Energy Efficient Wireless Charging for Multiple Devices

Anjaly Asokan[1], Arya C N[2], Sreedevi D S[3], Beena M Varghese[4]

[123]*Students, Department of Electrical and Electronics Engineering, M.A. College of Engineering, Kothamangalam, Kerala, India*

[4] *Associate Professor, Department of Electrical and Electronics Engineering, M.A. College of Engineering, Kothamangalam, Kerala, India*

Abstract – *Wireless Power Transfer (WPT) using Inductive Coupling, is one of the effective ways to transfer power between points without the use of conventional wire system. The world is advancing so the usage of WPT came into existence. Experiments are going so that the usage of wireless power can be done through all the home appliances thereby reduce the usage of wired technology. In this paper, an energy efficient wireless charging technique for multiple devices is devised and a feasible design using solar energy is modeled accordingly. Capacitive impedance matching networks are used to transfer power from single transmitter coil to multiple receiver coils. The most attractive part is that the transmitter coils are set up on a table, which can be installed anywhere like office, house etc. Various loads like mobile phone, laptop, wireless mouse etc. placed on the table, start to charge automatically without connectors or cables.*

Key Words: Wireless Power Transfer (WPT), Inductive Coupling, Impedance matching networks (IMN).

1. INTRODUCTION

Over a century ago, early pioneers of wireless power such as M. Hutin and M. Leblanc showed that wireless power and resonance techniques could be applied to traction systems and in 1897, Nicola Tesla successfully demonstrated the use of a pair of coils for wireless power transfer, in which a lighting device is wirelessly powered via a pair of coils. In fact, Tesla has pioneered both non radiative wireless power via near field magnetically coupled coils and radiative wireless power transfer techniques via high-tension Tesla coils. Nonradiative wireless power transfer relies on the near-field magnetic coupling of conductive loops. Energy is transferred over a relatively short distance, which is of the order of the dimension of the coupled coils [1]. In recent years, there has been increasing interest in research and development of wireless power technology to eliminate the last cable after Wi-Fi becomes widely accepted. Now imagine placing your mobile phone on a table, where it starts to charge automatically without connectors [2]. It would be even better if you can charge multiple devices simultaneously from a single transmitter. Impedance matching networks are essential for increasing power transfer efficiency in WPT using magnetic fields. One important feature of magnetic resonance using capacitive IMN is that multiple devices can be simultaneously charged by single transmitting coil [3]. Renewable energy sources in nature are regenerative or inexhaustible. So for the energy efficient design, solar energy is used as the prime source. Wireless power transfer is not much affected by placing hurdles like books, hands and plastic between transmitter and receiver coils [4].

2. METHODOLOGY

In this system, solar energy is used as the main source. Solar energy is converted into electric energy by a solar panel. A battery is charged by using this energy. It supplies energy to the transmitter circuit, microcontrollers etc.

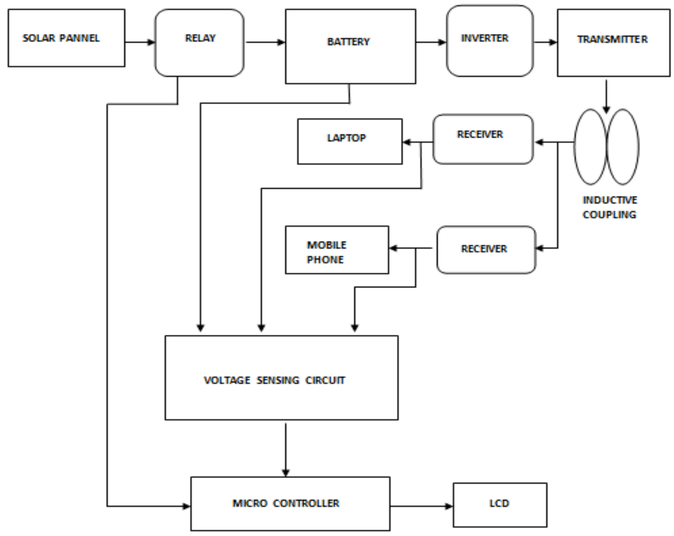

Fig -1: Block Diagram of energy efficient wireless charging system

A relay is connected in between solar panel and battery in order to control the charging of battery. The transmitter circuit includes capacitor impedance matching circuits so that many receiver loads can receive power from a single transmitter using inductive coupling. An inverter circuit with high switching frequency switches is used to convert DC into AC. Transformer steps up the AC voltage. Inductive coupling is employed using two coils with non radiative type wireless power transfer. Loads can be wireless mouse, laptops and mobile phones. Rectifier is used at the receiver end for converting AC into DC. The main attractive feature of this design is that it can charge both low power and high power devices simultaneously. Relay control, load control and display functions are done by the microcontroller. A 16*2 alphanumeric LCD display is also used to display load voltages, battery voltage and various warnings to the users.

2.1 Simulation

In this work, we have used Proteus software which combines advanced schematic capture, mixed mode SPICE simulation, PCB layout and auto routing to make a complete electronics design system.

2.1.1 Transmitter circuit

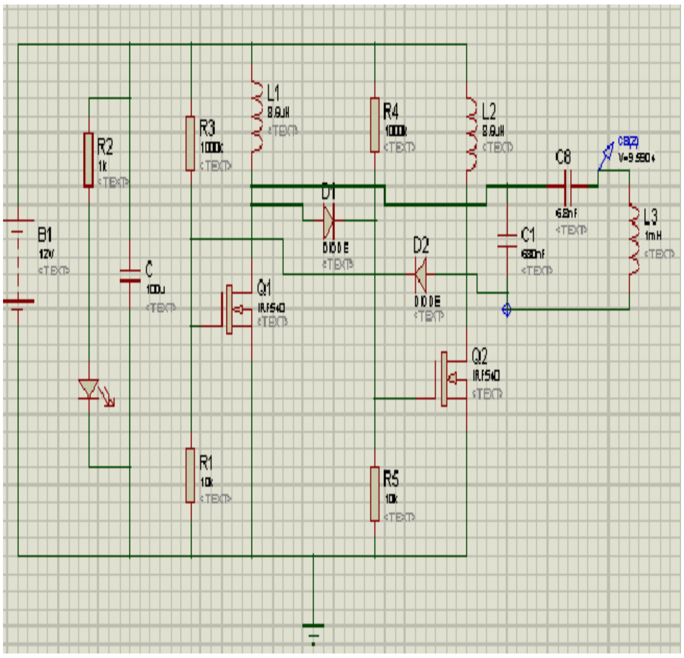

Fig -2: Simulated transmitter circuit using proteus software

It can be seen that a voltage of 9.55V is obtained across the transmitter coil from a 12V battery. Efficiency is about 80%.

2.1.2 Relay Interfacing

Relay is connected between solar panel and battery for the connection and disconnection of battery from solar panel. The overcharging and under discharging of battery is not preferable. If the battery voltage comes above 12V, then the battery is disconnected from the solar panel. And if it comes down 12V, battery will be connected to solar panel. The working of relay is controlled by a microcontroller.

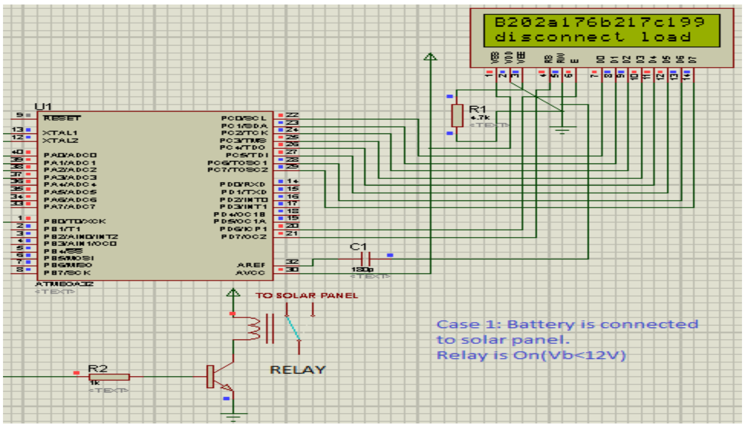

Fig -3: Simulation result for battery connected to solar panel.

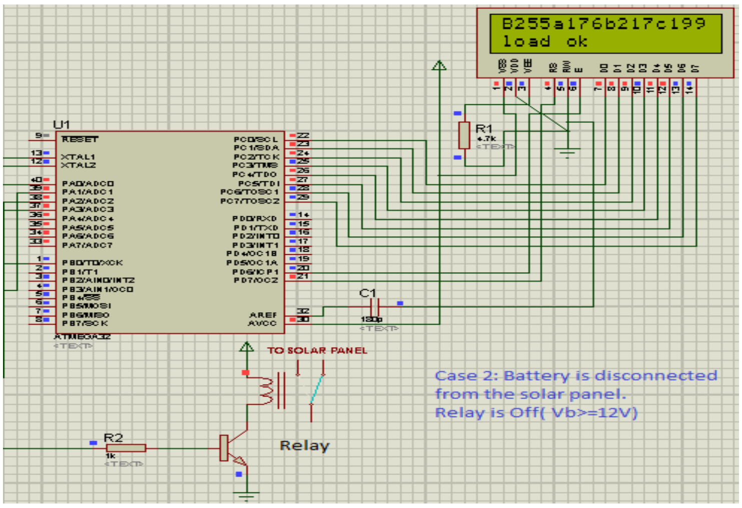

Fig -4: Simulation result for battery disconnected from solar panel.

Load voltages and battery voltages are measured and given to the ADC pins of microcontroller. These values will be displayed on the LCD screen. Various instructions are given to users based on the availability of sources. If battery voltage is not sufficient to power the loads, then it is displayed to 'disconnect load' as in fig-3 and else, it is displayed that the 'load is ok' as in fig-4.

3. OUTCOMES

3.1 Experimental Setup

Mobile phone and laptop are the loads chosen for experimental purpose. The charging voltage and current of a laptop is 19.5V and 3.33A respectively whereas for a mobile phone it is about 4V and 1A respectively. The output voltage varies with distance between the transmitter and receiver coils.

Fig -5: Experimental setup for mobile phone charging

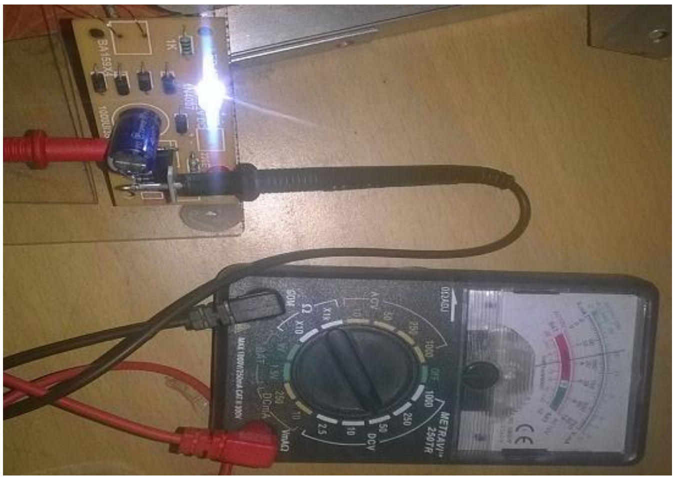

Fig -6: Experimental setup for laptop charging

Instead of laptop, multimeter is used for measuring voltage. Because for laptop, it is mandatory to give correct voltage, otherwise system got damaged.

3.2 Voltage Variation with distance between coils

Table -1: Voltage Variation with distance between coils for laptop and mobile phone charging.

Distance(cm)	Voltage obtained for laptop (V)	Voltage obtained for mobile phone (V)
1	19	5
2	14	5
3	10	5
4	5	4
5	2	3
6	1	2
7	0	1
8	0	0.5

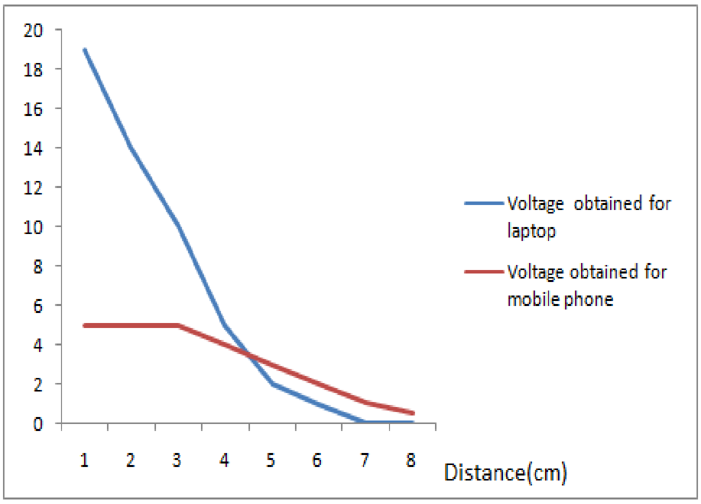

Chart -1: Voltage Variation with distance between coils for laptop and mobile phone charging.

From the chart, it is clear that voltage varies with distance. So in order to obtain more voltage at large distance, the coil dimensions has to be increased.

3. CONCLUSIONS

The main purpose of our work was to design an energy efficient charging wireless power transfer technology for multiple devices. The solar energy was used as primary source and a battery backup was also provided. With this system, a maximum efficiency of 80% can be obtained at a distance of 0.5cm with a transmitter of having 11 cm diameter and 35 numbers of turns and receiver coils of 9 cm diameter and 30 numbers of turns. This efficiency can be increased by increasing number of turns and coil diameter.

We were able to charge a laptop and mobile phone simultaneously from a single transmitter coil using capacitive impedance matching networks. Parallel-Series (PS) IMNs are used at both transmitter and receiver circuits because using a PS IMN at an receiver is more effective than using a Series-Parallel IMN for reducing the influence of the cross coupling between the neighboring receiver coils.

The efficiency of solar panel can be increased by maximum power point tracking (MPPT) technique implementation using stepper motor rotating mechanism of solar panel.

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BIOGRAPHIES

Anjaly Asokan is a B.Tech student of Electrical and Electronics Engineering Department of M.A.College of Engineering, Kothamangalam, affiliated to Mahatma Gandhi University, Kottayam, Kerala, India.

Arya C N is a B.Tech student of Electrical and Electronics Engineering Department of M.A.College of Engineering, Kothamangalam, affiliated to Mahatma Gandhi University, Kottayam, Kerala, India.

Sreedevi D S is a B.Tech student of Electrical and Electronics Engineering Department of M.A.College of Engineering, Kothamangalam, affiliated to Mahatma Gandhi University, Kottayam, Kerala, India

Beena M Varghese is an associate professor of Electrical and Electronics Engineering Department of M.A.College of Engineering, Kothamangalam, affiliated to Mahatma Gandhi University, Kottayam, Kerala, India. She is a ISTE life member and had her M.E. in control systems at P.S.G, Coimbatore.