Project: IEEEP802.15 Working Group for Wireless Personal Area Network(WPAN)

Submission Title: [**Study of mm wave propagation modeling Ⅳ to realize WPANs**]

Date Submitted: [March 2004]

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Re: [**Millimeter wave propagation characteristics**]

Abstract: [60GHz-band Propagation characteristics are presented in this document]

Purpose: [Contribute to mm wave interest group for WPANs]

Propagation Measurements for Millimeter-wave Vertically Connected Wireless Link

The following individuals support this proposal as co-authors:
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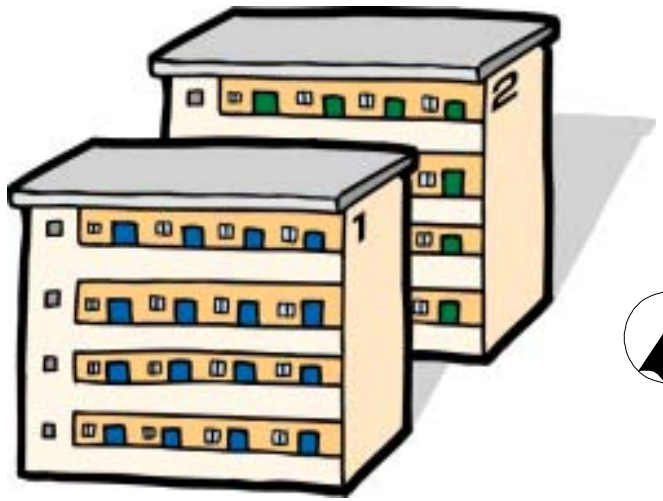
Background

Satellite broadcasting provides high-quality services.

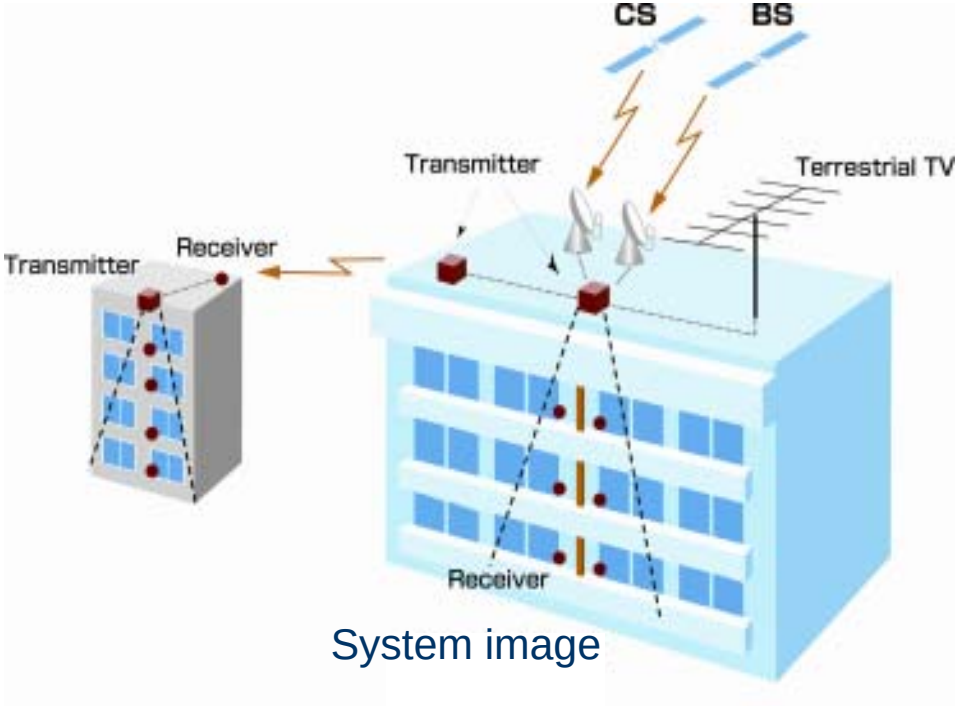
However some apartment buildings can not receive signals
Because of
obstacles for the satellite direction,
or, no balconies for satellite direction, or etc.

Ex. Balconies are located
in the north direction ・・・



According to a report of the MPHPT in 2002,
900,000 households can't receive
the broadcasting service.

Vertically Connected Wireless Link



System image

- Wide frequency band
- Small size and lightweight equipments
- Reduction of wiring costs
- Easy set-up
- Easy extension
- Un-license system

59 – 66 GHz: Un-license band in Japan

- Re-broadcasting system between the rooftop satellite antenna with individual receivers at balconies.
- 60 GHz band is used.

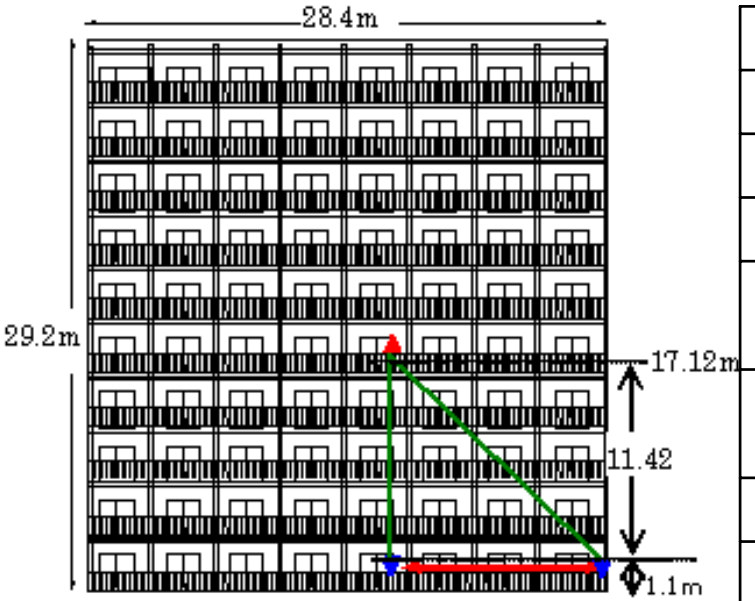
Required measurements to achieve VCWL

To achieve a VCWL, the 60-GHz band measurements are required in these environments.

- Propagation characteristics parallel to apartment
- Propagation characteristics in vertical directions
- Effect of obstacles between Tx and Rx antennas
- Effect of snow laid on Rx antenna

Measurement 1
Propagation characteristics parallel to apartment

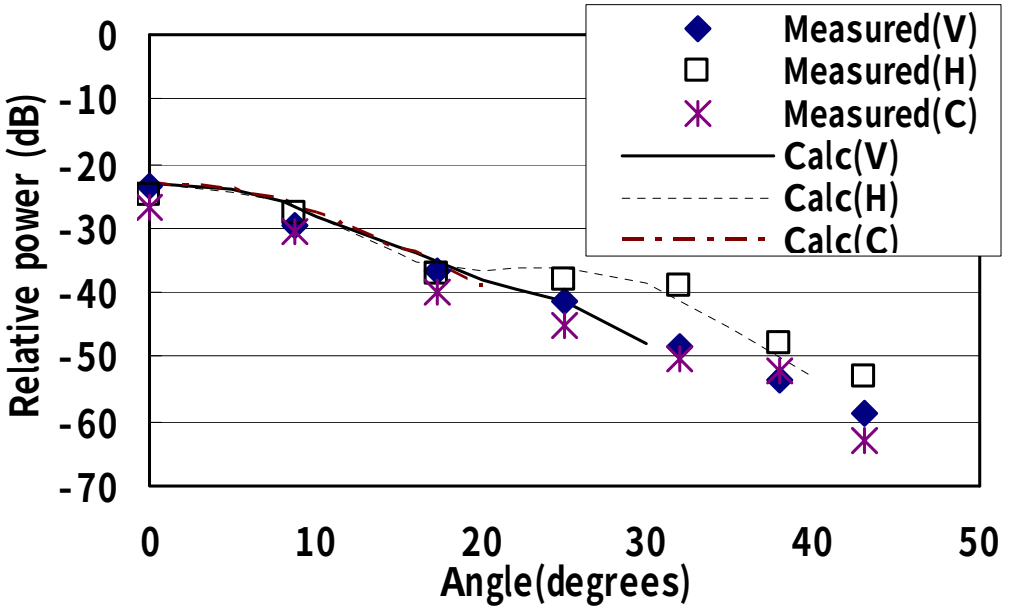
The measurements for the horizontal direction



Apartment	(A)
Antenna position	Tx : 5 F / Rx 1F
polarization	V / H / C
beam width	15° / 30°
Horizontal distance	Variable
Comment	0 to 10.65 m every 1.175 m
Depth	0.3 m
Vertical distance	11.42 m
Number of measurement	3 times for each position

Result 1

Propagation characteristics parallel to apartment



We confirmed that

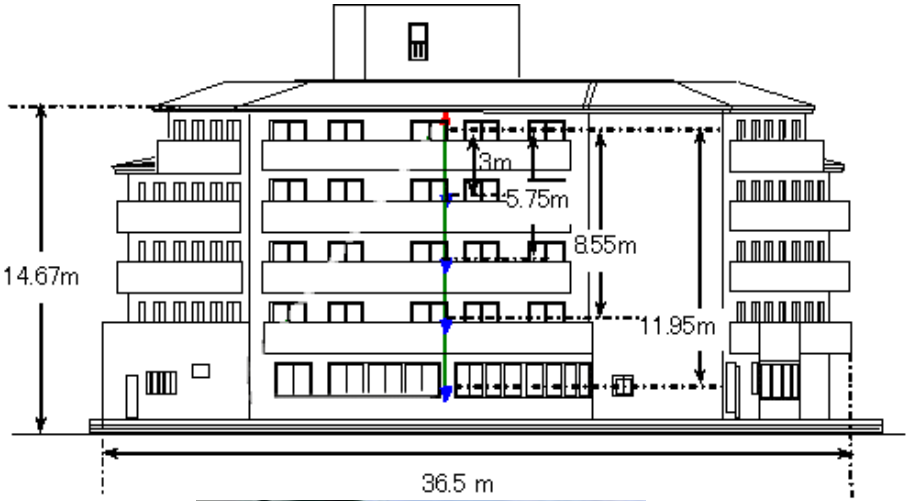
the received level depends on the antenna pattern.

delay spread : the maximum value was 1.2 ns.

Measurement 2

Propagation characteristics in vertical directions

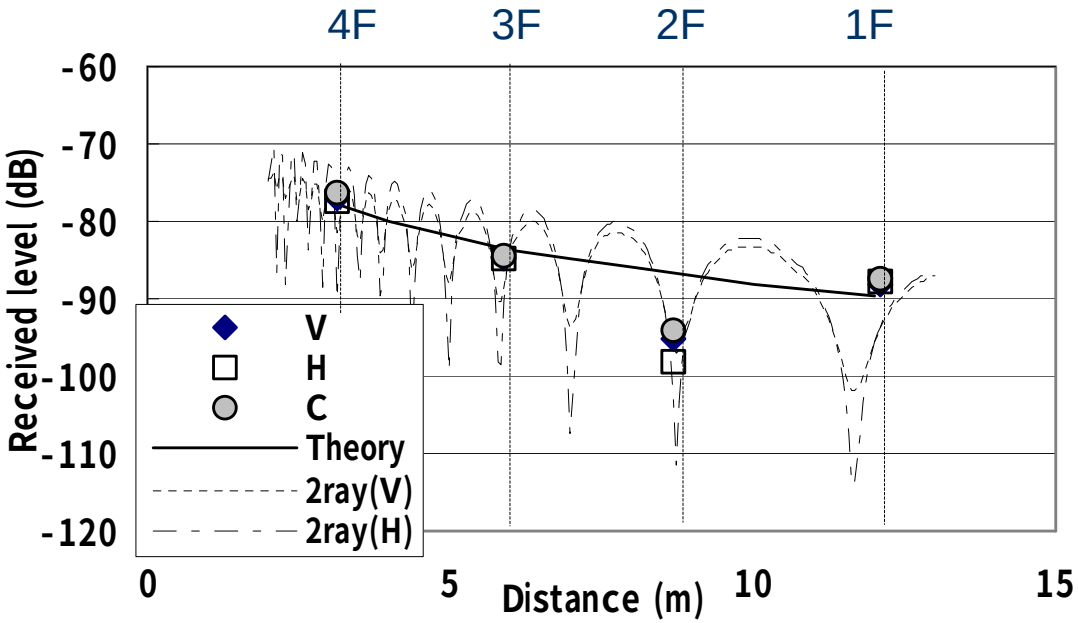
The measurements for the vertical direction



Apartment	(B)	
Antenna position	Tx: 5F / Rx: 1 F , 2 F , 3 F , 4 F	
polarization	V / H / C	
beam width	15º	
Horizontal distance	0 m	
Depth	Tx: 0.3 m	
	Rx: 0.15 m	Rx: 0.3 m
Vertical distance	Variable	
Comment	11.95 m / 8.55 m / 5.75 m / 3.00 m	
Number of measurement	3 times for each position	

Result 2 Propagation characteristics in vertical directions

- In most environments, the received level was calculated by free space pass loss equation.

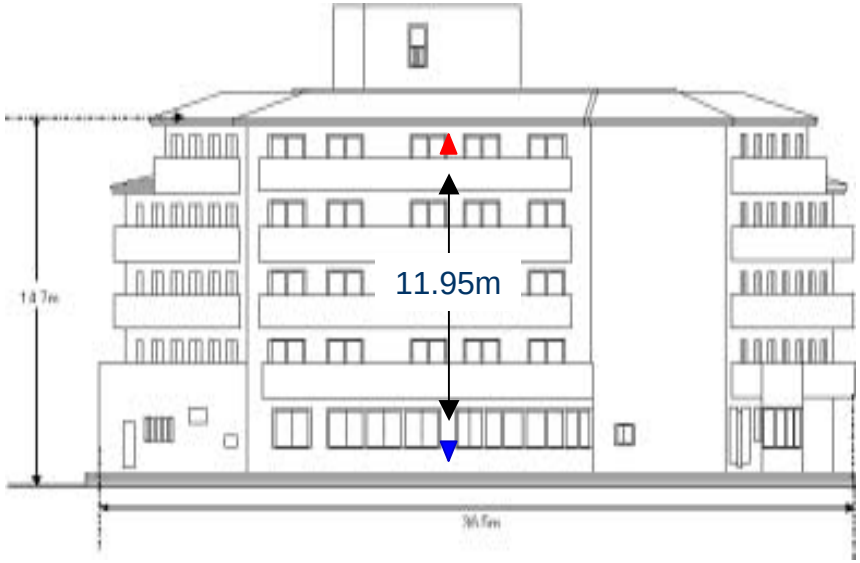


Tx : 30 cm, Rx: 30 cm

Two –ray path interference was observed between the direct signal and the reflection on the concrete wall.

delay spread : the value was 2.8 ns at this point.

Measurement 3 Effect of obstacles between Tx and Rx



Apartment		(B)	
Antenna position		Tx: 5F / Rx: 1 F , 2 F , 3 F , 4 F	
polarization		V / C	
beam width		15°	
Horizontal distance		0 m	
Vertical distance		11.95 m	
Depth (Y)	Tx	0.3 m	0.3 m
	Rx	0.15 m	0.15 / 0.3 m
Obstacles		Japanese style bed	CS antenna
Position		2 F / 3 F / 4 F	
Number of measurement		3 times for each position	

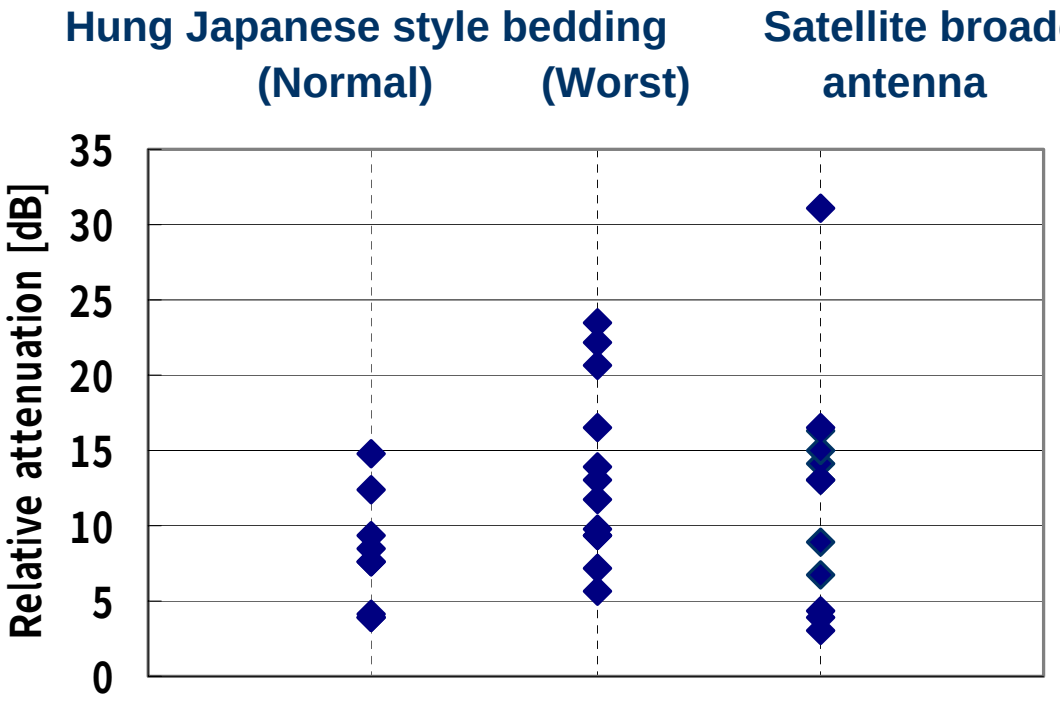
Experimental condition

Air the Japanese bedding (Futon)

Transmitter on the porch

Receiver on the ground

Result 3 Effect of obstacles between Tx and Rx

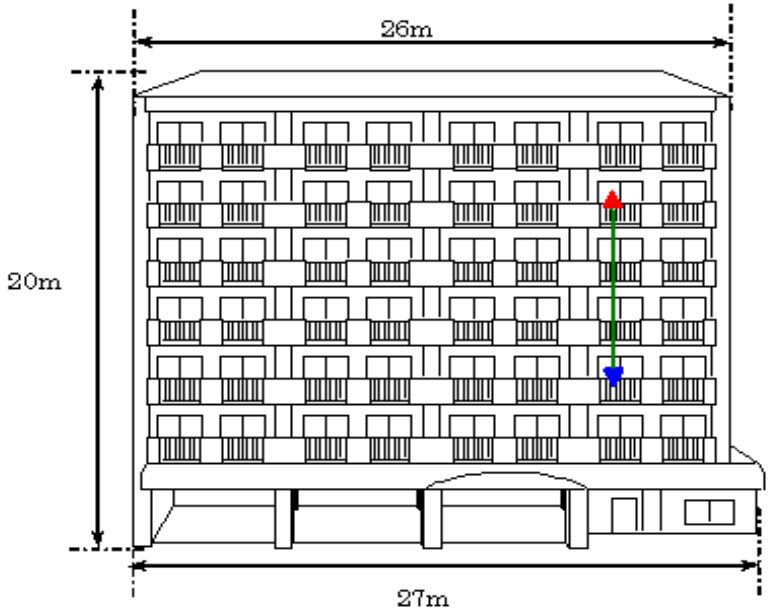


Normal case:
half the bed hung.
Worst case:
all the bed hung aiming to cut off the fresnel zone.

The delay spread was within 1 ns for hung Japanese style bedding.
The maximum delay spread was 3.5 ns for settled satellite broadcasting antenna

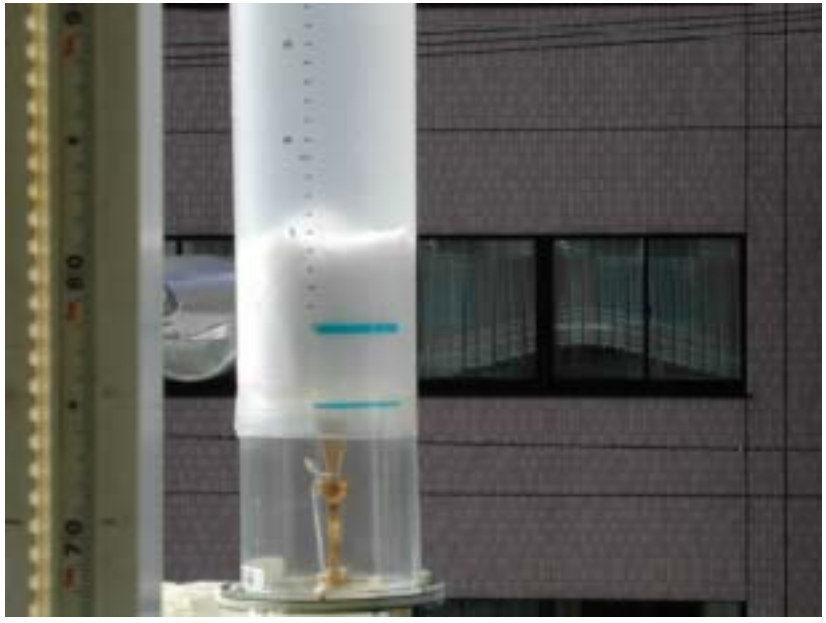
Measurement 4 Effect of snow

The measurements of the effect of the laid snow



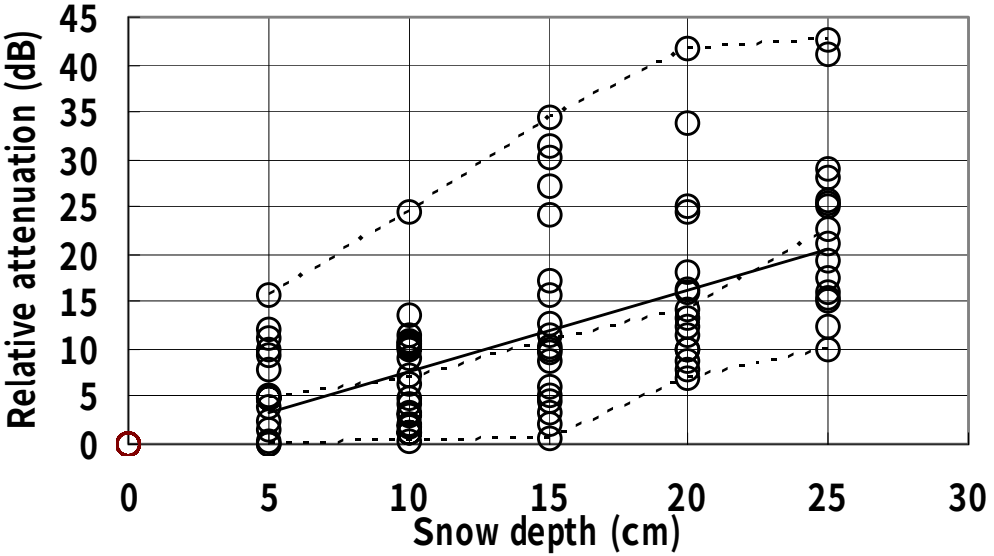
Apartment	(C)	
Antenna position	Tx: 6 F / Rx: 3F	
polarization	V	
beam width	15°	
Horizontal distance	0 m	
Depth	Tx: 0.65 m / Rx: 0.30 m	
Vertical distance	8.25 m	
Snow	Variable	
Comment	Snow depth 5 to 25 cm	Water content 0 to 500 cc

Experimental condition



Experimental conditions

Result 4-1Effect of snow depth on the Rx



5-cm-deep snow corresponds to a volume of 500 cc.

The density of the snow was 0.12 g/cc.

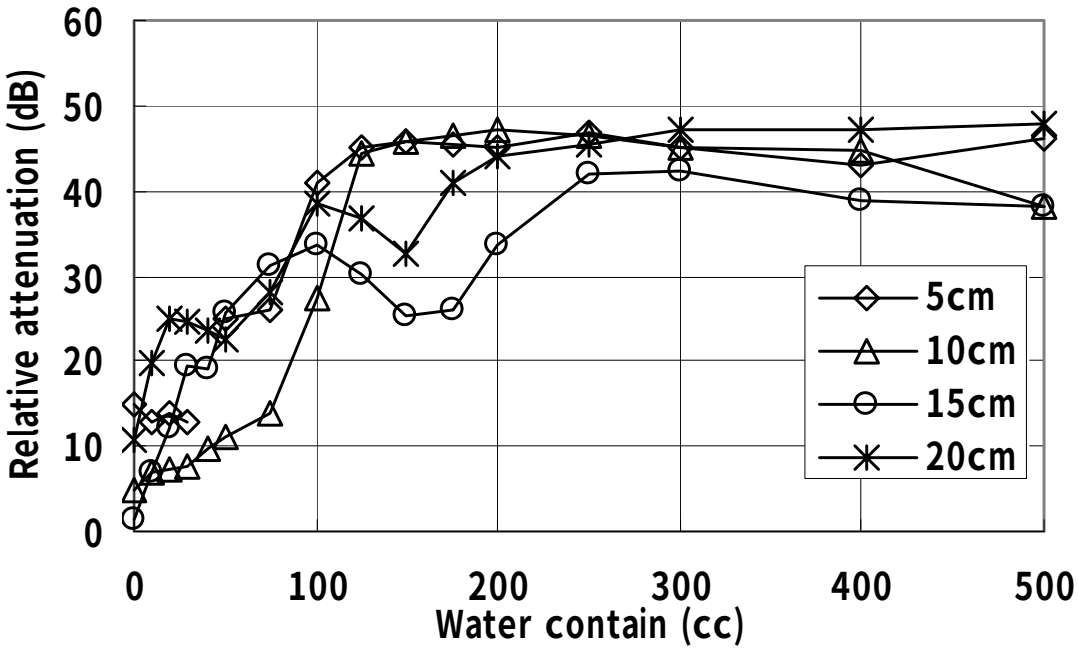
The relationship between the snow depth and median attenuation value is approximated by the following linear approximation

$$y_1 = 0.85x_1 - 0.95 \qquad (2)$$

where x_1 is the snow depth [cm] and y_1 is the relative attenuation [dB].

delay spread : the maximum value was 3.9 ns.

Result 4-2 Effect of water content for snow



The density of the snow was 0.072g/cc.

The measured attenuation increased according to the amount of water.
Delay spread : less than 1 ns when the water content was less than 100 cc,
increased when the water content exceeded 100 cc (max. 6.5 ns).

Conclusion

- We show the propagation measurement results for 60-GHz propagation for a vertical direction.
- As for obstacles, the position of the antenna is important to construct the VCWL system. (Since a small-sized system in the 60-GHz band can be realized, most of problems will be solved in the users' side in each environment.)
- As for laid snow, a countermeasure is needed.
  (Ex. improvement of antenna cover)