

**Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)**

**Submission Title:** [A scheme to evaluate PHY performance by computer simulation]

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**Re:** []

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

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

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# **A Scheme to Evaluate PHY Performance by Computer Simulation**

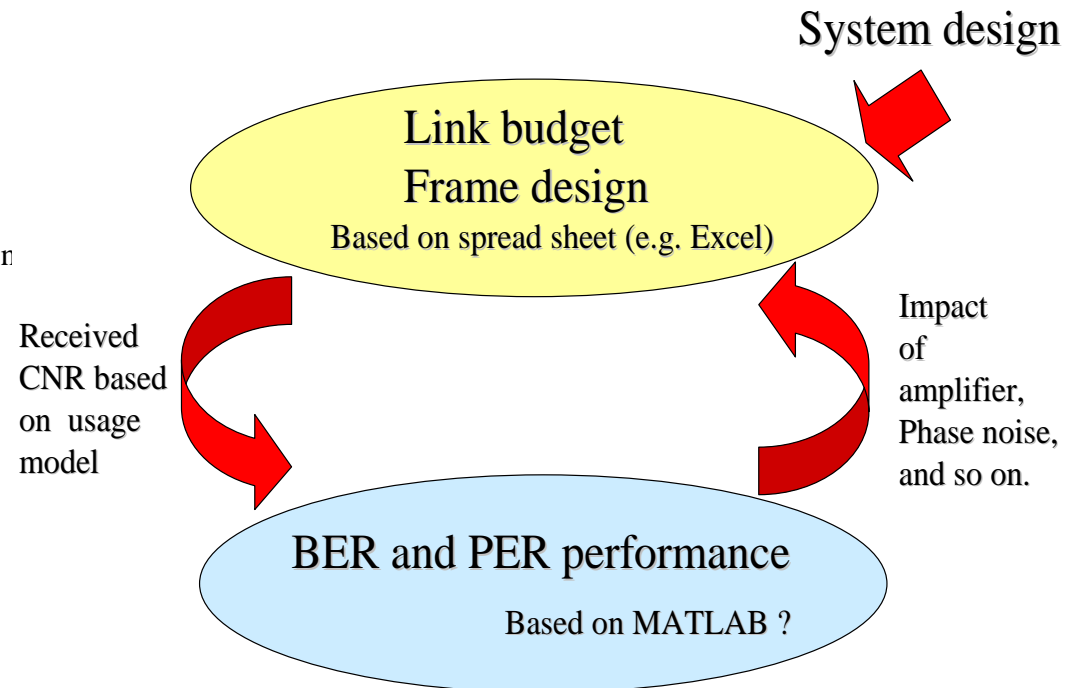
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# Summary of this document

- 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
  - Impact of phase noise
  - Impact of AD/DA converters
- Clarify items described in contributed document that shows PHY performance
- Propose two simulation procedures to reduce simulation time
  - Handling of angles of TX and RX antennas

# 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

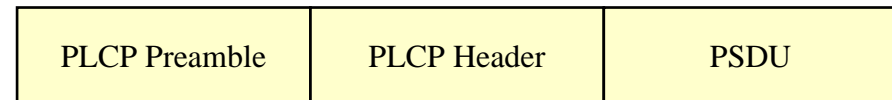
Distance	1	3	5	m
Carrier bit rate	2			Gbps
TX power	10			dBm
Tx antenna gain	10			dBi
Frequency band	59-66			GHz
Center frequency	62.5			GHz
wavelength	4.8			mm
Path loss	68.35939	77.90182	82.33879	dB
RX Antenna gain	10			dBi
Boltzmann constant	1.38065E-23			
Temperature	300			K
Rx Noise figure	10		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



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

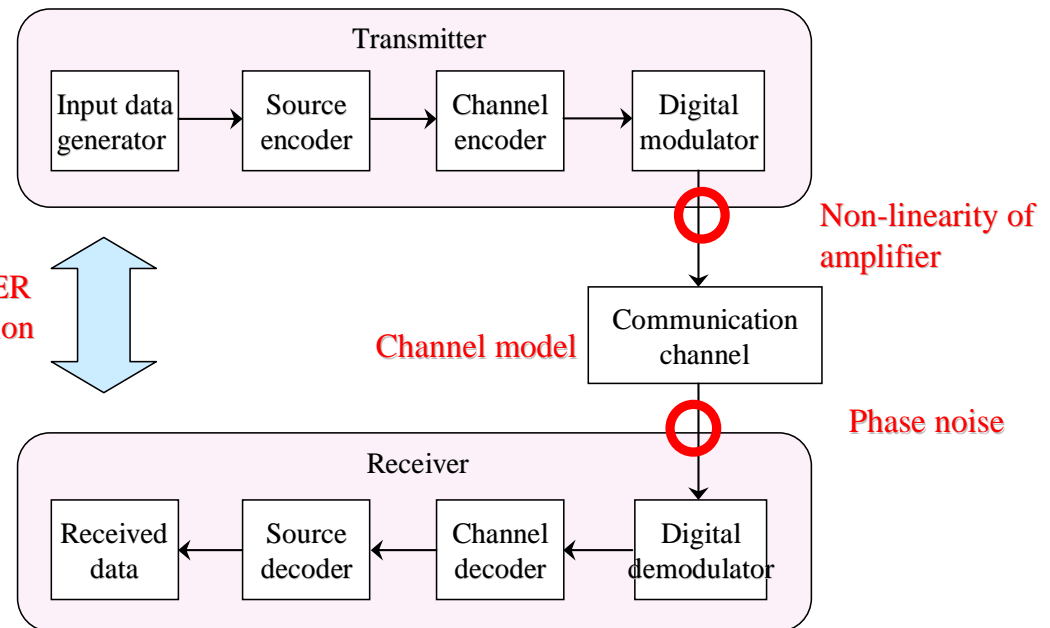
# BER and PER performance by MATLAB

- Functions in the simulation program

- Data generation
- Frame (Packet) configuration
- Modulation
- Power amplifier
- Channel
- Phase noise
- Demodulation
- Evaluation

Must be  
common ?

BER/PER  
evaluation



- Evaluation issue

- Packet synchronization performance
- BER (dependent on UM)
- PER (dependent on UM)
- Interference to adjacent channel
- Tolerance to interference from adjacent channel

# Propose 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.

Right figures show AM-AM and AM-PM model of a 60GHz power amplifier and BER performance to take the PA model (input power = -10dBm) into simulation.

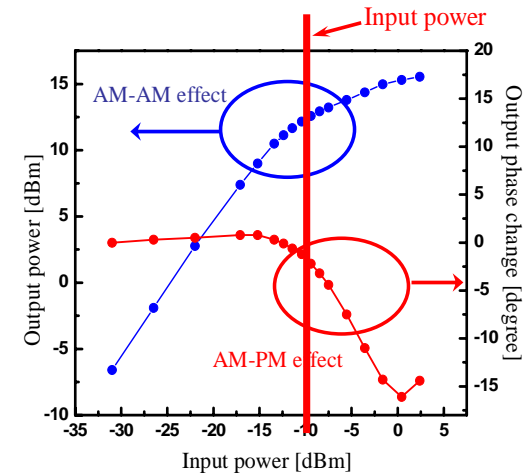
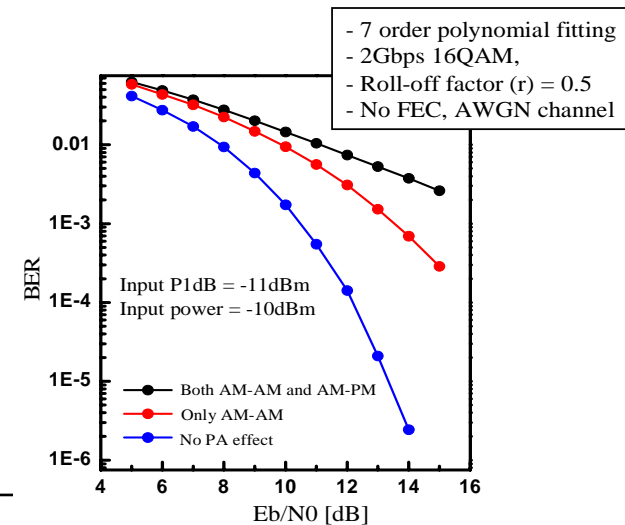


FIGURE: AM-AM and AM-PM results of GaAs nHEMT 60GHz HPA (from NEC)



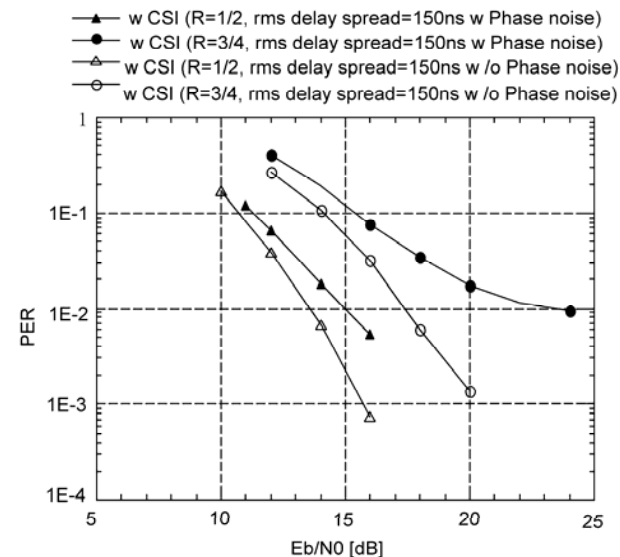
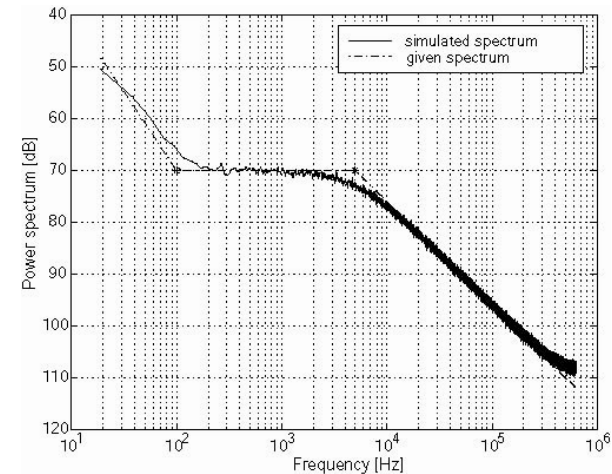


# Propose parameters to evaluate PHY performance

## (2) 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.

Right figures show an example of modeling of PN and the impact of the PN to the PER (1.5kB) @5GHz band Hyper-LAN2. The above shows the comparison simulated phase noise v.s. actual phase noise and the below shows PER performance to include the PN.



## **Propose parameters to evaluate PHY performance**

### **(3) Impact of AD/DA converters**

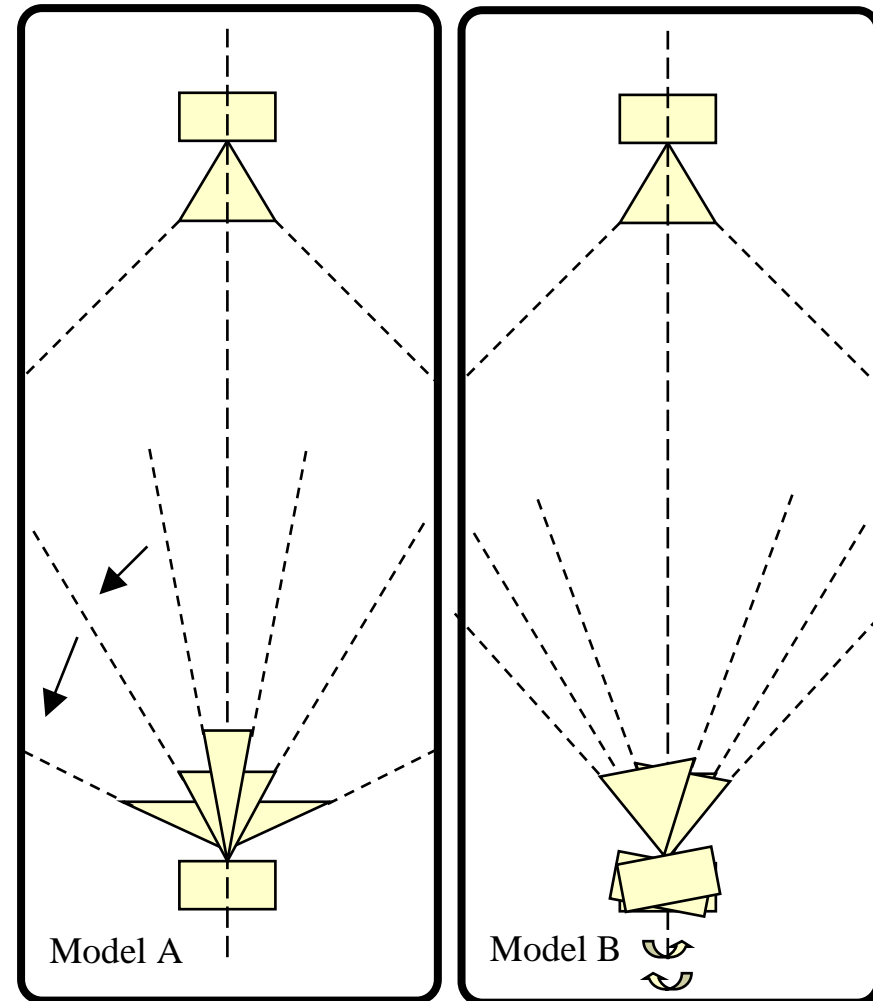
- To evaluate power consumption roughly, the impact of the resolution of AD/DA converters to the BER/PER performance must be shown
- Existence of AD/DA converters to realize the PHY proposals from contributors must be reported.

# 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

# Propose two simulation procedures to reduce simulation time

- Alignment between TX and RX antennas is the dominant issue to decide PHY simulation period.
  - If degree of freedom for the alignment is large, simulation time increases.
  - Is the consideration on the alignment needed to compare PHY proposals ?
- Two proposals
  - (Model A) TX antenna is fixed and the alignment between TX and RX is adjusted. By selecting width of antenna, PHY performance is evaluated.
  - (Model B) TX antenna is fixed initially, and the alignment between TX and RX is adjusted. By changing the center axis with a distribution (e.g. uniform, Gaussian), PHY performance is evaluated.



# Conclusions

- 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
    - Not AM-AM model but AM-PM must be needed because the degradation by AM-PM characteristics is larger than that by AM-AM.
  - Impact of phase noise
    - Call for data or data sheet for the phase noise, and make model voluntary
  - Impact of AD/DA converters
    - To evaluate power consumption, the impact of the resolution of AD/DA converter to the BER/PER performance must be discussed
- Clarify items described in contributed document that shows PHY performance
- Propose two simulation procedures to reduce simulation time
  - Handling of angles of TX and RX antennas
    - Two methods are proposed