International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

Iot based Smart Car Parking with Wireless Charging Feature for Electric Car

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Abstract - *Growing traffic congestion in metro cities poses a great requirement to introduce an efficient, convenient and hassle–free parking system. This project helps to solve the problem by employing an app based IoT smart parking system. In order to prevent long waits at the EV charging station, the parking system is equipped with wireless charging scheme for electric vehicles. The project serves dual advantage of parking vehicles as well as charging of electric vehicles. Hence the complete design of a wireless Electric Vehicle charger with output 104V and 64A is discussed in detail. Wireless charging solves a lot of problems like charger compatibility for different vehicles; reduced risk of electric shocks as charging is non-contact type. Real time data will be made available through the app ensuring greater security and reliable service. Promotion of electric vehicles will also lead to reduced carbon footprint on the world.*

***Key Words*: IoT, Smart parking, Electric Vehicles, Wireless Charger, Inverter, Resonant frequency**

1. INTRODUCTION

The problem of finding a parking space in metro cities is a herculean task in the fast moving world. The need of the hour is an IoT backed solution [4] wherein the availability is based on the reservation management facility [2]. The concepts of image processing have resulted in an enhanced security network [1] to ensure safety of vehicle on a real-time basis. With the promotion of Electric vehicles in the automotive world, creating an infrastructure for efficient charging and parking of electric vehicles has to be given priority[9].The Wireless charger designed in this project is a Resonant Inductive Power Transfer System[10] employed due to its consumer suitability and its effect on battery performance[6]. The coil coupling and power electronics infrastructure decide the efficiency of the charging system[8] and hence facilitates the charging of Electric Vehicles at the same speed as that of standard AC plug-in chargers[7].The result of the successful implementation of the project is the drastic reduction in global carbon footprint[4].

2. BLOCK DIAGRAM

2.1IoT based smart parking system

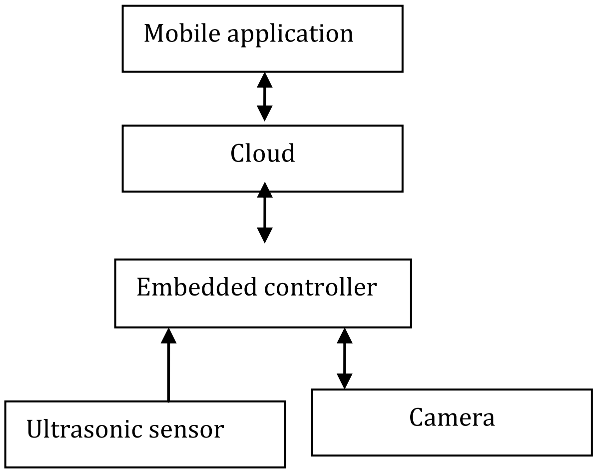


Fig 1-Block diagram of smart parking

Embedded controller [Raspberry pi] serves as the heart of IoT system as it is continuously fed with the data of parking spaces by the ultrasonic sensor and camera. The data obtained is then fed to the cloud and hence can be accessed through a mobile application. The parking time and hence the charging requirement can be provided by the user from a remote location.

2.2 Wireless Electric Vehicle charger

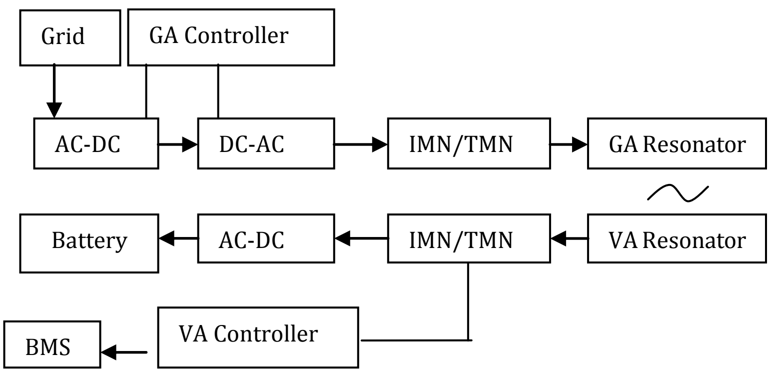


Fig 2-Block diagram of Wireless EV charger

Power from the grid is converted into DC to reduce the harmonics in the supply. The DC signal is then inverted to a high frequency AC signal and provided to the Ground Assembly resonator. Due to mutual induction, voltage is induced in the Vehicle Assembly resonator. IMN and TMN are Impedance Matching Network and Tunable Matching networks respectively, which facilitate impedance matching between GA and VA coils to ensure resonant inductive power transfer. The AC output voltage is converted to DC and fed to the battery. Ground Assembly controller and Vehicle Assembly controller ensure the correct placement and distance between transmitter and receiver coils.

3. DESIGN DETAILS

3.1 Selection of coil for transmitter and receiver of Wireless EV charger

The coils consist of around 100 strands of wires instead of a solid conductor to reduce skin effect. At a frequency of around 100 kHz the current flows along the outer part of conductor instead of the inner part. This increases the value of resistance. Selected diameter of wire is 0.9mm. In order to maintain the loss factor to a minimum value, the quality factor Q should be high. This high value of Q is ensured by having a high value for inductive reactance. Inductive reactance can be controlled by maintaining high frequency and inductance. The inductance of coil is further enhanced by using ferrite plates under the transmitter and receiver coil. Factory made coils of self-inductance 24µH are used as transmitter and receiver coils in this project.

3.2 Capacitance along transmitter and receiver coils

Capacitance, $\mathbf{C=1/(4\pi^2f^2L)}$

For a resonant frequency f=150 kHz and L=24µH

C=46.9nF

Hence capacitance of 47nF is to be connected in series with the transmitter and in parallel with the receiver.

3. 3 Bootstrap configuration of inverter circuit

To increase the current through transmitter coil an H bridge is built using IRLZ44N MOSFETs. Two IR2113 MOSFET drivers are used to drive the H-bridge circuit. Control Signals to drivers is given by 555 timer and 74HC4049N Hex inverting high to low level shifter IC.

3.4 Calculations for H-bridge inverter circuit in Boot strap configuration

Gate capacitance, $C_g=Q_g/V_{Q1g}$

Q_g=Gate charge=65nC [Data sheet of MOSFET IRLZ44N]

$V_{Q1g}=V_{DD}-V_{boot\ diode}$

$V_{boot\ diode}$=1.73V [Forward voltage of diode UF4007=1.73V]

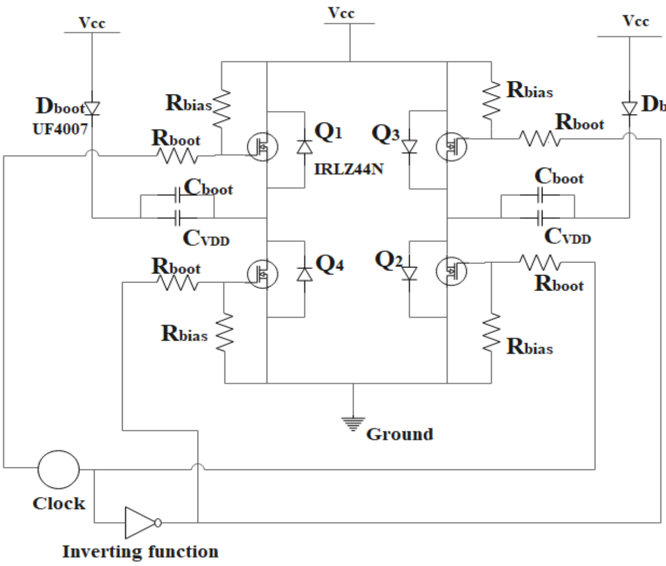
V_{Q1g}=12-1.73=10.3V

C_g=6.31nF

$C_{boot}>=10\ C_g$

C_{boot}=63.1nF

Hence the standard value of C_{boot}=100nF



$C_{VDD}>=10\ C_{boot}$

C_{VDD}=10µF

Energy stored in capacitor=(1/2)* C_{boot}*$(V_{c\ boot})^2$

The standard value obtained for $V_{c\ boot}$=7.74V [To limit the energy wastage]

E=3µJ

Energy stored, E=3* C_{boot}*R_{boot}

Hence, R_{boot}=10Ω

For a stable bias circuit,

$R_{bias}=1000R_{boot}$=10kΩ

3.5 Calculations for transmitter and receiver circuit of Wireless Electric Vehicle charger

The resonant topology used in this circuit is LC-LC series topology as this is the most appropriate one for our project specifications.

Let,

L_S, L_D-Self-inductance of transmitter and receiver coils respectively

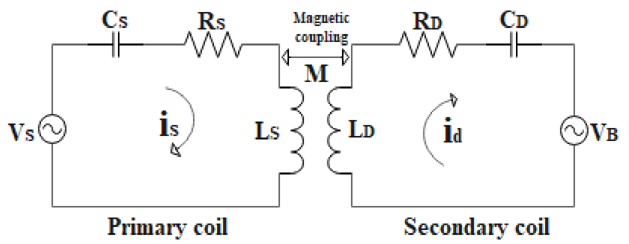
C_S, C_D-Resonant Capacitors on the transmitter and receiver side respectively

R_S, R_D-Parasitic resistances on the transmitter and receiver side respectively

V_S, V_B-Voltages across the transmitter and receiver side respectively

i_S, i_D-Current in the transmitter and receiver circuits respectively

M-Mutual inductance between transmitter and receiver coil



At resonance,

$V_S= i_S R_S - j\omega_r M i_D$ $\quad j\omega_r M i_S= i_D R_D + jV_B$-----------------------(1)

Solving equation (1),

$|i_S|=[V_S+(\omega_r M V_B/R_D)]/[R_S+((\omega_r M)^2/R_D)]$

$|i_D|=[(\omega_r M V_S/R_S)-V_B]/[R_D+((\omega_r M)^2/R_S)]$----------------------(2)

Hence the value of current on the receiver side depends on M, R_S, R_D, V_S,V_B

The value of V_B changes during charging, as it increases with the State Of Charge (SOC) of the battery.

R_S is in the order of mΩ. Hence,

$(\omega_r M V_S/R_S)>>V_B$--(3)

Substituting equation (3) in (2), i_D remains unchanged during the charging process. Therefore, it is a constant current charging process.

Now the product of R_S and R_D is much lesser than either of R_S or R_D

Equation (2) can be simplified as,

$|i_S|=V_B/(\omega_r M)$ $\quad |i_D|= V_S/(\omega_r M)$-------------------------(4)

For LC-LC series topology, the current characteristics are stable only when the loads are batteries or capacitive loads.

From equation (2) power transferred is given by,

$P=|i_D|*V_B$

Mutual inductance, $M^2=L_S*L_D$

The value of $L_S=L_D=M=24\mu H$ [Standard value of inductance for coils used in this project]

At resonant frequency, ω_r=10kHz with V_S=230V and V_B=104V

$|i_S|=433A$ $|i_D|=958A$

This value of current is not suitable from application point of view. Hence the resonant frequency applied is ω_r=150 kHz

$|i_S|=29A$ $|i_D|=64A$

Power output, P=64*106=6.6kW

For a battery capacity of 23kWh, the charging time is 2.5h

4. SIMULATION DETAILS

The simulation of the wireless electric vehicle charger was performed in the EasyEDA software.

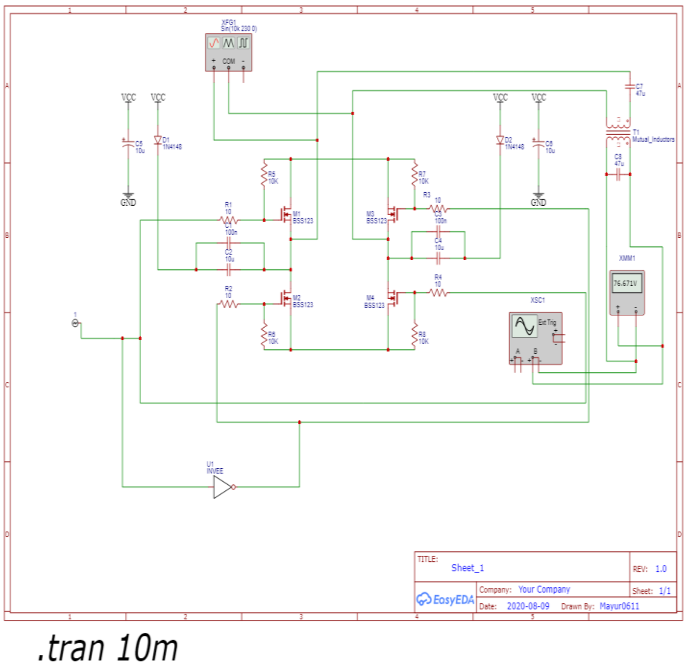


Fig 5- Circuit Diagram

The output voltage obtained is 104V(p-p). The output current depends upon the frequency applied.

5. HARDWARE DETAILS

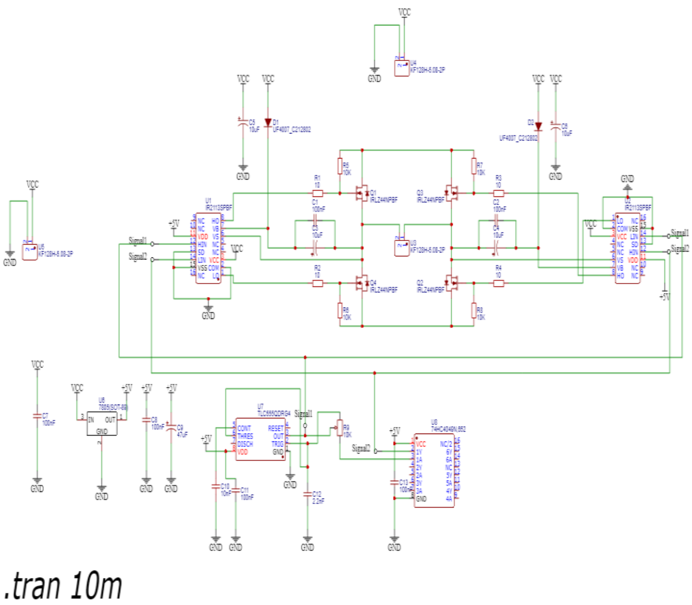


Figure 6-Schematic diagram of Wireless EV charger

The hardware circuit shown in the figure 6 consists of an H-bridge inverter circuit. Four IRLZ44N MOSFETs are connected in an H-pattern in Boot strap configuration to increase the value of current flowing in the transmitter coil. Each of the two diagonal MOSFETs are driven by two IR2113 MOSFET driver ICs. The MOSFET driver ICs are provided with pulses by a TLC555 timer and 74HC4049N Hex inverting high to low level shifter IC. Two of the diagonal MOSFETs generate positive half cycle of sinewave, while the remaining two generate the negative half cycle. Hence a pure sinewave output is obtained. This sinewave output has to be provided with a high frequency signal and supplied to the transmitter coil of the wireless circuit. The voltage in the transmitter coil induces a voltage in the receiver coil and hence can be utilized to charge the vehicle.

CONCLUSION

Electric vehicles are definitely the future of automobile industry and in order to support this revolution, the charging infrastructure has to be given the priority. The project supports this initiative and provides a solution to modern day problems of parking as well as wireless electric vehicle charging. The output voltage obtained is around 104V as per the simulation data. This project indeed has a potential to be implemented in real time and solves the obstacles which may arise in the rolling out of electric vehicles into the market. There is no problem of connectors for different types of vehicles as there is no electrical contact between the ground and vehicle assembly. It is safe from the operational point of view as well by reducing the risk of electrocution. The design can be further modified to obtain circuits with higher efficiencies and reduced complexity. So in order to provide a best possible replacement to petrol bunks in the current scenario, the hardware implementation and testing of this project on large scale would indeed encourage the electric automobile world and reduce the global carbon footprint.

ACKNOWLEDGEMENT

Gratitude is the greatest gift of god. We would like to express our deep sense of appreciation to our mentor, guide and an excellent teacher Ms. Lekshmi M who motivated us in the best possible way to achieve our targets. We extend our gratitude to our parents for their support in all our endeavors. We thank all our friends, well-wishers for their support.

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