

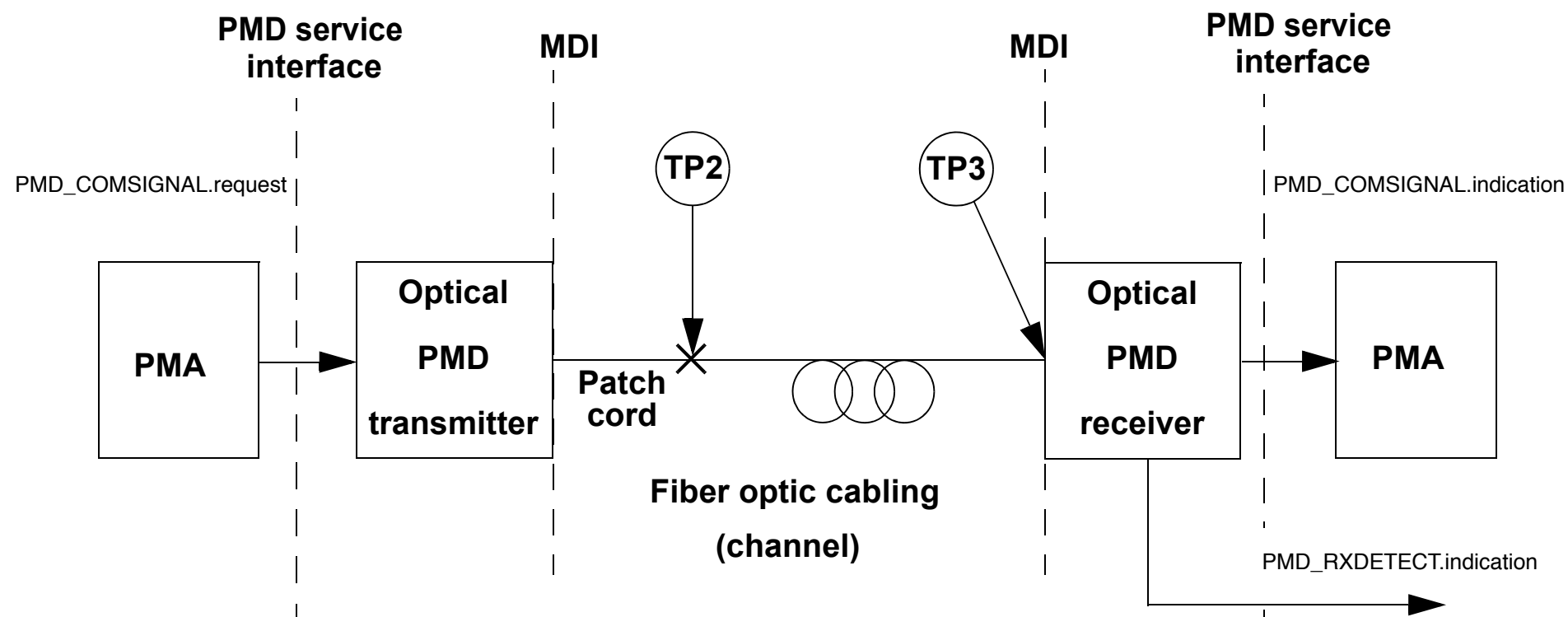


BASE-AU 980nm/OM3 baseline Transmitter and receiver characteristics

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Test points for BASE-AU PHY

For purposes of system conformance, the PMD sublayer is standardized at the points described here. The optical transmit signal is defined at the output end of a multimode fiber patch cord (TP2), between 1 m and 3 m in length. Unless specified otherwise, all transmitter measurements and defined tests are made at TP2. The optical receive signal is defined at the output of the fiber optic cabling (TP3) at the MDI. Unless specified otherwise, all receiver measurements and defined tests made at TP3.



TX and RX characteristics — 50 Gb/s



Transmit characteristics at TP2

Description	Value	Unit
Signaling rate (range)	26.5625 +/- 100 ppm	GBd
Modulation format	PAM4	
Center wavelength (range)	970 to 990	nm
RMS spectral width (max)	0.7	nm
Average launch power (max)	6.2	dBm
Average launch power (min)	-0.3	dBm
Outer Optical Modulation Amplitude (OMA) (max)	5.5	dBm
Outer Optical Modulation Amplitude (OMA) (min)	max(A, TDFOM + B)	dBm
A	-1.0	dBm
B	-0.2	dBm
Transmitter and distortion figure of merit (TDFOM) (max)	1.4	dB
Transmitter and distortion figure of merit (TDFOM) (min)	-1.9	dB
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	4	dB
RIN ₁₂ OMA (measured with BT4 with -3 dB BW = 20 GHz) (max)	-131	dB/Hz
Optical return loss tolerance (max)	12	dB
Random jitter RMS (max)	0.008	UI
Encircled flux (in accordance with IEC 61280-1-4)	≥ 86% at 19 um ≤ 30% at 4.5 um	

Receive characteristics at TP3

Description	Value	Unit
Signaling rate (range)	26.5625 +/- 100 ppm	GBd
Modulation format	PAM4	
Center wavelength (range)	970 to 990	nm
Damage threshold (min)	7.2	dBm
Average receive power (max)	6.2	dBm
Average receive power (min) (average receive power (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.)	-7.9	dBm
Receive power, OMA (max)	5.5	dBm
Receiver reflectance (max)	-12	dB
Stressed receiver sensitivity (OMA), condition 1 (max)	-3.8	dBm
Stressed receiver sensitivity (OMA), condition 2 (max)	-6.0	dBm
Receiver sensitivity (OMA) (max)	max(C, TDFOM + D)	dBm
C	-6.0	dBm
D	-5.2	dBm
Conditions of stressed receiver sensitivity test:		
Stressed TDFOM, condition 1	1.4	dB
Stressed TDFOM, condition 2	-0.8	dB

Illustrative link power budget (informative)

Parameter	Value	Unit
Effective modal bandwidth at 980 nm (min)	945	MHz·km
Power budget (min)	5.00	dB
Operating distance (min)	40	m
Channel insertion loss (max)	4.30	dB
Allocation for penalties (max)	0.70	dB
Additional insertion loss allowed (max)	0.00	dB

TX and RX characteristics — 25 Gb/s



Transmit characteristics at TP2

Description	Value	Unit
Signaling rate (range)	26.5625 +/- 100 ppm	GBd
Modulation format	NRZ	
Center wavelength (range)	970 to 990	nm
RMS spectral width (max)	0.7	nm
Average launch power (max)	5.2	dBm
Average launch power (min)	-1.4	dBm
Outer Optical Modulation Amplitude (OMA) (max)	4.5	dBm
Outer Optical Modulation Amplitude (OMA) (min)	max(A, TDFOM + B)	dBm
A	-2.1	dBm
B	-1.4	dBm
Transmitter and distortion figure of merit (TDFOM) (max)	1.5	dB
Transmitter and distortion figure of merit (TDFOM) (min)	-1.6	dB
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	4	dB
RIN ₁₂ OMA (measured with BT4 with -3 dB BW = 20 GHz) (max)	-124	dB/Hz
Optical return loss tolerance (max)	12	dB
Random jitter RMS (max)	0.02	UI
Encircled flux (in accordance with IEC 61280-1-4)	≥ 86% at 19 μm ≤ 30% at 4.5 μm	

Receive characteristics at TP3

Description	Value	Unit
Signaling rate (range)	26.5625 +/- 100 ppm	GBd
Modulation format	NRZ	
Center wavelength (range)	970 to 990	nm
Damage threshold (min)	6.2	dBm
Average receive power (max)	5.2	dBm
Average receive power (min) (average receive power (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.)	-12.7	dBm
Receive power, OMA (max)	4.5	dBm
Receiver reflectance (max)	-12	dB
Stressed receiver sensitivity (OMA), condition 1 (max)	-8.6	dBm
Stressed receiver sensitivity (OMA), condition 2 (max)	-10.8	dBm
Receiver sensitivity (OMA) (max)	max(C, TDFOM + D)	dBm
C	-10.8	dBm
D	-10.1	dBm
Conditions of stressed receiver sensitivity test:		
Stressed TDFOM, condition 1	1.5	dB
Stressed TDFOM, condition 2	-0.7	dB

Illustrative link power budget (informative)

Parameter	Value	Unit
Effective modal bandwidth at 980 nm (min)	945	MHz·km
Power budget (min)	8.70	dB
Operating distance (min)	40	m
Channel insertion loss (max)	8.30	dB
Allocation for penalties (max)	0.40	dB
Additional insertion loss allowed (max)	0.00	dB

TX and RX characteristics — 10 Gb/s



Transmit characteristics at TP2

Description	Value	Unit
Signaling rate (range)	10.625 +/- 100 ppm	GBd
Modulation format	NRZ	
Center wavelength (range)	970 to 990	nm
RMS spectral width (max)	0.7	nm
Average launch power (max)	5.2	dBm
Average launch power (min)	-2.4	dBm
Outer Optical Modulation Amplitude (OMA) (max)	4.5	dBm
Outer Optical Modulation Amplitude (OMA) (min)	max(A, TDFOM + B)	dBm
A	-3.1	dBm
B	-2.7	dBm
Transmitter and distortion figure of merit (TDFOM) (max)	0.6	dB
Transmitter and distortion figure of merit (TDFOM) (min)	-1.0	dB
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	4	dB
RIN ₁₂ OMA (measured with BT4 with -3 dB BW = 8 GHz) (max)	-120	dB/Hz
Optical return loss tolerance (max)	12	dB
Random jitter RMS (max)	0.02	UI
Encircled flux (in accordance with IEC 61280-1-4)	≥ 86% at 19 μm ≤ 30% at 4.5 μm	

Receive characteristics at TP3

Description	Value	Unit
Signaling rate (range)	10.625 +/- 100 ppm	GBd
Modulation format	NRZ	
Center wavelength (range)	970 to 990	nm
Damage threshold (min)	6.2	dBm
Average receive power (max)	5.2	dBm
Average receive power (min) (average receive power (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.)	-15.7	dBm
Receive power, OMA (max)	4.5	dBm
Receiver reflectance (max)	-12	dB
Stressed receiver sensitivity (OMA), condition 1 (max)	-12.8	dBm
Stressed receiver sensitivity (OMA), condition 2 (max)	-13.8	dBm
Receiver sensitivity (OMA) (max)	max(C, TDFOM + D)	dBm
C	-13.8	dBm
D	-13.4	dBm
Conditions of stressed receiver sensitivity test:		
Stressed TDFOM, condition 1	0.6	dB
Stressed TDFOM, condition 2	-0.4	dB

Illustrative link power budget (informative)

Parameter	Value	Unit
Effective modal bandwidth at 980 nm (min)	945	MHz·km
Power budget (min)	10.70	dB
Operating distance (min)	40	m
Channel insertion loss (max)	10.30	dB
Allocation for penalties (max)	0.40	dB
Additional insertion loss allowed (max)	0.00	dB

TX and RX characteristics — 5 Gb/s



Transmit characteristics at TP2

Description	Value	Unit
Signaling rate (range)	5.3125 +/- 100 ppm	GBd
Modulation format	NRZ	
Center wavelength (range)	970 to 990	nm
RMS spectral width (max)	0.7	nm
Average launch power (max)	5.2	dBm
Average launch power (min)	-3.3	dBm
Outer Optical Modulation Amplitude (OMA) (max)	4.5	dBm
Outer Optical Modulation Amplitude (OMA) (min)	max(A, TDFOM + B)	dBm
A	-4.0	dBm
B	-3.9	dBm
Transmitter and distortion figure of merit (TDFOM) (max)	0.4	dB
Transmitter and distortion figure of merit (TDFOM) (min)	-0.4	dB
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	4	dB
RIN ₁₂ OMA (measured with BT4 with -3 dB BW = 4 GHz) (max)	-120	dB/Hz
Optical return loss tolerance (max)	12	dB
Random jitter RMS (max)	0.02	UI
Encircled flux (in accordance with IEC 61280-1-4)	≥ 86% at 19 μm ≤ 30% at 4.5 μm	

Receive characteristics at TP3

Description	Value	Unit
Signaling rate (range)	5.3125 +/- 100 ppm	GBd
Modulation format	NRZ	
Center wavelength (range)	970 to 990	nm
Damage threshold (min)	6.2	dBm
Average receive power (max)	5.2	dBm
Average receive power (min) (average receive power (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.)	-17.9	dBm
Receive power, OMA (max)	4.5	dBm
Receiver reflectance (max)	-12	dB
Stressed receiver sensitivity (OMA), condition 1 (max)	-15.5	dBm
Stressed receiver sensitivity (OMA), condition 2 (max)	-16.0	dBm
Receiver sensitivity (OMA) (max)	max(C, TDFOM + D)	dBm
C	-16.0	dBm
D	-15.9	dBm
Conditions of stressed receiver sensitivity test:		
Stressed TDFOM, condition 1	0.4	dB
Stressed TDFOM, condition 2	-0.1	dB

Illustrative link power budget (informative)

Parameter	Value	Unit
Effective modal bandwidth at 980 nm (min)	945	MHz·km
Power budget (min)	12.00	dB
Operating distance (min)	40	m
Channel insertion loss (max)	10.30	dB
Allocation for penalties (max)	0.50	dB
Additional insertion loss allowed (max)	1.20	dB

TX and RX characteristics — 2.5 Gb/s



Transmit characteristics at TP2

Description	Value	Unit
Signaling rate (range)	2.65625 +/- 100 ppm	GBd
Modulation format	NRZ	
Center wavelength (range)	970 to 990	nm
RMS spectral width (max)	0.7	nm
Average launch power (max)	5.2	dBm
Average launch power (min)	-4.3	dBm
Outer Optical Modulation Amplitude (OMA) (max)	4.5	dBm
Outer Optical Modulation Amplitude (OMA) (min)	max(A, TDFOM + B)	dBm
A	-5.0	dBm
B	-5.0	dBm
Transmitter and distortion figure of merit (TDFOM) (max)	0.3	dB
Transmitter and distortion figure of merit (TDFOM) (min)	-0.3	dB
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	4	dB
RIN ₁₂ OMA (measured with BT4 with -3 dB BW = 2 GHz) (max)	-120	dB/Hz
Optical return loss tolerance (max)	12	dB
Random jitter RMS (max)	0.02	UI
Encircled flux (in accordance with IEC 61280-1-4)	≥ 86% at 19 um ≤ 30% at 4.5 um	

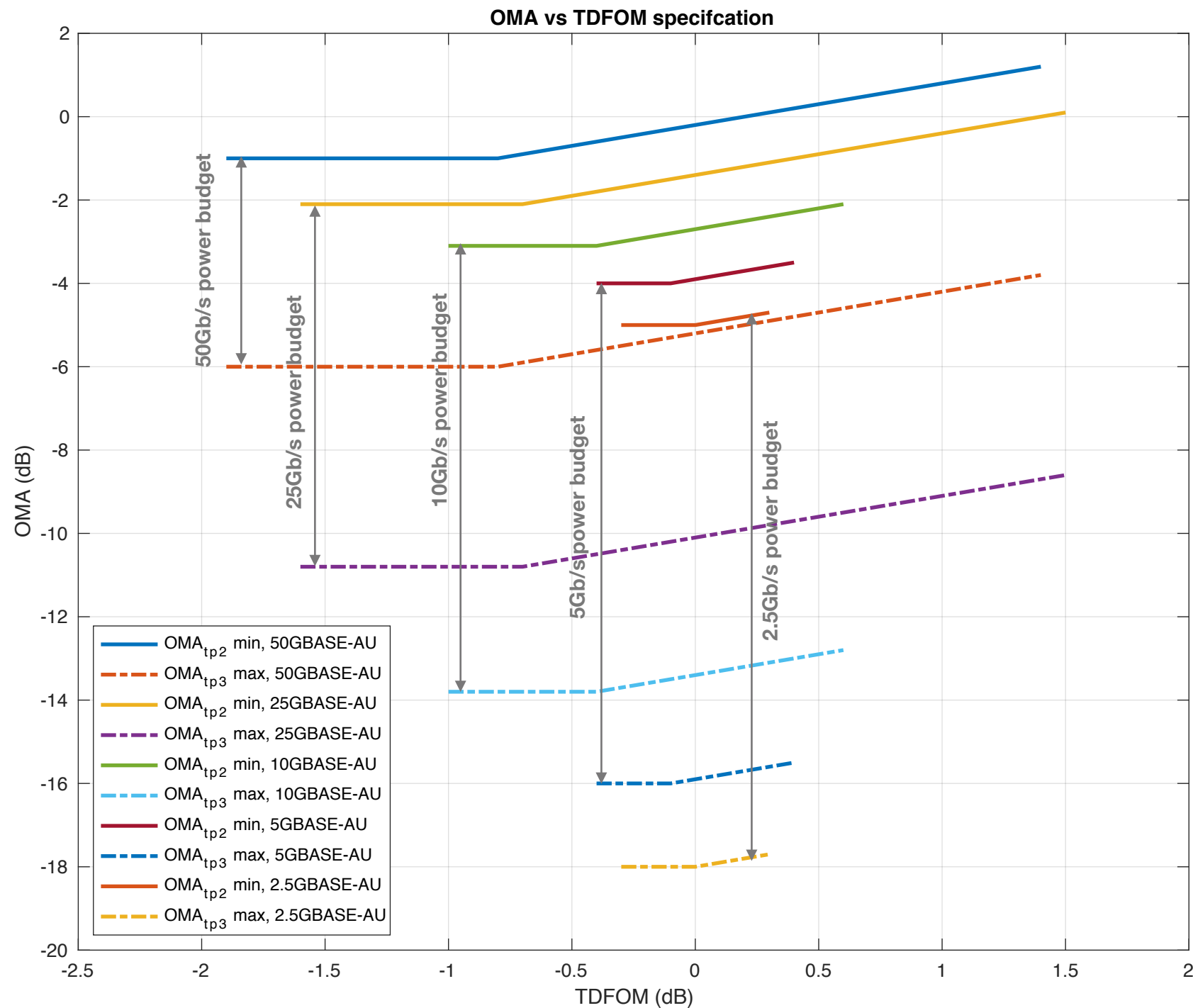
Receive characteristics at TP3

Description	Value	Unit
Signaling rate (range)	2.65625 +/- 100 ppm	GBd
Modulation format	NRZ	
Center wavelength (range)	970 to 990	nm
Damage threshold (min)	6.2	dBm
Average receive power (max)	5.2	dBm
Average receive power (min) (average receive power (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.)	-19.9	dBm
Receive power, OMA (max)	4.5	dBm
Receiver reflectance (max)	-12	dB
Stressed receiver sensitivity (OMA), condition 1 (max)	-17.7	dBm
Stressed receiver sensitivity (OMA), condition 2 (max)	-18.0	dBm
Receiver sensitivity (OMA) (max)	max(C, TDFOM + D)	dBm
C	-18.0	dBm
D	-18.0	dBm
Conditions of stressed receiver sensitivity test:		
Stressed TDFOM, condition 1	0.3	dB
Stressed TDFOM, condition 2	0.0	dB

Illustrative link power budget (informative)

Parameter	Value	Unit
Effective modal bandwidth at 980 nm (min)	945	MHz·km
Power budget (min)	13.00	dB
Operating distance (min)	40	m
Channel insertion loss (max)	10.30	dB
Allocation for penalties (max)	0.50	dB
Additional insertion loss allowed (max)	2.20	dB

OMA vs TDFOM specification (illustration)



Signal detect: common for all the data-rates



The PMD signal detect function determines the value of the `signal_detect` parameter of the `PMD_RXDETECT.indication` primitive, which is signaled when the value of `signal_detect` changes.

The value of the `signal_detect` parameter shall be generated in response to the average optical power present at the MDI according to the conditions defined in Table 166-XX. The PMD receive function is not required to verify whether a compliant BASE-AU signal is being received. This standard imposes no response time requirements on the generation of the `signal_detect` parameter.

signal_detect value definition

Receive conditions	signal_detect value
Average optical power at TP3 < -30 dBm	FAIL
Average optical power at TP3 > -24 dBm	OK
-30 dBm < average optical power at TP3 < -24 dBm	Unspecified (uncertainty range)



Annex: link budget analysis behind the spec

Link budget analysis behind spec — 50 Gb/s



50 Gb/s link budget

Parameter	Simulation	Equations	Proposal	Other penalties
TX characteristics				
<i>ER min (dB)</i>	4.00			
<i>ER factor min (dB)</i>	3.66			
<i>RIN_{OMA} max (dB/Hz)</i>	-131			
VCSEL SE variation (dB)	1.00	A		
VCSEL aging (dB)	0.50	B		
VCSEL to TP2 max coupling loss (dB)	2.00	C		
IL _{TP1-to-TP2} , min (dB)	0.50			
IL _{TP1-to-TP2} , max (dB)	3.50	D = A + B + C		
PD responsivity variation (dB)	0.80	E ₀		
TP3 to PD max coupling loss (dB)	2.50	E ₁		
IL _{TP3-to-TP4} , max (dB)	3.30	E = E ₀ + E ₁		
Insertion loss per inline connection, IL _{IC} max (dB)	2.00	F	2.00	
Number of inline connections (N _{IC})	2	G	2	
Macrobend insertion loss, max (dB)	0.22	H		
Microbend insertion loss, max (dB)	0.00	I		
Bending insertion loss, IL _{BEND} max (dB)	0.22	J = H + I		
Fiber attenuation max (dB/km)	2.00	K		
Channel attenuation, IL _{TP2-to-TP3} , max (dB)	4.30	L = (F × G) + J + (40/1000 × K)	4.30	
IL _{TP1-to-TP4} , max (dB)	11.10	M = D + E + L		
TDFOM ref (dB)	-0.80			
OMA _{TP1} min (dBm)	2.80	N		
OMA _{TP1} max (dBm)	6.00			
OMA _{TP2} min (dBm)	-0.70	O = N - D	-1.00	0.30
OMA _{TP2} max (dBm)	5.50			
OMA _{TP4} max (dBm)	-12.30	P		
OMA _{TP3} max (dBm)	-9.00	Q = P + E	-6.00	3.00
Power budget (dB)	8.30	R = O - Q	5.00	
Allocation for modal noise (dB)	0.70	S	0.70	
Unallocated margin (dB)	3.30	T = R - L - S	0.00	

Link budget analysis behind spec — 25 Gb/s



25 Gb/s link budget

Parameter	Simulation	Equations	Proposal	Other penalties
TX characteristics				
<i>ER min (dB)</i>	4.00			
<i>ER factor min (dB)</i>	3.66			
<i>RIN_{OMA} max (dB/Hz)</i>	-124			
VCSEL SE variation (dB)	1.00	A		
VCSEL aging (dB)	0.50	B		
VCSEL to TP2 max coupling loss (dB)	2.50	C		
IL _{TP1-to-TP2} , min (dB)	1.00			
IL _{TP1-to-TP2} , max (dB)	4.00	D = A + B + C		
PD responsivity variation (dB)	0.80	E ₀		
TP3 to PD max coupling loss (dB)	2.50	E ₁		
IL _{TP3-to-TP4} , max (dB)	3.30	E = E ₀ + E ₁		
Insertion loss per inline connection, IL _{IC} max (dB)	2.00	F	2.00	
Number of inline connections (N _{IC})	4	G	4	
Macrobend insertion loss, max (dB)	0.22	H		
Microbend insertion loss, max (dB)	0.00	I		
Bending insertion loss, IL _{BEND} max (dB)	0.22	J = H + I		
Fiber attenuation (dB/km)	2.00	K		
Channel attenuation, IL _{TP2-to-TP3} , max (dB)	8.30	L = (F × G) + J + (40/1000 × K)	8.30	
IL _{TP1-to-TP4} , max (dB)	15.60	M = D + E + L		
TDFOM ref (dB)	-0.70			
OMA _{TP1} min (dBm)	2.20	N		
OMA _{TP1} max (dBm)	5.50			
OMA _{TP2} min (dBm)	-1.80	O = N - D	-2.10	0.30
OMA _{TP2} max (dBm)	4.50			
OMA _{TP4} max (dBm)	-16.40	P		
OMA _{TP3} max (dBm)	-13.10	Q = P + E	-10.80	2.30
Power budget (dB)	11.30	R = O - Q	8.70	
Allocation for modal noise (dB)	0.40	S	0.40	
Unallocated margin (dB)	2.60	T = R - L - S	0.00	

Link budget analysis behind spec — 10 Gb/s



10 Gb/s link budget

Parameter	Simulation	Equations	Proposal	Other penalties
TX characteristics				
<i>ER min (dB)</i>	4.00			
<i>ER factor min (dB)</i>	3.66			
<i>RIN_{OMA} max (dB/Hz)</i>	-120			
VCSEL SE variation (dB)	1.00	A		
VCSEL aging (dB)	0.50	B		
VCSEL to TP2 max coupling loss (dB)	3.50	C		
IL_{TP1-to-TP2} , min (dB)	1.00			
IL_{TP1-to-TP2} , max (dB)	5.00	D = A + B + C		
PD responsivity variation (dB)	0.80	E ₀		
TP3 to PD max coupling loss (dB)	3.50	E ₁		
IL_{TP3-to-TP4} , max (dB)	4.30	E = E ₀ + E ₁		
Insertion loss per inline connection, IL_{IC} max (dB)	2.50	F	2.50	
Number of inline connections (N_{IC})	4	G	4	
Macrobend insertion loss, max (dB)	0.22	H		
Microbend insertion loss, max (dB)	0.00	I		
Bending insertion loss, IL_{BEND} max (dB)	0.22	J = H + I		
Fiber attenuation (dB/km)	2.00	K		
Channel attenuation, IL_{TP2-to-TP3} , max (dB)	10.30	L = (F × G) + J + (40/1000 × K)	10.30	
IL_{TP1-to-TP4} , max (dB)	19.60	M = D + E + L		
TDFOM ref (dB)	-0.40			
OMA_{TP1} min (dBm)	2.20	N		
OMA_{TP1} max (dBm)	5.50			
OMA_{TP2} min (dBm)	-2.80	O = N - D	-3.10	0.30
OMA_{TP2} max (dBm)	4.50			
OMA_{TP4} max (dBm)	-21.30	P		
OMA_{TP3} max (dBm)	-17.00	Q = P + E	-13.80	3.20
Power budget (dB)	14.20	R = O - Q	10.70	
Allocation for modal noise (dB)	0.40	S	0.40	
Unallocated margin (dB)	3.50	T = R - L - S	0.00	

Link budget analysis behind spec — 5 Gb/s



5 Gb/s link budget

Parameter	Simulation	Equations	Proposal	Other penalties
TX characteristics				
<i>ER min (dB)</i>	4.00			
<i>ER factor min (dB)</i>	3.66			
<i>RIN_{OMA} max (dB/Hz)</i>	-120			
VCSEL SE variation (dB)	1.00	A		
VCSEL aging (dB)	0.50	B		
VCSEL to TP2 max coupling loss (dB)	3.50	C		
IL_{TP1-to-TP2} , min (dB)	1.00			
IL_{TP1-to-TP2} , max (dB)	5.00	D = A + B + C		
PD responsivity variation (dB)	0.80	E ₀		
TP3 to PD max coupling loss (dB)	3.50	E ₁		
IL_{TP3-to-TP4} , max (dB)	4.30	E = E ₀ + E ₁		
Insertion loss per inline connection, IL_{IC} max (dB)	2.50	F	2.50	
Number of inline connections (N_{IC})	4	G	4	
Macrobend insertion loss, max (dB)	0.22	H		
Microbend insertion loss, max (dB)	0.00	I		
Bending insertion loss, IL_{BEND} max (dB)	0.22	J = H + I		
Fiber attenuation (dB/km)	2.00	K		
Channel attenuation, IL_{TP2-to-TP3} , max (dB)	10.30	L = (F × G) + J + (40/1000 × K)	10.30	
IL_{TP1-to-TP4} , max (dB)	19.60	M = D + E + L		
TDFOM ref (dB)	-0.10			
OMA_{TP1} min (dBm)	2.20	N		
OMA_{TP1} max (dBm)	5.50			
OMA_{TP2} min (dBm)	-2.80	O = N - D	-4.00	1.20
OMA_{TP2} max (dBm)	4.50			
OMA_{TP4} max (dBm)	-24.40	P		
OMA_{TP3} max (dBm)	-20.10	Q = P + E	-16.00	4.10
Power budget (dB)	17.30	R = O - Q	12.00	
Allocation for modal noise (dB)	0.50	S	0.50	
Unallocated margin (dB)	6.50	T = R - L - S	1.20	

Link budget analysis behind spec — 2.5 Gb/s



2.5 Gb/s link budget

Parameter	Simulation	Equations	Proposal	Other penalties
TX characteristics				
<i>ER min (dB)</i>	4.00			
<i>ER factor min (dB)</i>	3.66			
<i>RIN_{OMA} max (dB/Hz)</i>	-120			
VCSEL SE variation (dB)	1.00	A		
VCSEL aging (dB)	0.50	B		
VCSEL to TP2 max coupling loss (dB)	3.50	C		
IL_{TP1-to-TP2} , min (dB)	1.00			
IL_{TP1-to-TP2} , max (dB)	5.00	D = A + B + C		
PD responsivity variation (dB)	0.80	E ₀		
TP3 to PD max coupling loss (dB)	3.50	E ₁		
IL_{TP3-to-TP4} , max (dB)	4.30	E = E ₀ + E ₁		
Insertion loss per inline connection, IL_{IC} max (dB)	2.50	F	2.50	
Number of inline connections (N_{IC})	4	G	4	
Macrobend insertion loss, max (dB)	0.22	H		
Microbend insertion loss, max (dB)	0.00	I		
Bending insertion loss, IL_{BEND} max (dB)	0.22	J = H + I		
Fiber attenuation (dB/km)	2.00	K		
Channel attenuation, IL_{TP2-to-TP3} , max (dB)	10.30	L = (F × G) + J + (40/1000 × K)	10.30	
IL_{TP1-to-TP4} , max (dB)	19.60	M = D + E + L		
TDFOM ref (dB)	0.00			
OMA_{TP1} min (dBm)	2.20	N		
OMA_{TP1} max (dBm)	5.50			
OMA_{TP2} min (dBm)	-2.80	O = N - D	-5.00	2.20
OMA_{TP2} max (dBm)	4.50			
OMA_{TP4} max (dBm)	-27.70	P		
OMA_{TP3} max (dBm)	-23.40	Q = P + E	-18.00	5.40
Power budget (dB)	20.60	R = O - Q	13.00	
Allocation for modal noise (dB)	0.50	S	0.50	
Unallocated margin (dB)	9.80	T = R - L - S	2.20	



Thank you