ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

A Linearly Polarized Rectenna for Far-Field Wireless Power Transfer

M.I.Anju[1], R.Siva[2], S.Abisha[3], V.Nandhini[4], R.Priya[5]

Assistant Professor, Department ECE, New Prince Shri Bhavani College of Engg. & Tech., Chennai, India[1,2]

UG Student, Department ECE, New Prince Shri Bhavani College of Engg. & Tech., Chennai, India[3,4&5]

ABSTRACT: A rectenna, which consist of a yagi Microstrip antenna along with rectifier circuit is proposed for wireless power transmission in the far field region. The wireless power link is examined between an insitable antenna and an external antenna. A method of adding directors in yagi antenna is used to increase the wireless power link, thus to enhance the efficiency of the designed antenna. After calculating an receiver power level of an insitable antenna, the rectifier circuit efficiency is optimized. Yagi uda antenna is operated at a frequency of 2.4GHz to 2.485GHz.

KEYWORDS: Far field wireless power transfer, insitable rectenna, ISM band, power conversion, Yagi uda antenna.

I. INTRODUCTION

Wireless technology have gained a lot of attention recently. Wireless power transfer can be attained by two methods namely near field and far field region. When compared to near field wireless power transmission, far field wireless power transfer has achieved greater advantages such as longer distances and accurate alignment avoidance. An insitable antenna has many challenges when designing for various requirements. The requirements such as radiation efficiency, acceptable bandwidth and compact size.

Many research have been conducted on designing implantable antennas[2]-[13]. In [3] and[4] designing of insitable antenna in different environment is provided. To improve and extend the lifetime of insitable devices, a dual band antenna was studied in [6]. In [11] and [12] for biomedical application, antenna such as slot and microstrip antenna was studied respectively.In other words for far field wireless power transmission an insitable antenna is a important component. An insitable rectenna is used to receive and store energy from RF power and it consists of an rectifier circuit and an implantable for wireless power transmission , an efficient rectenna is needed. To optimize the antenna design optimal diode RF,dc impedances and function of input power were obtained in[15]. Circuarily polarized rectennas were studied in[16]and[18]. A low input RF power 2.45GHz rectenna were designed in [19]. Rectifier circuit conversion effciency of 15.7% at -20 dBm is obtained in[21]. In [22], separate transmit and receive on-chip antenna was designed for pressure monitoring application. A triple band implantable antenna was designed for wake up controller at 2.45GHz in[23],[24]. The proposed antenna provide an efficiency of 78% at a frequency range of 2.45GHz. In [25] wireless power transmission through dispersive tissue was studied. In the proposed work harmonic termination technique in a single voltage doubler rectifier is used to boost the DC output voltage and conversion efficiencies.

To achieve an longer distance, an insitable rectenna is designed in this paper, shown in Fig. 1. The designed insitable yagi antenna is utilized at the operating frequency of 2.45GHz for the wireless power link. After increasing the resonant frequency of the antenna in the implantable device, the wireless power is transferred. The power level received by the yagi antenna is calculated based on the certain rules. A rectifier circuit is designed finally and efficiency of rectenna is estimated.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

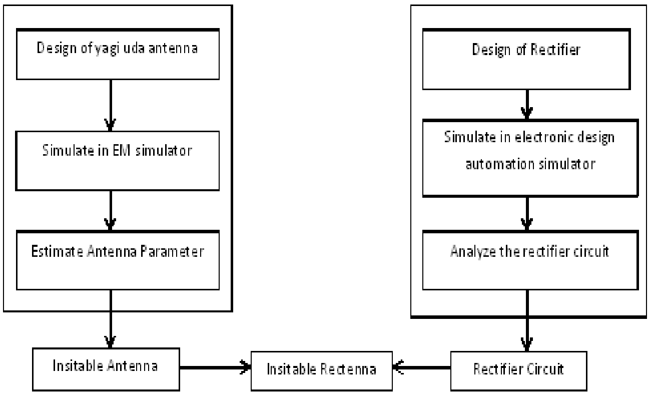

Fig. 1. Design of Yagi Uda antenna and rectifier circuit

II. INSITABLE ANTENNA DESIGN

A. Antenna Composition

An Insitable antenna shown in Fig. 2 is designed on theThree-layer FR-4 susbstrate with dielectric constant( ) of 4.4. The ground plane of yagi antenna are 100mm x 35mm. The dipole element height is 60.96mm and width is 3.05mm. Directors of yagi antenna are 3.4mm x 34.49mm.The spacing between dipole and directors are less than 0.3 .The reflector is designed greater then dipole and dipole is designed greater than directors. 2.4GHz were used in the simulation model. For design and analysis, Ansoft High Frequency Structure Simulator is used. Simulated reflection coefficient for the proposed antenna is shown in the Fig. 3. From Fig. 3. It is observed that the antenna covers from 2.3556GHz to 2.566GHz for $|S_{11}|$ less than -10dB. The gain obtained in the simulation is 8.14dBi at 2.45GHz is shown in Fig. 4. By tuning the resonant length and ground plane, the yagi antenna can operate at 2.45GHz with accurate matching. The geometry parameters of yagi antenna is shown in Fig. 2. The value of VSWR is estimated between 1 to 2 and results is shown in Fig. 3. The polar pattern of directivity is shown in Fig. 5. The comparison of frequency with reflection coefficient is shown in Fig. 6. The real and imaginary part of yagi uda antenna is shown in Fig. 7. Maximum efficiency of antenna is shown in Fig. 8. The loss tangent of an yagi antenna is 0.02.

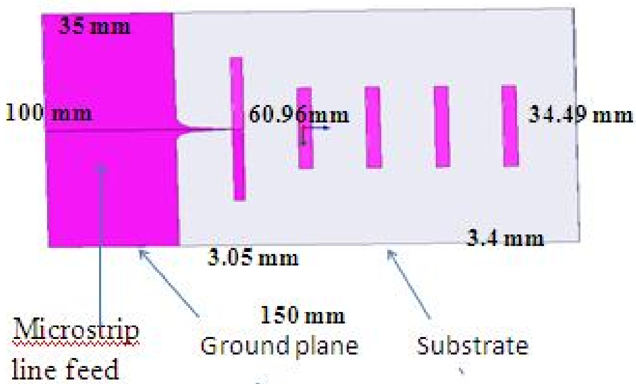

Fig. 2. Geometry of Yagi uda antenna

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

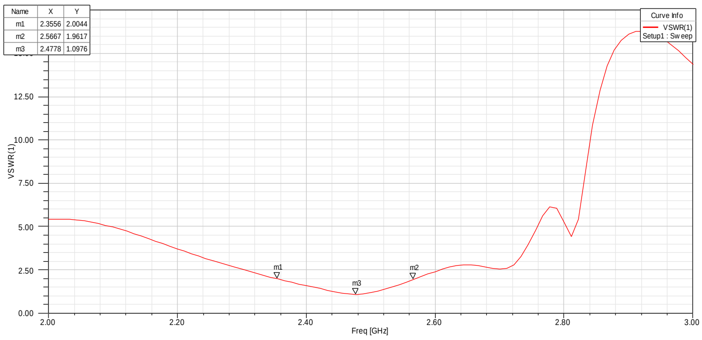

Fig. 3. Simulated VSWR of the Yagi antenna

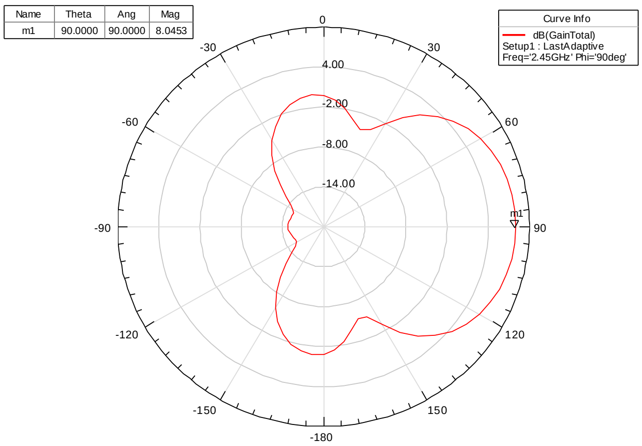

Fig. 4. Simulated Radiation pattern with gain(dBi)

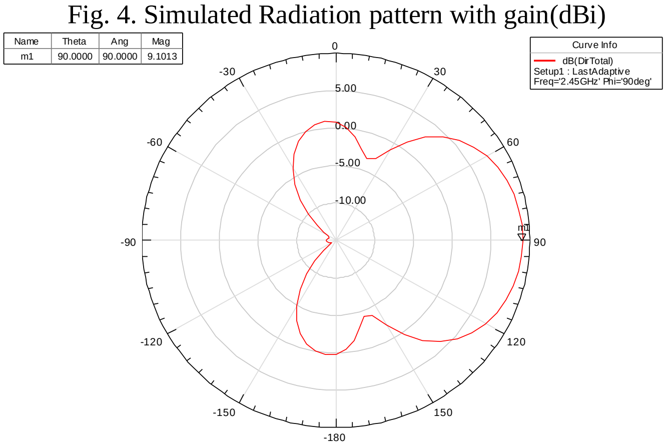

Fig.5. Simulated directivity(dB) with respect to theta

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

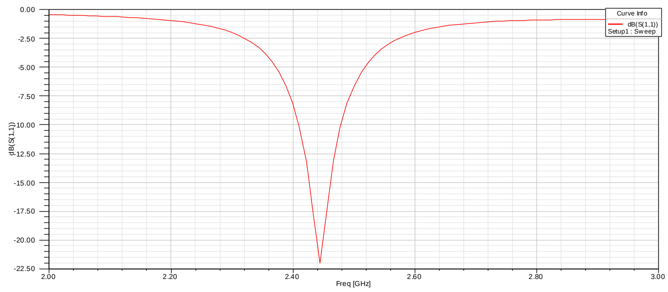

Fig. 6.Simulated Frequency Vs return loss

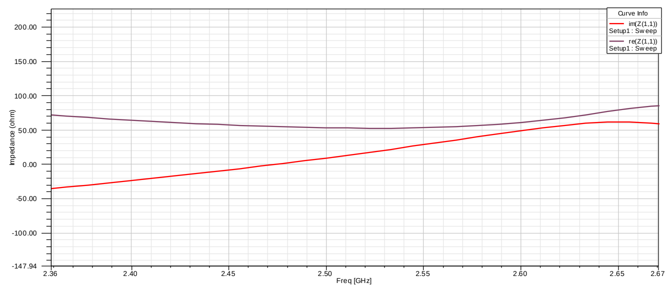

Fig. 7. Frequency Vs impedance

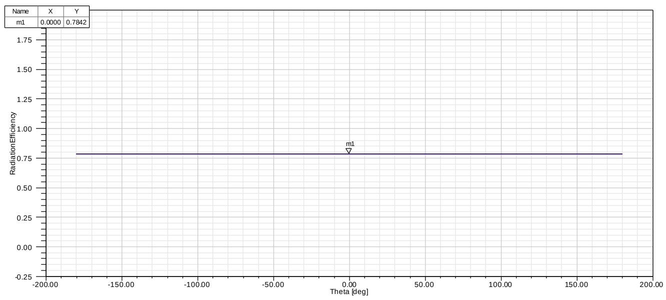

Fig. 8. Elevation angle Vs efficiency

B. Fabrication of Yagi Uda antenna

The designed antenna was fabricated on a copper material and substrate using standard photolithography technique. First the design was transferred on to a transparent mask. The copper material was cleaned, dried and applied using spinner. The thickness of FR4 substrate is 1.6mm. Above the substrate, an reflector with spacing of dipole and director is placed. Between the holder and reflector, an Microstrip line feed is soldered using copper material.One of the advantage of fabricating an yagi uda antenna is, the wider bandwidth is achieved. Fabricated yagi uda antenna is shown in Fig. 9.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

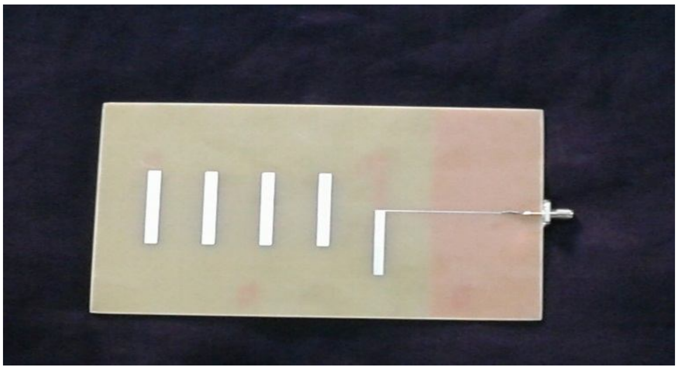

Fig. 9. 2.45GHz Fabricated Yagi Uda Antenna

III. ANTENNA FEEDING METHOD

The Microstrip antenna can be feed through various method. These methods is classified in to two types. 1. Contacting method, RF power is fed directly to the radiating antenna using a connecting element such as a Microstrip line feed. 2. Non-Contacting method, the EMF coupling is done directly to transfer the power between Microstrip line and the radiating element.

A. Microstrip Feeding method

The feeding method used in designing yagi uda antenna is Microstrip line feeding method. In this method, the conducting strip is connected from the reflector to the driven element is shown in Fig. 2. The strip which conducting the signal is vey thin, compare to the reflectors, driven elements and dipoles.

B. Measurement

By using homogeneous mixture liquid, the antenna was measured. 58.2% de-ionized water, 5.1% DGBE(Diethylene glycol butyl ether) are the recipes's used. The measured VSWR is shown in Fig. 3. Indicates that the measured impedance bandwidth of the proposed antenna is from 2.3556 to 2.557GHz for $|S_{11}|$ less than -10dB.

IV. RECTIFIER CIRCUIT

In this paper, the rectifier is proposed with schottky diode HSMS2860, SMA pF capacitor which is need to convert RF-to-DC for wireless power transfer.In order to improve the rectifier efficiency, the matching and filter is added between the antenna and rectifier and between the rectifier and the load.
HSMS2860 schottky diode was chosen because of its high speed and low voltage drop. In order to avoid impedance mismatching, the characteristic impedance is set to 50Ω with proposed insitable antenna. The proposed 2.45GHz linearly polarized Yagi Uda antennahas been designed and pertinent to the Microstrip rectifier to obtain the rectenna.

A. Fabrication of Rectifier

Matching stub, band pass filter, high frequency Schottky diode, DC filter, SMA capacitor is usedfor fabricating a rectifier. First we fabricate an ground plane and coated with copper material. Secondly, we placed an FR4 substrate on top of the ground plane. Thirdly, above the FR4 substrate, 5Ω resistor and capacitor is soldered, in between that schottky diode is soldered. Finally they are connected with transmission lines coated with copper material. The fabricated rectifier and antenna is connected with the help of RF cable known as rectenna. The fabrication of rectifier is shown in Fig. 10

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

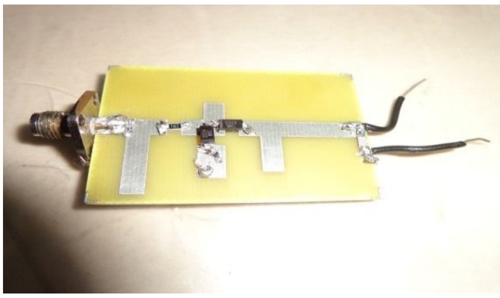

Fig. 10. Photograph of fabricated rectifier

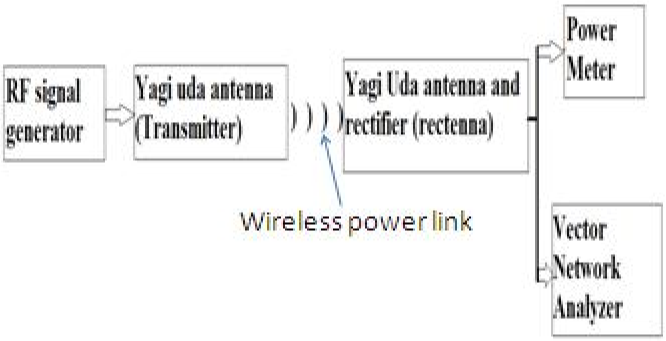

Fig. 11. Experimental setup for measurement

A. Measurement of Wireless Power Transfer

A Yagi Uda Antenna is placed in the transmitter side withgain of 8.14dBi at resonant frequency of 2.45GHz connected to the Agilent RF signal generator. In the receiver side a yagi uda antenna along with rectifier(rectenna) is placed. The input power fed to the yagi uda antenna is 10dBm. The distanceobtained between thistwo antenna is improved upto 2m. The power is transferred wirelessly between transmitter and receiver. The received power is measured using power meter. Measure the Dc output voltage of the rectenna and then estimated the total power transmission efficiency. The parameters such as VSWR, reflection coefficient, impedance is measured using Vector network analyzer(VNA). The measurement block diagram is shown in Fig. 11.The value obtained by 50Ω impedance matching of fabricated antenna is shown in Fig. 12.

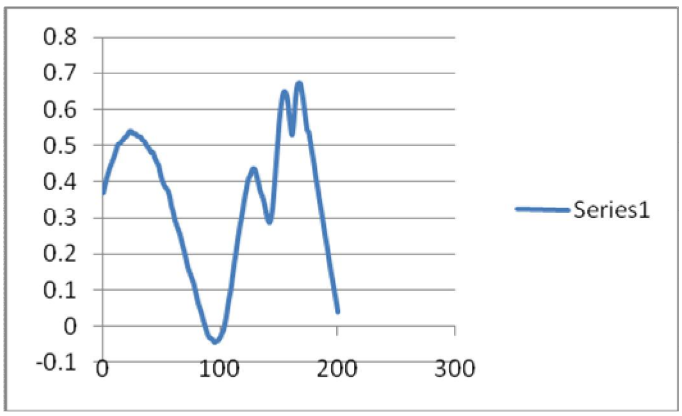

Fig. 12. Measurement of impedance mismatching using VNA

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

The reflection coefficient of fabricated antenna achieved an return loss with three different frequencies is shown in Fig. 13. VSWR of fabricated antenna is shown in Fig. 14.

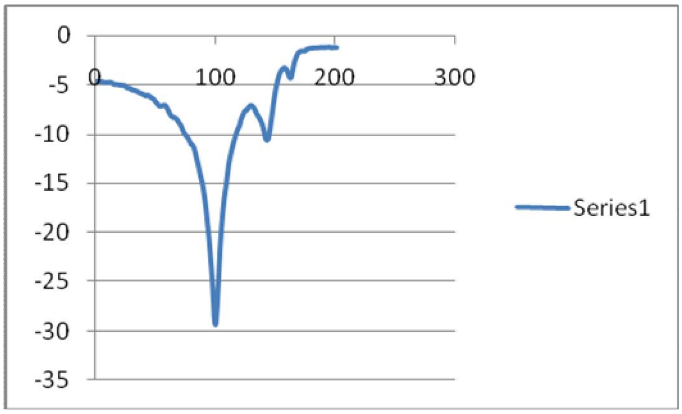

Fig. 13. Measurement of Reflection coefficient Vs return loss

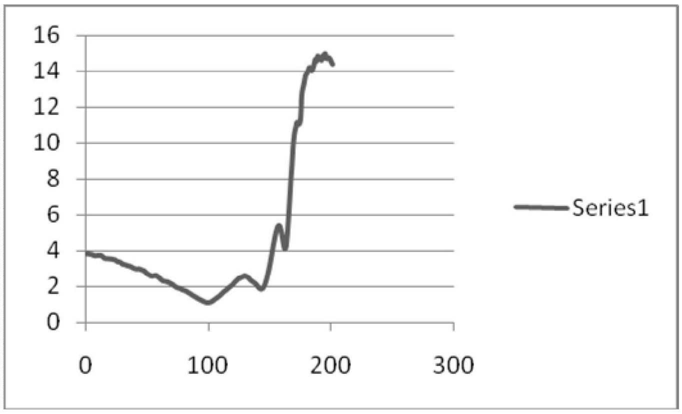

Fig. 14. Measurement of VSWR Vs Frequency

V. CONCLUSION

This paper presents a insitable rectenna for far field wireless power transfer at 2.45GHz. We first designed an yagi uda antenna and simulated using high frequency structure simulator with improved efficiency and gain. Secondly we designed rectifier for high RF to DC conversion HSMS2860 schottky diode.The value achieved between simulation and measurement is more or less similar. Further, frequency range can extend upto 20GHz, distance can be improved more and size of the rectenna can be miniaturize and it can be used for real time application.The simulated parameters is tabulated in Table given below

S.No.	Parameters	Microstrip Yagi Uda antenna
1.	Gain	8.14dB
2.	Directivity	9.19dB
3.	Efficiency	78%

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

REFERENCES

[1] C.Mikeka, H. Arai, “Design issues in Radio Frequency range,” IEEE transactions on, Vol. 54, no. 8,pp. 1709-1800,2011

[2] S. Imai et. al., “Efficiency and harmonics generation in microwave to dc conversion circuits of half-wave and full-wave rectifier types” in 2011 IEEE MTT-S International, May 2011, pp. 15-18.

[3] Dolgov, R. Zane, and Z. Popovic, “Power management system for online low power rf energy harvesting optimization,” Circuits and systems I: Regular papers, IEEE Transactions on, Vol. 56, no. 8, pp. 1808-1819,2010.

[4] J. Garnica, R. A. Chinga, and J. Lin, “Wireless power transmission:From far field to near field,” Proc. IEEE, vol. 101, no. 6, pp.1321–1331, Jun. 2013.

[5] E.Falkenstein, M.Roberg, and Z. Popovic, “Low power wireless power delivery,”IEEE Trans. Microw. Theory Tech.,vol.60,no 7,pp. 2277-2286,Jul.2012.

[6] S.Hu, J.H. Cheong, Y.Gao, M. C. K. Ho,M. Je, M. Madihian, and S.Khait, “A low-cost 2.45-GHz wireless power link for biomedical devices,”inProc. IEEE Asia-Pacific Conf. Antennas Propag. (APCAP), 2012, pp. 215–216.

[7] H. Sun,Y.-X. Guo, M.He, and Z. Zhong, “Design of a high-efficiency2.45-GHz rectenna for low-input-power energy harvesting,” IEEE AntennasWireless Propag.Lett., vol. 11, pp. 929–932, 2012.

[5]Z.Harouni,L.Cirio,L.Osman,A.Gharsallah,andO.Picon,“A dualCircularily polarized 2.45GHz rectenna for wireless power Transmission”,IEEE Antennas Wireless Propag.Lett.,vol.10pp.306-309,2011.

[6] G. Vera, A. Georgiadis, A. Collado, and S. Via, “Design of a 2.45 GHzrectenna for electromagnetic (EM) energy scavenging,” in Proc. IEEERadio Wireless Symp., 2010, pp. 61–64.

[7] Z.N.Chen, G.C. Liu, and T.S.P.See,’’Transmission of RF signals between MICS loop antennas in free space and implanted in the human head,”IEEETrans.Antennas Propoag.,vol57,no.6,pp. 1850-1854,Jun.2009.

[8] N.Cho, T.Roh, J.Bae, and H.J. Yoo,”A Planar MICS band antenna combined with a body channel communication electrode for body sensor network,”IEEE Trans. Microw. Theory Tech.,vol.57,no.10,pp.2515-2522,oct.2009.

[9] C.-M. Lee, T.-C. Yo, F.-J. Huang, and C.-H. Luo, “Dual-resonant-shape with double L-strips PIFA for implantable biotelemetry,”Electron.Lett., vol. 44, no. 14, pp. 837–838, Jul. 2008.

[10] M.Ali, G.yang , and R.Dougal,“A New circularily polarized rectenna for wireless power transmission and data communication,’’IEEE Antenna Wireless Propag.Lett.,vol.4,pp.205-208,2005.