V2G and G2V plug-in and wireless charging integration in Vehicle Parking

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Abstract - Electric vehicles (EV) are becoming a conventional preference and in coming times they will overtake conventional engines due to their countless advantages over them. the Only challenge is the limitations of battery charging infrastructure availability while traveling. Currently, an open-source charging dock employs a plug-in charging system, where the individual needs to plug in the charging cable to EV and from the charging dock.

This unguarded charging dock involves risk factors like inexpertness to manually chose the required mode with personal safety and surrounding conditions, etc. therefore, in this paper, we are introducing an Automatic charging docks system, which involves automatic detection between the V2G and G2V mode of charging so as to counter the errors involve in non-expert handling procedure. This especially enhances the charging infrastructure safety in the plug-in system. Furthermore, the wireless power transfer charging system would be for Electric vehicles without a Plug-in alternative, which will facilitate the safety of all types of passengers especially the women, the aged people who cannot combat and the passengers with precious belongings from the external factors of weather and thieves. This type of wireless charging is the key to the future of electric vehicle adaptability by all non-experts for easiness.

Key Words: EV, charging dock, risk, smart detection, V2G, G2V, wireless charging

1.INTRODUCTION

Vehicles are one of the most parts of today's human life. even though, it has become a basic need for humans after food clothing, and shelter. automobiles are in various forms like two-wheelers, four-wheelers, multi- wheels bus, trucks, etc. Currently, the vehicles are work with the help of fuels like petrol, diesel, etc. and the fuels are getting depleted rapidly. Also, these fossil fuels take time for their formation. These all factors lead to an ecological imbalance of the earth. Recently a rapid advancement has taken place in the automobile sector for the development of electric vehicles, plug-in hybrid vehicles, etc. They need batteries or battery-fuel combinations to operate. The charging of these vehicles is done with the help of charging outlets from the power grid. This electricity provided to the charging dock largely comes from the conventional sources of coal and other fossil fuels. They are also a contributor to the ecological imbalance due to limited availability and pollution. Hence, solutions need to find an alternative source of power. Renewable energy sources can be used in order to curb this problem. Apart from these vehicles also can be used as electricity-generating utilities.

In this paper, we are presenting a working model representation of Grid-tied smart parking. This type of parking will help generate electricity through various renewable energy sources like solar, wind, piezo, etc. Also, the vehicle's batteries can act as an energy storage option for the load.

This is known as Vehicle to Grid (V2G) or Grid to Vehicle (G2V). Furthermore, energy conservation measures are taken through human detection sensor installed at the parking lot. This sensor will also serve the purpose of security against the entry of humans into the parking lot. Also, the Radiofrequency tag system will serve against illegal entrants on the campus while opening the gate. The driverless car with a wireless charging facility is also worked out in this model project. The conventional charging system of wired connectors is also shown for easy comparison.

1.1 Vehicle to Grid(V2G)

Vehicle to grid (V2G) technology can be defined as a system in which there is a capability to control, bi-directional flow of electric energy between a vehicle and the electrical grid. The integration of electric vehicles into the power grid is called the vehicle-to-grid system. Any electric-drive vehicle has within them the energy source and power electronics combining making it capable to drive the power requirements of homes and offices.

It has been calculated that 92% of the total vehicles remain parked even during peak hours. When a vehicle is not being operated, the onboard battery is connected to a nearby electrical grid via appropriate communication devices. The idea is to use the power from idle vehicles to provide load-shedding and peak shaving and many other functions. The vehicle batteries can be fully charged during low-demand hours and the flow can be reversed at any time according to the requirements. This can be fulfilled by utilizing the concept of 'smart grid' which is an electricity network capable of processing the information, manages the electricity flow to fulfill the end-users varying power demand, and is able to provide communication between generation sources and end-users. This concept works to balance the 'off-peak' and 'peak' demand. The Vehicle can get charged during off-peak hours and can sell it back to the grid during peak hours.

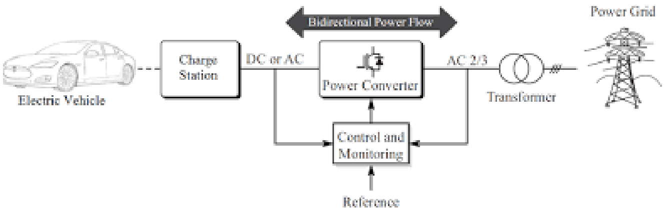

Figure 1: V2G System

Advantages and Applications of V2G
Electric Vehicles and PHEV

PHEVs can be operated as a load while charging, a distributed storage, including services like reactive regulation, motor starting, or a standalone energy source such as peak sharing. Although care has to be taken while discharging the onboard batteries as excessive discharge might affect the battery life and its expectancy. The PHEV fleet is large enough and if a particular portion of the vehicle's stored energy could be tapped while parked, it would provide the power grid with large amounts of energy at a given time of the day. This section concentrates on the benefits of using PHEVs as a distributed storage.

The stored battery energy can be used to provide power to help balance loads by charging at night when the demand is low (valley filling) and providing power to the grid when the demand is high (peak sharing). Peak sharing also provides additional advantages such as the reduction of a variety of unwanted factors like line losses, delay transmission, transmission congestion, etc. It also helps in reducing the stressed operation of a power system, thus adding to its longevity in terms of lasting. This leads to avoiding heavy investments in installing peaking power plants. Power regulation authorities have a good ability to predicting the peak loads (mostly during summers due to the load of the AC's).

Using hybrid vehicles as a distributed storage acts as a robust alternative to expensive and capital-demanding 'peaking plant' generators. Generally, power-seeking bodies purchase electrical energy through long-term contracts with generation companies or from spot electricity markets in the short run. Peak load periods, see the highest electricity prices. Peak shaving applications of the PHEV fleet reduces the cost of electricity during peak periods. The money saved in the case can be used to further propel the utilities of PHEVs by investing in research facilities and expanding their horizon. The average benefits from the V2G participation of an EV are estimated to range from $392 to $561 annually per vehicle. Thus, PHEVs offer the power system with a flexible, controllable load and could provide load leveling during off-peak periods.

1.2 Components and Construction

Copper Coil: The Induction coil is an electrical device for producing an intermittent source of high voltage. An induction coil consists of a central cylindrical core of soft iron on which are wound two insulated coils: an inner or primary coil, having relatively few turns of copper wire, and a surrounding secondary coil, having a large number of turns of thinner copper wire. An interrupter is used for making and breaking the current in the primary coil automatically. This current magnetizes the iron core and produces a large magnetic field throughout the induction coil.

Atmega328 Microcontroller: The high-performance Microchip picoPower® 8-bit AVR® RISC-based microcontroller combines 32 KB ISP Flash memory with read-while-write capabilities, 1024B EEPROM, 2 KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented Two-Wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts.

Astable Multivibrator: When we say to an astable multivibrator circuit. Most people think of IC-555. It is famous for making pulse generators and timers. But here we are using CD4047. It is also an Astable multivibrator circuit on CMOS chips.

We can use it in many circuits. Most used in an AC inverter, Square wave generator, LED flasher, and more. It has an advantage over 555 IC that outputs a 50\% duty cycle and requires a wide voltage supply. (3V to 15V).

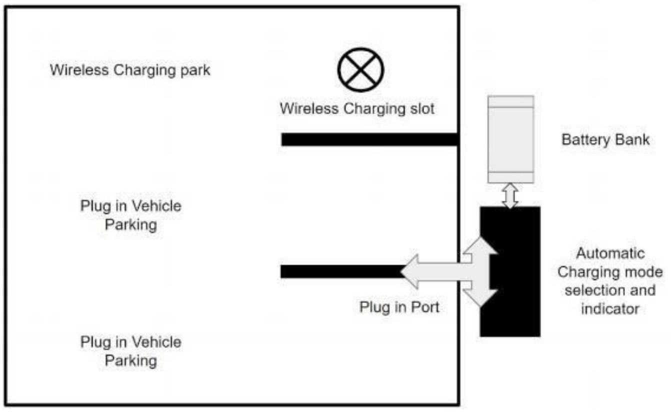

Figure 2: Construction

2. Designing an Inverter circuit and Buck-Boost converter

In this project, we have developed a 60 W inverter circuit, which can be further increased to 100 W using a higher rating transformer and more robust heat management system.

The inverter is a multivibrator IC-based MOSFET powered output for 50 Hz frequency through a battery-powered Dc supply of 12 volts.

Since the Indian national grid recommends 50 Hz as the standard frequency for synchronization purposes, we have constructed the inverter to synchronize the T- box power generation with the national grid, to contribute to national power generation and meet the load demand.

The voltage rating we will be getting out of this inverter is 230v AC, 50 Hz.

Following is the circuit diagram for the inverter circuit.

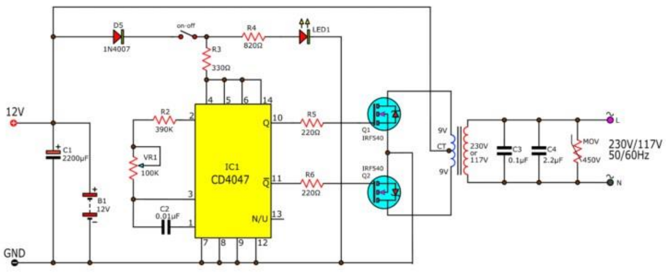

Figure 3: Inverter Circuit

2.1 Basic Square wave Generator

6V DC input to the chopper. DC-DC conversion 12V DC output from the chopper circuit is a constant DC voltage and is then input to the inverter circuit After the RC modulation for pulse width, the CD4047 multivibrator IC will give an output at its terminal.

Both this output signal from Q and Q' is then amplified using a MOSFET circuit and is then connected to the center-tapped transformer at each end. The center connection of the transformer is then connected directly to the ground connection of the DC input.

This square waveform is alternating in nature, ideal only for simple applications, but it will involve too much distortion noise content. The Frequency OUPUT will not be constant and can cause damage to the connected AC appliance.

So, a capacitor is added to make the circuit smooth. The step-up transformer would then convert the 12 V AC voltage to 230 V AC. One more capacitor would filter the ripple content generated due to conversion and the circuit would give full AC pure 50 Hz waveform.

We use 12-battery as a power supply. The output will be a square wave, which has three forms are:

It would Get 50% duty Cycle. Pin 13 is the basic frequency obtained by the VR1 and C1 across pins 1,2 & 3. Pin 10 (Q) and Pin 11(Q) shows the half frequency of the original frequency at pin 13.

Both frequencies at pins 10 and pin 11 are inverted to each other phases. The inverted Outputs are 180 degrees out of phase. Three outputs have the 50% duty cycle. See the waveform signal of three outputs. We cannot adjust the duty cycle of this circuit. It always is a duty cycle of 50% that symmetry exists.

Then, we can set the frequency output by adjusting VR1 and charging C1.

The value of VR1 is used in a range of 1K to 1M. To Adjust to the desired frequency. And, the C1 will determine the frequency. The value is used to determine the various range. You can see this from the table below. The value of C1 in the circuit as Figure 1 to determine the frequency use.

0.01uF = 100Hz-10kHz

And VR1 potentiometer is 250K.

Another simple practical approach for frequency generation

Frequency= 1 / time

50 = 1/ R*C 50 = 1/ (R * C)

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50 = 1/ (R * 0.01 * 10 -6)

50 * R * 10--8 = 1

R = 1/ (0.0012394)

R = 806 ohms.

Thus, if we use a capacitor of 0.01 uF and set a target of 50 Hz frequency, we need to adjust our variable resistor to around 806 ohms.

Stepwise conversion from 12 v DC to 230 v AC

6V DC input to the chopper. DC-DC conversion
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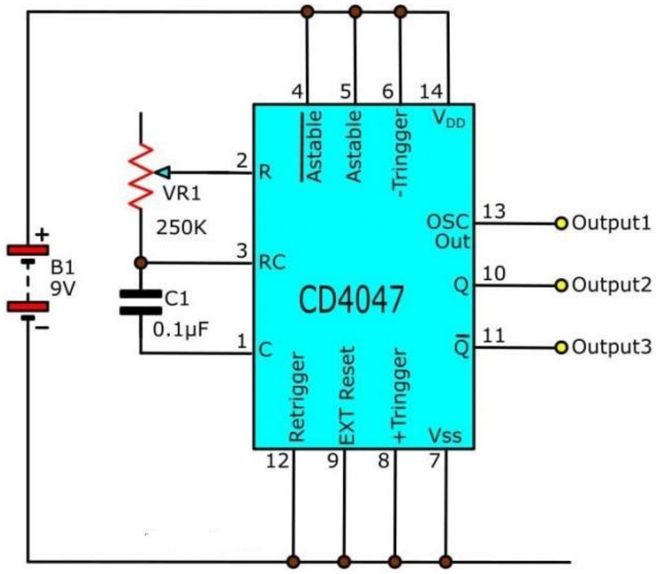

Figure 4: Square wave Generator

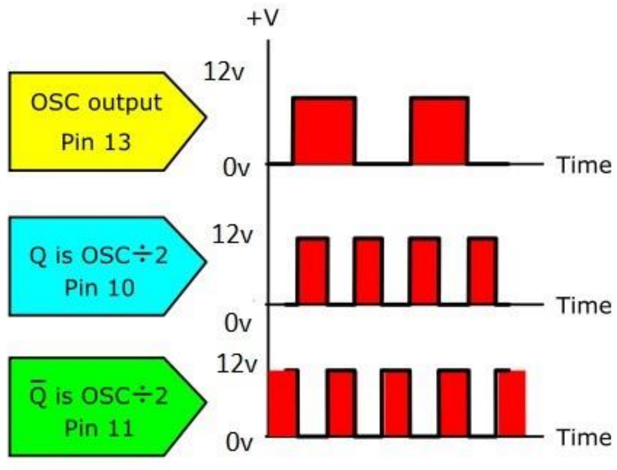

Figure 5: Waveform

Buck-Boost converter

DC-DC converters are also known as Choppers. Here we will have a look at Buck Boost converter which can operate as a DC-DC Step-Down converter or a DC-DC Step-Up converter depending upon the duty cycle, D.

$$V0/Vin\ =\ -D/1-D$$

D varies between 0 and 1. If D>0.5, the output voltage is larger than the input; and if D<0.5, the output is smaller than the input. But if D = 0.5 the output voltage is equal to the input voltage.
A circuit of a Buck-Boost converter is shown below.

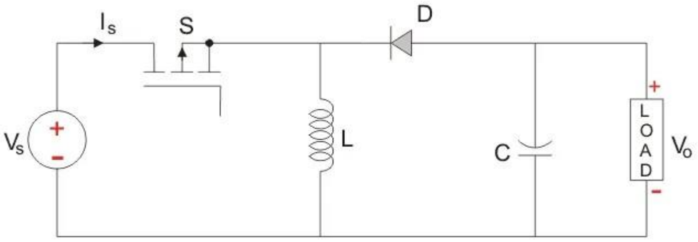

Figure 6: Buck-Boost Converter

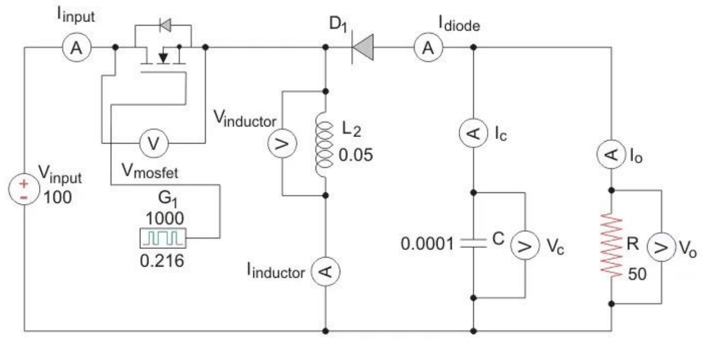

Figure 7: Buck-Boost Converter

Operation

In this project, a representation of a parking system for 3 vehicles is shown. The first two vehicles would be conventional electric vehicles, which have a plug-in charging system.

These vehicles would have a certain voltage across the batteries. We have considered a reference voltage of around 6 volts.

So, depending on the usage the vehicles could be either over the 6v range or under it. When the vehicle is parked the user would need to plug in the wire from the charging port towards the vehicle.

The voltage would be measured across the battery in the vehicle and sent to the microcontroller.

The microcontroller is pre-programmed would compare the voltage value with the reference value of 6 volts.

Depending on the difference it would decide as Grid to Vehicle (G2V) for undercharged condition (<6V) and Vehicle to Grid (V2G) for overcharged condition (>6V). A boost converter and buck converter would be employed for that purpose respectively.

The indicator would be placed at the dock to indicate the activated mode between V2G or G2V. A bidirectional relay would be employed for that purpose.

The third vehicle would be a working representation for G2V mode, but with a wireless charging technique.

Here, the user would not need to get outside of the vehicle for charging and plug-in purpose.

The vehicle would just need to be parked to facilitate the matching of charging coils closely.

The Led indicator would indicate the status of wireless charging in operation.

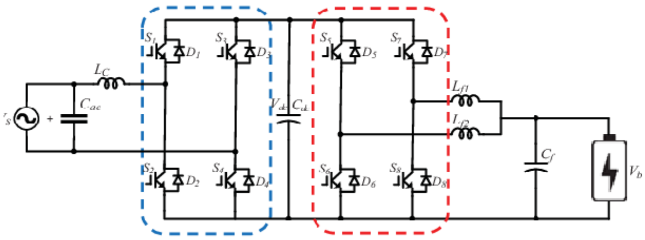

Figure 8: Grid to Vehicle

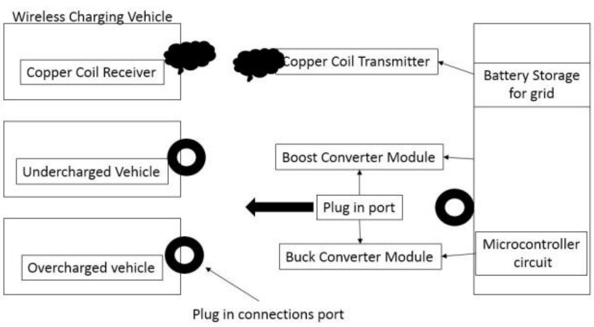

Figure 9: Block Diagram

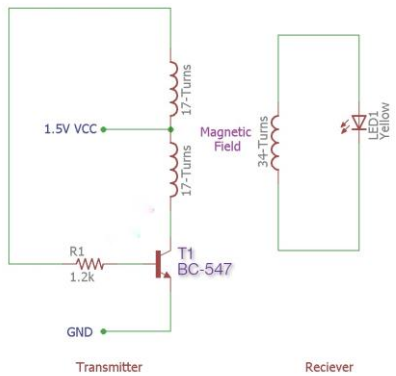

Figure 10: Wireless power transfer circuit

Results

Vehicle – Grid Relation on Arrival of Vehicle in Parking Space (Reference voltage = 6 V)

Car battery voltage	Status compared with reference	Condition applied
>6 V	Overcharged	V2G
= 6 V	Needs charging	G2V
<6 V	Undercharged	G2V

Table 1: Result V-G

Wireless Charging

Vehicle (Receiver Coil) arrived in parking slot (Transmitter Coil) with -	Charging status
Receiver Inductive coil in field area of wireless transmitter	Wireless Charging Initiated
Receiver Inductive coil away from field area of wireless transmitter	Idle State

Table 2: Result WPT

Conclusion

In this paper research has been done on V2G and G2V plug in and wireless charging integration in vehicle parking. We have successfully researched and developed a working prototype model for integration of Vehicle Parking space into National Electricity grid with the help of V2G and G2V concept along-with the future wireless charging concept for EV. The following points were noted while developing the prototype-

A. EV is not widely adopted due to poor charging infrastructure.
B. The conventional charging system is not reliable
C. The service providers for EV charging face expensive land cost and initial investment in comparison to Return on Investment.

However, with our project following points were observed -

A. EV parking space will no longer be a burden due to V2G technology.
B. The ROI period would be drastically reduced due to monetization of charging in parking space.
C. Wireless charging technology ensured less wear and tear of the charging equipment.
D. Wireless charging also ensured safety of passengers from external weather and privacy concerns.

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