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PROJECT REPORT ON

"LOW COST BATTERY CHARGER USING NON CONVENTIONAL ENERGY"

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INTRODUCTION

Overview of the project: **RF energy** is currently broadcasted from billions of radio transmitters around the world, including mobile telephones, handheld radios, mobile base stations, and television/ radio broadcast stations. The ability to **harvest RF energy**, from ambient or dedicated sources, enables **wireless charging** of low-power devices and has resulting benefits to product design, usability, and reliability. Battery-based systems can be trickled charged to eliminate battery replacement or extend the operating life of systems using disposable batteries. Battery-free devices can be designed to operate upon demand or when sufficient charge is accumulated. In both cases, these devices can be free of connectors, cables, and battery access panels, and have freedom of placement and mobility during charging and usage.

The obvious appeal of harvesting ambient RF energy is that it is essentially "free" energy. The number of radio transmitters, especially for mobile base stations and handsets, continues to increase. ABI Research and iSupply estimate the number of mobile phone subscriptions has recently surpassed 5 billion, and the ITU estimates there are over 1 billion subscriptions for mobile broadband. Mobile phones represent a large source of transmitters from which to harvest RF energy, and will potentially enable users to provide power-on-demand for a variety of close range sensing applications. Also, consider the number of WiFi routers and wireless end devices such as laptops. In some urban environments, it is possible to literally detect hundreds of WiFi access points from a single location. At short range, such as within the same room, it is possible to harvest a tiny amount of energy from a typical WiFi router transmitting at a power level of 50 to 100 mW. For longer-range operation, larger antennas with higher gain are needed for practical harvesting of **RF** energy from mobile base stations and broadcast radio towers. The meaning of Energy Harvesting (also called energy scavenging or power harvesting), is the process by which energy from different sources is captured and stored. Generally, this definition applies when we talk about autonomous devices that require a low amount of energy to function.

Another advantage of this type of technology is that, unlike the production of large-scale power, we can consider that the energy source is free if you take into account the electromagnetic energy of transmitting mobile stations and radio and TV broadcasting antennas.

The use of batteries has two disadvantages: the lifetime of the batteries is very limited even for low-power batteries, requiring impractical periodical battery replacement, the use of commercial batteries usually overkills the power requirements for uW sensor nodes, adding size and weight while creating the problem of environmental pollution due to the deposition of these batteries, as well as increases significantly the cost overhead of disposable nodes.

This work focuses on incident low-power density; designing, measuring and testing a Rectenna to harvest electric energy from the RF signals that have been radiated by public communications systems (GSM-900 and GSM-1800) and the 2.4 GHz ISM band; also the work is motivated by two types of applications: powering low-power sensor networks and RF energy recycling.

State of the Art

2.1 History of Power Transmission by Radio Waves.

When we talk about power transmission by radio waves, we mean a complex process that can be divided into three stages: 1) to transform the DC power in RF power, 2) RF transmit this RF power through a wireless medium from one point to another; and 3) turn back the received RF power to DC power. Then, we can conclude that the overall system efficiency is directly dependent on the efficiency of each of these stages. The modern history of power transmission studies, in many respects, has focused on improving and developing the elements of the transmitting and receiving ends of this system, focusing on high efficiency, low costs, reliability and low mass.

2.1.1 The Early History

Power transmission dates back to the early work of Hertz [1], He wasn't only the first who showed the propagation of electromagnetic waves in free space, he was also the first to experiment with parabolic reflectors at both the transmitter and receiver ends.

At the end of the 19th century, Nikola Tesla, a genius in the area of generation and power transmission became interested in their studies applied to power transmission from one place to another without wires. His first attempt was carried out in 1899 in Colorado, USA, with the support of the Colorado Springs Electricity Company. He built a giant coil over which rose a mast of 70 meters with a copper sphere at the end. However, there is no record of how many energy was radiated to the space and whether there was any collected energy at any other place. From today's perspective, we can say that Tesla's attempts of efficient power transmission were ahead of the developed technology of this time. 30 years later, in 1934, H. V. Noble, this time in a laboratory, using two 100 MHz dipoles separated by 8 meters, collected several hundred of watts. With this experiment, he laid the basis for power transfer demonstrations.

The main cause of the lack of interest to develop this area was that several experts had determined that to achieve high efficiencies, concentrations of electromagnetic energy in a narrow band were needed. During the first 35 years of the 20th century, there were no devices that have these capabilities, but in the late 30's, the development of the velocity-modulated beam tube (Klystron tube) and the microwave cavity magnetron, allowed the generation of microwave power dedicated to this new technology.

2.1.2 The Modern History of Free-Space Power Transmission.

The modern history of power transmission, as far as microwaves are concerned, not only includes the development of technologies for microwave power transmission (MPT), the approach also includes various applications, whose achievements contributed to the development of new ideas and new technologies. This history of free-space power transmission will be divided in the early period beginning in 1958 and the period beginning in 1977 with the assessment study, by the DOE / NASA, of the concept of the solar-power satellite.

The Early Beginning

In the late 50's, several developments, made the idea of transmitting large amounts of power with high efficiency a reasonable concept, among these developments was the growing need to be able to communicate over long distances with line of sight. This could be solved with some kind of platform located at high altitude. Subsequently, this was solved with a satellite, but back then, a microwave powered vehicle was a logical approach.

Raytheon Company proposed a platform supported by a large helicopter, but did not get the necessary support of the Defense Department; however, they encouraged the development of technologies necessary to make it feasible. Among the technologies that were needed to develop were the high-power microwave tubes required for the transmitter and the technology to directly convert microwave-dc power to drive the motors of helicopter rotors. Between the years 1960-63 were developed some solutions to these problems (the Amplitron and thermionic rectifier respectively) and they did some demonstrations to receive funds, but some flaws (as the high directivity of the receiving antennas attached to the helicopter and the short-life of thermionic diode) made that the project couldn't be successfully finalized. Due to the low collection efficiency of energy and the directivity of the horns, the concept of rectenna was conceived. This solution consisted in to attach the rectifiers in half-wave dipoles and put a reflector panel behind them. With the application of this rectenna concept the helicopter project (Fig 2.1), the first of July 1964, the first flight of a heavier than air vehicle supported solely by power received from a microwave beam was made.

2.3 EM/RF energy harvesting

When we refer to EM/RF harvesting, we do not refer to energy sources that have been specifically designed for powering wireless devices, we talk about the energy that we can collect from public services. In cities and very populated areas there is a large number of EM/RF sources like broadcasting radio and TV stations, mobile telephony base stations, and wireless networks. It is possible to collect part of this energy and convert it into useful energy. For our application, the main interest is in telecommunication services operating in the microwave region of the frequency spectrum, especially Global System for Mobile Communications (GSM) and Wireless Local Area Network (WLAN). As the most commonly used frequencies are well known, low-power devices have an antenna and a rectifier circuit (Rectenna), optimized to maximize energy harvesting at these frequencies[4]. For these services and their frequency bands.

In laboratory environments, efficiencies above 90% have been observed, but when harvesting energy in the GSM or WLAN band on real scenarios, one has to deal with very low power density levels [5].

Table 2.1: Energy Harvesting Estimates

Energy Source Harvested Power	**Harvested Power**
Vibration/Motion	
Human	4 $\mu W/cm^2$
Industry	100 $\mu W/m^2$
Temperature Difference	
Industry	1 – 10 mW/cm^2
Light	
Indoor	10 $\mu W/cm^2$
Outdoor	10 mW/cm^2
RF/EM	
GSM	0.1 $\mu W/cm^2$
Wi-Fi	0.001 mW/cm^2
Solar	
Outdoor	10 mW/cm^2
Indoor	< 0.1 mW/cm^2
Acoustic	
75 – 10 dB of noise	0.003 – 0.96 $\mu W/cm^2$
Human Body Sources	
Body heat	0.2 – 0.32 W (neck)
Walking	5 – 8.3 W

Table shows of various microwave power sources and their typical power density levels. Also shown is the range of expected power densities used in the solar power satellite (SPS) and wireless power transmission (WPT) applications. The range of power densities for this work is indicated.