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Zeta Converter Based Electric Vehicle Charging

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ABSTRACT: The future mode of transportation has a great deal of Electric vehicles. The pavement of E-Vehicles has led to the most efficient, affordable means of transportation than the conventional gasoline or diesel-based and is shaping the future for a cleaner, energy- efficient transport electrification. The most important characteristic of E-Vehicles and its success relies heavily on the converter presence of high efficiency charging methods. This project aims to design and develop fast charging infrastructures and bringing out the best in terms of parameters such as output power, power factor and reliability thereby overcoming the various challenges faced. The prototype is simulated using MATLAB simulink to understand the functioning and to design the most suitable technique that suits the best for fast charging. It also evaluates the different converter types that can be inculcated in charging stations in order to get a faster, time reducing, effective charging methodology. This project not only aims at the technical aspects of E-Vehicle charging station but also fulfils the various environmental queries involved leading to sustainable development. Implementing this in the future can be one of the easiest, fastest, efficient designs for mini electric vehicle charging and can indeed pave the way for one of the easiest, fastest method of charging electric vehicles right from small range to higher range of ratings and capacity.

I.INTRODUCTION ELECTRIC VEHICLES

An electric vehicle (EV) is a vehicle that uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels, fuel cells or an electric generator to convert fuel to electricity. E-Vehicles include, but are not limited to, road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft.

It first came into existence in the mid-19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time.

II ZETA CONVERTER

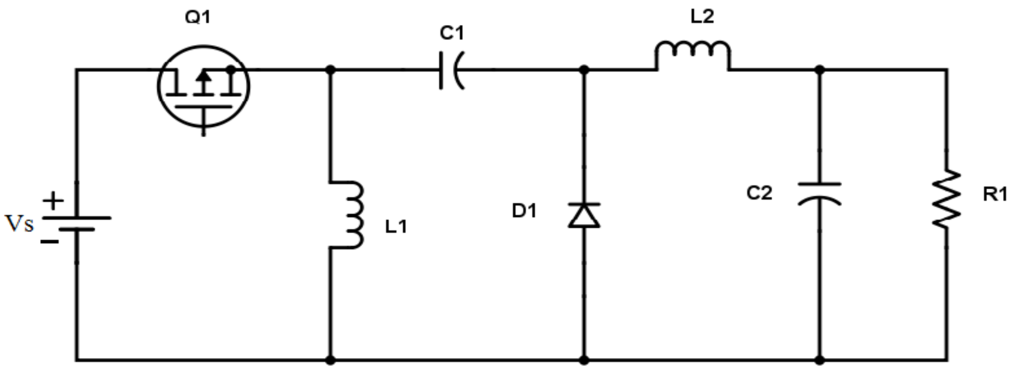

Figure 1 Zeta Converter Circuit

A Zeta converter is a form of DC voltage converter that can convert a positive DC voltage supplied into either a

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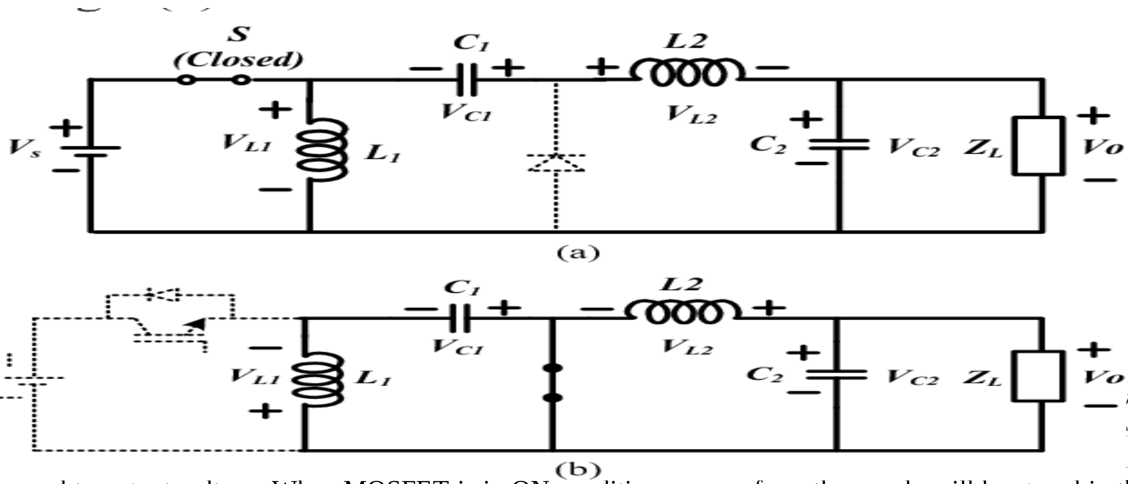
higher or lower positive DC output voltage. This converter is used in power supply modules for electronic circuits. Adapted Zeta converter types with galvanic isolation are used in switched-mode power supplies for active reactive power compensation.

Zeta converter consists of switch MOSFET, two Capacitors (C1 & C2), two Inductors (L1 & L2),one Diode (D) and the load Resistor (R). Zeta converter circuit is operating under continuous conduction mode (CCM) for switching condition like ON & OFF.The duty cycle to output voltage small-signal transfer function of dc-dc Zeta converter is obtained using state-space technique and Leverrier algorithm. Then this transfer function is used for designing Arduino controller using stability equations to meet specific phase margin and desired cross-over frequency.

MODES OF OPERATION:



Mode ... voltage (Vs), th... ration. The inc... tor C1 starts charged to output voltage. When MOSFET is in ON condition, energy from the supply will be stored in the two inductors (L1, L2) and also C1and L2 provides output currents.

Mode 2: In mode 2, the switch is OFF condition, now diode is in forward biased, capacitor will be parallel to L2 inductor and across the inductor output voltage will be available, since C1 is discharged and C2 is charged to voltage in output. Whatever energy stored in the inductor (L) will be carry forward to the load resistor. So this kind of mode of operation is discharging conditions.

III EXISTING METHOD

The commonly used charging methods today include a Level 1 EVSE that uses commonly-available 120 VAC/230 VAC power sources, draws current in the order of a 12 A to 16 A range and can take anywhere from 12 to 17 hours to fully charge a 24-kWh battery. L1 chargers can go up to a maximum power of 2 kW and is used in residential applications.These fast charging applications require modular power converters which can be paralleled to cater to different power levels, thereby enabling fast charging.

A Level 2 EVSE (typically used in commercial spaces such as malls, offices, and so forth) uses poly-phase 240 VAC sources to power a more robust vehicle charger and draws anywhere between 15 A and 80 A to completely charge a 24-kWh battery in about eight hours (power level up to 20 kW).DC charging stations require high-power converters which are capable of charging to 80% SOC in under 30 minutes. These fast charging applications require modular power converters which can be paralleled to cater to different power levels, thereby enabling fast charging.

The most important parameters are the energy density and system efficiency. Energy density is the amount of energy that can be transferred for a given volume of converter. If we can double the power output for the same size, it results in significant cost savings and also helps in fast charging.These fast charging applications require modular power converters which can be paralleled to cater to different power levels, thereby enabling fast charging.

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IV BLOCK DIAGRAM

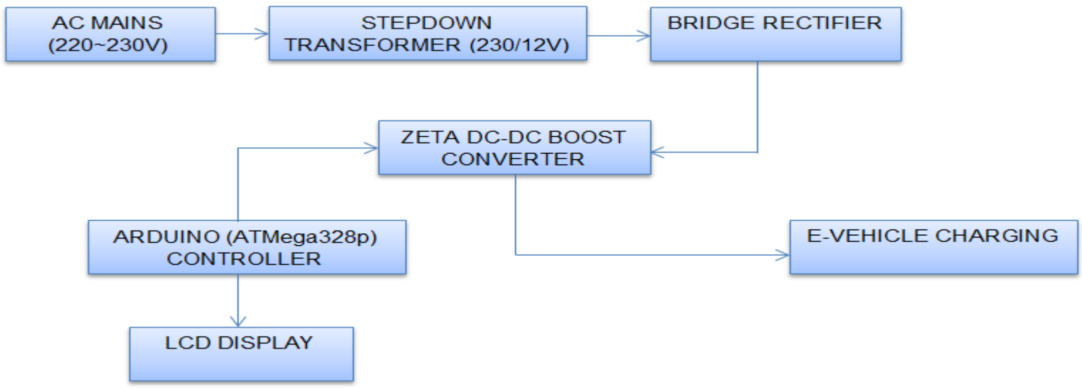

Figure 3 Schematic Block Diagram

BLOCK DIAGRAM DESCRIPTION

In this project, the source is the AC supply that is readily available from the grid which values around 220-230 V. It is fed to an AC transformer (230/12V) that steps down the value from 230V to 12V. This 12V AC is now converted to the DC form through a bridge rectifier that consists of diodes. The output of the bridge rectifier which is DC is now the main source to the Zeta DC-DC converter that boosts up the value of the input given.

The Zeta converter uses a Mosfet switch for which the gating pulses are given from an Arduino microcontroller in the form of Pulse Width Modulation (PWM). The boosted output is now given to a proper rechargeable battery that is present in Electric vehicles. The values of the input and output voltages are viewed through the LCD screen (16*2) that is interfaced with the microcontroller. A voltage sensor is in built which performs the task of adjusting the given input to an acceptable range of the microcontroller board.

CIRCUIT DIAGRAM

The circuit diagram for the entire project is shown below.

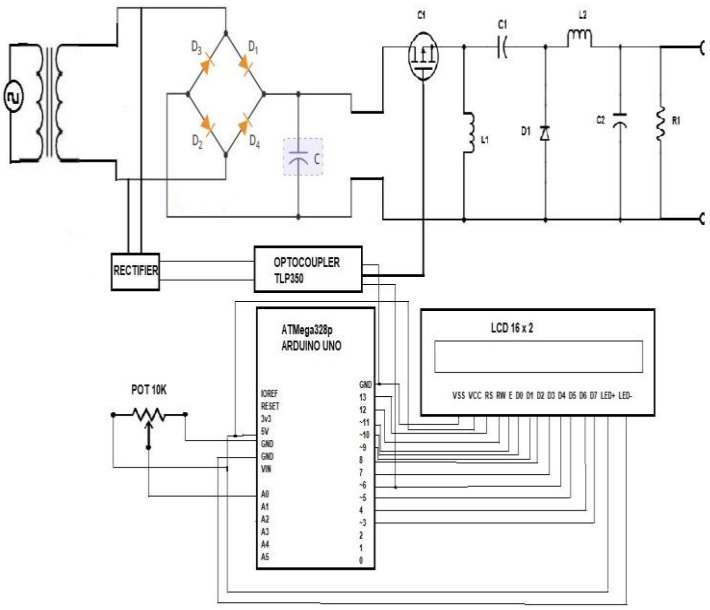

Figure 4 Detailed Circuit Diagram

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CIRCUIT DIAGRAM DESCRIPTION

At first, the supply is taken from the grid that is available in the form of alternating current. This supply ranges around 220-230 V to the maximum. This supply is the source of the entire AC charging method for electric vehicle. It is then given as a supply to the step down transformer which steps the value from 230V to 12V AC. The supply is given to the primary of the transformer. Hence, the stepped down value of 12 V AC is the source for the bridge rectifier circuit which converts the AC to Direct current form. The bridge rectifier consists of 4 Diodes (IN4007) and a capacitor of 2200uF that acts as a filter to reduce the amount of ripple in the output of the bridge rectifier. The output is the fed to the Mosfet (IRF540) module that consists of an Optocoupler IC and a snubber as protective devices. The gate terminal of the switch module is connected to pin 6 of the controller board. The gating pulses are provided in the form of Pulse width modulation through which the duty cycle is varied through the potentiometer which is powered from the microcontroller.

The Mosfet module is the switching device that constantly switches ON and OFF. This charges the Inductor (L1-1mH) that energizes and de-energizes at switch OFF position. This process keeps repeating which is a function of the switching frequency which is 50 KHz here. The output capacitor which is 33mF accumulates the charge which is connected parallel to the output terminals at which the boosted voltage can be taken.

An Arduino ATMega328p microcontroller is used to provide the gating pulses in the form of PWM and is accordingly programmed. It is also interfaced with an LCD display screen at pins (3,4,5,6,7,8,9,10,11,12) to depict the values of input and output voltage of the entire circuit. An output load resistor of 50 ohms is connected across which the output voltage can be measured either through a voltmeter or multimeter.

Output Graph:

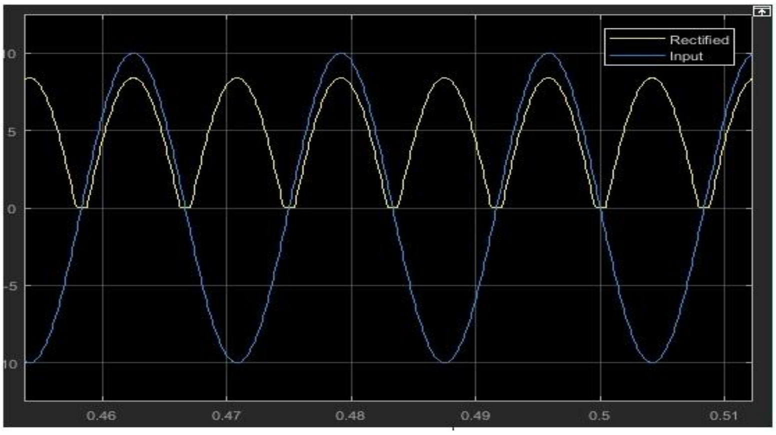

Figure 5 MATLAB Output

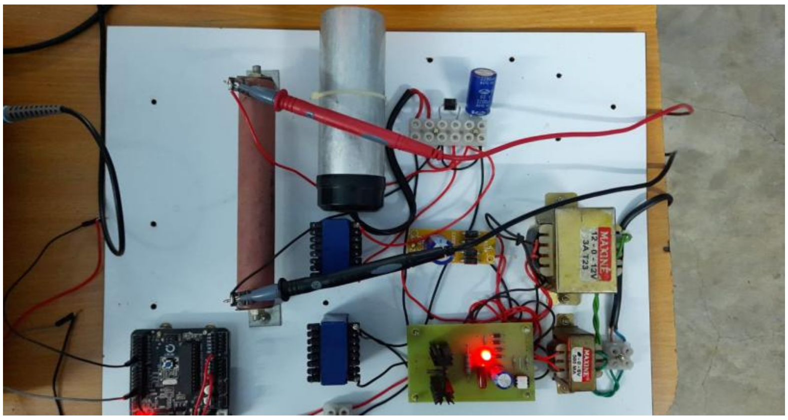

Figure 6 Final Project Setup

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V.CONCLUSION

A simple power electronic controller for interfacing an Electric Vehicle Charger has been simulated based on Zeta topology. A comparative study was first made between the conventional boost converter and the proposed zeta converter design and the basic necessary details were studied along with the details of the components. Thus, the simulation and hardware implementation of Zeta converter based electric vehicle charging for smaller range of electric vehicles was done successfully. The proposed system was simulated using MATLAB Simulink platform. It is one of the easiest designs for electric vehicle charging and can be done with the help of simpler, small range and rating of components. The main reason behind using a Zeta Converter is that it draws a line current proportional to the input voltage in a manner similar to the fly back converter, with no harmonic current. Also it also showed other advantages like low conduction loss, improved efficiency, low output ripple voltage and better switching time.

Parameters	**Obtained Value**
Input Voltage	24 V
Output Voltage	50 V (Varies depending on the duty cycle)
Output Current	1-1.5 A
Output Power	96-100 W
Battery Rating	12 V, 120 W, 7.2Ah

Mathematical analysis of the Zeta converter is carried out for the design of values of parameters of the capacitor and inductor. It is an efficient step-up DC-DC converter used in in numerous electronics devices. It possesses many advantages like reduced components, high performance, less weight and accuracy. The converter output depends on the duty cycle of the converter which is varied through a potentiometer in our project. But, in advanced methods we can implement a switch or any developed methods to vary the duty cycle which can change the output voltage as required in our applications.

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