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Wireless Battery Charger: Architecture

[1] Dr. Sakkaravarthi R, [2] Ganana Jeba Das

[1], [2] Department of Electronics and Communication Engineering, Galgotias University, Yamuna Expressway
Greater Noida, Uttar Pradesh

[1] sakkaravarthi@Galgotiasuniversity.edu.in, [2] jeba.das@galgotiasuniversity.edu.in

Abstract: In this paper a revolutionary concept for handheld electronic devices is suggested for a wireless battery charger. The wireless power transmission is carried out by means of a magnetic coupling between a power transmitter that is connected to the grid and a power receiver that is built into the load unit. It presents an advanced receiver architecture which greatly improves the efficiency of power conversion. The solution proposed is norm compatible and appropriate for application of IC. SPICE simulations perform a distinction between a modern and the new receiver architectures. As shown by simulation tests, the proposed solution produces a power consumption gain of 40-45 per cent. A laboratory version of the planned wireless battery charger was performed and evaluated for system performance tests. As the experimental results reveal, due to the suggested design, the receiver performance lies within the 95.5 percent 99.5 percent range over the entire range of operating conditions.

Keywords: Inductive power transfer, Wireless power transfer, Battery charger, SPICE, Modelling and simulation.

INTRODUCTION

Wireless connectivity has been in use in telecommunications for a long time. Radio waves, radio communications and Wireless Network are just a few forms of wireless transmission. Recently, there has been a growing interest in playing with a highly daunting concept for wireless applications: selling cordless electronic devices. Developing, implementing and introducing this new concept will make life considerably simpler for customers, as wired chargers are often viewed as noisy and bulky items. The magnetic coupling between a power transmitter and a control receiver, just a few millimeters from each other, has provided the most convenient way to wireless charging so far. In addition, a less efficient power transfer is accomplished through the use of certain energy transfer technologies, such as power storage, optical beam transmission or acoustic coupling [1].

The power transmitter is described by a grid-connected magnetic pad by magnetic induction, while the power receiver is embedded within the load unit. Users position their handheld device on the magnetic pad only. Magnetic coupling allows simultaneous charging of several items. Academic and industry researchers have contributed greatly in recent years to the production of modern magnetic devices for wireless power transfer. Innovative techniques for measuring the reciprocal inductance and the capacity of power transfer. Compatibility between chargers and tablets is a crucial issue to address for the proliferation of wireless battery charging. The Wireless Power Consortium (WPC) has recently developed an international standard, also known as the "Qi-standard," which aims to promote the full interoperability of power charging stations and rechargeable devices.

As far as power conversion performance is concerned, the most sophisticated wireless battery charger approach achieves a value of 75 per cent, measured taking into account the entire system from the power transmitter to the power receiver, including both the coupled inductors [2]. Even though high-quality components add a few percentage points more, wireless power transmission has not been a viable solution relative to wired technology due to poor conversion efficiency. Focusing only on the receiver segment, state-of - the-art architectures reach a maximum efficiency of 93 per cent.

Applications of Wireless Battery Charging

Smart Phones, Portable Media Players, Digital Cameras, Tablets and Wearables:

Consumers are seeking easy-to-use devices, greater placement flexibility and faster charging times. Usually, such applications require 2 W to 15 W of electricity. Interoperability for various requirements is favored. Through NFC (Near Field Communication) and Bluetooth, wireless charging will coexist, allowing some creative solutions. For starters, when placed back-to-back, paired phones will charge each other up after securing the correct host and customer.

Accessories:

Wireless power delivery is of interest to headphones, wireless speakers, controllers, keyboards and many other devices. Connecting charging cables to the tiny plugs of ever-shrinking computers is a challenge to durable construction. Of starters, to work in a gym environment, the Bluetooth headsets must be sweat-proof. The chance is only be made possible by wireless charging.

Public Access Charging Terminal:

Deployment in the public domain of charging pads (transmitters) includes devices that are safe and secure. Nevertheless, smart charging devices go much further than stand-alone charging solutions. These will allow easy network-connection and, if needed, build billable charging stations. Both conditions are sponsored by many coffee shops, airport kiosks and hotels. Manufacturers of furniture also design discrete wireless transmitters in their end and side tables.

In-Cabin Automotive Applications:

A wireless adapter is suitable for charging mobile phones and key fobs by putting them either on the car's dash or center console, with no awkward wires connecting to the lighter socket for cigarettes. However, as Bluetooth and Wi-Fi need authentication to link telephones to car electronics, integrating NFC with wireless charging will allow the user not only to charge the device, but also to attach it automatically to the car's Wi-Fi and Bluetooth networks without having to go through any special setup process.

Computer Systems:

Laptops, laptops, ultra-novels, and tablet PCs are all applicants as hosts or clients for wireless charging. The options are endless.

Electric Vehicles:

Now coming up are smart charging stations for EVs (electric vehicles), but they need much greater power. Standards are changing.

Key components of wireless charging device

1. The wireless charging transmitter is operated by 5 V to 19 V input DC line, usually generated from either a USB port or an AC / DC power adapter.
2. Use two or four FETs a connected transistor bridge powers a coil and a sequence condenser. A resonant frequency is set internally, using the condenser array.
3. The transmitter has an electromagnetic induction coil to transfer power. Many transmitters enable multi-coil clusters, powered by independent bridges that are chosen randomly to provide the maximum

coupling strength to the wireless power receiver.

4. The induced power is coupled to the wireless power receiver, which is equipped with a similar coil to gather input power.
5. The receiver rectifies the power through diode rectifiers, which are usually made of FETs to improve the efficiency. It also collects the power using ceramic output condensers and then adds it to the battery that needs to be charged, either via a linear stage or a switching regulator.
6. Inside the portable device the battery absorbs the electricity and charges up. The receiver may instruct the transmitter to change the charge current or voltage, as well as to completely stop transmitting power when the charge stops.

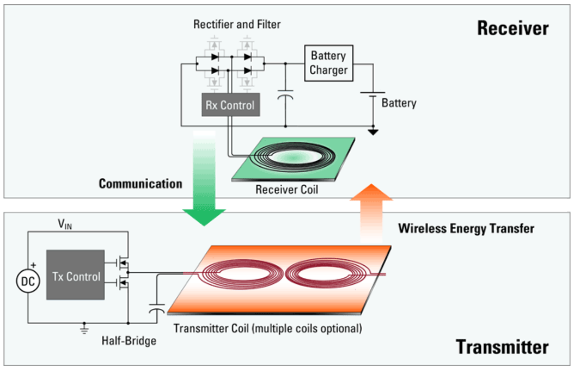

Figure 1. Architecture of wireless charging system

LITERATURE REVIEW

The paper provide a comprehensive overview of wireless charging methods, the improvements in technical standards, and their recent advances in network implementations. In specific, with respect to network implementations, we study the static charger scheduling techniques, desktop charger dispatch strategies and wireless charger delivery strategies. Furthermore, when introducing wireless charging systems we address open issues and obstacles. Finally, we envisage other realistic potential wireless charging network implementations [1]. A brief description on the operating concepts of a series-series resonant WPTS is given before outlining the design method of the control circuitry required for its service, i.e. an alternating-current-direct-current converter cascaded by a high-frequency inverter in the transmitting section and a diode rectifier cascaded by a chopper in the receiving portion [2]. This paper presents a new multi-objective concept design paradigm for sitting wireless chargers in a multi-route electric bus network based on life cycle assessment (LCA). Compared to previous research, this multi-objective optimization approach assesses not only the minimization of system-level expenses, but also newly integrates the targets of reducing greenhouse gas (GHG) life cycle pollution and energy consumption throughout a wireless charging bus system's lifespan. The LCA-based optimization method is more detailed than previous studies in that it covers not only the challenges associated with the introduction of wireless charging systems, but also the benefits of downsizing electric bus batteries and the use-phase energy consumption of automobiles attributable to light weighting, which are directly related to battery positioning [3]. This paper addresses the Secure Charging Problem (SCP) of timing power chargers so that more energy is obtained when no field position has electromagnetic radiation (EMR) above a given threshold Rt ad shows that SCP is NP-hard and suggests a solution that proves to outperform SCP's optimal solution with a relaxed EMR threshold [4]. This paper provides a comprehensive review of existing wireless power transmission technology solutions used in battery chargers for electric vehicles. The design of each approach is thoroughly reviewed and considering the current shortcomings of power electronics technologies, expense and market approval, the viability is assessed. Furthermore, it addresses the drawbacks and benefits of each development. Ultimately a detailed comparison is made and a possible hybrid conductive / wireless charging network approach is recommended to address the existing problems inherent [5]. This research includes an innovative way to combine the versatility of wired and wireless charging with vehicle side boost converter incorporation and preserve insulation to provide the best solution for consumers of plug-in electric vehicles (PEV). The latest output of the revised design is demonstrated at different power rates for wired and wireless charging solutions [6]. This research includes an innovative way to combine the versatility of wired and wireless charging with the incorporation of vehicle side boost converters and preserve insulation to provide the best solution for plug-in electric vehicle consumers (PEV). The new performance of the revamped specification for wired and wireless charging systems is illustrated at different power levels [7]. This paper develops a framework, constructs a proof-of-concept prototype, performs laboratory tests to determine viability and efficiency in small networks, and conducts detailed simulations to test its output in large networks. Results from testing and simulation demonstrate that the proposed system will successfully use the wireless charging technology to extend the lifespan of the network by transmitting electricity to where it is required by a robot [8]. This paper introduces wireless circuitry for recharging batteries built for an implantable pressure sensor. The interfaces include a 150-mV end-of-charge hysteresis RF/DC rectifier, voltage limiter, and constant-current battery adapter. An AM demodulator drawing zero DC current requires commands to be sent to the carrier for recharge. Receiving a time-and value-coded shutdown order brings the implantable device into a standby mode of 15 Nano ampere [9].

METHODOLOGY

An effective strategy for reducing power losses means the immediate elimination of the resistive modulation network according to the simulation findings. It clearly results in a major increase in efficiency. The receiver design introduced here further enhances conversion efficiency by active changes in both the full-wave rectifier and the biasing network. Figure 2 Shows the simulation model of the wireless battery charger solution proposed here, which involves, on the left, the same power transmitter as mentioned in the previous paragraph and, on the right, a revolutionary power receiver configuration.

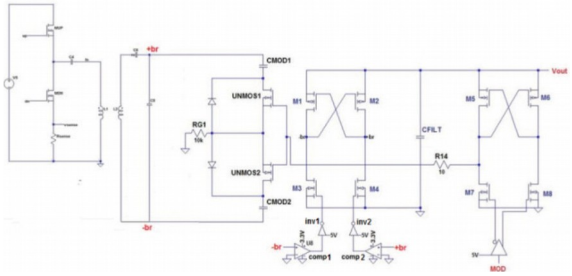

Figure 2. Simulation model of the proposed wireless battery charger

A "cross-coupled" design is applied to the rectifier chain. This consists of four MOSFETs: PMOS enhancement is M1 and M2; NMOS enhancement is M3 and M4. The AC input signal is transmitted between PMOS gate terminals, while the rectified voltage between the PMOS source terminals and ground is sensed. PMOS root terminals are interconnected. Connect M1 gate terminal to M4 drain terminal. Connect M2 gate terminal to M3 drain terminal. Connected are drain terminals M1 and M3, as well as drain terminals M2 and M4. Sensing the drain terminals of both PMOS through a network consisting of one comparator (comp) and one inverting driver (inv) for each NMOS properly produces all NMOS gate drive signals. The rectifier's AC input is distributed between the +br and –br terminals, which applies to the M2 drain terminal and the M1 drain terminal, respectively.

The + br terminal is favorable to ground during the positive half-wave while the -br voltage is negative to ground. So, M3 and M2 active switches rectify the current peak voltage, while M1 and M4 are off concurrently. Vice versa, + br terminal is negative to ground during the negative half-wave, while-br terminal voltage is favorable to land. Then M1 and M4 active switches rectify the current peak voltage when M2 and M3 are off concurrently. As shown in Fig.2, MOSFETs are M5-M6-M7-M8 which compound the biasing circuit. M5 and M6 are PMOS upgrades while M7 and M8 are NMOS upgrades. The NMOS gate terminals are out of the microcontroller powered externally by the optical modulation signal MOD.

Among M7's gate terminal and MOD signal an inverter is added. M7 and M8 are therefore chased out of process. The biasing circuit function is the gate drive signal of both the MOSFETs, UNMOS1 and UNMOS2 capacitive modulation. Both PMOS source terminals are connected to the DC bus rail whilst both NMOS source terminals are linked to the deck. When M6 and M7 are off, if the MOD signal is strong, both M5 and M8 are forced into conduction. The biasing output node is therefore connected by M5 to the DC bus rail and both capacitive modulation MOSFETs are forced into conduction, linking the CMOD1 and CMOD2 modulation condensers to the network. Then, M5 and M8 are off while M6 and M7 are on when the MOD signal is weak. The biasing output node is therefore connected by M7 to ground links, and both capacitive modulation MOSFETs are forced into prohibition. SPICE simulations of the proposed wireless battery charger were carried out and the contrast of the traditional design with the simulation results is also presented. The microcontroller also configures the swapping frequency to 192 kHz.

CONCLUSION

A revolutionary concept of a wireless battery charger was suggested in this article, and experimental results were shown to determine the performance of the power conversion. SPICE simulations also carried out a distinction between the standard and the current receiver architectures. As shown by simulation tests, the proposed solution offers an increase in power output of around 40 percent under active modulation and about 7 percent without modulation. A concept laboratory was developed and tested to assess system performance. The power conversion performance of the proposed power receiver is quite independent of the operating parameters, such as the sum of transmitted power and the operating frequency, as shown by the experimental results. The receiver output falls within the 96.5 percent range of 999.9 percent over the entire range of operating conditions. The estimated output between the secondary coil and the load system is now truly close to a unit value due to the proposed design. Therefore the efficiency of power conversion is now based only on magnetic coupling.

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