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Wireless Mobile Phones Charging – A Comprehensive Study

Ibrahim Yehya Dallal Bashi

Department of Electrical Techniques, Technical Institute of Mosul, Northern Technical University, Iraq

Abstract In recent years, an increasing development has been noticed in researches of wireless power transfer techniques to eliminate the use of the cables after Wi-Fi became widely utilized. When traveling, we could simply overlook about USB cables and the traditional chargers. Normally, the users of the mobile devices have the anxiety of power lack during carrying out a critical job and have no possibility of access to a charger. The users keen to always keep their mobile devices with electric power as much as possible. Also, power sharing techniques have been modified, based on user's nearness mobile devices, that became able to get power from them. This paper will show an overview study and basis of the wireless mobile phones charging techniques.

Keywords Wireless charging, Inductive charging, PAD, Solar cell, Fulton's charging, Chargebite

1. Introduction

All over the world, there are billions of people utilize mobile devices such as tablets, smartphones and laptops. The growing in utilization of, for example smart glasses and watches i.e. wearables, expands this eco-system to high levels. The different tasks, for example, sending email, doing a phone call, finding location …etc. presented by these mobile devices, grow every day more and more bring our life easier also making us increasingly count on this equipment. However, this equipment is battery-powered and regularly recharged, usually by connecting them to a power cord [1] [2]. The traditional charger is normally used to recharge the rechargeable batteries, which is normally a power supply of ac to dc (in case that the mains is ac) or a power supply of dc to dc (in case that a car battery is used). A cord i.e. electric cable is used to connect the traditional charger i.e. the power supply to the required battery to be charged, which is normally placed in the portable device [3].

Wireless power transfer (WPT) can be defined as the electric energy transmit to an electric load from a power source without using a physical connection between them. WPT is allowing mobile devices to be continuously charged conveniently, easily and without constraints of using a power cord. Hence an efficient method of transfer of electric power is required to transmit it from the charger to the mobile device across an air gap without utilizing wire or other material [4-16].

* Corresponding author:
ibrahimbashi2004@yahoo.com (Ibrahim Yehya Dallal Bashi)
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In smartphones, the battery lives are short, it is unavoidable that the user can stand up to a certain case in which a critical job such as doing an emergency call, sending an urgent email or receiving contact information in the mobile phone may not be carried out. In addition, a recent analysis on users' habits for battery charging present that there are many users who charge their mobile phones frequently with short time periods, and aimed to hold them with as much energy as possible [6] [17-21]. This is due to the worry of loss of the power during a critical job without possibility of approach to charging instruments. An alternative method of charging mobile devices is using the power of batteries of other mobile devices. All such devices in the closeness is very unlikely will drain their power of battery at the same time. Power sharing is the method, that could be a hopeful solution especially in urgent cases in which a little charge could be helpful to carry out the emergency job. However, there are good challenges of incentivizing the mobile devices users and minimizing the encumbrance of such operation on users [1].

Wireless methods are always advantageous than cumbersome, untidy wiry networks. You can have a lot of options if the facility of wireless charging of mobile phones is somehow implemented. The need of different type of chargers by different manufacturers is totally eliminated [7] [22]. This research includes a comprehensive study of related literature of mobile phones charging techniques in order to gain wireless charging review. The advantages and disadvantages have been explained.

2. Wireless Charging Using Microwave

The microwave charging set up consists of two sections:

the first section is the transmitter and the other, located in the mobile phone side, is the receiver section. To carry out the mobile phones recharging anywhere you want without traditional charger this is achieved only when there is utilization of microwave signal which is transmitted from transmitter at a frequency of 2.45GHz [22].

Typically, the transmitter design includes generation of a carrier signal, which is normally sinusoidal, optionally one or more frequency multiplication stages, a modulator, a power amplifier, and a filter and matching network to be connected to an antenna [22-26]. The antenna is of slotted waveguide antenna type [23-31] as shown in Figure 1.

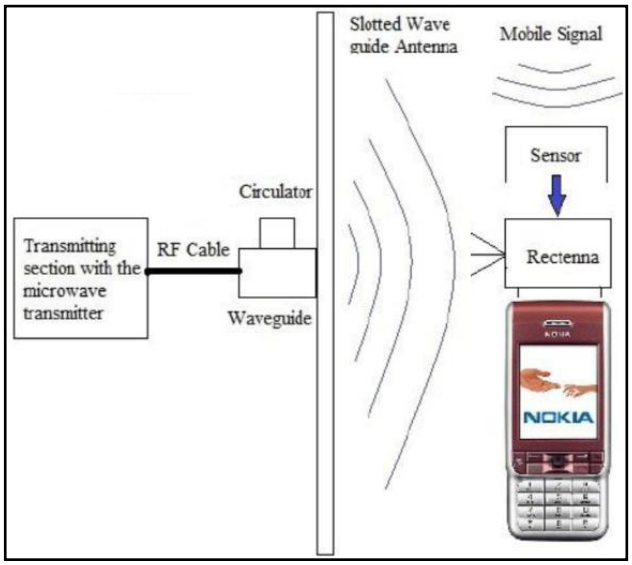

Figure 1. Whole set up for microwave charging [24-26] [28] [29] [31]

The receiver side includes a rectenna and a sensor. The function of the rectenna is to convert the microwave signal into the dc power. Schottky diodes are used to construct rectenna. They are normally arranged in a mesh pattern. Rectenna is very efficient to convert the microwave signal into the dc electric power. The dimensions of rectenna can be reduced by utilizing the nano technology. The sensor is another important part of the receiver. The phone is going to be charged while a person is talking. So, the function of the sensor is to detect whether the mobile phone is utilizing microwaves or not [22-27] [29-33].

Advantages: [22] [23] [27] [28]

- Electric energy is saved.
- The mobile phone can be charged anytime anywhere even if the position is freed from facilities for mobile phone charging.
- The microwave radiation works on far field at a greater distance. In addition, for the far-field technique, the transmitter is not affected by the absorption of the radiation.

Disadvantages: [22] [23] [26] [32]

- The transmitter and the receiver also should be very powerful devices as the distance increases the charging is very slower.
- The far-field power charging is inversely proportional with the distance.
- When supplied equal power, mobile phones take longer time to charge comparing with the traditional charging, due to its lower efficiency.
- Not safe when the microwave density exposure is high.
- It is costlier.
- Line-of-sight charging.

3. Inductive Coupling Wireless Charger

Inductive power transfer technique is being utilized in various applications for transmitting power wirelessly. Chargers of inductively coupled type are being utilized for wireless charging of iPad, MP3 Player, mobile phones, and other handheld devices [34] [35].

WPT using inductive wireless charger can be included three parts. First, sender, the sender transmits electromagnetically power through inductive coils which provide a wireless transmit of power to receiver part. Second part is inductive coupling (sender coil and receiver coil), which acts as the antenna (sender antenna and receiver antenna), and forwards the power to the bridge rectifier. Third, bridge rectifier that converts the induced voltage from the ac to the dc voltage, and finally the dc voltage will recharge the battery and provide the load. Figure 2 depicts the block diagram of inductive WPT [3] [23] [34] [36-39].

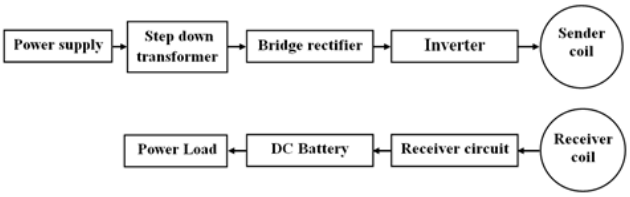

Figure 2. Block Diagram of inductive WPT [35]

Depending on experimental study done by [34], the results proved that the WPT using inductive coupling has relationship with the distance, range of the used frequency and the results show that the shorter the distance, the higher is the voltage transferred. Shielding materials like the presence of books, hands and certain types of plastics do not affect the WPT much [34].

Advantages: [23] [35] [40]

- No tedious wire work required.
- Safety increases.
- Low maintenance cost.
- Durability, less wear and tear on the socket of the device and attaching cable.

Disadvantages: [40]

- Efficiency is lower.
- Charging is slower.
- Doesn't work over large distances.

4. Wireless Charger PAD

QI is an interface standard developed by the Wireless Power Consortium for inductive electrical power transfer over distances of up to 4 cm (1.6inches) [23] [40] [41]. This system includes a transmission (charging) pad and a receiver (mobile phone) compatible to receive the transmitted power. The mobile phone is put on the charging pad (see Figure 3) and the charging process begins [5] [40] [41]. Various mobile manufacturers are working with the standard and that includes HTC, SAMSUNG, BLACKBERRY, NOKIA … etc. [42].

Wireless charging pads used for portable consumer electronic devices is a multidisciplinary emerging technology that includes planar magnetic designs, power electronics, and radio-frequency circuits and technologies [43].

The transfer of energy from the transmission pad to the receiver occurs due to resonant inductive coupling. Resonant inductive coupling is wireless transmission of electrical energy over short distances between two coils which are tuned at the same frequency. Coil ring generates an oscillating magnetic field producing energy in the coil. The second coil in the receiver when brought closer to the first coil, the energy gets transferred before it is lost [5] [40] [41].

Figure 3. Wireless charging pad [44]

Advantages: [40]

- Multiple devices can be charged at a time.
- Cheaper
- Less maintenance required
- Since it does not required plug and unplug the device continuously, the device durability would be enhanced and its application would become more appropriate [5].

Disadvantages: [5] [40]

- Low efficiency as compared to inductive transfer in conventional transformers.
- It needs electronic circuits and coils that increase the complexity in manufacturing and raise its cost.

5. Wireless Solar Cell Phone Charger

Solar cell phone charger is a device which uses a small solar panel to convert the solar energy absorbed from the sun to charge the battery of device. To fulfill this, customer need to carry an extra device along with their cell phones, this brings in the inconveniency. To avoid this, a small version of solar panel is built on the cell phone itself [45]. The devices of gathering solar energy using photovoltaic (PV) cells are to transform the incident light into electric energy. As such, they influence the wide development carried out and progress obtained in reducing the cost and increasing the efficiency of PV. Solar devices can yield energy from both indoor and outdoor light sources. The outdoor incident light sources yield around two to three orders of value of electric energy per unit area more than that of indoor incident light sources. Comparing with other electric sources, solar devices under direct sun can obtain high energy densities, but will not work in areas with no light (e.g. ducts, areas with highly overshadow …etc.). Nowadays solar cells have various applications including traffic signals, mobile phones as well as iPDAs, calculators, and wristwatches …etc. [46] [47]. The solar cells are produced also in the form of straps, placing the solar cells on the outer surface and a battery within. Basically, solar panel is normally put in a well-lit area, and it converts light energy into electric energy that charges an internal battery of Lithium Polymer (LiPo) type. The electric energy that is stored in the LiPo battery can be used to charge mobile phones or other mobile devices [48]. Voltaic Amp is one of the best solar phone chargers of 2017, see Figure 4.

The great thing about the Voltaic Amp is its detachable battery. The company makes great solar panels for this portable phone charger, but the rechargeable 5-volt Lithium Polymer batteries are very nice. The batteries are smaller than most smart phones and not permanently attached to the solar panel. They're also elegant enough that you won't be embarrassed to be seen using one out in public. One of these batteries can be charged in under 5 hours when plugged into a USB, and hardly longer than that when plugged into the solar panels [49].

Figure 4. Voltaic Amp image [49] [50]

Advantages: [40]

- Cost effective.
- It does not cause any harm to the environment.
- Relatively long-life span.

- Less maintenance.

Disadvantages: [40] [45]

- Low efficiency.
- Substantial power loss.
- Thickness of solar cell.

6. Fulton's Bidirectional Wireless Charger

Fulton Innovation revealed its bidirectional charging technology called eCoupling. The technology would essentially allow someone to charge their mobile phone by simply putting it on the back of a tablet, as shown in Figure 5, or another device that has enabled Qi [51]. Fulton Innovation has modified Qi WPT technique that permits for the charging of mobile devices without plugging the mobile devices in, by simply placing them on a power station connected to an outlet [52].

In the bidirectional power supply as the name suggests, phone will not only receive the power but it also can transmit power to another device which can receive this power. Here all you need to do is to install eCoupled technology in your phone [53]. First when these two Qi enabled phone will come near to each other the device with more battery than other will ask user how much percent he wants the charging in the other device. According to it, the device with extra battery will charge the other device [54]. It can not only charge the phone but with the help of it we can charge something more power consuming than phone.

Figure 5. Fulton's bidirectional wireless charging [55]

Advantages: [40]

- We will not need any pad to charge the phone.
- It charges the phone as a speed of wall mounted wired charger.

Disadvantages: [40]

- We cannot use the phone while the charging is in process.
- We cannot charge the phone by putting it away from the host phones.

7. Chargebite Wireless Charger

Due to the short battery lives in smartphones, it is inevitable that one can face a situation in which a critical task such as making an emergency phone call, sending a business-related email or reaching a contact information in the device may not be performed. As it is very unlikely that all such devices in the vicinity will deplete their battery at the same time, such a power sharing solution could be a promising remedy especially in emergency situations in which even a small amount of charge could be sufficient to perform the urgent task because even a short duration of energy sharing could extend a critical task (e.g., 12 seconds of charging will enable one-minute call or two minutes of charging can support 4 minutes of video watching) [1]. Power sharing between mobile devices could be achieved by various power sharing methods such as chargebite charger.

Chargebite was firstly introduced by Asaf Gaber and his partner Liran Elihay [56]. The working of chargebite is so much different from the other entire wireless charger available in the market. Basically, chargebite is a device with which we have to connect another two iPhones and these two iPhones charge the third iPhone which is connected. It drains battery from two iPhones and delivers the power to the third one [40].

Chargebite is completely portable and can be attached to a keychain as shown in Figure 6a. Chargebite contains no power USB, ports outlets, or charging cables. It can be called as social charger which needs no pre-charging or preparations because it acts no more than a transmission medium between mobile phones [57]. ChargeBite combinations can be obtained in three different colors as depicted in Figure 6b [58].

(a)

(b)

Figure 6. (a) Demonstration of power transfer from one phone to the other using ChargeBite, (b) ChargeBite in three different color combinations [58]

Advantages: [40]

- It does not need any induction coil or a capacitive batter.
- It is reliable.
- It is small in size and hence portable.

Disadvantages: [40] [59]

- It works with 30-pin iDevices only.
- It needs at least another two iPhones to charge a single iPhone.

8. Conclusions

The primary purpose of this research is to study the related literature of mobile phones charging in order to gain wireless charging review. These devices eliminate the need to use messy cords giving a more convenient experience.

We have successfully carried out an overview study and principles of five charging techniques of wireless mobile phones, as well as the sixth technique of direct connection between iPhone mobiles. The advantages and disadvantages have been explained.

The goal of the future researches is to reduce the size of the related devices and increase the distance and power transfer and the efficiency of devices as well as focusing on the techniques with less harmfulness to the human and the environment.

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