Vol. 5, Issue. 3, 2018, ISSN 2349-0780

Wireless Power Transfer for Smart Applications

S Christo Jain[#], Aakash P S[*], Aishwarya V H[*], Akhil D R[*], Anusha R[*]

[#]Assistant Professor, [*]BE students ECE Branch

Department of Electronics and Communication, K S Institute of Technology

Bangalore, Karnataka, India

Email: s.christojain@gmail.com, aakashps95@gmail.com, aishu17296@gmail.com, akhil.dr26@gmail.com, anusha.r2502@gmail.com

Abstract – In recent years, wireless power transfer system have successfully been used in various applications like mobile communication devices, electric vehicles, etc. due to their contactless power transfer feature. This technology replaces the conventional conductive power transfer systems where physical connection is either inconvenient or impossible and enables transfer from one system to another across an air gap. Wireless power transfer (WPT) technologies mainly focus on high efficiency and to increase the distance of transmission. The wireless power transmission using the inductive coupling method improves transfer efficiency but there might losses due to heating. In order to overcome these problems, we go for Wireless Power Transfer using radiation technology. Generally, this power transfer methods are preferred for long distances, but due to omnidirectional nature of the radiation power emission, the energy efficiency of power transmission is low but can be improved for short and mid-range application as well as the problems of various kinds of losses that occur in inductive coils (Non-radiation methods of WPT) can be overcome. Thus, this improves the overall efficiency of the system.

I. INTRODUCTION

Wireless power transfer system (WPTS) is a way of transferring power from one device to another device without any wire or cable connections. The technology can be divided into different categories based on the medium, the distance and technology. Radio frequency (RF) signals radiated by transmitters can be used to transmit power wirelessly. This can be achieved by using radio waves, microwave radiation as well as by applying resonant or inductive coupling. Table 1 shows the details of the different technologies. The distance that the power transfers plays an important role in the design of the WPTS. The space around the antenna can be divided into two regions- near and far field.

Wireless power transfer systems are devices which transfer power to electrical systems wirelessly. This concept paves way for charging of cell phones, laptops and other electronic devices wirelessly

	WPT via radio waves	**Resonant coupling**	**Inductive coupling**
Field	Electro-magnetic	Resonance (EM)	Magnetic
Method	Antenna	Resonator	Coil
Efficiency	Low to high	High	High
Distance	Short to long	Medium	Short
Power	Low to high	High	High
Safety	EM	None	Magnetic
Regulation	Radio wave	Under discussion	Under discussion

Table 1: Characteristics of different WPTS

This technology is in high demand because of its convenience to customers and industrial marketplaces. Here, the antenna method or the radiation method is used instead of the inductive coil method to overcome the heating losses caused in case of the inductive transfer and to improve the efficiency of the system. Here, the radiative power generated from the microwave source can be transmitted with the help of antenna which propagates through the medium in the form of electromagnetic waves. The receiving antenna captures the received power which can be utilized by the load.

The major highlight in the proposed system is the use of free space for the transmission of radio wave and the advantage is that the alternating current is not strongly absorbed by the free space , as a result the loads on the receiver side is better equipped with sufficient power with reduced attenuation and power losses. The omnidirectional nature of the radiative power emission helps to improve the overall efficiency and the load capacity.

The rest of the paper is organized as follows: Section II presents the background of the WPT system and our motivation. Section III presents the solution to the problem in the previous section.

Vol. 5, Issue. 3, 2018, ISSN 2349-0780

II. LITERATURE REVIEW

Akshya Swain, Dhafer Almakhles, Michael J Neath and Alireza Nasiri. Robust Control of Wireless Power Transfer System. *13th IEEE International Conference on Control & Automation (ICCA) July 3-6, 2017.* -The main goal of this paper is the robust control of wireless power transfer system. These systems behave as higher order resonant networks and hence are highly sensitive to changes in system parameters. The control design is carried out following Ricatti approach. This result in output feedback controller regulates the power in both directions in the presence of large uncertainties in various circuit parameters.

Chenxi Qiu, Ankur Sarker and Haiying Shen. Power Distribution Scheduling for Electric Vehicles in Wireless Power Transfer Systems. *978-1-5090-6599-8/17 ©2017 IEEE.*Electric vehicles (EVs) will become a component of the future generation intelligent transportation system. The WPT system charges EVs in motion when they pass the charging lanes installed in roads without requiring physical contact between utility power supply and vehicle battery. In this paper, the power distribution scheduling problem is studied. The goals are: i) balancing the state of charge (SOC) of the EVs, ii) balancing the amount of stored power of the EVs, and iii) minimizing the total power charged.

Nurcan Keskin and Huaping Liu. Unit Antenna Based Wireless Power Transfer Systems. 2015 Electronic Components & Technology Conference, *978-1-4799-8609-5/15 ©2015 IEEE.* Wireless power transfer systems are used in a broad range of applications.Due to detuning of the transmitter and receiver antennas, the efficiency of wireless power transfer may vary. In this paper, a unit antenna based wireless power transfer system is proposed to tune the system to its resonant frequency of 13.56MHz. This can be achieved by using radio waves, microwave radiation as well as by applying resonant or inductive coupling.

Manika la Nagababu, Karthik C Airani, Karthik K S, Shambulinga M. 4x4 Microstrip Antenna array for Wireless Power Transmission.*2015 International Conference on Applied and Theoretical Computing and Communication Technology, pages 719-722.* The major requirement of wireless power transmission is the antenna with high directivity. To increase the transmitted power of the sensor networks, a circularly polarized microstrip patch antenna with simple meta material slab and refractive index based meta material with operating frequency of 35GHz, gain of 18.1dBi and a return loss of -43.43dB is used. The analysis for power transfer efficiency by varying different parameters like different

orientation, different distances between the transmitting and the receiving antenna is done. When the loss resistance is low in the coupled mode region, high power transfer efficiency is achieved. Microstrip antennas are used because of its ease in design and array construction.

Gonçalo Dias, Pedro Pinho, Ricardo Gonçalves, Nuno Carvalho. 3D Antenna for Wireless Power Transmission. In this paper, a 3D antenna is used for wireless power transmission. For this, printing technology is adapted to develop a lens antenna for wireless power transfer operating at 20 GHz. The design, simulation and measurement of an aperture coupled microstrip antenna with dielectric lens.3D printers are useful for the development and rapid prototyping of dielectric structures for radiation manipulation and support of antennas.

Tianwei Wei, Jianwen Zhang, Xiaojun Yuan and Rui Zhang. Multi-antenna Constant Envelope Wireless Power Transfer. *978-1-5090-1328-9/16 ©2016 IEEE.* In this paper, the wireless power transfer in a multiuser multiple-input single-output (MISO) system, where a base station equipped with N antennas wirelessly transfers power to distributed single-antenna users is studied. To reduce the implementation cost, a constant-envelope analog beamforming scheme to simultaneously transfer power to multiple users which requires only a single radio frequency (RF) chain at the multi-antenna transmitter is used.

Prateek Kukreja, Croydyn Berly and Dr Usha Kiran. Wireless power transfer system using loop antenna and its gain enhancement using SRR metamaterial. *3rd International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics,978-1-5090-5434-3©2017 IEEE.* The goal is design and development of loop antenna and SRR(split ring resonators) metamaterial with desired specifications. Gain enhancement by metamaterial is demonstrated between transmitting and receiving antennas. The difference in this wireless power transfer technique and the others are that by using meta material, the energy is transferred more efficiently and over longer distance. Benefits -Wireless charging of mobile devices and pacemakers and charging of radio frequency tags (RFID) and allows greater versatility to electronic devices and comfort to users

Talha Ahmad, Ramy H. Gohary, Halim Yanikomeroglu, Saad Al-Ahmadi, and Gary Boudreau. Coordinated Port Selection and Beam Steering Optimization in a Multi-Cell Distributed Antenna System using Semi definite Relaxation. *IEEE transactions on wireless communications, vol. 11, no. 5, pages 1861-1871, May 2012*. In this paper, the Beam steering optimization in a multi-cell distributed antenna system using semi definite relaxation is obtained. Coordinated downlink transmission in a cellular system wherein each base station (BS) has multiple geographically dispersed antenna ports. The goal is to

maximize the minimum signal-to-interference-plus-noise ratio observed by the user. It is also shown that the proposed technique results in significant power savings when compared with other transmission strategies.

III. DESCRIPTION

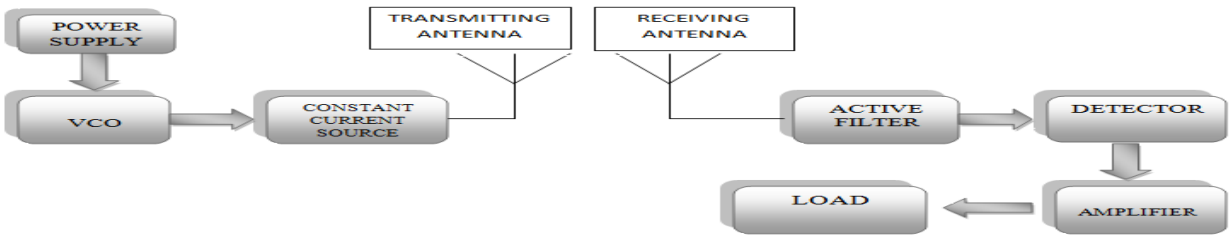

Fig 1. Block Diagram of the proposed system

The above figure shows the model of the proposed wireless power transmission system. In this paper, we have adopted the antenna method of power transmission for increased efficiency. The actual process of wireless power transfer using this antenna method is as shown in the figure and can be described as follows:

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert the electric current from a source to the correct voltage, current and frequency to power the load. A VCO or voltage controlled oscillator is an electronic oscillator whose oscillation frequency is controlled by a voltage input. The applied input voltage determines the instantaneous oscillation frequency. A VCO can also be used for frequency modulation (FM) or phase modulation (PM) by applying a modulating signal to the control input. VCOs can be of two types- linear or harmonic and relaxation oscillators. A current source is an electronic circuit that delivers or absorbs an electric current which is independent of the voltage across it. A current source is the dual of a voltage source. An independent current source delivers a constant current. A dependent current source delivers a current which is proportional to some other voltage or current in the circuit. A transmitting and receiving antenna is used to convert the electrical energy to electromagnetic energy and then transmit and vice versa. Both the transmitting and the receiving antennas can be of many types. Some of them are the log

periodic, monopole, dipole, helical, bow-tie, loop, log periodic dipole array, wire, Yagi- Uda, rectangular micro strip patch, planar inverted F-antenna, corner reflector, parabolic reflector antenna, etc. An active filter is a type of analog circuit implementing an electronic filter using active components, typically an amplifier. Amplifiers are used to improve the cost, performance and predictability of filter. Different types of filters can be used as per the requirement based on the application. An amplifier is an electronic device that can increase the power of a signal. An amplifier uses the electric power from a power supply to increase the amplitude of a signal. An amplifier is a circuit that has a power gain greater than one. A detector is an electronic component in a radio receiver that extracts information contained in a modulated radio wave, a demodulator. The detector is used to receive the audio signal information which was not available in the earlier devices. An electrical load is an electrical component or portion of a circuit that consumes the active electric power. This is opposed to a power source, such as battery or generator, which produces power in electric power circuits.

Microwave power transmission (MPT) is now the most efficient far field technique which allows power transmission for several kilometers in range. This method includes microwave frequencies from 1GHz up to 1000GHz. In microwaves and optical power transmission systems, the reception area can be shaped. This can be achieved through high directivity antennas in microwaves case and laser beams in optical systems case. This is why they can be used to transfer electric power wirelessly over long distances. Microwave power transfer begins with producing the microwaves by using a microwave generator. Generated radio waves then pass though Coax to Waveguide adapter to the waveguide circulator to isolate the microwaves generator and prevent detuning its desired frequency. Finally, microwaves are transmitted through antenna. At the receiver terminal, microwaves are received by a rectenna, then they pass through a low pass filter, to finally produce DC power. The filter filters out the unwanted high frequency components from the received signal at the receiving antenna end. Then, the detector detects the received signal and feeds it to the amplifier circuit. Here, we have used the voltage amplifier as the voltage received at the receiving antenna might be of low intensity due to losses and attenuation. Hence, the amplifier is responsible to improve the received voltage so that they can be used for the further applications as per the requirement.

For the microwave generator, devices that are called Microwave Vacuum Tubes are used to generate microwaves and they have several types including klystron, magnetron, and the Travelling Wave Tube (TWT). Magnetron is the most used device which generates microwave by passing electrons through magnetic field. Travelling Wave Tubes are too expensive and power limited, making it unsuitable for practical implementation of power transfer systems. Klystron is the best microwave generator for

WPT applications, but it is somewhat expensive. Magnetrons are efficient and cheap, but their output frequency is not precisely controllable as TWT or klystron. Using small magnetrons are advantageous because 300W to 1kW magnetrons are already mass produced for microwave ovens.

2.45GHz is practically the most efficient frequency to be used in microwave power transmission. For the transmitter antenna, micro strip patch, parabolic dish antennas and slotted wave guide are usually used. Due to its high efficiency, slotted wave guide is used in high power applications. Rectenna, which is used in microwave power receivers, stands for rectifying antenna. The rectenna is used to convert microwave energy to DC power. The basic rectenna consists of a dipole antenna and RF diode connected between the dipoles. The diode rectifies the received high-power microwave signal and delivers the rectified current to later stages for smoothing and controlling the output DC power delivered to the connected load.

As mentioned before, experiments showed that 2.45 GHz frequency achieves the best efficiency for the rectenna. Efficiency exceeding 95% has been realized for modern rectennas.

IV. APPLICATIONS

The wireless power transmission can be used in various applications such as the automatic wireless charging of mobile electronics in home, car, Wi-Fi hotspots, office, etc, while devices are in use and mobile, electric vehicle charging, aerial vehicles like SHARP, solar power satellites and more.

V. CONCLUSION

The main aim of this paper is to transfer the power wirelessly using the microwave power transmission. It can be concluded that it is extremely beneficial to the society if it is implemented in home electronics. There can be no power transmission in the system unless there is an input signal from the transmitting antenna. It is safer method of transmission for both humans and animals. This method offers an extremely efficient alternative to previous attempts at providing the wireless power.

VI. REFERENCES

[1] Akshya Swain, Dhafer Almakhles, Michael J Neath and Alireza Nasiri. Robust Control of Wireless Power Transfer System. *13th IEEE International Conference on Control & Automation (ICCA) July 3-6, 2017.*

[2] Chenxi Qiu, Ankur Sark6er and Haiying Shen. Power Distribution Scheduling for Electric Vehicles in Wireless Power Transfer Systems. *978-1-5090-6599-8/17 ©2017 IEEE.*

[3] Nurcan Keskin and Huaping Liu. Unit Antenna Based Wireless Power Transfer Systems. 2015 Electronic Components & Technology Conference, *978-1-4799-8609-5/15 ©2015 IEEE.*

[4] Manika la Nagababu, Karthik C Airani, Karthik K S, Shambulinga M. 4x4 Microstrip Antenna array for Wireless Power Transmission.*2015 International Conference on Applied and Theoretical Computing and Communication Technology, pages 719-722.*

[5] Gonçalo Dias, Pedro Pinho, Ricardo Gonçalves, Nuno Carvalho. 3D Antenna for Wireless Power Transmission.

[6]Tianwei Wei, Jianwen Zhang, Xiaojun Yuan and Rui Zhang. Multi-antenna Constant Envelope Wireless Power Transfer. *978-1-5090-1328-9/16 ©2016 IEEE.*

[7] Prateek Kukreja, Croydyn Berly and Dr Usha Kiran. Wireless power transfer system using loop antenna and its gain enhancement using SRR metamaterial. *3rd International Conference on Advances in Electrical, Electronics, Information, Communication and Bio- Informatics ,978-1-5090-5434-3©2017 IEEE.*

[8] Talha Ahmad, Ramy H. Gohary, Halim Yanikomeroglu, Saad Al-Ahmadi, and Gary Boudreau. Coordinated Port Selection and Beam Steering Optimization in a Multi-Cell Distributed Antenna System using Semi definite Relaxation. *IEEE transactions on wireless communications, vol. 11, no. 5, pages 1861-1871, May 2012.*

[9] Derrick Wing Kwan Ng, Ernest S. Lo and Robert Schober. Energy-Efficient Resource Allocation in OFDMA Systems with Large Numbers of Base Station Antennas. *IEEE transactions on wireless communications, vol. 11, no. 9, pages 3292-3304, September 2012.*

[10] Osama N. Alrabadi, Julien Perruisseau-Carrier, and Antonis Kalis. MIMO Transmission Using a Single RF Source: Theory and Antenna Design. *IEEE transactions on antennas and propagation, vol. 60, no. 2, pages 654-664, February 2012.*

[11] G.Vigneau, M.Cheikh, R.Benbouhout, S.Bouguern, and A.Takacs, "Power source evaluation of a wireless power transfer system," in *Proc. Of the IEEE Wireless Power Transfer (WPTC),* Jun.2014

[12] Y.Tanabe, *Member, IEEE,* T.Chang, *Student Member, IEEE*, Alexander.J.Yeh, and Ada S.Y.Poon, *Senior Member,IEEE.* A small Dual-band Asymmetric Dipole Antenna for 13.56MHz power and 2.45 GHz Data Transmission. *IEEE Antennas and Propagation Letters, Vol.14, 2014.*