BA-4000 Bit Analyzer

800G BIT ERROR RATE (BER) TESTER

Electrical BER tester supporting NRZ and PAM4 coding, with advanced FEC tools and with testing capabilities up to 800G.



KEY FEATURES

Supports NRZ and PAM4

Supports PRBS 7/9/11/13/15/23/31/13Q/31Q, SSPRQ

Advanced FEC tools

Supports RS-FEC Scrambled Idle Pattern

Channel simulator

Burst/random error injection

O-SMPM connection

Channel histogram

Channel mapping

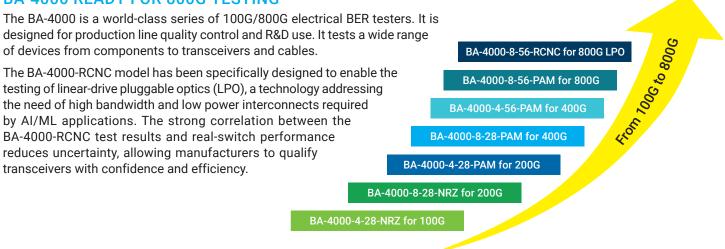
Powerful and user-friendly GUI

Automation: API support

LPO testing supported by RCNC model



BA-4000 READY FOR 800G TESTING



POWERFUL AND SIMPLIFIED USER INTERFACE

The BA-4000 graphical user interface (GUI) provides simplified and real-time test results per channel. It requires an external Windows-based PC with Ethernet capability to run the GUI and API.

EXFO	v 5.3.2.1 Setup Help				ري ا				-	
	MultiRate 1.5Vpp	Symbol Rate	26.5625 GBd P4	AM4	Т	X/RX Configuration		BER Co	nfiguration	Relock
172.16.81.65	FEC S6G	Clock (A-B)	Rate/8)	<u> </u>			Run		orce Relo
	Channel 1		Channel 2			Channel 3			Channel 4	
Pre BER	8.737e-09	Pre BER	2.372e-09		Pre BER	3.636e-05		Pre BER	3.834e-0	9
Pre Errors	4,696 PN31	Pre Errors	1,279	PN31	Pre Errors	19,674,924	PN31	Pre Errors	2,08	2 PN31
Corrected	4,696 PN31	Corrected	1,279	PN31	Corrected	19,674,924	PN31	Corrected	2,08	2 PN31
Post BER	0.000e+00 Sync	Post BER	0.000e+00	Sync	Post BER	0.000e+00	Sync	Post BER	0.000e+0	0 Sync
Margin	80% (max: 3) KP4	Margin	80% (max: 3)	KP4	Margin	40% (max: 9)	KP4	Margin	80% (max: 3	() KP4
# Bits	537,460,265,600	# Bits	539,295,8	04,160	# Bits	541,134,1	26,592	# Bits	542,968	,437,504
Time 🤇	10 s	Time	10 s		Time	10 s		Time	10 s	
		+			<u> </u>			<u> </u>		
	Channel 5		Channel 6			Channel 7			Channel 8	
Pre BER	Channel 5 3.671e-11	Pre BER	Channel 6 3.489e-06	•••	Pre BER	Channel 7 2.545e-05	•••	Pre BER	Channel 8 1.976e-0	6 💽
		Pre BER Pre Errors		• 🏄 PN31	Pre BER Pre Errors		● <u>}</u> PN31	Pre BER Pre Errors		
Pre Errors	3.671e-11		3.489e-06			2.545e-05		\geq	1.976e-0	9 PN31
Pre Errors	3.671e-11 • /	Pre Errors	3.489e-06 1,907,057	PN31	Pre Errors	2.545e-05 13,961,536	PN31	Pre Errors	1.976e-0 1,052,88	9 PN31 9 PN31
Corrected	3.671e-11 • 20 20 PN31 20 PN31	Pre Errors Corrected	3.489e-06 1,907,057 1,907,057	PN31 PN31	Pre Errors Corrected	2.545e-05 13,961,536 13,961,536	PN31 PN31	Pre Errors Corrected	1.976e-0 1,052,88 1,052,88	9 PN31 9 PN31 9 Sync
Pre Errors Corrected Post BER	3.671e-11 PN31 20 PN31 20 PN31 0.000e+00 Sync	Pre Errors Corrected Post BER	3.489e-06 1,907,057 1,907,057 0.000e+00	PN31 PN31 Sync KP4	Pre Errors Corrected Post BER	2.545e-05 13,961,536 13,961,536 0.000e+00	PN31 PN31 Sync KP4	Pre Errors Corrected Post BER	1.976e-0 1,052,88 1,052,88 0.000e+0 80% (max: 3	9 PN31 9 PN31 9 Sync
Pre Errors Corrected Post BER Margin # Bits	3.671e-11 20 PN31 20 PN31 0.000e+00 Sync 80% (max: 3) KP4	Pre Errors Corrected Post BER Margin	3.489e-06 1,907,057 1,907,057 0.000e+00 80% (max: 3)	PN31 PN31 Sync KP4	Pre Errors Corrected Post BER Margin	2.545e-05 13,961,536 13,961,536 0.000e+00 60% (max: 6)	PN31 PN31 Sync KP4	Pre Errors Corrected Post BER Margin	1.976e-0 1,052,88 1,052,88 0.000e+0 80% (max: 3	9 PN31 9 PN31 0 Sync 4) KP4
Pre Errors Corrected Post BER Margin # Bits	3.671e-11 20 PN31 20 PN31 0.000e+00 Sync 80% (max: 3) KP4 544,804,921,728	Pre Errors Corrected Post BER Margin # Bits	3.489e-06 1,907,057 1,907,057 0.000e+00 80% (max: 3) 546,644,1	PN31 PN31 Sync KP4	Pre Errors Corrected Post BER Margin # Bits	2.545e-05 13,961,536 13,961,536 0.000e+00 60% (max: 6) 548,487,2	PN31 PN31 Sync KP4	Pre Errors Corrected Post BER Margin # Bits	1.976e-0 1,052,88 1,052,88 0.000e+0 80% (max: 3 532,769 10 s	9 PN31 9 PN31 0 Sync 1) KP4
Pre Errors Corrected Post BER Margin # Bits Time	3.671e-11 20 PN31 20 PN31 0.000e+00 Sync 80% (max: 3) KP4 544,804,921,728	Pre Errors Corrected Post BER Margin # Bits	3.489e-06 1,907,057 1,907,057 0.000e+00 80% (max: 3) 546,644,1 10 s	PN31 PN31 Sync KP4	Pre Errors Corrected Post BER Margin # Bits Time	2.545e-05 13,961,536 13,961,536 0.000e+00 60% (max: 6) 548,487,2 10 s	PN31 PN31 Sync KP4 45,696	Pre Errors Corrected Post BER Margin # Bits Time	1.976e-0 1,052,88 1,052,88 0.000e+0 80% (max: 3 532,769 10 s	9 PI 9 PI 9 S 1,596,4



FEC SIMULATION

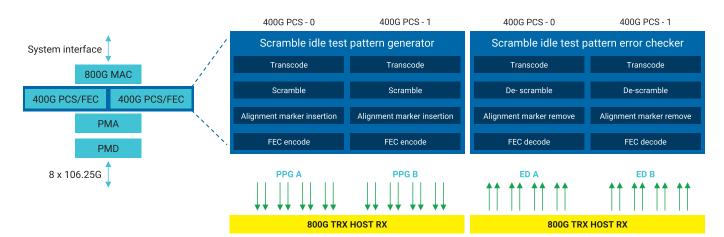
The BER tester includes FEC simulation capabilities. This provides powerful burst error analysis.

Main features include:

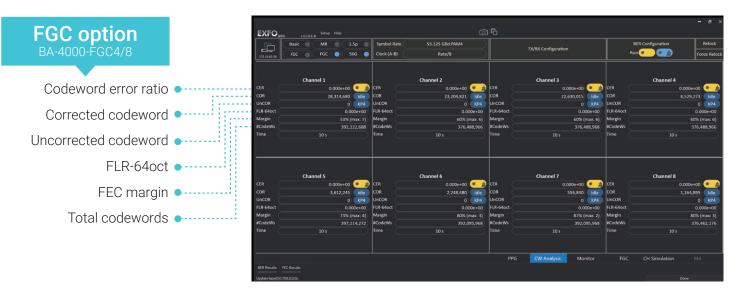
- PRBS error check and correction
- Pre-FEC and Post-FEC BER
- KP4/KR4 and low latency FEC protocols
- FEC lane striping function
- · FEC symbol error distribution plot: codewords vs symbol errors
- FEC margin auto-calculation

FEC encoded scrambled idle

With the FEC Generator and Checker (FGC) option, the BA-4000 addresses RS-FEC scrambled idle pattern for testing 53 GBd host side interfaces as part of the development of new-generation 800G optics, including optical transceivers, DAC, etc.



⁸⁰⁰G function flow structure



FEC encoded scramble idle metrics in the GUI



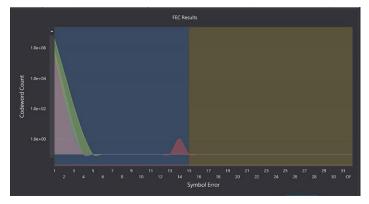
WITH PAM4 CODING, A SIMPLE BER TEST IS NOT ENOUGH

Bit Select	Injection Type	Amour	nt	
MSB	Single B/PKT	PKT Gap	0	Inject
LSB	Burst B/PKT	PKT Count	1	Errors

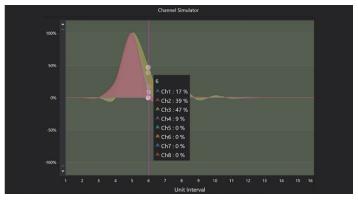
Pre BER	5.003e-08	• ;
Pre Errors	26,581	PN31
Corrected	26,581	PN31
Post BER	0.000e+00	Sync
Margin	87% (max: 2)	KP4
# Bits	531,315,8	33,984
Time	10 s	

Burst and random error injection





FEC symbol error distribution plot



Channel response simulation



Channel histogram



7-tap mode



All specifications are typical, at 23 °C ± 2 °C unless otherwise specified.

SPECIFICATIONS					
BA-4000	x-28-NRZ	x-28-PAM x-28-PAM-FECx	x-56-PAM-FECx x-56-PAM-FGCx-FECx	x-56-HP-FECx x-56-HP-FGCx-FECx	x-56-RCNC-FECx
Number of channels	4 (x = 4) or 8 (x = 8)	4 (x = 4) or 8 (x = 8)	4 (x = 4) or 8 (x = 8)	4 (x = 4) or 8 (x = 8)	8 (x = 8)
Modulation	NRZ only	NRZ/PAM4	NRZ/PAM4	NRZ/PAM4	PAM4 only
Data rate per lane (GBd) ^{a,k}	8.5, 9.95328, 10, 10.3125, 10.709, 11.3176, 12, 12.5, 14.025, 21.0, 24.33024, 24.8832, 25, 25.06752, 25.78125, 26.5625, 27.95, 28.05, 28.125, 28.9	24.8832, 25, 25.06752, 25.78125, 26.5625, 27.95, 28.05, 28.125, 28.9, 29.0625	24.8832, 25, 25.06752, 25.78125, 26.5625, 27.95, 28.05, 28.125, 28.9, 29.0625, 49.765, 49.7664, 50, 50.13504, 51.5625, 53.125, 55.9, 55.90747, 56.125, 56.25, 57.8, 58.125, 59.375	24.8832, 25, 25.06752, 25.78125, 26.5625, 27.95, 28.05, 28.125, 28.9, 29.0625, 49.765, 49.7664, 50, 50.13504, 51.5625, 53.125, 55.9, 55.90747, 56.125, 56.25, 57.8, 58.125, 59.375	n/a
Data rate per lane (GBd) ^k under FEC mode	n/a	24.8832, 25.0, 25.06752, 25.78125, 26.5625, 27.95, 28.05, 28.125, 28.9, 29.0625	24.8832, 25, 25.06752, 25.78125, 26.5625, 27.95, 28.05, 28.125, 28.9, 29.0625, 49.765, 49.7664, 50, 50.13504, 51.5625, 53.125, 55.9, 55.90747, 56.125, 56.25, 57.8, 58.125, 59.375	24.8832, 25, 25.06752, 25.78125, 26.5625, 27.95, 28.05, 28.125, 28.9, 29.0625, 49.765, 49.7664, 50, 50.13504, 51.5625, 53.125, 55.9, 55.90747, 56.125, 56.25, 57.8, 58.125, 59.375	26.5625, 53.125
Data rate per lane (GBd) under FGC mode	n/a	n/a	25.78125, 26.5625 (support NRZ and PAM4), 51.5625, 53.125 (support PAM4)	25.78125, 26.5625 (support NRZ and PAM4), 51.5625, 53.125 (support PAM4)	n/a
Data rate adjustment (ppm)	0 to ±300	0 to ±300	0 to ±1000	0 to ±1000	n/a
		PRBS 7/9/11/13/15/23/31	PRBS 7/9/11/13/15/23/31	PRBS 7/9/11/13/15/23/31	
Pattern supported by PPG and ED	PRBS 7/9/15/23/31 and user-defined pattern	PRBS 7Q/9Q/11Q/13Q/ 15Q/23Q/31Q	PRBS 7Q/9Q/11Q/13Q/ 15Q/23Q/31Q Only PPG supports	PRBS 7Q/9Q/11Q/13Q/ 15Q/23Q/31Q Only PPG supports	n/a
		Only PPG supports PRBS16Q, SSPRQ, user- defined pattern	PRBS16Q, SSPRQ, user-defined pattern	PRBS16Q, SSPRQ, user-defined pattern	
Pattern supported by PPG and ED	n/a	PRBS 7/9/11/15/ 23/31	PRBS 7/9/11/15/23/31	PRBS 7/9/11/15/23/31	Tx: PRBS 13Q/ 15Q/31Q, SSPRQ,
under FEC mode	II/a	PRBS 7Q/9Q/11Q/ 15Q/23Q/31Q1	PRBS 7Q/9Q/11Q/15Q/ 23Q/31Q ⁺	PRBS 7Q/9Q/11Q/15Q/ 23Q/31Q ⁺	user-defined patterr Rx: PRBS 15Q/31Q
Maximum amplitude (mV _{ppd})	800 ^{b, c}	800 ^{c, e, j}	800 ^{f, j}	800 ^{f, j}	800 ^{f, j}
Rise/fall time (20% to 80%) (ps)	16.5/16.5°	11/11°	10/10° (53.125G) 10/10° (25.78125G)	10/10° (53.125G) 10/10° (25.78125G)	n/a
PAM4 eye width (zero hit) (ps)	n/a	23 ^d	5.5 ^f (53.125G) 23 ^d (26.5625G)	5.5 ^f (53.125G) 23 ^d (26.5625G)	6 º (53.125G) 23 ª (26.5625G)
Jitter RMS (fs)	750°	450°	500° (53.125G) 450° (25.78125G)	500° (53.125G) 450° (25.78125G)	n/a
Sensitivity (mV _{ppd}) ^h	100 (NRZ 25.78125G)	200 (PAM4 26.5625G)	250 ⁱ (PAM4 53.125G)	200 ^{i, m} (PAM4 53.125G)	150 ⁱ (PAM4 53.125G
CTLE (dB)	0 to 7	0 to 8	n/a	n/a	Auto-adaptive
ED damage level (mV _{ppd})	1200	1200	1200	1200	900
Clock ratio (clock frequency / symbol rate)	/8, /16	/2, /4, /8, /16, /32, /64	/2, /4, /8, /16, /32, /64	/2, /4, /8, /16, /32, /64	/8, /16, /32, /64
Connector type		0-SMPM	connector (up to 67 GHz bandy	vidth)	
BER monitor	Supported	Supported	Supported	Supported	Supported
FEC plot	n/a	Supported (FEC option required)	Supported	Supported	Supported
Channel histogram	n/a	Supported	Supported	Supported	Supported
Channel simulation	n/a	Supported (FEC option required)	Supported	Supported	Supported
Error injection	Supported	Supported	Supported	Supported	n/a

a. Fixed rate.

b. Amplitude step is 200 mV_{ppd}

c. NRZ 25.78125 GBd signal measured by 50 GHz bandwidth scope with 40 GHz 2.92 mm, 15 cm RF cable.

d. PAM4 26.5625 GBd signal measured by 50 GHz bandwidth scope with 40 GHz 2.92 mm, 15 cm RF cable.

e. NRZ 53.125 GBd signal measured by 50 GHz bandwidth scope with 50 GHz 2.4 mm, 15 cm RF cable. Post-cursor is -2%.

f. PAM4 53.125 GBd signal measured by 50 GHz bandwidth scope with 50 GHz 2.4 mm, 15 cm RF cable. Post-cursor is -2%

g. PAM4 53.125 GBd signal measured by 50 GHz bandwidth scope with 50 GHz 2.4 mm, 15 cm RF cable. Post-cursor is 0%. h. Measured by direct loopback from PPG to ED with 40 GHz O-SMPM, 20 cm RF cable.

i. BER ≤ 10⁻¹⁰

j. Support overdrive 900 mV_{_{ppd}}

k. Use GUI version 6.17 or newer.

I. Under FEC mode, no support of PRBS13Q, PRBS16Q, SSPRQ, and user-defined pattern at ED. m. Receiving range is up to 500 mV $_{\rm ppd}$ and BER $\leq 10^{-10}$

EXFO

GENERAL SPECIFICATIONS				
Size (H x W x D))	103 mm x 442 mm x 300 mm (4.1 in x 17.4 in x 11.8 in)		
Weight		≤ 10 kg (22 lb)		
Temperature	Operating Storage	5 °C to 40 °C (41 °F to 104 °F) −20 °C to 70 °C (−4 °F to 158 °F)		
Relative humidity		20% to 80%		
Power		100 Vac to 240 Vac (47 Hz to 63 Hz) 60 W typical / 80 W max.		

COMPARISON TABLE

	BA-4000-8-56-PAM-FEC8	BA-4000-8-56-RCNC-FEC8
Description	8×56 GBd NRZ/PAM4 BERT, FEC simulator included BA-4000-8-56-PAM-FEC8	8×53 GBd PAM4 BERT (reflection cancellation, noise cancellation), FEC simulator included
Applications	DSP-based transceivers and cables	LPO and DSP-based transceivers
Modulation	NRZ/PAM4	PAM4 only
Data rate per lane (GBd) under FEC mode	24.8832, 25, 25.06752, 25.78125, 26.5625, 27.95, 28.05, 28.125, 28.9, 29.0625, 49.765, 49.7664, 50, 50.13504, 51.5625, 53.125, 55.9, 55.90747, 56.125, 56.25, 57.8, 58.125, 59.375	26.5625, 53.125
Data rate adjustment (ppm)	0 to ±1000	n/a
Pattern supported by PPG and ED under FEC mode	PRBS 7/9/11/15/23/31 PRBS 7Q/9Q/11Q/15Q/23Q/31Q Only PPG supports PRBS16Q, SSPRQ, and user-defined pattern	PPG: PRBS 13Q/15Q/31Q, SSPRQ, user-defined pattern ED: PRBS 15Q/31Q
Eye width (zero hit) (ps)	5.5 (PAM4 53.125G) 23 (PAM4 26.5625G)	6 (PAM4 53.125G) 23 (PAM4 26.5625G)
Sensitivity (mV _{ppd}) @ BER \leq e-10	250 (PAM4 53.125G)	150 (PAM4 53.125G)
CTLE (dB)	n/a	Auto-adaptive
FFE taps	16	20
RCNC (reflection cancellation, noise cancellation)	n/a	Supported
ED damage level (mV _{ppd})	1200	900
Clock output amplitude (mV_{_{ppd}})	400	300
Clock ratio (clock frequency / symbol rate)	/2, /4, /8, /16, /32, /64	/8, /16, /32, /64
Error injection	Supported	n/a

AVAILABLE OPTIONS

BA-4000	FEC4	FEC8	FGC4	FGC8
4-28-NRZ				
8-28-NRZ				
4-28-PAM	\checkmark			
8-28-PAM		~		
4-56-PAM-FEC4			\checkmark	
8-56-PAM-FEC8				~
4-56-HP-FEC4			~	
8-56-HP-FEC8				\checkmark
8-56-RCNC-FEC8				



EXFO

BA-4000- <u>XX-XX</u>	
Models 4-28-NRZ = 4×28 GBd NRZ BERT with O-SMPM connector 8-28-NRZ = 8×28 GBd NRZ BERT with O-SMPM connector 4-28-PAM = 4×28 GBd NRZ/PAM4 BERT with O-SMPM connector 8-28-PAM = 8×28 GBd NRZ/PAM4 BERT with O-SMPM connector 4-56-PAM-FEC4 = 4×56 GBd NRZ/PAM4 BERT with O-SMPM connector and FEC simulator included 8-56-PAM-FEC4 = 4×56 GBd NRZ/PAM4 BERT with O-SMPM connector and FEC simulator included 4-56-HP-FEC4 = 4×56 GBd NRZ/PAM4 BERT (better sensitivity, narrower receiving range) with O-SMPM connector and FEC simulator included 8-56-HP-FEC8 = 8×56 GBd NRZ/PAM4 BERT (better sensitivity, narrower receiving range) with O-SMPM connector and FEC simulator included 8-56-HP-FEC8 = 8×56 GBd NRZ/PAM4 BERT (better sensitivity, narrower receiving range) with O-SMPM connector and FEC simulator included 8-56-RCNC-FEC8 = 8×53 GBd PAM4 BERT (reflection cancellation, noise cancellation)	- Options FEC4 = FEC simulator software 4CH ^a FEC8 = FEC simulator software 8CH ^b FGC4 = FEC pattern generator and checker 4CH ^a FGC8 = FEC pattern generator and checker 8CH ^a
with O-SMPM connector and FEC simulator included	Example: BA-4000-8-56-PAM-FGC8-FEC8

a. Available for BA-4000-4-28-PAM.

b. Available for BA-4000-8-28-PAM.

c. Available for BA-4000-4-56-PAM-FEC4 and BA-4000-4-56-HP-FEC4.

d. Available for BA-4000-8-56-PAM-FEC8 and BA-4000-8-56-HP-FEC8.

MODEL LIST

FULL MODEL NO.	DESCRIPTION
BA-4000-4-28-NRZ	4×28G NRZ BERT
BA-4000-8-28-NRZ	8×28G NRZ BERT
BA-4000-4-28-PAM	4×28G NRZ/PAM4 BERT
BA-4000-4-28-PAM-FEC4	4×28G NRZ/PAM4 BERT with FEC simulator
BA-4000-8-28-PAM	8×28G NRZ/PAM4 BERT
BA-4000-8-28-PAM-FEC8	8×28G NRZ/PAM4 BERT with FEC simulator
BA-4000-4-56-PAM-FEC4	4×56G NRZ/PAM4 BERT with FEC simulator
BA-4000-4-56-PAM-FGC4-FEC4	4×56G NRZ/PAM4 BERT with FEC pattern generator and checker and FEC simulator
BA-4000-8-56-PAM-FEC8	8×56G NRZ/PAM4 BERT with FEC simulator
BA-4000-8-56-PAM-FGC8-FEC8	8×56G NRZ/PAM4 BERT with FEC pattern generator and checker and FEC simulator
BA-4000-4-56-HP-FEC4	4×56G NRZ/PAM4 BERT (better sensitivity, narrower receiving range) with FEC simulator
BA-4000-4-56-HP-FGC4-FEC4	4×56G NRZ/PAM4 BERT (better sensitivity, narrower receiving range) with FEC pattern generator and checker, and FEC simulator
BA-4000-8-56-HP-FEC8	8×56G NRZ/PAM4 BERT (better sensitivity, narrower receiving range) with FEC simulator
BA-4000-8-56-HP-FGC8-FEC8	8×56G NRZ/PAM4 BERT (better sensitivity, narrower receiving range) with FEC pattern generator and checker, and FEC simulator
BA-4000-8-56-RCNC-FEC8	8×53G PAM4 BERT (reflection and noise cancellation) with FEC simulator

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