IEEE P802.11
Wireless LANs

BreezeCom 5 GHz OQM PHY Performance Comparison Submission

Date: March 10, 1998

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Introduction

This document is an update of 98/76 document submitted by BreezeCom on February 23, 1998. The document completes several missing necessary details (such as performance with phase noise) and adds some more details such as performance for different equalizer lengths. The document follows the form prescribed by document 98/57.

This submission addresses the performance of the OQM modulatiom method as proposed on behalf of BreezeCom of in document 98/21. However, majority of it applies to the joint NEC and BreezeCom proposal as described briefly in 98/107 and in detail in 98/109. The new proposal is based on OQM modulation with a Square Root Raised Cosine pulse shape and we believe that all of the results, excluding ACI results, apply to it. This is being verified as this document is submitted.

General Description

Parameter	Value(s)
Data Rates Supported	20.9677 Mbit/s (mandatory), 25.0000 Mbit/s (mandatory), 41.9355 Mbit/s (optional), 50.0000 Mbit/s (optional), 62.9032 Mbit/s (optional/impractical), 75.0000 Mbit/s (optional/impractical), 83.8710 Mbit/s (optional/impractical), 100.0000 Mbit/s (optional/impractical)
Channel Spacing	25 MHz
Center Frequencies	lower: 5.175, 5.200, 5.225, 5.250 GHz middle 5.275, 5.300, 5.325 GHz upper: 5.750, 5.775, 5.800, 5.825 GHz
Power Levels	
Sensitivities	20.9677 Mbit/s: -77 dBm 25.0000 Mbit/s: -75 dBm 41.9355 Mbit/s: -67 dBm 50.0000 Mbit/s: -65 dBm
CCA threshold	
Clock Rate accuracy	10 ppm
Carrier Frequency accuracy	10 ppm (60 kHz)
Waveform implementation accuracy specification method	RMS residual ISI when optimizing with respect to slack parameters – frequency, phase and timing offset, and a short equalizer (joint NEC Breeze proposal)

Power Backoff in RF PA	Saturated in Breeze proposal 1 dB to 6 dB depending on modulation and U-NII subband (NEC+Breeze)
Implementation Complexity	100-200 Kgates, depending on equalizer length.

Per-Rate Feature Summary

Parameter	21 Mbit/s	25 Mbit/s	42 Mbit/s	50 Mbit/s
Data rate	20.9677 Mbit/s	25.0 Mbit/s	41.9355 Mbit/s	50.0 Mbit/s
ECC method	Hamming	none	Hamming	none
Interleaving method	write rows, encode columns, read rows depth 8	None	write rows, encode columns, read rows depth 16	none
Suggested minimal sensitivity	-77 dBm	-75 dBm	-67 dBm	-65 dBm
Suggested Co-Channel rejection				
Suggested Adjacent Channel rejection				
Suggested Alternate Channel rejection				
Implementation Accuracy				

Per-Rate Performance Summary

The data relates to DFE receiver with 16 taps in feed-forward filter and 15 decision feedback taps. Data for shorter equalizers will be provided soon.

Parameter	21 Mbit/s	25 Mbit/s	42 Mbit/s	50 Mbit/s
Eb/No at PER=10%, AWGN, 64b	7.2 dB	9.5 dB	10 dB	12.5 dB
Trms at PER=10%, noise free, 64b	240 nsec	230 nsec	120 nsec	100 nsec
Eb/No @ 20%, with Trms @ 10%, 64b				17 dB
Eb/No at PER=10%, AWGN, 1000b	8.5 dB	11.2 dB	12.5 dB	14.2 dB
Trms at PER=10%, noise free, 1000b	185 nsec	170 nsec	95 nsec	70 nsec
Eb/No @ 20%, with Trms @ 10%, 1000b	15 dB?	17 dB?	19 dB	22 dB?
CCI immunity [dB]	-13 dB	-15 dB	-17 dB	-20 dB
ACI immunity [dB] for BreezeCom proposal	40 dB 28 dB (sat adj)	42 dB 30 dB (sat adj)	34 dB	36 dB
ACI immunity [dB] for joint NEC-BreezeCom proposal (P=1 PA model)	25-26 dB at 2 dB backoff	23-24 dB at 2 dB backoff	17 dB at 6 dB backoff	15 dB at 6 dB backoff
CW jammer immunity [dB]	-10 dB	-11 dB	-18.5 dB	-21 dB
Narrowband Gaussian noise immunity [dB]				
Phase noise tolerance, (BW=50 kHz), rad^2 [dBc] at which PER becomes 10%	-10 dB	-12 dB	-16 dB	-20 dB

Timing and Overhead related parameters

Attach verbal explanation of the assumptions taken for each parameter

Attribute	**Suggested Value**
aSlotTime	6.0 µs in Breezecom 7.4 µs in joint proposal
aCCATime	3.0 µs
aRxTxTurnaroundTime	1.4 µs
aTxPLCPDelay	0.4 µs
aRxTxSwitchTime	0.4 µs.
aTxRampOnTime	0.4 µs.
aTxRFDelay	0.4 µs.
aSIFSTime	12.0 µs. in Breezecom 13.4 µs in joint proposal
aRxRFDelay	1.0 µs.
aRxPLCPDelay	7.0 µs.
aMACProcessingDelay	0.6 µs. in Breezecom 2.0 µs in joint proposal
aTxRampOffTime	0.4 µs.
aPreambleLength	10.24 µs in Breezecom 12.8 µs in joint proposal
aPLCPHdrLength	3.2 µs
aMPDUDurationFactor	1.1923 (if ECC used)
aAirPropagationTime	0.8 µs
aCWmin	15
aCWmax	1023

Description of Simulation Setup

The enclosed graphs are all simulated. The waveform used for transmission is as described in the proposal.

In the receiver an IF filter of square-root-raised-cosine shape was utilized to limit the noise and adjacent channels, after which the data was sampled one complex sample per symbol. The resulting sample stream was passed through a decision feedback equalizer. The number of feedforward taps and feedback taps varied, but in most simulations 16 feed-forward and 15 feedback taps were used. Comparison was conducted with shorter equalizers as well (stressing shortening of the feedforward part). The tap spacing is 40 nsec.

The equalizer compensated for multipath as well as for timing offset - no separate timing loop was assumed.

The computation of equalizer from channel estimate was computed by an optimal routine (involving matrix inversion). Suboptimal equalizer initialization routines which are cheaper on implementation are currently under investigation. The equalizer initialization assumes white Gaussian noise after the IF filter, which is not true; on the other hand, this assumption is both computationally simpler and it is also beneficial for improving ACI rejection.

The channel estimation includes a frequency estimation and compensation, and all the data provided includes equalizer derived from estimated channel.

The performance in AWGN, without multipath, was degraded by about 1 dB due to the use of estimated channel response relatively to perfect knowledge of the channel.

The Adjacent Channel Interference was tested both in Offset Quadrature Modulation mode and in GMSK mode. In ACI and CCI simulations the start instant was randomized over a symbol interval and the center frequency was randomized over 1% of symbol rate. When in the adjacent channel the interferer is operating with saturated amplifier, the spectral sidelobes are higher, and a price of about 12 dB is paid in ACI rejection. The difference in ACI rejection between 1 bit/s and 2 bits/s is about 7 dB, with ECC improving about 1.5-2 dB.

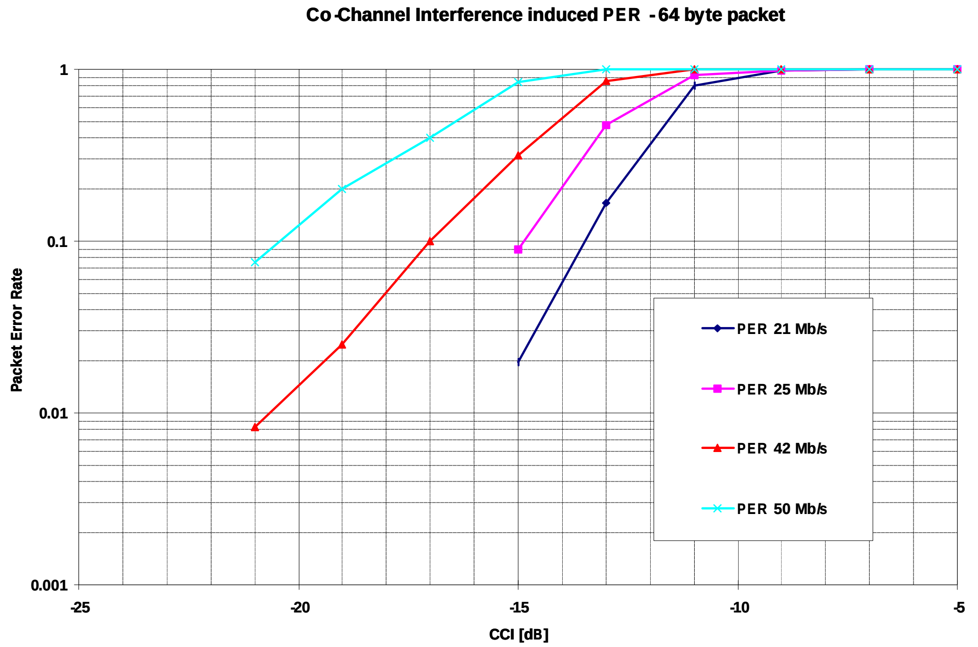

Fig.1: Packet Error Rate vs. Co-Channel Interference level. Continuous pseudorandom transmission of same modulation type used as an interferer.

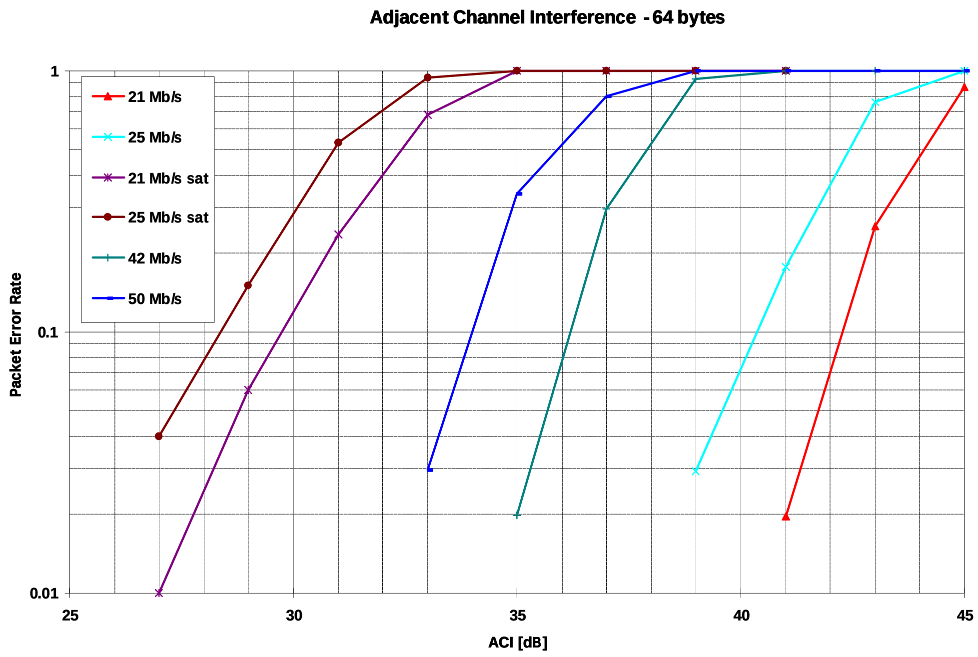

Fig.2: Packet Error Rate vs. Adjacent Channel Interference level for BreezeCom pulse shape. Continuous pseudorandom transmission of same modulation type used as an interferer. The saturated curves (leftmost) indicate the case when the interferer is a binary transmitter running in a saturated (GMSK) mode.

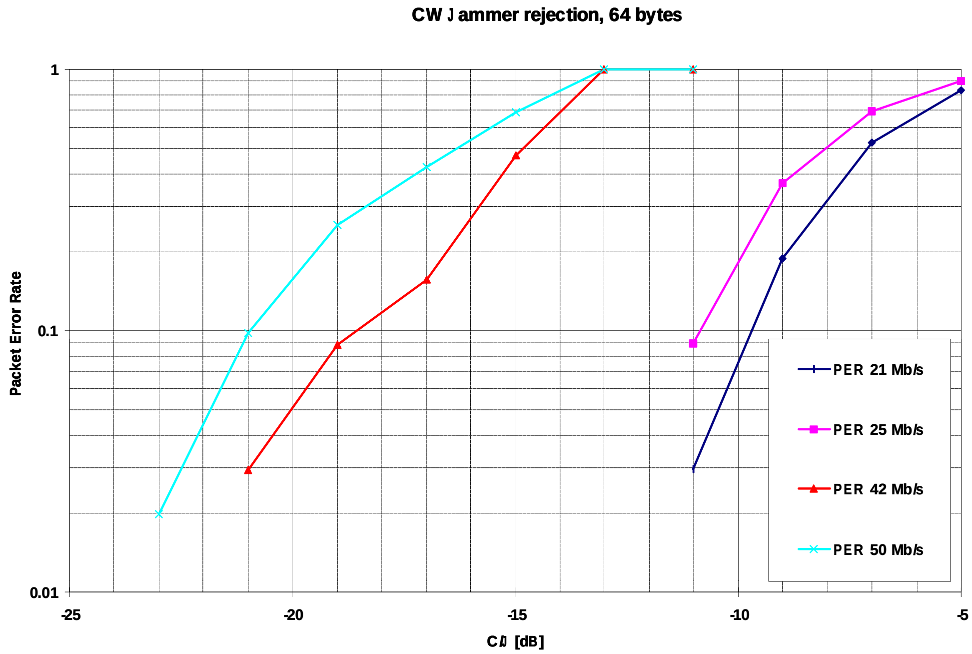

Fig.3: Packet Error Rate vs. CW Interference level. The frequency of the interfering CW signal is chosen randomly for each packet in a +/-0.25Fsym, where most of signal energy is contained.

Fig.4: Packet Error Rate vs. Narrowband noise interference level. (to be provided).

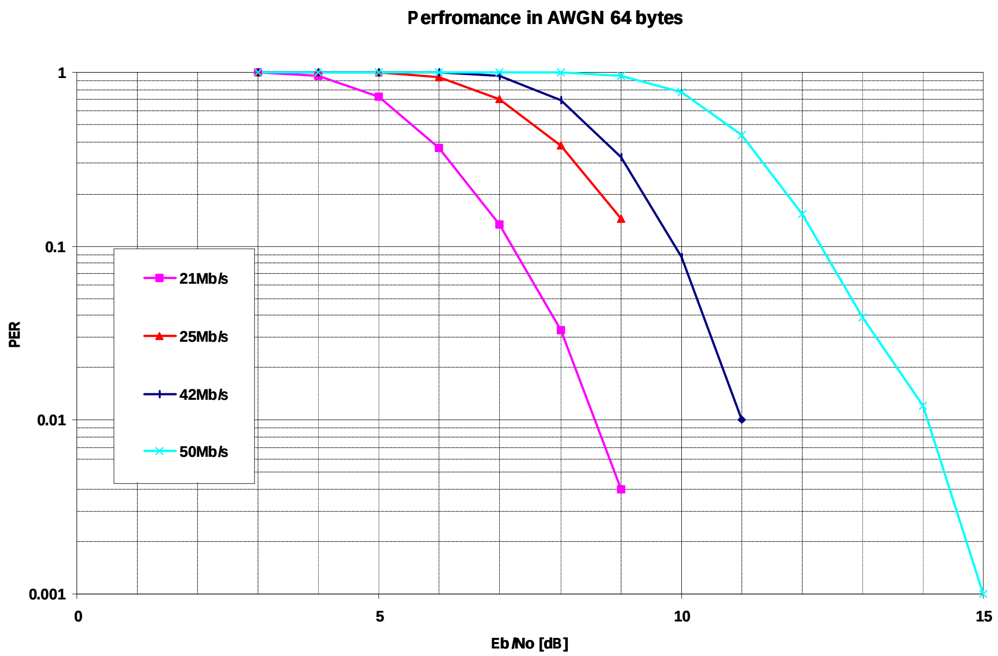

Fig. 5: Performance in AWGN, 64 byte packet length.

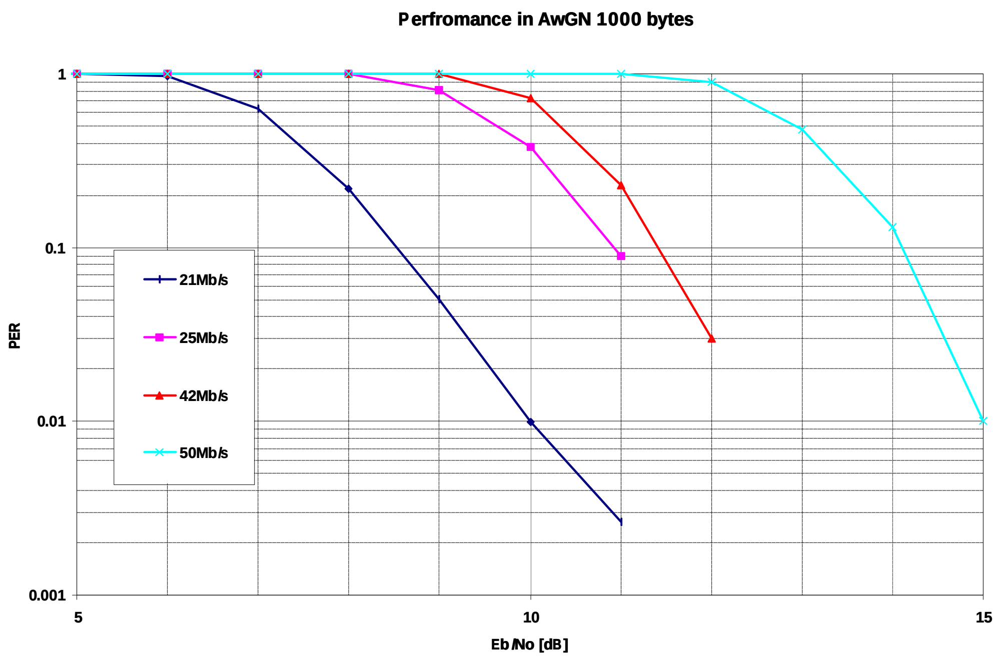

Fig. 6: Performance in AWGN, 1000 byte packet length.

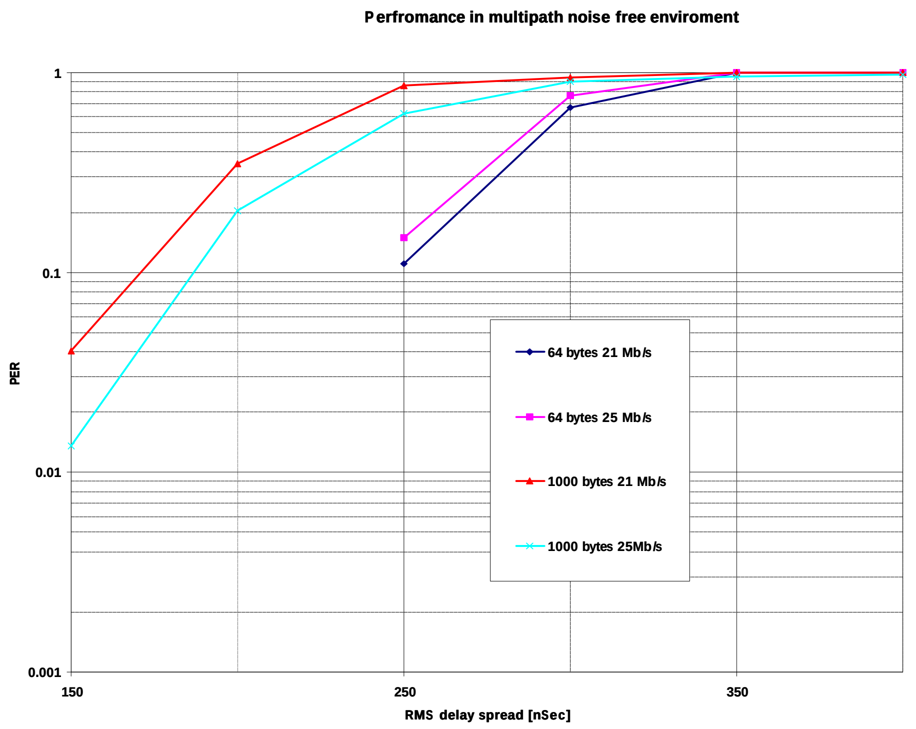

Fig. 7: Performance in multipath, noise free, 1 bit/symbol.

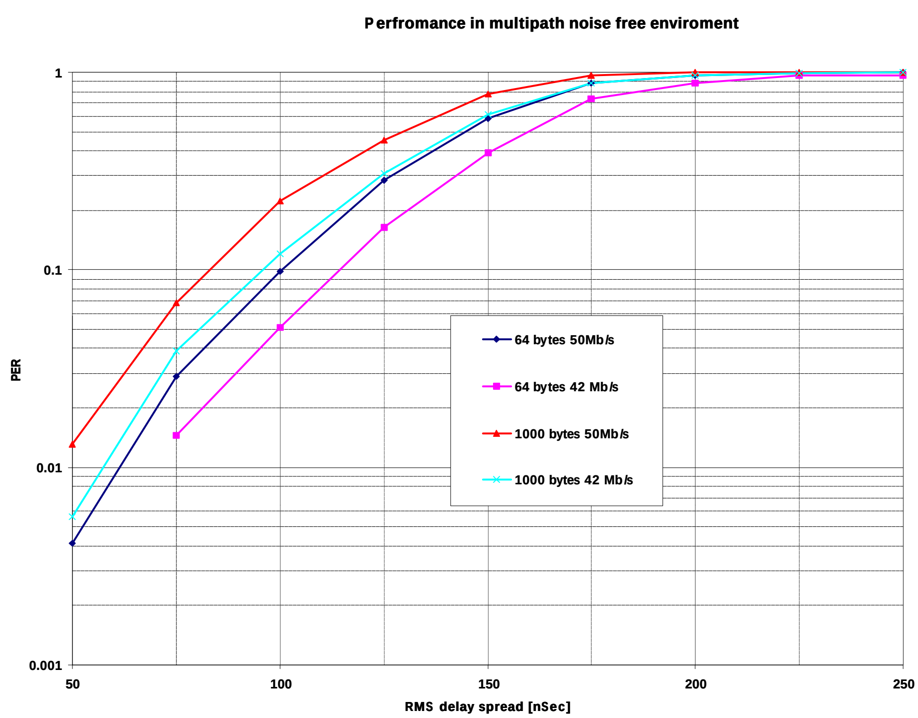

Fig. 8: Performance in multipath, noise free, 2 bit/symbol.

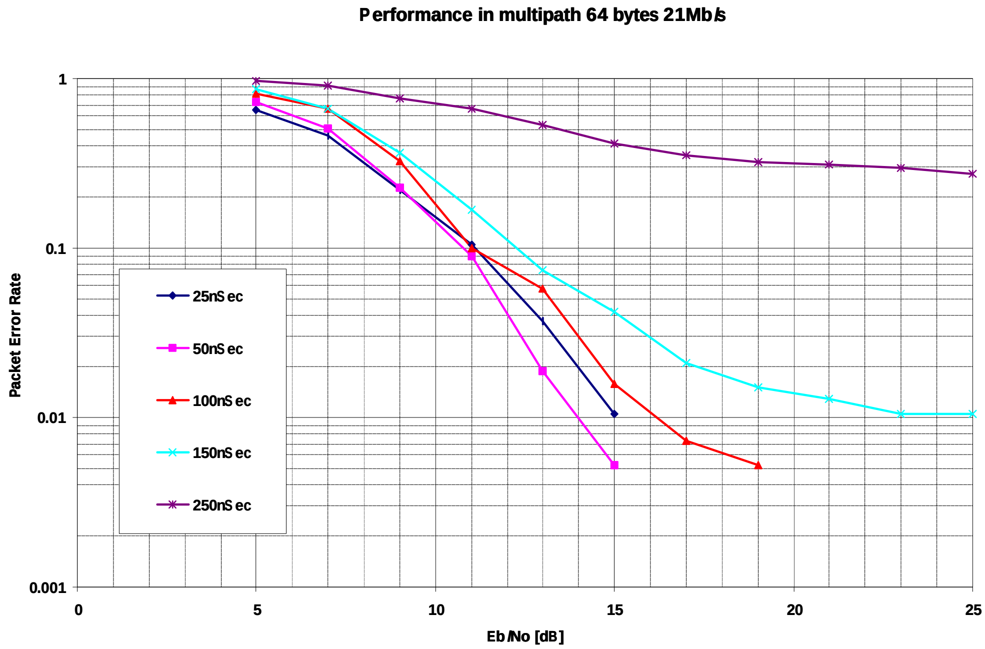

Fig 9: PER vs. Eb/No for different Trms values, 21 Mbit/s, 64 byte packet.

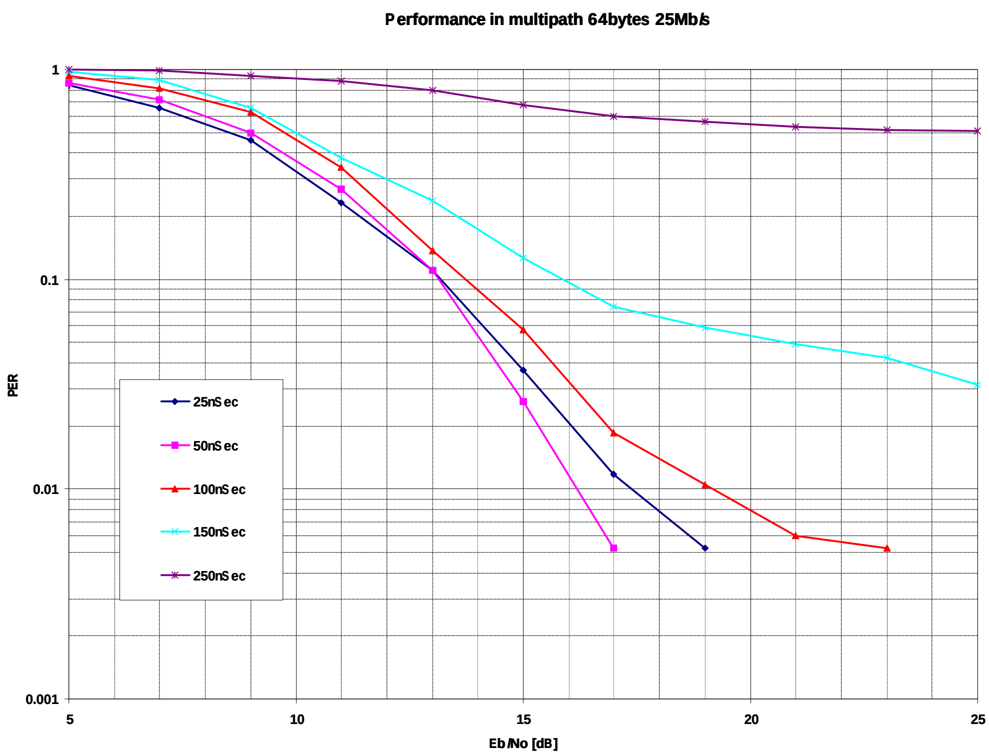

Fig 10: PER vs. Eb/No for different Trms values, 25 Mbit/s, 64 byte packet.

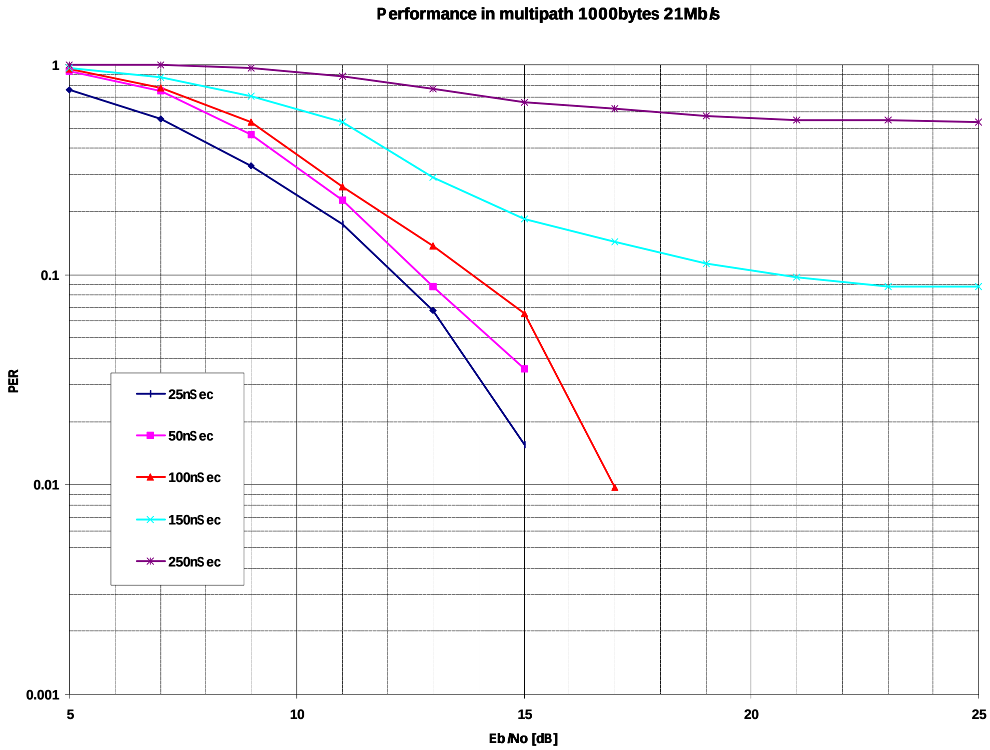

Fig 11: PER vs. Eb/No for different Trms values, 21 Mbit/s, 1000 byte packet.

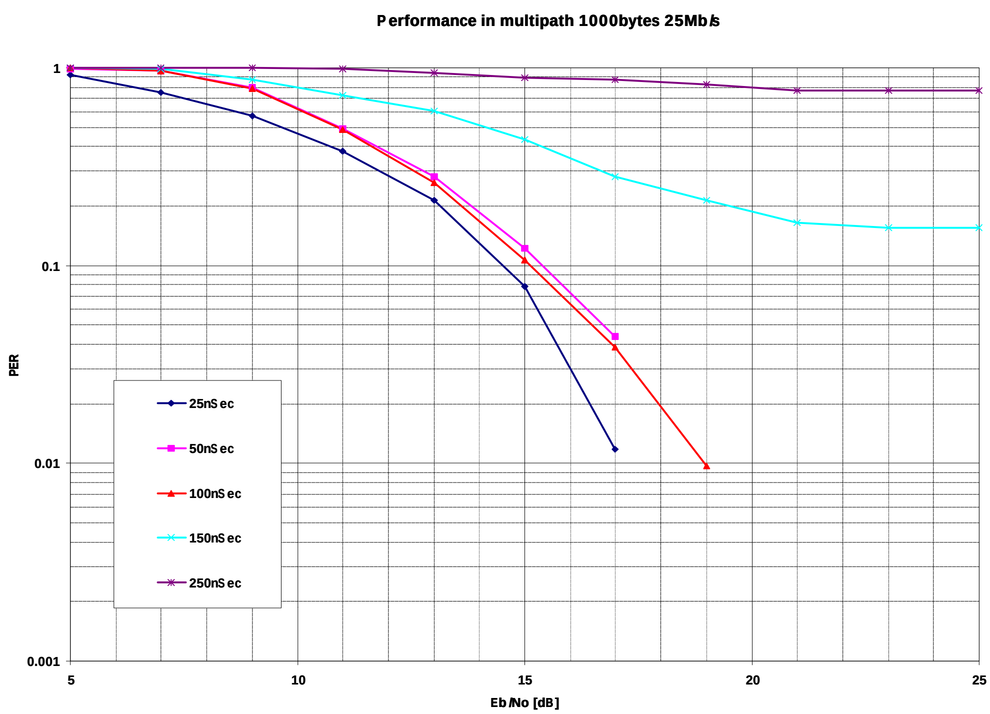

Fig 12: PER vs. Eb/No for different Trms values, 25 Mbit/s, 1000 byte packet.

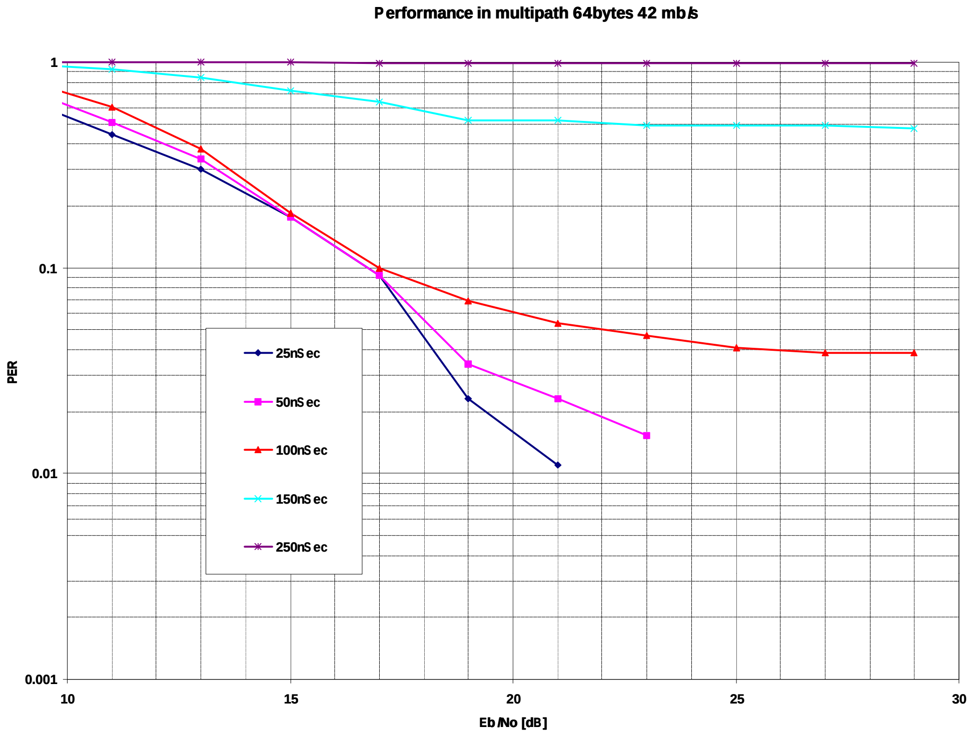

Fig 13: PER vs. Eb/No for different Trms values, 42 Mbit/s, 64 byte packet.

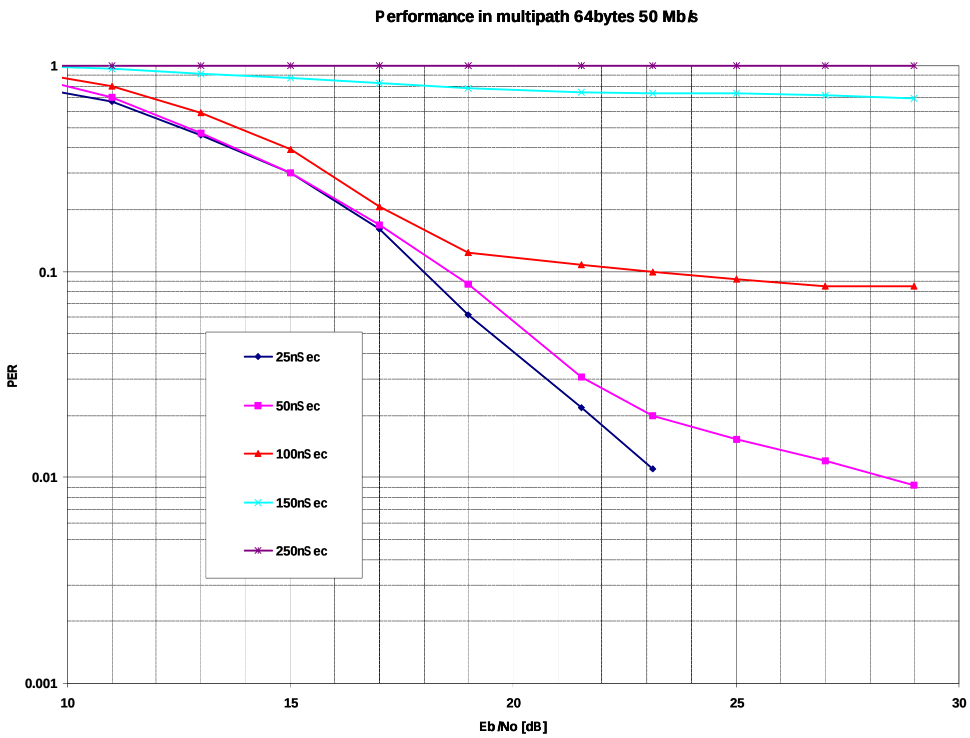

Fig 14: PER vs. Eb/No for different Trms values, 50 Mbit/s, 64 byte packet.

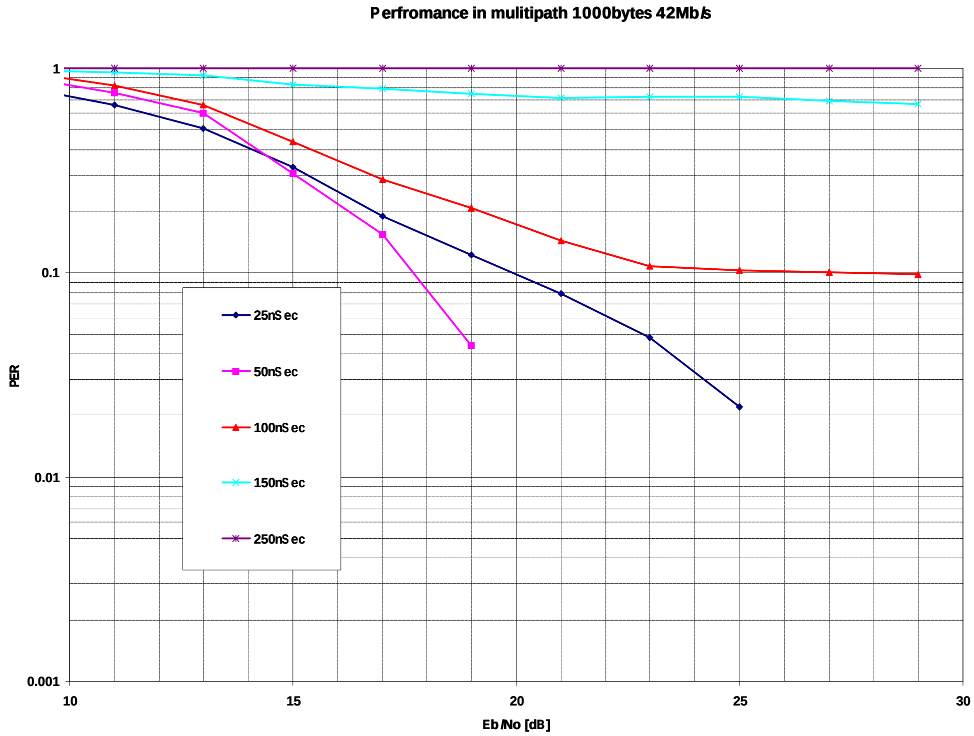

Fig 15: PER vs. Eb/No for different Trms values, 42 Mbit/s, 1000 byte packet.

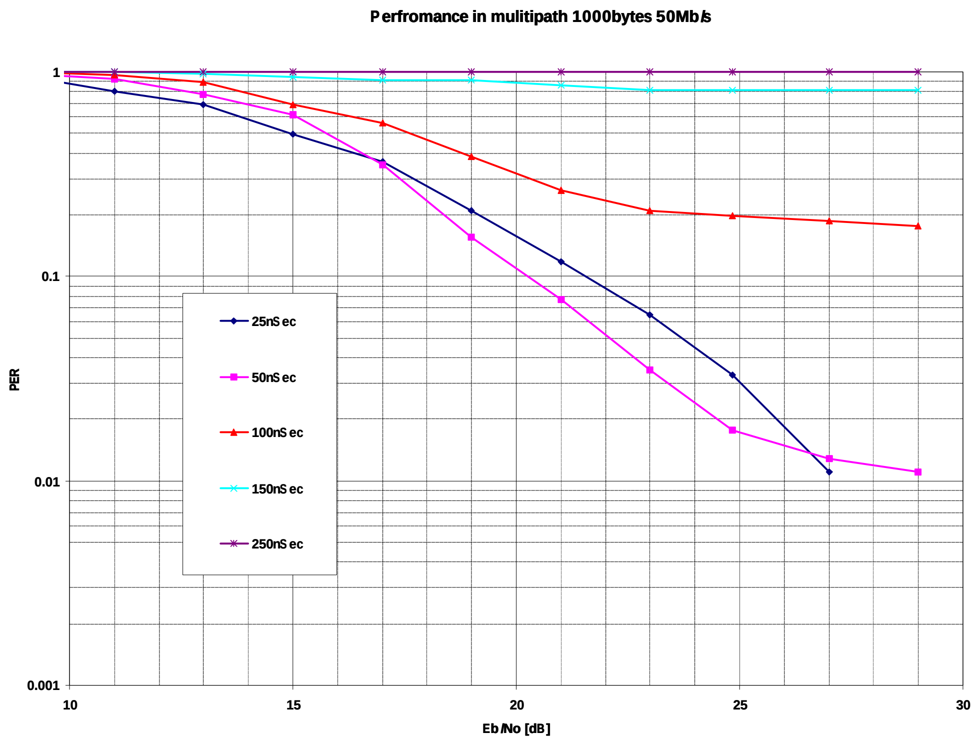

Fig 16: PER vs. Eb/No for different Trms values, 50 Mbit/s, 1000 byte packet.

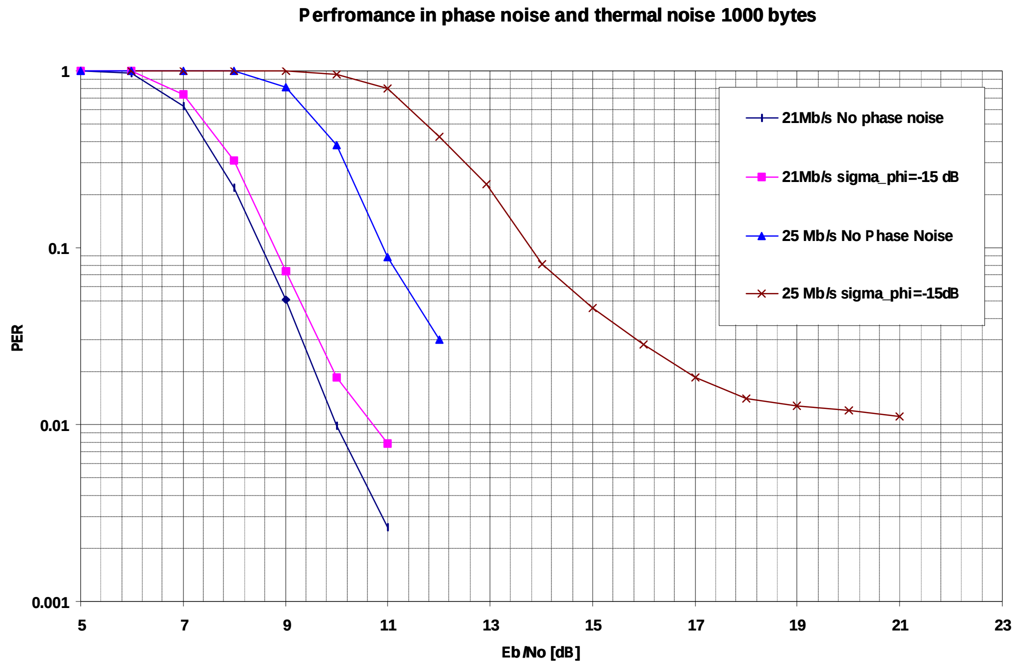

Fig 17: PER vs. Eb/No with and without phase noise, 21 Mbit/s and 25 Mbit/s, 1000 byte packet.

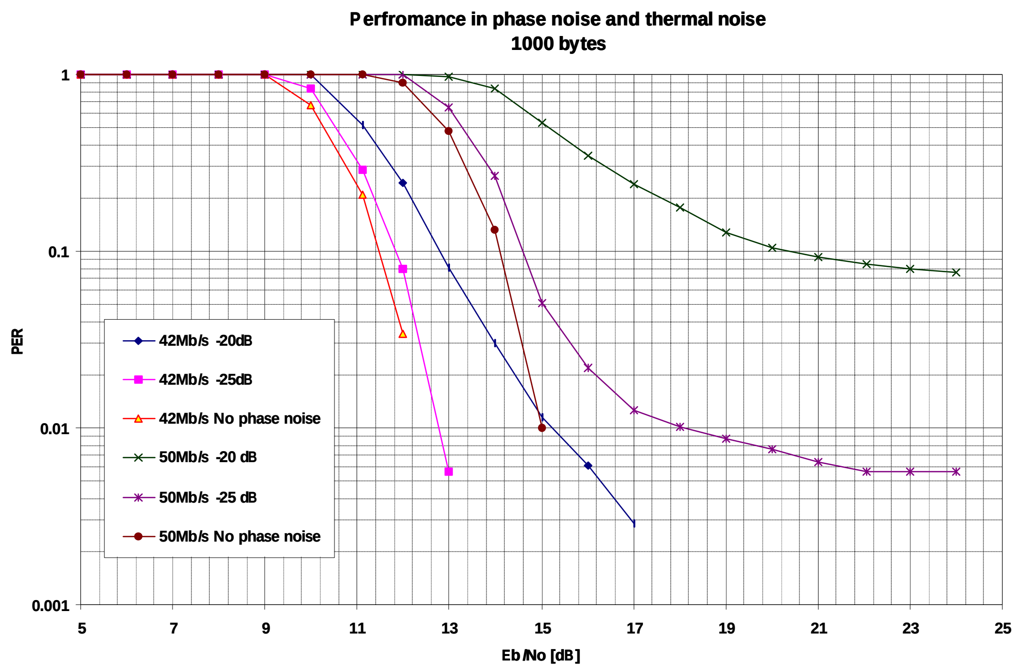

Fig 18: PER vs. Eb/No with and without phase noise, 42 Mbit/s and 50 Mbit/s, 1000 byte packet.

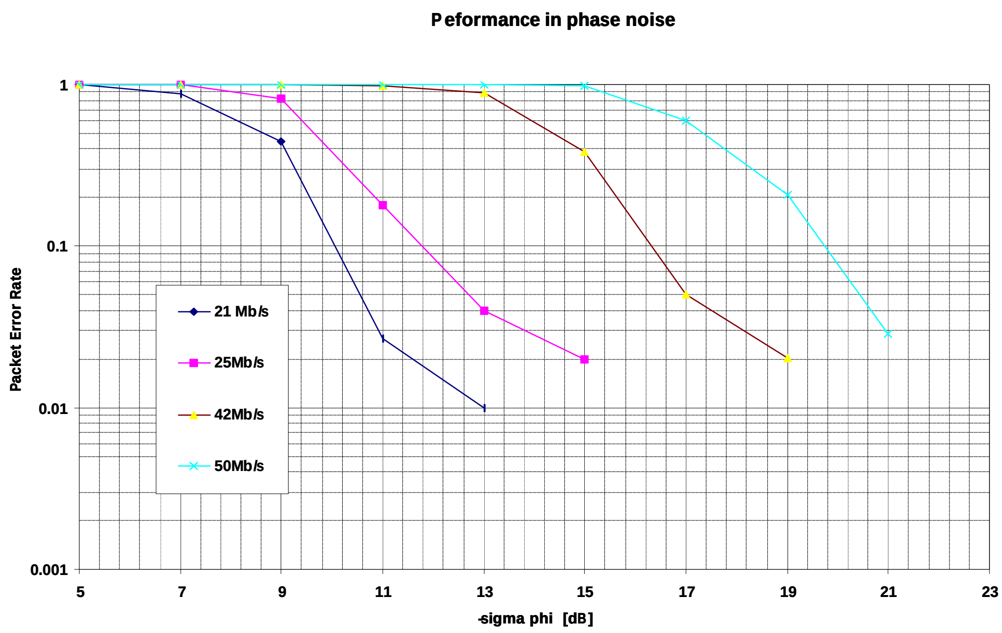

Fig 19: PER vs. phase noise level, without thermal noise.

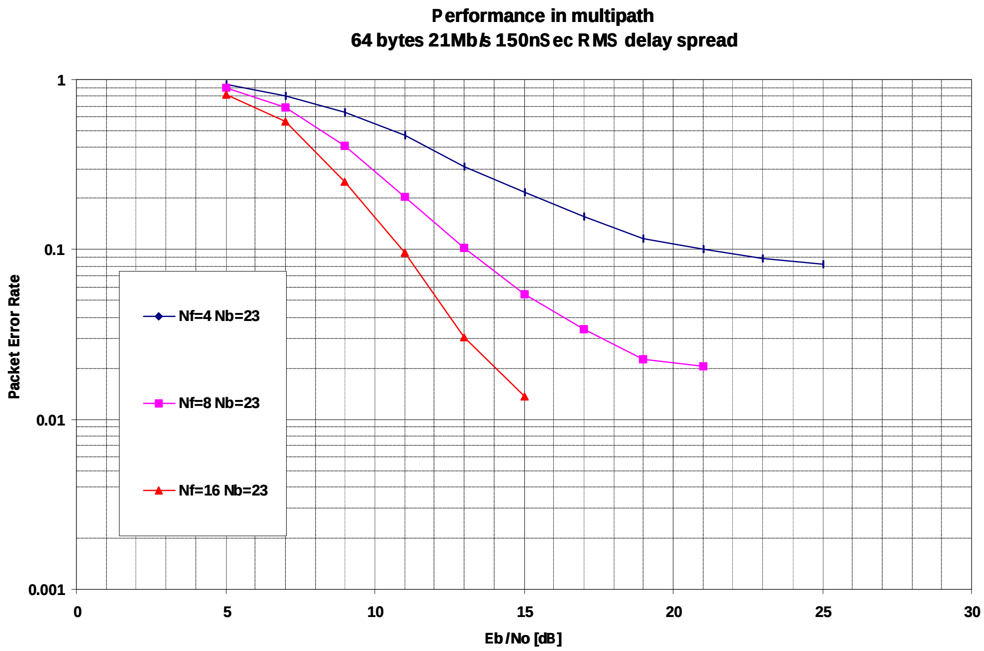

Fig 20: PER vs. Eb/No for different Equalizer lengths, 21 Mbit/s.

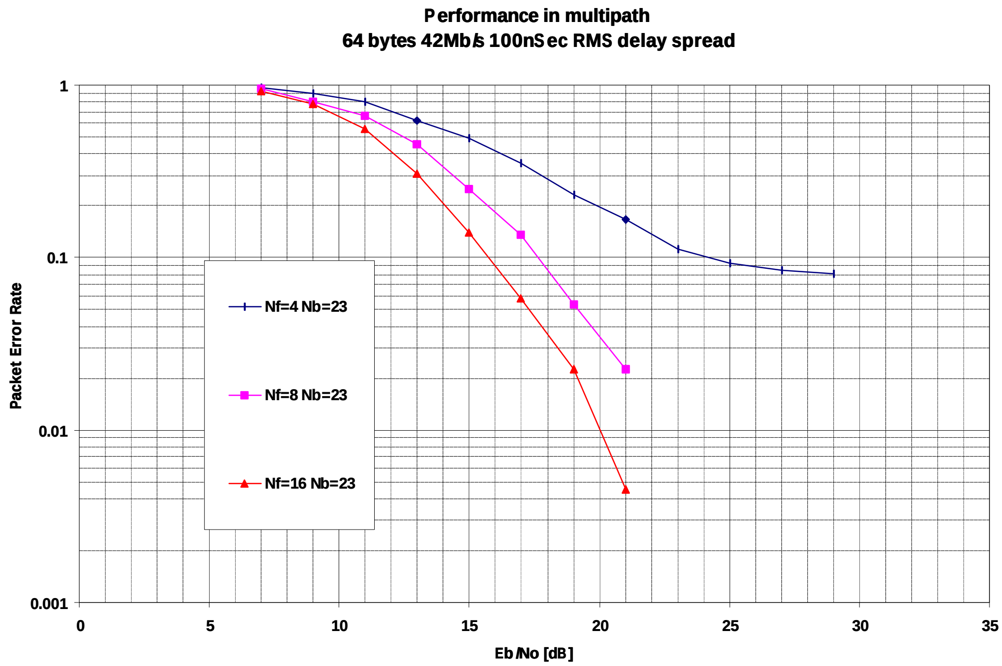

Fig 21: PER vs. Eb/No for different Equalizer lengths, 42 Mbit/s.