WIRELESS CHARGING SYSTEM FOR SMARTPHONE

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Abstract: This paper presents a wireless charging system for cellphones that makes use of a specially constructed circuit, a transmitter coil, and a receiver coil. This clever device effectively provides 12.5 watts of power, making it possible to quickly and easily charge smartphones. The technology makes charging easier for users, lessens wear on charging ports, and does away with the need for physical wires and connectors. We explore the design of the system, focusing on circuitry and coil designs, and we also cover critical issues like compatibility with different smartphone models, safety, and power efficiency. This wireless charging system is a potential development in smartphone charging, meeting the growing need for practical, sustainable, and effective power sources for a society that is becoming more and more digitally and mobile.

Introduction: In the current world, electricity is a necessity. It would be quite challenging to survive without electricity given the sheer amount of appliances we use. The electrical power is typically carried from one location to another using wires or cables. But in recent years, a technology known as wireless power transfer (WPT) has arisen that allows electrical power to be delivered wirelessly from one location to another. The primary goal of WPT is to do away with the unsafe utilization of wires while also making it simpler to organize power cords. As an illustration, battery power is typically required by portable electronic devices such as smartphones, tablets, laptops, drones, and home robots. These portable devices are becoming a regular part of our daily lives as a result of their quick growth and the vast array of uses. Additionally, there is a growing need for smart devices that can charge wirelessly, doing away with the need for cords. There is a need to develop new technology, as a result, to do away with cumbersome wires and charges [1] - [3].. The coil's limited potential prevented it from being a useful application for wireless electricity transfer because it could only transmit electricity wirelessly over small distances [4]. It is also possible to use RF technology, which uses radio waves to transfer electricity. Federal Communications Commission (FCC) laws limit it to a 5 W transmitter and, once again, it can interfere with other RF devices. The power transmitted to the receiving end is restricted to the mW range due to this power constraint on the transmitter [5]. Energy can be securely and wirelessly transferred using magnetic coupling. It does not require line of sight conditions and does not transmit RF or IR signals. This technique is the preferred option for wireless power transfer due to its advantages. At the Massachusetts Institute of Technology, The 60W of energy that Marin Soljai was able to successfully transmit over a 2 m distance [6]. It becomes crucial to periodically recharge the gadgets with the aid of wired chargers in case of natural disasters like cyclones, earthquakes, and so forth. Is there any way to wirelessly transfer power from one mobile phone to another in that situation? In their research, Keerthana and Pragadeshwar addressed this issue by allowing for the simple transfer of power via magnetic coupling between two smartphones [7]. In an emergency, this could be quite helpful. Power can be transmitted using inductive coupling (short-range), resonant induction (mid-range), and electromagnetic wave transmission (long-range) can be used to transfer power. This project's goal was to fast and effectively charge a low-power gadget via inductive coupling [8]. Pravin suggested efficient and less time-consuming microwave power transmission techniques for charging mobile devices in his project [9]. Louis Paul et al emphasized the need for designing a model for WPT and charging the battery to eliminate all the hassles with today's battery technology [10]. Sultana proposed a method named inductive coupling by placing WPT circuitry inside the vehicles [11]. Mou discussed the unsolved WPT research problems in his work and also offers the prospect of simultaneously charging several devices with wireless power transfer soon [12]. The present study offers a thorough investigation of the major variables affecting wireless power transfer in smartphone charging systems. In this project:

1. We've carefully designed our transmitter and receiver to maximize their capabilities. A powerful magnetic field is produced by the transmitter, and maximum power reception with great efficiency is the goal of the receiver's construction. Because of the way our design is made, only one phase of the electromagnetic wave interacts with both coils most of the time, optimizing energy transfer and coupling efficiency.

Methodology: In the wireless smartphone charging system (WSCS), the design of the coil is a crucial factor for optimizing power transfer to the recipient. This paper selects Resonant Power Transfer (RPT) as an effective model for WSCS. To enable high-frequency operation, the coil has been meticulously designed and simulated using ANSYS Electronic Desktop shown in fig.1. While the transmitter coil remains stationary, adjustments in both horizontal and vertical positions are made to the receiver coil. These coils are utilized in creating a resonant circuit tailored to this purpose. The evaluation of power and efficiency is conducted from the receiver's perspective.

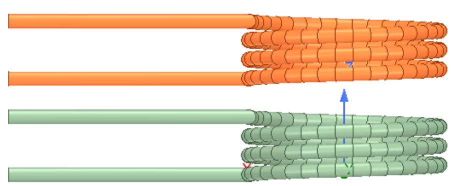

Fig. 1 : Transmitter and Receiver Coil Design

Different shapes of coil are used in WSCS systems. The circular coil is the most effective structure in high-frequency than rectangular or other shapes of coil wireless transfers system as there are no sharp edges. So, the eddy current is kept to as low as possible than other shapes. Considering high-frequency operation, the coil has been designed to meet the operating condition. All the coil parameters shown in Table 1.

Table 1: Coil Specification

Name	Transmitter Coil	Receiver Coil
number of turns, N	3	3
segments per turn	36	36
wire radius	0.5mm	0.5mm
coil radius	40mm	40mm

From this coil design, value of L1, L2 and M has been found shown in Table 2. Using the value of M,

Table 2: Coil Design Findings

Parameters	Value
L_1	1.3215 uH
L_2	1.31607 uH
M	216.4499 nH
C_1	3.482 nF
C_2	3.496 nF

resonant frequency (f_o) has been found by equation (1) . An equivalent circuit of the RPT system has been shown in Fig. 2. C_1 and C_2 are resonant capacitors of the transmitting pad and receiving pad respectively found by equation (2). R_1 and R_2 are the resistance of the transmitting and receiving coil which are caused by the length of the wire. The circuit simulation has been done in Ansys Twin Builder simultaneously. In this work, series-series(S-S) compensation network has been used. The resonant frequency is set to 2.346 MHz. As the circuit operates at resonant frequency, it will satisfy the equations.

$$M=\sqrt{\frac{(R_S+R_1)(R_{2+}R_L)}{w_o}} \ldots\ldots\ldots\ldots\ldots(1)$$

$$W=\frac{1}{\sqrt{L_1C_1}}=\frac{1}{\sqrt{L_2C_2}} \ldots\ldots\ldots\ldots\ldots(2)$$

$$R_1=R_2=\frac{\rho L}{A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$K=\frac{M}{\sqrt{L_1L_2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

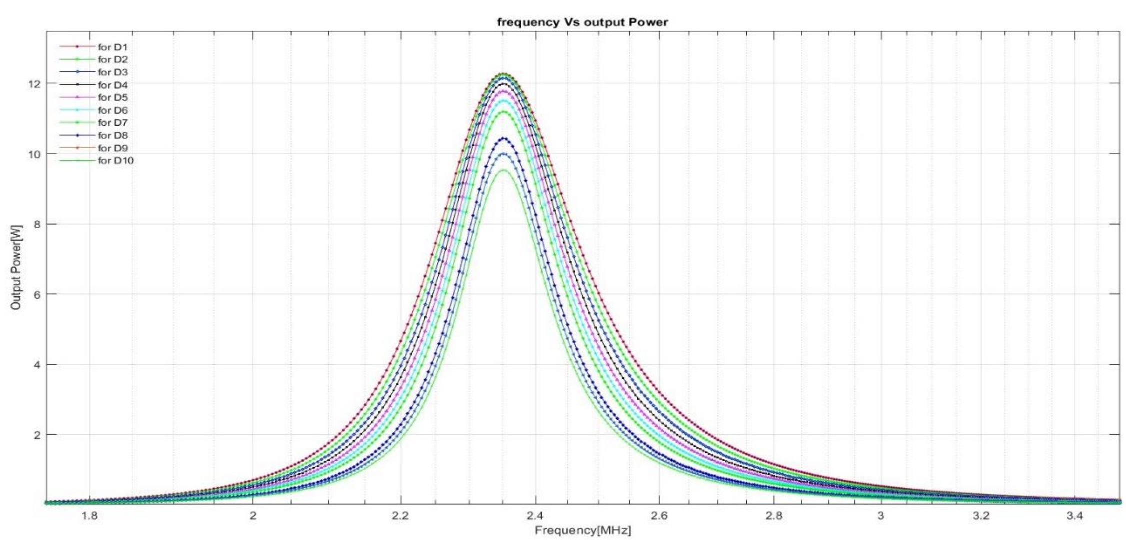

Fig.2: Frequency vs output power

Considering operating frequency, the Value of the compensating capacitor has been found in equation (2) shown in the table. Meanwhile resistance of the coil has been calculated from equation (3). Equation.(5) & (6) is the basic equation for the transmitter and receiver side. From these equations, it can be said that input and output currents are highly dependent on mutual inductance(M) or coupling coefficient(K) which can be measured from eq.(4).

$$(R_s+R_1+jwL_1+1/jwc_1)I_1-jwMI_2 = V_s \quad \text{......................}(5)$$

$$(R_2+R_L+jwL_2+1/jwc_2) = jwMI_1 \quad \text{........................} (6)$$

Considering the resonant condition, there will be no impact on the reactance of the capacitor and inductor. In resonant frequency, maximum power at the output side can be achieved because of minimum loss at the circuit. The output curve shown in figure 2.

Results: The designed transmitter coil and receiver coil, along with the integrated circuit, have successfully achieved a maximum power output of 12.5 watts at the resonant frequency of 2.34625 MHz for the smartphone charging system. This accomplishment was made possible through the implementation of a series-series compensation network, which played a crucial role in optimizing the energy transfer efficiency. The achieved power output and resonant frequency underscore the effectiveness of the wireless charging system, offering a promising and practical solution for charging smartphones and other portable electronic devices. This result holds significant potential for enhancing user convenience and reducing the reliance on traditional wired charging methods, contributing to the advancement of wireless power transfer technology.