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Wireless Charging of Mobile Phones using Microwaves

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Abstract: With mobile phones becoming a basic part of life, the recharging of mobile phone batteries has always been a problem. The mobile phones vary in their talk time and battery standby according to their manufacturer and batteries. All these phones irrespective of their manufacturer and batteries have to be put to recharge after the battery has drained out. The main objective of this current proposal is to make the recharging of the mobile phones independent of their manufacturer and battery make. In this paper a new proposal has been made so as to make the recharging of the mobile phones is done automatically as you talk in your mobile phone! This is done by use of microwaves. The microwave signal is transmitted from the transmitter along with the message signal using special kind of antennas called slotted wave guide antenna at a frequency is 2.45 GHz. There are minimal additions, which have to be made in the mobile handsets, which are the addition of a sensor, a Rectenna, and a filter. With the above setup, the need for separate chargers for mobile phones is eliminated and makes charging universal. Thus the more you talk, the more is your mobile phone charged! With this proposal the manufacturers would be able to remove the talk time and battery standby from their phone specifications!

Keywords: **M**obile, Microwave, Electromagnetic Spectrum, Wireless Technology.

I. INTRODUCTION

A. The Electromagnetic Spectrum

To start with, to know what a spectrum is: when white light is shone through a prism it is separated out into all the colors of the rainbow; this is the visible spectrum. So white light is a mixture of all colors. Black is NOT a color; it is what you get when all the light is taken away. Some physicists pretend that light consists of tiny particles which they call photons. They travel at the speed of light (what a surprise). The speed of light is about 300,000,000 meters per second. When they hit something they might bounce off, go right through or get absorbed. What happens depends a bit on how much energy they have. If they bounce off something and then go into your eye you will "see" the thing they have bounced off. Some things like glass and Perspex will let them go through; these materials are transparent. Black objects absorb the photons so you should not be able to see black things: you will have to think about this one. These poor old physicists get a little bit confused when they try to explain why some photons go through a leaf, some are reflected, and some are absorbed. They say that it is because they have different amounts of energy. Other physicists pretend that light is made of waves. These physicists measure the length of the waves and this helps them to explain what happens when light hits leaves. The light with the longest wavelength (red) is absorbed by the green stuff (chlorophyll) in the leaves. So is the light with the shortest wavelength (blue). In between these two colors there is green light, this is allowed to pass right through or is reflected. (Indigo and violet have shorter wavelengths than blue light.). Well it is easy to explain some of the properties of light by pretending that it is made of tiny particles called photons and it is easy to explain other properties of light by pretending that it is some kind of wave. The visible spectrum is just one small part of the electromagnetic spectrum. These electromagnetic waves are made up of to two parts. The first part is an electric field. The second part is a magnetic field. So that is why they are called electromagnetic waves. The two fields are at right angles to each other.

B. The Microwave Region

Microwave wavelengths range from approximately one millimeter (the thickness of a pencil lead) to thirty centimeters (about twelve inches). In a microwave oven, the radio waves generated are tuned to frequencies that can be absorbed by the food. The food absorbs the energy and gets warmer. The dish holding the food doesn't absorb a significant amount of energy and stays much cooler. Microwaves are emitted from the Earth, from objects such as cars and planes, and from the atmosphere. These microwaves can be detected to give information, such as the temperature of the object that emitted the microwaves. Microwaves have wavelengths that can be measured in centimeters! The longer microwaves, those closer to a foot in length, are the waves which heat our food in a microwave oven. Microwaves are good for transmitting information from one place to another because microwave energy can penetrate haze, light rain and snow, clouds, and smoke. Shorter microwaves are used in remote sensing. These microwaves are used for clouds and smoke, these waves are good for viewing the Earth from space Microwave waves are used in the communication industry and in the kitchen as a way to cook foods. Microwave radiation is still associated with energy levels that are usually considered harmless except for people with pace makers.

TABLE I: FREQUENCY RANGES

Designation	Frequency range
L Band	1 to 2 GHz
S Band	2 to 4 GHz
C Band	4 to 8 GHz
X Band	8 to 12 GHz
Ku Band	12 to 18 GHz
K Band	18 to 26 GHz
Ka Band	26 to 40 GHz
Q Band	30 to 50 GHz
U Band	40 to 60 GHz

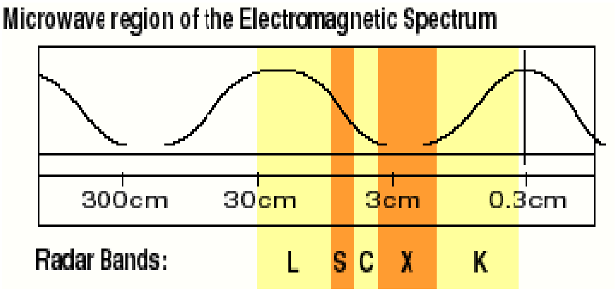

Fig 1: Microwave region of the electromagnetic spectrum.

Here in figure 1 we are going to use the S band of the Microwave Spectrum. The frequency selection is another important aspect in transmission. Here we have selected the license free 2.45 GHz ISM band for our purpose. The Industrial, Scientific and Medical (ISM) radio bands were originally reserved internationally for non-commercial use of RF electromagnetic fields for industrial, scientific and medical purposes. The ISM bands are defined by the ITU-T in S5.138 and S5.150 of the Radio Due to variations in national radio regulations. In recent years they have also been used for license-free error-tolerant communications applications such as wireless LANs and Bluetooth: 900 MHz band (33.3 cm) (also GSM communication in India) 2.45 GHz band (12.2 cm) IEEE 802.11b wireless Ethernet also operates on the 2.45 GHz band.

II.TRANSMITTER DESIGN

A. The Magnetron

From figure 2, the magnetron (A), is a self-contained microwave oscillator that operates differently from the linear-beam tubes, such as the TWT and the klystron. View (B) is a simplified drawing of the magnetron. Crossed-electron and magnetic fields are used in the magnetron to produce the high-power output required in radar and communications equipment.

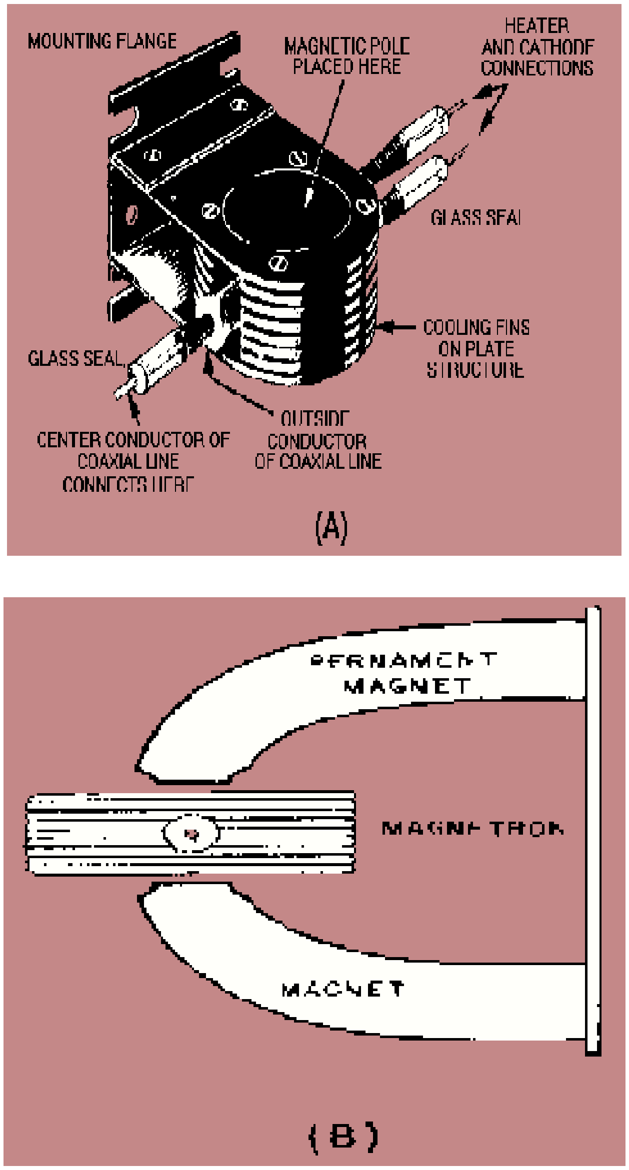

Fig 2: Transmitter Design

The magnetron is classed as a diode because it has no grid. A magnetic field located in the space between the plate (anode) and the cathode serves as a grid. The plate of a magnetron does not have the same physical appearance as the plate of an ordinary electron tube. Since conventional inductive-capacitive (LC) (fig 3) networks become impractical at microwave frequencies, the plate is fabricated into a cylindrical copper block containing resonant cavities that serve as tuned circuits. The magnetron base differs considerably from the conventional tube base. The magnetron base is short in length and has large diameter leads that are carefully sealed into the tube and shielded. The cathode and filament are at the center of the tube and are supported by the filament leads. The filament leads are large and rigid enough to keep the cathode and filament structure fixed in position. The output lead is usually a probe or loops extending into one of the tuned cavities and coupled into a waveguide or coaxial line. The plate structure is a solid block of copper.

The cylindrical holes around its circumference are resonant cavities. A narrow slot runs from each cavity into the central portion of the tube dividing the inner structure into as many segments as there are cavities. Alternate segments are strapped together to put the cavities in parallel with regard to the output. The cavities control the output frequency. The straps are circular, metal bands that are placed across the top of the block at the entrance slots to the cavities. Since the cathode must operate at high power, it must be fairly large and must also be able to withstand high operating temperatures. It must also have good emission characteristics, particularly under return bombardment by the electrons. This is because most of the output power is provided by the large number of electrons that are emitted when high-velocity electrons return to strike the cathode. The cathode is indirectly heated and is constructed of a high-emission material. The open space between the plate and the cathode is called the interaction space. In this space the electric and magnetic fields interact to exert force upon the electrons.

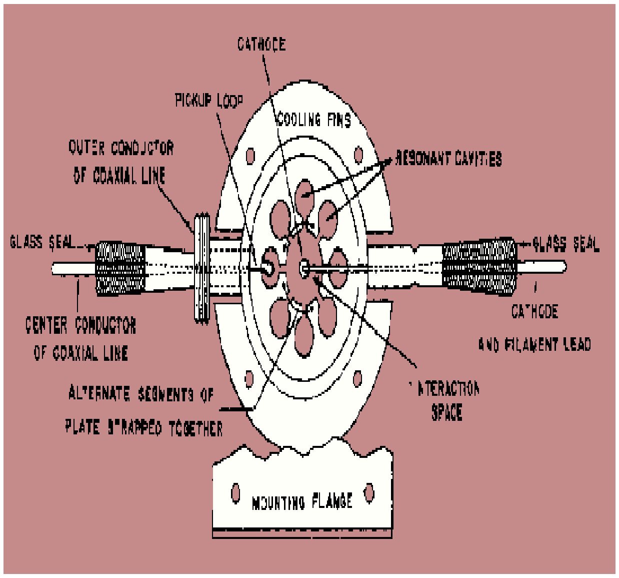

Fig 3: Conventional Inductive-Capacitive

III. RECEIVER DESIGN

The basic addition to the mobile phone is going to be the rectenna. A rectenna is a rectifying antenna, a special type of antenna that is used to directly convert microwave energy into DC electricity. Its elements are usually arranged in a mesh pattern, giving it a distinct appearance from most antennae. A simple rectenna can be constructed from a Schottky diode placed between antenna dipoles. The diode rectifies the current induced in the antenna by the microwaves. Rectennae are highly efficient at converting microwave energy to electricity. In laboratory environments, efficiencies above 90% have been observed with regularity. Some experimentation has been done with inverse rectennae, converting electricity into microwave energy, but efficiencies are much lower--only in the area of 1%. With the advent of nanotechnology and MEMS the size of these devices can be brought down to molecular level. It has been theorized that similar devices, scaled down to the proportions used in nanotechnology, could be used to convert light into electricity at much greater efficiencies than what is currently possible with solar cells. This type of device is called an optical rectenna. Theoretically, high efficiencies can be maintained as the device shrinks, but experiments funded by the United States National Renewable energy Laboratory have so far only obtained roughly 1% efficiency while using infrared light. Another important part of our receiver circuitry is a simple sensor. This is simply used to identify when the mobile phone user is talking. As our main objective is to charge the mobile phone with the transmitted microwave after rectifying it by the rectenna, the sensor plays an important role. The whole setup looks something like this.

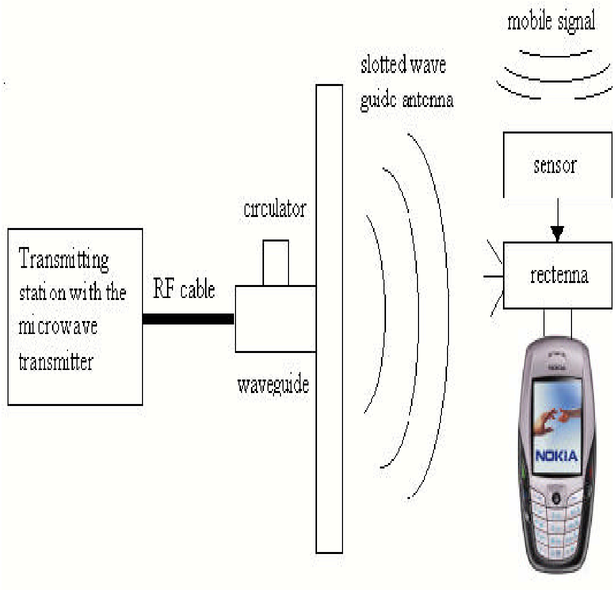

Fig 4: A Rectifying Antenna rectifies received microwaves into DC current.

IV. PROCESS OF RECTIFICATION

A rectenna comprises of a mesh of dipoles and diodes for absorbing microwave energy from a transmitter and converting it into electric power. Its elements are usually arranged in a mesh pattern, giving it a distinct appearance from most antennae. A simple rectenna can be constructed from a Schottky diode placed between antenna dipoles as shown in Fig.. The diode rectifies the current induced in the antenna by the microwaves. Rectenna are highly efficient at converting microwave energy to electricity. In laboratory environments, efficiencies above 90% have been observed with regularity. In future rectennas will be used to generate large-scale power from microwave beams delivered from orbiting SPS satellites.

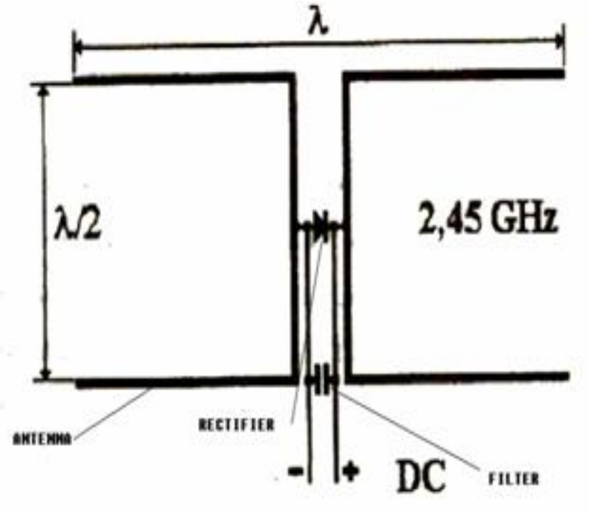

Fig 5: Brief introduction of Schottky Barrier Diode

A Schottky barrier diode(fig 5) is different from a common P/N silicon diode. The common diode is formed by connecting a P type semiconductor with an N type semiconductor, this is connecting between a semiconductor and another semiconductor; however, a Schottky barrier diode is formed by connecting a metal with a semiconductor. When the metal contacts the semiconductor, there will be a layer of potential barrier (Schottky barrier) formed on the contact surface of them, which shows a characteristic of rectification. The material of the semiconductor usually is a semiconductor of n-type (occasionally p-type), and the material of metal generally is chosen from different metals such as molybdenum, chromium, platinum and tungsten. Sputtering technique connects the metal and the semiconductor.

A Schottky barrier diode is a majority carrier device, while a common diode is a minority carrier device. When a common PN diode is turned from electric connecting to circuit breakage, the redundant minority carrier on the contact surface should be removed to result in time delay. The Schottky barrier diode itself has no minority carrier, it can quickly turn from electric connecting to circuit breakage, its speed is much faster than a common P/N diode, so its reverse recovery time Trr is very short and shorter than 10 nS. And the forward voltage bias of the Schottky barrier diode is under 0.6V or so, lower than that (about 1.1V) of the common PN diode. So, The Schottky barrier diode is a comparatively ideal diode, such as for a 1 ampere limited current PN interface. Below is the comparison of power consumption between a common diode and a Schottky barrier diode:

$$P=0.6*1=0.6W$$

$$P=1.1*1=1.1W \quad (1)$$

It appears that the standards of efficiency differ widely. Besides, the PIV of the Schottky barrier diode is generally far smaller than that of the PN diode; on the basis of the same unit, the PIV of the Schottky barrier diode is probably 50V while the PIV of the PN diode may be as high as 150V. Another advantage of the Schottky barrier diode is a very low noise index that is very important for a communication receiver; its working scope may reach 20GHz.

V. SENSOR CIRCUITRY

The sensor circuitry is a simple circuit, which detects if the mobile phone receives any message signal. This is required, as the phone has to be charged as long as the user is talking. Thus a simple F to V converter would serve our purpose. In India the operating frequency of the mobile phone operators is generally 900MHz or 1800MHz for the GSM system for mobile communication. Thus the usage of simple F to V converters would act as switches to trigger the rectenna circuit to on. A simple yet powerful F to V converter is LM2907. Using LM2907 would greatly serve our purpose. It acts as a switch for triggering the rectenna circuitry. The general block diagram for the LM2907 is given below figure 6. Thus on the reception of the signal the sensor circuitry directs the rectenna circuit to ON and the mobile phone begins to charge using the microwave power.

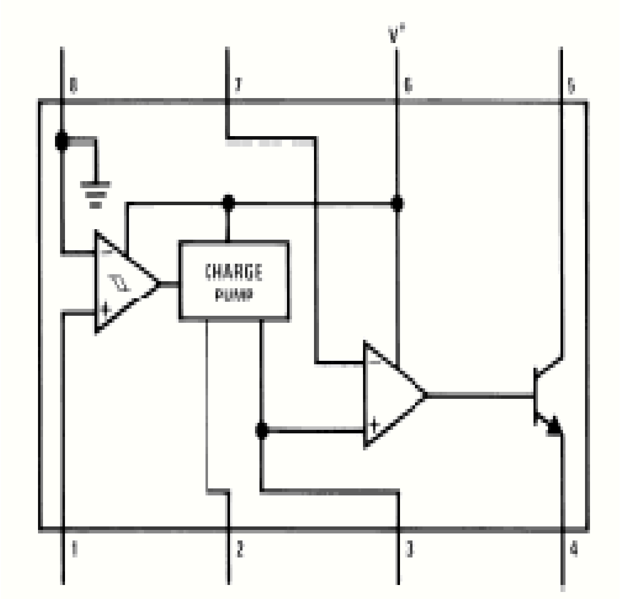

Fig 6: The general block diagram for the LM2907.

VI. CONCLUSION

Thus this paper successfully demonstrates a novel method of using the power of the microwave to charge the mobile phones without the use of wired chargers. Thus this method provides great advantage to the mobile phone users to carry their phones anywhere even if the place is devoid of facilities for charging. A novel use of the rectenna and a sensor in a mobile phone could provide a new dimension in the revelation of mobile phone.

VII. REFERENCES

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