ISSN(Online): 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 2, February 2016

A Survey on Different Rectenna Designs as an Energy Harvester

Kuntal Shukla[1], Renuka Makwana[2]

PG Student, Department of Electronics and Communication, Sardar Vallabhbhai Patel Institute of Technology Vasad, India[1]

Assistant Professor, Department of Electronics and Communication, Sardar Vallabhbhai Patel Institute of Technology Vasad, India[2]

ABSTRACT*:* In order to harvest higher amount of ambient energy from surroundings, various rectenna design approaches have been used. Among them, Microstrip Patch antenna is widely used because of low profile and compact structure.Conventional Patch antenna having various shapes of patch design available for distinct applications This paper begins with an discussion of various designs put forward with an aim of reconfigurability and harmonic rejection of dualband, multiband and braodband configurations. Finally, Microstrip patch rectennas are compared with various methods.

KEYWORDS: Rectenna, wireless power transmission, wireless energy harvesting, rectenna conversion efficiency, Microstrip Patch Antenna.

I. Introduction

In this emerging world of various communication technologies like 2G, 3G, WLAN (2.4 GHz, 5.8 GHz) range of frequencies are spread around us. Some of energy is getting used by subscribers but fractional part of frequencies is getting wasted in surrounding. On the other hand, radiation of microwave frequencies are severely affecting human health hence an approach of collecting a specific range of frequencies & convert it into dc current which in turn results in energy harvesting system.

The headway of multifunction and various emerging energy harvesting solutions increased in past few years. Natural and renewable energy sources like wind turbines, solar panels have their own limitations but valuable in the sense of inexhaustible sources with little or no adverse effects.

Energy harvesting devices are particularly attractive as replacement of batteries in low-power electronic device is cumbersome at some extent. The cost of procuring, storing and getting someone to charge a battery can easily cost as much as an energy harvester. At short range, a tiny amount of energy (microwatts) can be harvested from typical Wi-Fi router transmitting at a power level of 50-100mW. For longer-range operation, antennas with higher gain are needed for practical harvesting of RF energy from mobile base stations and broadcast radio towers.

In addition to energy harvesting, rectenna have wide range of applications in efficient monitoring planarity of Structures for satellite communications [1], RFID and Wireless sensor network transponder especially in remote locations where battery replacement is major issue [2], Wireless body area networks for self charging of pacemakers and other battery operated medical devices[3] and automotive radar applications.

This paper organized as follows. Section II provides the overview of Energy Harvesting System., the next section provides description of rectenna as an energy harvesting solution The section IV presents different types of rectenna designs. Finally, the conclusion is specified in section V.

II. Overview Of Energy Harvesting Systems

Energy harvesting has been around in the form of windmills, watermills and passive solar power systems. In recent decades, technologies like wind turbines, thermal power generators, hydro-electric generators and solar panels have turned harvesting into a small contributor to the energy needs to all over the world. This technology offers two

ISSN(Online): 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 2, February 2016

significant advantages over battery-powered solutions. The most promising low power harvesting technologies extract energy from vibration, temperature differentials and light. Scavenging energy from RF emissions is interesting.

Generally energy harvesting system suffers from low, variable and unpredictable levels of available power. Due to low powered communication device, an attraction is increased towards low power energy harvesting techniques. EM/RF sources such as TV & Radio broadcasting also provide a part in Energy Harvesting but with wider antenna sizes hence we have focused our work in telecommunication services which operates in microwave region of frequency spectrum.

III. RECTENNA AS AN ENERGY HARVESTER

A rectenna is a system that basically consist of a receiving antenna, impedance matching circuit followed by filter and a rectifier. This system act as a transducer which converts RF or microwave power into small amount of DC current.

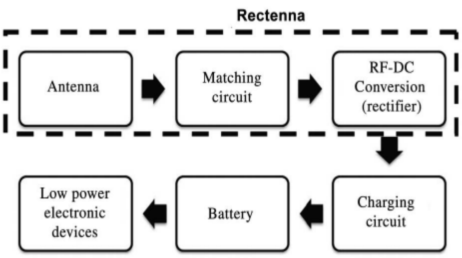

Fig 1. Basic Block Diagram of RF Energy Harvesting system [4]

Being an RF energy harvester, rectenna captures ambient energy from surrounding and act as a power generator. Figure 1 consists of RF energy harvesting system. The incident waves within spectral range of an antenna are received by it which in turns matched with filter and rectifier circuit via impedance matching network.

Earlier researchers have proposed Dual Band[5]-[7], Multiband[8], Broadband[9]-[10], Dense dielectric configuration[11], Multisource harvester[12] which have contribute in energy harvesting approaches.

IV. DIFFERENT TYPES OF RECTENNA DESIGNS

The review work on design of various energy harvesters is divided into various parts as follows:

A. *Dual Frequency Rectenna:*

A dual band rectenna[5] consist of a half wavelength ($\lambda 0/2$) dipole antenna at 915 MHz is folded to miniaturize the antenna and a slot is loaded the middle of antenna to introduce the second resonant frequency at 2.45 GHz. This structure is matched with 50 Ω rectifier designed using Schottky diode. The optimum matching network consist of three inductors (L1 = 7.5 nH, L2 = 10 nH and L3 = 8.7 nH) and a radial stub. This rectenna design achieves RF to DC conversion efficiency of 37% and 20% at 915 MHz and at 2.45 GHz respectively for power density 1µW/ cm2 at input power of -9 and -15 dBm.

A broadband 1x4 quasi yagi antenna array [6] harvest bandwidth from 1.8 GHz to 2.2 GHz. This structure exhibits an output dc voltage varies between 300 to 400 mV when measured in ambience. Measurement results achieve RF to DC power conversion efficiency of 40% and output voltage of 224 mV at input power density of 455 $\mu W/m^2$.

A dual frequency CPS dipole antenna[7] along with low pass filter integrated with two bandstop filter effectively block the second order harmonics at 2.45 GHz and 5.8 GHz. The measured conversion efficiencies achieved at free space are 84.4 and 82.7% at 2.45 and 5.8 GHz respectively.

B. *Multiband Rectenna*

A ring loaded bowtie antenna[8] is used to collect the EM energy coming from RFID systems and a 2-stage voltage rectifier used to convert it into DC power. To operate at different frequency each antenna is required the different rectifier to harvest separately DC power hence a possible solution is to use only one Multiband antenna to overcome this drawback. This configuration resulted as RF input power1 (900 MHz) and RF input power2 (2.4 GHz) gives the

ISSN(Online): 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 2, February 2016

rectification efficiency of about 75% with the total DC output power of about 3mW and DC output voltage of as bout 13V.

C. *Broadband Rectenna*

A rectenna that covers wide range of frequencies consist of broadband antenna designs [9]-[10]. Broadband antenna is fed by grounded coplanar waveguide structure (GCPS) [9] with high gain act as a receiving antenna. By designing the input and output impedance match networks, a broadband GCPW rectifying circuit based on the voltage doubler principle provides broad operation bandwidth and high mw-dc efficiency. The bandwidth of mw-dc efficiencies higher than 50% is 16.3% (2.2–2.6 GHz) at 13 dBm received power.

As an approach of broadband rectenna is accomplished by designing truncated triangular monopole antenna [10] followed by Schottky diode-based voltage doublers for rectification. The antenna has a stable radiation pattern from 850 MHz to 1.94 GHz. In addition, at a distance of 25 m from a cell site, a voltage of 3.76 V for open circuit and 1.38 V across a 4.3 kΩ load is obtained using an array of two elements of the rectenna.

D. *Multisource Rectenna*

In addition to RF energy, Solar panel integration on transparent ultra-wideband antenna [11] enables to provide wireless transmission and reception on both sides of a glass window or glass building covers from 2.49 to 2.58 GHz range of frequencies. This structure when connected to a 2.55-GHz rectifier is able to produce 18-mV dc in free space and 4.4-mV dc on glass for an input power of 10 dBm at a distance of 5 cm.

E. *Comparative View*

From above survey, microstrip patch antennas are found to be used extensively because of their low profile, compact size, ease of fabrication and nearly omni directional radiation patterns. Modifications in patch designs and rectifying circuit elements results in improved characteristics of energy harvester.

V. CONCLUSION

Therefore paper describes the progressive development of rectenna in terms of its applications in various fields; Microwave Power Transmission, Circularly Polarized Radiation, High Efficiency and Dual Frequency characteristics in the range of ISM as well as other high frequency bands.

Antenna being a vital component of rectenna, the modification on its design can yield a compact size, suppress unwanted harmonics, and provide frequency and polarization diversity. Hence microstrip patch antenna provides all advantages in single package over wide range of frequencies. In addition, modifications in matching and rectifying circuit elements results into optimum energy harvesting.

REFERENCES

1. J. Kim, S. Choi and K. Song, "Microwave Rectenna Based Sensor Array for Monitoring Planarity of Structures", US 20090237093A1, 2009.
2. Y. Tikhov, Y. Min and Y. Kim, "Small planar antenna with enhanced bandwidth and small rectenna for RFID and wireless sensor transponder", EP 1 628 360 A1, 2006.
3. Giuseppina Monti et al.," UHF Wearable Rectenna on Textile Materials", IEEE Transactions On Antennas And Propagation, vol. 61, no. 7, pp. 3869-3873, July 2013.
4. Arrawatia et al, "Differential Microstrip Antenna for RF Energy Harvesting", IEEE Transactions On Antennas And Propagation, vol.63, no. 4, pp. 1581-1588, April 2015
5. K. Niotaki et al., "A compact dual-band rectenna using slot-loaded dual band folded dipole antenna," IEEE Antennas Wireless Propag. Lett., vol. 12, pp. 1634–1637, Dec. 2013..
6. H. Sun, Y.-X. Guo, M. He, and Z. Zhong, "A dual-band rectenna using broadband Yagi antenna array for ambient RF power harvesting," IEEE Antennas Wireless Propag. Lett., vol. 12, pp. 918–921, Jul. 2013.
7. Y.-H. Suh and K. Chang, "A high-efficiency dual-frequency rectenna for 2.45- and 5.8-GHz wireless power transmission," IEEE Trans. Microw. Theory Tech., vol. 50, no. 7, pp. 1784–1789, Jul. 2002
8. S. Jadhav and Dr. Veeresh G. K., "Multiband Rectennas Using a Bowtie Antenna - A Review" International Journal of Emerging Technology and Advanced Engineering., vol. 3, issue. 3, pp. 862–866, Mar. 2013.
9. Mei-Juan Nie and Xue-Xia Yang et al., "A Compact 2.45 GHz Broadband Rectenna Using Grounded Coplanar Waveguide", , IEEE Antennas And Wireless Propagation Letters, vol.14, pp. 986-989, 2015.
10. Arrawatia et al, "Broadband Bent Triangular Omnidirectional Antenna for RF Energy Harvesting", vol. 15, IEEE Antennas And Wireless Propagation Letters, pp. 36-39.

ISSN(Online): 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 2, February 2016

11. Peter et al.," A Novel Transparent UWB Antenna for Photovoltaic Solar Panel Integration and RF Energy Harvesting", IEEE Transactions On Antennas And Propagation, vol.62, no. 4, pp. 1844-1853, April 2014.

BIOGRAPHY

Kuntal Shukla is a PG Student in the Electronics & Communication Department, Sardar Vallabhbhai Patel Institute of Technology Vasad. He received the B.E Degree in Electronics and Telecommunication Engineering from Sardar Patel University, Anand in 2011. His research interest is on Antenna designs and Energy Harvesting.

Renuka Makwana is an Assistant Professor in the Electronics & Communication Department, Sardar Vallabhbhai Patel Institute of Technology Vasad. She received the B.E. degree in Electronics and the M.E. degree in Industrial Electronics from the Maharaja Sayajirao University, Vadodara in 2002 and 2004 respectively. She is currently pursuing from C. U. Shah University, Surendranagar. Her research interest is on Antennas, Microwaves and Electromagnetics.