Implementation of Wireless Transfer of Electrical Low Power System

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Abstract - Wireless charging through inductive coupling could be one of the next technologies that carry the futures forward. This paper designs, implements and practically tests the wireless charging of low power appliances and it has been shown that it is possible to charge low power devices via inductive coupling. With this we can avoid the confusion and danger of having long, hazardous and tangled wiring. It minimizes the complexity that arises from the use of conventional wire system. In addition, the study also opens up new possibilities of wireless system in other daily life uses. Much interest in the research has been conducted to determine the feasibility of system design and implementation of wireless low power transmission and simulation process of charging the load at different distances. The wireless charger of 12 volt power source with new charging technique is designed and implemented. The circuit is capable of charging low power appliances.

Keywords: Approaches of WPT; Application of WPT; System Implementation and Experimental results.

I. INTRODUCTION

Electrical transmission lines are used to transmit electric energy and signals from one point to another, specifically from a source to a load, this may include the connection between a transmitter and antenna, connections between computers in network, or between a hydroelectric generating plant and a substation several hundred miles away [1]. Such as electromagnetic waves or acoustic waves, as well as electric power transmission. However in communications and electronic engineering, the term has more specific meaning. In these fields, transmission lines are specialized cables and other mediate signal carry Alternating Current (AC) and electromagnetic waves of high frequency. Transmission lines are used for purposes such as connecting radio transmitters and receivers with their antennas, distributing cable, television signals, and computer network connections.

Transmission lines use specialized construction such as precise conductor dimensions and spacing, and impedance matching, to carry electromagnetic signals with minimal reflections and power losses. Types of transmission line include the higher frequency; the shorter are the waves in a transmission medium. Transmission lines must be used when the frequency is high enough that the wavelength of the waves begins to approach the length of the cable used. To conduct energy at frequencies above the radio range, such as millimeter waves, infrared, and light, the waves become much smaller than the dimensions of the structures used to guide them, so transmission line techniques become inadequate and the methods of optics are used.

The theory of sound wave propagation is very similar mathematically to that of electromagnetic waves, so techniques from transmission line theory are also used to build structures to conduct waves through the space; and these are also called transmission lines [2].
II. WIRELESS POWER TRANSMISSION

Wireless Power Transmission (WPT) refers to energy transmission from one point to another without interconnecting wires. There are many applications for WPT, such as wireless power charging for mobile phones [3-5], wireless power distribution systems in buildings and wireless charging for Battery Electric Vehicles (BEVs). The range for these applications varies widely but can be divided into three main regions: short distance, intermediate distance and long distance.

The principle of WPT is to convert prime Direct Current (DC) power to Radio Frequency (RF) and then transmit the power by Electro-Magnetic (EM) wave propagation. A block diagram of energy transfer is shown in Fig. 1. At receiver, there is a rectifier which has the ability to convert EM waves back to direct current [6].

Figure 1: Wireless power transmission diagrams.

A. History WPT

The concept of WPT is simply to transmit electrical power from one point to another through the atmosphere without the physical need of transmission lines or cables. This process usually entails dc-to-ac power conversion, followed by the transmission of this Electro-Magnetic (EM) energy through the radiation of RF, microwave, laser or light. At the designated target, the reverse process occurs where the ac energy is rectified and converted into dc energy which is then used for power. The power can be used directly, but is most often used to charge a battery.

Brown wrote a descriptive paper on the history of WPT and its progress through the years. In it, he gives detailed accounts of the milestone advances in the work of WPT and the problems that it faced along the way. His references date back to Hertz who was the first to discover that electrical energy could be transmitted through electromagnetic fields in the air. His work was further explored by Tesla who noted that the earth had its own resonance that could be used to sustain low frequency power transmissions for a virtually endless amount of time [7, 8]. However, Tesla’s work was hampered by funding issues and the requirement of extremely large plots of land to conduct his experiments [9].

B. Early Experimentations

A number of advances in different areas came together around the late 1950s which enabled WPT to become a reality. The first advance was the ability to focus electromagnetic power into a beam and achieve high efficiencies, and the second was the amplifier tube, which created the required amount of transmitting power to power the electromagnetic beam. With these two advances, the efficient transmission of microwave power was satisfied and the next step was then to look at the reception and conversion of the microwave power.
The first completed microwave power transmission system was conducted in May 1963, where 100 W of dc power was converted from a 400 W transmitter, was used to drive a motor attached to a fan. The advancement of WPT was, however, hampered by the short lifespan and unreliability of the thermionic diode used in the rectification process. Soon thereafter solid state semiconductor diodes were developed and the concept of a RECTENNA, consisting of a half-wave dipole antenna connected to the rectifying diode with a ground plate behind it, was conceived. Although the power handling capability of the diode in each RECTENNA was relatively small, these RECTENNA elements were then configured in an array to generate sufficient power required for the application. On 28 Oct 1964, the concept and demonstration of a microwave power helicopter was presented to the mass media. Following the buildup of interest, a non-stop 10 hour hovering of a helicopter was conducted in November of that year [10-13].

III. SYSTEM IMPLEMENTATION

Further study about wireless power transfer came up with the idea of a wireless charger for the low power devices such as mobile phones, camera etc. The main idea was to charge these low power devices using inductive coupling [14-18]. The overall process required a transmitter and a receiver as shown in Fig. 1 and Fig.2 respectively.

The LC tank circuit shown in Fig. 2 and Fig. 3 are the part where heavy current circulates, and are required to be sturdy. The copper pipe used as conductor heats up significantly under high current it is passing continuously. The receiver module of this study is made up of a receiver coil, a rectifier circuit and a filter. An A.C. voltage is induced in the receiver coil. The rectifier circuit converts it to D.C [19].

Figure 2: Transmitter module.

Figure 3: Receiver module.
IV. EXPERIMENTAL RESULTS

After accomplish the study, it is found that can be charge the load wirelessly at specified distance and frequency.

C. Results with Zero Distance

Fig. 4 represents the load voltage; it is found that the battery is able to charge 3.3 V. However, the battery is heavily loading, rectifier voltage and dropping it from 6.98 V to almost 3.68 V and the current has been drown by the load is 0.13A. Fig. 5 and Fig. 6 represent the load current of each diode (D₂ and D₄), and it is found the load current, only about 0.13A has been drawn by the battery. As shown in Fig. 7, each one of these two diode charge in half cycle of the source.

![Figure 4: Load voltage.](Image)

![Figure 5: Load current of D2.](Image)
When comparing the voltage in Fig. 8 with voltage in Fig. 6, it is found that, the maximum voltage when the distance between transmitter and receiver is so small (there is no distance). The distance increased at the same input voltage in the transmitter, the voltage decreased, and respectively the transmitted power will decrease. By increasing the distance plenty times the load become unable to charge, because of the frequency which has been transferred from the transmitter become very low. This means that inductive coupling really is suitable to the small distance to charge the load.

Fig. 9 and Fig. 10 represent the load current of each diode (D₂ and D₄) at (16 cm), and load current, only about 0.017A has been drawn by the load.
Figure 8: Load voltage.

Figure 9: Load current of D2.

Figure 10: Load current of D4.
Fig. 11 represents the load current of two diode (D2, D4) at 16 cm. It’s found that when the distance is so far the current decrease to 0.017 A, and that will decrease the transmitted power from 0.91 W at 0 cm to 0.043 W at this distance.

The task of DC battery in this study, which has expected has been accomplished, but has many other drawbacks in its simplicity. All the most modern battery chargers are on. Charging can be stopped once a certain voltage is reached, it detects the battery is full, or if an unsafe temperature is detected. The battery charging circuit used in this project does not have any of these features nor does not protect against overcharging.

V. PERFORMANCES AND ANALYSIS

The performance and analysis of this study is accomplished as shown in Table I and Table II. The voltage curve at different distance which has drawn from Table 1. It realized that when the distance increase the voltage decrease until reach the cut off frequency point is shown in Fig. 12.

<table>
<thead>
<tr>
<th>TABLE I: Result of the AC Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (cm)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>16</td>
</tr>
</tbody>
</table>
TABLE II: Result of the DC circuit

<table>
<thead>
<tr>
<th>Current (mA)</th>
<th>DC Voltage (V)</th>
<th>Current (mA)</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.98</td>
<td>130</td>
<td>0.91</td>
</tr>
<tr>
<td>2</td>
<td>6.8</td>
<td>110</td>
<td>0.75</td>
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<td>6</td>
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<td>8</td>
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<td>50</td>
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<td>12</td>
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<td>14</td>
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<td>19</td>
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</tr>
<tr>
<td>16</td>
<td>2.7</td>
<td>17</td>
<td>0.043</td>
</tr>
</tbody>
</table>

VI. THE EFFICIENCY OF THE CIRCUIT

The efficiency of wireless power is the ratio between power that reaches the receiver and the power supplied to the transmitter. 12V is provided to the input of the oscillator circuit. 8.6V is calculated across the transmitter coil, and the efficiency evaluated in this study as shown in Fig. 13.

Figure 12: The voltage curve.

Figure 13: Efficiency curve.
VII. CONCLUSION

The goal of this study is to design, implement and test a wireless charger for low power devices via inductive coupling. After analyzing the whole system step by step for optimization, a system was designed and implemented. Experimental results showed that significant improvements in terms of power-transfer efficiency have been achieved. Measured results are in good agreement with the theoretical models. It was described and demonstrated that inductive coupling can be used to deliver power wirelessly from a source coil to a load coil and charge a low power device (battery of cell phone, laptop computers and other portable electronics and being capable of charging themselves without ever being plugged in. This mechanism is a potentially robust means for the future low power devices it could developed to reduce our society’s dependence on batteries, which are currently heavy and expensive. The main disadvantages of inductive charging are its lower efficiency for far distances and increased resistive heating in comparison to direct contact. Implementations using lower frequencies or older drive technologies charge more slowly and generate heat within most portable electronics and slower charging - due to the lower efficiency. In this application the efficiency exceeding 85% have been realized.

REFERENCES