Power Over Wi-Fi: Power Transmission Through Existing Wi-Fi Routers

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Abstract—IoT based devices have gained an amazing popular-ity during the recent years. Its mainly due to the fact that, many things can be carried out without direct human intervention. Low power sensors play a major role in IoT based devices. Here arise the major issue of powering up the device. Currently the sensors/microcontrollers are always powered up either using batteries or directly plugging in to the power socket. It leads to a power loss that are not negligible. The proposed work defines a new method, in which Wi-Fi signals are made used to power up the devices. Since the devices are IoT based, they are in any case connected to neighbouring Wi-Fi modem/router. The system mainly consists of an antenna, a RF to DC converter circuit and boost converter. As a future scope we can use this method to charge batteries which in turn can be also used to charge our mobile phones. The proposed circuit were designed and simulated using Keysight Advanced Design System ADS.

Index Terms—Wi-Fi, Energy Harvesting, IoT, WPT

I. INTRODUCTION

Wireless power transfer (WPT) or wireless energy trans-mission is the transmission of electrical power from a power source to a consuming device without using solid wires or conductors[1]. It is a generic term that refers to a number of different power transmission technologies that use time-varying electromagnetic fields. Wireless transmission is useful to power electrical devices in cases where interconnecting wires are inconvenient, hazardous, or are not possible. In wireless power transfer, a transmitter device connected to a power source, such as the mains power line, transmits power by electromagnetic fields across an intervening space to one or more receiver devices, where it is converted back to electric power and utilized. Nikola Tesla pioneered the concept of WPT during his time and also did many experiments. But the concept of wireless power transmission didnt develop from its inception stage due to many parameters. Now-a-days, mjor attraction factor of electronic devices is the factor of mobility. It is acheived by using batteries to power up the device. But the battery life is a major concern due to the complex devices. Hence they should be recharged at regular intervals. Wireless charging pads for mobiles are introduced recently which uses the inductive charging principles. But, mobile phones should be kept on the pads for charging, hence we cannot completely call it as wireless. Thus a robust system is required to completely charge or power up the devices wirelessly[2].

II. BASICS OF WIRELESS POWER TRANSFER

A. Wireless Power Transfer

Wireless power transmission is a collective term that refers to a number of different tech- nologies for transmitting power by means of time-varying electromagnetic fields. The tech-nologies differ in the distance over which they can transmit power efficiently, whether the transmitter must be aimed (directed) at the receiver, and in the type of electromagnetic energy they use: time varying electric fields, magnetic fields, radio waves, microwaves, or infrared or visible light waves[1]. In general a wireless power system consists of a ”transmitter” device connected to a source of power such as mains power lines, which converts the power to a time varying electromag-netic field, and one or more ”receiver” devices which receive the power and convert it back to DC or AC electric power which is consumed by an electrical load. In the transmitter the input power is converted to an oscillating electromagnetic field by ”antenna” . The word ”antenna” is used loosely here; it may be a coil of wire which generates a magnetic field, a metal plate which generates an electric field, an antenna which radiates radio waves, or a laser which generates light[2]. A similar antenna or coupling device in the receiver converts the oscillating fields to an electric current. An important parameter which determines the type of waves is the frequency f in hertz of the oscillations. The frequency determines the wavelength = c/f of the waves which carry the energy across the gap, where c is the velocity of light.

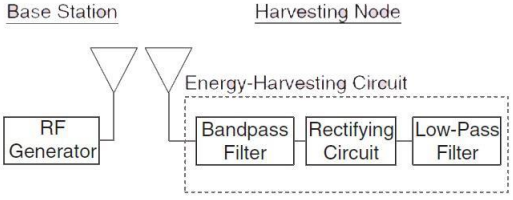

Fig. 1. A Basic WPT system

B. ISM Band

The varied requirements of the proposed applications have had a profound disciplinary impact upon the direction in which the technology has developed. Another disciplinary consid-eration are those factors which have confined the frequency used in the development of the technology and thus far in its applications to the 2.45 GHz band, reserved for industrial, scientific, medical (ISM) application. Although the frequency was originally used because of the use of the ISM band for experimental purposes and the availability of components there. It is also a frequency where the efficiencies of the microwave components are very high[5]. GSM frequency or 900 MHz frequency cannnot be used since they cannot be used for experiments and we need special permission from Department of Telecommunications.

C. Antenna Theory

The IEEE definition of an antenna would be the part of a transmitting or receiving system that is designed to radiate or receive electro-magnetic waves. A simple definition would be any conducting element capable of sensing electro-magnetic waves and is used for transmitting or receiving them. An antenna can also be defined as an electrical device which couples radio waves in free space to an electrical current used by a radio receiver or transmitter. In reception, the antenna intercepts some of the power of an electro-magnetic wave in order to produce a tiny voltage that the radio receiver can amplify. Alternatively, a radio transmitter will produce a large radio frequency current that may be applied to the terminals of the same antenna in order to convert it into an electromagnetic wave (radio wave) radiated into free space. [3]

There are many parameters present for antenna. Few of them are

- Gain
- Directivity VSWR
- S-Parameter
- Input impedence

D. RF Energy-Harvesting Principles

Nearly all modern energy-harvesting circuits use semiconductor-based rectifying elements in a variety of topologies to convert RF to dc power. While semiconductors are individually able to handle relatively small amounts of power (for WPT applications), their low cost and small form factor makes them ideal for a variety of applications. In SPS systems, Schottky diodes are chosen because of their low voltage threshold and lower junction capacitance than PN diodes [4]. This low threshold allows for more efficient operation at low powers, and the low junction capacitance increases the maximum frequency at which the diode can operate. To produce large amounts of power for SPS systems, large arrays of RF rectifiers are used. Standard CMOS processes do not support Schottky diode fabrication, so discrete components are typically used in SPS harvesting arrays. On the other hand, RFID applications leverage CMOS technology with diode-connected transistors that significantly increases the energy-harvester efficiency at lower powers because of lower parasitic values and customizable rectifiers. Furthermore, digital logic can be incorporated onto the same die. The ultra-low power levels needed by these realized electronics along with the cost savings by incorporating the entire device on a single integrated circuit make CMOS processes the dominating technology for RFID energy harvesters[4].

III. PROPOSED WORK

As mentioned earlier, IoT based devices are gaining greater popularity in the present and we can expect a booming pres-ence in the next level of automation. Powering up the devices all the time will lead to lot of power wastage. Instead of powering up the hardware all the time, we can use our existing Wi-Fi routers to send power packets, which can be converted to DC voltage. This DC voltage obviusly will be of lower magnitude and can only be used to power devices that requires low power due to the inefficiencies of the prevailing design methods and ISM band architecture. Proposed system consists of an antenna that operates at 2.4GHz, which is the frequency of Wi-Fi signal. It receives the Wi-Fi signals from routers around.Wi-Fi signal is a RF signal which can be considered as a an AC signal. Then the AC signal can be converted to DC signal by using a rectifier or AC to DC converter. Then the voltage can be level shifted to a higher value by using DC-DC level converter. Then the output of the level converter can be used to power up the low power devices. The proposed system is expected to deliver enough power that can be used to power up various low power sensors, microcontrollers, cameras that find many number of application in IoT based architectures. Greinacher circuit topology is used for RF to DC conversion. The rectifier must be designed to maximize its output voltage.At a high level, our rectifier tracks twice the envelope of the incoming signal and converts it into power. Specifically, it adds the positive and negative cycles of the incoming sinusoidal carrier signal to double the amplitude. To do this, it uses a specific configuration of diodes and capacitors. However, in practice, diodes and capacitors have losses that limit the output voltage of the rectifier. We use SMS7630-061 diodes by Skyworks [5] in ultra-miniature 0201 SMT packages which low losses, i.e., loss threshold voltage, low junction capacitance and minimal package parasitics.

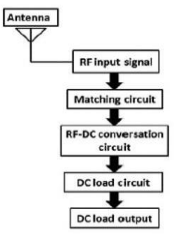

Fig. 2. Proposed Power over Wi-Fi system

IV. RESULTS

Proposed systems were designed and simulated in Advanced Design System by Keysight Technologies. Advanced design system is an electronic design automation software system produced by Keysight EEs of EDA a division of keysight Technologies. Dimensions of various antenna parameters are also shown in the below table.

TABLE I

DIMENSIONS OF 2.4 GHZ ANTENNA

Serial No.	Parameter	Dimension(mm)
1	Lp	28
2	Wp	31
3	Ls	20
4	Ws	3
5	Sw	0.5
6	Wa	42
7	La	47

Figure shows the designed antenna array at 2.4 GHZ in Keysight Technologies Advanced Design System and simu-lated layout in the same.

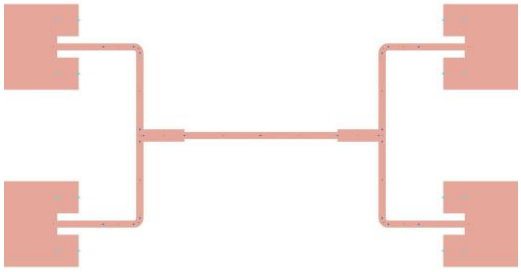

Fig. 3. 2x2 Antenna Array

S-parameter of the designed antenna array is shown in the below figure 4. It shows that the designed antenna is meeting the required conditions for operating normally.

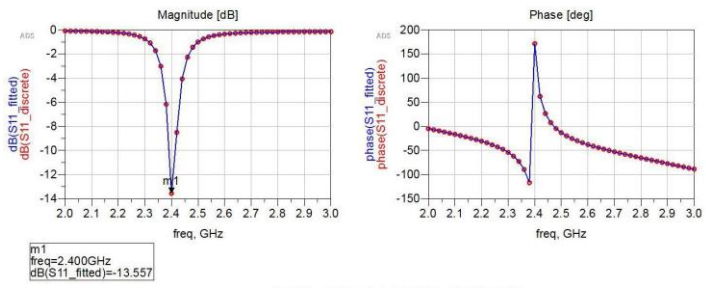

Fig. 4. S-Parameter of the antenna array

Greinacher circuit topolgy is used for RF to DC conversion. They are made using SMS 7630-061 schottky diodes. A 4-stage circuit is used to obtain a output voltage of 3.7 Volts. Figure 5 shows the circuit diagram.

Output voltage obtained from the 4-Stage Greinacher circuit is plotted in the Figure 6.

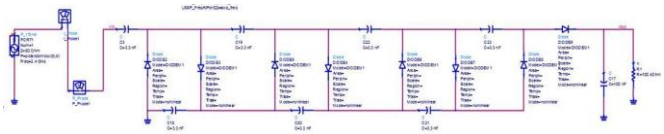

Fig. 5. 4 Stage Greinacher Circuit

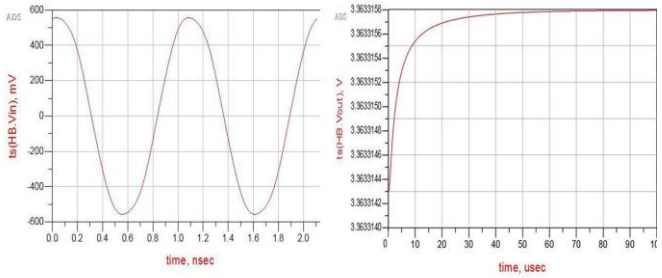

Fig. 6. Output Voltage Obtained

V. CONCLUSION

The proposed work focuses on the possibilities of using Wi-Fi signals as a method of wireless power transfer. Due to the presence of Wi-Fi signals in plenty, we dont need any modifi-cation or new system to transmit the power. All the simulations were done in Keysight Technology's Advanced Design System (ADS) and shown very much promising results. The output of the rectifier circuit shown a voltage of 3.6V by giving an input of 500mV. Further increase in the output voltage can be obtained by making use of CMOS techonology which is deviod of all the disadvantaages that diodes posses.

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