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Re: []

Abstract: [The overview of the visible light communication (VLC) channel modelling simulation and its simulation result. The research issues, which should be discussed in the near future, also are presented.]

Purpose: [Contribution to IEEE 802.15 SG-VLC]

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VLC channel modeling simulation in indoor application

2008.05.13

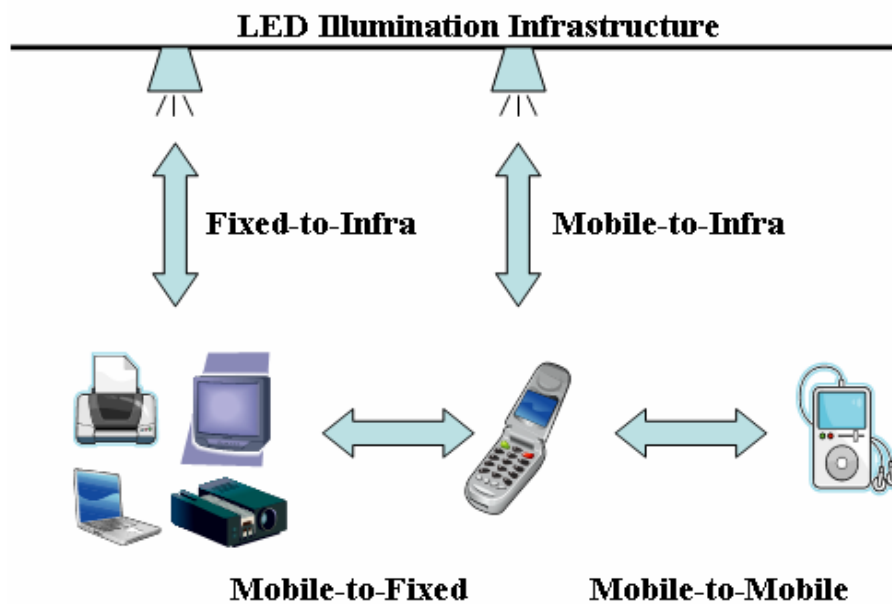
Samsung Electronics

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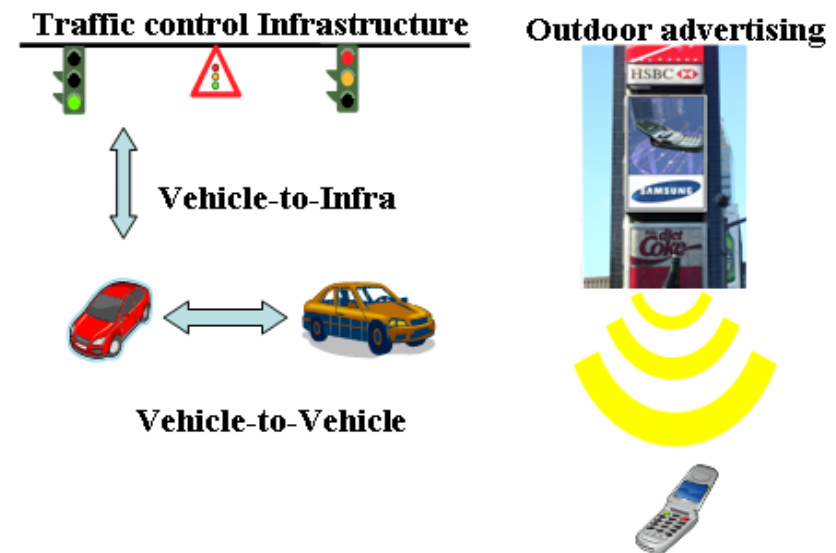
VLC Indoor/Outdoor Applications

- VLC Indoor Applications



- Indoor Applications
 - Mobile to Mobile
 - Mobile to Fixed
 - Mobile to Infra
 - Fixed to Infra

- VLC Outdoor Applications



- Outdoor Applications
 - Traffic Control
 - Vehicle to Infra
 - Vehicle to Vehicle
 - Outdoor Advertising

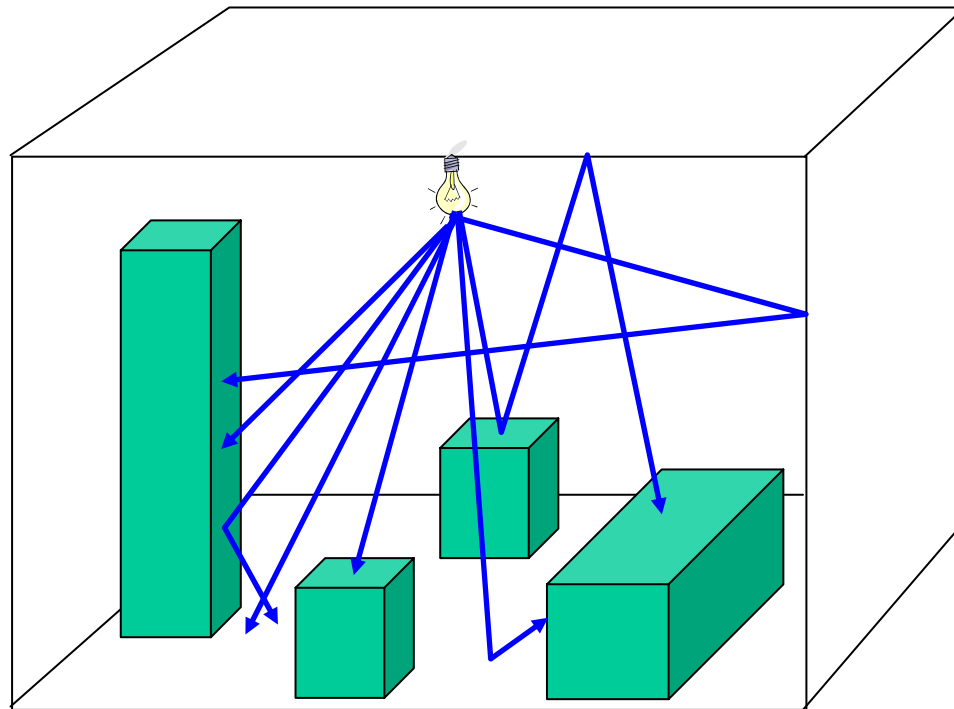
VLC Indoor Applications

	Mobile to Mobile	Mobile to Fixed	Mobile to Infra	Fixed to Infra
Link	Bi-direction	Bi-direction	Bi-direction Or Uni-direction	Bi-direction Or Uni-direction
Distance	~1m	~1m	~3m	~3m
Data rate	~100Mbps	~100Mbps	~10Mbps	~10Mbps
Application	Contents sharing	File transfer Video streaming	LBS Networked Robot	Data broadcast
Alternative connectivity	IrDA, Bluetooth,UWB	IrDA, Bluetooth,UWB		WLAN

VLC Channel Modeling Environments

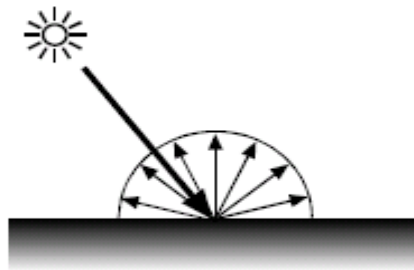
	Size	Window	Distance between TxS	Indoor brightness
Home	Small	None	Short	Medium
Hospital	Small	None	Short	High
Café	Medium	Window	Long	Low
CD shop	Medium	None	Medium	Low
Museum	Large	Window	Long	Low
Office	Large	Window	Long	High

Photon model

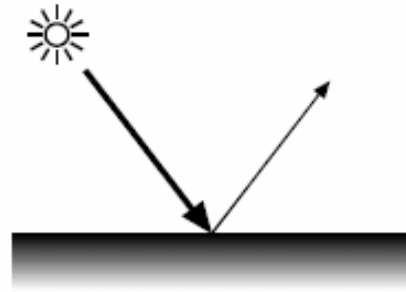


- Trace the light path
 - Photon Model
 - Quantum theory
 - Ray tracing
 - Computer simulation tool
 - RF channel modeling method

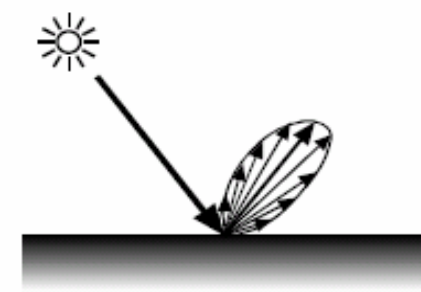
Reflection Type



diffuse



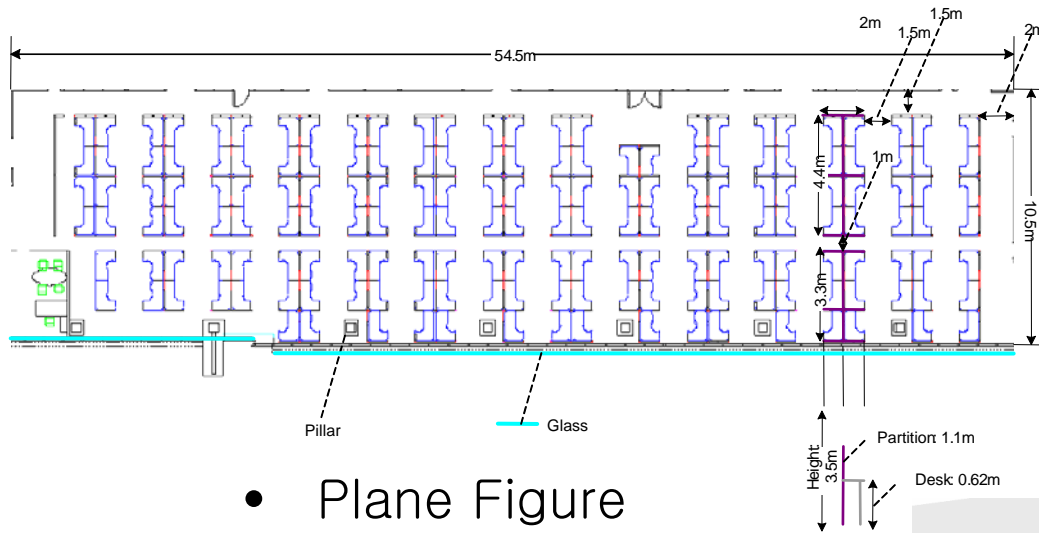
mirror / specular



glossy / specular

- Diffuse
 - Rough surface
 - Clothing, paper and asphalt road
 - Lambertian reflection
- Mirror/Specular
 - Smooth surface
 - Mirror or calm water
 - Reflection Index
- Glossy/Specular
 - Not diffuse, mirror
 - BRDF (Bidirectional Reflectance Distribution Function)

Office 3D Modeling



- Plane Figure
 - 246 desks
 - 6 pillar
 - 1 window



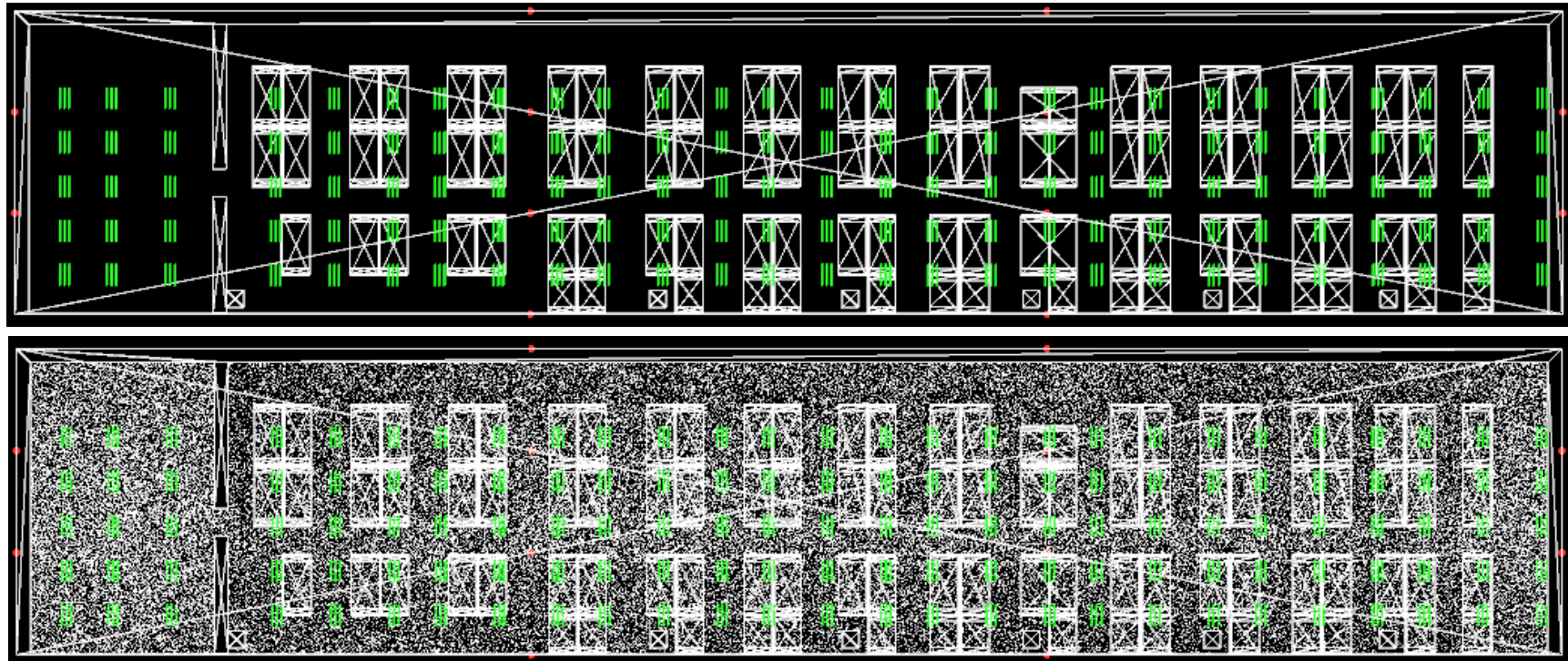
- 3D modeling of Office

Simulation Parameters

Size	61.05m x 12.1m x 5.5m
Transmitted optical power	100mW
Number of Tx	405 TxS
Size of Tx	0.8m x 0.084m (fluorescent lamp size)
Height of Tx	3.5m
Pattern of Tx	Uniform(2π)
Reflection type	Specular/Mirror reflection
Number of reflection	3 times
Reflection index (Based on color)	Floor: 93% Ceil: 93% Wall: 93% Desk: 48% Partition: 18% Window glass: 8%
Rx height	0.62m, 1m
Rx FOV	60°

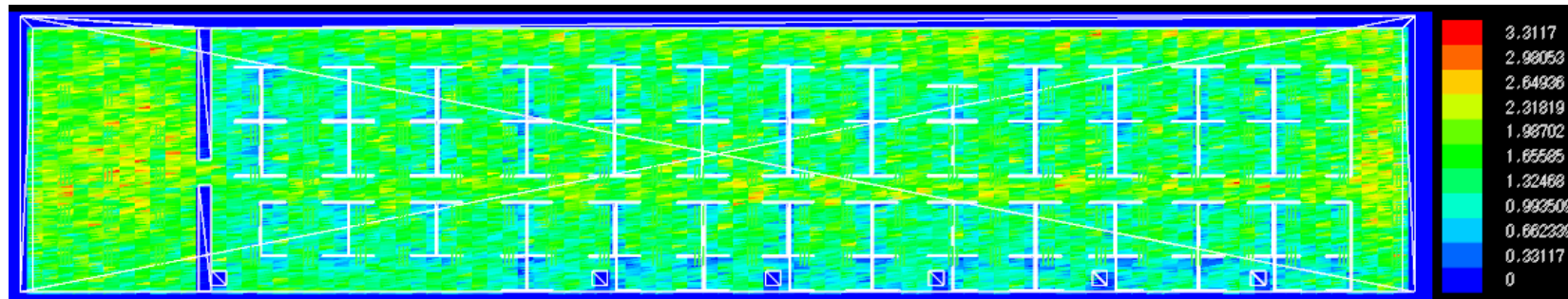
Photon Map

- Photon map of office environment
 - 405 LED Tx(3.5m)
- Photon
 - White dot

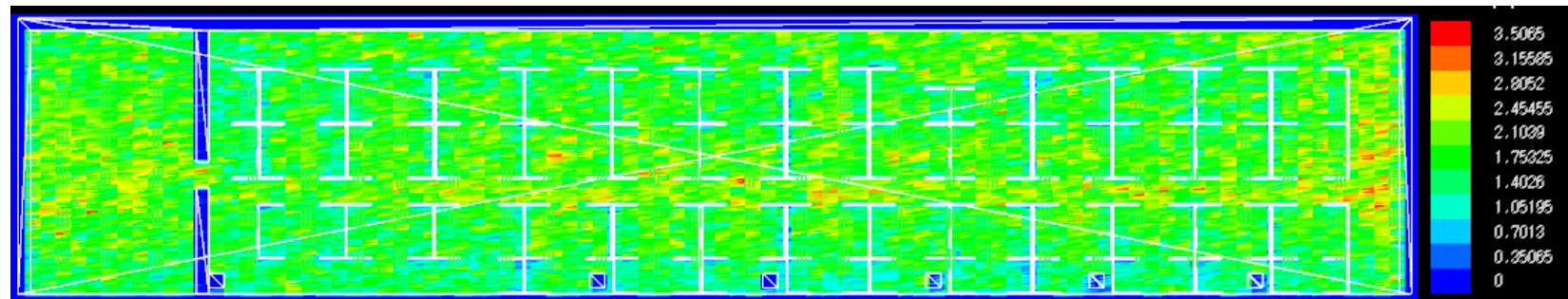


Simulation Result(1/3)

- Power mean at 0.62m and 1m
 - 1m on the desk
 - 0.62m on the desk
- (a) 0.62m (on the desk)

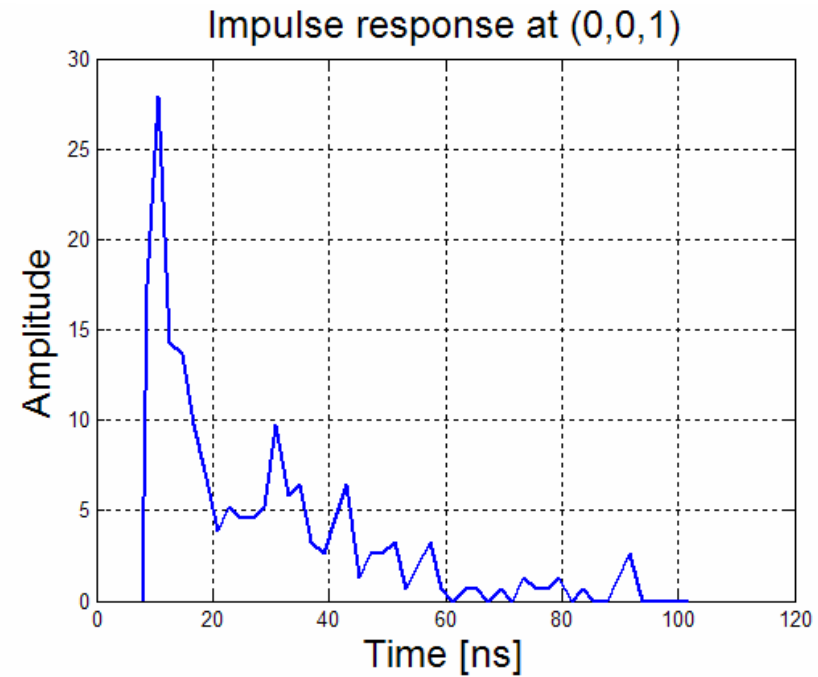
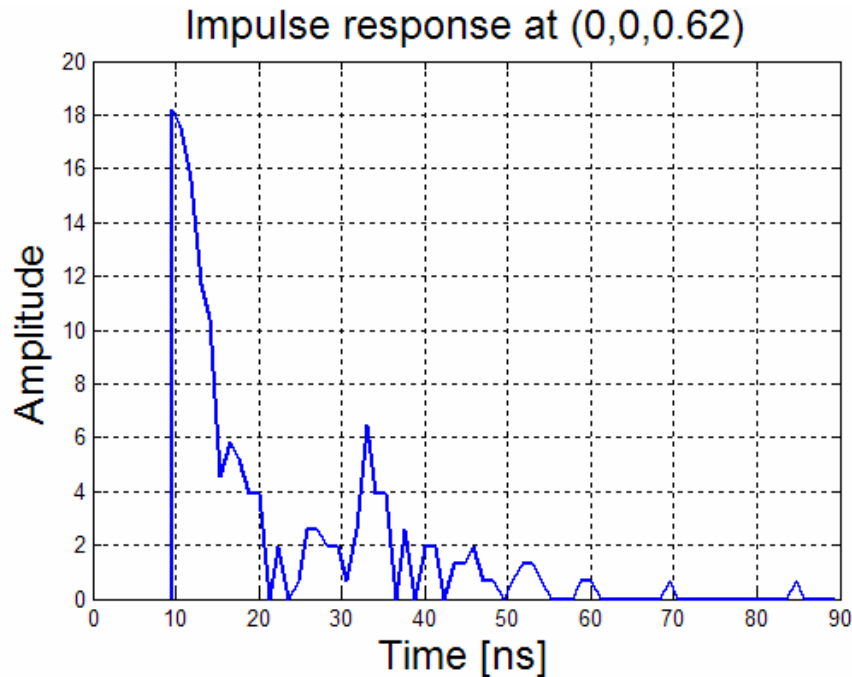


- (b) 1m (Handheld case)



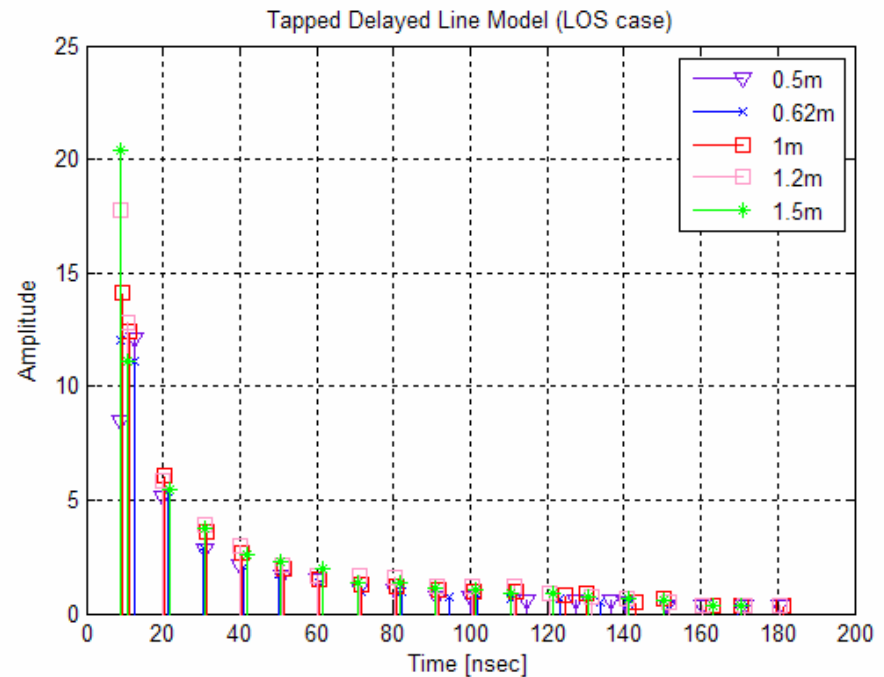
Simulation Result(2/3)

- Impulse response at $(0,0,1)$, $(0,0,0.62)$
 - On the desk and handheld case



Simulation Result(3/3)

- TDL (Tapped Delay Line) model
 - Generally, communication channel is continuous time channel
 - Minimum unit delayed discrete time channel model from continuous time channel
 - 100 x 100 blocks
 - Only LOS channel block
 - 1 nsec unit



Future Works

- Channel modeling simulation
 - 5 more VLC modeling environment
 - Home, CD-shop, hospital, museum, cafe
 - RGB LED channel modeling
 - Reflection
 - Diffuse, Glossy reflection simulation

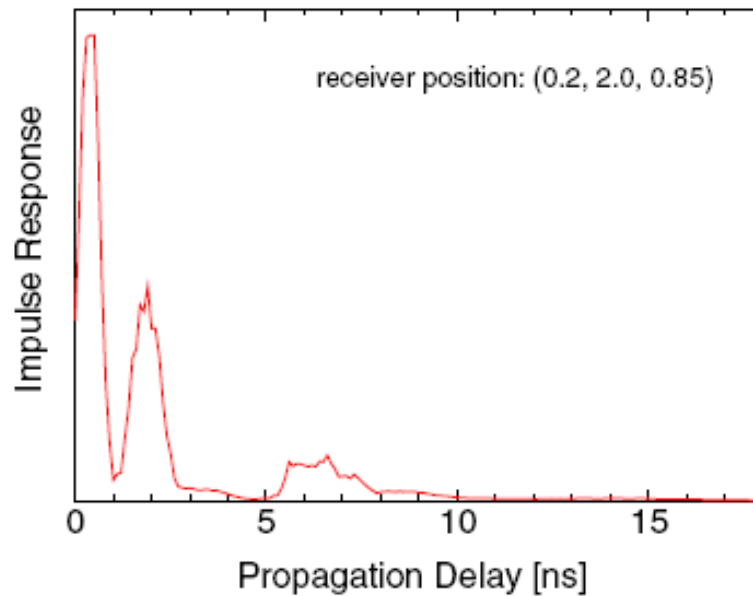
Thank You~
Q&A

Appendix

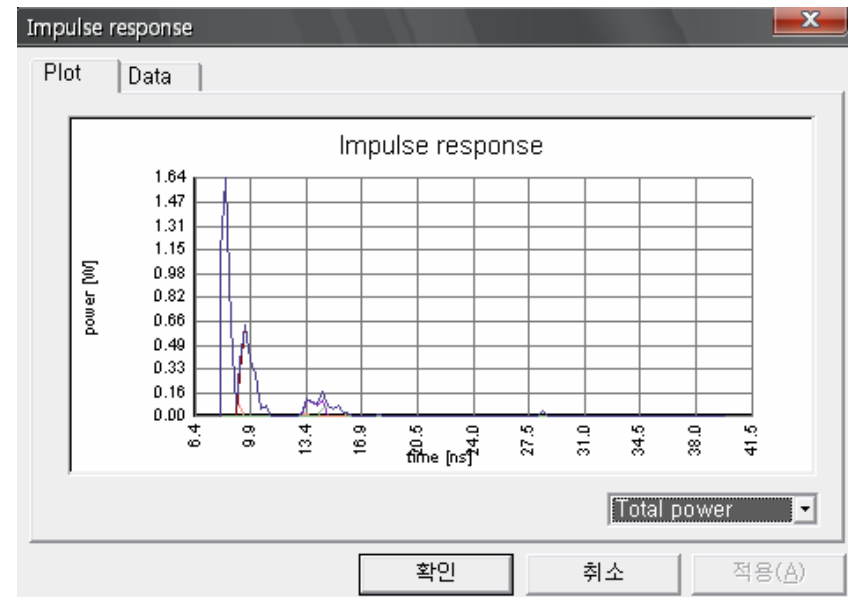
- Simulation result comparison
 - Komine, T. Jun Hwan Lee Haruyama, S. Nakagawa, M. , "Adaptive Equalization for Indoor Visible-Light Wireless Communication Systems, " *2005 Asia-Pacific Conference*, 03-05 Oct. 2005, pp:294 – 298
 - Simulation parameters

Size	Height of Tx	Height of Rx	Number of Tx	FOV	Tx Power	Etc
5m x 5m x 3m	3m	0.85m (0.2,2.0, 0.85)	4	Rx: 80°	174mW	Optical filter gain: 1.0

- Impulse response comparison



- (a) Prof. Nakagawa



- (b) Samsung