Wireless Communications inside Robots

Complete wireless signal transmission for control signal for each motor, and sensor signal

Now, it operates using a large number (about 60) of motors (WABIAN etc.).

Increasing weight and securing wiring problem at creation time

Disconnection due to operation, inflexible configuration

Non-contact connector, power transmission, with all control signals and sensor signals wireless and wiring free

Establish low latency, reliable communication between multiple proximity sensors

Lightweight, flexible design possible

Wired like Wireless Communication

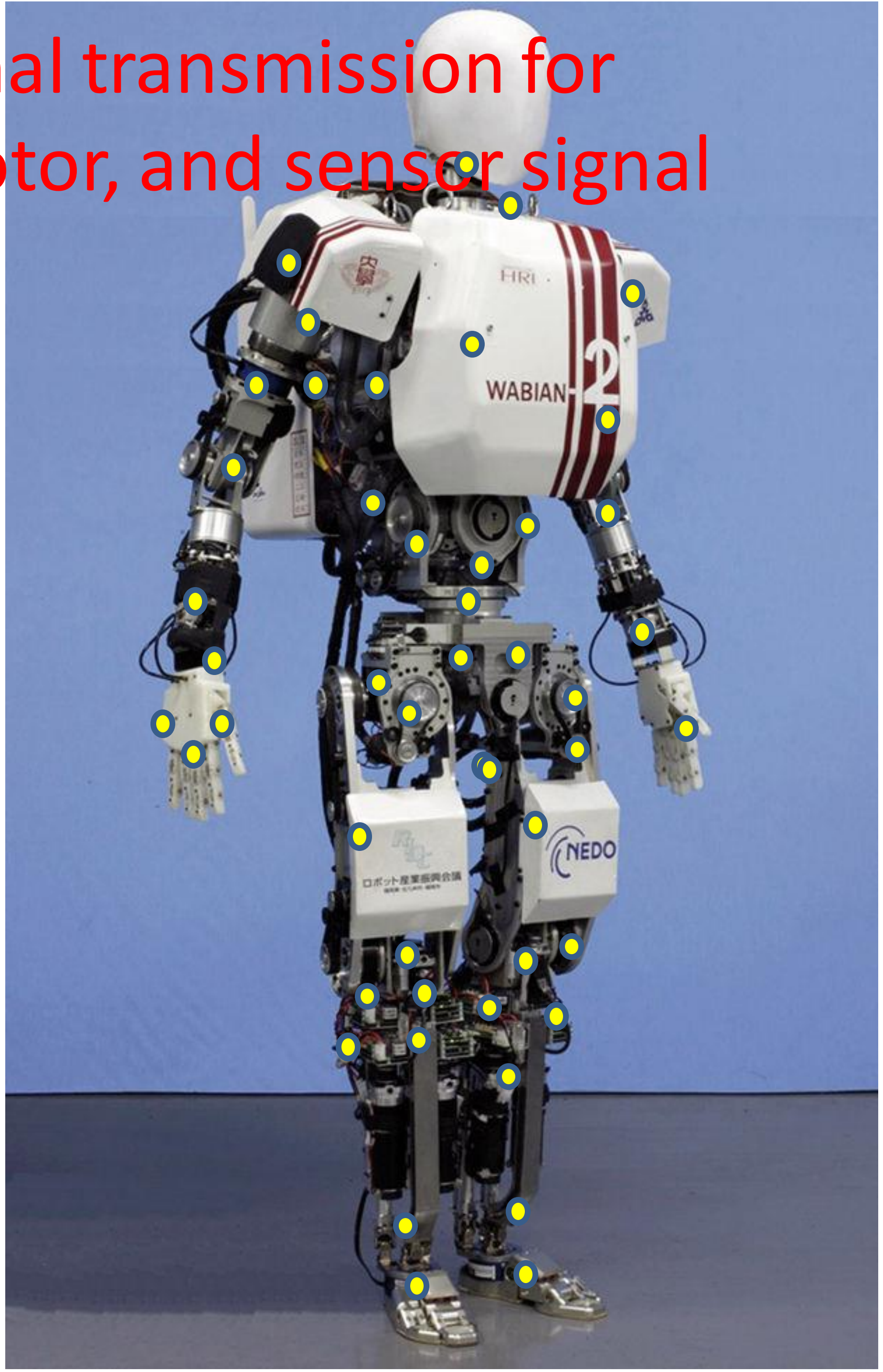
Target value

Number of simultaneous connections

100 sensors or devices

Delay　0.1msec

Reliability　99.999% (Almost 100%)



Ultra-reliable, ultra-low delay communication technology for harness free

Ultra-reliable, ultra-low delay communication for harness free

Research on complete wireless communication system instead of wired system

⇒ Aiming for new utilization of high frequency band

Aimed at

Realization of ultra-reliable and ultra-low delay communication enables complete wireless communication using inside and near autonomous mobile objects etc.

Realization of “**Wired like Wireless Communication !**

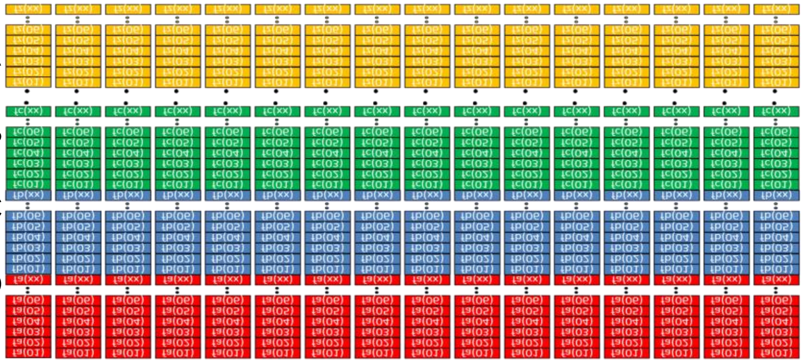
- With100devices, delay0.1msec, reliability 99.999%
- Massive Channel Access,ultra-reliable NOMA

2足歩行ロボット

車両

【Massive Channel Access】

Each frequency band is divided into several hundred channels , which are accessible based on frequency band, channel and time diversity



【Ultra-reliable NOMA】

Access control that enables dynamic power allocation on time axis and frequency axis

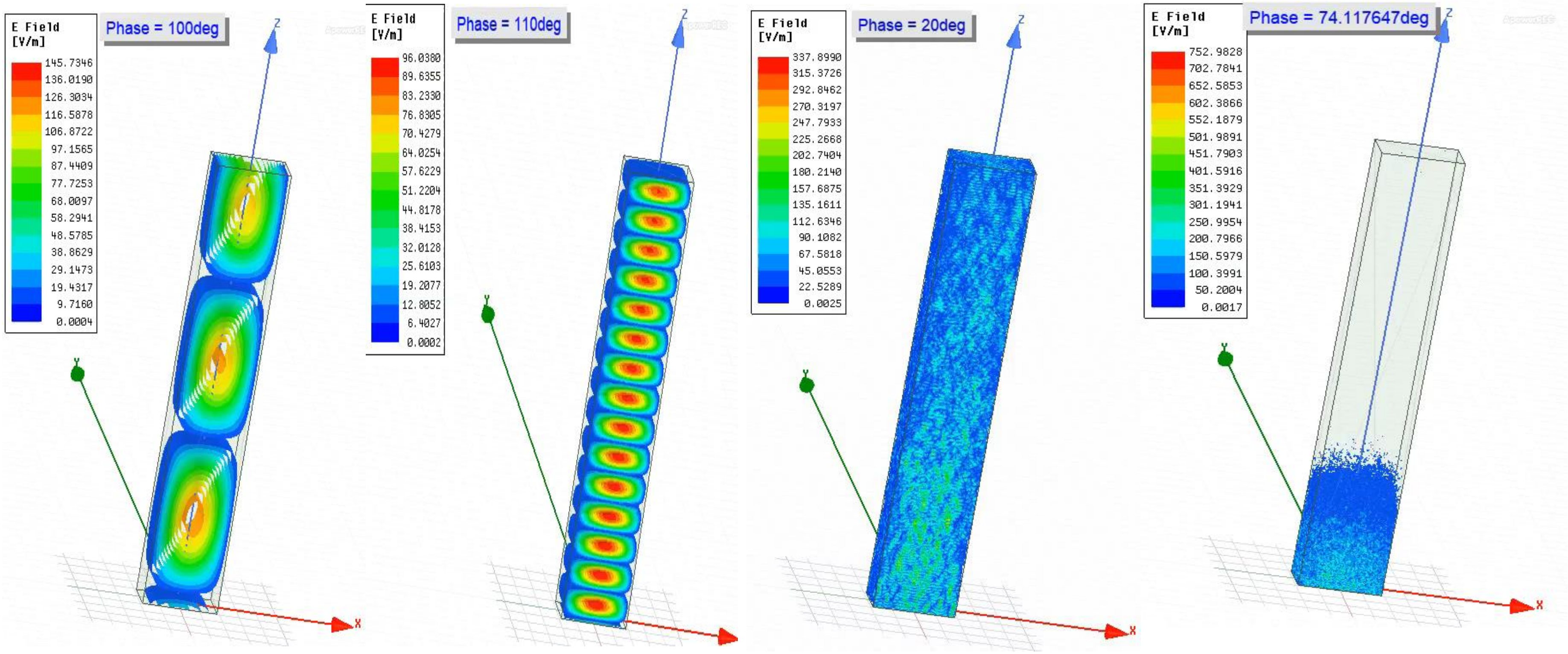
power level	4	p13	p14	p15	p16	p9	p10	p11	p12	p5	p6	p7	p8	p1	p2	p3	p4
	3	p9	p10	p11	p12	p5	p6	p7	p8	p1	p2	p3	p4	p13	p14	p15	p16
	2	p5	p6	p7	p8	p1	p2	p3	p4	p13	p14	p15	p16	p9	p10	p11	p12
	1	p1	p2	p3	p4	p13	p14	p15	p16	p9	p10	p11	p12	p5	p6	p7	p8
slot		1	2	3	4	5	6	7	8	9	10	11	12	12	14	15	16
		frame 0				frame 1				frame 2				frame 3			

【Millimeter wave OOK transmission】

Simplify, reduce delay of interface and circuit to send as OOK signal by millimeter wave

V- Hybrid MAC and Signal Propagation

Rectangular shape (width, a=190mm, height, b=95mm)



a) 900 MHz frequency band

b)2.4 GHz frequency band

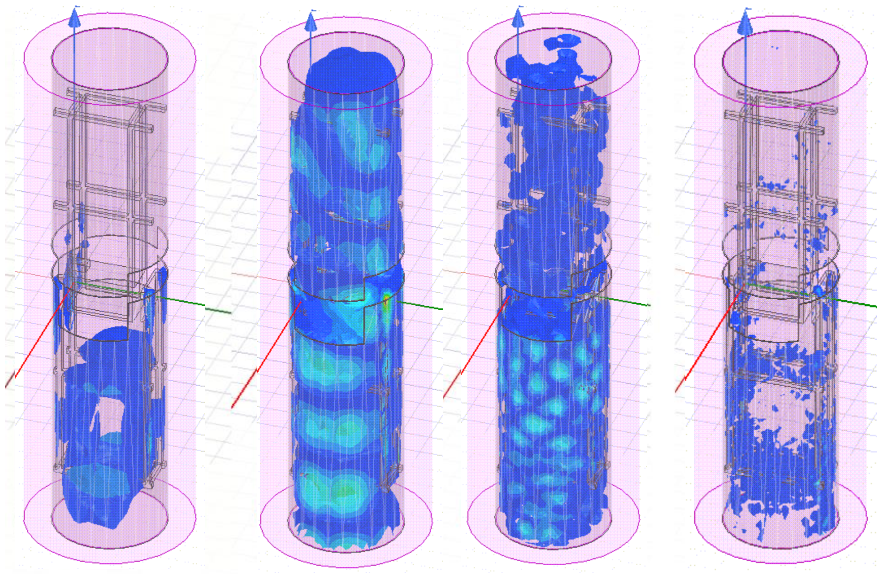
c) 24 GHz frequency band

d) 55 GHz frequency bands

Fig. 25: 20 dBm signal transmission inside the rectangular waveguide **190 mm** width, **95mm** height and 1000mm long over different frequency bands.

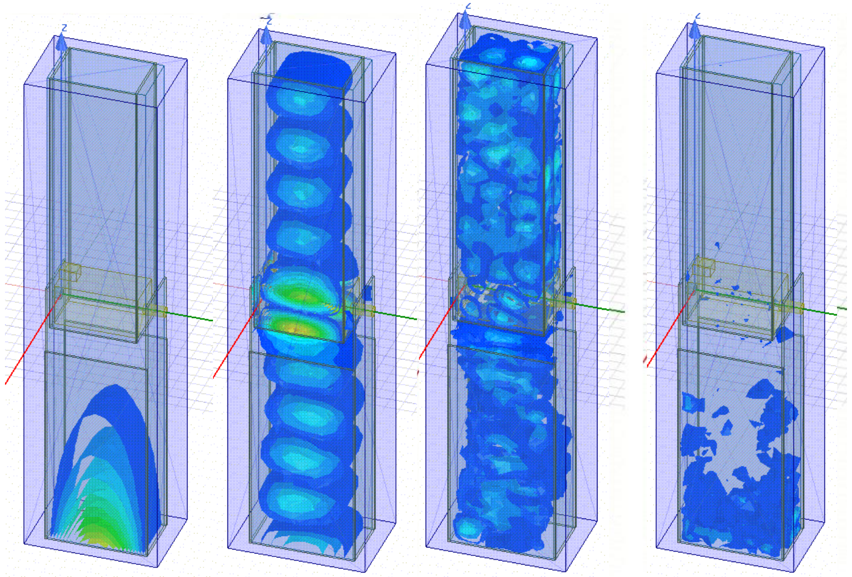
Interfere waveguide model

- Iron Circular Interfere model



(A) (B) (C) (D)

Fig. 8 Signal propagation in circular interfere model with different frequency. (A)900MHz, (B)2.4GHz, (C)5.5GHz, (D)24GHz



(A) (B) (C) (D)

Fig. 5 Signal propagation in iron rectangular interfere model with different frequency. (A)900MHz, (B)2.4GHz, (C)5.5GHz, (D)24GHz

Realistic model

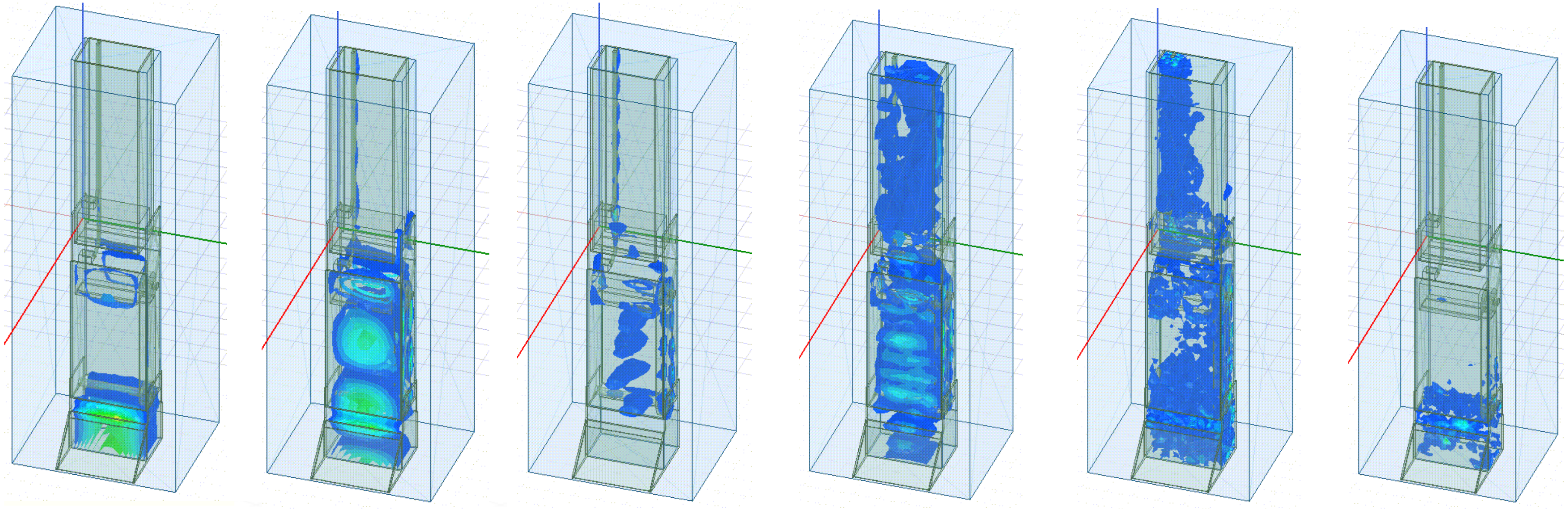
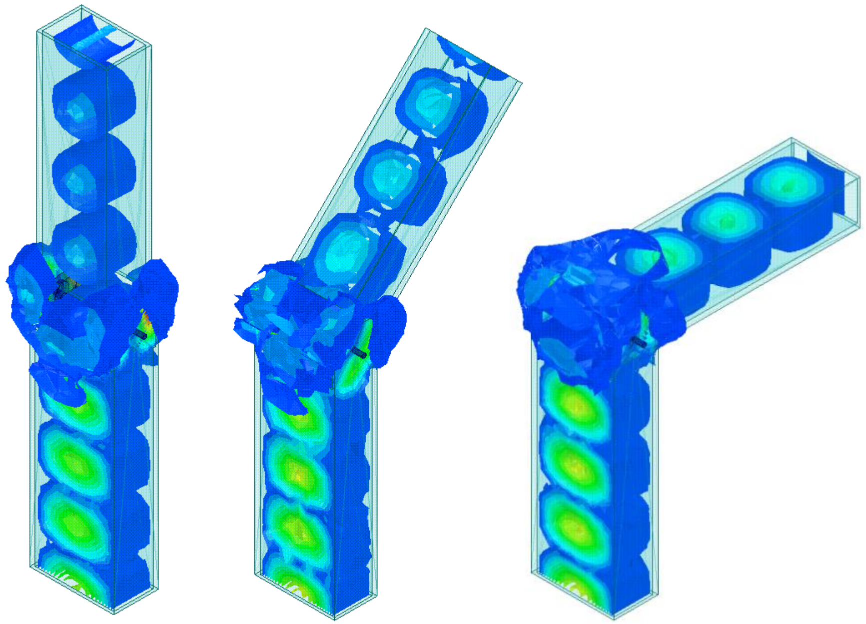


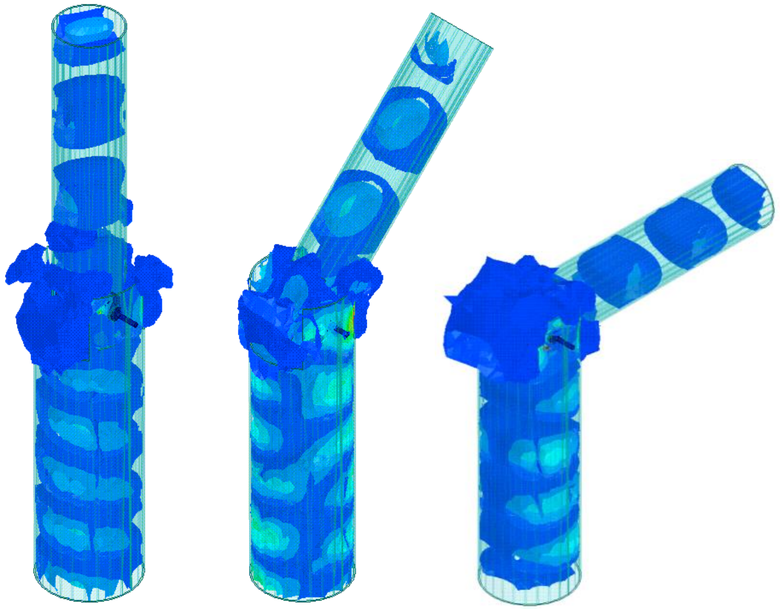
Fig. 10 Signal propagation in realistic rectangular robot leg model with different frequency.
(A)900MHz, (B)1.5GHz, (C)2.4GHz,(D)5.5GHz, (E)15GHz, (F)24GHz

Simulation Results

Rectangular robot leg model



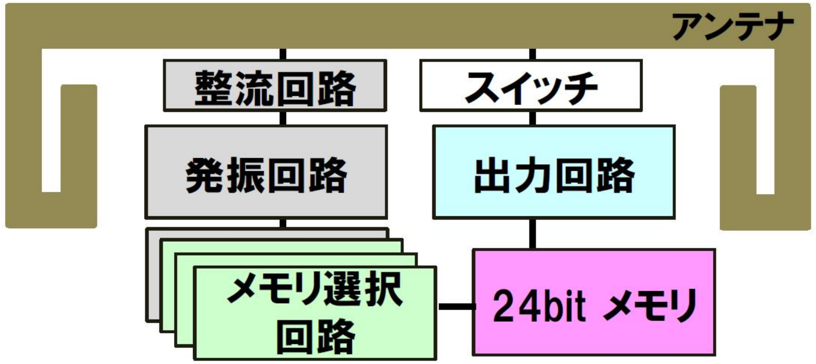
Circular robot leg model



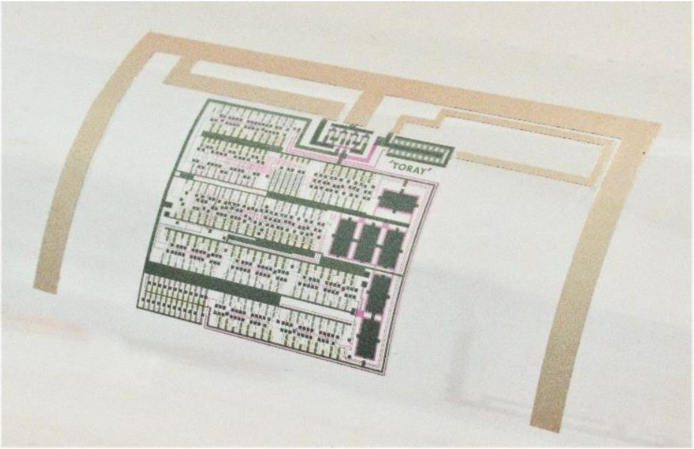
RFID Communication

Carbon Nanotube based RFID

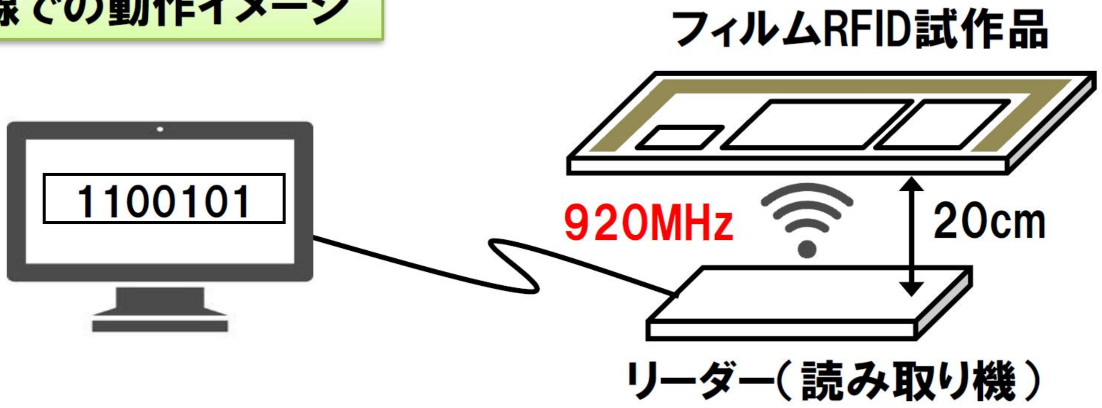
フィルムRFIDの試作品



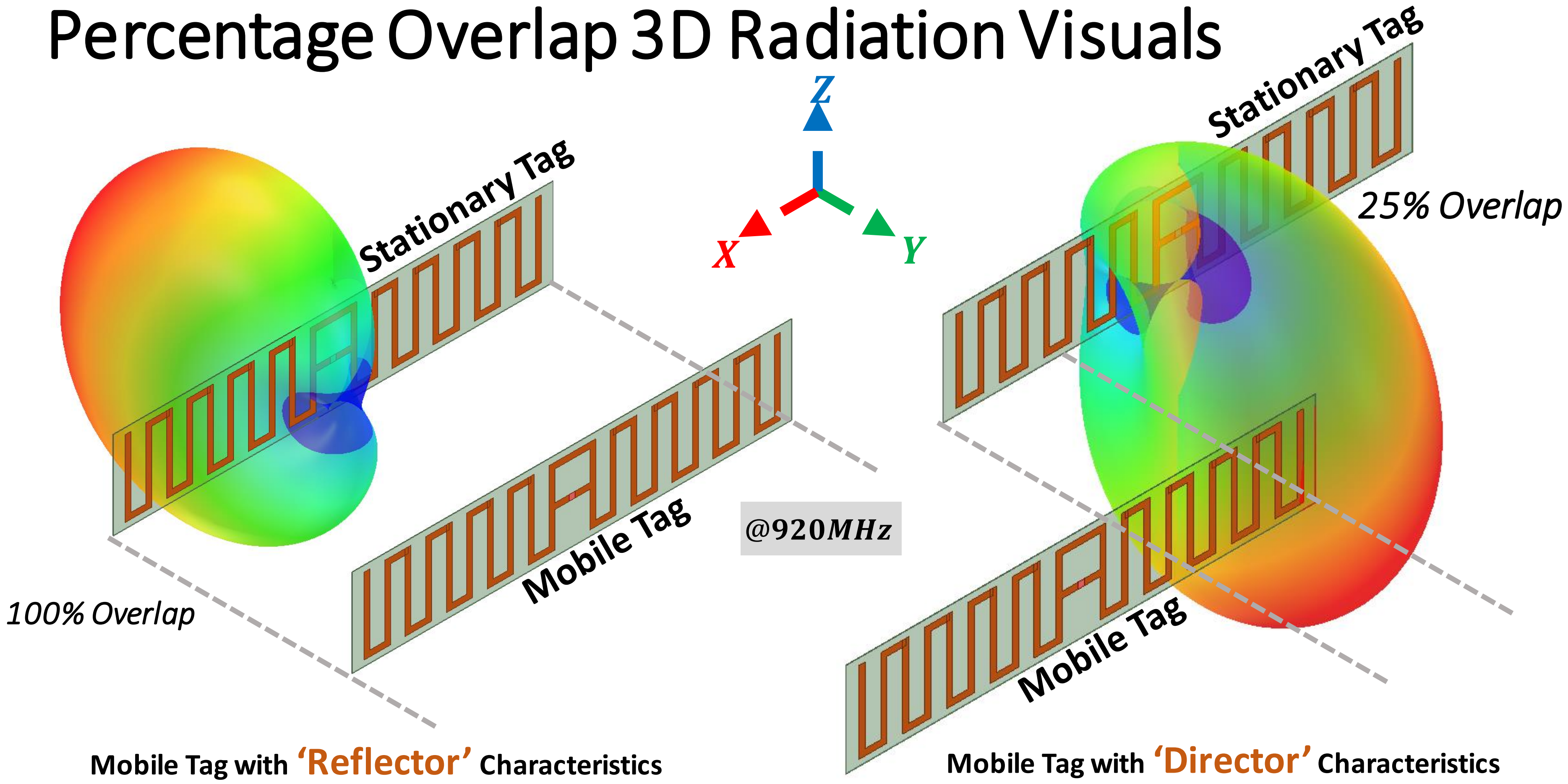
フィルムRFID試作品写真



UHF帯無線での動作イメージ



Percentage Overlap 3D Radiation Visuals



Proposed ALOHA-SIC-based System

Application Specific

- Dielectric shelves
  - Used as scatterers and attenuators
  - **Passive power control**
  - ⇒ Greater **power level differences**
- 2 Shelves = 3 power levels

ALOHA-SIC-based Smart Refrigerator

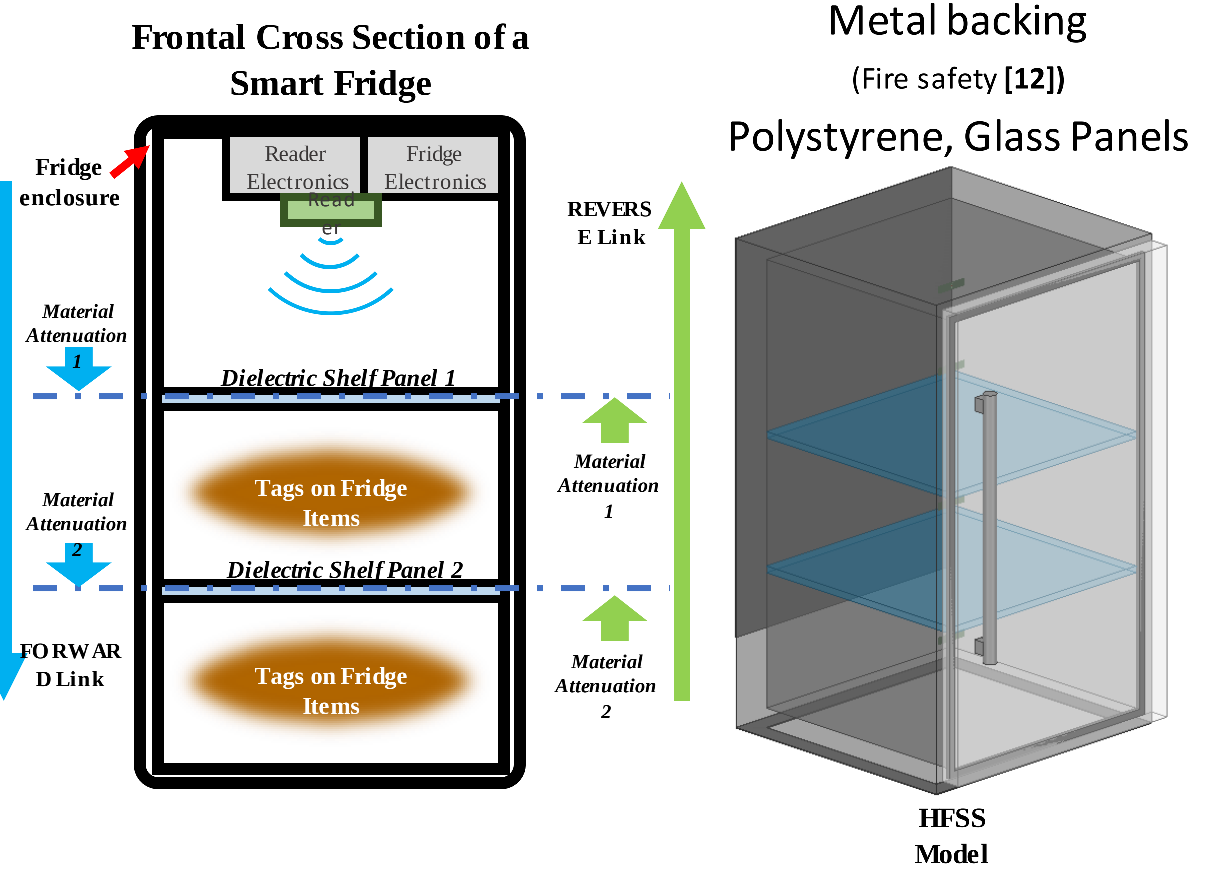
Dimensions (mm)

550x550x1000

Metal backing

(Fire safety **[12]**)

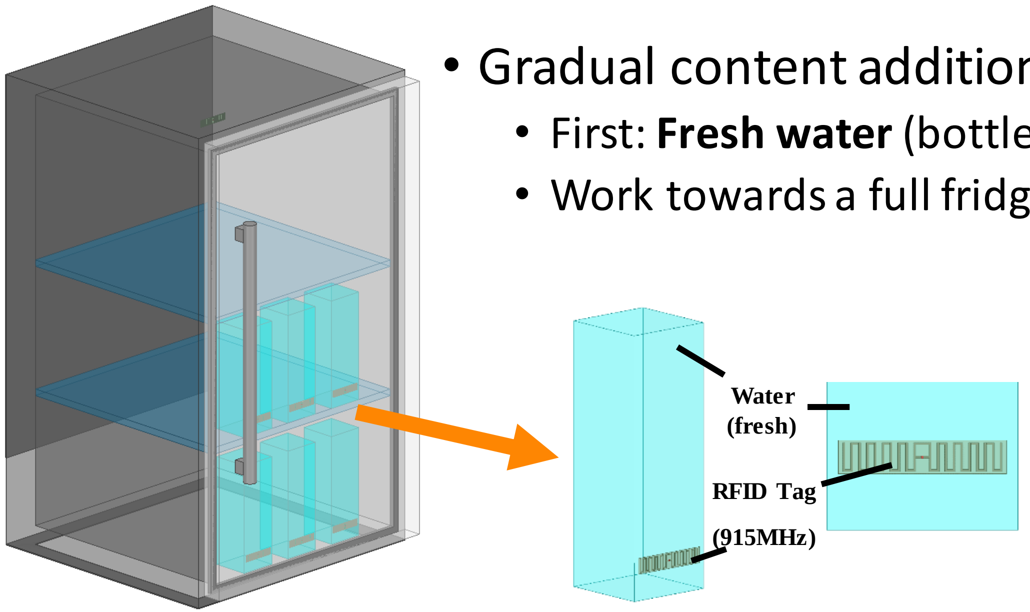
Polystyrene, Glass Panels



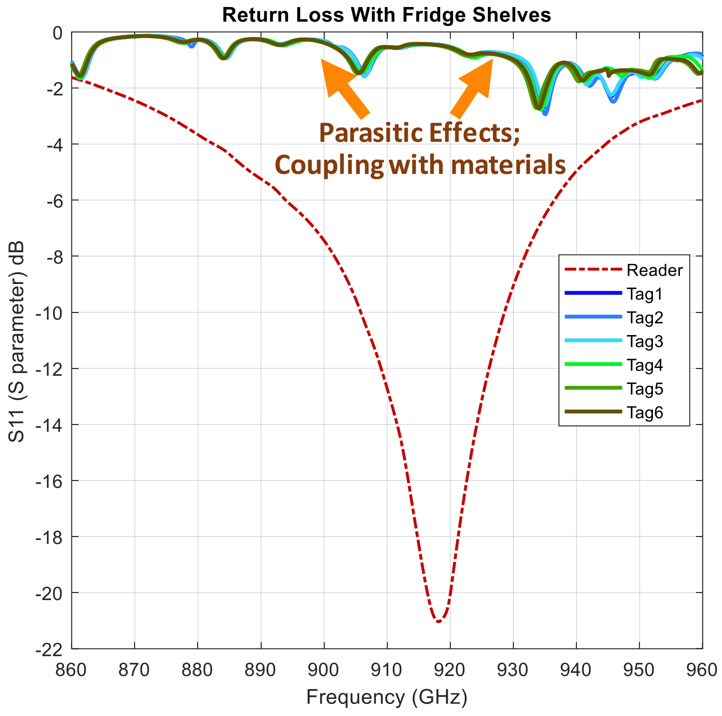
Refrigerator Content

- Next step: Addition of **fridge content**
  - Approach real-world use

- Gradual content addition
  - First: **Fresh water** (bottles)
  - Work towards a full fridge



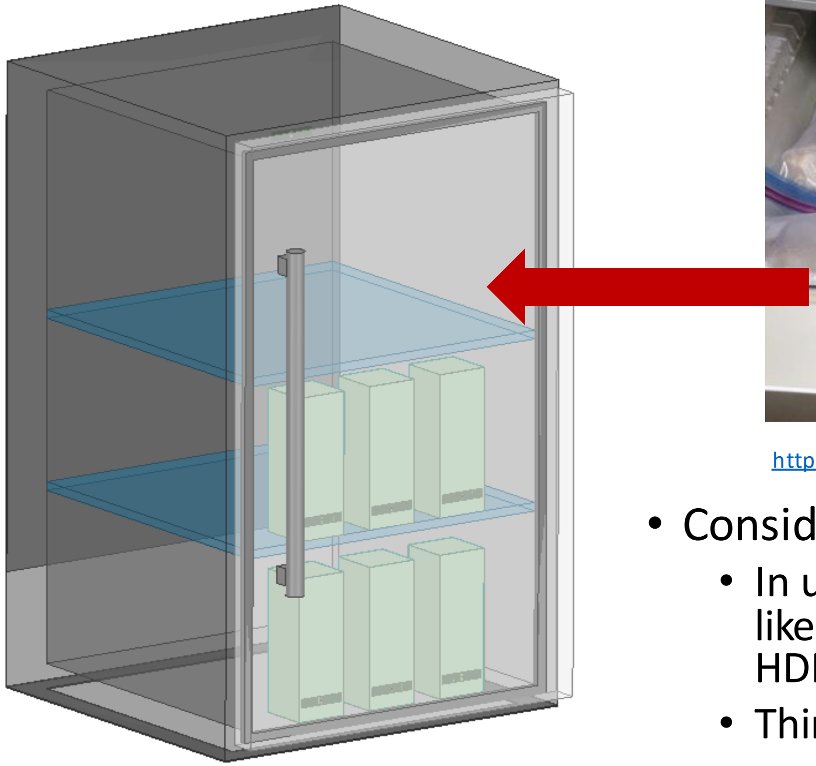
Return Loss Resulting from addition of water bottles



Challenges: Reflections + resonance

Solutions: Matching elements on tag

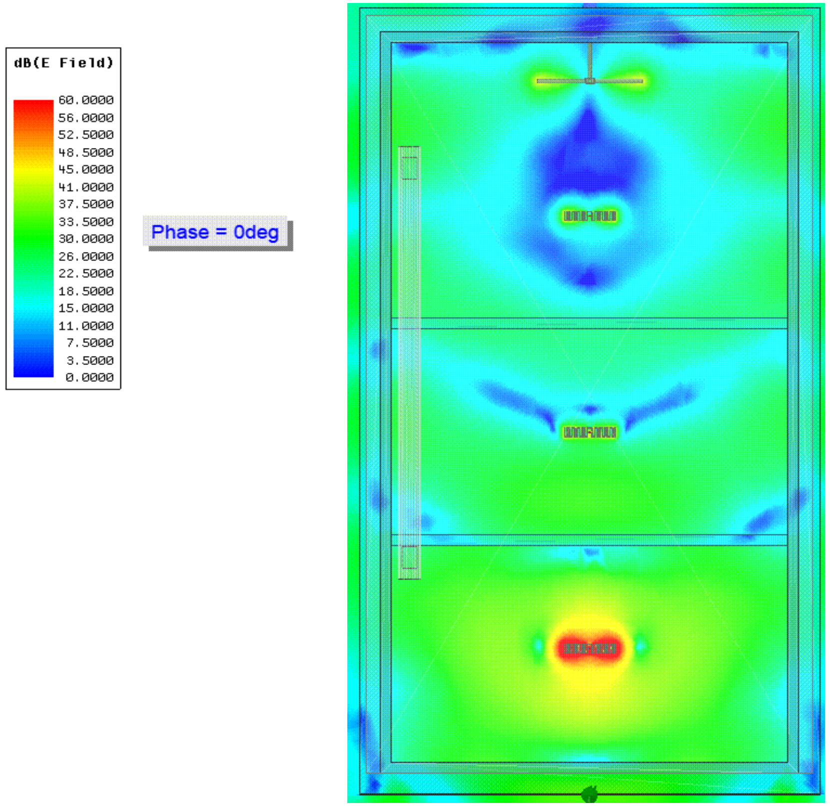
Future Plan 2/2



https://www.maff.go.jp/j/syouan/seisaku/foodpoisoning/frige.html

- Considering put foods inside the model
  - In usual, foods are packed with Ziploc or something like that (consisted of High-density polyethylene, HDPE)
  - Thinking about approximating them by PE model

Change Reader into Dipole (Simulation Result)



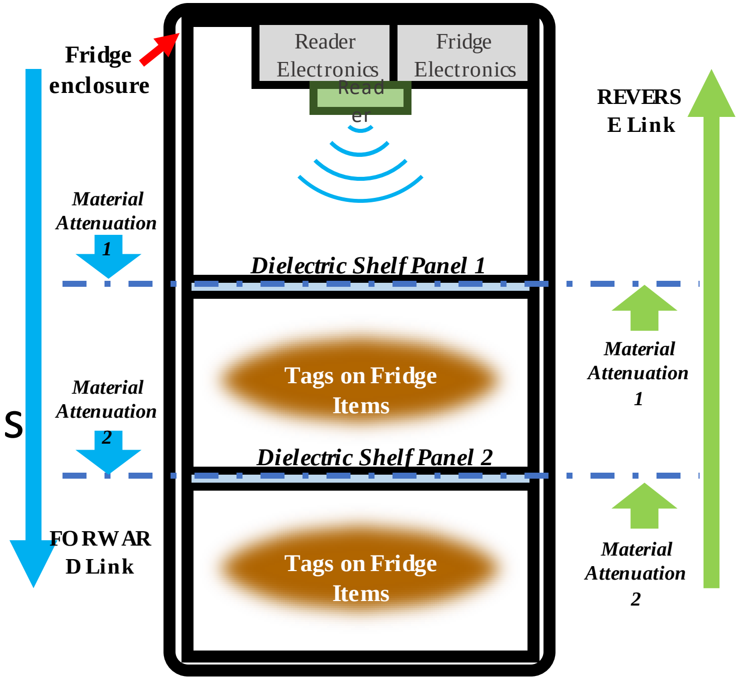
- Animation result
  - Electric power level is **lower when it's closer to dipole antenna** (need more study about dipole antenna effects)
  - -> Better to put foods in lower shelf for simulation

Pro

Application Specific

- Dielectric shelves
  - Used as scatterers and attenuators
  - **Passive power control**
  - ⇒ Greater **power level differences**
- 2 Shelves = 3 power levels

Frontal Cross Section of a Smart Fridge



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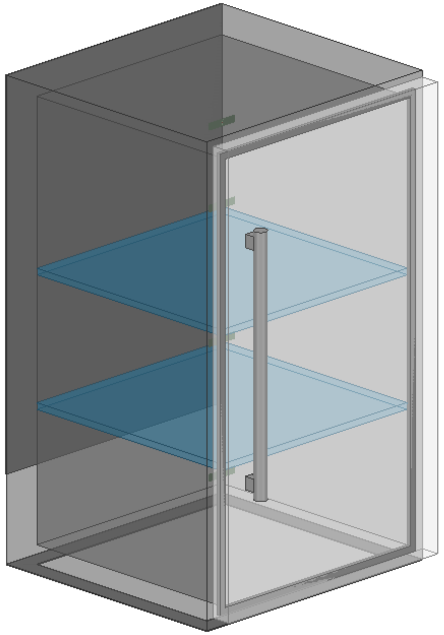
Polystyrene, Glass Panels



HFSS Model