A Study on the Impact of UWB Sensor on the Mobile station of Next Generation mobile System in Korea

Young-Keun Yoon

Radio Technology Research Group

Feb. 27, 2007

ETRI
Electronics and Telecommunications Research Institute

Contents

1. Overview

ETRI

- Ultra-wideband (UWB) techniques have desired features such as high bit rates and low power consumption
- But, the spectrum for UWB cannot allocated exclusively so that UWB signal band overlaps with those of existing systems (‘Underlay Shared’)
- UWB wide signals cause harmful interference to wide or narrow band systems
- How should we do so as to protect the existing system from harmful interference by UWB wide signal?
- Next, I described for UWB interference assessment in worst case
- Finally, I will give you to UWB emission limit for protecting the existing system

2. UWB Sensor & Next Generation System

ETRI

- **UWB Sensor developed in Korea**
  - **Motion Sensor using the Ultra-wideband (UWB) technologies**
  - **Device to detect intrusion at points of entry into protected area**
    - **Operation : 4.5GHz band (outdoor), 8.5GHz band (indoor)**
- **Next generation system**
  - **4-generation(4G) system is being desinged in Korea**
  - **Based on TDD(or FDD) and OFDMA**
  - **Assumption for simulation:**
    - **System specification: Portable Internet Service in Korea**
    - **Out of several candidate operation frequency : 4GHz - 5GHz bands was considered.**

3. Interference Analysis Method

ETRI

❑ How to evaluate whether UWB interference is or not.

❖ Methods in our study : MCL, Simulation

❖ MCL stands for Minimum Coupling Loss

- Kind of link budget calculation due to protection criteria (c.f. UWB I/N)
- Finding minimum separation distance between a victim receiver and an interferer

❖ System level simulation (SLS)

- Kind of Monte-Carlo scheme (Statistical Calculation)
- Finding interference probability (or Outage probability)

❑ Spectral power level of UWB sensor transmitter (Measurement Results)

Frequency band	Indoor Application		Outdoor Application	
	E-Field Strength@3m [dBuV/m]	EIRP (dBm/MHz)	E-Field Strength@3m [dBuV/m]	EIRP (dBm/MHz)
0GHz~1GHz	19.83	**-77.7**	19.87	**-77.6**
1GHz~2GHz	21.33	**-82.9**	20.17	**-84.0**
2GHz~3GHz	21.17	**-86.0**	21.17	**-86.0**
3GHz~4GHz	21.17	**-87.2**	21.50	**-86.9**
4GHz~5GHz	20.83	**-87.2**	**39.47**	**-68.5**
5GHz~6GHz	20.67	**-85.4**	23.33	**-82.7**
6GHz~7GHz	21.83	**-84.8**	21.67	**-84.9**
7GHz~8GHz	22.17	**-84.9**	22.17	**-84.9**
8GHz~9GHz	**32.50**	**-65.6**	21.67	**-76.4**
9GHz~10GHz	28.17	**-69.8**	21.50	**-76.5**
10GHz~11GHz	21.33	**-76.6**	21.50	**-76.4**
11GHz~12GHz	21.50	**-76.4**	21.67	**-76.2**

4. Evaluation : separation distance calculation using MCL

ETRI

- **Analysis for the impact of single UWB sensor on a next generation mobile station (NG-MS)**

  - **Scenario**

    - **Service coexistence environment : Indoor**
    - **Interferer: Single UWB sensor (Operation : 8.5GHz bands)**
    - **Victim Receiver: Next generation mobile station (NG-MS) (Operation: 4.5GHz bands)**

  - **When NG-MS is actively close to only one UWB sensor in indoor, and then,**

    - **How far is minimum allowable separation distance between a UWB sensor and NG-MS when UWB power spectral density (PSD) = -87.2 dBm/MHz (Provided by Korea in Indoor)**

4. Evaluation : *separation distance calculation using MCL - cont'd*

ETRI

- **Analysis for the impact of single UWB sensor on a next generation mobile station (NG-MS)**

  - **Calculate separation distance using MCL scheme in table**

Parameters	Value	Units	Equation
Frequency	4500	MHz	F
Thermal noise density	-174	dBm/Hz	*kT*
NG-MS Rx bandwidth	10	MHz	*B*
NG-MS Rx noise figure	8	dB	*NF*
NG-MS Rx noise floor	-96	dBm	$N = kT + BW + NF$
Allowable interference criteria in NG-MS Rx	-6	dB	$I - N$
Permissible interference power in NG-MS Rx bandwidth	-102	dBm	*I*
UWB E.I.R.P in 10 MHz	-77.2	dBm	$P = - 87.2+10\log(B)$
NG-MS Rx antenna gain	0	dBi	*GR*
NG-MS Rx line loss	2	dB	*LR*
Path loss required	22.8	dB	$Lp= P + GR - LR - I$
Permissible minimum separation distance	0.14	m	Free space (LOS)

- **Analysis for the impact of multiple UWB sensors on a next generation mobile station (NG-MS)**

  - **Scenario**

    - **Service coexistence environment : Outdoor**
    - **Victim Receiver: Next generation mobile station (NG-MS) (Operation: 4.5GHz bands)**
    - **Interferers: Multiple UWB sensors (Operation : 4.5GHz bands)**
      - ✓ **UWB Sensor: the sensing distance is within 40m, the fixing height on fence pillar is 2.2m, the space among sensors is 40m, the beam width : horizontal is 150°, vertical is 35°**
    - **Simulation radius = 0.6km (UWB sensor distributed area)**

- **Analysis for the impact of multiple UWB sensors on a next generation mobile station (NG-MS)**

  - **Key parameters of NG-MS (Victim Receiver)**

Parameters	Value	Units	Equation
Operation Frequency	4500	MHz	F
Thermal noise density	-174	dBm/Hz	*kT*
Channel bandwidth	10	MHz	B
Noise figure	8	dB	*NF*
Noise floor	-96	dBm	$N = kT + BW + NF$
Allowable interference criteria	-6	dB	$I - N$
Antenna gain	0	dBi	*GR*
Rx line loss	2	dB	*LR*
Rx antenna height	1.5	m	

- **Analysis for the impact of multiple UWB sensors on a next generation mobile station (NG-MS)**

  - **Key parameters of UWB sensor (Interferer)**

Parameters	Value	Units
Operation frequency	4500	MHz
UWB power spectral density (E.I.R.P)	- 68.5	dBm/MHz
Transceiver antenna height	2.2	m
Sensing distance	40	m
Number of active interferers	25	

4. Evaluation : *interference probability estimation using SLS - cont'd*

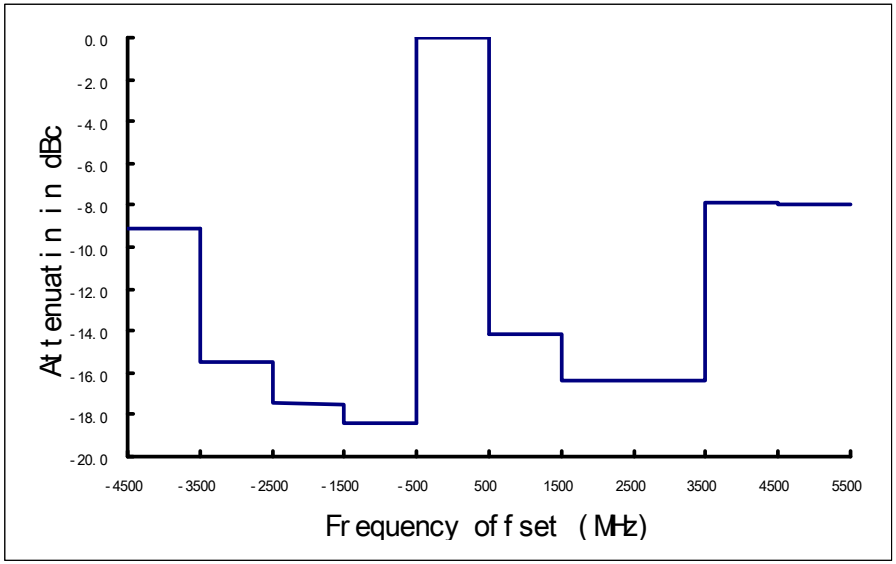
ETRI

❑ Analysis for the impact of multiple UWB sensors on a next generation mobile station (NG-MS)

❖ Emission of UWB sensor

Frequency offset (MHz)	UW B Emission (dBm/MHz)	Attenuation in dBc
-4500 ~ -3500	-77.6	-9.1
-3500 ~ -2500	-84.0	-15.5
-2500 ~ -1500	-86.0	-17.5
-1500 ~ -500	-86.9	-18.4
-500 ~ 500	-68.5	0
500 ~ 1500	-82.7	-14.2
1500 ~ 2500	-84.9	-16.4
2500 ~ 3500	-84.9	-16.4
3500 ~ 4500	-76.4	-7.9
4500 ~ 5500	-76.5	-8

This table is based on spectral power level of UWB sensor transmitter in Korea (c.f. slide 6)



This picture is spectrum mask for interference analysis, which is based on the left side table

4. Evaluation : *interference probability estimation using SLS - cont'd*

- **Analysis for the impact of multiple UWB sensors on a next generation mobile station (NG-MS)**
  - **After setting-up scenario based on above key parameters, and then**
  - **Simulation on UWB interference impact**
    - **UWB Signal type : Unwanted Emission, Interference protection criteria : I/N = -6 dB. Simulation Repetition time: 50000**
  - **Results**
    - **When UWB PSD is - 68.5dBm/MHz@4.5GHz, interference probability is 0.04%**
    - **When UWB PSD is - 80dBm/MHz@4.5GHz, interference probability is zero**

5. Conclusions

- UWB interference impact on next generation mobile station were analyzed using MCL and SLS

- When I/N of – 6dB is chosen as interference criteria

  - In indoor environment and UWB PSD = - 87.2 dBm/MHz (in Korea), the minimum allowable distance should be 14cm between NG-MS and UWB sensor in the case of single UWB sensor (interferer)

  - For Outdoor environment, when number of active UWB sensors = 25, UWB PSD should be - 80 dBm/MHz below, UWB sensor system will not give interference to NG-MS in the case of multiple UWB sensors.