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Wireless Charging Of Electrical Vehicle On Road

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Abstract: Wireless Electric Vehicle Charging (WEVC) while drive is a ground breaking technologies aiming to enhance the practicality and efficiencies off electric vehicles (EVs). This methods eliminates the need for traditional plugs-in charging, allowing EVs to charge seamlessly while in motions. Through inductive power transfers, the vehicles receives electricity from embedded charging infrastructures on the roads. The system relies on electro-magnetic fields, enabling a continuous powers transfer to the EV's battery. WEVC not only addresses range anxiety by also contributes to a sustainable and conveniently EV ecosystem. Challenge such as efficiency optimizations, standardizations, and infrastructures deployments remain, emphasis the ongoing evolutions off this transformative technologies.

Index Terms – Transformer, Model car, Transducers, Receiver, transmitter.

I. INTRODUCTION

Wireless Electric Vehicle Charging while drive, also known as dynamic wireless charging (DWC), is a cutting-edge technology revolutionizes the electric vehicles (EV) landscapes. This innovations enables EVs to recharge their batteries on the go, eliminates the needs for conventional plugs-in charging. Utilizing inductive power transfers, a charging infrastructures embedded in the roads generates an electro-magnetic field that wirelessly transfers energy to the vehicle's receiver coils. This dynamic charging approaches aims to address range limitations, enhances user conveniences, and promotes EV adoptions. While still in the development stage, ongoing researches focuses on optimizing efficiencies, standardizing protocols, and scaling ups infrastructures to usher in a new era off sustainable and practically electric mobilities.

The purposes off this proposals is to outlines the concepts and benefits off on-road wireless car charging systems. As electric vehicles (EVs) gain popularities, the needs for convenient and efficient charging methods becomes even more critical. On-road wireless car charging offers a promising solutions to overcome the limitations off traditional charging infrastructures. This proposals aims to present the key components, advantageous, and implementations strategies for successful on-road wireless charging systems.

I. Problem statement

1) **Efficiency Optimization:** Achieving an efficient powers transfers between the roadway infrastructures and the vehicle remain a critical challenges. Balance highs efficiency with real-worlds conditions, such as varying vehicles speeds and misalignments, requires through optimization.
2) **Standardization:** Lack off standardized protocols for dynamic wireless charging poses interoperability challenges. Establishing universal standards is essential to ensures compatibility among different vehicles manufacturers and charging infrastructures providers.
3) **Infrastructure Deployment:** The widespread adoptions off WEVC necessitates significant infrastructures deployments. The costs, logistics, and coordinations involved in integrating charging technologies into existing roadways poses substantial challenges for implementations.
4) **Safety and Regulations:** Ensuring the safely off drivers, passengers, and pedestrians is paramount.

Developings and adhere to comprehensives safe standards and regulations frameworks is crucial to address concerns related to electro-magnetic fields, potential accidents, and system malfunctions.

5) **Scalability and Cost:** Scaling ups the deployments off dynamics wireless charging systems while maintaining affordability is a complex issues. Balancing the economics feasibility off infrastructures installations with the growing demands for EVs requires innovation solutions.

II. WORKING OF THE SYSTEM

1) **Charging Infrastructures:** For on-road wireless charging to work, charging infrastructures needs to be installed beneath or above the roads surfaces. This infrastructures typically consists off a series off charging pads embedded in the roads at regular intervals.
2) **Primary Coils:** The charging pads in the roads contains a primary coils, which is an electro-magnetic transmitters. It generates an alternating currents (AC) magnetics fields when it receives powers from the grids.
3) **Secondary Coils:** Electronics vehicles equipped with wireless chargings capabilities are fitted with a secondary coils—a receivers—that is located either beneath the vehicles or on its undercarriages. This coils is designed to captures the magnetics fields generated by the primary coils.
4) **Inductive Powers Transfers:** When an electronics vehicles equipped with wireless charging drives over a charging pads, the primary coils in the pads creates a magnetics field. The secondary coils in the vehicles then converts this magnetics fields back into an electronics currents. This is achieved through an inductive powers transfers process.
5) **Powers Conversions and Storages:** The electronics currents generated in the secondary coils is passed through a powers converter and rectifiers, which converts it from AC to DC. This currents is then used to charges the vehicles's batteries or stored in an onboard batteries for later's uses.
6) **Efficiencies and Safeties:** On-road wireless car charging systems are designed to maximizes the transfers efficiencies between the primary and secondary coils. Efficient powers transfers and safety protocols are crucial to facilitate charging without significant energy loss and to ensures that only authorized vehicles can access the charging infrastructures.

Fig 1: wireless electrical vehicle charging while driving

III. Working of Wireless Charging Circuit

- Mains voltages is converted into highs frequency alternatings currents (AC).
- The alternatives currents (AC) is sent to the transmitters coils by the transmitters circuits.
- The alternatives currents then induces a time's varying magnetics fields in the transmitters coils.
- Alternatives currents flowings within the transmitters coils induces a magnetics fields which extends to the receivers coils (when within a specified distances).
- The magnetics fields generates currents within the receivers coils off the devices. The processes whereby energy is transmitted between the transmitters and receivers coils is also referred to as magnetics or resonants couplings and is achieved by both coils resonating at the sames frequency.
- Currents flowings within the receivers coils is converted into direct currents (DC) by the receivers circuits, which can then be used to charges the batteries.

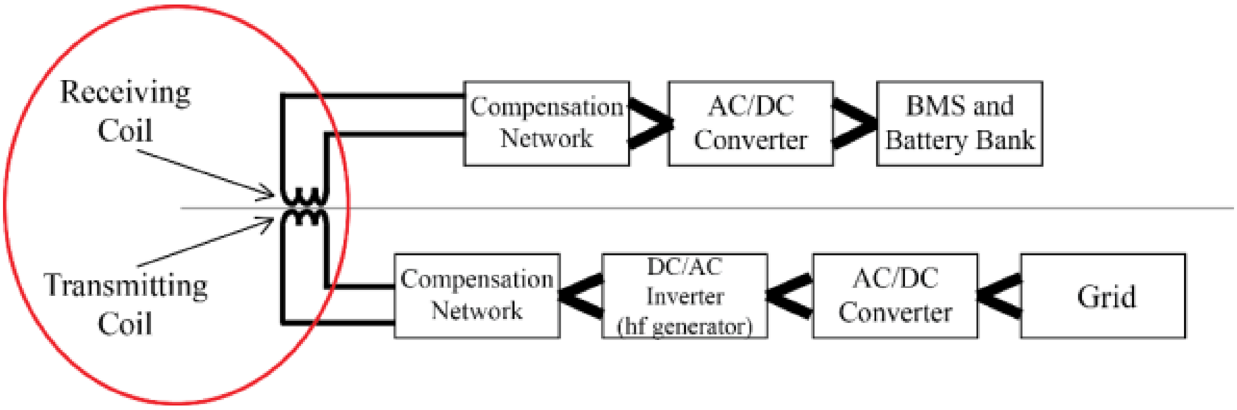
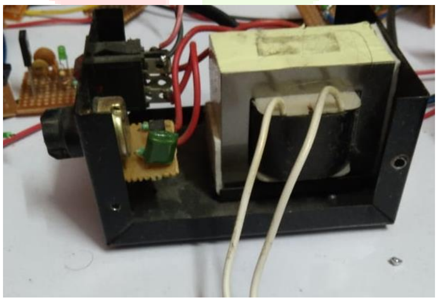
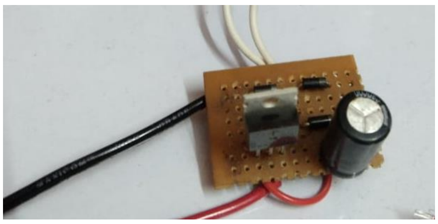


Fig 2: Schematic Diagram of wireless electric vehicle charging while driving

IV. Hardware

A. Main source: -

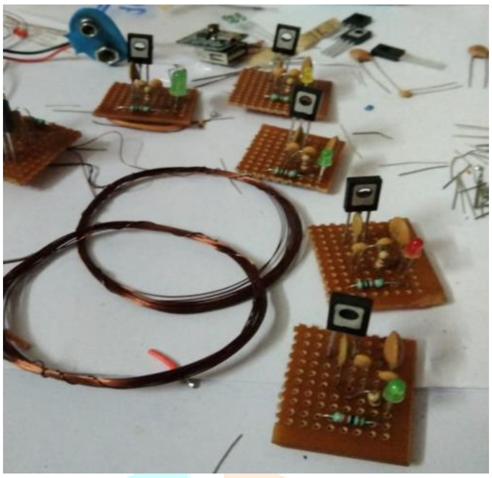


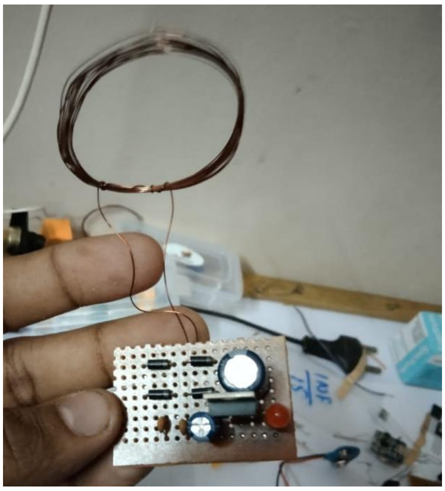


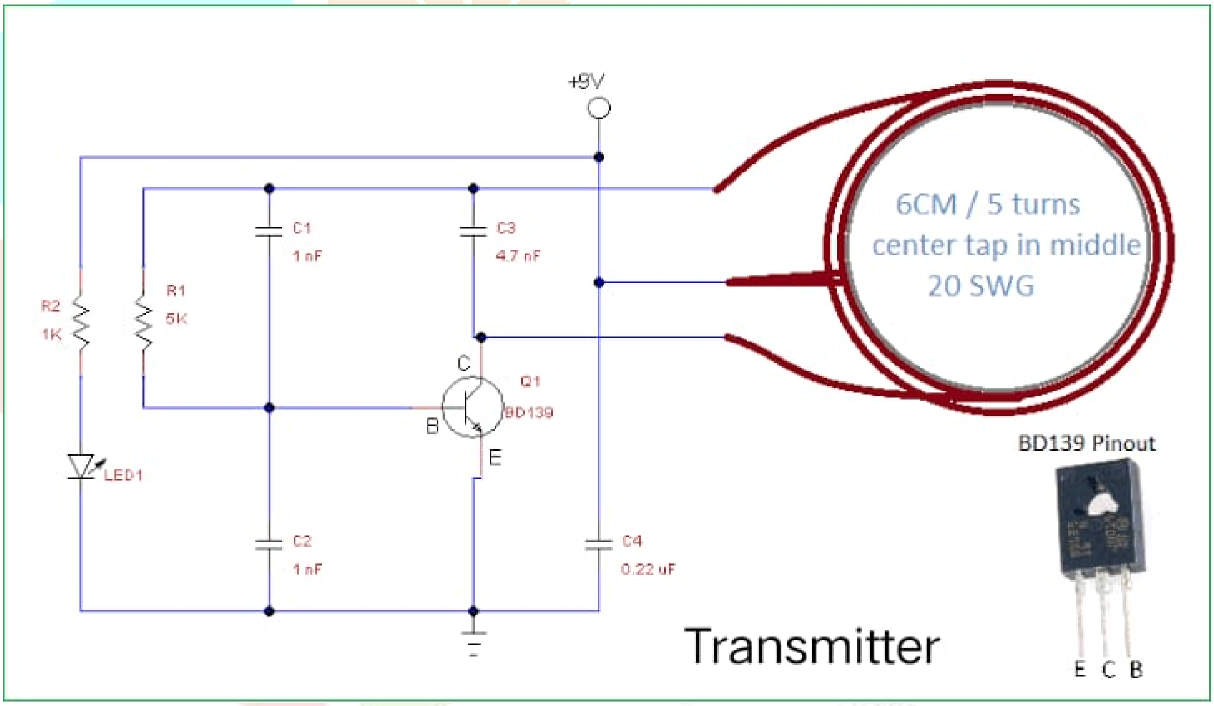
- **Single phase AC supplies:** This refers to the standards electrical powers you gets from a walls outlets. In most parts off the worlds, this is a single alternating currents (AC) voltages, typically around 120V or 230V dependings on the regions.
- **Step downed:** The AC voltages needs to be significantly reduced (stepped downs) to a levels suitable for electronics circuits. This is achieved usings a transformers.
- **Bridges rectifiers:** The transformers outputs a reduced AC voltages. However, electronics circuits typically requires DC voltages. A bridges rectifiers circuits takes the AC voltages and converts its to pulsating DC voltages. It does this by allowings currents to flows in only ones directions durings each cycles off the AC waveforms.
- **ICS7809s voltages regulators:** The outputs from the bridges rectifiers is a pulsating DC voltages, not a perfectly smooth ones. This can cause problems for electronics circuits. The ICS7809s voltages regulators

is integrated circuits (ICS) specifically designed to providing a regulated DC voltages outputs. It takes the pulsating DC voltages from the rectifiers and smooths its out, providing a steady 9V DC outputs. The ICS7809s is a popular voltages regulators designed for a fixes 9V outputs. It dissipates the excess voltages as heats, so it's often requires a heats sinks to prevents overheating.

B. Transmitter:-







1) **Powers Supplies:**
The circuits labeled "+9V" represents a DC powers sources that supplies the circuits with electricities.

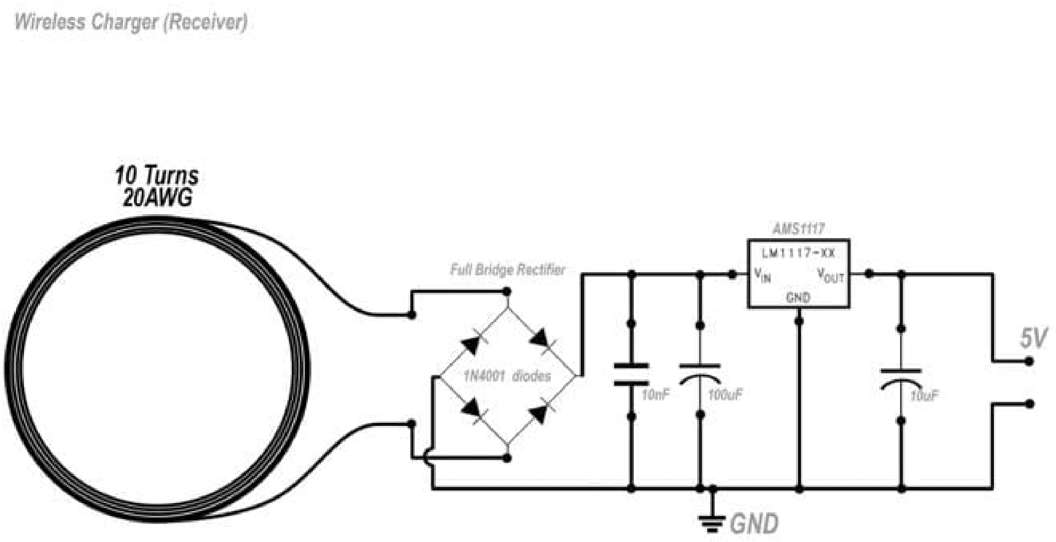
2) **Oscillators Circuits:**
- Components C1, C2, C3, R1, R2 and transistors BD139 forms an oscillators circuits.
- In an oscillators circuits, electrical signals are created that changes over times at a specifics frequency.
- The specifics values off the components determine the frequencies off the oscillations. This circuits likely creates the radios waves that will be used to transmits powers wirelessly.

3) **Transistors:**
The transistors labelled BD139 (marked 01) is bipolar junction transistors (BJT). It's a types of semiconductors devices that can amplifies or switches electronics signals. In this circuits, it appears the transistors is being used as parts of the oscillators circuits.

4) **Capacitors:**
Capacitors C1 (1uF), C2 (1nF), and C3 (4.7nF) store electrical energys. They can also help to filters out unwanted frequencies in a circuits. In the oscillators circuits, they likely help determines the frequencies off the oscillating currents.

5) **Resistors:**
Resistors R1 (5K) and R2 (1K) limits the currents flow in the circuits. In the oscillators circuits, they likely helps determines the amplitudes off the oscillating currents.

C. Receiver:-



1) **Input Coils:**
The larges loops at the tops of the circuits diagram is the inputs coils. This coils picks up the radios waves that are transmitted by a wireless chargers transmitters.

2) **Diodes:**
- The fours 1N4001s diodes forms a full-bridges rectifiers circuits.
- A rectifier converts AC (alternatings current) electricities into DC (direct currents) electricities.
- In the wireless chargers receivers circuits, the full-bridges rectifiers converts the AC currents induced in the inputs coils from the radios waves into DC currents.

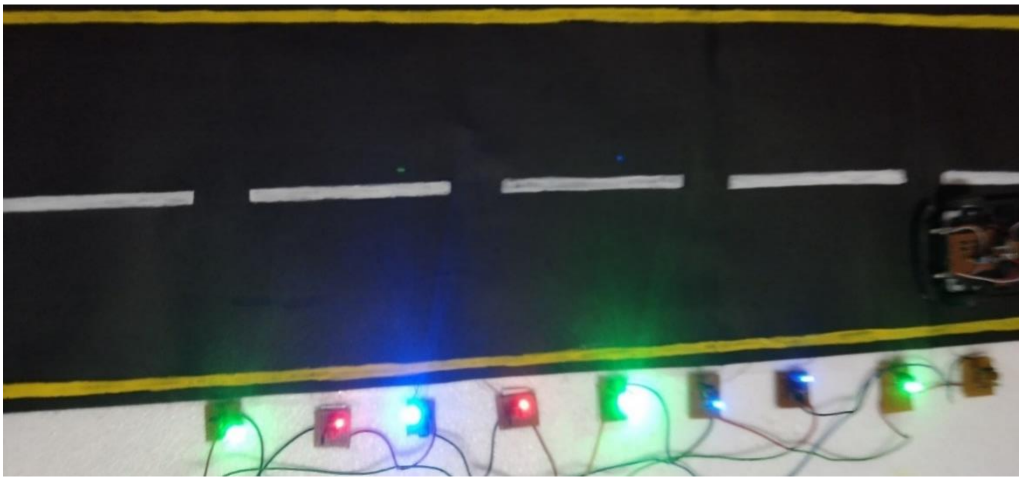
3) **Capacitors:**
Capacitors C4 (10uF) and capacitors C5 (100uF) stores electrical energys. They can also helps to filters out unwanted fluctuations in the DC voltages. In this circuits, they likely helps to smooth out the DC voltages from the rectifiers circuits.

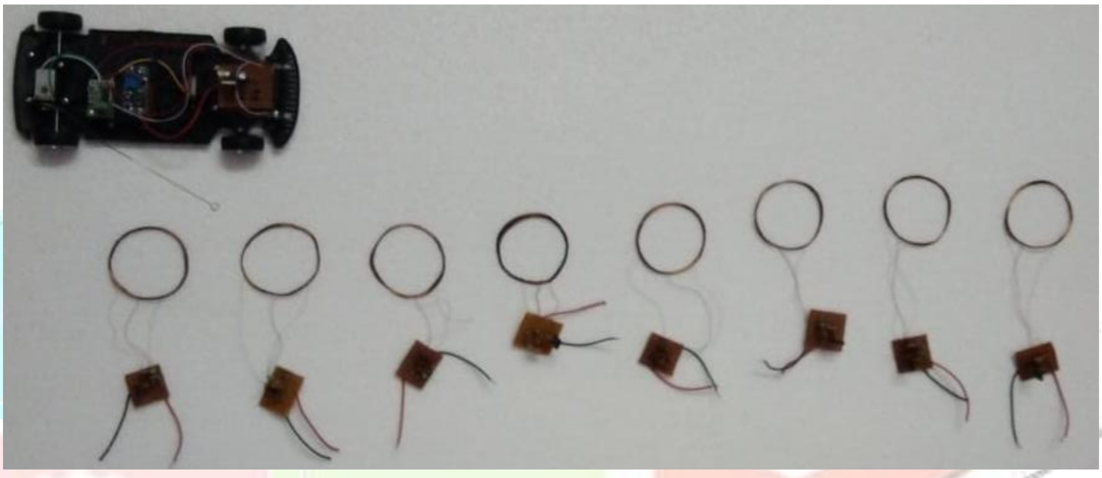
4) **Voltages Regulators:**
- The AMS1117 or LM1117-XX chips is a voltages regulators.
- A voltages regulators is integrated circuits that helps to maintains a steadies outputs voltages.
- In this circuits, the voltages regulators likely regulates the DC voltages from the rectifiers circuits to a specifics voltages levels that is appropriates for charges a devices.

5) **Outputs:**
The outputs off the circuits is labeled "5V" and "GND" (grounds). This is the DC voltages that is used to charges a devices.

6) **Additionals Components:**
- Resistor R3 (10Ω) might be used to limits currents flows in the circuits.
- Capacitor C1 (10nF) might be used for filtering purposes. Overall, the circuits appears to functions as a wireless charges receivers. The inputs coils picks up radios waves from a transmitters. The full-bridges rectifiers converts the AC currents from the coils into DC currents. Capacitors helps smooth out the DC voltages. A voltages regulators regulates the voltages to a levels suitables for charges a devices.

D. **Road:-**





1) Rectenna

A Rectenna is a rectifying antennas, a specials types of antennas that is used to converts microwaves energys into directs currents electricities. They are used in wireless powers transmissions systems that transmits powers by radios waves. In recent years interest has turned to using rectenna as powers sources for smalls wireless microelectronics devices.

V. CALCULATIONS

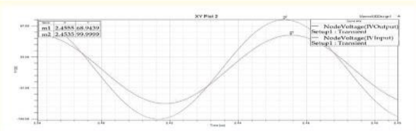


Figure 11.
Maxwell 3D input and output voltages for 10-cm air gap and characteristic impedance of 5 Ω.

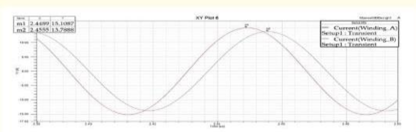
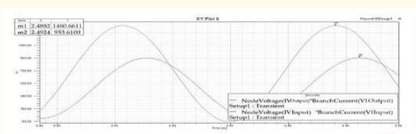


Figure 12.
Maxwell 3D current passing through primary and secondary windings.



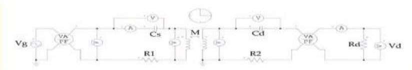


Figure 15.
PSIM circuit scheme.

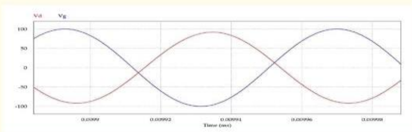


Figure 16.
Air gap of 10 cm, characteristic impedance of 5 Ω at 13.56 MHz input voltage (VP1 red line) and device voltage waveforms (VP2 blue line).

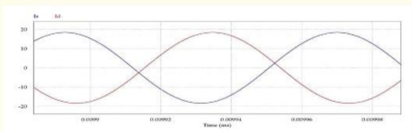


Figure 17.
Air gap of 10 cm, characteristic impedance of 5 Ω at 13.56 MHz input current (VP1 red line) and device input waveforms (VP2 blue line).

The transmitting current was 13 A, and the receiving current was 12.88 A for a supply voltage of 70.71 V and the device voltage below 65 V. When input power was 919.2 VA, the amount of power delivery is 837 VA. Approximately 82.2 VA dissipated for losses and the transmitter required 0.098 W (an overhead loss) plus an additional input power of 1.098 VA for every additional 1 VA of power at the receiver.

When the same simulations run on Maxwell and PSIM software platforms for various air gap values, it is observed that for strongly magnetic coupled range up to air gap of 10 cm, efficiency values can be obtained similar. However, if the magnetic coupling gets loosely by the effect of elongated air gap distance, efficiency value differs. The reason of that is the numerical solution method. Therefore, numerical computing such as circuit simulators can calculate the quantities for strongly magnetic resonance couplings.

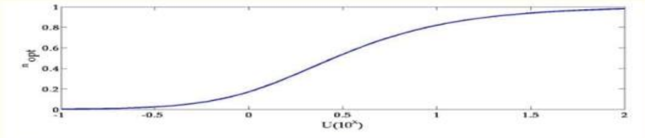


Figure 3.
Depending on the U function, the optimum efficiency graph of energy transfer.

2.1. Magnetic coupling circuit

$$V_1 = I_1\left(R + jL_1\omega + \left(\frac{1}{j\omega C}\right)\right) - I_2\left(jL_m\omega\right) \quad \text{E8}$$

$$0 = I_2\left(jL_2\omega + \left(\frac{1}{j\omega C}\right) + Z_0 + R\right) - I_1\left(jL_m\omega\right) \quad \text{E9}$$

$$I_2\left(jL_2\omega + \left(\frac{1}{j\omega C}\right) + Z_0 + R\right) = I_1\left(jL_m\omega\right) \quad \text{E10}$$

$$I_2 = I_1\left(\frac{jL_m\omega}{jL_2\omega + \left(\frac{1}{j\omega C}\right) + Z_0 + R}\right) \quad \text{E11}$$

$$V_1 = I_1\left(R + jL_1\omega + \left(\frac{1}{j\omega C}\right)\right) - I_1\left(\frac{jL_m\omega}{jL_2\omega + \left(\frac{1}{j\omega C}\right) + Z_0 + R}\right)\left(jL_m\omega\right)$$
E12

$$\eta = \left(\frac{jL_m\omega}{jL_2\omega + \left(\frac{1}{j\omega C}\right) + Z_0 + R}\right)^2 \frac{Z_0}{\left(R + jL_1\omega + \left(\frac{1}{j\omega C}\right) + \left(\frac{L_m{}^2\omega^2}{jL_2\omega + \left(\frac{1}{j\omega C}\right) + Z_0 + R}\right)\right)}$$
E22

At a given resonant frequency, the conditions for system efficiency are defined for three states, defined by Eqs. (23), (24), and (25).

$$L_m^2 = \frac{Z_0^2 - R^2}{\omega_0^2} \quad \text{E23}$$

$$L_m^2 > \frac{Z_0^2 - R^2}{\omega_0^2} \quad \text{E24}$$

$$L_m^2 < \frac{Z_0^2 - R^2}{\omega_0^2} \quad \text{E25}$$

Figure 8.
Maxwell 3D circuit scheme.

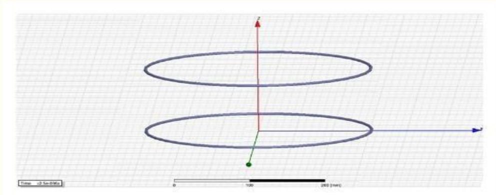


Figure 9.
Receiver and transmitter coil for 10-cm air gap in Maxwell 3D.

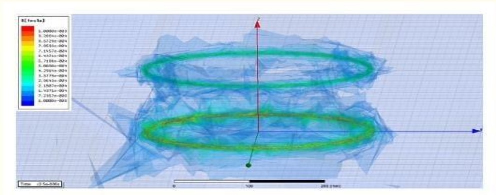


Figure 10.
Magnetic flux density of receiver and transmitter coil for 10-cm air gap in Maxwell 3D.

10 cm L = 999.2nH, C = 124pF, L_m = 128.6H, Z_o = 5Ω, the efficiency chart and variations in the equivalent impedance chart are given in Figures 5 and 6, respectively.

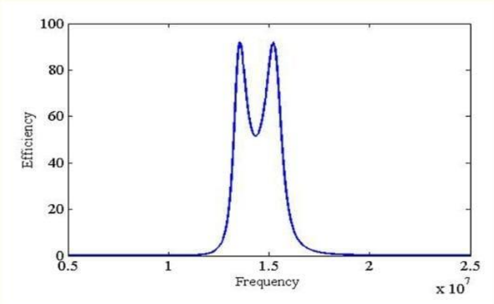
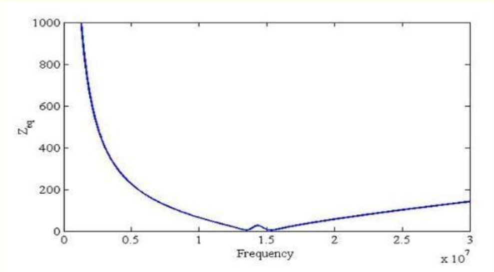


Figure 5.
Efficiency chart.



Eqs. (21) and (14) are substituted for Eq. (20);

$$\eta = \left(\frac{jL_m\omega}{jL_2\omega + \left(\frac{1}{j\omega C}\right) + Z_0 + R}\right)^2 \frac{Z_0}{\left(R + jL_1\omega + \left(\frac{1}{j\omega C}\right) + \left(\frac{L_m{}^2\omega^2}{jL_2\omega + \left(\frac{1}{j\omega C}\right) + Z_0 + R}\right)\right)}$$

E22

At a given resonant frequency, the conditions for system efficiency are defined for three states, defined by Eqs. (23), (24), and (25).

$$L_m^2 = \frac{Z_0^2 - R^2}{\omega_0^2} \quad \text{E23}$$

$$L_m^2 > \frac{Z_0^2 - R^2}{\omega_0^2} \quad \text{E24}$$

$$L_m^2 < \frac{Z_0^2 - R^2}{\omega_0^2} \quad \text{E25}$$

VI. CONCLUSION

Wireless charging holds immense promise for electric vehicles, potentially eliminating the need to physically plug in. While stationary charging pads mimicking phone chargers are being standardized, the ultimate goal is dynamic in-road charging. This technology faces challenges in terms of cost, efficiency at highway speeds, and infrastructure development. However, with ongoing advancements, wireless charging has the potential to revolutionize electric transportation, enabling constant charging, extending range anxiety, and creating a seamless user experience.