[UCI]I804:24011-200000266211

February 2017

Master's Degree Thesis

RFID System for Power Transmission and Data Communication between Patch-Type and Smart Devices

Graduate School of Chosun University

Department of IT Fusion Technology

Janghyun Lee

RFID System for Power Transmission and Data Communication between Patch-Type and Smart Devices

웨어러블 디바이스용
RFID 기반 전력 전송 및 데이터 통신 시스템

February 24, 2017

Graduate School of Chosun University

Department of IT Fusion Technology

Janghyun Lee

RFID System for Power Transmission and Data Communication between Patch-Type and Smart Devices

Advisor : Prof. Youn Tae Kim

This thesis is submitted to The Graduate School of Chosun University in partial fulfillment of the requirements for the Master's degree

October 2016

Graduate School of Chosun University

Department of IT Fusion Technology

Janghyun Lee

This is to certify that the Master's Thesis of Janghyun Lee

has been approved by the Examining Committee for the thesis requirement for the Master's degree in IT Fusion Technology

Committee Chairperson
Prof. Sung Bum Pan ____________________ (Sign)

Committee Member
Prof. Hyun-Sik Choi ____________________ (Sign)

Committee Member
Prof. Youn Tae Kim ____________________ (Sign)

November 2016

Graduate School of Chosun University

Table of Contents

List of Tables

List of Figures

Acronyms

RFID	Radio Frequency IDentification
PDMS	PolyDiMethylSiloxane
IBS	Institute for Basic Science
CST	Computer Simulation Techonology
ADS	Advanced Design System
UHF	Ultra High Frequency
PCB	Printed Circuit Board

요 약

패치형 디바이스와 스마트 디바이스 간 전력전송 및 데이터 통신을 위한 RFID 시스템

이장현
지도교수: 김윤태 교수 Ph. D.
조선대학교 대학원 IT 융합학과

최근 헬스케어 분야의 웨어러블 디바이스들은 스마트 디바이스와 연동하여 인체 표면에서 다양한 생체 신호를 실시간 모니터링 할 수 있는 초소형 초박형 패치형태로 개발되고 있다. 이러한 패치형 디바이스들의 초소형 초박형 특성으로 인하여 초소형 배터리 또는 무선 전력전송 기능이 필수적으로 요구된다. 본 연구에서는 passive RFID 방식을 사용하고 전송 효율을 높이기 위해 신호손실 최적화 매칭 방식을 사용하여 스마트 디바이스와 패치형 디바이스 간 데이터 통신 및 전력전송을 동시에 하는 방식을 제안하였다.

Passive RFID 기술은 태그에 배터리가 없고 리더기에서 생성되는 전기장으로부터 자기장유도를 통해 태그로 전력이 전달된다. 배터리를 사용하지 않기 때문에 초소형으로 제작할 수 있으며 가볍고 반영구적으로 사용할 수 있다. 그러나, 인식 거리가 매우 짧고 리더기에서 많은 전력을 소모해야 한다는 단점을 가지고 있다. 이러한 passive RFID 기술을 사용하면 패치형 디바이스에 배터리를 사용하지 않고 리더기인 스마트 디바이스로부터 전력을 전송받아 사용할 수 있지만 스마트 디바이스의 전력 소모가 많아진다.

신호손실 최적화 매칭은 입력반사계수를 줄이고 신호손실을 최대한 작게 하는 매칭방법이다. 신호손실이 작아지면 리더와 태그 간 인식거리가 증가하게 된다. 이러한 매칭 방법을 이용하여 리더기에서 많은 전력을 소모하

지 않고 인식 거리를 늘려서 사용할 수 있다.

I. Introduction

The subminiature ultra-thin patch-type devices, which can monitor various human body signals by latching onto the skin, have recently emerged as wearable device applications for the healthcare industry [1]-[2]. This patch device referred to as electronic skin has various functions such as measuring various human body signals and injecting drugs into the skin [3]. To implement skin patch-type devices, wireless power supply in real time is required to transmit data and power simultaneously without batteries. It is impossible to apply these devices to various body parts due to increase in size and decrease in comfort when including a battery, MCU, regulator, etc. in patch-type devices. Moreover, human body signal data measurement may experience interferences in case separate antennas are manufactured for wireless power transmission and power section. The problems regarding battery charge or wireless power supply functions for developed skin patch-type devices have not been solved yet.

This study proposes a system that may transmit data and power simultaneously, without using a battery, between a patch-type module and smart device using a passive RFID system. Figure 1.1 shows the schematic of data communication and power transmission between biometric sensors and smart devices. The smart biometric sensors and smart device are positioned horizontally along the forearm. The smart device is used for transmitting data and power (as an RFID reader), and the tag is used for sensing bio-signals and transmitting data. The data measured using the sensor in the patch device are transmitted by a transmit-and-receive antenna as a real-time reader.

II. Previous methods

A. Purpose

This research presents the feasibility of passive RFID for efficient data communication and power transmission between patch-type and smart devices.

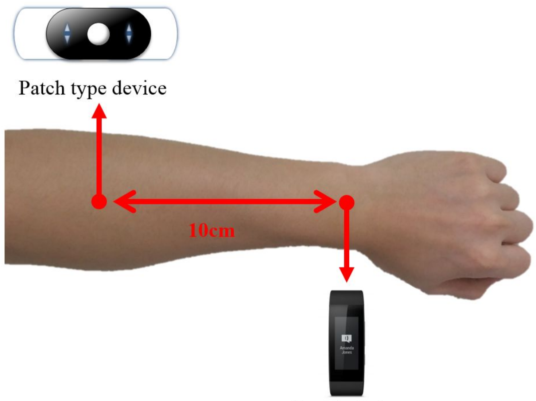


Figure 1.1. Data communication and power transmission between a smart and patch-type devices.

B. Wireless power transmission technologies

Wireless power transmission is the transfer of electrical energy from a source to an electrical device without connecting wires. The power can be transmitted by magnetic resonant coupling, inductive coupling, and microwave radiation. Figures 2.1(a) and 2.1(b) show the state of the art technologies for microwave radiation, magnetic coupling, and inductive coupling methods [4].

	Power cast	WiTricity	Intel	MIT
Test Product				
Distance	Max. 10m	A few m	60cm	0.6~2m (10MHz)
Efficiency	10~50% (1w)	- (60w)	70% (60w)	40~50% (50w)
Safety	Need certification of FCC	Insist no risk	Insist no risk	Insist no risk

Figure 2.1 (a). Microwave radiation and magnetic coupling method.

	Fulton Innovation	Seiko-Epson	Convenient Power	東光(日)	Powermat	WIPower	Tokyo Unversity
Test Product							
Distance	A few mm	3mm Max.	-	A few mm	A few mm	A few mm	A few mm
Efficiency	Max. 98.6%	70% (0.5w)	-	Over 65% (2~3w)	-	-	81% (40w)
Safety	Using shield of Set	Regulation in Japan	-	-	-	-	-

Figure 2.1 (b). Inductive coupling method.

The magnetic resonant coupling method uses resonant frequency between the sending and receiving antennas. As shown in figure 2.2, MIT proposed a method based on strongly coupled magnetic resonances composed of four coils; drive, transmit resonance, receive resonance, and load coils [1]-[2]. The copper wire coils are 50 cm in diameter and 20 cm in width when the number of coil turns is 5.25 and the resonant frequency of the sending and receiving coils is 9.9 MHz. This method showed a transmission efficiency of 40% at a distance of 2 m, which was carried with a power transfer of 60 W. This technique is expected to commercialize mid-range wireless power transfer. However, if the system is composed of many coils, weak coupling affects the system characteristics. Hence, it is difficult to apply this method for very small patch-type devices.

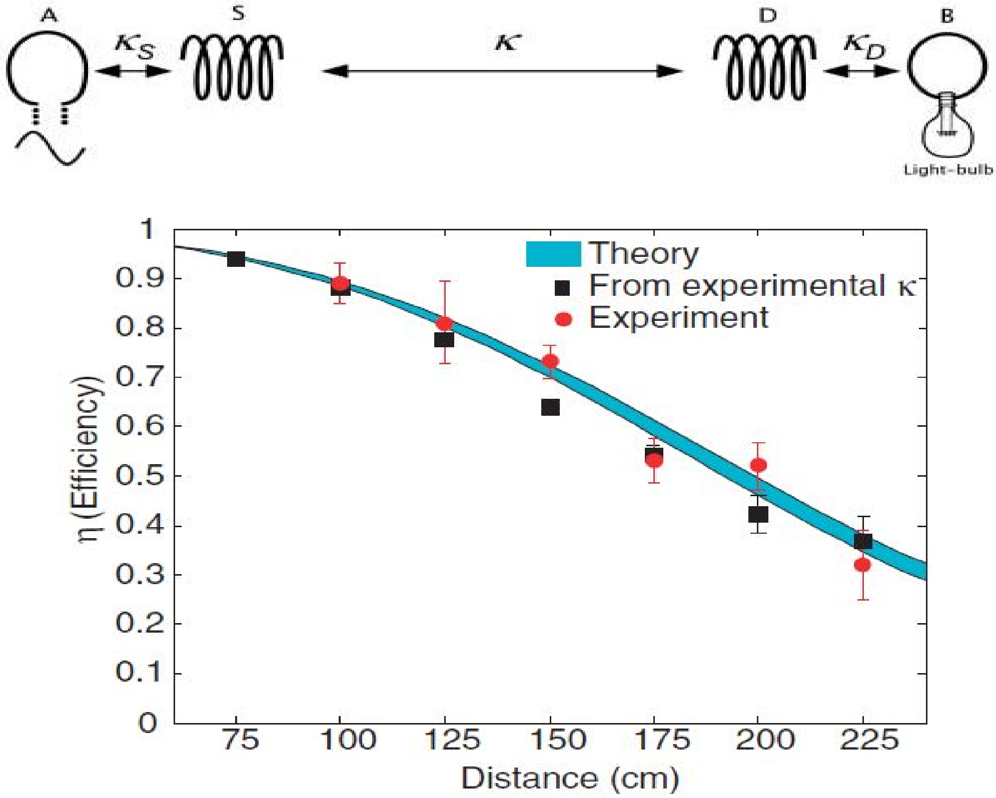


Figure 2.2. Magnetic coupling method in MIT.

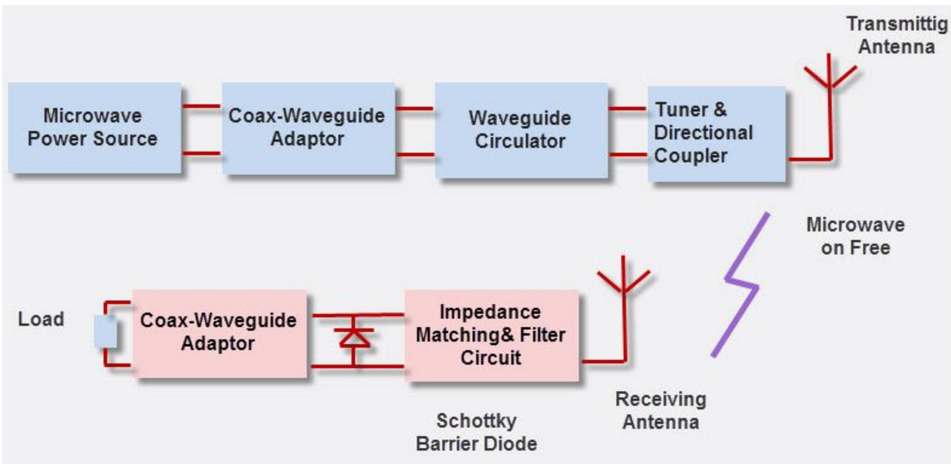


Figure 2.3. Microwave power transmission.

Microwave radiation method transforms power into a radio wave whose wavelength is of the order of a few centimeters and then transmits the radio wave to a device, as shown in figure 2.3. This method utilizes microwave as the medium for carrying radiant energy [5]-[6]. It is useful for long distances ranging from several tens of meters to kilometers, but is harmful to the human body when the RF density exposure is high. The module for transmission is bulky, expensive, and difficult to incorporate in a circuit design when compared with other methods.

The passive RFID using an inductive coupling method can transmit power and information simultaneously for healthcare devices [7]. As shown in figure 2.4, the inductive coupling method [8] is based on magnetic field induction, which transmits power between the sending and receiving coils [9]. This method can be easily used for a wide range of applications, including smart phones, tablets, toothbrushes, RFID transponders, contact-less smart cards and vehicle battery charging systems with a high transmission efficiency of up to 80%. However, the transmission distance is generally close to 1 cm and is typically shorter than 30% of the coil diameter. Furthermore, tight alignment is required for the chargers and charging devices.

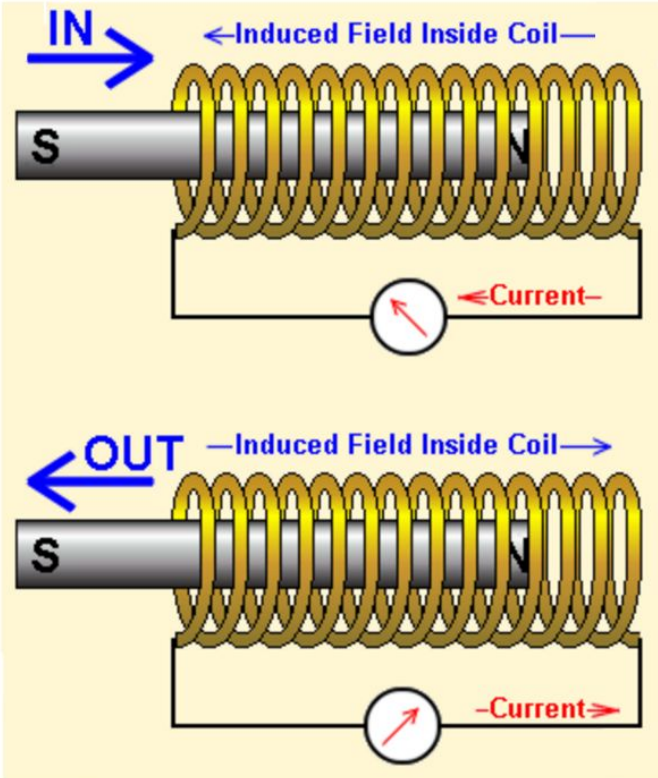


Figure 2.4. Electromagnetic induction method.

C. RFID system

The RFID system consists of a reader, transponder, and software application that collects RFID information. The RFID system is classified according to usable power and frequency bandwidth. Figure 2.5 denotes the block diagram of the general RFID system [10]-[11].

The RFID identifies and tracks a transponder using transmitting and receiving antennas. The transponder collects energy from reader's radio waves and the response is received by the reader.

The transponder is classified as active-type, passive-type, and semi passive-type according to the battery condition. The active transponders with batteries are used for long distance communications, about 10 m apart.

Although it can reduce the power consumption of the reader and expand the read distance, various problems may occur such as high fever, relatively large size, and time limit constraints. The passive transponders without batteries are used for short distance communications, about 70 cm apart. The power is supplied by using magnetic induction method from reader, as shown in figure 2.6. The systems with relatively small sizes can be used semi-permanently. However, the passive reader requires additional power consumption.

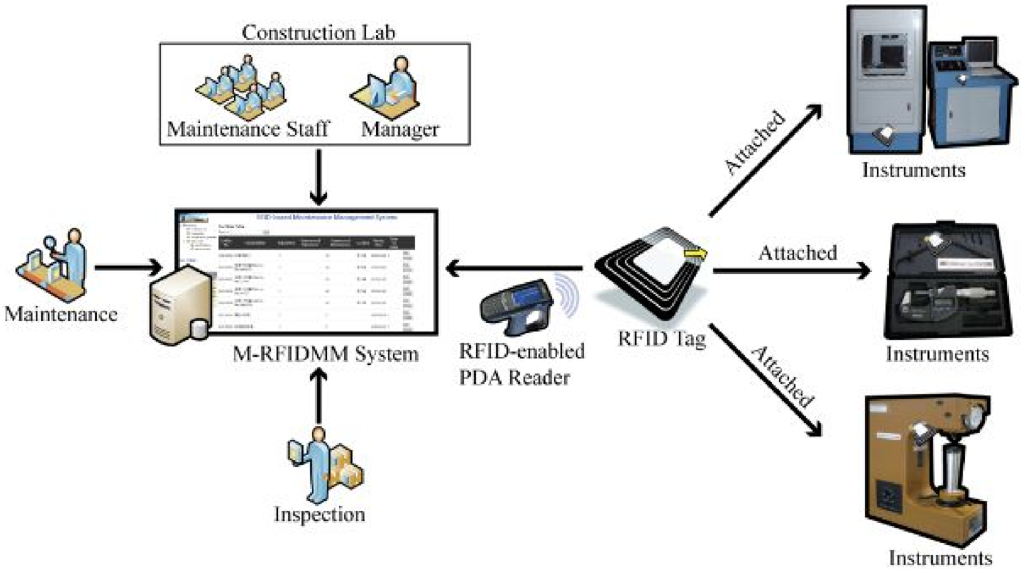


Figure 2.5. Block diagram of a typical RFID system.

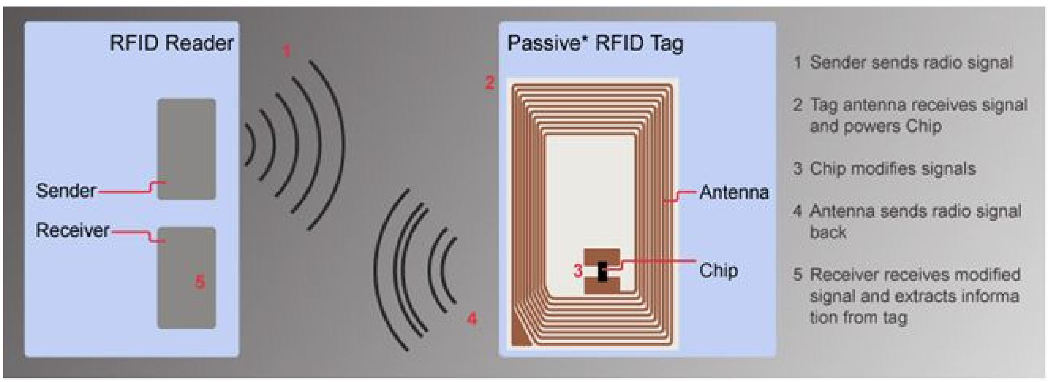


Figure 2.6. Structure of passive RFID.

The semi passive transponders with batteries are similar to the active transponders. However, the semi passive transponder cannot work before receiving a signal from reader. Thus, it may operate for a long time.

Table 1 shows classification table for RFID transponder in Yamada [12].

Items	Passive RFID tag	Active RFID tag (Con.)	Active RFID tag (new)
Comm. Range	70cm/ 3m - 7m	more than 10m	around 10m
Battery life	(no battery)	around 1 year	around 1 year
Security	weak	N/A, or weak	strong
Cost	less than $1	less than $10	around $10
Application	distribution/ inventory control of goods.	tracking person (restricted area)	tracking person (no restriction)

Table 1. Classification of RFID transponders.

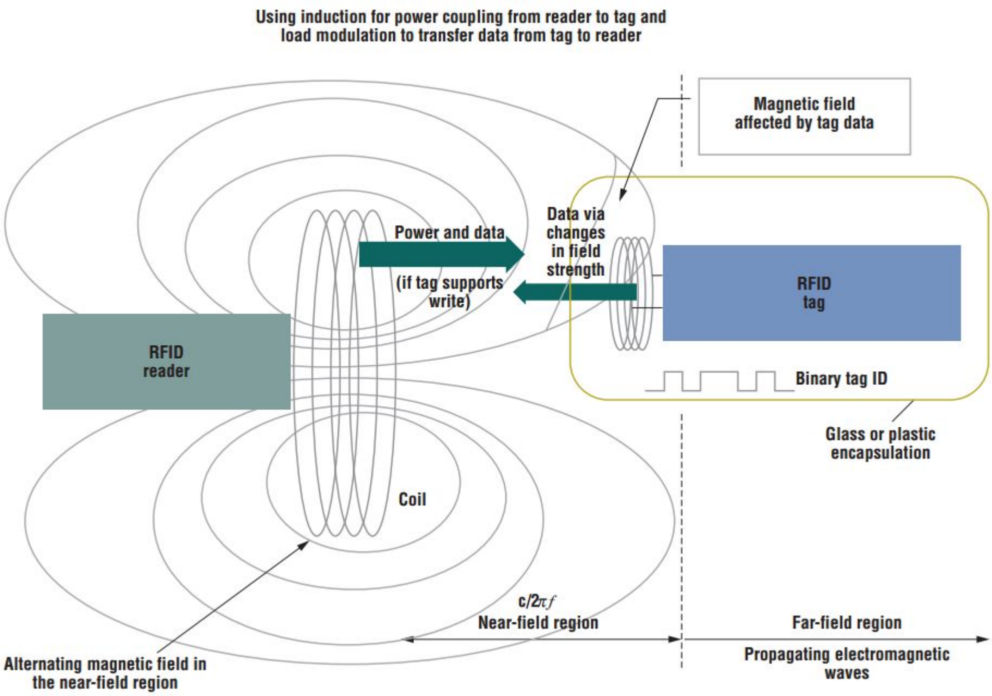


Figure 2.7 Near-field power/communication mechanism for RFID.

Near-field coupling based on Faraday's principle of magnetic induction is used between a reader and transponder. As shown in figure 2.7, a reader passes a large amount of alternating current through a reading coil, resulting in an alternating magnetic field in its locality. If a transponder is placed, which incorporates a smaller coil in this field, an alternating voltage will appear across it. If this voltage is rectified and coupled to a capacitor, a reservoir of charge accumulates, which the transponder chip can be used to power [13].

The RFID transponders often operate using near fields at low frequency bands, which follow Faraday's principle. Nevertheless, newer types of RFID transponders operate using far fields when the frequency band is more than 100 MHz.

The RFID transponders are classified according to frequency bands, which consist of radio frequencies of 125-134.2 KHz, 13.56 MHz, 850-960 MHz, and 100 KHz-2.45 GHz. Table 2 shows various standards for an RFID system. The RFID operates at a short distance and the data rate is slow when the frequency band is low.

	LF	HF	UHF	Active
Frequency	125 – 134.2 KHz	13.56 MHz	850 – 960 MHz	100 KHz – 2.45GHz
Range	0.2 – 2m	Up to 1m	Up to 3m	Up to 100m
Cost	Typ. 3 GBP	(Typ. 0.50 GBP)	(Typ. 0.30 GBP)	(Typ. 20 GBP)
Memory	Typ. 64 bits	Typ. 2048 bits	Typ. 96 bits	Typ. 32 bits
Penetration of Materials	V. Good	Good	Poor	V. Good
Data Rate	Slow	Fast	Fast	Fast
Reader Cost	50 – 500 GBP	50 – 3000 GBP	1000- 3000 GBP	200-600 GBP
Read Multiple Tags	Poor	Good	Very Good	Good
Applications	Animal Tags, Vehicle Immobilisers, Industrial Applications	Item Tracking, Access Control, Smart Labels	Box and Pallet tracking Some Item Tracking	Industrial Applications. Asset Tagging Location Systems

Table 2. Various standards for RFID.

Figure 2.8 shows an epidermal strain sensor that use RFID transponder. The transponder can detect the eyebrow flash or stretching of the skin on the neck for paraplegic patients who move facial muscles. The transponder is designed on a barium titanate loaded PDMS substrate and assessed to demonstrated strain gauge sensitivity and repeatability as a function of skin stretch [14].

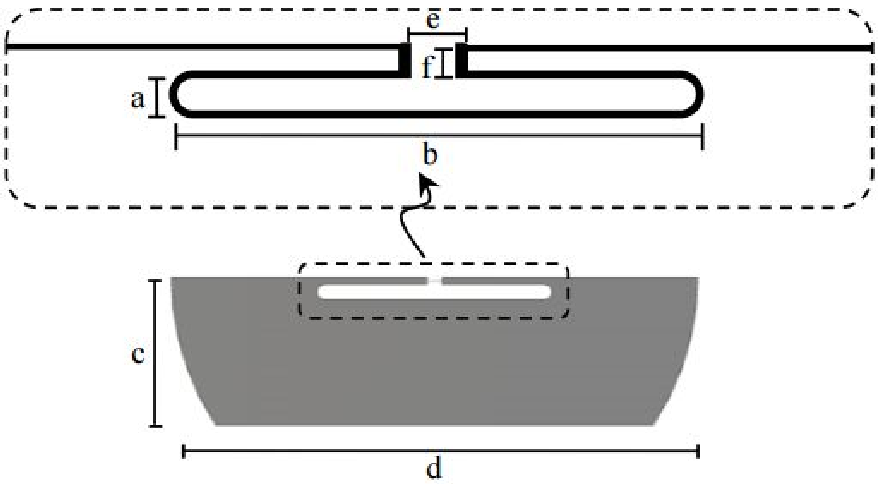


Figure 2.8. RFID strain sensor.

Figure 2.9 shows epidermal dual-loop transponder. This transponder can be attached to the surface of the human body and used in UHF bandwidth. In addition, it can be used at short and long distance through a dual-loop antenna [15].

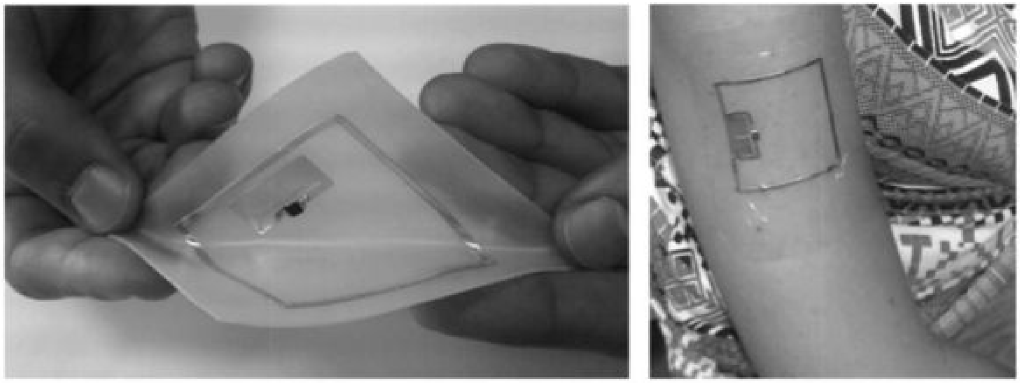


Figure 2.9. Epidermal RFID transponder.

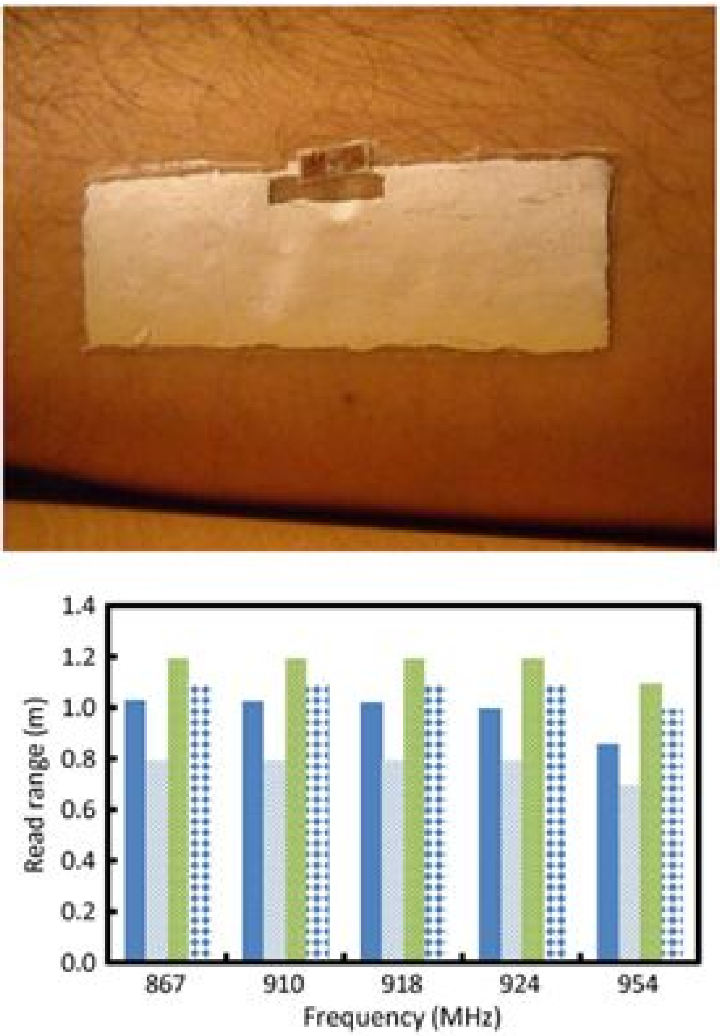


Figure 2.10. UHF passive RFID transponder.

A UHF Passive RFID transponder has the form of a patch, similar to an epidermal transponder, which can be mounted directly onto the skin surface. The read distance of the transponder is measured on different parts of a subject's body and compared to simulated read range values for the entire RFID band. The maximum read distance is 1.2 m for UHF bands. However, a drawback of this transponder is that consumes considerable power and operates for only 5 hours [16].

D. Wearable device

In recent years, wearable devices that are more practical to wear have been developed, such as smart watches, smart glasses, smart shoes, and epidermal transponders attachable to the skin. Patch-type healthcare devices are expected to be used as edible and attachable devices.

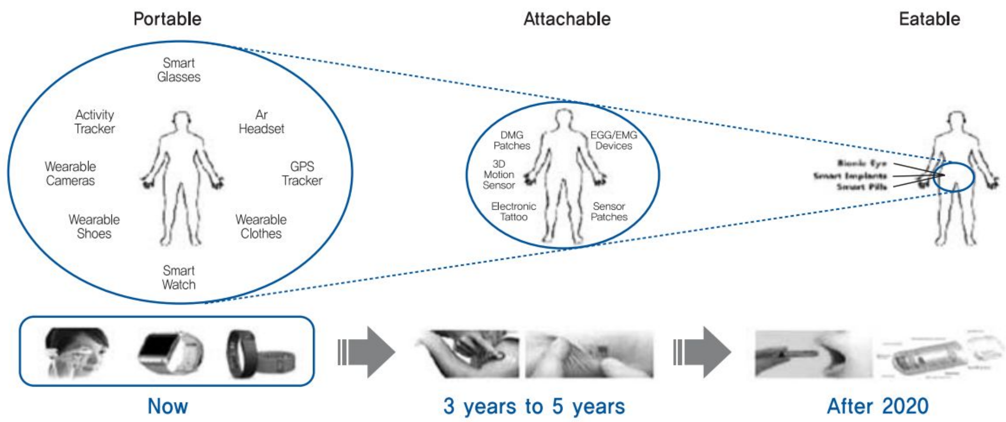


Figure 2.11. Trend in wearable devices.

Techniques for measuring functions of human body organization through skin and stimulation involve electrical measurements using X-rays of the brain. However, there has been no development of these types of techniques, or others, for 80 years. A method for connecting circuits and power supply devices has been developed using rubbing conductive gels on the skin with a string or clamp. These existing systems are difficult to apply inside patient's bodies in terms of ease and safety in the long term, owing to comparatively large volume and weight.

A wearable sensor technique, referred to as electronic skin, which can monitor human body signals by attaching on the skin like a sticker or tattoo, has been developed. Electronic skin has light and flexible characteristics, suitable for using simultaneously with sensors, power supply devices, and communication components as considerably thin electrodes. Various human body signal sensors, such as thermal sensors, strain sensors, LEDs, inductors, generators, and diodes, can be combined on electronic skin, and it is possible to realize a power supply device using a solar battery and wireless coil. In addition, it is possible to collect data, monitor various human body signals in real time, such as heart rate, temperature, amount of absorbed ultraviolet rays, and amount of action, by attaching it on the skin. Collected data are analyzed by transmitting to cloud servers through smart devices.

Figure 2.12 shows the electronic skin developed in John Roger's laboratory, University of Illinois. This device used considerably thin Si, and it could be attached on the skin surface in a stable manner through Van der Waals forces [3].

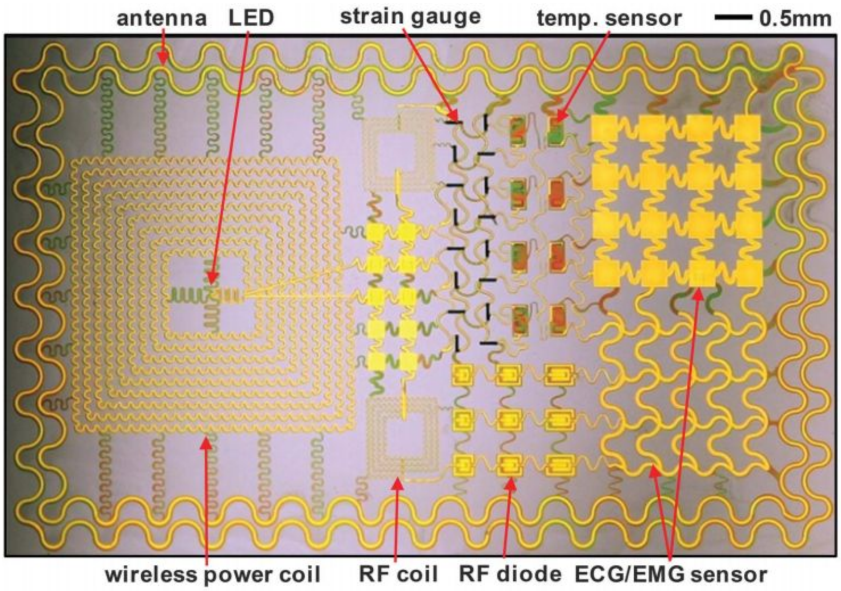


Figure 2.12. Schematic of epidermal electronics in University of Illinois at Urbana Champaign.

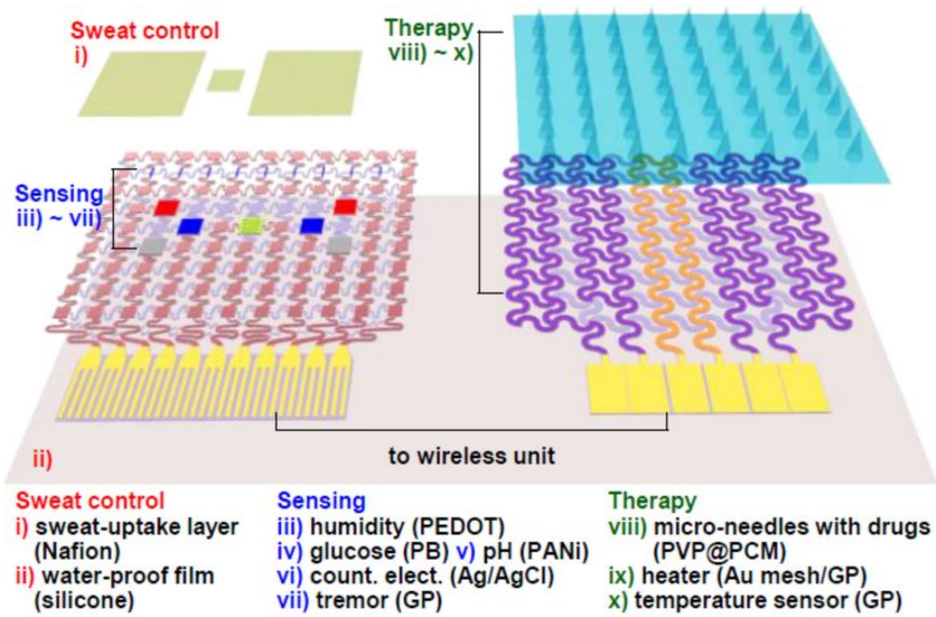


Figure 2.13. Schematic electrochemical device of in IBS.

Figure 2.13 shows the diabetes patch developed by IBS. This patch can measure blood sugar by measuring the sugar content in sweat, sweat temperature, and acidity (pH) in real time. In addition, blood sugar control is possible by injecting drugs on skin automatically [17].

III. Experiment and result

A. Antenna simulation

The measurement setup consisted of an antenna and a matching circuit, which was matched to 50 Ω to minimize input and output return losses. Figure 3.1 shows the structure of the antenna simulation. The TRF7970A device (Texas Instruments) was used for the simulation. It is an integrated analog front end and data-framing device for a 13.56 MHz RFID. The antenna set-up, consisting of a 0.127 cm thick spiral coil, was designed on a printed circuit board (PCB) with a thickness of 0.157 cm. The spiral coil was 3.8 cm in width and 5.3 cm in length when the number of coil turns was 4.

It is required to design new antennas for optimal performance of RFID system at 13.56 MHz. The antennas were modeled as a rectangular spiral coils with a diameter (d), length (l), and the number of coil turns (n). The antennas were designed to have a resonant frequency of 13.56 MHz based on the following equations.

$$L = \frac{d^2 n^2}{l + 0.45d} \, [\mu H] \quad (1)$$

$$C = \frac{1}{(2\pi \times 13.56 \times 10^6)^2 L} \, [F] \quad (2)$$

The inductance and capacitance determined from the equations and used for calculating the resonant frequency [18]. Figure 3.1 shows the antenna schematic and matching circuit.

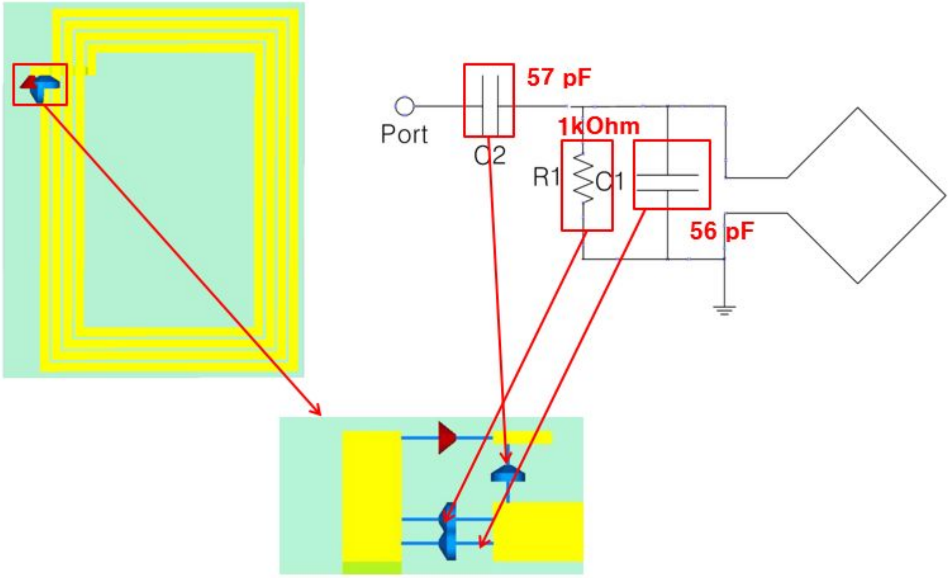
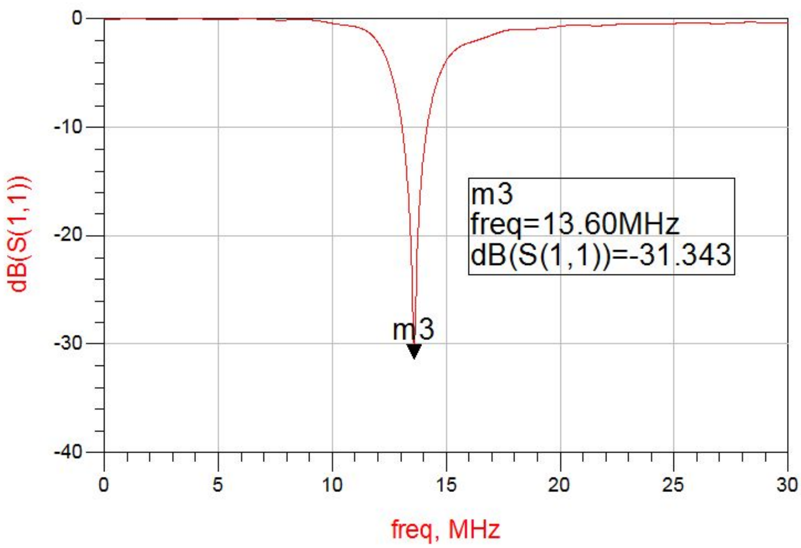


Figure 3.1. Antenna schematic and matching circuit.

Figure 3.2 shows the reflection coefficient and Smith chart of antenna that was simulated using a matching circuit with an impedance of 50 Ω. The reflection coefficient of the designed antenna was -31.34 dB at 13.60 MHz, and the impedance was 47.61 Ω.



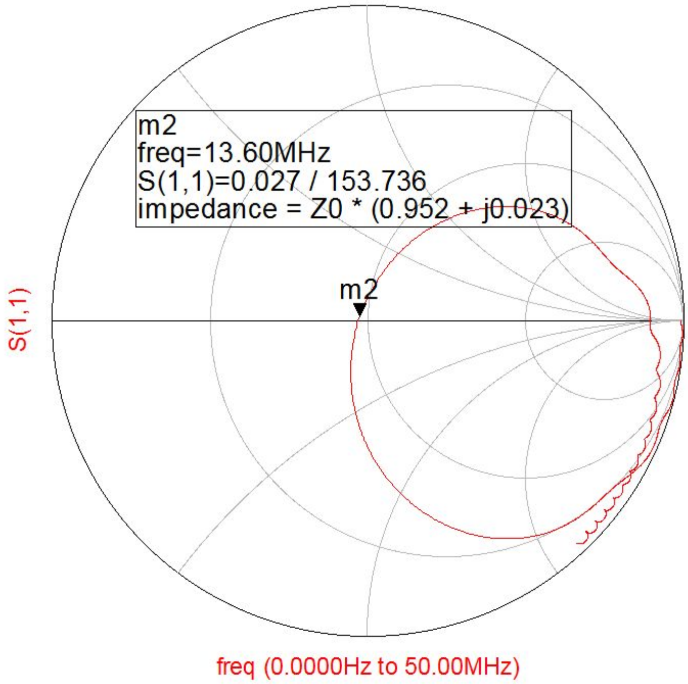


Figure 3.2. Reflection coefficient and Smith chart.

B. Impedance matching for optimized signal loss

Impedance was matched to 50 Ω by optimizing the input reflection loss for general antenna design. Although the reflection coefficient is minimized in case of matching input reflection loss optimization, the signal loss significantly increased and the operation distance decreased. Signal loss optimization matching can increase the operation distance by optimizing signal loss of two antennas.

Figure 3.3 denotes simulation setup of transmitter-receiver antenna located in wrist and arm considering a smart and skin patch-type devices.

Signal loss is influenced by coupling among transmitter-receiver antennas more than reflection loss considering the transmission distance due to small antenna size. Thus, matching method is selected that has the lowest signal loss between the transmitter-receiver antenna in resonance frequency to increase power efficiency as well as data transmission efficiency.

Transmission distance should be more than 10 cm for various applications.

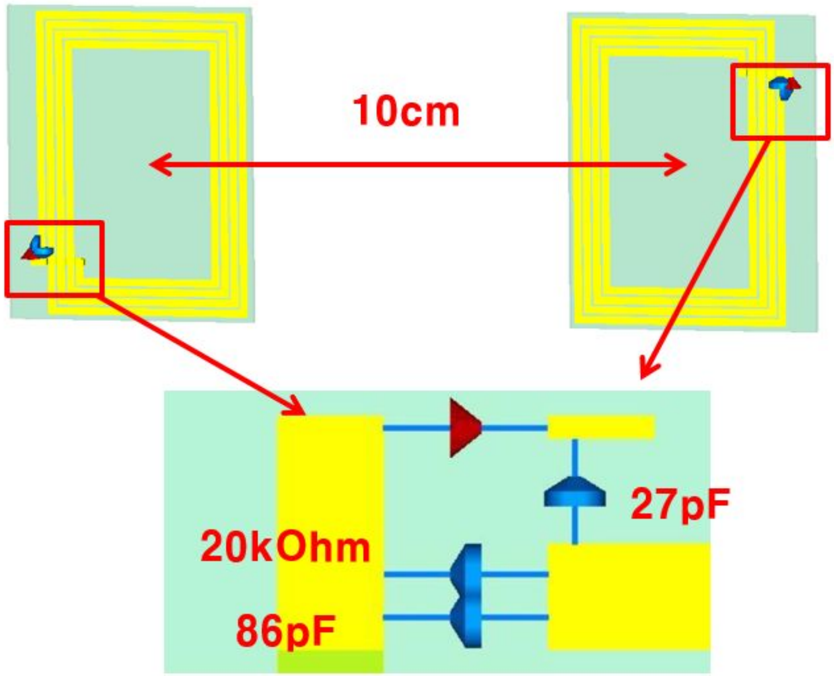


Figure 3.3. Simulation setup for optimizing matching circuit.

Figure 3.4 shows the ADS simulation setup used to optimize matching circuit. The GRH708 capacitors (Murata Manufacturing) were used for the simulation, which were connected in parallel for matching. The setup was simulated for optimizing the matching circuit at 13.56 MHz. Table 3 shows the simulation result according to the matching component. The result from Data1 was simulated for return loss, and the results from Data2 to Data5 were simulated to minimize the insertion loss.

Figure 3.5 denotes the signal loss according two matching methods when the transmission distance of the transmitter-receiver antenna is 10 cm in the horizontal direction. When the resonance frequency is 13.56 MHz, the signal loss value of the transmitter-receiver antenna, which uses the impedance matching method, was -36.5 dB.

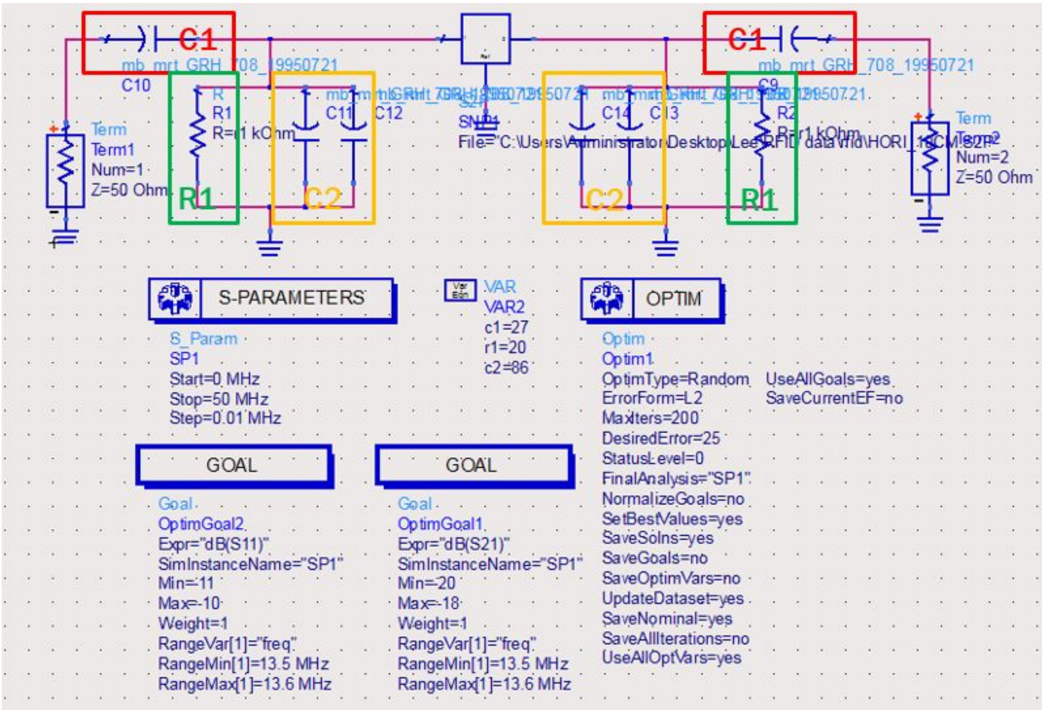
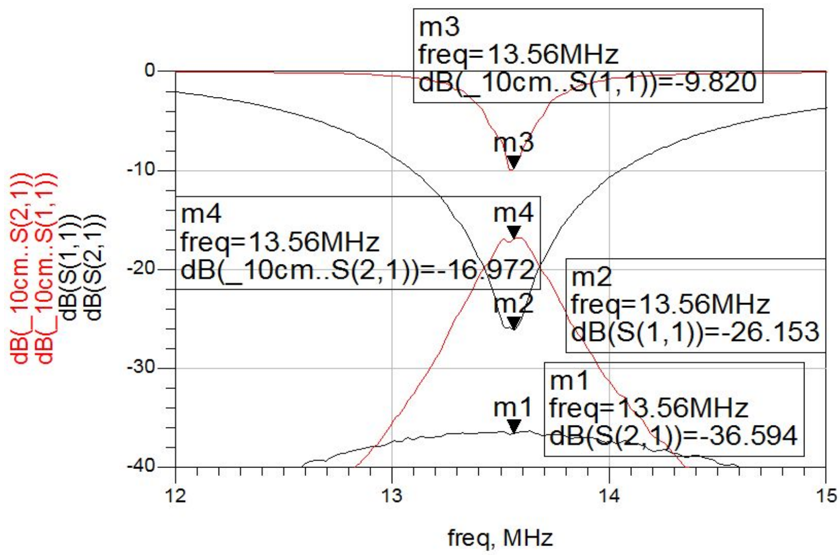


Figure 3.4 ADS simulation setup.

	Data1	Data2	Data3	Data4	Data5
c1 [pF]	57	22	22	27	27
c2 [pF]	56	82	82	80	86
r1 [kOhm]	1	15	10	20	20
S(1,1) [dB]	−26.153	−8.7716	−17.353	−6.476	−9.820
S(2,1) [dB]	−36.594	−18.021	−17.498	−19.545	−16.972
Frequency [MHz]	13.56	14	14.16	13.98	13.56

Table 3. Simulation result according to matching component.



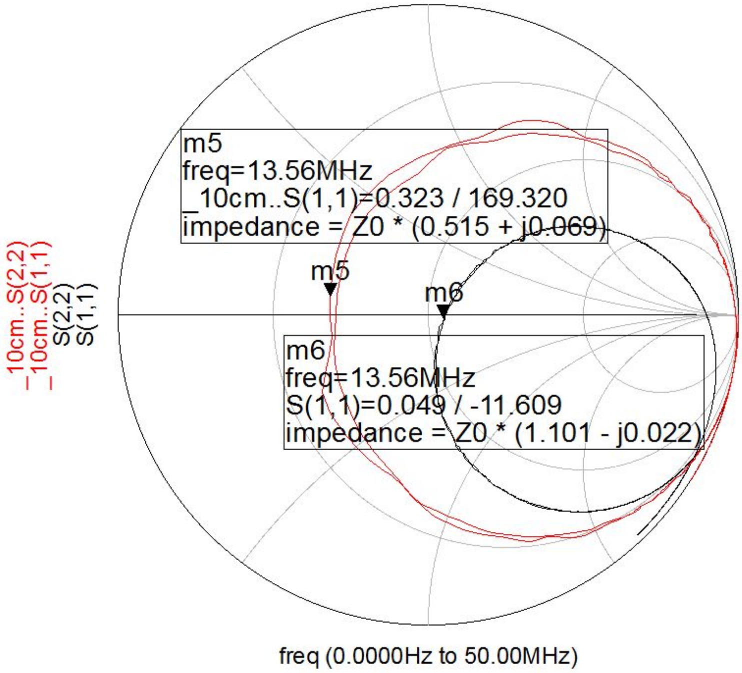
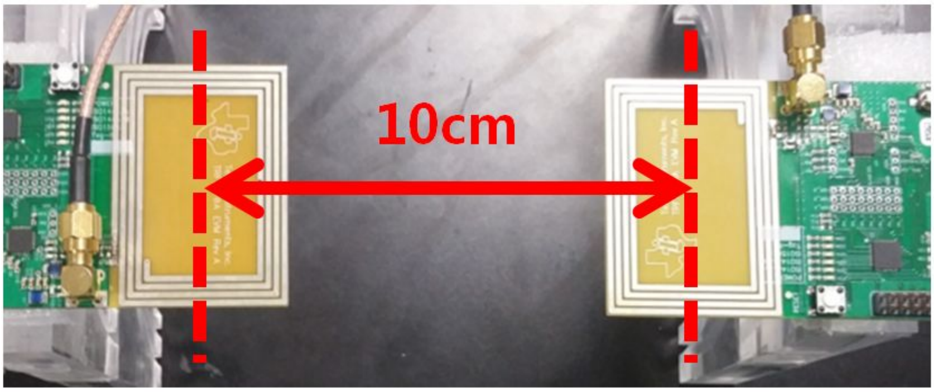
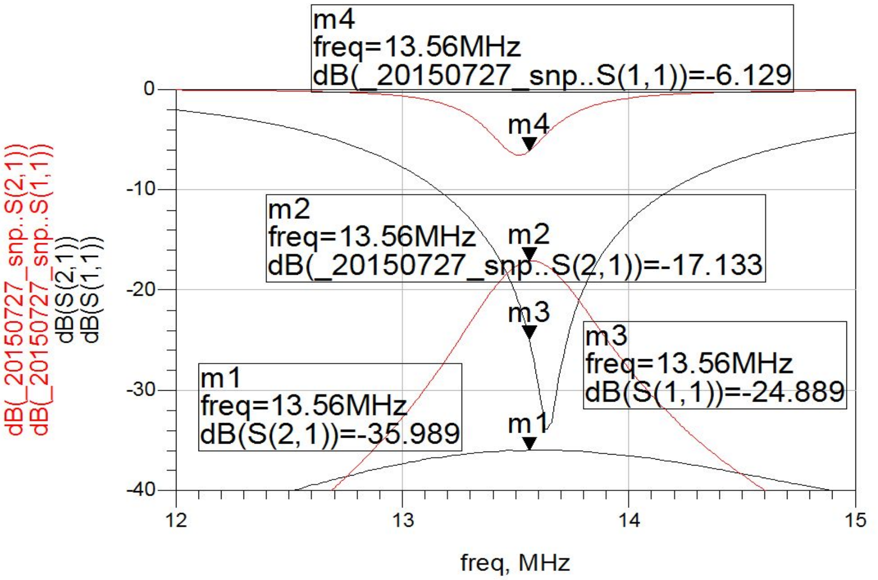


Figure 3.5. Simulation result of signal loss.

C. Measurement setup and result to measure transmission distance

The insertion loss of the antennas was measured at a distance of 10 cm without the matching circuit, and then the matching circuit was composed to minimize the insertion loss using simulation. Figure 3.6 shows the measurement setup and measured insertion loss of the sending and receiving antennas as well as the return loss. The insertion loss of the antennas using the impedance matching method was -35.9 dB at 13.56 MHz when the read distance was 10 cm. In addition, the insertion loss of the antennas using the matching method between the sending and receiving antennas decreased to -17.1 dB. Thus, the insertion loss difference between the measurement and simulation results were less than 1 dB and almost identical.


10cm


m4
freq=13.56MHz
dB(_20150727_snp..S(1,1))=-6.129
m2
freq=13.56MHz
dB(_20150727_snp..S(2,1))=-17.133
m3
freq=13.56MHz
dB(S(1,1))=-24.889
m1
freq=13.56MHz
dB(S(2,1))=-35.989
dB(_20150727_snp..S(2,1))
dB(_20150727_snp..S(1,1))
dB(S(2,1))
dB(S(1,1))
0
-10
-20
-30
-40
12
13
14
15
freq, MHz

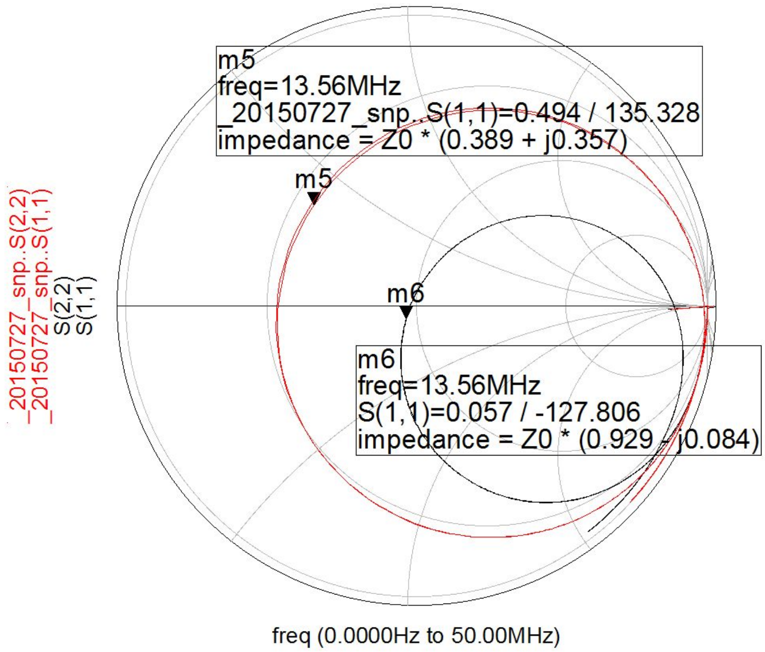


Figure 3.6. Measurement setup and result.

Figure 3.7 shows the set up used to measure the read distance when the matching methods changed. The RFID reader and transponder were positioned horizontally. The transmitting signal was generated using the RFID reader; the output power of the reader was 100 dBm. The generated signal was then input into the RFID transponder for data transmission. After being received at the RFID transponder, the receiving signal was returned to the RFID reader. As the matching condition was changed for the return loss matching method and the matching method between the sending and receiving antennas, the maximum read distances for each method were 8 cm and 12.5 cm, respectively. The reason for this difference is that the insertion loss was lowest for the matching method between the sending and receiving antennas; thus, the read distance and power transmission efficiency were improved. The measured results show that the increase in the read distance was 4.5 cm and the power transmission efficiency was increased from 0.03% to 2% at a distance of 10 cm.

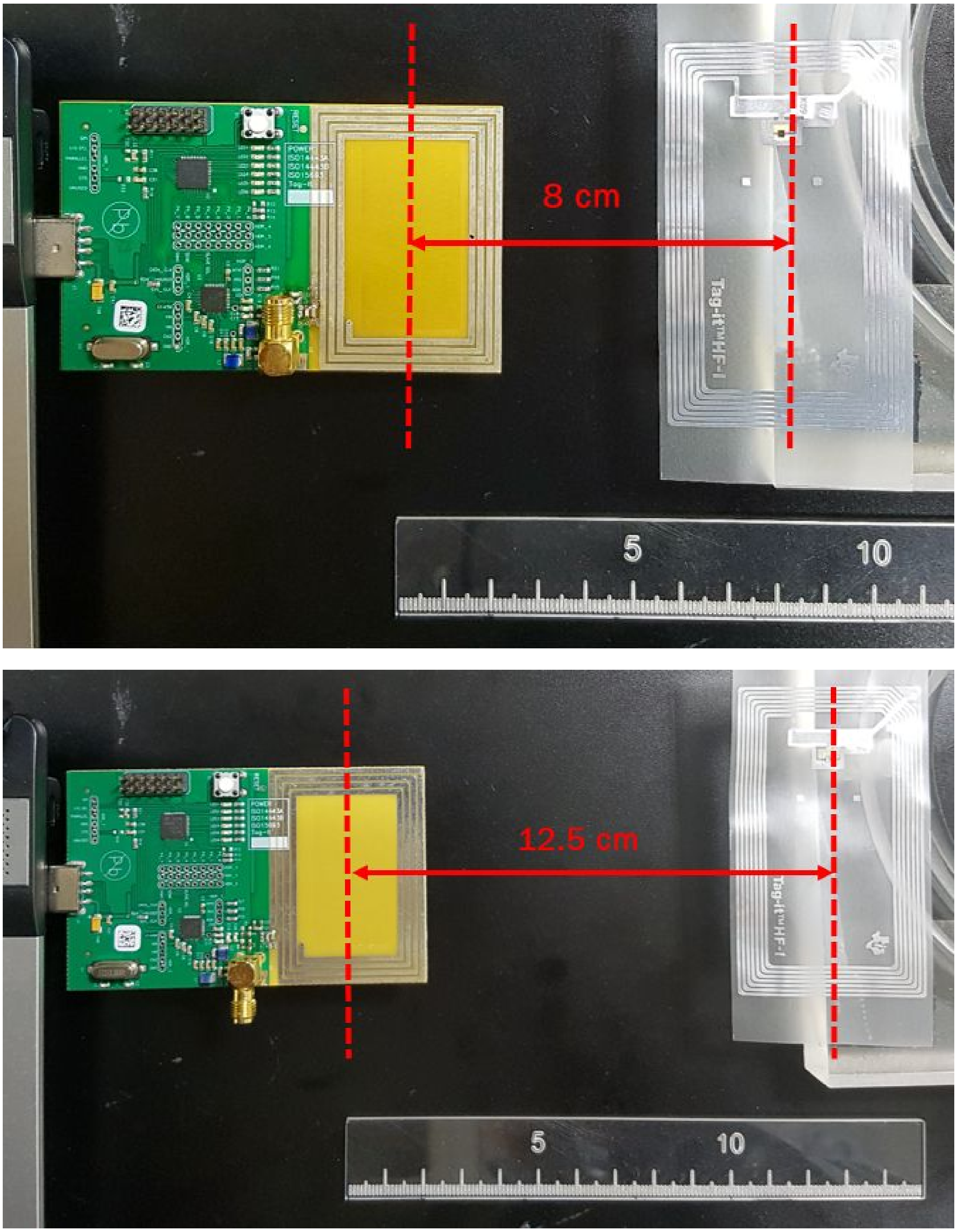


Figure 3.7. Reading distance between the RFID reader and transponder.

Ⅳ. Conclusion

This study proposed a patch-type module that can transmit data and power without using a battery [19]. This research is an initial step in an ultra-small and thin epidermal electronics-type patch device for medical care. When the sending and receiving antennas were compared, it was found that the variation in the insertion loss was less than 1 dB. After the matching method was changed, the read distance was measured using the RFID reader and transponder. The transmission efficiency decreased dramatically depending on the distance; however, the transmission efficiency was increased to 2% at a distance of 10 cm when the matching condition between the sending and receiving antennas was improved. In addition, the read distance was increased to 12.5 cm, which was about three times the antenna diameter. Therefore, the proposed technology can be applied to passive RFID systems that can transmit data and power between the patch-type module and wearable devices, such as a smart device. It was also shown that the system can be an integrative solution, overcoming reading distance and continuous power supply for real-time medical diagnostic devices and wearable monitoring systems.

Reference

[1] A. Kurs et al., "Wireless Power Transfer via Strongly Coupled Magnetic Resonances," Science, vol. 317, pp. 83-86, July 2007.

[2] A. Karalis, J.D. Joannopoulos, and M. Soljacic, "Efficient Wireless Non-radiative Mid-range Energy Transfer," Annal Physics, vol. 323, pp. 34-48, 2007.

[3] Kim, Dae-Hyeong, et al. "Epidermal electronics." science 333.6044 (2011): 838-843.

[4] 김정호, 장병준, and 안준오. "무선전력전송 기술개발 및 표준화 동향." (2011).

[5] X. Lu et al., "Resource Allocation in Wireless Networks with RF Energy Harvesting and Transfer," to appear, IEEE Network.

[6] X. Lu et al., "Dynamic Spectrum Access in Cognitive Radio Networks with RF Energy Harvesting," IEEE Wireless Commun., vol. 21, no. 3, June 2014, pp. 102–10.

[7] V Chawla, DS Ha. "An overview of passive RFID" Communications Magazine, IEEE, 2007.

[8] Xie, L., Shi, Y., Hou, Y. T., & Lou, A. (2013). Wireless power transfer and applications to sensor networks. IEEE Wireless Communications, 20(4), 140-145. ISO 690

[9] Z.N. Low et al., "Design and Test of a High-Power High-Efficiency Loosely Coupled Planar Wireless Power Transfer System," IEEE Trans. Ind. Electron., vol. 56, no. 6, May 2009, pp. 1801-1812.

[10] S. Shepard, RFID: Radio Frequency Identification, McGraw-Hill, 2005.

[11] http://hakyongkim.net/

[12] I. Yamada, S. Shiotsu, A. Itasaki, et al.2005Secure active RFID transponder system, Ubicomp2005 Workshop.

[13] Want, R. (2006). An introduction to RFID technology. IEEE Pervasive Computing, 5(1), 25-33.

[14] Rakibet, Osman O., et al. "Epidermal passive RFID strain sensor for assisted technologies." IEEE Antennas and Wireless Propagation Letters 13.1 (2014): 814-817.
[15] Amendola, Sara, Stefano Milici, and Gaetano Marrocco. "Performance of Epidermal RFID Dual-loop transponder and On-Skin Retuning." IEEE Transactions on Antennas and Propagation 63.8 (2015): 3672-3680.
[16] Lee, Hyunjae, et al. "A graphene-based electrochemical device with thermoresponsive microneedles for diabetes monitoring and therapy." Nature nanotechnology (2016)
[17] Ziai, M. A., & Batchelor, J. C. (2011). Temporary on-skin UHF passive RFID tag. IEEE Transactions on Antennas and Propagation, 59(10), 3565-3571.
[18] H.A. Wheeler, "Simple Inductance Formulas for Radio Coils," Proc. I.R.E., vol. 16, pp. 1398-1400, Oct. 1928.
[19] Lee, J.H. Kim, Y.S. Kim, W. Y. & Kim, Y. T. (2015, November). Development of patch-type sensor module for battery-free power transfer and data transmission. In SENSORS, 2015 IEEE (pp. 1-4). IEEE.

List of Publications

Paper

Hyoung, C. H., Hwang, J. H., **Lee, J. H.**, Kang, S. W., & Kim, Y. T. (2016). Energy harvesting from electromagnetic interference induced in the human body. Electronics Letters, 52(22), 1881-1883.

List of Publications

Patent

"Apparatus for transferring power wireless using capacitively-coupled method and clothes comprising thereof", Y. T. Kim, **J. H. Lee**, K. H. Park, M. J. Jeong, J. J. Baek, S. W. Kim, KR (10-2016-0144852)

"Apparatus and method of charging mobile terminal using energy harvesting device", Y. T. Kim, M. J. Jeong, K. H. Park, J. J. Baek, **J. H. Lee**, S. W. Kim, KR (10-2016-0032004)

"Apparatus and method of charging mobile terminal using energy harvesting device", Y. T. Kim, **J. H. Lee**, K. H. Park, M. J. Jeong, J. J. Baek, S. W. Kim, U.S.A (15/351,651)

List of Publications

Conference

"Analysis on frequency-dependency of conductive signal transmission channel for biosensor network", **J. H. LEE**, K. H. Park, M. J. Jeong, J. J. Baek, S. W. Kim, Y. T. Kim, IEEE Sensors 2016, Nov. 2016.

"Development of patch-type sensor module for battery-free power transfer and data transmission", **J. H. Lee**, Y. S. Kim, W. Y. Kim, Y. T. Kim, IEEE Sensors 2015, Nov. 2015.

"Conductive power transmission for implantable devices", Jong Jin Baek, **J. H. LEE**, Y. T. Kim, IEEE International Symposium ISCE 2014, Jun. 2014.

"AC-DC converter for wireless power transmission of energy harvesting system", Tae-il Yun, **J. H. Lee**, Jong Jin Baek, Y. T. Kim, IEEE International Symposium ISCE 2014, Jun. 2014.

Abstract

RFID System for Power Transmission and Data Communication between Patch-Type Device and smart device

Janghyun Lee
Advisor : Prof. Youn Tae Kim, Ph.D.
Department of IT Fusion Technology,
Graduate School of Chosun University

In recent times, wearable devices, which are ultra-small, thin and path-type such that they can be attached onto the body surface, have been developed in the healthcare sector. Such patch-type devices require subminiature batteries or wireless power transmission owing to their ultra-small and thin properties.

This study proposes a system that uses a passive RFID method for increasing the efficiency of power transmissions, which can transmit data and power simultaneously between a patch-type and smart device using an optimized signal loss method. Passive RFID technology is transmitted to the transponder through an induced magnetic field from the electric field generated by the reader as there are no batteries in the transponder. This technology can be used semi-permanently and can be subminiaturized because of the absence of batteries. However, it faces problems of short reading

distance and high power consumption.

Consequently, in passive RFID technology, it is necessary to reduce power consumption in smart devices. The optimized signal loss matching method can reduce reflection coefficients and signal losses. If the signal loss decreases, the reading distance between reader and transponder increases. Such a matching method can be used for increasing the read range without consuming much power from the reader.

Acknowledgement

I would like to thank my advisor, Professor Youn Tae Kim for his supervision, understanding, support, encouragement and personal guidance as I was working on this research and the thesis. I am deeply grateful to all of the professors from whom I have learned great deal of knowledge.

In addition, I have the deepest appreciation for the constructive criticism and excellent advice that provided by Prof. Hyun Sik Choi, Prof. Sung Bum Pan and Prof. Youn Tae Kim during the preparation of my thesis, as well as for their detailed review of the thesis after it was completed.

During this work, I collaborated with all my colleagues in the laboratory and I have great regard for all of them and wish to extend my sincerest thanks to all those in the Department of IT Fusion Technology who helped as I conducted my work.

My deepest thanks go to my family for all the care and support they have given me over many years. They are the best family in the world.

November 2016

Janghyun Lee