Wireless Body Area Network (WBAN)

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– IEEE 802.15.6 and Human Body Communication –

1. IEEE 802.15.6
2. UHF Narrow Band Radio
3. UWB (Ultrawide Band)
4. HBC (Human Body Communication)
5. Communication between Person and Robot using Human Body Communication
6. Joint Study on Human Body Communication between Korea and Japan
7. Next Generation Human Body Communication

Hideyuki Nebiya
AMPLET Communication Lab.

1. IEEE 802.15.6

Medical and Healthcare
Short Range Wireless Communication (IEEE 802.15.6)

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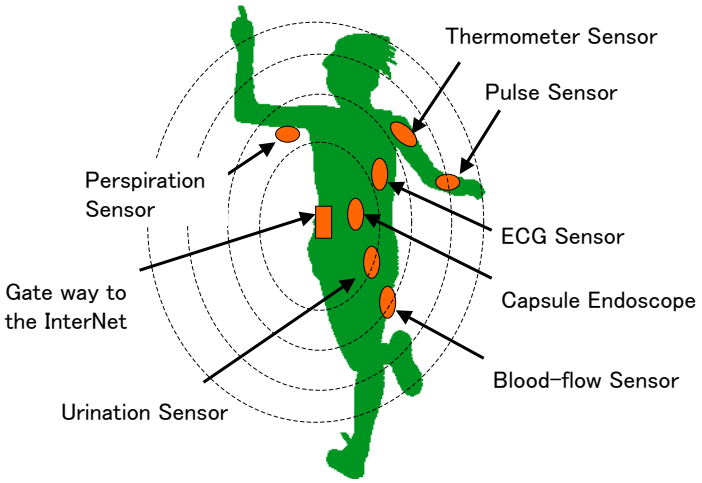

Summary of the WBAN Standard "IEEE 802.15.6"

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	IEEE 802.15.6			
	UHF Narrow Band Radio		UWB	HBC
PHY	NB-PHY		UWB-PHY	HBC-PHY
Band	402～405MHz	For Implant Equipment (World Wide)	3.1～10.6GHz (UWB)	21MHz Band (5.25MHz Bandwidth)
	420～450MHz	Medical Telemeter (Japan)		
	863～870MHz	ISM Band (Europe)	Depends on the Regulation of Each Country	
	902～928MHz	ISM Band (U.S.A.)		
	950～956MHz	ISM Band (Japan)		
	2.36～2.40GHz	For Medical Equipment (U.S.A.)		
	2.4GHz Band	ISM Band (World Wide)		
MAC	Recommend the same MAC as other similar Wireless Systems			
Range	2m			
Modulation	BPSK, QPSK, GMSK, etc.			
Packet Budget	256 Byte Max			
Data Speed	1～10Mbps			
Power Consumption	Less than 10mA at 3V Operation			
Network	Star Network			

2. UHF Narrow Band Radio

Super – Low – Power Consumption
UHF Narrow Band Radio ・・・ ANT, BLE

The market where the Super – Low – Power – Consumption Radio is expected

- Communication between a smart phone, or a tablet PC and a wrist watch
- Communication between a smart phone, or a tablet PC and a health care equipment
- ANT : Original proposed protocol by Dynastream Innovations
  The de facto standard of the substantial industry
  Organization → ANT+ Alliance
- BLE : bluetooth low energy
  Organization → Bluetooth SIG

ANT

- Members of ANT Alliance : Sony Ericsson Mobile Comm, Qualcomm, Samsung, Garmin, Nordic, Suunto, Timex, Citizen, Tanita, Pioneer, A and D, etc.
- Standard decision which is conscious of the smart phone vendor
- Application Platform : ANT+
- The licensing fee is free of charge concerning the development of the equipment corresponding to ANT and software compatible with ANT+.
- De facto standard in the sport related industry.
- Track record to a sport wrist watch and running shoes.

	ANT	
	nRF24AP2 (Nordic)	CC257X (TI)
Frequency	2.4GHz ISM Band	2.4GHz ISM Band
Maximum Bit Rate	20kbps	1Mbps
Output Power	0dBm	+4dBm
Sensitivity	−85dBm	??

BLE

- Lower Power Consumption based on Bluetooth
- Members of BLE PUID WG : Apple, Qualcomm, Nokia, Sony Ericsson Mobile Comm, Casio, Citizen, Toshiba, Murata, etc.
- Members of BLE Medical Device WG : Atheros Comm, Broadcom, CSR, Intel, TI, Nokia, Mindtree, Murata, etc.
- Members of BLE HID : IC chip vendors, Peripheral equipment vendors, etc.
- An application profile is almost completed.
  PUID → Time, Proximity, Find me, Alert Nortification, Phone Alert Status, Soft Button, Network Availability, Emargency

  Medical Device → Heart Rate Monitor, Physical Activity Monitor, Blood Glucose Meter, Health Thermometer, Health Device Information, Pulse oximeter, Weight Scale

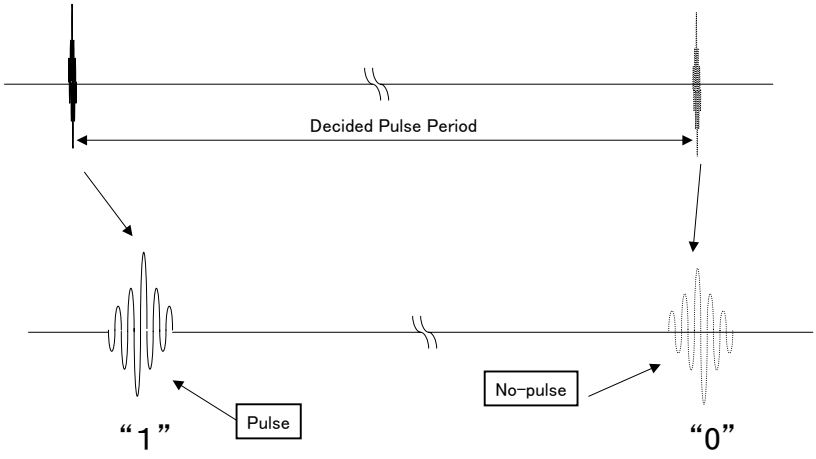
  HID → Key Board, Wireless Remort Controller, etc.
- BLE in a smart phone is expected from the past BT track record.

BLE

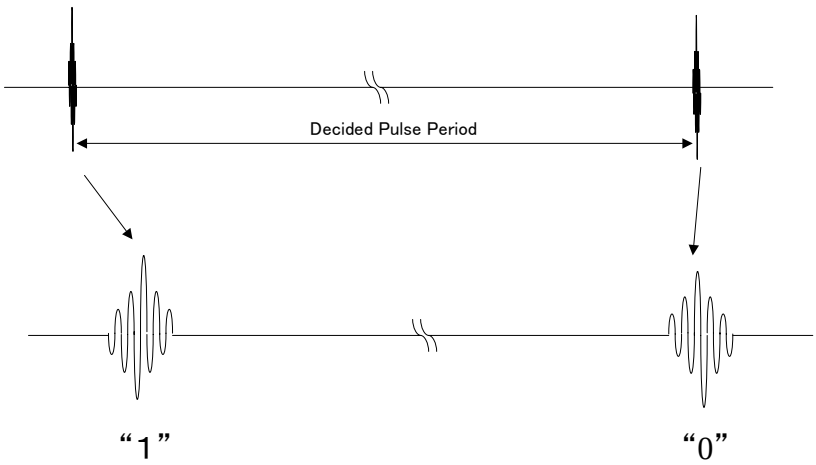
	Bluetooth (EDR Mode)	BLE (Bluetooth Low Energy)
Frequency	2.4GHz ISM Band	2.4GHz ISM Band
System	Frequency Hopping Spread Spectrum (FH-SS)	
Modulation	GFSK, π/4-DQPSK, 8DPSK	GFSK
Number of FHSS Channels	79	40
FHSS Channel Separation	1MHz	2MHz
Output Power	+20dBm (Class-1)	+8dBm (CSR1000/CSR)
	+4dBm (Class-2)	+4dBm (CC2540/TI)
		0dBm (nRF8001/Nordic)
Communication Range	30～50m (TX output 0dBm)	
Sensitivity	Less than -70dBm	-92dBm (CSR1000)
		-93dBm (CC2540)
		-87dBm (nRF8001)
ACK Packet Length	126μS	80μS
Maximum Packet Length	2875μS	328μS
Maximum Bit Rate	3Mbps	305kbps (CSR1000)
		1Mbps (CC2540)
		Variable (nRF8001)
Pico Net Topology	Corresponding	Un-corresponding
Voice Communication	Corresponding	Un-corresponding

3. UWB (Ultrawide Band)

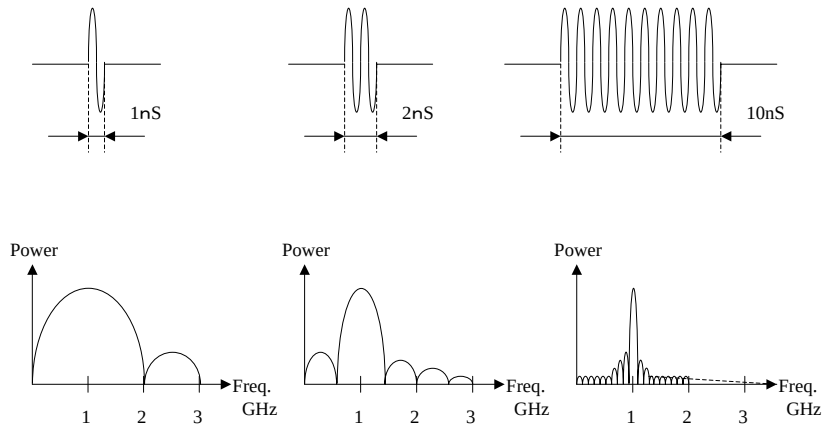
ASK Impulse UWB



PSK Impulse UWB

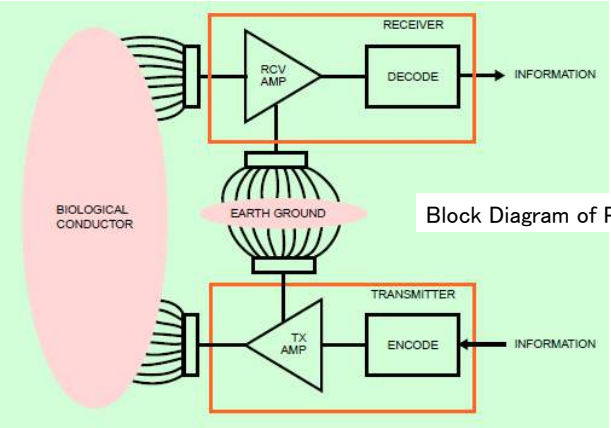


Relation between Impulse and Spectrum



4. HBC (Human Body Communication)

Electric Field Communication System
by Dr. Thomas G. Zimmerman



Block Diagram of PAN

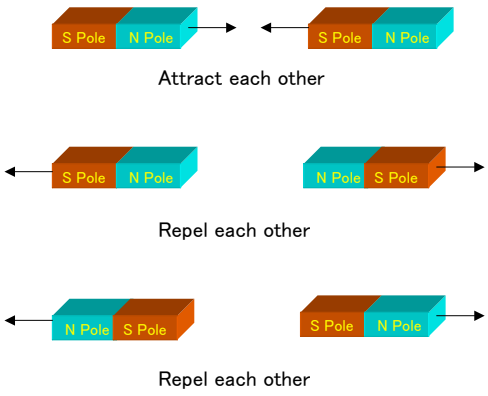
Personal Area Networks: Near–field intrabody communication,
Thomas G. Zimmerman, IBM SYSTEMS JOURNAL, VOL 35, NOS 3&4, 1996

4–1. Ultra Basic Electromagnetism

What is Magnetic Field ?

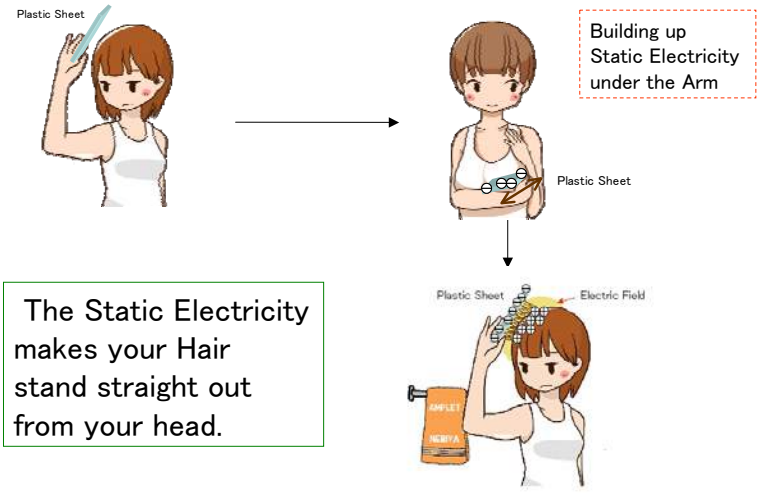
What is Electric Field ?

Magnetic Force



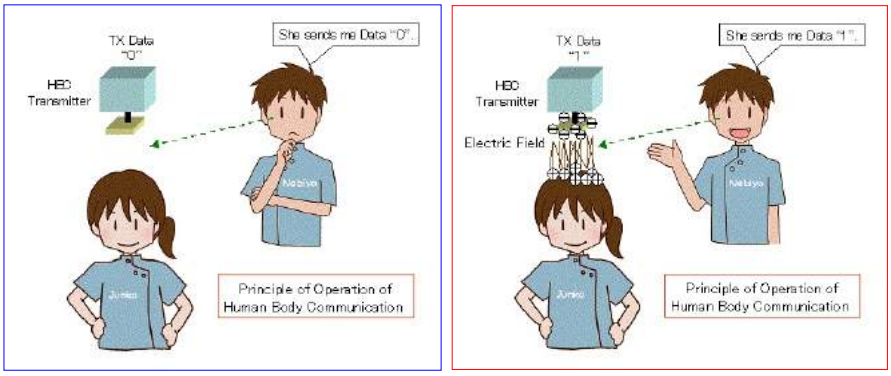
As well known, a Magnet gives the power to pull certain things. Magnetic Field depicts the Force exerted on between one north pole and one south pole.

Experiment using Static Electricity



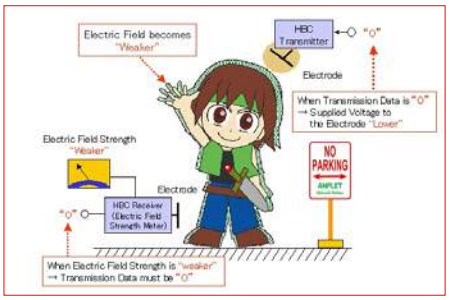
The Static Electricity makes your Hair stand straight out from your head.

Concept of HBC

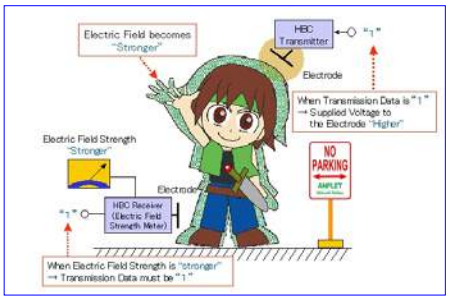


TXD = 0 TXD = 1

Operation Principle of HBC



TXD = 0



TXD = 1

4-2. Body as a Transmitter

Body as a Transmitter

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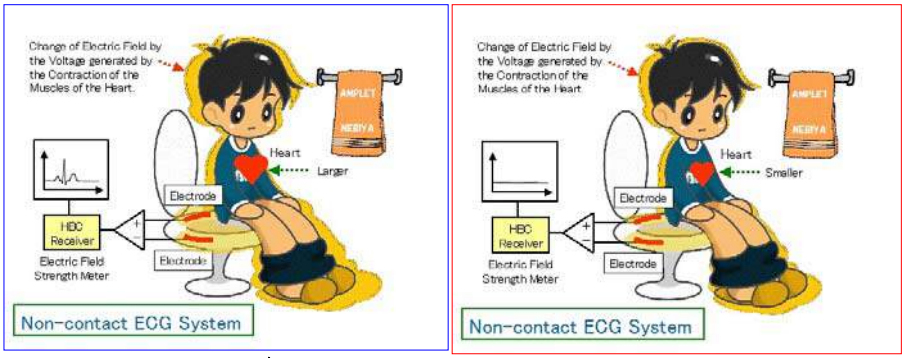

The cyclic movement of the Heart

HBC System with ECG (electrocardiogram)

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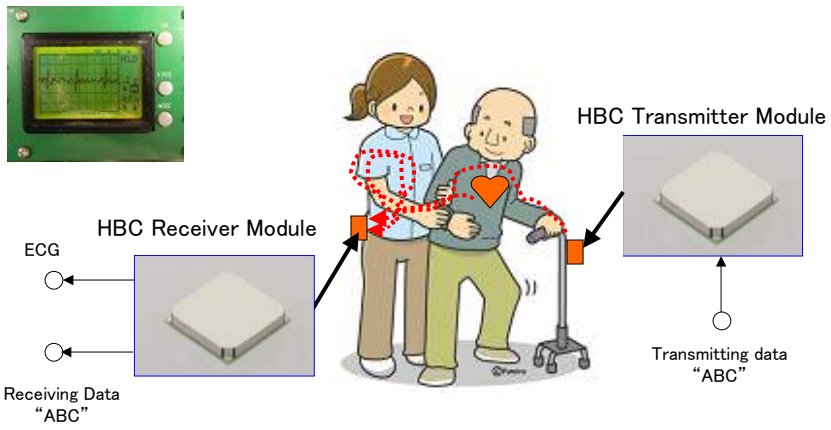
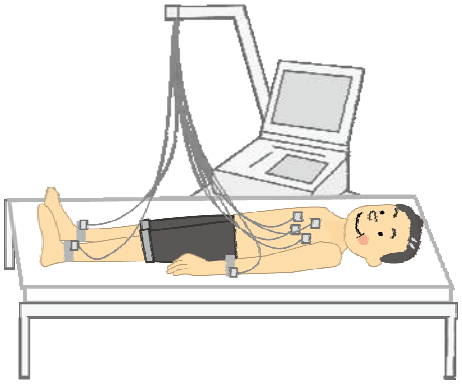


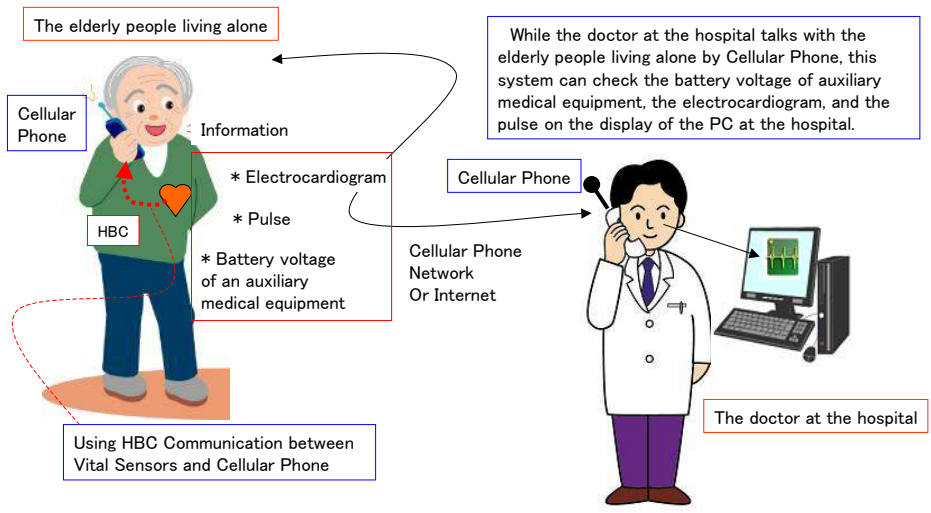
HBC Applications for Medical



If a patient uses wearable vital sensors connected to a data logging equipment, a patient cannot change sides of the bed, and cannot go to a toilet.

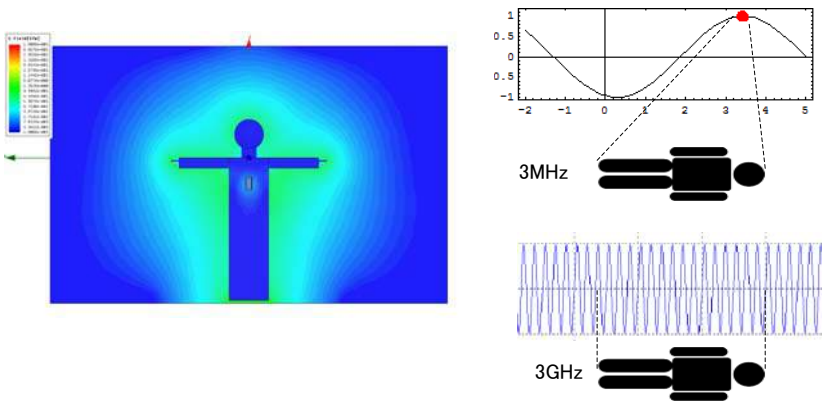
This is the reason why the HBC as short range wireless communication to be required at the hospital.

The HBC Project at the University of Tokyo Hospital



4–3. Suitable Frequency for "Electric Field Communication System"

Radiation from the Body



Suitable Frequency for "Electric Field Communication System" is HF.

Normalized Propagation Characteristics by Experiment between a Wearable Transmitter and a Wearable Receiver

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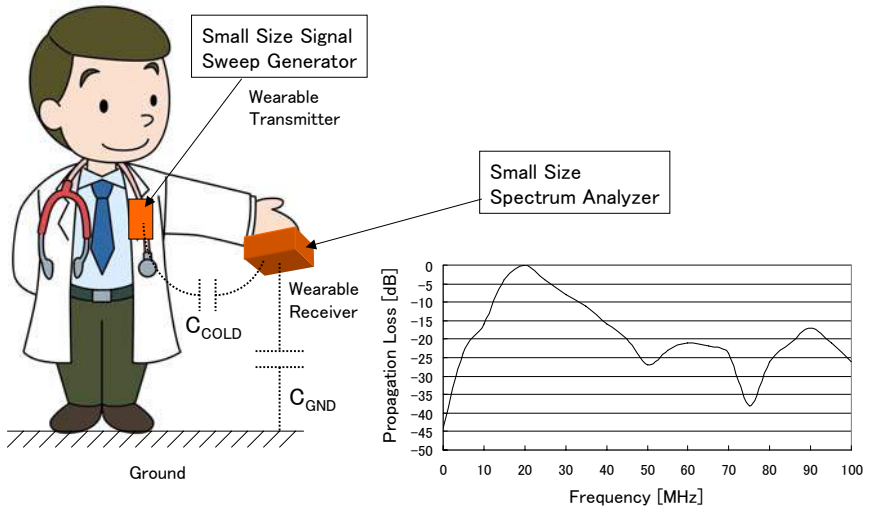

Normalized Propagation Characteristics by Experiment between a Desk-mounted Transmitter and a Desk-mounted Receiver

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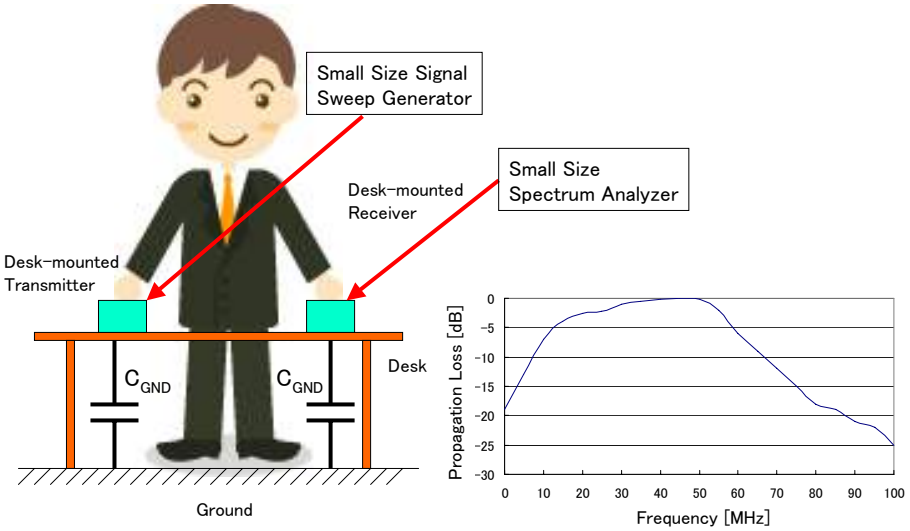
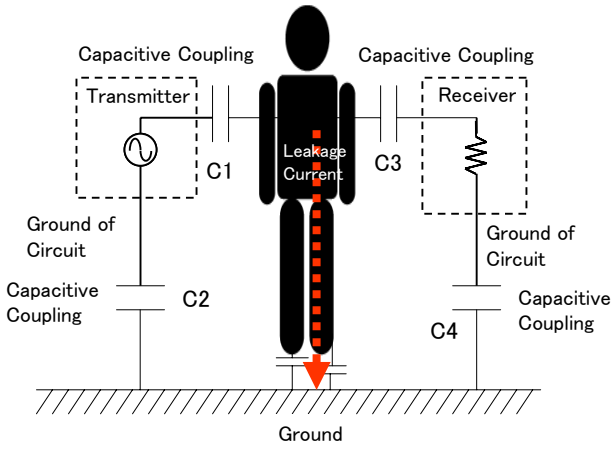
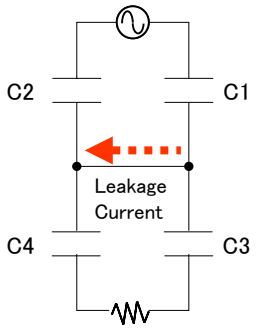


4-4. How to design an Electrode

How to design an Electrode



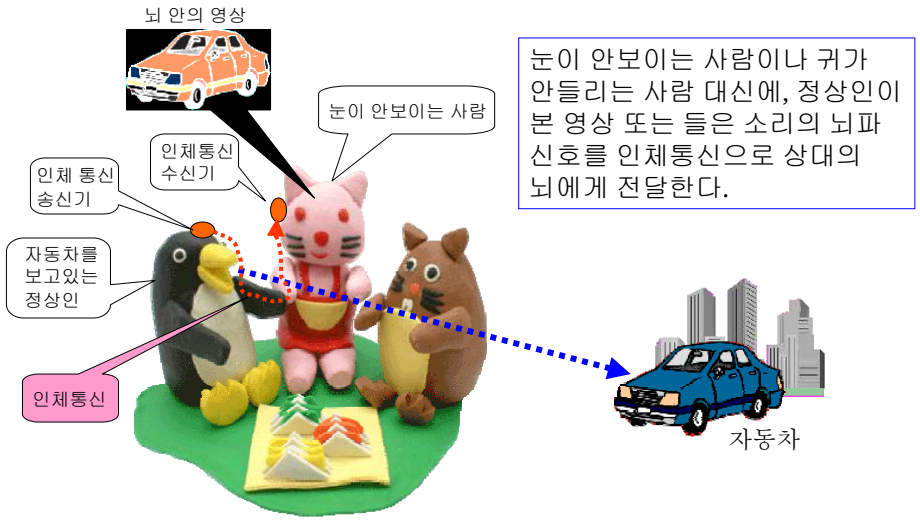


Condition of Leakage Current = 0

→ C1 : C3 = C2 : C4

4-5. Our Dream using HBC Technology

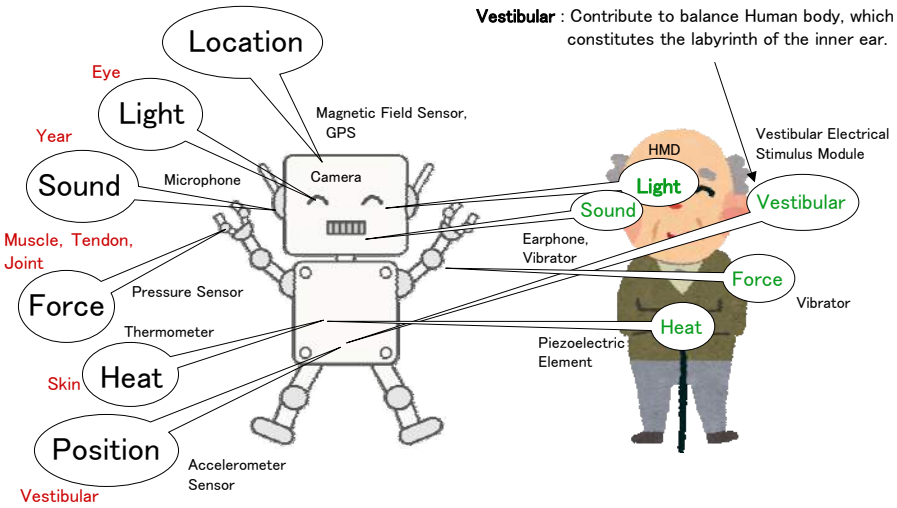
인체통신의 미래



눈이 안보이는 사람이나 귀가 안들리는 사람 대신에, 정상인이 본 영상 또는 들은 소리의 뇌파 신호를 인체통신으로 상대의 뇌에게 전달한다.

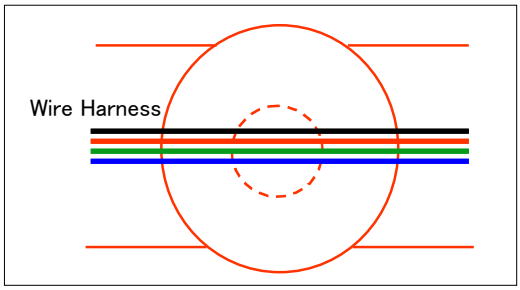
5. Communication between Person and Robot using Human Body Communication

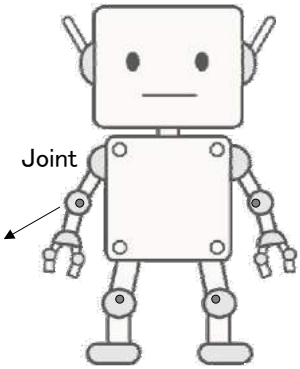
The Personal Care Robot for aged Person



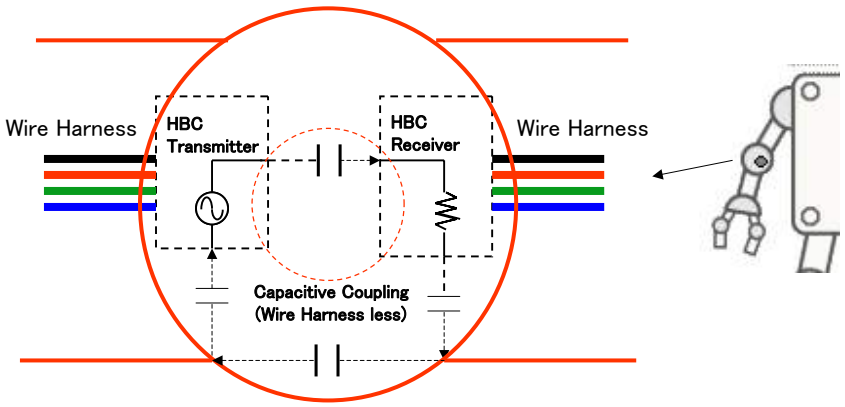
The Issue of Wire Harness Breakage at Joints of a Robot

After many times bending Arms of the Robot ・・・
Wire Harness Breakage at the Joint should happen to occur. It is a Problem !!





The Solution of Wire Harness Breakage using Human Body Communication Technology



6. Joint Study on Human Body Communication Between Korea and Japan

Joint Seminar on Human Body Communication MoU between ETRI, Korea and AMPLET, Japan

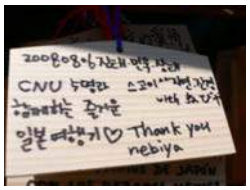
AMPLET Communication Laboratory

Chair of Korea: Dr. Byong Nam Lee (ETRI)
Chair of Japan : Dr. Hideyuki Nebiya (AMPLET, The University of Tokyo)

Education Agreement on Human Body Communication
MoU between CNU, Korea and AMPLET, Japan

AMPLET Communication Laboratory

Korea : Prof. Jong Myung Woo (CNU)
Japan : Dr. Hideyuki Nebiya (AMPLET Communication Laboratory)



7. Next Generation Human Body Communication

On-body Communication / In-body Communication

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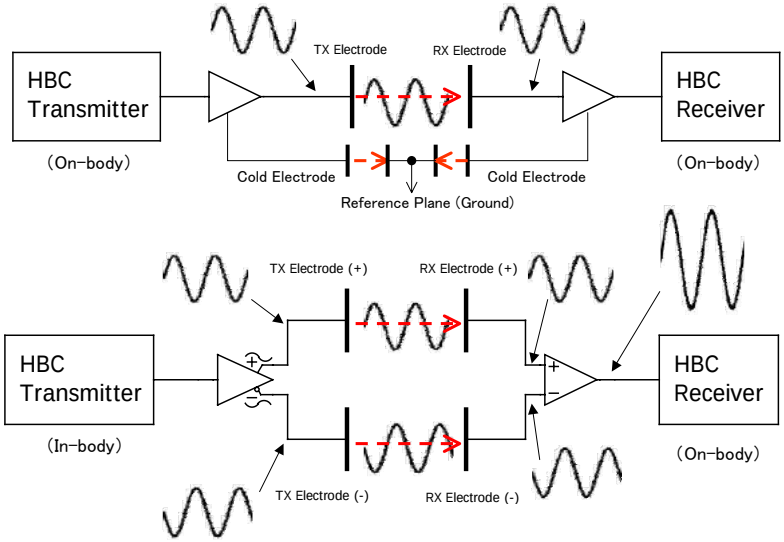

In-body Communication (Capsule Endoscopy)

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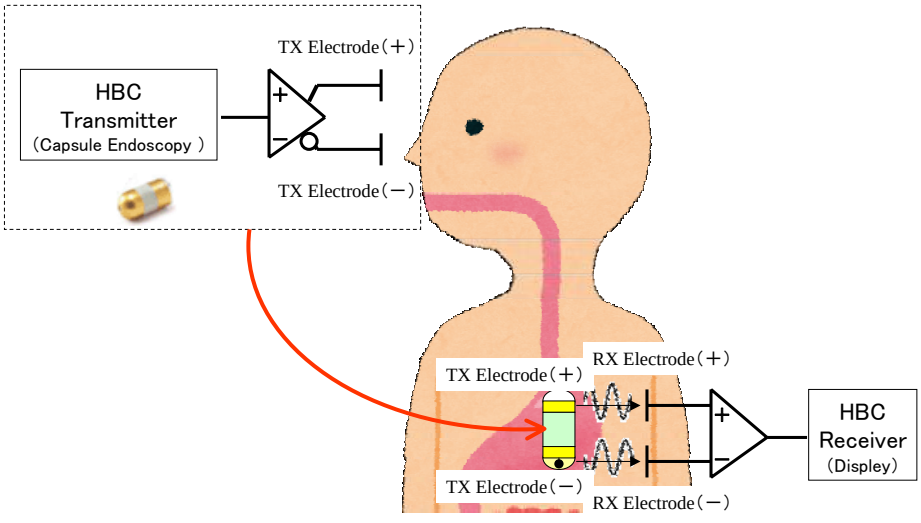
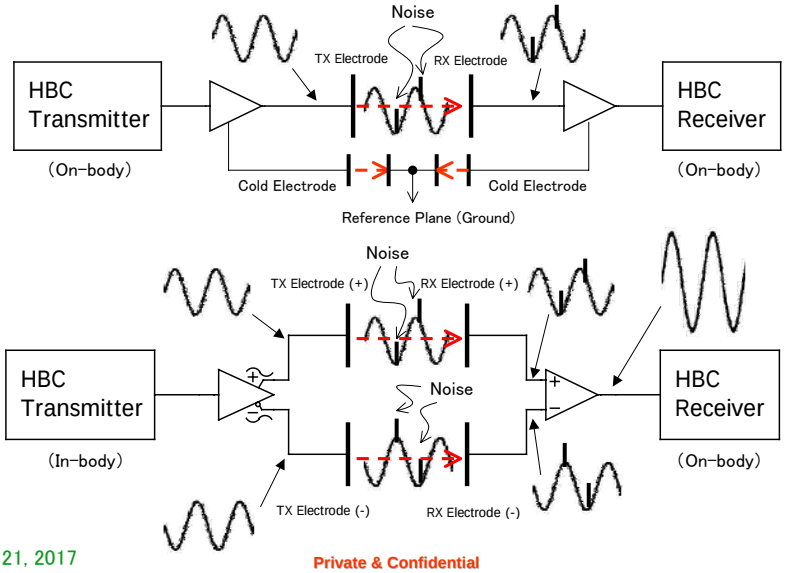
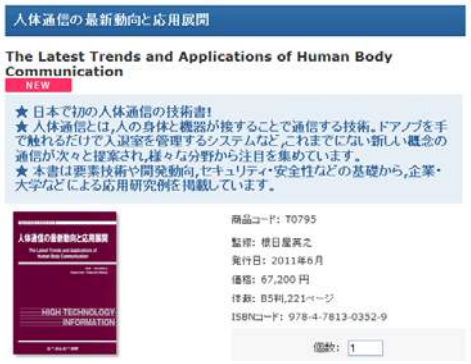


Noise Suppression using Differential Electrodes



Thank you for your attention.



HBC Technical Book
by Hideyuki Nebiya as Editorial Supervisor