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Rf power and photodiode energy Based battery free cellular phone

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Abstract: A typical high end smart phone is supposed to have enough battery life to get through a full day. But over a time a lot of people find their phones with lack of battery. Perhaps, battery life actually seems to be getting worse with successive generations which leads to dead phone in emergencies. This paper purposes the study of cell phone which aims to overcome the shortcomings of existing phone due to lack of battery. In companies that require employees to be stationed at areas which are prone to power cutoffs and loss of connectivity, usage of RF waves for harvesting energy to the mobile device is a convenient solution. By working on this project for ONGC the aim is to eliminate the aforesaid problem. Battery free cell phone includes interfacing of antenna for transmission and reception of signals. RF harvester for gathering the RF signals from atmosphere and photodiode harvester for gathering the ambient light from the atmosphere and converting it into power. The key challenge in achieving this is that a cellphone is required to perform multiple basic operations: sensing speech at the device, transmitting it to the base station, receiving speech information from the base station and finally actuating the speaker/earphones. Designing a battery-free cell phone system requires us to perform all these functions, in real time, using only a few micro-watts of power. Existing ADC and DAC based approaches to transmitting and receiving speech consume too much power to be applicable for real-time battery-free applications.

Keywords: Battery free cellphone, RF harvester, photodiode, DC-DC Booster, RF- DC Conversion

I. INTRODUCTION

When cell phones were first introduced to the public, they were bulky, expensive, and some even required a base unit that had to be transported along with the phone. Good reception was a major problem and in general, early cell phones could only be used in certain locations where the signal was particularly strong. As cell phone technology advanced, the difficulty in using them became less of a problem. Today, cell phone reception has improved greatly due to the use of satellites and wireless services. As cell phones improved and became simple to use, the importance of cellphones increased accordingly. This only proves to us that development and evolution is the way of life and survival. Smart phones are unquestionably one of the most useful devices of the 21st century but they continue to have one critical flaw - battery life. All have been there - forgetting to charge our Smartphone and having 10% battery life left to see us through the day. To think of ways to charge our phone, perhaps stopping off at a local coffee shop to hook up to a power adapter, switching the phone off to make an important call later, or maybe you've even purchased a portable power pack to charge it on the go. To address these shortcomings, this is presentation of analogue techniques for speech transmission and reception that consume only a few microwatts of power. In companies that require employees to be stationed at areas which are prone to power cutoffs and loss of connectivity, usage of RF waves for harvesting energy to the mobile device is a convenient solution. By working on this project for ONGC our aim is to eliminate the aforesaid problem. The batteries add weight, bulk, and cost, require recharging and replacement, a positive answer would enable phones that have two-way communication capabilities without the need for batteries. Further, a micro-watt power phone can use cheap and lightweight harvesting sources including radio signals and photodiodes instead of bulky and expensive solar cells. Such a design would represent a fundamental leap in the capability of battery-free devices. A cellphone is required to perform three basic operations: communicate and co-ordinate with a base station, sense and transmit speech and receive speech and actuate the speakers. The battery-free device performs all these operations by leveraging a dedicated base station. This prototype will be able to perform basic functions of transmission and reception to speech and taking the user input from capacitive touchpad. In section II goals are discussed. Furthermore in section III, IV, V, VI and VII proposed system, proposed methodology, results, future scope and references are discussed.

II. OBJECTIVE

The aim of this project is to achieve the solution for stated problem. Objective of this project is to fulfill the requirement of Oils and Natural Gases (ONGC) Company by providing them the required outcome to overcome the problems of loss of connectivity and power cutoffs. Also the aim of this system is to provide the replacement for satellite phones used in company rigs of Oils and Natural Gases (ONGC). The main objective also includes the solving of problems that are faced by people because of the lack of battery. By using this phone hustle of charging the mobile phones can be eliminated. This can also be used as replacement to walky-talkies. Proposed system can be used as back up for emergencies.

III.THEORY

The paper 'Battery free cell phone' published in Paul G. Allen School Of Computer Science and Engineering and Department of Electrical Engineering, University of Washington by Vamsi Talla, Bryce Kellogg, Shyamnath Gollakota and Joshua R. Smith, Paul G in the year July 2017 mentions that the current implementation of battery-free phone operates up to 50 feet with photodiode power. The operating range of phone is determined by the performance of the analog backscatter microphone, which can be improved by using multiple techniques. Utilizing ambient light in combination with ambient radio frequencies enables the mobile phone to perform varied operations. A single wideband antenna followed by several narrowband rectifier chains is used to harvest the ambient radio frequencies and convert it to required dc levels. Each rectifier chain consists of a band pass filter, a tuned impedance matching network, and a rectifier are combined via a novel diode summation network that enables good performance even when only a subset of the narrowband harvesters is excited. The multiband harvester provides three distinct benefits which are RF source flexibility, access to additional power and improved sensitivity. A theoretical analysis of the effect on antenna size on parameters such as gain, bandwidth, and efficiency were studied. Both near zone and far zone directive gains are considered. The maximum gain obtainable from a broad-band antenna is approximately equal to that of uniformly illuminated aperture. If higher gain is desired, the antenna must necessarily be a narrow-band device. The input impedance becomes frequency sensitive so rapidly that, for large antennas, no significant increase in gain over that of the uniformly illuminated apertures is possible. Also, if the antenna is lossy, the efficiency falls rapidly as the gain is increased over that of the uniformly illuminated aperture.

IV.PROPOSED SYSTEM AND HARDWARE

The proposed system includes interfacing of antenna for transmission and reception of signals. RF harvester for gathering the RF signals from atmosphere and photodiode harvester for gathering the ambient light from the atmosphere and converting it into power. These harvesters will consume 2.15 microwatts of power. Capacitive touchpad is interfaced to get the user input. Speaker and microphone interfacing to get the speech as output and for input speech transmission respectively. All these components will be interfaced by MSP430 microcontroller. This microcontroller consumes very less power which is equivalent to 0.83 microwatts.. Figure1 shows the block diagram of proposed system.

1) RF Harvester: The RF energy harvester consists of a rectifier that converts the incident RF signal into low voltage DC power. This power is fed to a DC–DC boost converter which increases the voltage to 1.8–2.4 V to match the requirements of the microcontroller and sensors.

2) Photo diode Harvester: To harvest from ambient light, we use a photodiode and since the output is already a low voltage DC, we boost this voltage using a DC– DC boost converter to increase the voltage to 1.8–2.4 V range. The output power of the boost converter is stored on a capacitor.

3) Microcontroller: The phone has an MSP430 micro-controller which implements a digital state machine and controls different modules of the phone. The MSP430 micro-controller which implements control and state machine operates in low power mode (LPM3) and has a quiescent power consumption of 0.86 μW

4) LED: It also has capacitive touch buttons and LEDs to interact with the user and uses digital backscatter to occasionally communicate state information with the base station. The user dials the phone number and controls the phone using capacitive touch buttons. The cell phone has twelve buttons for digits 0-9, * and # for dialing and two buttons A and B for control.

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5) Antenna: A single antenna is used for energy harvesting, speech transmission as well as speech reception. Thus, the performance of RF energy harvesting or the amount of energy that can be harvested from incident RF signal is a function of the operating mode of the phone.

6) Speaker and Microphone: Speaker is used to transmit speech. Microphone is used for reception of speech.

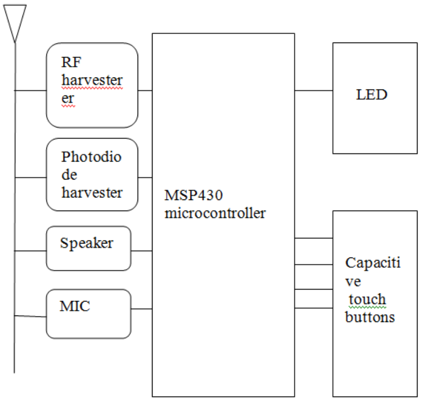

Fig. 1 Block diagram of proposed system

V. METHODOLOGY

Using power harvested from ambient light, with a tiny solar cell, the device will be able to communicate with the base station. The phone uses harvester to convert RF or ambient light into DC power. The phone has an MSP430 micro-controller which implements a digital state machine and controls different modules of the phone. It also has capacitive touch buttons and LEDs to interact with the user and uses digital backscatter to occasionally communicate state information with the base station. The battery-free phone has two distinct modes of operation: sleep mode and active mode. In sleep mode, the cell-phone ceases all operations and enters the low power mode consuming minimal amount of power. In this mode, the phone is exclusively and efficiently harvesting energy. When the phone has harvested sufficient energy, it transitions into active mode to receive speech, transmit speech or communicate digital state with the base station. This current proposed system will have basic functionalities of transmission and reception of speech. The Harvested energy will be rectified by RF-DC converter and then it is boosted by DC-DC boost converter. This is supplied as power to the cell phone.

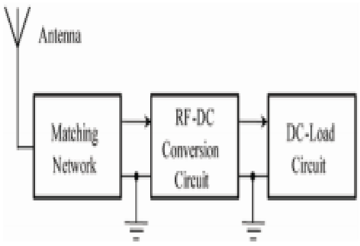

Fig. 2 Schematic view of RF energy harvesting system

VI. RESULT

When the phone would harvest power from incident RF signals, the antenna would simultaneously be used for both RF energy harvesting and other functionalities such as speech reception and transmission. Thus, the performance of RF energy harvesting would be a function of the operational mode of phone. First stage is Evaluation of how the transmission and reception of speech would impact the performance of RF energy harvesting. Next, to configure the RF powered phone to receive speech in the active mode where we would connect our speech envelope detector circuit to the antenna. When the phone would be in the active mode, the base station should transmit speech using the amplitude modulation technique. However, when the phone would transition to sleep mode, the base station would transmit a single tone signal for the phone to efficiently harvest power. So transmission and reception of speech would be possible by battery free cell phone. Then the evaluation the quality of the speech signal received at the battery-free phone.

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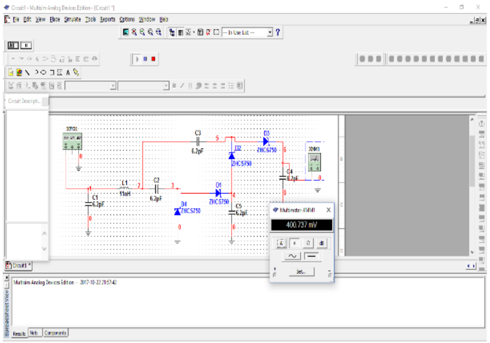

Fig.3 . Simulation of RF energy harvester

VII. FUTURE SCOPE

Further advancement in the proposed system can be introduced by interfacing less power consuming LCD for display. Solar panels can also be added in order to increase the amount of gathered power. Other techniques for transmission and reception can be introduced that consume lesser amount of power. Type of antenna can be replaced in order to improve the range of transmission and reception of signals. As the technical advancements can be introduced and new features can be added in this system easily, the system is flexible and technically feasible. The system can be improved according to the need in future.

VIII. CONCLUSION

Current battery-free phone design implements the basic functionalities of a phone (speech and data transmission and user input via capacitive touch). It is believable that one can easily integrate additional functionalities into our battery-free design. E-ink displays operating on harvested RF and solar power has been demonstrated which can be used to add a display to the battery-free cell phone. Additionally, with prior work on All See, it has been seen that a user can interact using simple hand gestures while consuming only few micro-watts of power that can be harvest from RF and ambient light. Such low-power gesture recognition technology can be integrated with our battery-free cell phone design.

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