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A Study on Spectrum Management Technique by Using Adaptive Low Duty Cycle

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Agenda



Introduction

- ☒ Ultra Wideband (UWB)
- ☒ Coexistence environment problem
- ☒ Interference mitigation techniques



Aim of Study



System model

- ☒ LDC-UWB system model
- ☒ wideband OFDM system model
- ☒ Major parameter of both system



The Performance Analysis of interference mitigation capability



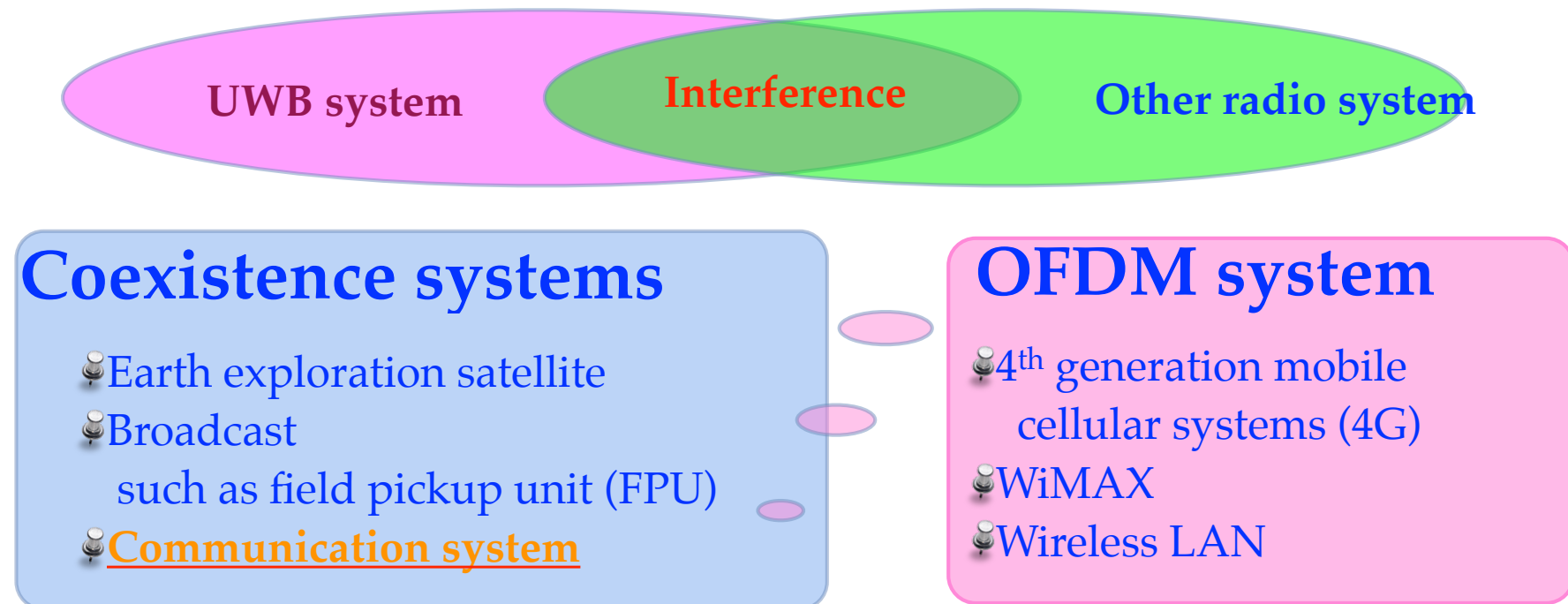
Conclusion

Introduction

The potential applications of UWB communication

- High data rate WPAN can achieve more than 100 Mbps over short distance
- Sensor networks providing low data rate UWB over medium range combined with precise ranging and positioning capability.
- UWB is a promised technology to apply various application.

Coexistence environment problem of UWB radio systems and other radio systems

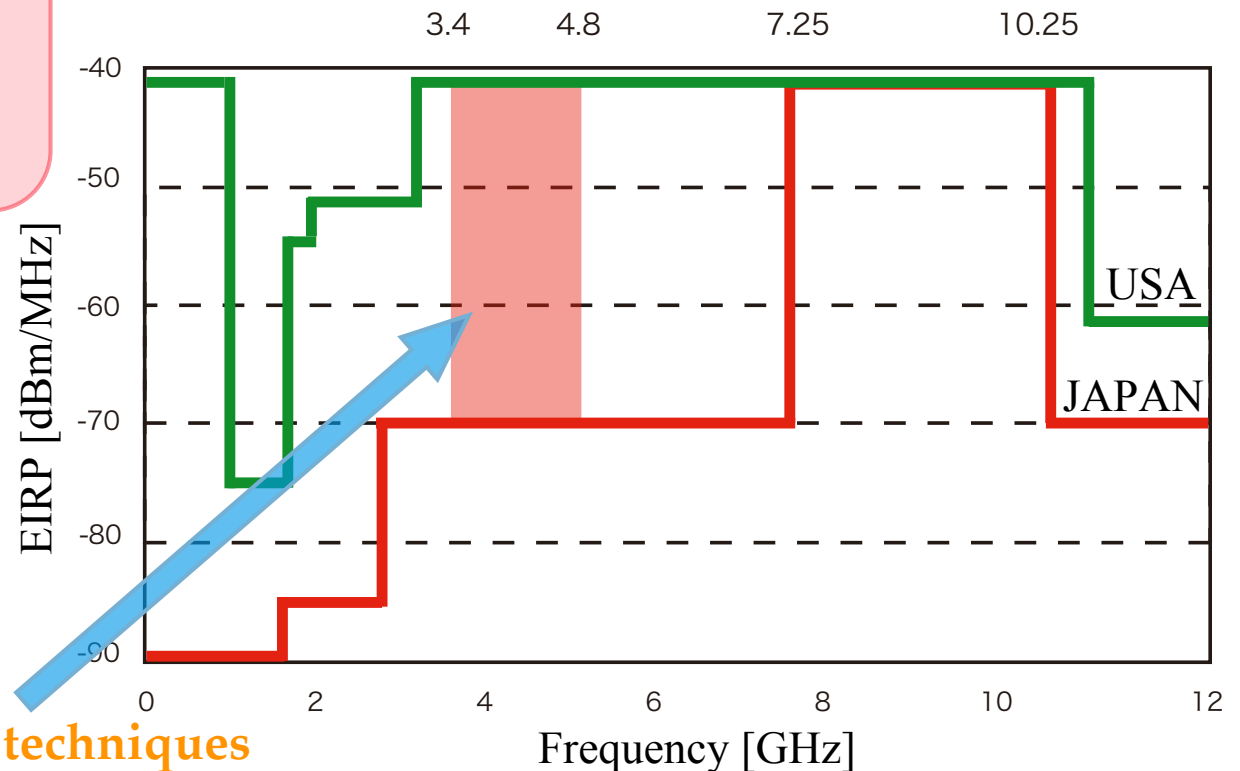


Coexistence environment problems

In Japan and Europe, it is essential for UWB radio communications to equip interference mitigation techniques.

Interference mitigation techniques

detect and avoid (DAA)
low duty-cycle (LDC)



Need the interference mitigation techniques

Interference Mitigation Techniques

Definition of DAA

Detect the victim systems signals
Avoid the interference for them.

Major DAA techniques

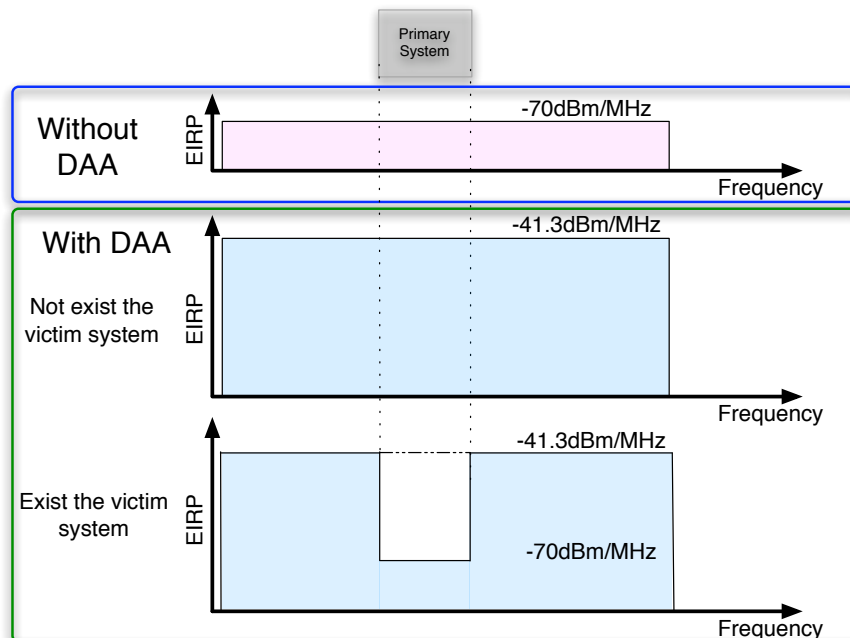
Frequency domain DAA

Time domain DAA

Space domain DAA

Issues

Increase the calculated amount.
The terminal size, Production costs



Definition of LDC

By using lowering pulse repetition interval or pulse occupation time.

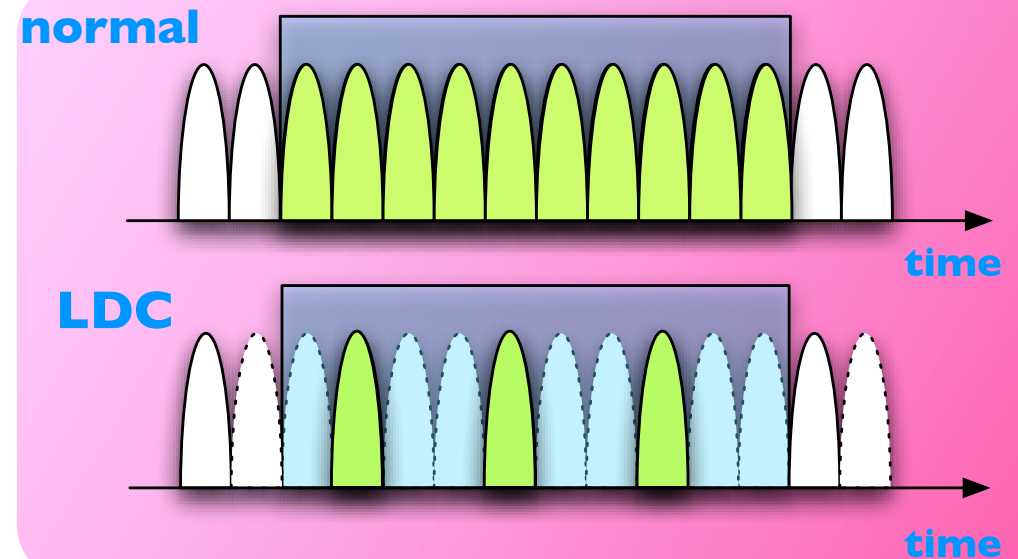
Major characteristics of LDC

Low data rate

Low power consumption

Issues

Despite all the benefits inherent to LDC, UWB system still interfere with the other radio system.



Interference Mitigation Techniques

Definition of DAA

Detect the victim systems signals
Avoid the interference for them.

Major DAA techniques

Frequency domain DAA

Time domain DAA

Definition of LDC

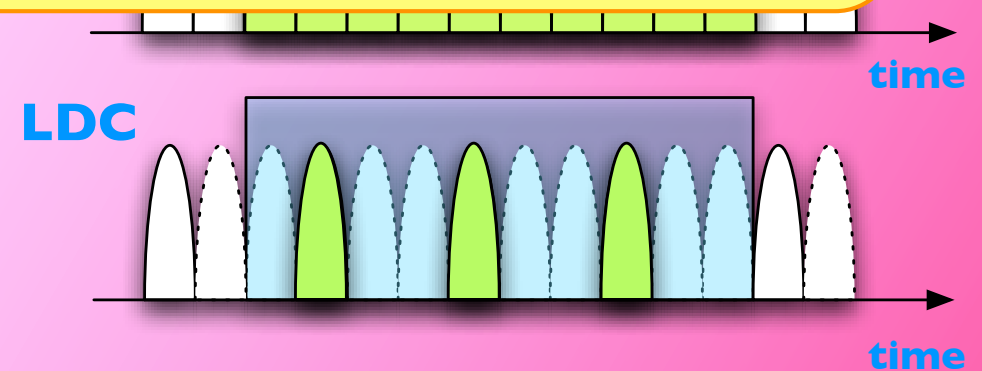
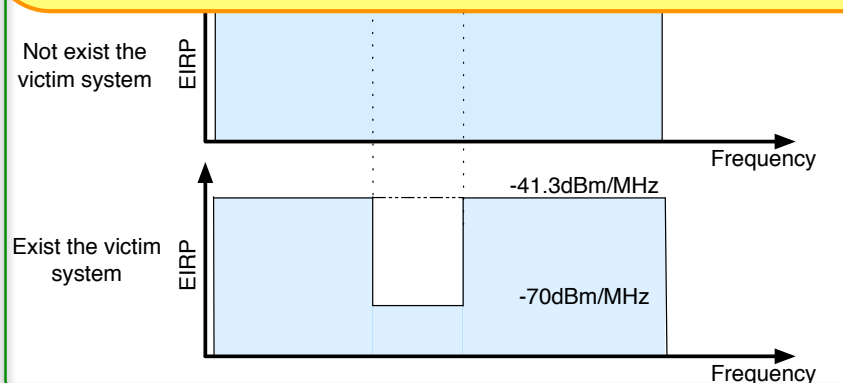
By using lowering pulse repetition interval or pulse occupation time.

Major characteristics of LDC

Low data rate

Low power consumption

The interference mitigation techniques are different by the demand of data rate of the application such as Wireless PAN, sensor network, and etc.



Interference Mitigation Techniques



DAA

- ✓ **High data rate UWB (IEEE 802.15.3a)**
 - ✓ **wireless USB, WPAN**
 - ✓ **Short range**
- ✓ **For the applications demand high data rate**



LDC

- ✓ **Low data rate UWB (IEEE 802.15.4a)**
 - ✓ **sensor networks, body area network**
 - ✓ **Middle rang**
- ✓ **For the applications demand low data rate and low power consumption.**

Aim of study

The coexistence environment between LDC-UWB system and wideband OFDM system is considered.

- In order to analyze the interference mitigation capability of LDC-UWB system, the frame error rate (FER) of wideband OFDM system is presented.
- Two types of LDC-UWB signals interference are considered such as binary pole signal and mono pole signal.
- We present that LDC-UWB is an efficient interference mitigation technique for low data rate UWB.
- The definition of UWB transmission power has been approached in two different manners:
 - Fixed power per pulse and fixed power per unit of time.
- The question that may arise at this point is how to design the duty-cycle of LDC- UWB system by each definition of UWB transmission power.
- Therefore, we further investigate the adequate duty-cycle of LDC-UWB system for each definition.

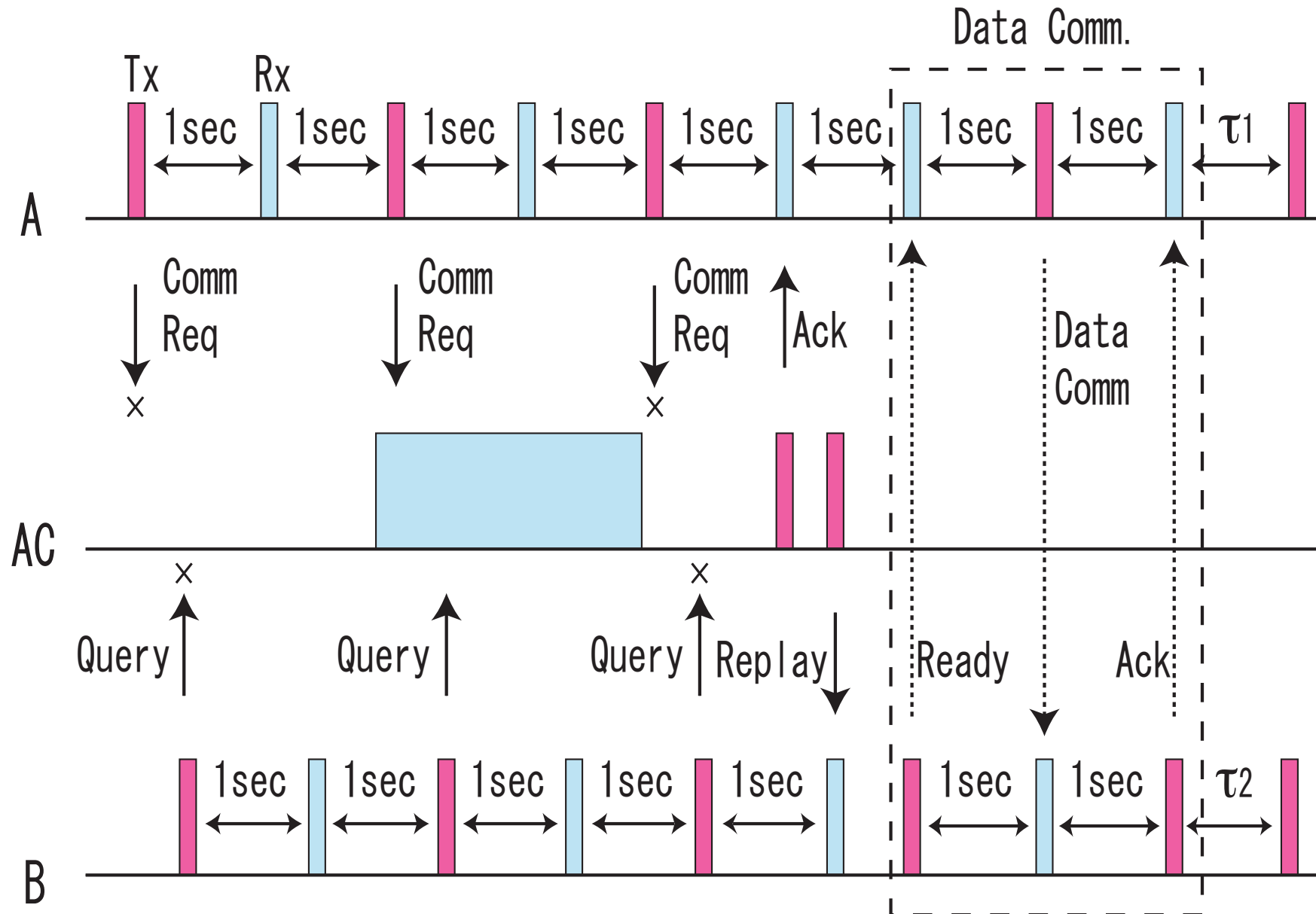
UWB system model

- Low data rate UWB communication system is considered such as sensor network and BAN.
 - The data rate is below 1 Mbps.
 - The pulse repetition frequency (PRF) is given as 3.9 MHz or 15.6 MHz (IEEE 802.15.4a).
 - PRF is defined as number of the pulse in 1 frame of the transmit slot of LDC-UWB.
- Two types of LDC-UWB signal interference are considered : binary pole or mono pole signals.
- Two types of definition of UWB transmission power:
 - Fixed power per pulse and fixed power per unit of time.

Specifications of LDC-UWB system

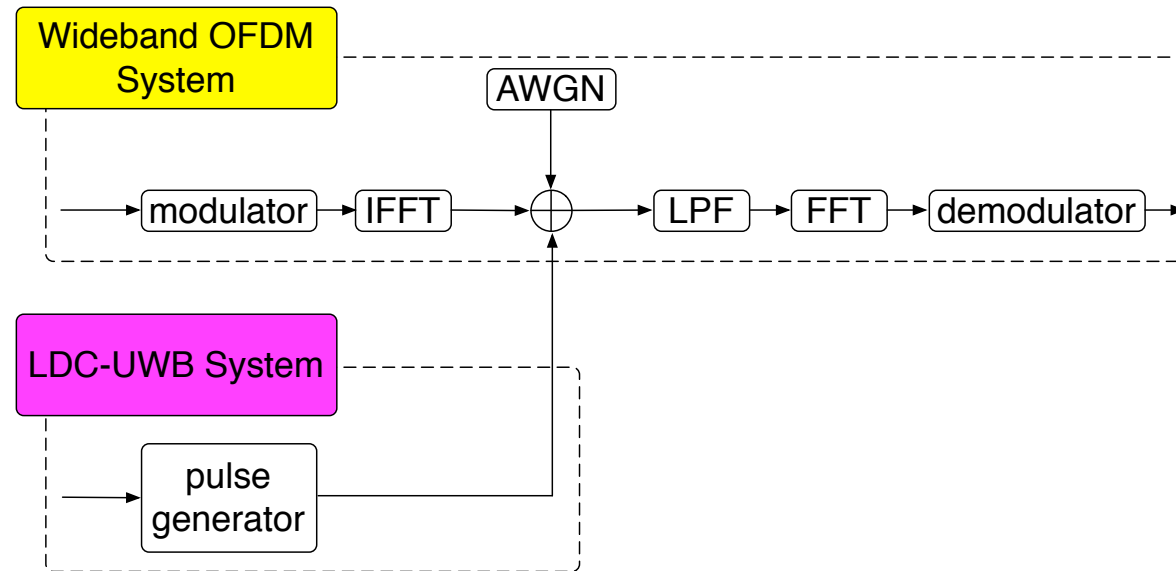
- Every UWB communication devices only wake up for short time to communicate with each other and timing schedule for communication is not available at each device.
- In order to establish a communication link, access controller (AC) is introduced.
- The wireless network based on LDC protocol must have one AC device, which may be allowed relatively high power consumption and high duty- cycle (HDC) compared with those of non-AC devices.
- AC can receive messages from all UWB devices belonging to its own network besides having AC has the timing schedule of every UWB devices.
- Note that this protocol is suitable for indoor applications since AC device should be connected to the power

Timing schedule



Wideband OFDM system model

the block diagram of the wideband OFDM system



- We focus on the coexistence environment of LDC-UWB systems and wideband OFDM systems.
- The bandwidth of the wideband OFDM system is about 100 MHz
- Thus, its data rate is 100 MHz bps.
- The equivalent baseband model is employed, therefore, the interference of the UWB signals is introduced by adding the UWB signal to the transmitted OFDM signal.

System Parameters

LDC-UWB system

DATA Rate	> 1 Mbps
UWB type	Pulse-based UWB
center frequency	4.0 GHz
Bandwidth	2.0 GHz
Duty-Cycle	0.1, 0.5, 1, 10, 50, 100%
SIR	10 dB
PRF	3.9 MHz, 15.6MHz
Tx slot	1 ~ 1,001 ms
Sleep period	1000 ~ 0 ms
Frame length	2,002 ms

Wideband OFDM system

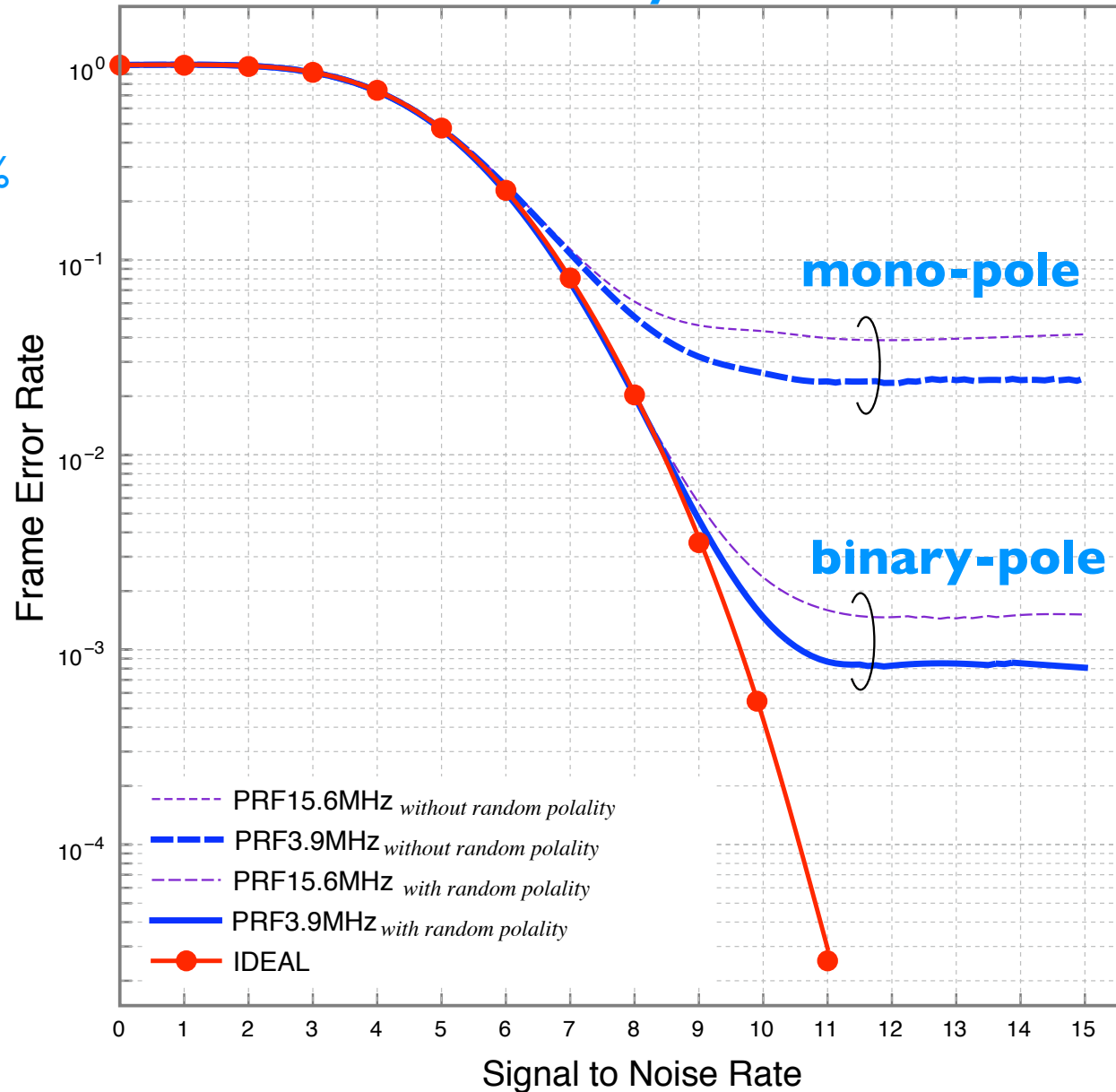
DATA Rate	> 100 Mbps
Center frequency	4,635 MHz
Number of sub-carriers	768
Sub-carrier interval	131.8 kHz
Frame length	500 μs
Modulation	QPSK

Simulation Results I

LDC-UWB transmitter power is power per pulses

The FER of the wideband OFDM system over AWGN channel

SIR=10dB,
Duty-Cycle=0.1%

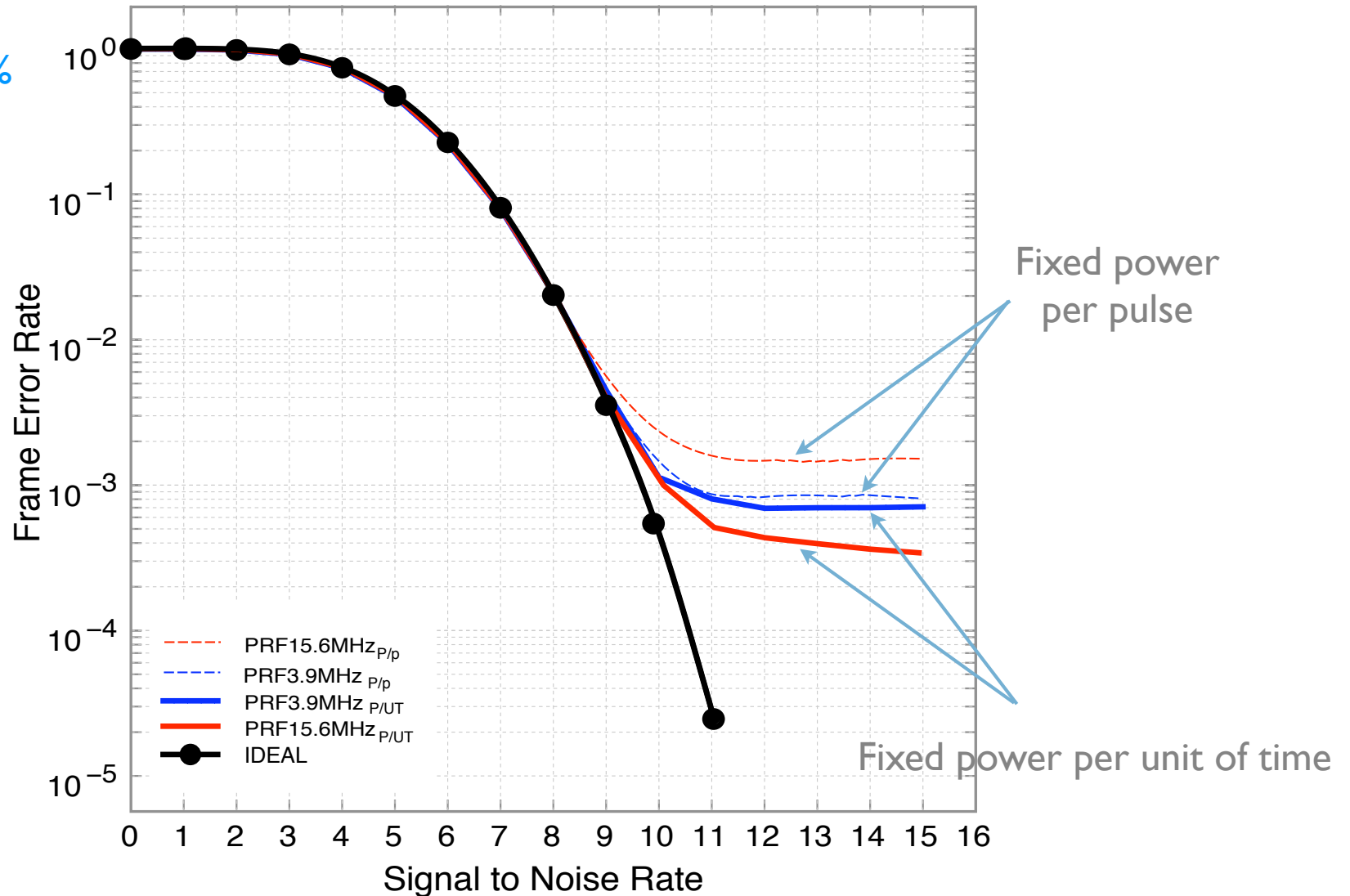


Simulation results II

The difference of the definitions of transmission power of LDC-UWB

The FER of wideband OFDM systems over AWGN channels

SIR=10dB,
Duty-Cycle=0.1%

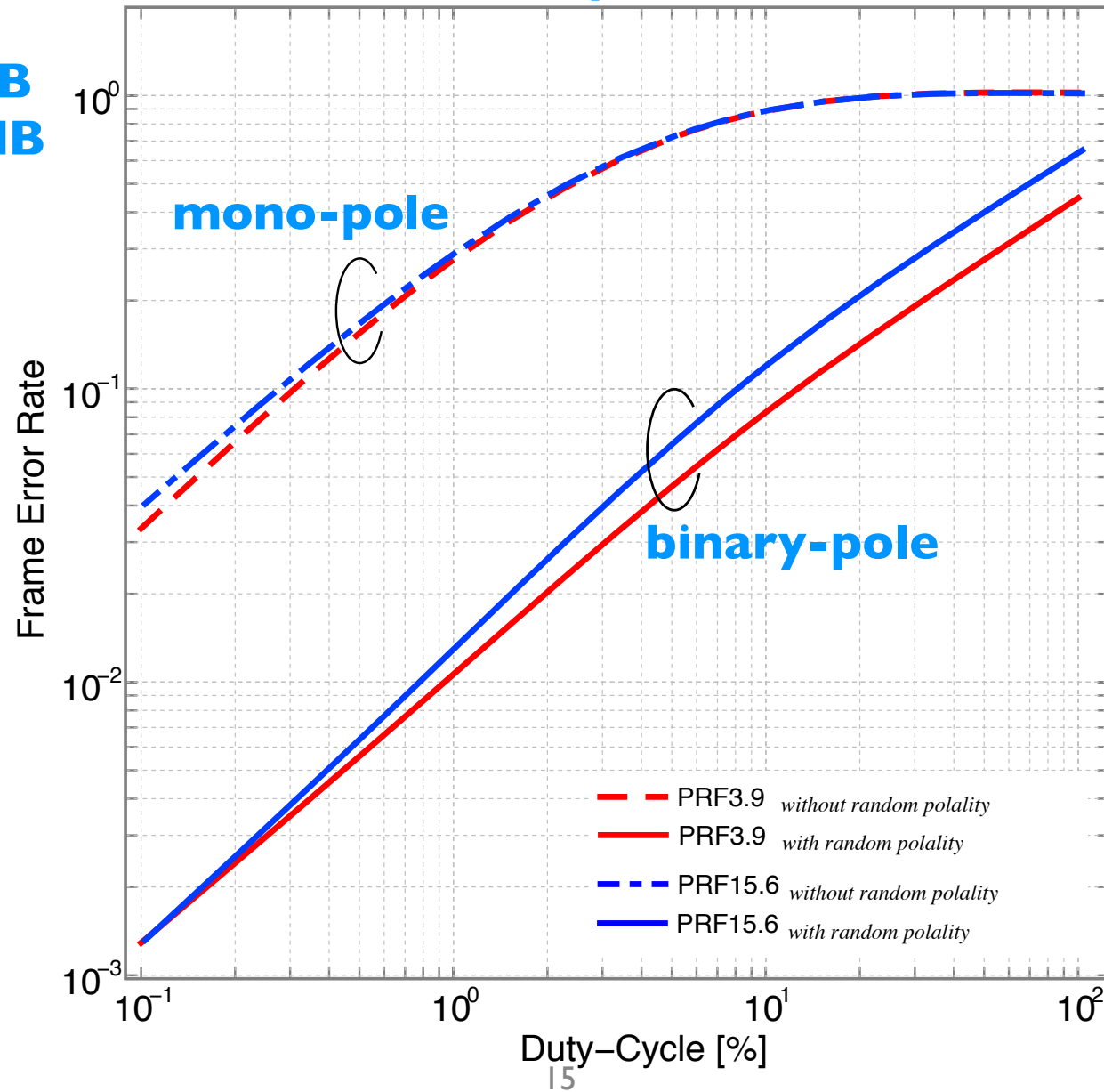


Simulation results III

Fixed power per pulse : Changing Duty-Cycle of LDC-UWB system

The FER of wideband OFDM system over AWGN channel

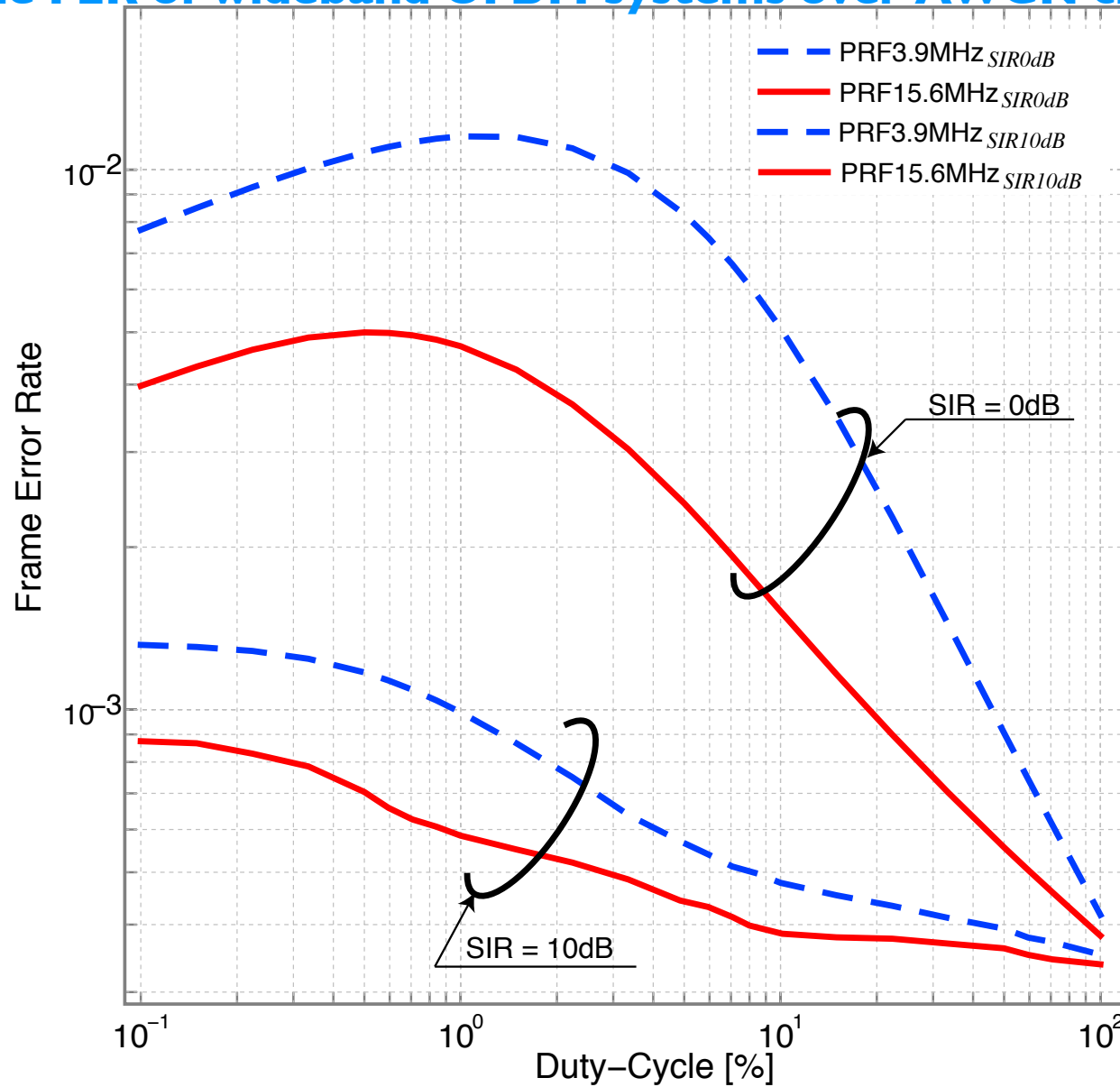
SIR=10dB
SNR=10dB



Simulation results IV

Fixed power per unit of time

The FER of wideband OFDM systems over AWGN channels



Conclusion

- ☑ We have focused on the coexistence environment between LDC-UWB and wideband OFDM system and analyzed the interference mitigation capability of LDC-UWB system in the presence of wideband OFDM system based on FER.
- ☑ The binary pole signals has been necessary to mitigate the interference for wideband OFDM system
- ☑ By the definition of the LDC-UWB transmission power, the Duty-Cycle of LDC-UWB system has been needed to establish in consideration of the request of tne each LDC-UWB applications.
- ☑ We have presented the design issues of PRF and duty-cycle are different with each definition of LDC-UWB transmission power.
- ☑ We can conclude that LDC is an efficient interference mitigation technique for low data rate UWB communication since the FER of wideband OFDM systems is improved with decreasing of the duty-cycle of LDC-UWB.
- ☑ LDC cannot suppress interference to wideband OFDM systems completely.
- ☑ The duty-cycle of LDC-UWB should be chosen carefully in consideration of the quality of the service required by the wideband OFDM system in the physical layer.
- ☑ The duty-cycle of LDC- UWB system should be chosen carefully in consideration of the requirements of the each LDC-UWB application.

Thank You For your Attention !!