx_Sensitivity_Ave_OMA	-29.22
ITU_Rx_Sensitivity_Ave_OMA	1.20
IEEE_Rx_Stressed_Sensitivity_Ave	-29.00
IEEE_Rx_Stressed_Sensitivity_OMA	-28.22
IEEE_Rx_Stressed_Sensitivity_OMA	1.51
IEEE_Rx_Sen_Ave	-30.00
IEEE_Rx_Sen_Ave	1.00
IEEE_Rx_Sen_OMA	-29.22
IEEE_Rx_Sen_OMA	1.20
Rx_Overload	-11.00

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PX40-U

Transmitter parameters	
ITU_ERnom	6.00
ITU_Tx_Ave_Min	2.00
ITU_Tx_Ave_Max	7.00
IEEE_Tx_OMA_Min	2.78
IEEE_Tx_OMA_Min	1.90
IEEE_Tx_OMA_Max	7.78
IEEE_Tx_OMA_Max	6.00
Tx_Wavelength_Min	1290.00
Tx_Wavelength_Max	1330.00
Tx_Wavelength_Uc	1310.00
Tx_Chirp_Parameter_Max	-2.00
Tx Data Rate	1250.00

Link parameters	
Fibre_Attenuation_Curve	lambda^-4
Fibre_Attenuation_Curve_Type	min
Fibre_Attenuation_Base_Value	0.35
Fibre_Attenuation_Base_Wavelength	1310.00
Fibre_Attenuation_Value	0.35
Channel_Length_Max	20
Fibre_Loss	7.00
PSC_Split_count	32.00
PSC_Loss_Curve	max
PSC_Loss	18.40
SRS_Loss	1.00
Excess_Loss	6.60
ITU_Optical_Path_Penalty	1.00
Channel_Loss_Min	18.00
Channel_Loss_Max	33.00
Power Budget	34.00
Dispersion_Uo_Min	1300.00
Dispersion_Uo_Max	1324.00
Dispersion_So	0.09
Dispersion_D_Max	2.70
Dispersion_D_Min	-3.29
Dispersion_Penalty	-0.01
TDP	1.00

Receiver parameters	
ITU_Rx_Sensitivity_Ave	-32.00
ITU_Rx_Sensitivity_Ave_OMA	-31.22
ITU_Rx_Sensitivity_Ave_OMA	0.76
IEEE_Rx_Stressed_Sensitivity_Ave	-31.00
IEEE_Rx_Stressed_Sensitivity_OMA	-30.22
IEEE_Rx_Stressed_Sensitivity_OMA	0.95
IEEE_Rx_Sen_Ave	-32.00
IEEE_Rx_Sen_Ave	0.63
IEEE_Rx_Sen_OMA	-31.22
IEEE_Rx_Sen_OMA	0.76
Rx_Overload	-11.00

Bringing you Closer

Thanks!