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

Submission Title: [Wideband Measurement for Body Effect of BAN Channel]

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Abstract: [Wideband measurement results of BAN channels in an anechoic chamber and BER evaluation of UWB single path receiver are introduced. Body effects are considered.]

Purpose: [To help encouraging the discussion in SG-BAN]

Wideband Measurement for Body Effect of BAN Channel

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Outline

- Background
- Measurement Set up
- Wideband Measurement Results
- UWB BER Simulation
- Evaluation
- Conclusion

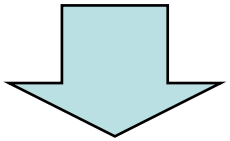
Background

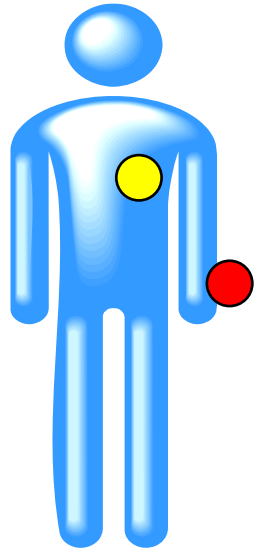
Link between Sensor Nodes and BAN Coordinator

- Star or Star with Relay or Mesh Topology?
- Need to know Propagation Loss of Body Effects

In Multipath-rich

or Less Multipath Environments

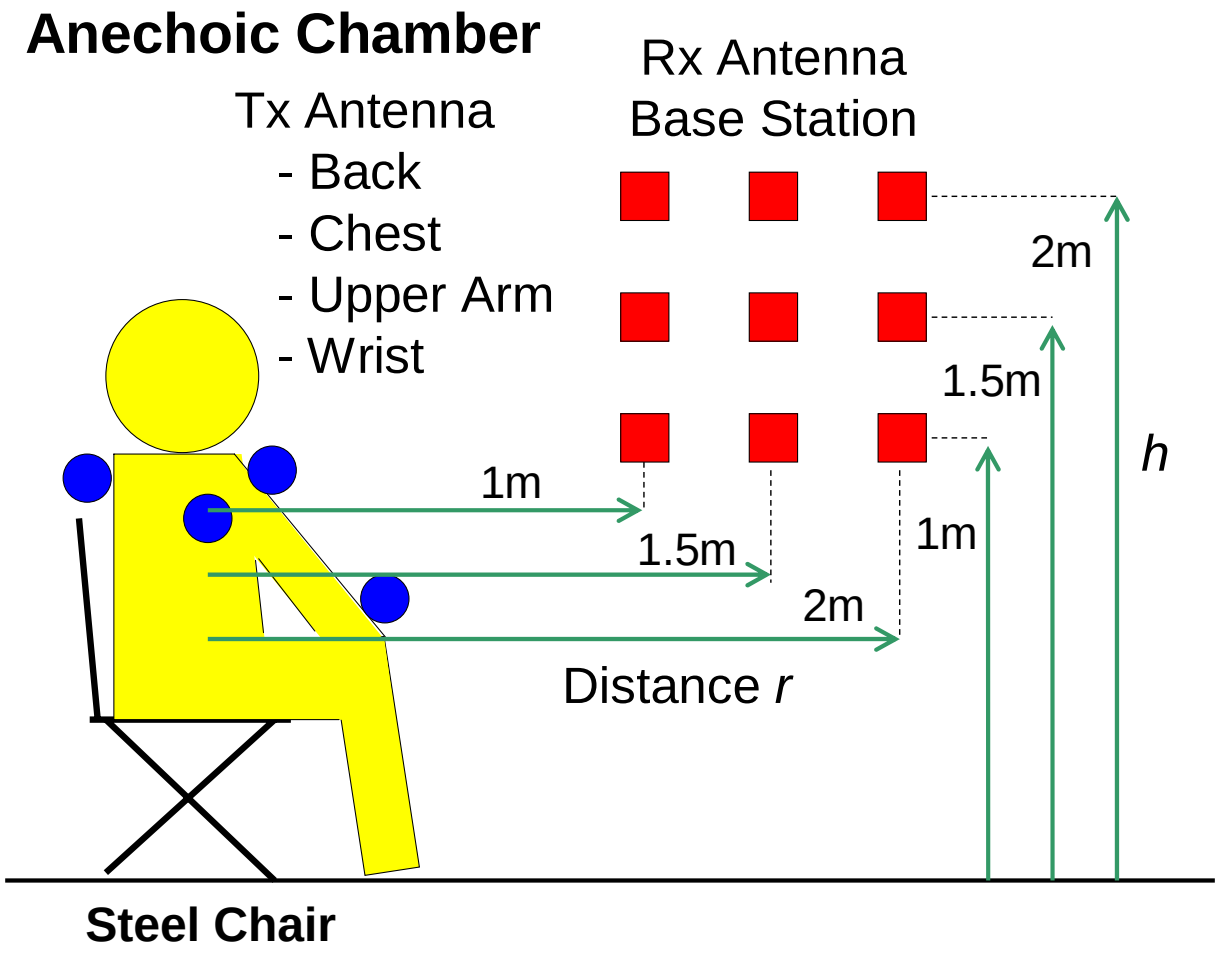




Wideband Channel Measurements Needed

- for Narrow band or UWB PHY
- In **Less Multipath Environment for Baseline**

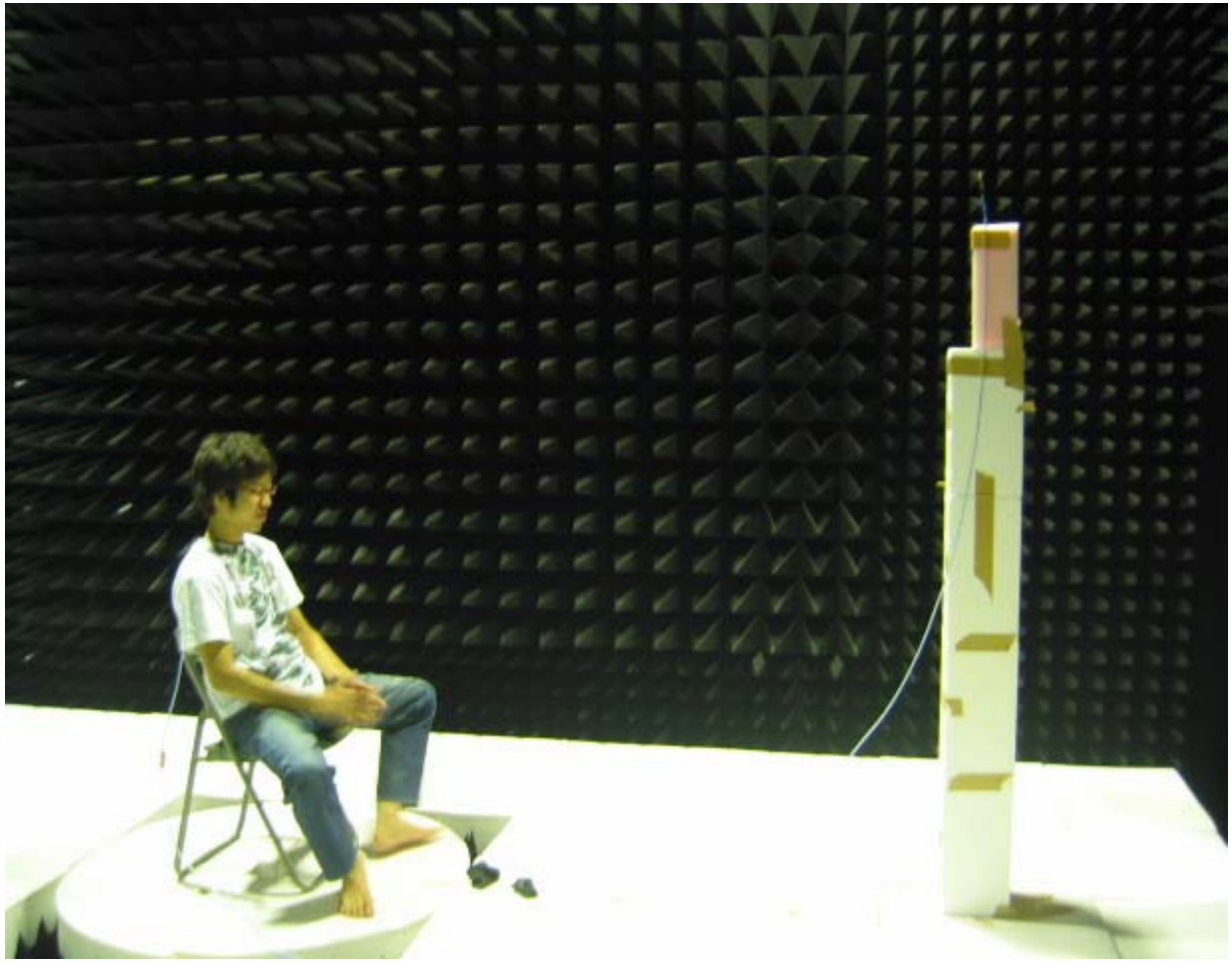
Measurement Conditions



Major Specification

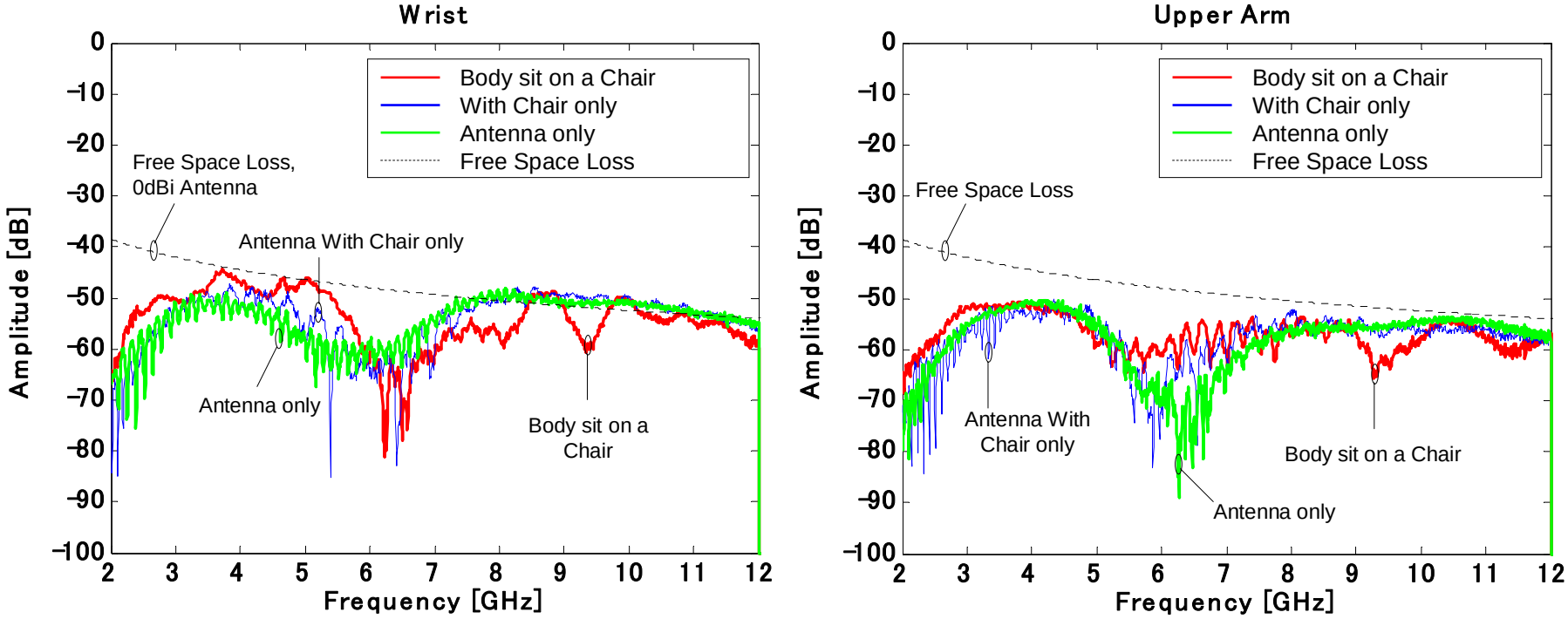
Measuremet mode	S21 Measuremet with Network Analyzer
Base Station Rx Antenna Height: h	1.0, 1.5, 2.0 [m]
Tx-Rx Distance: r	1.0, 1.5, 2.0 [m]
Frequency Range	2.0 – 12.0 [GHz]
Antenna	UWB Dielectric

Scenery of Experiment
Anechoic Chamber at Meiji Univ.



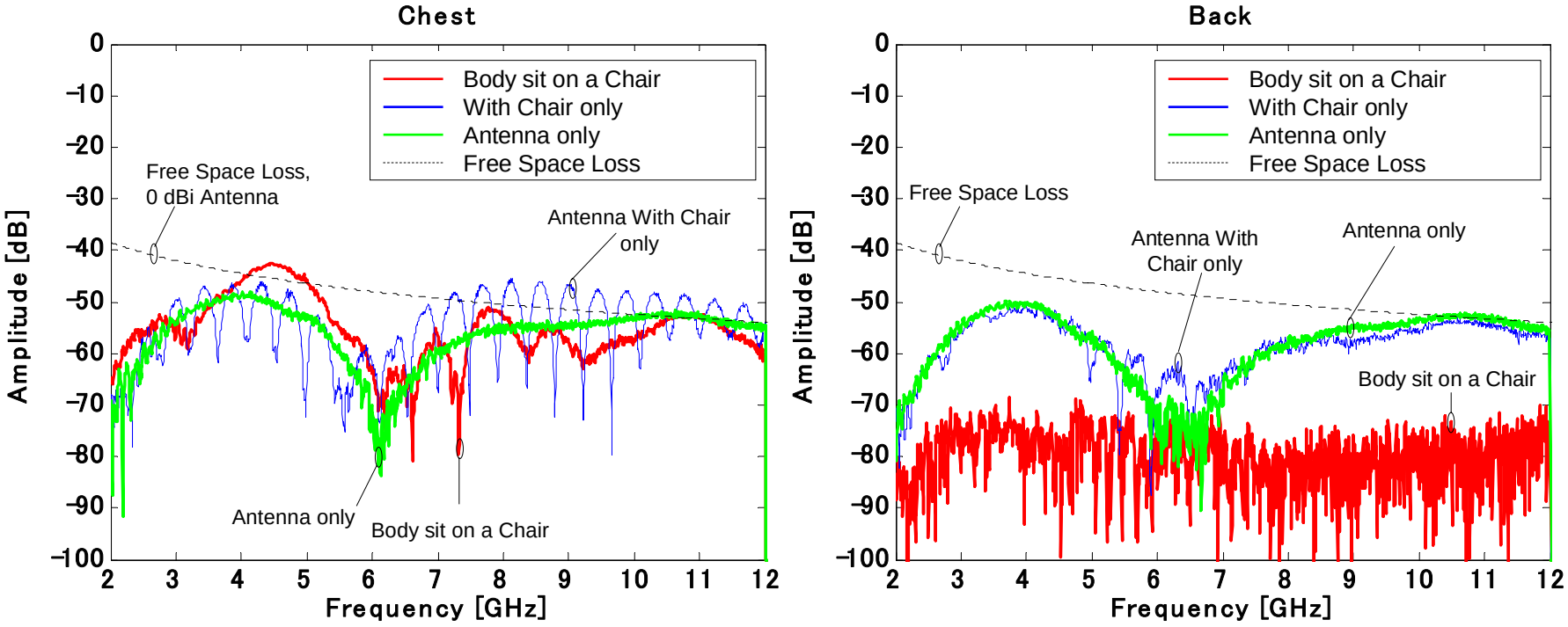
Measurement Results

Frequency Domain Characteristics (Tx Antenna: Wrist or Upper Arm)



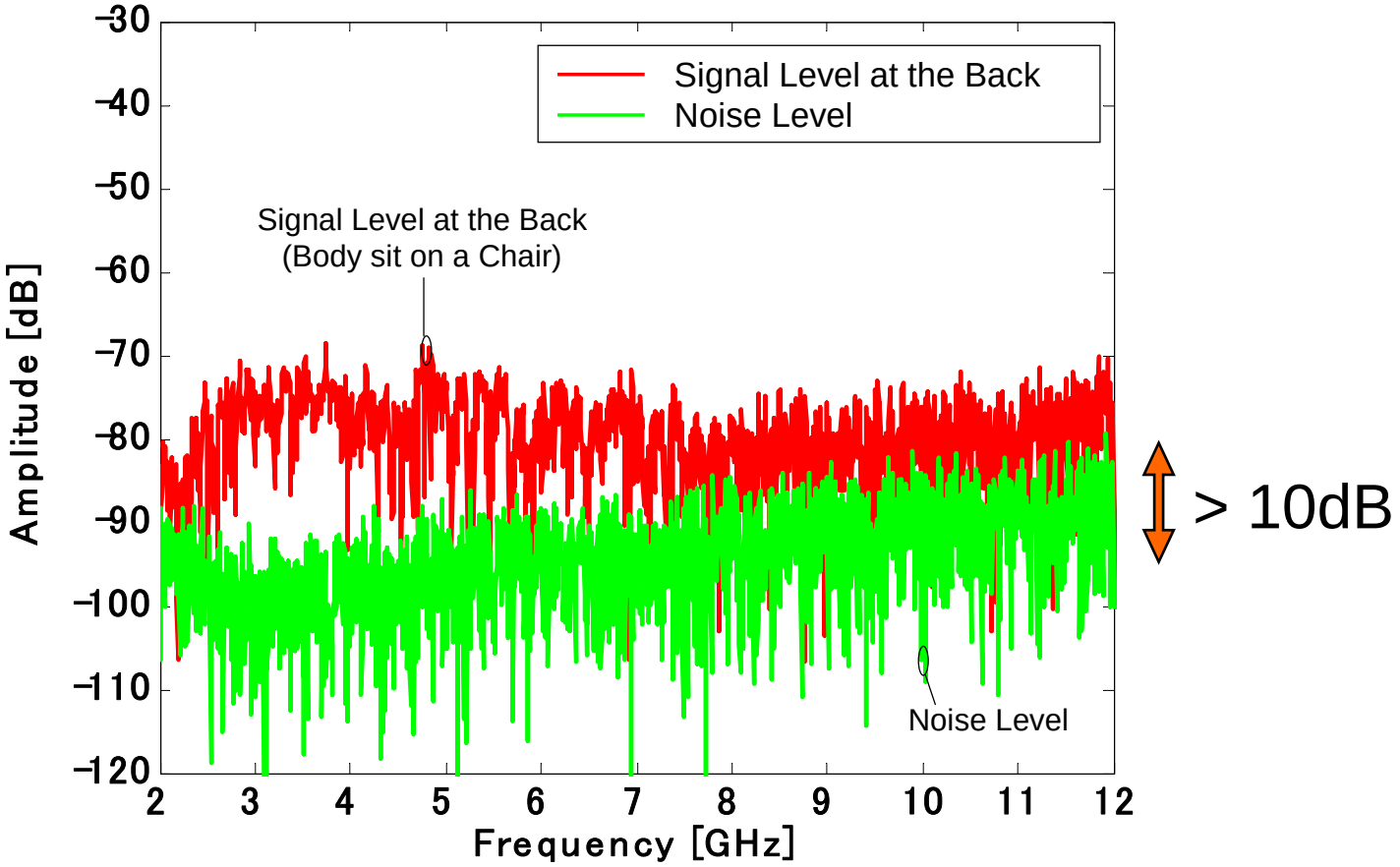
Height of the Base Station : h = 1 [m],
Transmitter-Receiver Distance : r = 1 [m]

Frequency Domain Characteristics (Tx Antenna: Chest or Back)



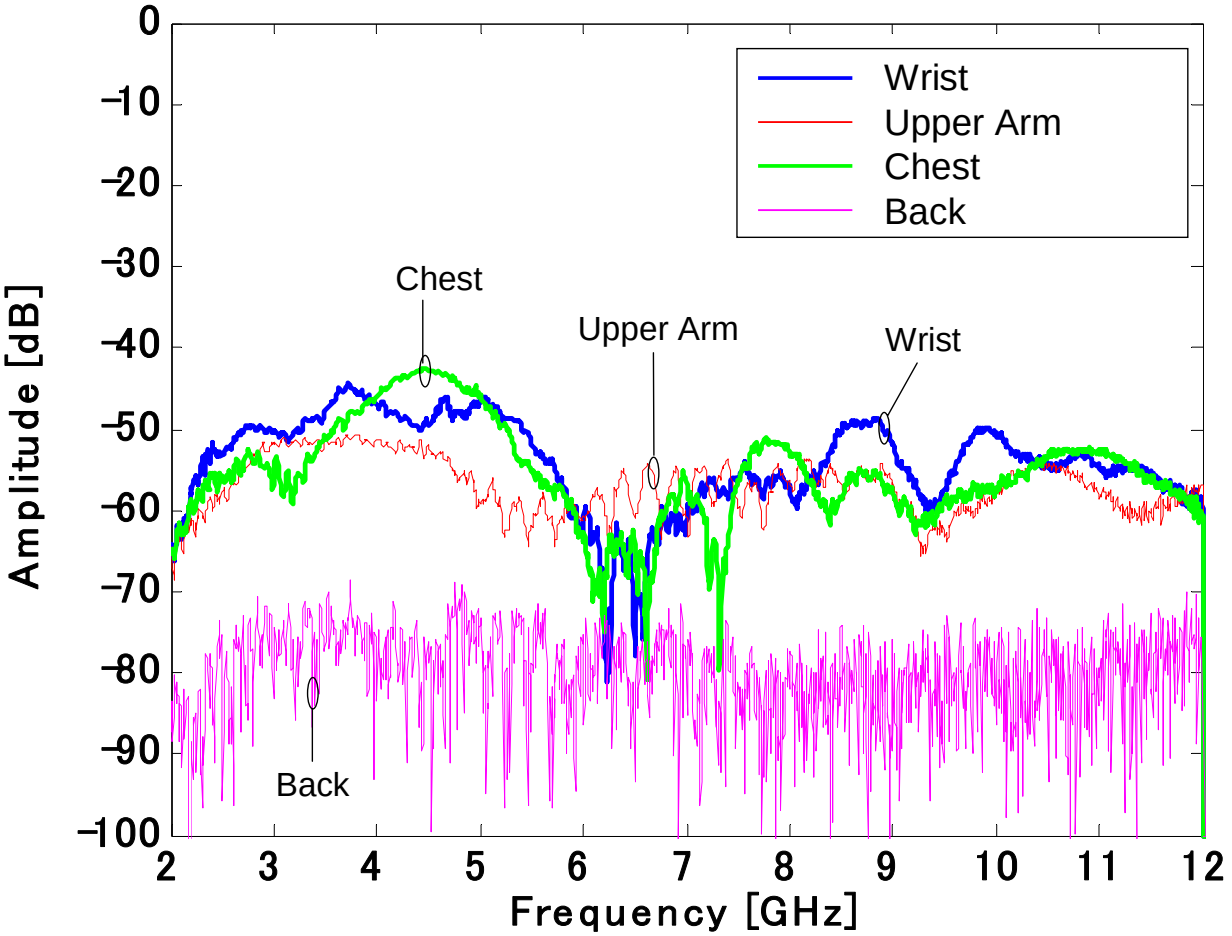
Height of the Base Station : h = 1 [m],
Transmitter-Receiver Distance : r = 1 [m]

Signal Level at the Back and Noise Floor



Height of the Base Station : h = 1 [m],
Transmitter-Receiver Distance : r = 1 [m]

Frequency Domain Characteristics (h =1 [m])



Height of the Base Station : h = 1 [m],
Transmitter-Receiver Distance : r = 1 [m]

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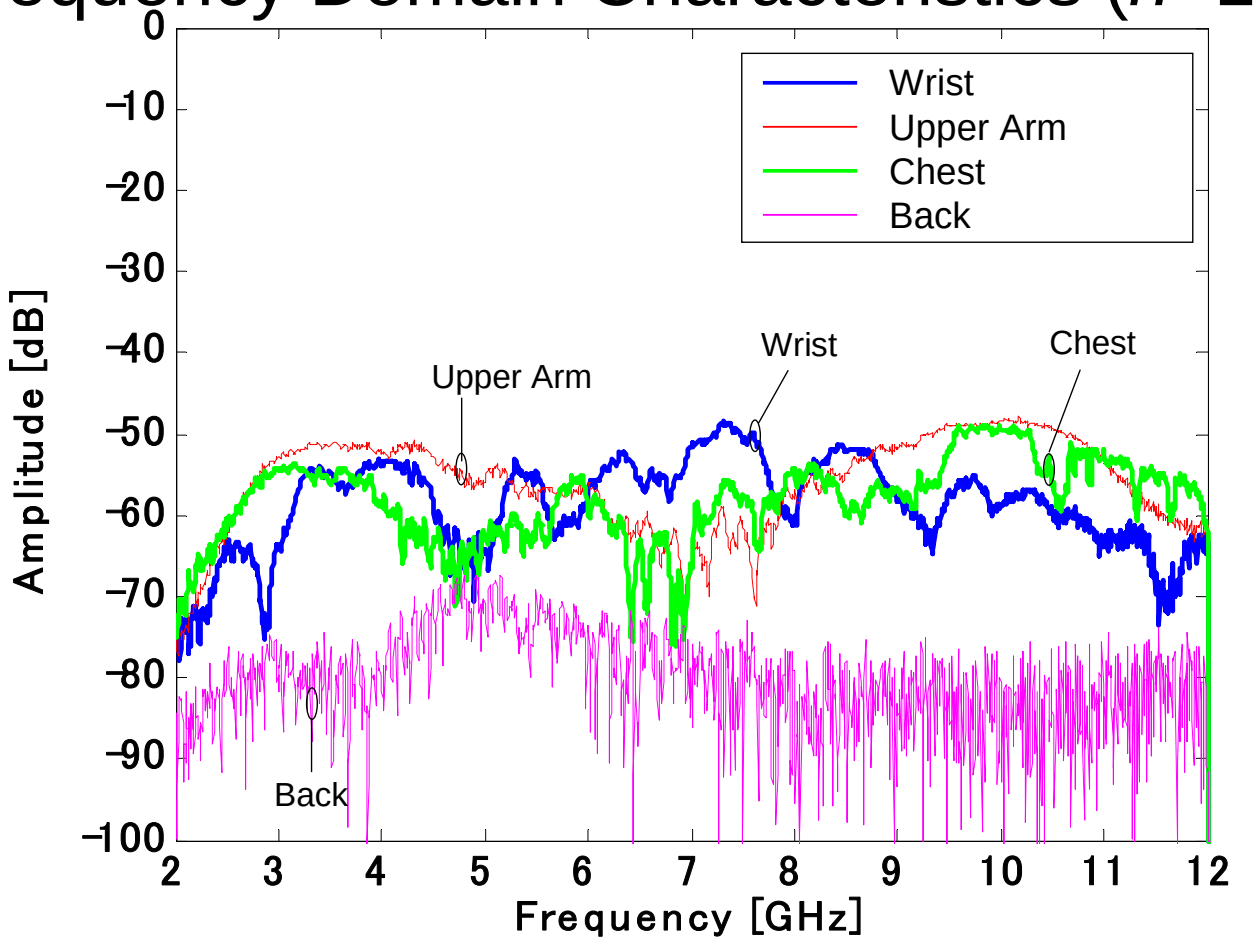
Frequency Domain Characteristics (h=1.5 [m])



Height of the Base Station : h = 1.5 [m],
Transmitter-Receiver Distance : r = 1 [m]

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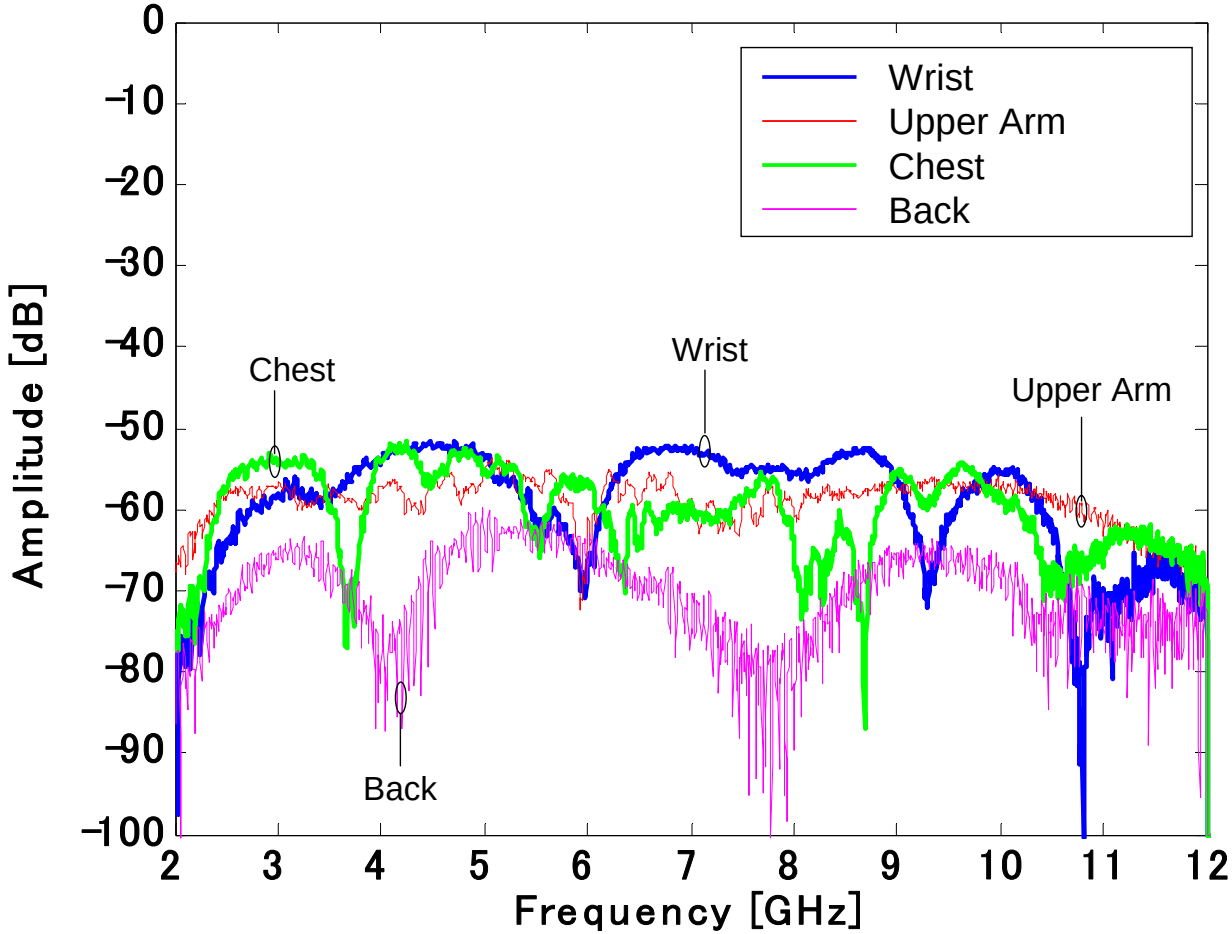
Frequency Domain Characteristics (h = 2 [m])



Height of the Base Station : h = 2 [m],
Transmitter-Receiver Distance : r = 1 [m]

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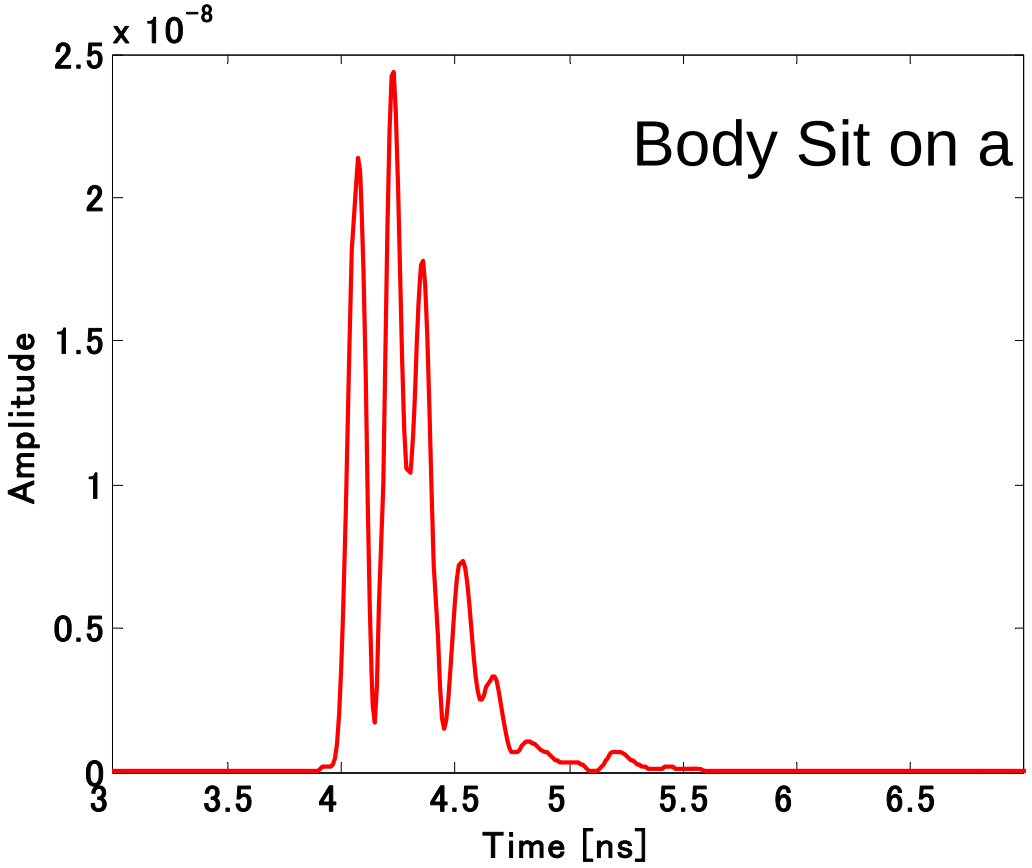
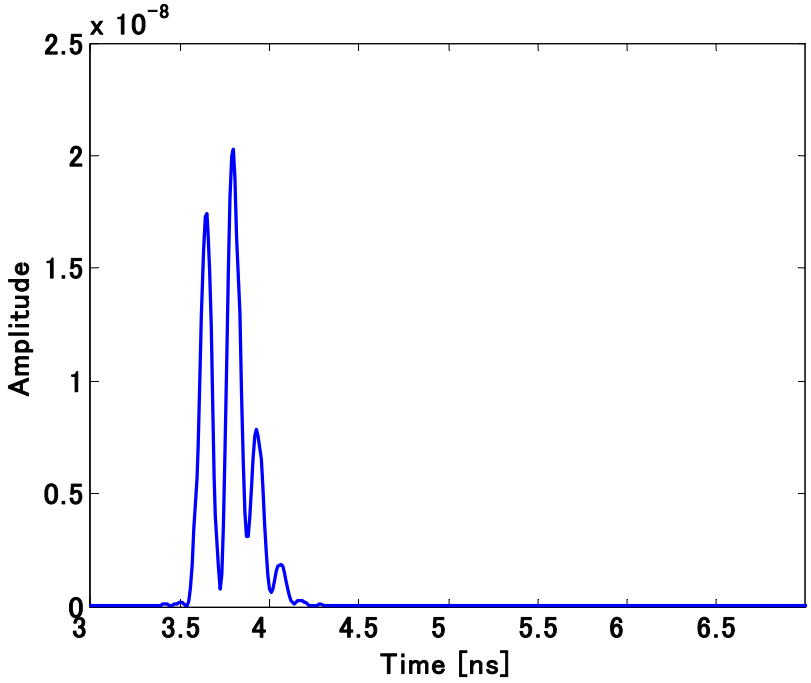
Time Domain Characteristics at Chest Position



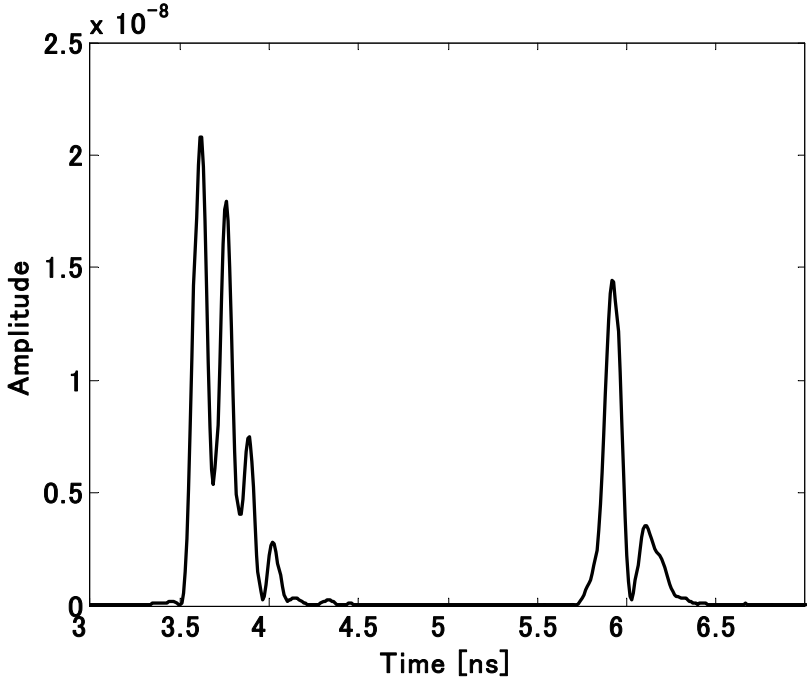
Body Sit on a Steel Chair

Height of the Base Station : h = 1 [m],
Transmitter-Receiver Distance : r = 1 [m]

Time Domain Characteristics at Chest Position



Antenna only



Antenna with Steel Chair only

Height of the Base Station : h = 1 [m],
Transmitter-Receiver Distance : r = 1 [m]

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Measurement Results

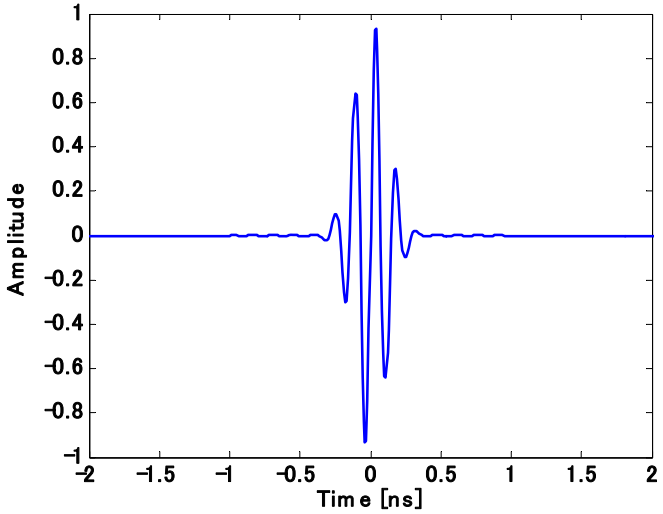
- Link Loss and Response Depends on Antenna Position on Body and Height of Base Station Antenna
- When Link is Blocked by Body (Antenna is on Back)

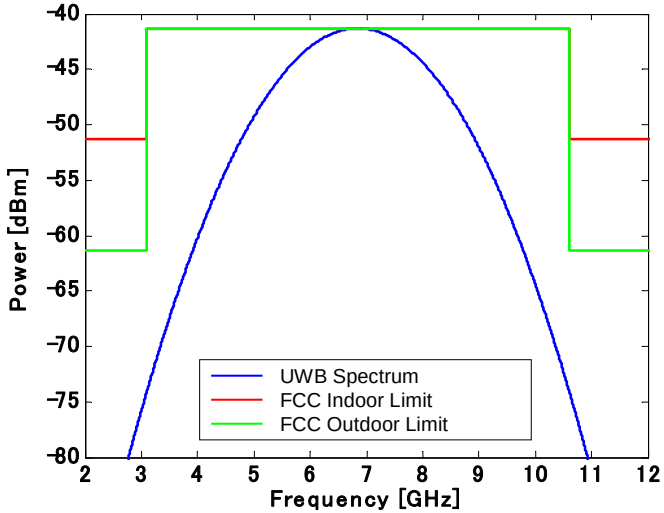
  ~15 to 25 dB Loss
- Steel Chair Causes Multipath

  However, Body Masks the Effects of Multipath

UWB Transmission Performance Evaluation, Bit Error Rate Simulation

Assumed UWB Pulse Waveform for BER Evaluation





- UWB Pulse:

$$s_0(t) = \exp\left(-\frac{at^2}{\tau^2}\right)\sin(2\pi f_0 t)$$

- Pulse Parameter:
  - Center Frequency, f_0= 6.85[GHz]
  - Pulse Width, 2τ= 0.5[ns]
- Modulation Type: Bi-Phase (BPSK)
- Detection: Correlation Detection, Largest Path Selection

BER Simulation

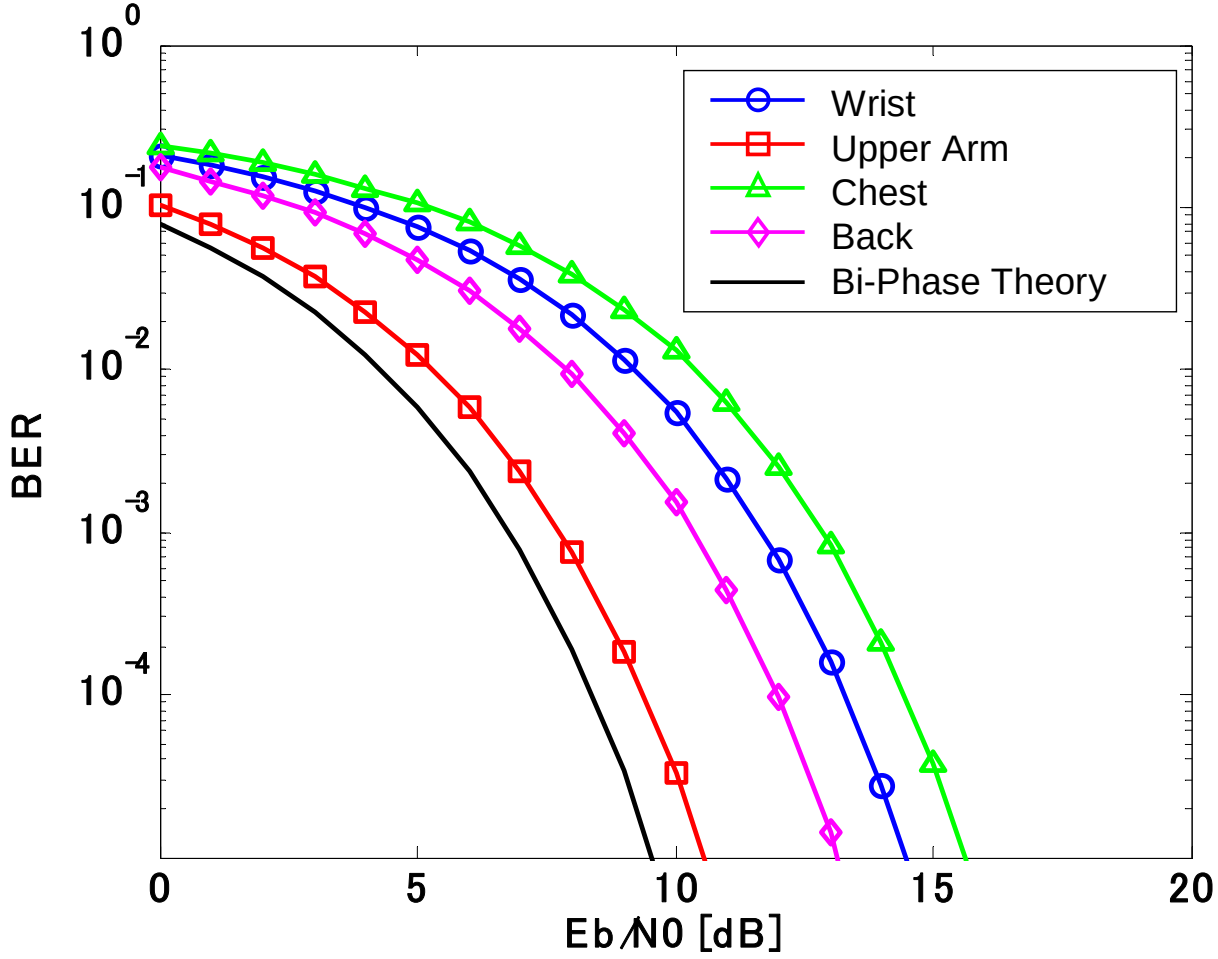
- Measured Frequency Responses at each Antenna Position with Normalized Total Received Power are used.

  Energy Capture is evaluated.

- Assume Single Path Coherent Receiver with the Largest Path Selection

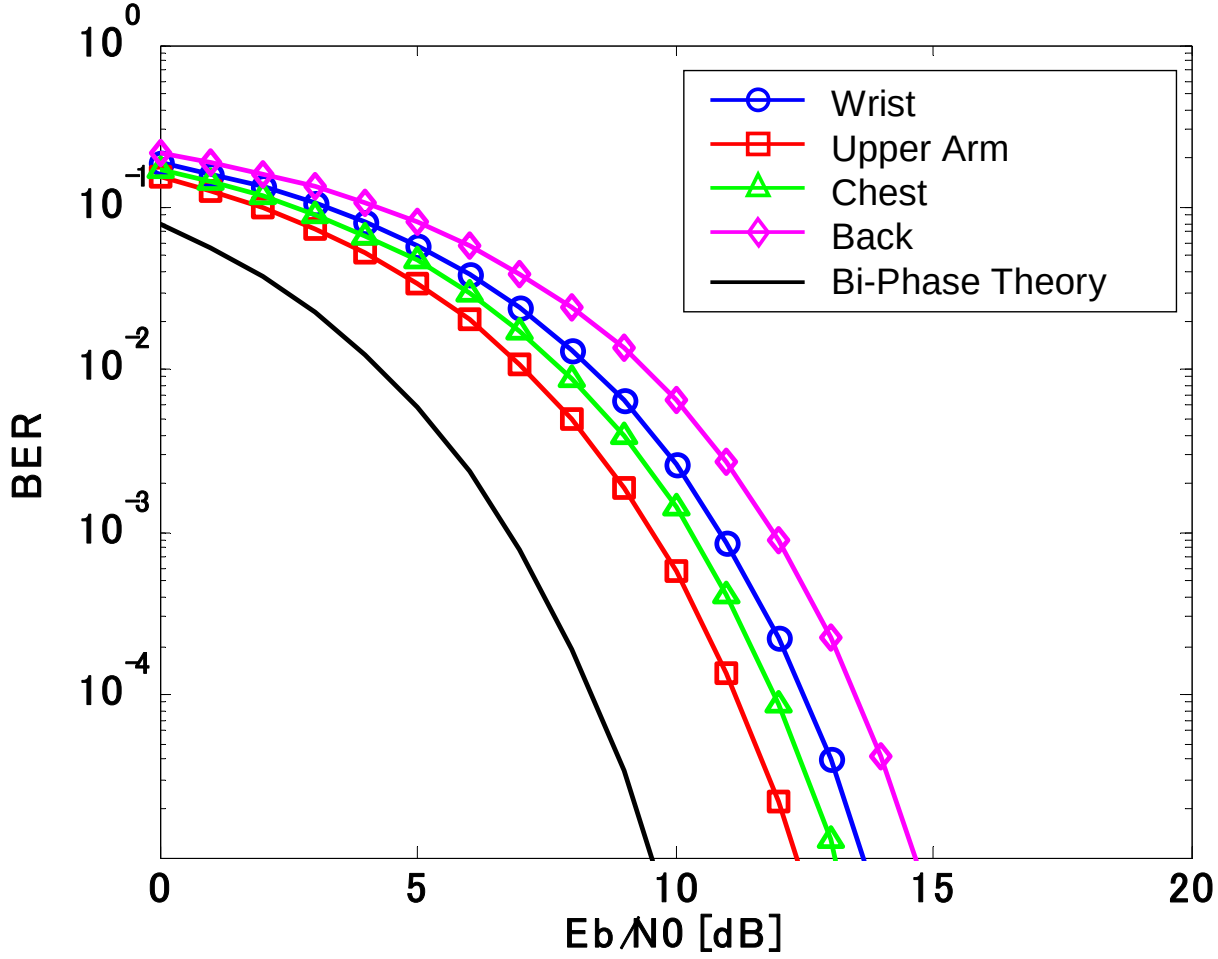
  Simpler Rx Implementation for BAN PHY

BER Performance



Height of the Base Station : h = 1 [m],
Transmitter-Receiver Distance : r = 1 [m]

BER Performance



Height of the Base Station : h =1.5 [m],
Transmitter-Receiver Distance : r = 1 [m]

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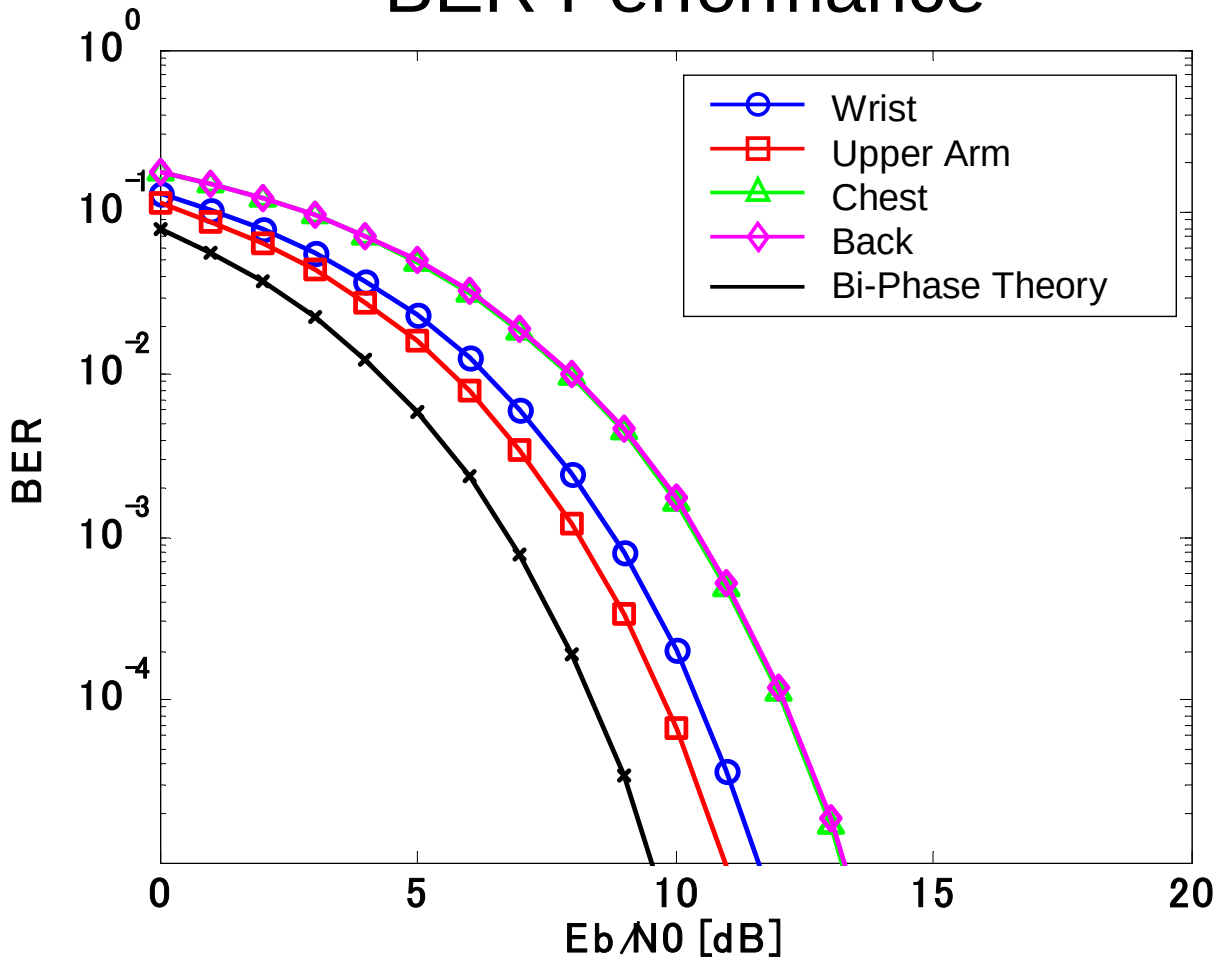
BER Performance



Height of the Base Station : h = 2 [m],
Transmitter-Receiver Distance : r = 1 [m]

BER Degradation [dB] @10e-4, 1 [m] Distance

Tx Antenna Position \ Rx Antenna Hight	1 [m]	1.5[m]	2 [m]
Wrist	4.90	4.10	2.04
Upper Arm	0.98	2.79	1.39
Chest	6.07	3.54	3.67
Back	3.60	5.11	3.72

Evaluation of BER Simulation

- Single Path UWB Coherent Receiver with the Largest Path Selection

  Correlation loss: 1 to 6 dB

  Fairly Good, because of Less Multipath Condition of Anechoic Chamber

Conclusions

- Wideband Channel Measurements for Narrow band or UWB PHY in Less Multipath Anechoic Chamber Environment as a Baseline Study
- Link Loss and Response Depends on Antenna Position on Body and Height of Base Station Antenna
- When Link is Blocked by Body: 15 to 25 dB Loss
- Steel Chair Causes Multipath

  However, Body Masks the Effects of Multipath
- Simulation: Single Path UWB Coherent Receiver with the Largest Path Selection: Correlation loss: 1 to 6 dB

  Fairly Good, because of Less Multipath Condition of Anechoic Chamber

Thank you!

References

[1] T. Yamada, T. Kobayashi, H. Matsuda, N. Yamazaki, K. Ohno, T. Ikegami, “Evaluation and Compensation of Channel Characteristics around Human Body for UWB System,” Technical Report of IEICE, WBS2006-60, Mar. 2007.

[2] T. Yamada, K. Ohno, T. Ikegami, “Compensation for Frequency Characteristic of UWB Transmission with Multi-carrier pulse waves,” SITA2006, 16.3, Nov.2006.

[3] K.Ohno, T.Ikegami, “Multipath Compensation by Using Template Waveform Processing in UWB Radio,” WPMC2005, Sep.2005.

[4] K.Ohno, T.Ikegami, “Interference Mitigation Study for UWB Radio Using Template Waveform Processing,” IEEE Transaction on Microwave Theory and Technique, Vol. 54-4, Apr. 2006.