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A BATTERY-LESS OR ENERGY HARVESTING DEVICE WIRELESSLY POWERED FROM A MIMO-OFDM SIGNALS

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Abstract- *This paper provides an overview of the optional MIMO (Multiple-Input Multiple-Output) antenna scheme that can be used to improve robustness and increases capacity by sending two data streams in a single radio frequency channel. The energy harvesting devices can also harvest their power from these ambient broadcast wirelesses TV signals. The usage of cross-polarized antenna MIMO scheme allows the video signals to be carried over multi-carrier frequencies via OFDM at much wider bandwidth in the UHF bands.*

The electronic devices operating at 3V or less than 3V can also be used to scavenge their power from such type of broadcasting by means of a dipole antenna. The condition is that the dipole should lie within a range of 6.5km from the source.

***Key Words*: OFDM (Orthogonal Frequency Division Multiplexing), MIMO (Multiple Input Multiple Output), EM (Electromagnetic), ERP (Effective Radiated Power), UHF (Ultra High Frequency)**

1. INTRODUCTION

Wireless communication is the use of EM waves to transfer data between two users. Wireless communications have developed into a key element of modern society. From satellite transmission, radio and television broadcasting to the new ubiquitous mobile telephone, wireless communications has revolutionized the way societies function. It has many advantages over the earlier successful wired communication: These are its portability, flexibility and coverage [1]. Ambient wireless power in the UHF bands due to digital TV broadcasts can offer a perpetual power source for sustaining battery-less, limited duty cycle operation of a number of low power embedded and wireless transceivers for autonomous wireless sensing with “smart skins”; implantable and wearable sensors for bio-monitoring; and “Internet of Things” applications. In this paper, we present a unique prototype capable of scavenging wireless power from Digital TV broadcasts over ranges of kilometers for powering on low power embedded processors and wireless transceivers.

2. AMBIENT WIRELESS MIMO TECHNOLOGY

MIMO technology leverages multipath behavior by using multiple “smart” transmitters and receivers with an added “spatial” dimension to dramatically increase performance and range. MIMO allows multiple antennas to send and receive multiple spatial streams at the same time. A wireless adapter with 3 antennas may have a speed of 600mbps while an adapter with 2 antennas has a speed of 300mbps [2].

MIMO makes antennas work smarter by enabling them to combine data streams arriving from different paths and at different times to effectively increase receiver signal-capturing power. If there are more antennas than spatial streams, the additional antennas can add receiver diversity and increase range. The electronic devices operating at 3V or less than 3V can also be used to scavenge their power from such type of broadcasting by means of a dipole antenna streams, the additional antennas can add receiver diversity and increase range. The usage of cross-polarized antenna MIMO scheme allows the video signals to be carried over multi-carrier frequencies via OFDM at much wider bandwidth in the UHF bands [3]. The electronic devices operating at 3V or less than 3V can also be used to scavenge their power from such type of broadcasting by means of a dipole antenna. The condition is that the dipole should lie within a range of 6.5km from the source.

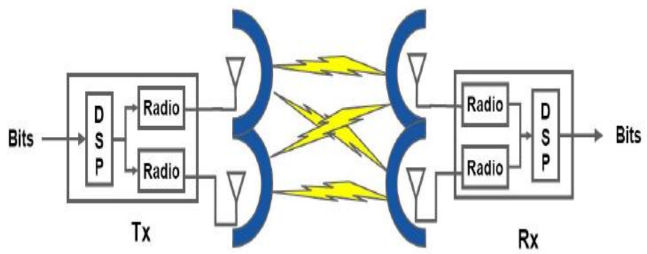


Diagram of a MIMO wireless transmission system

3. WIRELESS POWER TRANSFER MECHANISMS

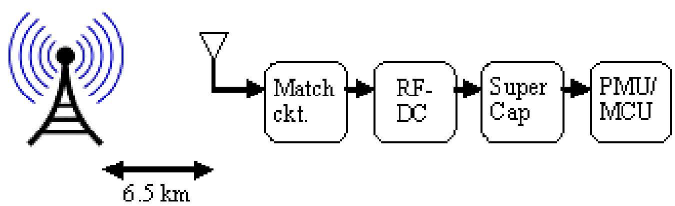
Digital TV broadcasts have lower transmitted power compared to an older analog TV, and are designed to beam out high-definition TV (HDTV) programs for long duration of time and wider coverage in most urban areas. Ambient wireless power in the UHF bands due to digital-TV broadcasts can offer a perpetual power source for sustaining battery-less limited duty-cycle operations of a number of low-power (LP) embedded and wireless transceivers.

Wireless power transfer mechanisms are primarily classified as near- or far-field systems. Near-field systems use magnetic induction to transfer power wirelessly with high efficiency typically within a wavelength from the source. However, beyond near-field, magnetic fields decay rapidly at a rate of 60dB/decade, which make them useful only for distances that are close to the radius of near-field coil-type antennas [4].

Compared to near-field systems, wireless power in the far field propagates using transverse electromagnetic waves, which decay less rapidly at about 20dB/decade, thereby allowing for power transfer over longer range. Bose first demonstrated the use of wireless signals to transfer power and audio signals in the far-field through his invention of the crystal radio in 1894, which is the precursor to the modern AM radio. Since then, a number of RF/wireless energy harvesting work has been reported in frequency bands from 60 Hz to 8 GHz.
The biggest use of wireless power has been in RF identifications (RFIDs) for consumer and industrial tracking applications. A number of research groups have also used near- and far-field WPT schemes based on RFID technologies for powering or activating bio-implanted sensors in the human body for electrocardiogram (ECG), electroencephalography (EEG), electromyography (EMG), and ocular sensing. Most of the wireless power harvesting work in the far field has been in the UHF bands between 862–928 MHz for RFID-based sensors. Most of the new designs use sub-micron CMOS technology with RF input sensitivities down in the tens of microwatts with a reported range of 9.25 m

4. IMPLEMENTATION

Harnessing enough energy out of such low amounts of incident wireless power in order to use it to power on electronics requires the design of an optimized antenna, an RF-to-DC charge pump circuit, a proper power matching between them to minimize reflection losses and a low leakage power management circuitry to keep the embedded end device from draining the charge tank super capacitor till it has reached a high turn on voltage as in the system



System level description of energy harvesting device

At long distances from the source, well into the far field range of the TV broadcasting antenna, the amount of useful power that can be harnessed from the incident Electric field in the UHF bands is a function of the antenna aperture area (AE), which is a function of the antenna gain (G); its conjugate load matching with the RF to DC charge pump circuit (); the wavelength of the incident electric field; and any polarization mismatch losses either due to the antenna orientation. Since TV broadcasts are linear in polarization, linear antennas such as dipoles or monopoles or its arrays offer lower losses due to polarization mismatch and therefore present a larger Antenna aperture area to the incident wireless electric fields [5].

A. Dipole Antenna

An optimized linear dipole antenna was designed and fabricated using an inkjet printing process to efficiently convert the incident Electric field hitting it at UHF bands into RF signal form to be fed into an impedance matched RF to DC charge pump circuit that stores the harnessed energy in the form of a charge across a low leakage super capacitor. The antenna length was optimized to be about half wavelengths long to maximize its gain (G) & the effective aperture area (Ae), which would increase the voltage at its terminals and the incident wireless power collected.

B. RF to DC Charge Pump Circuit

The incoming power transduced across the antenna is in RF form and induces a very low voltage across the antenna terminals. Being able to harness this power requires it to be rectified and stepped up to a voltage of 1.8V or higher at which most electronic devices such as embedded processors and transceivers used for wireless sensing operate. A 5 stage RF charge pump circuit was optimized for this task as given in its battery-less ability to step up and rectify the incoming RF voltage across the antenna compared to DC-DC power converters albeit with less gain control [6].

The RF charge pump circuit exhibited very low power dissipative losses with an input impedance of about 0.52-j7.3 ohms at UHF TV bands with the tank capacitor charged between 1.8 and 3.0V (VCAP). An optimal matching network was designed to match the 50 ohm antenna impedance to the varying capacitive load of the Charge Pump Circuit across the digital UHF TV bands.

Low forward voltage Schottky diodes and proper circuit layout design help minimize circuit losses, turn on power and reverse leakage from the energy storing charge tank capacitor. Properly selected high Q capacitors used in the charge pump help minimize leakage and shorten the charge build up time in its output charge tank.

C. Matching circuit

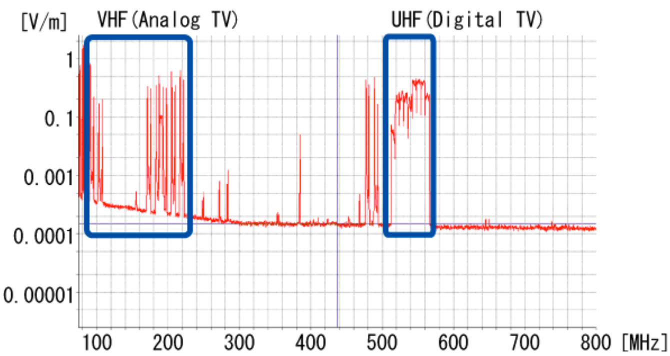
The amount of wireless power required by the Charge pump circuit to charge the tank capacitor to 1.8 and 3.0V are 38 and 70 micro-watts respectively at 550 MHz, which is close to the wireless power captured by the antenna from the UHF TV bands at the POI as shown in Fig 5. Based on Fig 5, the energy harvesting circuit was expected to charge the charger tank closest to 3V at the POI which was verified by on field measurements as shown in Fig 6. At a distance of 6.5km from Tokyo TV tower, the energy harvesting circuit charges up the 100uF charge tank to 2.9V in 3minutes making such a device ideal for battery less operation of wireless sensors for remote monitoring/sensing in most urban areas using just the existing terrestrial TV broadcast infrastructure for power.

5. ANALYSIS

In order to maximize coverage and range, TV and Radio broadcast towers are spaced at regular geographic intervals in most urban areas, each broadcasting out between 10-100 kilowatts of effective radiated power (ERP) wireless in Japan and the US. The amount of this power that can be captured using a polarization matched linear antenna on the receiver within a range of around 6.5 kilometers can be estimated to be in the 10 to-100s of micro-Watts range using Friis equation:-

$$P_R = P_T.\, G_T.\, G_R.\, \left(\frac{\lambda}{4.\, \Pi.\, R}\right)^2$$

Wireless power estimates at such long distances from the source were verified by ambient wireless spectrum measurements carried out at the point of interest in downtown (POI) using a NARDA SRM-3000 Radiation meter, which show significant wireless activity in the VHF and UHF bands between 480 and 580 MHz due to radio and TV broadcasts. The wireless spectrum measurement carried out at the POI at a distance of 6.5 km from TV broadcasts atop tower is shown in Fig 1. The measured wireless signal levels due to Analog and Digital TV broadcasts in the UHF bands in terms of their incident electric field intensity (V/m) are listed in the table:-



Measured UHF and VHF TV and Radio Broadcasts

6. CONCLUSION

An energy harvesting device was successfully designed to harvest power from ambient wireless TV signals at a distance of over 6.5km. The electronic devices operating at 3V or less than 3V can be used to scavenge their power from such type of broadcasting.

REFERENCES

[1] Mohammad El-Hajjar and Lajos Hanzo, "A Survey of Digital Television Broadcast Transmission Techniques"; IEEE Communication Surveys & Tutorials, Volume:15, Issue:4, PP: 1924-1949, 2013.

[2] K Swathi and S. Mallikarjun Rao," Energy Efficiency of MIMO-OFDM Communication Systems"; Journal of Engineering research and Applications' Volume:4, Issue:9, PP:28-34,2014.

[3] Arjun Chopra and Komal Arora, "PAPR Reduction in STBC MIMO OFDM System using AMS and PTS Schemes"; International Journal of Computer Applications Volume: 96, Issue :8, June 2014.

[4] Rushi J. Vyas, Benjamin Rushi J. Vyas, Benjamin B. Cook, Yoshihiro Kawahar and Manos M. Tentzeris, "E WEHP: A Batteryless Embedded Sensor-Platform Wirelessly Powered From Ambient Digital-TV Signals"; Volume: , Issue:, PP: , 2013.

[5] Rushi Vyas, Hiroshi Nishimoto, Dr. Manos Tentzeris, Dr. Yoshihiro Kawahara and Dr. Tohru Asami, "A Battery-Less, Energy Harvesting Device for Long Range Scavenging of Wireless Power from Terrestrial TV Broadcasts"; Microwave Symposium Digest(MTT), 2012 IEEE MTT-S Standard International PP: 1-3 , 2012.

[6] Dolgov et. al, "Power Management System for Online Low Power RF Energy Harvesting Optimization." IEEE Transactions of Circuits & Systems, Vol: 57, Issue: 7, 2010.

[7] "RF energy harvesting and wireless power," Powercast\ Corporation, Pittsburgh, PA, USA, Apr. 2012.

[8] R. Vyas, V. Lakafosis, Z. Konstas and M.M. Tentzeris,"Design and Characterization of a novel battery-less, solar powered wireless tag for enhanced-range remote tracking applications,"; Eur. Microw. Conference PP: 169–172, 2009.

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