

FEC Analysis PAM4 ED MU196040B

Signal Quality Analyzer-R MP1900A Series



Preliminary The contents of this document may change without prior notice.

Background

Data centers supporting next-generation, high-speed, large-capacity 5G mobile communications are progressing with introduction of equipment meeting the 400 GbE communications standard, while also starting investigation of 800 GbE and 1.6 TbE standards to facilitate even faster speeds.

The PAM4 transmission method used by 400 GbE expresses digital data using four voltage levels per unit time to transmit twice as much data compared to the earlier conventional NRZ method. However, due to the narrower differences between the four voltage levels, the greater susceptibility to noise and transmission-path losses makes error-free transmission more difficult than using the conventional NRZ method. As a result, error correction using FEC is applied to assure transmission quality. Consequently, evaluation of devices and transceivers supporting PAM4 not only requires jitter tolerance and sensitivity evaluations based on conventional bit error and error-free measurements, but also requires measurement of error-correction capability using FEC.

Features of FEC Analysis Function

- Detects both bit errors and FEC Symbol Errors in real-time
- Measures jitter tolerance referenced to FEC Symbol Error count as a pass/fail criterion
- Displays distribution of FEC Symbol Errors per Codeword in real-time

MP1900A PAM4 BERT

 Supports input signal capture at timing exceeding FEC symbol threshold to debug burst errors

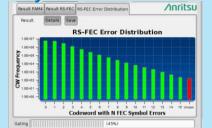
[Target Applications] 50, 100, 200, 400, and 800 GbE

High-sensitivity 116-Gbit/s PAM4 ED supports reliable FEC Symbol Error measurements

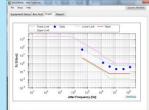


		Uncorr.			Bit	
		Codeword	FEC Symbol	Total	INS	OMI
MSE	ER		2.192 300E-06	2.199 500E-07	4.382 900E-07	1.555 200E-09
1136	EC		25 623	26 876	26 781	95
LSB	ER		2.728 900E-03	2.758 500E-04	4.223 500E-04	1.293 100E-04
LSD	EC		3.189 400E+07	3.223 900E+07	2.468 300E+07	7 556 450
MSE +	BR	0.000 000E-00	1.365 500E-03	1.381 200E-04	2.116 100E-04	6.462 300E-05
LSB	EC	0	3.192 000E+07	3.375 500E+07	2.586 000E+07	7 895 263

FEC Symbol Error Distribution







Test Board

PHY IC

FEC Symbol Capture



Real-time FEC Symbol Error Measurement

Uncorrectable Codeword, FEC Symbol Error, and Bit Error measurement results on one screen MSB/LSB Errors and Codeword Counts and Rate for

Details(Slot6)

MU196040B PAM4 ED Result Screen	Result F	PAM4 Result RS-FEC]			<u> </u>
PAM4 ED 🖪 PAM4 🔻 C 🚳 S 🥥 E 🥥 🕨 Start 🔳 Stop 🙄 Diagnostics Mode			L			
		Uncorr.		Bit		
Result Measurement 🛛 Pattern 🖾 Input Capture Logging Miscl		Codeword	FEC Symbol	Total	INS	OMI
Input	MSB ER		6.934 500E-04	3.503 500E-05	6.975 900E-05	3.121 300E-07
Data XData G U/L Threshold Sync	EC		1 841 995	1 861 282	1 852 991	8 291
0.231 0.237 v OFF Data-XData v -0.006 v	LSB ER		6.315 700E-03	3.258 400E-04	3.116 500E-04	3.400 300E-04
0.012 0.018 V Low Fraudrey Des	EC		1.677 600E+07	1.731 000E+07	8 278 443	9 032 132
	MSB ER	5.120 000E-08	3.504 500E-03	1.804 400E-04	1.907 000E-04	1.701 700E-04
-0.207 -0.201 V OFF 0.000 dB OFF 0	LSB EC	1	1.861 800E+07	1.917 100E+07	1.013 100E+07	9 040 423
■ Delay - 360 mUl -6.750 ps ■ Calibration						
	FI	EC Symbol Error Coun		Code word Rate	Code wor	d Count
Zoom History Reset Date&Time 🔽 2021/01/07 16:36:16			0	4.330 7008		6 187 331
Result PAM4 Result RS-FEC RS-FEC Error Distribution			2	1.582 500		3 090 827
Result PAM4 Result RS-FEC RS-FEC Error Distribution			3	6.127 6008		1 196 814
Uncorr. Codeword FEC Symbol Bit			4	2.105 9008	E-02	411 311
ER 5.120 000E-08 3.504 500E-03 1.804 400E-04			5	6.644 2008		129 771
EC 1 1.861 800E+07 1.917 100E+07			6	2.030 0008		39 649
%EFI 90.000 0.000 0.000 Details			8	6.084 0008		11 883 3 601
El 1 10 Deta k			9	5.631 900		1 100
			10	1.607 6008		314
Frequency(kHz) 53 124 999 Clock Count 5.312 400E+10			11	4.352 0008	5-06	85
			12	2.048 0008	5-06	40
Total Codeword Count 1.953 100E+07			13	6.144 0008		12
Clock Loss 0 🚳 🚳 FEC Symbol Error(MSB) 🥥 🔿			14	3.584 0008		7
Sync Loss 0 0 FEC Symbol Error(LSB)		Uncorr.Co	15	1.024 0008		2
PAM4 Symbol/Bit Error 🖉 🕗 Uncorr. Codeword Error 🕲 🔿		Uncorr.cot	reword	5.120 0000	-00	1
	Clock Loss		0 🔘 🔘 PAN	14 Symbol/Bit Error	Sec Symb	ol Error(MSB) 🙆 🔿
	Sync Loss			-	••••••••••••••••••••••••••••••••••••••	ol Error(LSB)
	Sync Loss			.on. codeword Erro	e 🕑 🕑 🖓 FEC Symb	

each Symbol Error Count on Details Screen

6] PAM4 ED 🖪 PAM4 🔻

Jitter Tolerance Measurements Based on FEC Symbol Errors

Sample Video

One-button jitter tolerance measurement is supported based on whether or not error correction using FEC is possible.

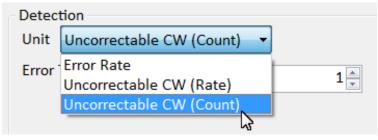
MP1900A PAM4 BERT



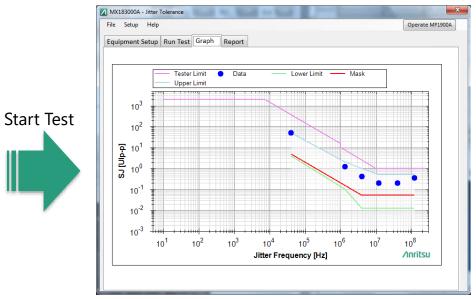
Jitter Frequency and Test Mask Settings

le Se	etup Help					Operate M	P1900
quipm	ent Setup Run Test	Graph Re	port				
Chec	eck All	Μ	leasurement: 12,0	00,000 Hz, 0.060 U	Ip-p Detail	Stop Test	
No.	Jitter Freq. [Hz]	Mask [UI]	Upper Limit [UI]	Lower Limit [UI]	Meas. [UI]	Meas. Judge	
☑ 1	120,000,000	0.052	0.500	0.012	0.348	PASS	UC
☑ 2	40,000,000	0.052	0.500	0.012	0.204	PASS	UC
√ 3	12,000,000	0.052	0.500	0.012			
V 4	4,000,000	0.052	1.000	0.012			
▼ 5	1,333,000	0.152	2.000	0.100			
☑ 6	40,000	5.000	50.000	4.000			
•							+

Test Criterion Setting, Bit Error or Uncorrectable Codeword



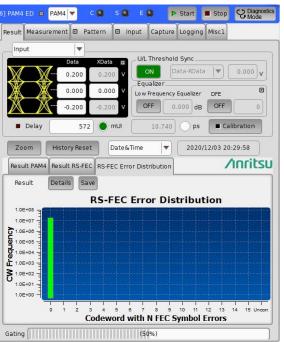
Correctable Error Jitter Tolerance Test Result



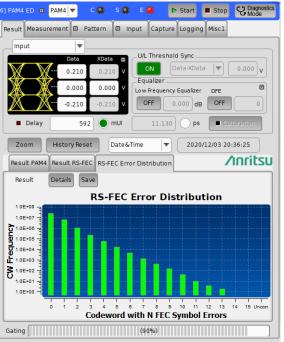
FEC Symbol Error Distribution in Real-time



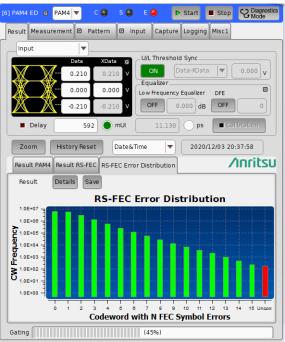
Error Free



Correctable Errors



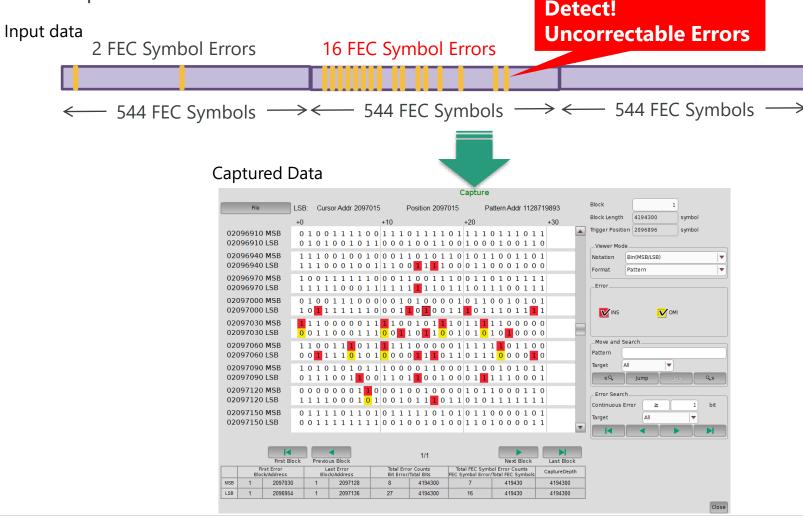
Uncorrectable Errors



Stress Injection

FEC Symbol Capture

The input data is captured when the number of FEC Symbol Errors exceeds the threshold setting. The causes of FEC-uncorrectable errors can be analyzed from the captured data.







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