

Symmetrical 2-pair and Asymmetrical 1-pair TDD operation SNR Margin with updated parameters

Kamal Dalmia

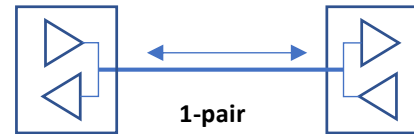


Aviva Links Inc.

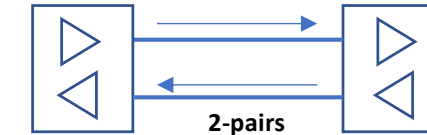
Realistic parameters

- PCB loss – added 1.5 m to cable length
- AFE noise -140 dB/Hz
- Temperature 80 deg C
 - Average for the overall length. Parts of cable may be at higher or lower temp.
 - Do we need further margin for aging of cable?
- Implementation loss = 2 dB
 - Margin for EMC and digital implementation loss

2-pair Operation: PAM 4



Eco Cancellation



No Eco Cancellation

- Realistic parameters as listed on last page
- All input parameters (green cells) are identical except EC cancellation
- 2-pair operation has no echo. Hence, cancellation is not required. This is represented by EC cancellation cell input = 100dB
- Micro-reflections is a non-issue with 2-pair operations but left at -40 dB.
- 2-pair operation has 1.1 dB SNR margin which is adequate. The margin is similar to 802.3ch with “realistic parameters”

	Upstream	Downstream
Requirements		
Data Rate [Gbps]:	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	12.5	12.5
Wire u-reflections [dB]:	-40	-40
Number of Connectors:	4	4
Modulation		
PAM Levels:	4	4
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
RS-FEC Correction Efficiency:	100%	100%
Bits per FEC Symbol:	10	10
TDD Time Duty-Cycle:	100%	100%
Framing Overhead:	1.875%	1.875%
Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-140
EC cancelation [dB]:	5	5
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	2	2
Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
Temperature [°C]:	80	
Max Simulation Frequency:	9.00E+09	

	Upstream	Downstream
Calculated Values		
Theoretical Slicer SNR [dB]:	19.27	19.27
Estimated Slicer SNR [dB]:	17.27	17.27
Required Slicer SNR [dB]:	17.78	17.78
SNR Margin [dB]:	-0.51	-0.51
Nyquist Frequency [GHz]:	7.03	7.03
Insertion Loss @ Nyquist [dB]:	32.79	32.79



	Upstream	Downstream
Requirements		
Data Rate [Gbps]:	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	12.5	12.5
Wire u-reflections [dB]:	-40	-40
Number of Connectors:	4	4
Modulation		
PAM Levels:	4	4
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
RS-FEC Correction Efficiency:	100%	100%
Bits per FEC Symbol:	10	10
TDD Time Duty-Cycle:	100%	100%
Framing Overhead:	1.875%	1.875%
Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-140
EC cancelation [dB]:	100	100
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	2	2
Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
Temperature [°C]:	80	
Max Simulation Frequency:	9.00E+09	

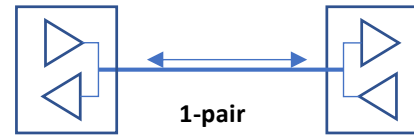
	Upstream	Downstream
Calculated Values		
Theoretical Slicer SNR [dB]:	20.88	20.88
Estimated Slicer SNR [dB]:	18.88	18.88
Required Slicer SNR [dB]:	17.78	17.78
SNR Margin [dB]:	1.10	1.10
Nyquist Frequency [GHz]:	7.03	7.03
Insertion Loss @ Nyquist [dB]:	32.79	32.79

Not Feasible

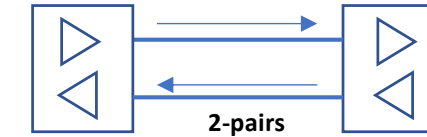
Feasible

source: https://www.ieee802.org/3/cy/public/adhoc/jonsson_3cy_01a_12_01_20.xlsx

2-pair Operation: PAM 5



Eco Cancellation



No Eco Cancellation

- Realistic parameters as listed on last page
- All input parameters (green cells) are same as last slide except PAM levels
- PAM 5 has 0.25 dB more margin than PAM 4
- Given that we are near the limit, having extra 0.25 dB is desirable

	Upstream	Downstream
Requirements		
Data Rate [Gbps]:	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	12.5	12.5
Wire u-reflections [dB]:	-40	-40
Number of Connectors:	4	4
Modulation		
PAM Levels:	5	5
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
RS-FEC Correction Efficiency:	100%	100%
Bits per FEC Symbol:	10	10
TDD Time Duty-Cycle:	100%	100%
Framing Overhead:	1.875%	1.875%
Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-140
EC cancelation [dB]:	5	5
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	2	2
Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
Temperature [°C]:	80	
Max Simulation Frequency:	9.00E+09	

	Upstream	Downstream
Calculated Values		
Theoretical Slicer SNR [dB]:	21.41	21.41
Estimated Slicer SNR [dB]:	19.41	19.41
Required Slicer SNR [dB]:	19.87	19.87
SNR Margin [dB]:	-0.45	-0.45
Nyquist Frequency [GHz]:	6.06	6.06
Insertion Loss @ Nyquist [dB]:	29.84	29.84

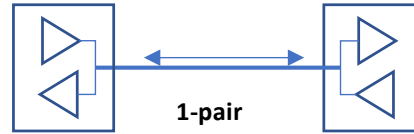
Not Feasible

	Upstream	Downstream
Requirements		
Data Rate [Gbps]:	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	12.5	12.5
Wire u-reflections [dB]:	-40	-40
Number of Connectors:	4	4
Modulation		
PAM Levels:	5	5
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
RS-FEC Correction Efficiency:	100%	100%
Bits per FEC Symbol:	10	10
TDD Time Duty-Cycle:	100%	100%
Framing Overhead:	1.875%	1.875%
Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-140
EC cancelation [dB]:	100	100
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	2	2
Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
Temperature [°C]:	80	
Max Simulation Frequency:	9.00E+09	

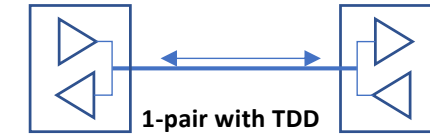
	Upstream	Downstream
Calculated Values		
Theoretical Slicer SNR [dB]:	23.23	23.23
Estimated Slicer SNR [dB]:	21.23	21.23
Required Slicer SNR [dB]:	19.87	19.87
SNR Margin [dB]:	1.36	1.36
Nyquist Frequency [GHz]:	6.06	6.06
Insertion Loss @ Nyquist [dB]:	29.84	29.84

Feasible

1-pair Operation: TDD with PAM 4



Echo Cancellation



No Eco Cancellation

- Echo cancellation section is same as previous PAM 4 slide
- TDD is intended for asymmetrical operation.
- TDD section has effective data rates adjusted for 99% - 1% duty cycle
- TDD 1-pair asymmetrical operation has the same amount of positive margin as 2-pair symmetrical operation!

	Upstream	Downstream
Requirements		
Data Rate [Gbps]:	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	12.5	12.5
Wire u-reflections [dB]:	-40	-40
Number of Connectors:	4	4
Modulation		
PAM Levels:	4	4
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
RS-FEC Correction Efficiency:	100%	100%
Bits per FEC Symbol:	10	10
TDD Time Duty-Cycle:	100%	100%
Framing Overhead:	1.875%	1.875%
Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-140
EC cancelation [dB]:	5	5
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	2	2
Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
Temperature [°C]:	80	
Max Simulation Frequency:	9.00E+09	

	Upstream	Downstream
Calculated Values		
Theoretical Slicer SNR [dB]:	19.27	19.27
Estimated Slicer SNR [dB]:	17.27	17.27
Required Slicer SNR [dB]:	17.78	17.78
SNR Margin [dB]:	-0.51	-0.51
Nyquist Frequency [GHz]:	7.03	7.03
Insertion Loss @ Nyquist [dB]:	32.79	32.79

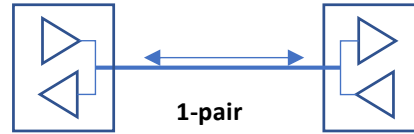
Not Feasible

	Upstream	Downstream
Requirements		
Effective Data Rate [Gbps]:	24.75	0.25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	12.5	12.5
Wire u-reflections [dB]:	-40	-40
Number of Connectors:	4	4
Modulation		
PAM Levels:	4	4
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
RS-FEC Correction Efficiency:	100%	100%
Bits per FEC Symbol:	10	10
TDD Time Duty-Cycle:	99%	1%
Framing Overhead:	1.875%	1.875%
Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-140
EC cancelation [dB]:	100	100
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	2	2
Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
Temperature [°C]:	80	
Max Simulation Frequency:	9.00E+09	

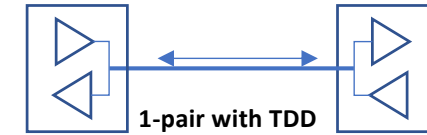
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Calculated Values		
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Estimated Slicer SNR [dB]:	18.88	18.88
Required Slicer SNR [dB]:	17.78	17.78
SNR Margin [dB]:	1.10	1.10
Nyquist Frequency [GHz]:	7.03	7.03
Insertion Loss @ Nyquist [dB]:	32.79	32.79

Feasible

1-pair Operation: TDD with PAM 5



Eco Cancellation



No Eco Cancellation

- All input parameters (green cells) are same as last slide except PAM levels
- PAM 5 has more margin than PAM 4
- TDD has the same amount of positive margin as 2-pair operation with PAM 5

	Upstream	Downstream
Requirements		
Data Rate [Gbps]:	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	12.5	12.5
Wire u-reflections [dB]:	-40	-40
Number of Connectors:	4	4
Modulation		
PAM Levels:	5	5
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
RS-FEC Correction Efficiency:	100%	100%
Bits per FEC Symbol:	10	10
TDD Time Duty-Cycle:	100%	100%
Framing Overhead:	1.875%	1.875%
Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-140
EC cancelation [dB]:	5	5
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	2	2
Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
Temperature [°C]:	80	
Max Simulation Frequency:	9.00E+09	

	Upstream	Downstream
Calculated Values		
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Estimated Slicer SNR [dB]:	19.41	19.41
Required Slicer SNR [dB]:	19.87	19.87
SNR Margin [dB]:	-0.45	-0.45
Nyquist Frequency [GHz]:	6.06	6.06
Insertion Loss @ Nyquist [dB]:	29.84	29.84



	Upstream	Downstream
Requirements		
Effective Data Rate [Gbps]:	24.75	0.25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	12.5	12.5
Wire u-reflections [dB]:	-40	-40
Number of Connectors:	4	4
Modulation		
PAM Levels:	5	5
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
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Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
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Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
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	Upstream	Downstream
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Required Slicer SNR [dB]:	19.87	19.87
SNR Margin [dB]:	1.36	1.36
Nyquist Frequency [GHz]:	6.06	6.06
Insertion Loss @ Nyquist [dB]:	29.84	29.84

Not Feasible

Feasible

Conclusions

- Echo-cancellation based 1-pair symmetrical or asymmetrical operation does not have sufficient margin
- Symmetrical operation over 2-pairs has sufficient margin
- Asymmetrical operation over 1-pair using TDD has sufficient margin
- PAM 5 has more margin than PAM 4

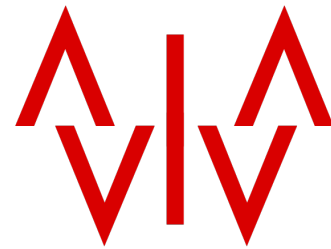
One 25G PHY that uses PAM 5 and operates in two modes:

(a) 2-pair symmetrical mode

(b) 1-pair asymmetrical mode (TDD)

Meets all adopted objectives and is an optimum choice for 802.3cy

Thank You



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