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Wireless Charging Solution of Mobile Phone Batteries using Microwaves via Cellular Communication

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ABSTRACT

In today's era, mobile phones have become a basic part of our day to day lives and their phone side to excessive use of mobile phones leads to early drainage of mobile phones batteries which have been a great issue. The mobile talk time and battery stand by varies in every mobile phone and it depends upon its battery manufacturer. This proposes mid to facilitate the recharging of mobile batteries easily to the extent that the phone battery will get recharge wireless via cellular communication. This means that whenever the user is on call, the phone will charge automatically. This technology is an application of RF energy harvesting. Since the availability of RF energy in our surroundings is abundant. In earlier times too, it was a belief that wireless charging replaces wires and cables like how Bluetooth and Wi-Fi have modernized personal communication. The prevailing methods of wireless charging highly depend upon the concept of inductive and resonance coupling using the electromagnetic field that transfers energy from the transmitter to the receiver. The main focus of this proposed solution is to design a system that recharges the mobile phone batteries via cellular communication and independent of their battery manufacturer and type of cables and wires used for a particular USB port. This entire process is done by the employment of microwaves and RF energy harvesting in an eco-friendly way. The microwave signal is transmitted from the high power microwave generator Magnetor which acts as a transmitter with the help of a slotted waveguide antenna and transmits the power along with the message signal at a frequency up to 2.45GHz. With this advancement, there is some minimal addition to the hardware design of the mobile handset. It includes the addition of a Rectenna which is a mesh network of rectifying diode, rectifying filter, and sensor circuitry. Further, the advantages, limitations and drawbacks and future improvements associated with wireless charging of mobile phones are discussed in this paper.

KEYWORDS: *Advanced Power Transfer, Inductive Coupling, Electromagnetic Field, RF Energy Harvesting, Rectenna, Sensor Circuitry*

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I. INTRODUCTION

Wireless transfer of power is not a new technology for us. It all started in 1831 when Michael Faraday discovered induction by sending electromagnetic force through space. In the late 1800s and the early 1900s, Nicola Tesla had a vision and he demonstrated wireless broadcasting and power transmission. He wanted the world to believe that there is a possibility that electricity can be transmitted without wires too and there is no magic in that. This is practically possible. But at that time due to the unavailability of sponsors and funds, this project and idea got paused. Later on, he was able to more than 100 bulbs on a bridge several miles apart, all wirelessly.

The first question that arises to our mind while asking for a mobile charger is "What kind of adapter do you have?". Do you have a Type A/B/C cable?" These type of questions indicates, today, it is difficult for us to charge our portable devices without being dependent on external devices like wires, cables, and adapters. But this hectic problem can be reduced if there is the elimination of such dependency of cables and adapters.

The solution to the above-stated problem is Wireless Charging. Wireless charging can be used to charge a wide variety of devices including laptops, smartphones, smartwatches, electric cars, robots and many more. In this project, the aim behind using the concept of wireless charging is to charge batteries without the use of cables or device-specific adapter. It will eliminate the use of physical connections, wires, and cables by providing safe, convenient and efficient charging solutions.

Understanding the working principle of wireless charging, according to Faraday's Law: "Whenever there is a change in Flux, EMF is induced". Wireless charging is very much similar to radio transmission. Since the radio waves are abundantly viable in the environment. Hence, the smart use of using these radio waves for wireless power transmission in electronic devices is a great implementation. Many kinds of researches and studies have been done in this field to make the existing solution better and reliable. The available solutions are not much practical in use and are inefficient. The entire elimination of wires and cords from the battery

chargers are still impossible. There is also a fact that has been recorded from past researches that wireless charging is way too inefficient than wired charging. This paper is focused to eliminate all such notions and to provide the collective knowledge about all the available and upcoming wireless battery charging trends. There are many techniques and methodologies available to charge up portable devices. RF harvesting, induction charging, thermal charging, piezoelectric, charging using microwaves, etc. are the methods that fantasize the electronic manufacturers and mobile devices users to charge their devices all wirelessly. Since, due to the availability of many charging solutions, a concluded study and literature review of all the available theories and studies have been done here in the proposed work.

II. PROBLEM STATEMENT

Nowadays, A lot of people face this problem of charging their mobile devices due to the unavailability of charger cables. Carrying a charger or charging cable is not the most liked option so far because of the wear and tear of the cable can cause a loss in its cable's life. A lot of mobile users face this problem of battery drainage while having a conversation on calls rather than using mobile for other applications. All the mobile devices are dependent on their manufacturers and battery design for the recharge of their batteries, thus making all the users dependent upon a certain type of charging cables.

III. OVERVIEW

The important goal of the undertaking is if the battery of the mobile device will get automatically charged while having a conversation on call. This could be done with some additional changes in the circuitry of the mobile device. This is nothing but another important application of wireless charging which is a better version of inductive charging. Because in inductive charging, there is contact between the charging pad and the mobile device but here, the device will get charged automatically using RF power or microwaves. Wireless charging needed a global standard. There are three wireless Charging Standard Groups, one of them is Wireless Power Consortium, which accomplished the wireless charging standard for mobile phones in 2008 by introducing the Qi (pronounced as Chee) norm. In September 2012, Nokia Lumia 920 became the first commercially available smartphone to offer built-in wireless charging based on the Qi Specifications. This wireless standard is a kind of revolution for wireless charging of smartphones and it began the trend for device manufacturers to design and offer chargers for Qi-compatible devices with 5 watts of power. This standard is mostly used by all the leading smartphone companies in the market. This standard enables inductive pad style charging and short distance electromagnetic charging up to the distance 1.5cm or less. In this entire process, the smartphone needs to get placed over the exact position on the charging pad for the wireless power transmission. Other standards like Power mat are also widely used wireless standards that have partnered with the greatest electronic car companies, cafes, restaurants. to provide wireless charging at public places by rolling out wireless charging induction pads. Many coffee shops, restaurants, airports have already adopted this technology of providing wireless charging solutions Apart from smartphones, this technology is finding its ways to get launch sooner in metro trains and resonant-enabled furniture shortly in which furniture will provide wireless charging options. Smartphones have completely changed our way of living whether it is online or offline. With each new model, we are used to getting more processor speed, new features and programs, and entirely new ways of using them. Wireless charging is set to change the problems related to the messy chaos created by the interconnected cables, wear and tears and early power drainage problems. We want to eradicate the problem of the dead battery by the means of wireless power transmission and by harvesting the available resources in an eco-friendly way.

IV. LITERATURE REVIEW

The literature review has been made after reviewing the IEEE conference and transaction papers and many articles based on RF energy harvesting. Two papers based on wireless charging has been reviewed for this process. The entire concluded study of the review process adopted, the technology used, weakness and strengths of the papers.

A. Review of Existing Wireless Charging Solutions

There are several methods for transmitting power wirelessly. The most popular and effective methods of wireless power transmission are inductive coupling, resonant inductive coupling, RF energy harvesting capacitive coupling, radiofrequency, microwave power transmission, and laser power beaming. This section will discuss the different approaches to wireless charging devices.

B. Microwave Power Transmission

Microwaves are highly used for the applications in which point-to-point communications are required because of their small wavelength. This property of microwaves allows conveniently-sized antennas to direct them in narrow beams so that they can be pointed easily direct at the receiving antenna. This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do.

Microwave power transfer (MPT) uses the far-field effects of electromagnetic radiation to transfer power wirelessly over Most of today's wireless chargers use Inductive charging is the most used method of wireless charging with transmitting and receiving coils in the proximity. It is a short distance wireless charging. It works on the principle of Electromagnetic Induction. In this process, the charger device acts as a transmitter which will create an electromagnetic field with alternating polarity using a coil of insulated copper wire. A Similar coil will be placed inside the mobile device which will convert the EM field back to electric current thereby charging the battery. This method was first implemented in Wireless chargers use Inductive charging is the most used method of wireless charging with transmitting and receiving coils in the proximity. It is a short distance wireless charging. It works on the principle of Electromagnetic Induction. In this process, the charger device acts as a transmitter which will create an electromagnetic field with alternating polarity using a coil of insulated copper wire. A Similar coil will be placed inside the mobile device which will convert the EM field back to electric current thereby charging the battery. This method was first implemented in Electric toothbrushes Its other applications include MP3 players, waterproof Vibrating Razors, etc.

C. Radio Charging

Radio waves are widely used to transmit and receive signals in cellular phones, Television, radio, Wi-Fi & Bluetooth. Radio waves once transmitted, propagates in all directions until it reaches an antenna which is further tuned to the proper frequency to receive it. A transmitter device is used for this which is plugged into a socket and generates radio waves. These radio waves are then received by the receiver with the help of a coupler and a tuner tuned at the same frequency. This method is suitable for low-power consumption devices operating within an area of 10 to 15meter radius from the transmitter to charge batteries and find its applications in various electronic and biomedical implantation and devices like medical implants, hearing aid machines, digital watches, Bluetooth devices, IoT appliances and Radio Frequency Identification (RFID) operating chips.

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V. TECHNOLOGY OVERVIEW

Since the wireless charging of mobile phones using inductive charging pads is already in use. To make wireless charging more convenient, independent of any supportive device and easy, we have introduced an idea of wireless charging of mobile phones using microwaves over a wide range of areas covering many mobile users at a time. Hence, microwaves are used to power our mobile devices.

The basic design mainly consists of four sole parts:

A. Transmitter Design

The mobile base stations and cell towers used for cellular communications are our transmitting ends here. In the transmitter, the design includes the generation of a carrier signal, which is generally sinusoidal, a modulator, an influence op amplifier, a filter, and an impedance matching network to attach to an antenna. Here, high microwave power generation is done by using CW magnetrons which operate at 2.45Ghz frequency and produce high power microwave signals. To make these magnetrons more reliable for high bandwidth broadcast systems, phase-controlled magnetrons can be employed in the system. More elaborate transmitters allow better control over the modulation of the emitted signal and improve the steadiness of the transmitted frequency. Here, there are two major parts in the transmitter part:

1. Microwave Generator: Magnetron

The microwave generator is the one that generates the high power microwave of preferred frequency. Since the power is transfer during the phone calls so the magnetron is designed to match with the frequency of cellular communication. We have used a high powered Magnetron in the transmission process. Pulsed Magnetrons are used in radar applications as they are capable of generating high power. Continuous-wave magnetrons are also used for this purpose. After many experimental approaches, it has been concluded that Phase-Amplitude controlled Magnetrons of frequency cause network traffic and it will limit the power transmission. Some of the features of Magnetron are as follows:

- It is a high power microwave oscillator which generates microwave signals.
- Magnetron functions at a self-excited microwave oscillator.
- It is capable to deliver high power with high efficiency of 50% to 80%.
- It is an extremely powerful permanent magnet in its construction.

2. Slotted Waveguide Antenna

There are many types of slotted waveguide antenna available. When the electrical current passes through the slotted waveguide antenna, it induces a magnetic field, which oscillates at high frequency. We have used a slotted waveguide antenna here. It consists of 8 waveguide sections with 8 slots on each section. The 64 slots radiate the power uniformly through free space to the rectenna. It is ideal for power transmission due to higher efficiency and high power handling. It has a gain of 13db and frequency 2.4GHz.

B. Receiver Design

The microwaves generated by the transmitter are then received by the mobile handsets during the call. For this, a minimal addition of a rectennas and sensor circuitry has been done in the mobile handsets. Along with this, a frequency to voltage comparator IC LM 2907 is also used. Various components which are used in the receiver part are as follows:

1. Rectenna

In recent years, extensive advancements and innovations in the field of communication and RF technology have developed. Due to advancements, small microwave devices use rectenna as a power source. They are used in RF energy harvesting in the form of wireless power transmission that transmits energy by radio waves. In the proposed solution, we are using high High-Band efficiency Rectenna operating at 2.4GHz band. The schematic circuit diagram of rectenna is shown below:

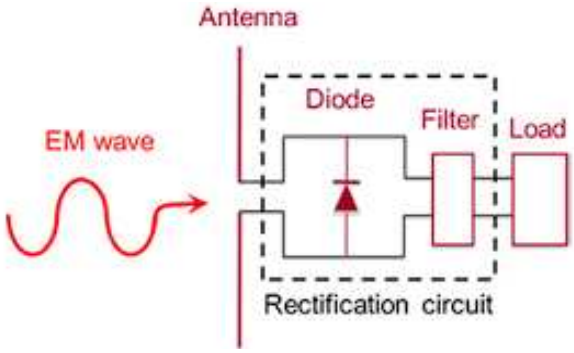

Fig.1 Schematic Diagram of Rectenna

Rectenna is a combination of Rectifier and Antenna. A rectenna is a combined form of rectifying antenna It receives the transmitted power and converts power into DC power. The elements of rectenna are rectifying diode, low pass filter and output load which is connected in mesh arrangement. The optimum efficiency of the antenna depends upon the number of end-users, output circuit load and network traffic

in the case of cellular communication. In the receiver design, six rows of dipole antennas are used. Each row is connected to a rectifying circuit which consists of a low pass filter and a rectifier. In the circuit diagram of rectenna, it is very clear that the antenna is used to collect the wireless energy from EM waves and interfaces it with rectifying GaAs diode and low pass filter. The rectifier diode is made up of GaAs Schottky Barrier diode that helps to match the impedance to the dipoles by a low pass filter.

2. Sensor Circuitry

Another important part that is added to our receiver circuitry is a simple sensor. It is a simple circuitry that detects if the mobile phones receivers any signal. The need for this sensor circuitry is to ensure whether the phones are receiving any power while talking on call or not. This sensor circuitry is added to the mobile handset and it is responsible for the proper charging of the battery. A simple Frequency to Voltage converter IC is used for this purpose.

3. LM 2907 IC

This LM2907 is a frequency to Voltage converter IC which converts frequency or pulses into proportional equivalent voltage when the frequency exceeds a limit or selected rate. Here in this application, when the EM waves are received in rectenna, after passing those EM waves into rectifying diode and filter, its output levels are set to a limited rate of the output voltage. During the conversion of frequency pulses into output voltage, this IC manages its threshold value. The construction of this Ic includes a combination of RC circuits and high gain Op Amps.

VI. METHODOLOGY

The process of Wireless Power Transmission using microwaves is shown using the block diagram given below.

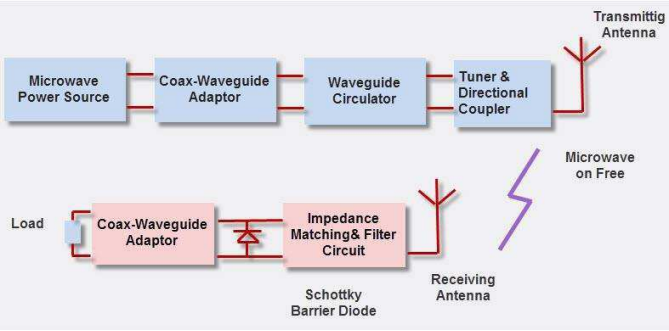

Fig 1.Block Diagram of Wireless Power Transmission

The steps in this process are given below:

- The mobile base stations are transmitting stations.
- At the transmitting end, there is a microwave source that is producing microwaves. Here Magnetron is used to generate microwave signals in pulse form.
- When the user makes a call, the generated microwave signals are then transmitted along with the message signal using a slotted waveguide antenna.
- At the receiver end, sensor searches for the mobile signal beside it have "Rectenna".
- The rectenna receives the transmitted power and converts the microwave power to DC power.

VII. HEALTH & SAFETY CONCERNS

The use of mobile phones for communication is now inevitable. We all are dependent on mobile phones for our daily life communications. There are many possibilities that these electromagnetic radiations coming from mobile phones might cause harm to human body tissues. Since microwaves are functional to particles of its size only and human body tissues are susceptible to it. Long term exposure to these radiations may cause many health and mental problems. Many studies and research in this domain have shown that there are positive as well as negative effects of these radiations on the human body. Let us discuss these two categories more in detail:

A. Positive effects of EM radiations

The positive effects of these radiations are lesser than the negative impacts. Some of the positive effects of radiations are given below:

- In Chemotherapy, microwaves are used to cure and reduce the toxic effects caused during the process.
- Exposure to low-level radiations also helps many to kill cancer cells.
- Microwave exposure is beneficial in many medical diagnosis procedures like CT-Scan, MRI and X-rays.

B. Negative Effects on the Human Body

Since there are many health-related issues caused due to microwave radiations. Here we are going to discuss only the negative effects of radiation caused by mobile phones only. Because the amount of radiation caused by mobile phones is less than compared to our microwave sources which produce radiation and causes damage to the human body.

The radiation caused by mobile phones and towers affects the human body in numerous ways. These are as follows:

- The long term exposure to mobile phone microwave radiations causes physiological, neurological, cognitive and behavioral changes in the human body.
- It causes DNA and chromosomal damage in individuals which also causes testicular damage, decreases protein levels and damages reproductive organs.
- It causes headaches, dizziness, numbness in tighs, and heaviness in the chest, change is heartbeat rate, etc. These are the parts that experience the major radiations during phone calls when users keep their mobiles close to these parts.
- Many reports have been shown the cases of inner ear damage due to the release of harmful rays from mobile handsets.
- Reports have shown that continuous exposure to these low-intensity microwave radiations coming from cell phones might result in an adverse effect on brain cells, affect brain memory and increases the rate of DNA damage.

VIII. CONCLUSION

Wireless technology has created a wide ecosystem of wireless charging of electronic devices. Charging our smartphones using wireless technology is an application of this vast technology that has successfully eliminated the use of wires, cords, and cables and allowed users to get rid of frequent plug-in and plug-out of chargers of their smart devices. In our proposed work, we have successfully demonstrated a novel method of using the abundantly available RF energy in the form of microwaves. Microwaves are radio waves that are used by mobile phones for cellular communication. In this proposal, microwaves are used to

charge mobile phones without the use of any wire or cable. Thus this method provides a great advantage to mobile phone users to carry their phones anywhere even if the place is devoid of facilities for charging. The solution is proposed after a combined study of all the existing research papers and the latest advancements in this field. The proposed solution focuses more on RF energy harvesting. In the methodology adopted, wireless power transmission in mobile phones while talking on call is made possible. The transmission of microwave power is initiated by the high power microwaves generators installed at the mobile base stations. This microwave power is then received by the end-users while receiving any call. The novel use of the rectenna and an additional sensor circuitry in a mobile phone is implemented at the power receiver end. Which further adds up a new dimension to mobile manufacturing. Future studies in this proposal aim to reduce its size and weight by combining this rectenna and sensor on a single chip using SoC. could provide a new dimension in the revelation of the mobile phone. Later, we have discussed the wide variety of wireless charging applications applied in various fields of our day to day life which clearly shows its significance in terms of cost reduction, technological advancements and to provide the best methodology for energy harvesting to charge their devices. Despite many advantages, there are some limitations and drawbacks of this technology which are further discussed in detail and safety measures and improvements in battery consumptions and management by 2,45Ghz are useful in this process. Magnetrons of high-frequency 5.8Ghz are then designed which are a boost to this technology to generate microwaves at large scale but very costly and the large area of connected users will be required.

IX. LIMITATIONS & DRAWBACKS

The wireless charging trend is on the boom nowadays. Although there are significant advantages and applications of this technology, it is still not perfect and has another weak side as well. Especially, in this application where the mobile is charging while talking on the phone. This technology has already been in an experimental and research phase only. No practical implementation of this application has been shown by any manufacturer, company or laboratory yet. Some of the areas at which this technology fails and has its drawbacks are shown below:

- The transmitter and receiver also should be very powerful devices as the distance increases the charging is very slow.
- It causes some drastic effects on the human body because of its radiation.
- It is practical possibilities are not yet applicable in this field.
- Network traffic is responsible for its perfect implementation.
- High-cost process.
- Installation and implementation of high power microwave generator magnetron at mobile base stations are still not practical.
- Variation is sim network frequency when the user is moving from one city to another is a major drawback.

X. FUTURE SCOPE

The huge masses of mobile phone users all around the world believe that their wired cables will charge their phones even more fats then the wireless chargers. Despite this disbelief, this is not the case as the wireless charger has been around the world for years but only 29% of the mobile users use it. Although most mobile phone users are happy with using the traditional mobile chargers, we know that technology is inevitable and who doesn't want to become more technically smart and use smart gadgets in this advance era of smart devices that uses wireless charging of their batteries. This technology eliminates the messy network of cables and wear and tear of wired cables and chargers. Moreover, today's wireless chargers are more safe and improved in terms of radiations as compared to earlier versions or wired and wireless chargers. Most of the smartphone companies are launching their new smart devices with wireless charging pads which chargers the smart devices faster than existing wired fast chargers.

There are so many advancements that are going to happen shortly in this field such as doubling the fast charging speed up to 40 watts which is 2.5 times faster than currently available chargers. Soon, the distance between the charging mat and the device would be more improved and the users would be able to charge their devices at a particular distance without making a contact with the charging pad. Wireless charging is an evergreen technology which is widely used in various applications including electric Toothbrushes, electric razors, trimmer, hair blower, smart furniture, smart city, building automation, security, CCTV, commercial applications like in labs, airports, restaurants, cabs, smart vehicles, libraries, cafes, etc. hence, the wireless charging is the only step stone towards more safe, reliable and smart innovations in the field of Rf energy harvesting and for the formation of the foundation of robust smart charging solutions in the world.

Reference

[1] Priya A. Rewaskar et al, International Journal of Computer Science and Mobile Computing, Vol.3 Issue.4, April- 2014, pg. 427-432

[2] Wireless Power Transmission – A Next-Generation Power Transmission System,

[3] Lander, Cyril W. "2. Rectifying Circuits". Power electronics London: McGraw-Hill.

[4] Tae-Whan yoo and Kai Chang, "Theoretical and Experimental Development of 10 and 35 GHz rectennas" IEEE Transaction on Microwave Theory and Techniques

[5] R. M. J. D. J. AndrÃ© KursAristeidisKaralis and M. S. Peter Fisher, _Wireless power transfer via strongly coupled magnetic resonances, _ Science, vol. 317, pp. 83_85, June 2007.

[6] M. Kline, _Capacitive power transfer, _ M.S. thesis, University of California at Berkeley, Berkely, CA, 2010.

[7] W. C. Brown and E. E. Eves, _Beamed microwave power transmission and its application to space, IEEE Transactions on Microwave Theory and Techniques, vol. 40, no. 2, pp. 1239_1251, 1992.

[8] M. Ishiba, J. Ishida, K. Komurasakil, and Y. Arakawa, Wireless power transmission using a modulated microwave, Conference Paper, Uji, Kyoto, Japan, 2011.

[9] M.Venkateswara Reddy, K.Sai Hemanth, CH.Venkat Mohan, Microwave Power Transmission" A Next-Generation Power Transmission System, IOSR Journal of Electrical and Electronics Engineering (IOSRJEEE) Volume 4, Issue 5 (Jan. - Feb. 2013)

[10] N. Shinohara, "Wireless Power Transfer via Radiowaves (Wave Series)", ISBN 978-1-84821-605-1, ISTE Ltd. and John Wiley & Sons, Inc., 2014.1

[11] N. Shinohara (ed.), "Recent Wireless Power Transfer Technologies Via Radio Waves", ISBN 978-879360-924-2, River Publishers, 2018.5

[12] Erkmen, F., T. S. Almoneef, and O. M. Ramahi, "Electromagnetic energy harvesting using full-wave rectification," IEEE Transactions on Microwave Theory and Techniques, Vol. PP, 1–9, 2017.

[13] Kang-Rong Li, Kye-Yak See, Wee-Jin Koh, and Jun-Wu Zhang, "Design of 2.45 GHz Microwave Wireless Power Transfer System for Battery Charging Applications", Progress In Electromagnetics Research Symposium — Fall (PIERS — FALL), Singapore, 19–22 November 2017

[14] Shareen Noronha, Prajna P, Prateeksha Prasad, Pratheeksha, Saritha, Sachin Bhat, "WI-MOB: Power Transmission System for Charging Smart Phones using RF Module through Wi-Fi", International Journal of Advanced Research in Computer and Communication Engineering ISO 3297:2007 Certified Vol. 6, Issue 5, May 2017.

[15] Priyanka Sinha, Ritesh Diwan. "Review Paper on Wireless Power Transmission for Energy Harvesting System". International Journal of Science and Research. Vol.5, Issue 5, pp. 181-186. May 2016