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Re: []

Abstract: [Proposing a modifiedsimulation scheme and summarizing items to evaluate PHY performance]

Purpose: [To be considered in 15.3c technical requirement by computer simulation]

A Modified Performance Evaluation Scheme for Computer Simulation

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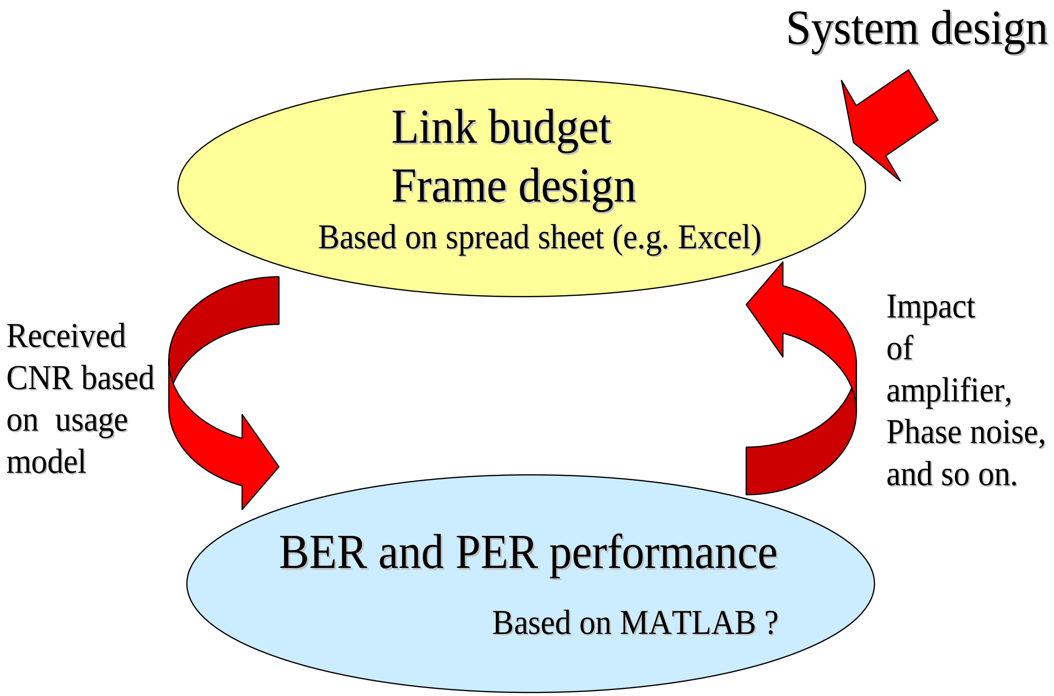
Summary of this document

- Propose a scheme to evaluate PHY performance by computer simulation in TG3c
  - Link budget
  - Frame design
  - BER (and/or) PER performance
- Propose parameters to evaluate PHY performance
  - Impact of power amplifier (PA)
  - Impact of channel model (CM)
  - Impact of phase noise (PN)
- Summarize items described in contributed document that shows PHY performance
- Show simulated results of transmission performance by considering the impact of PA, CM, and PN by single carrier system (BPSK, QPSK, OQPSK, MSK)

Propose a scheme to evaluate PHY performance by computer simulation in TG3c

- Two evaluations for system design
  - Calculation of link budget
    - Clarify received CNR when considered usage model discussed in TG3c
  - Frame design
    - Confirm that transmission rate at PHY-SAP satisfies the requirement specified in usage model
- BER and/or PER performance
  - Show CNR v.s. BER/PER
    - Clarify transmission performance at several CNR
    - Clarify transmission impact of power amplifier, phase noise, channel model, coding, and so on
    - How many dB must be gained/reduced to/from link budget when the above impact is considered (feed back to calculation of link budget)



An example of link budget calculation

Distance	1	3	5	m
Carrier bit rate	2			Gbps
TX power	10			dBm
Tx antenna gain	10			dBi
Frequency band	59-66			GHz
Center frequency	62.5			GHz
wavelength	4.8			mm
Path loss	68.35939	77.90182	82.33879	dB
RX Antenna gain	10			dBi
Boltzmann constant	1.38065E-23			
Temperature	300			K
Rx Noise figure	10			dB
Eb/N0	32.45826	22.91583	18.47886	dB
	BPSK	QPSK	DQPSK	
Required Eb/N0 for BER=10^-5	9.5	9.5	12	dB
Required Eb/N0 for BER=10^-12	14	14	16.2	dB

This is an example and the data shown in this sheet is NOT equal to the proposal for PHY model from contributors.

An example of frame design

System Bandwidth (Bt)	7	GHz
Number of channels (Nch)	3	
Maximum band width/channel	2.333333	GHz
M-ary modulation level	2	
Symbol rate	1.6	GHz
Roll off rate (a)	0.35	
Band width	2.16	GHz
PSDU in one packet	2048	byte
PSDU Coding rate	3/4	
PSDU transmission time	6826.667	ns
PSDU data transmission rate	3.2	Gbps
PLCP Header	25	byte
PLCP Coding rate	1/2	
PLCP Header duration	125	ns
PLCP Data transmission rate	3.2	Gbps
PLCP Preamble duration	100	ns
Shared ratio	0.968093	
PSDU transmission rate(PHY-SAP)	2.323422	Gbps

Packet configuration

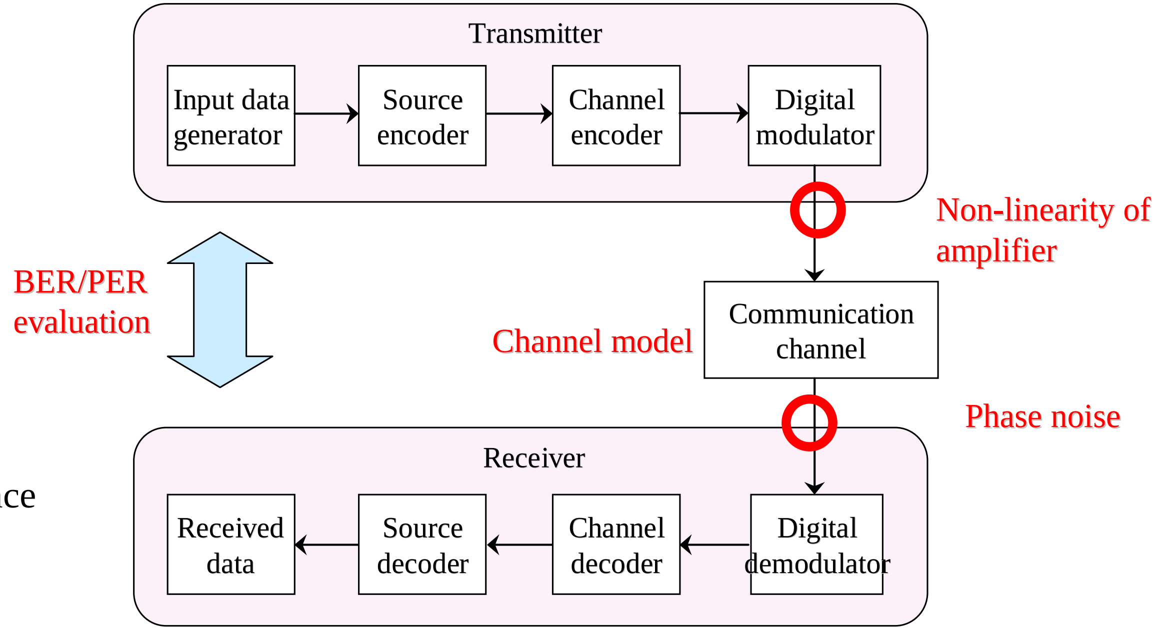
PLCP Preamble	PLCP Header	PSDU

This is an example and the data shown in this sheet is NOT equal to the proposal for PHY model from contributors.

BER and PER performance by MATLAB

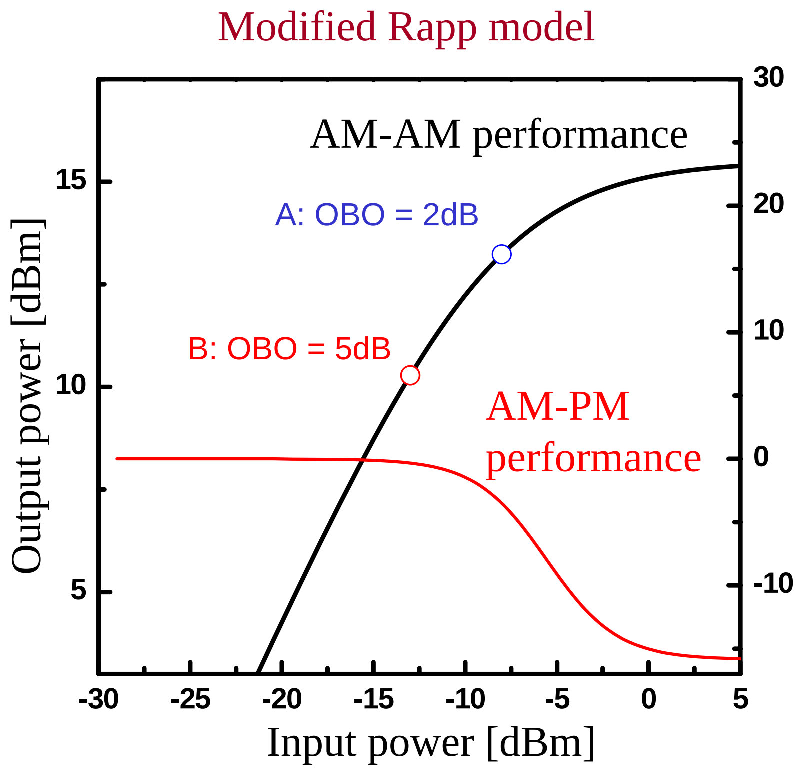
- Functions in the simulation program
  - Data generation
  - Frame (Packet) configuration
  - Modulation
  - Power amplifier
  - Channel
  - Phase noise
  - Demodulation
  - Evaluation
- Evaluation issue
  - Packet synchronization performance
  - BER (dependent on UM)
  - PER (dependent on UM)
  - Interference to adjacent channel
  - Tolerance to interference from adjacent channel

Must be common ?

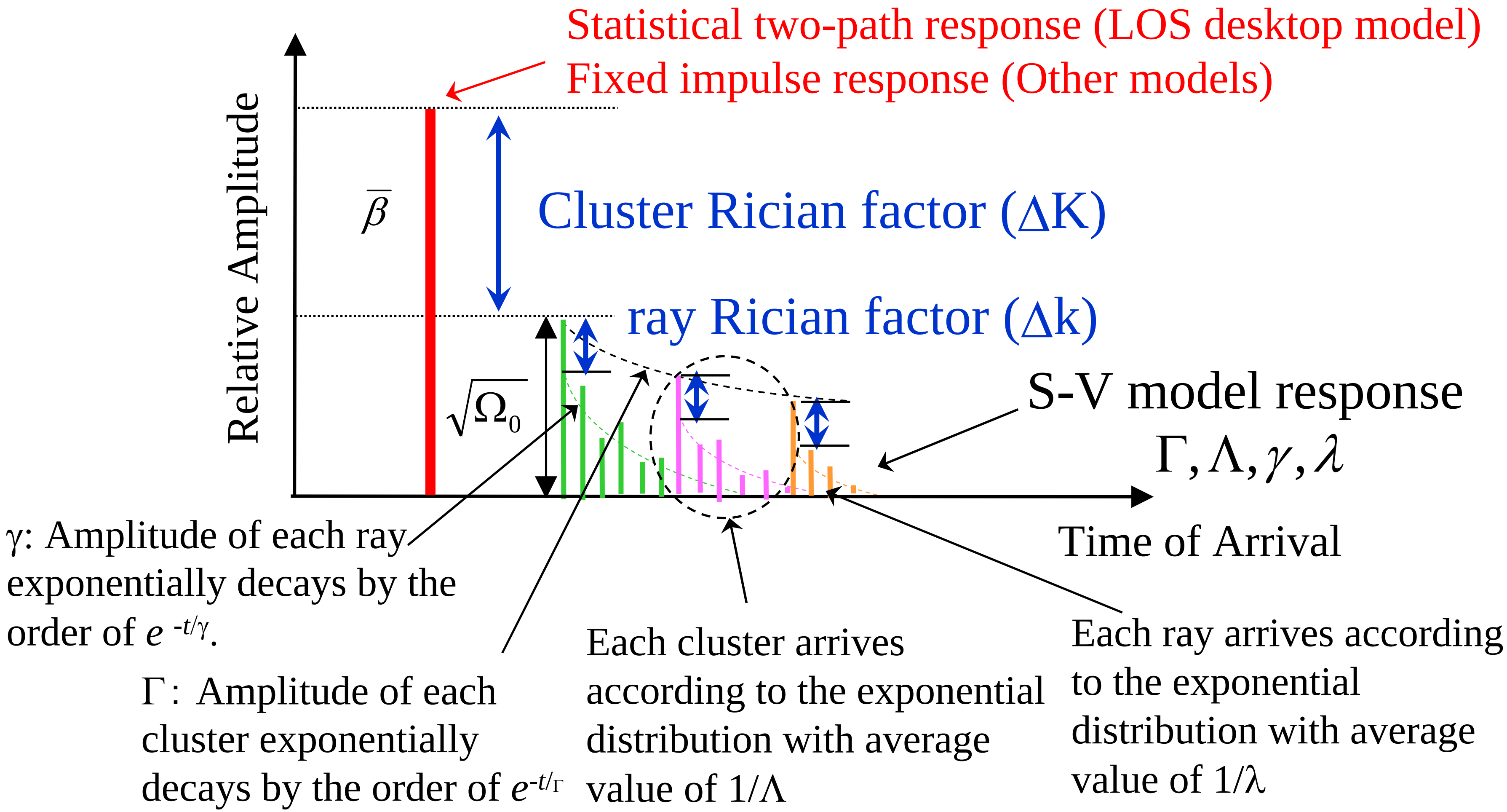


Proposed parameters to evaluate PHY performance (1) Impact of power amplifier (PA)

- PA model
  - System performance of 60GHz WPAN is degraded by PA non linearity
  - Spectrum of 60GHz WPAN is also expanded by non-linearity of PA
  - Not only AM-AM model but also AM-PM must be needed because the degradation by AM-PM characteristics is larger than that by AM-AM.
- To prepare PA model
  - Correct or call for data-sheet of AM-PM performance of PA
  - Based on such sheet, a MATLAB code for the simulation needs to be prepared.
  - One proposal was shown in the doc. IEEE15-06-0396-01-003c based on modified Ghorbani model



Impulse response of TSV model



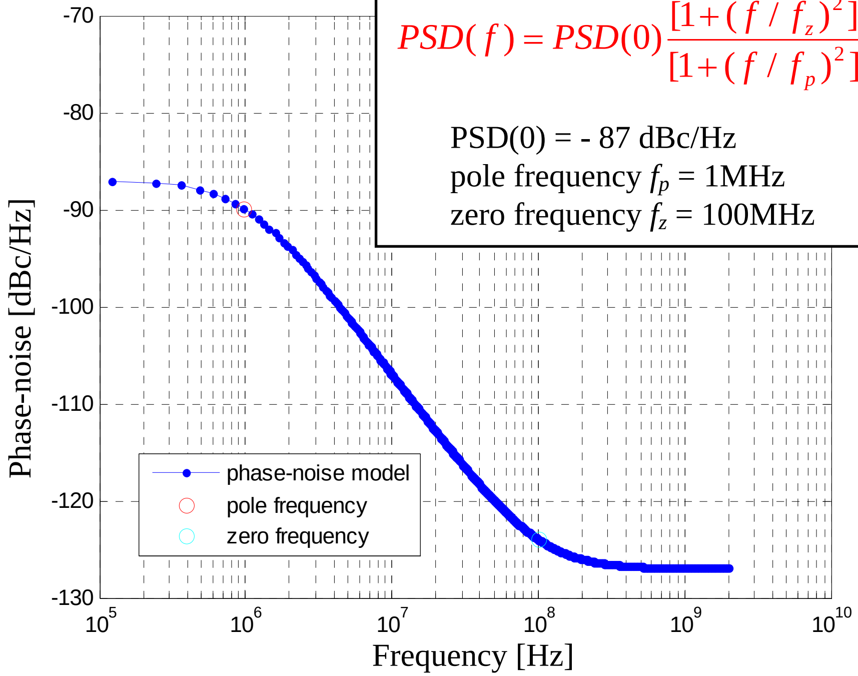
Proposed parameters to evaluate PHY performance (3) Impact of phase noise (PN)

- Phase noise model
  - System performance of 60GHz WPAN is degraded by PN
  - Phase noise affects signal generators of TX and RX
  - For the simulation, relative phase noise must be considered at receiver side

- To prepare PN model
  - Call for data-sheet of phase noise performance
  - Based on such sheet, a MATLAB code for the simulation needs to be prepared.
  - One proposal will be shown in the doc. IEEE15-06-0477-00-003c

$$PSD(f) = PSD(0)\frac{[1+(f/f_z)^2]}{[1+(f/f_p)^2]}$$

PSD(0) = - 87 dBc/Hz
pole frequency f_p = 1MHz
zero frequency f_z = 100MHz



Proposed phase-noise model for TG3c

Items described in contributed document that shows PHY performance

- Show basic PHY parameter
  - Modulation scheme
  - Demodulation scheme
  - Coding
  - Filter configuration (TX and RX)
  - Total bandwidth
  - Transmission speed
  - Interleave (if use)
  - Frame configuration
  - Used Channel model
- Show proposed link budget
- Show proposed frame structure
- Show the performance
  - CNR v.s. BER and PER
  - Packet synchronization performance
  - Interference to adjacent channel
  - Tolerance to interference from adjacent channel

Example of PHY simulation

- Modulation scheme
  - BPSK/QPSK/OQPSK/MSK
- Demodulation scheme
  - Coherent detection
- Coding
  - Convolutional coding R=7/8, K=7 (BPSK)/ R=3/4, K=7 (others)
- Channelization
  - 2 (BPSK), 4 (QPSK/OQPSK/MSK)
- PA model
  - Shown in slide 8: OBO=1 or 3dB
- Phase noise model
  - Shown in slide 10: Pole frequency =1 MHz, Zero frequency = 100 MHz, PSD(0)=-90dBc/Hz
- Channel model
  - TSV-model (doc.: IEEE 15-06-0468) / LOS office
- Evaluation
  - BER performance /PER (2kbyte) performance

Channel model used in the simulation

- Channel model used for evaluation
  - LOS office model (analyzed by NICT)
    - Assuming distance between Tx and Rx: 1 m
    - Directional antenna pattern:
      - Pattern: Gaussian distribution
      - Half-power angle of antenna: Tx 60 deg, Rx 30 deg

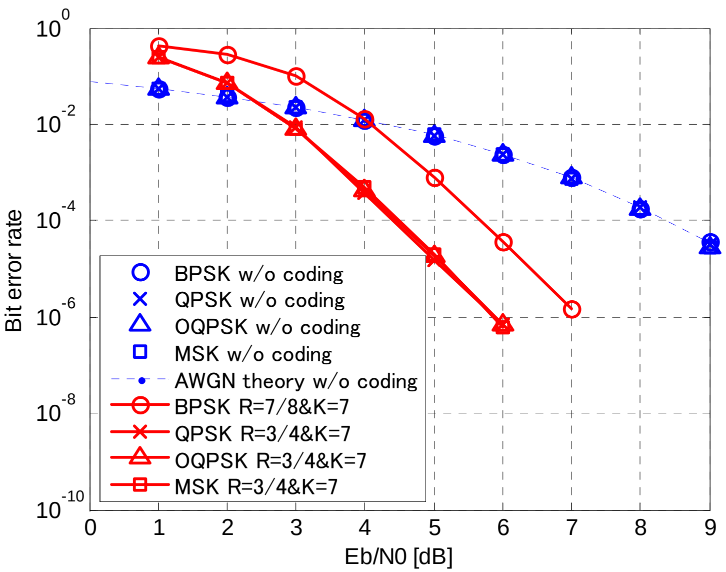
	Decay factor Of NLOS clusters	Small Rician Effect	S-V model oriented parameter							Number of clusters
Channel model	$\Omega_0(D)$ [dB]	k (Δk)	Γ [ns]	$1/\Lambda$ [ns]	γ [ns]	$1/\lambda$ [ns]	σ_1 cluster	σ_2 ray	σ_ϕ [deg]	N
LOS office Tx:60 Rx:30*	-90.2	2.63 (11.4 dB)	38.8	37.6	64.9	3.41	8.04	7.95	66.4	5

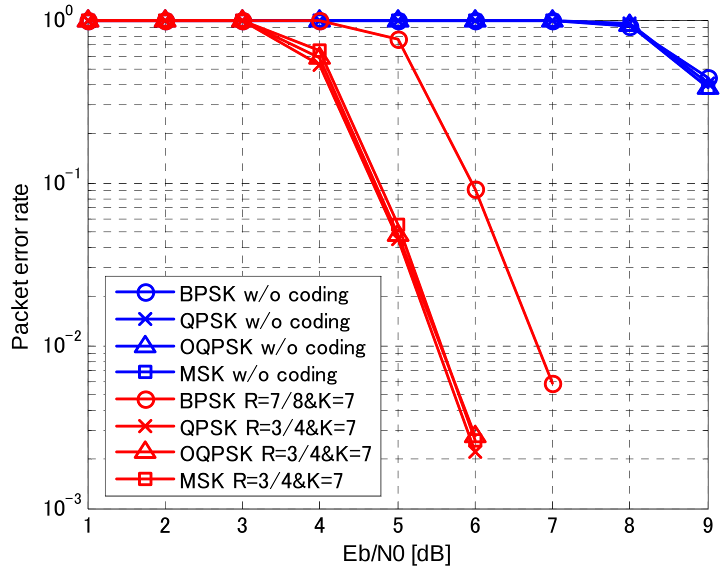
(* Rx antenna beam-width were changed from 60 deg, which were used in the experimental analysis to 30 deg for simulation evaluation

A frame design

Total system bandwidth (Bt)	7	7	GHz
Assuming channelization	3	2	
Maximum band width per channel	2.333333333	3.5	GHz
	QPSK/OQPSK/MSK	BPSK	
Detection	coherent	coherent	
M-array modulation level	2	1	
Symbol rate	1.6	2.8	Gsps
Roll off rate (a)	0.35	0.35	
Bandwidth	2.16	3.78	GHz
Number of channels	1	1	ch
PSDU in one packet	2048	2048	byte
PSDU Coding rate	3/4	7/8	
PSDU transmission time	6826.666667	6687.346939	ns
Transmission rate w/o coding	3.2	2.8	Gbps
PSDU transmission rate	2.4	2.45	Gbps

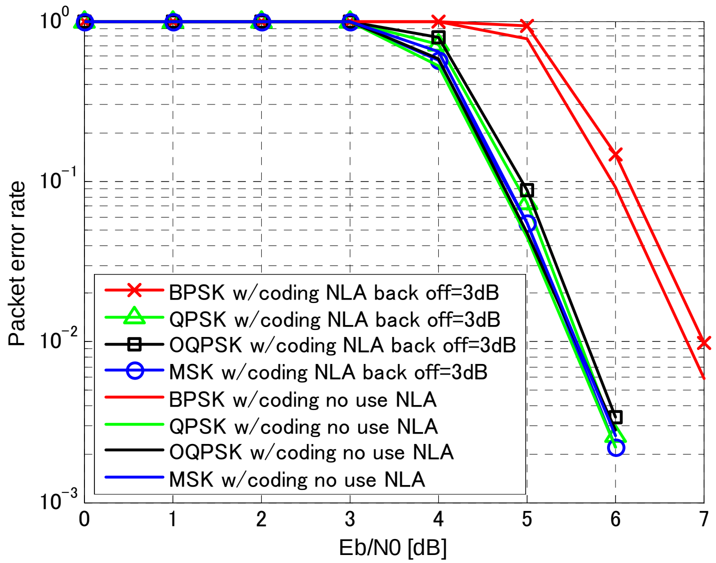
BER and PER performance (AWGN) (w/o, w coding)



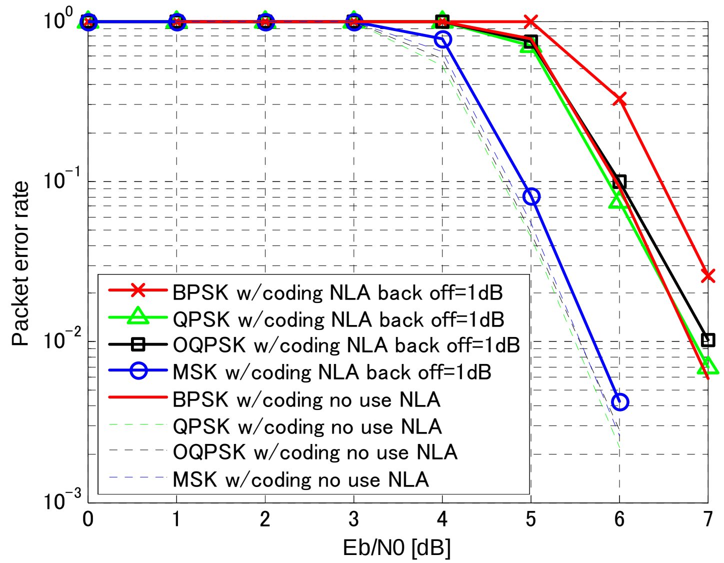


By using coding R=3/4 K=7, Eb/No=5dB is required to got less than 8% of PER.

BER and PER performance (AWGN) (Impact of PA, w coding)



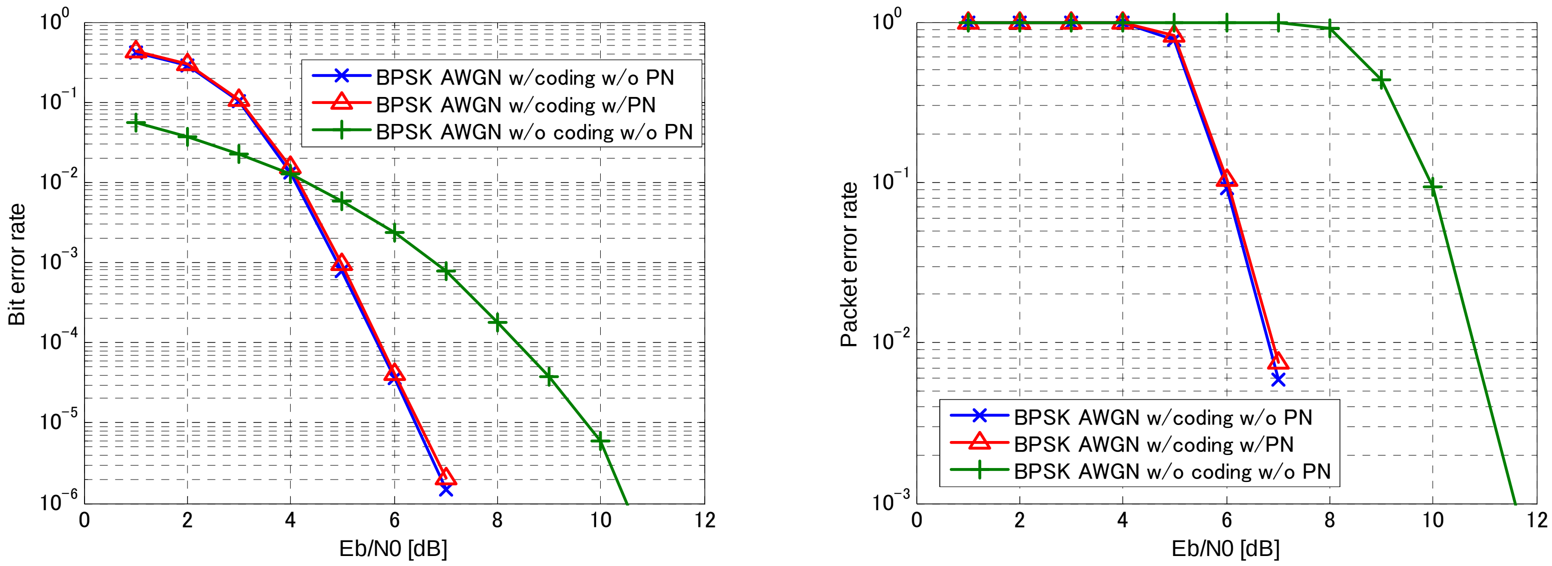
Back Off = 3dB



Back Off = 1dB

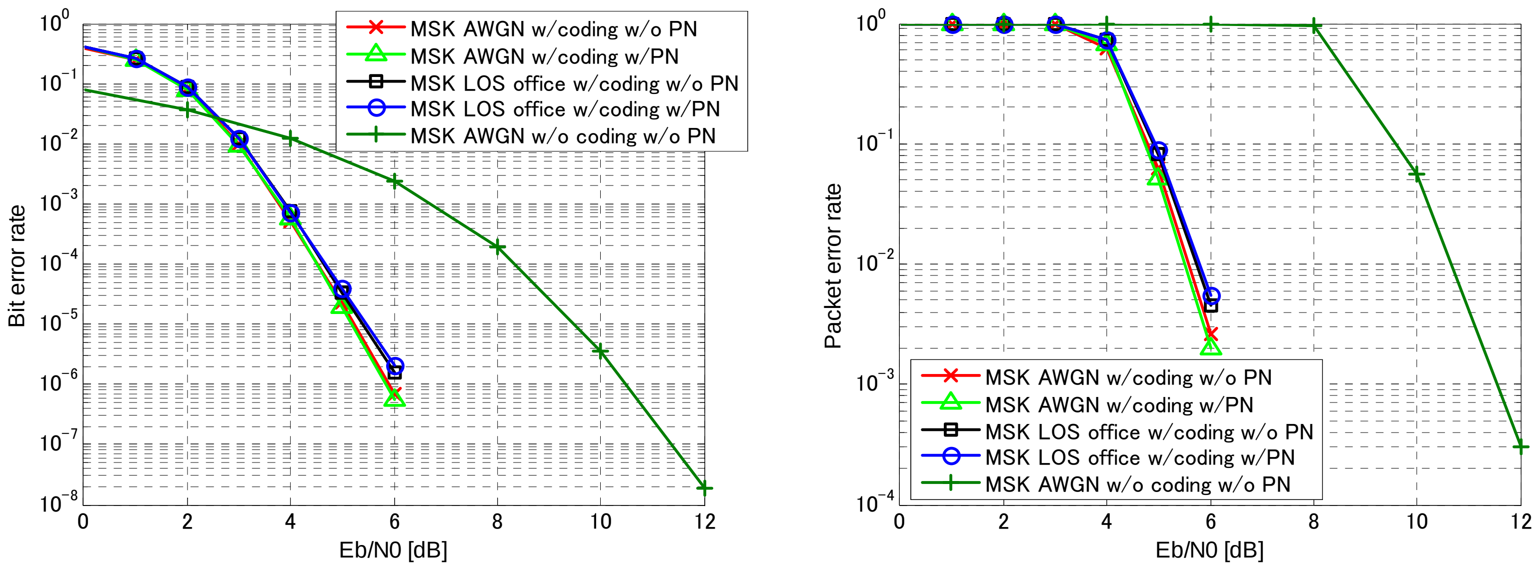
The impact of PA model is less than 0.5 dB degradation.

BER and PER performance (AWGN) (Impact of Phase noise, w/o PA, w coding)



The impact of PN model (PLL) is less than 0.3 dB degradation.

BER and PER performance (LOS office-TSV) (Impact of Phase noise and PA, w coding)



Back Off = 3dB

By using coding R=3/4 K=7, Eb/No=5dB is requred to get less than 8% of PER when MSK is used under LOS office environment.

Conclusions

- Proposed a scheme to evaluate PHY performance by computer simulation in TG3c
  - Link budget
  - Frame design
  - BER (and/or) PER performance
- Proposed parameters to evaluate PHY performance
  - Impact of power amplifier (PA)
  - Impact of channel model (CM)
  - Impact of phase noise (PN)
- Summarized items described in contributed document that shows PHY performance
- Showed simulation results of transmission performance by considering the impact of PA, CM, and PN by single carrier system (BPSK, QPSK, OQPSK, MSK)
  - Impact of PA to BER or PER is less than 0.5 dB
  - Impact of PN to BER or PER is less than 0.3 dB
  - In the case of MSK, required Eb/N0 is 5dB to get 8% of PER in the LOS office environment.
- Clarified that coding is very important item to get PER performance required in TG3c and the impact of PA and PN is minimized by the coding