



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 4, April 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

A Bidirectional Electric Vehicle Charger for Wide Output Voltage Range Application

A.BALAJI¹, P.PAVANI PRIYA², P.SRI KRISHNA³, M.RAVI⁴, K.VAMSI KRISHNA⁵

Assistant Professor, Department of Electrical & Electronics Engineering, Usha Rama College of Engineering & Technology, Krishna, Andhra Pradesh, India¹

U.G. Students, Department of Electrical & Electronics Engineering, Usha Rama College of Engineering & Technology, Krishna, Andhra Pradesh, India^{2,3,4,5}

ABSTRACT: For both high voltage (HEVs) and low voltage (LEV) electric vehicles to be charged in a home, offboard chargers are necessary. In light of this, the design and control of a single-stage, bidirectional electric vehicle (EV) charger with a broad output voltage range of 72 V to 240 V are shown in this work. Additionally, the provided bidirectional EV charger makes it easier for the user to use the battery of their car to power their home appliances—a practice known as vehicle-to-home operation—when grid power is unavailable. For this EV charger, a bidirectional bridgeless Cuk converter with a switching inductor is constructed and examined. The controlled battery current and improved grid side performance with a lower component count during bidirectional operation are the primary benefits of this bidirectional EV charger.

KEYWORDS: Electric Vehicle, Battery Charger, AC/DC Conversion, Power Quality.

I. INTRODUCTION

It is obvious that a single-stage, bidirectional EV charger that can charge both high- and low-voltage EVs over a broad voltage range still needs to be created.

This study realizes a single-stage bidirectional battery charger with this requirement in mind. The created EV charger's battery current stays within the relevant norm. Additionally, it keeps the grid current quality within the parameters specified by IEC 61000-3-2. The following are some of this work's main highlights.

There is a discussion of the battery charger's design and working concept. This article discusses the working concept of the switching inductor-based Cuk converter-derived battery charger both in terms of charging and vehicle-to-home (V2H) operations. In order to confirm the battery charger's functionality and behavior throughout a broad voltage range, the constant-current (CC) charging mode is examined. Two battery charging operations—one at 72 V and the other at 240 V—are used to verify this operation.

A 1.5 kW system is intended to examine the EV charger's dynamic and steady-state performances in a variety of scenarios, including distorted and fluctuating grid voltage situations. Using a 240 V battery, the vehicle-to-home operation verifies the bidirectional operation.

II. PROPOSED RESEARCH WORK

CHARGER CONFIGURATION

Figure 1 depicts the topology of the broad voltage range EV charger that is being shown. Notably, the Cuk converter serves as the basis for the single-stage bidirectional EV charger that is being demonstrated. In this case, the grid current's high frequency switching harmonics must be filtered out by the input inductor, L_{in} . Furthermore, the inductor L_{in} serves as the Cuk converter's input inductor. Additionally, during the positive half cycle, switches S1 and S3 together function as the input side switch, and during the negative half cycle, switches S2 and S4 together function as the input side switch. In order to achieve the high voltage conversion ratio, a switched inductor cell with switches Q1 and Q2 is also used at the converter's output. Interestingly, discontinuous conduction mode (DCM) operation is intended for the output inductors. The grid's current quality is thus controlled in accordance with the IEC standard. Furthermore, because grid current takes the form of the output current, a current sensor is not necessary to measure grid current [7].

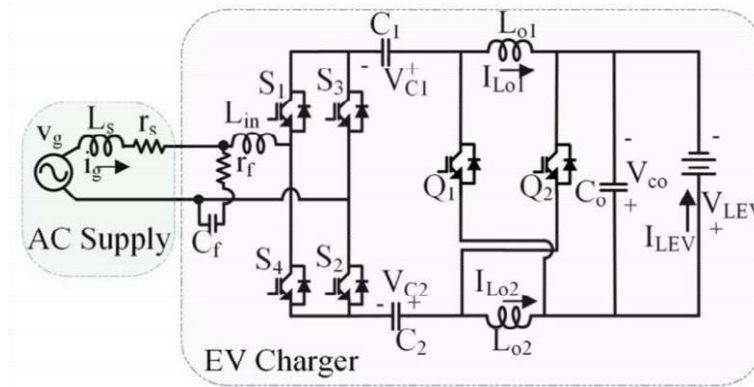


Fig1: Circuit Diagram Of Wide Output Voltage Range EV Charger

III. DESIGN OF CHARGER

The EV charger that is being offered is made to function across a large output voltage range. According to this perspective, the design is completed for an EV battery's maximum output voltage rating, which in this case is 240V. In addition, Table I lists the rating parameters that were used for the developed EV charger's performance analysis. Additionally, Table II provides the design equations, computed values, and chosen values for the parts of this EV charger.

TABLE I

SELECTED PARAMETER FOR EV CHARGER

Parameters	Rated Value
Power	1.5 kW
Grid voltage	230 V
Switching freq., f_{sw}	20 kHz
Nominal battery voltages, V_B	72 V and 240 V

TABLE II

PARAMETERS ESTIMATION

Parameters	Design estimation	Remarks	Estimated value
L_{in}	$V_{g,max} D_{max} / f_s \Delta i_{L_{in}}$	$D=0.28$; $f_s = 20$ kHz; $\Delta i_{L_{in}}=30\%$ of $i_{L_{in}}$	2.32 mH
$L_{o1,C}=L_{o2,C}$	$R_{Lmin} / f_s (1 - 2M_{max})$	$f_s=20$ kHz; $R_L=V_{LEV} / I_{LEV}$; $M_{max}=D/2D_1$;	0.2 mH
$C_1=C_2$	$1 / ((2\pi f_{res})^2 \times (L_{in} + L_{o1} + L_{o2}))$	$f_{res}=2$ kHz; $L_{o1}=L_{o2}=60$ μ H;	2.59 μ F
C_o	$P / (2 \times \omega_{DC} \times v_{rip})$	$v_{rip} = 10\%$ of $V_{DC}=72$	4605.2 μ F

IV. PROJECT MODEL

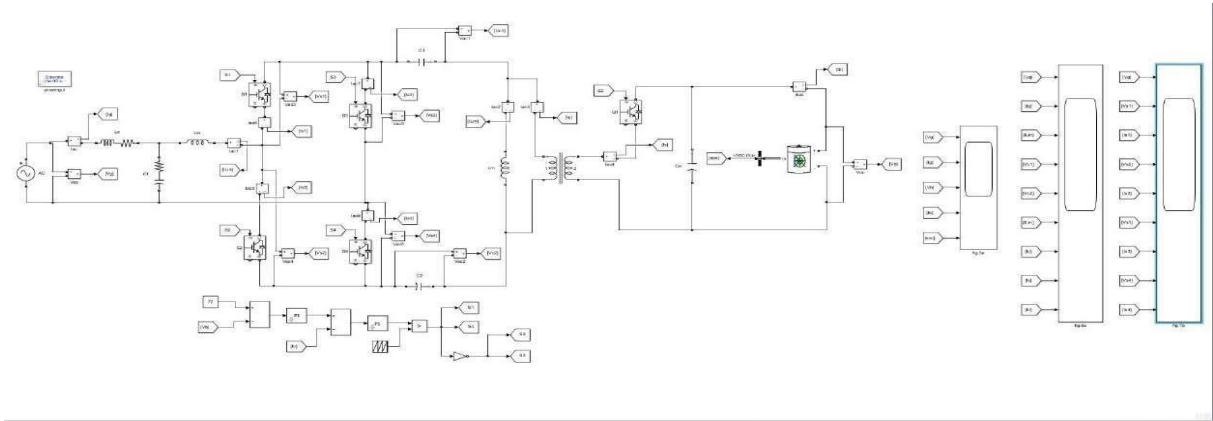


Fig2: Performance Analysis of LEV Charger with 72V Battery

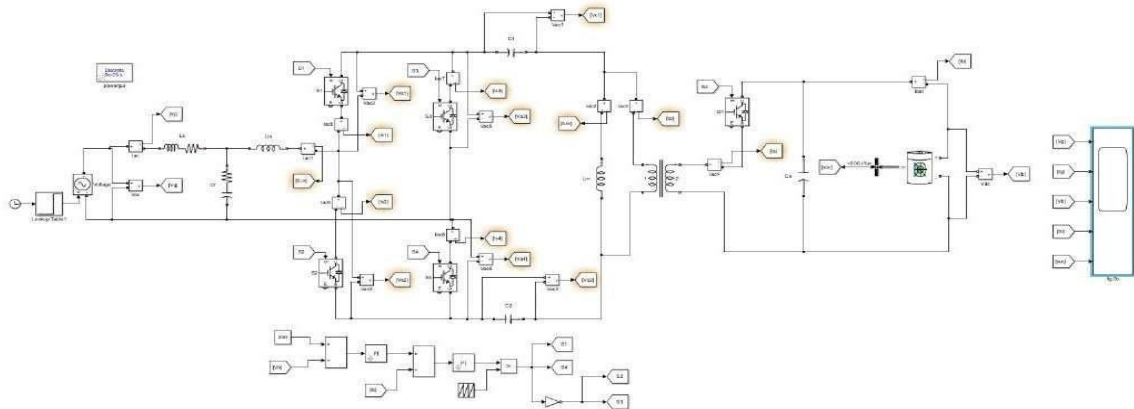


Fig3: Performance Analysis of LEV Charger with 240V Battery

V. CONTROL ALGORITHM

The control block diagram is displayed in Fig. 4. The charger controller that is being shown is intended for use in two different scenarios: grid-to-vehicle (G2V) and vehicle-to-home (V2H). EVs that are connected to the grid are used to charge their batteries during vehicle operation. The design is completed by taking into account the maximum voltage as the rated output voltage because the operation has a wide voltage range. In addition, the controller is made to supply the car with constant current-constant voltage (CC-CV) charging. The following are the controller's thorough descriptions for both G2V and V2H activities.

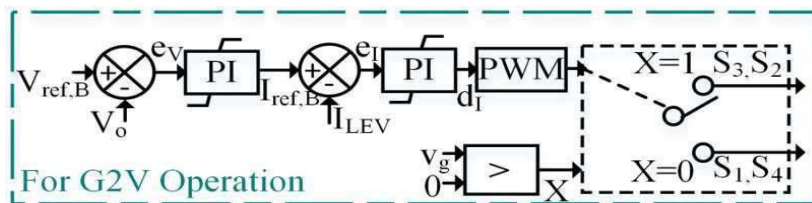


Fig4: Control block diagram (a) Grid to Vehicle Mode Control



A. Grid to Vehicle Mode Control

The controller for G2V operation is shown in Fig. 4(a). Notably, a proportional-integral (PI) controller is used to handle the voltage error once the battery voltage is sensed and compared to the reference battery voltage. The reference battery current is the PI controller's output. Following a comparison between the measured battery currents, the output inductor currents' envelope thanks to this DCM procedure. The grid current quality is controlled in this way, staying within the relevant bounds. As a result, both the complexity of the control and the need for current sensors are decreased.

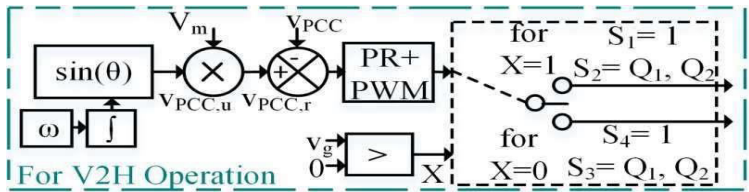


Fig4: (b) Grid to Vehicle Mode Control

B. Vehicle to Home Mode Control

At the charger's point of common coupling (PCC), the EV charger is in charge of controlling the AC voltage needed by the single phase home load during the vehicle-to-home mode control. In light of this, the reference AC voltage and the measured voltage at PCC are compared, and the proportional resonant (PR) controller is used to handle the computed error. As shown in Fig. 4(b), the output of the PR controller is employed in accordance with the voltage polarity. The controller provides the home load with power in this manner.

VI. RESULTS

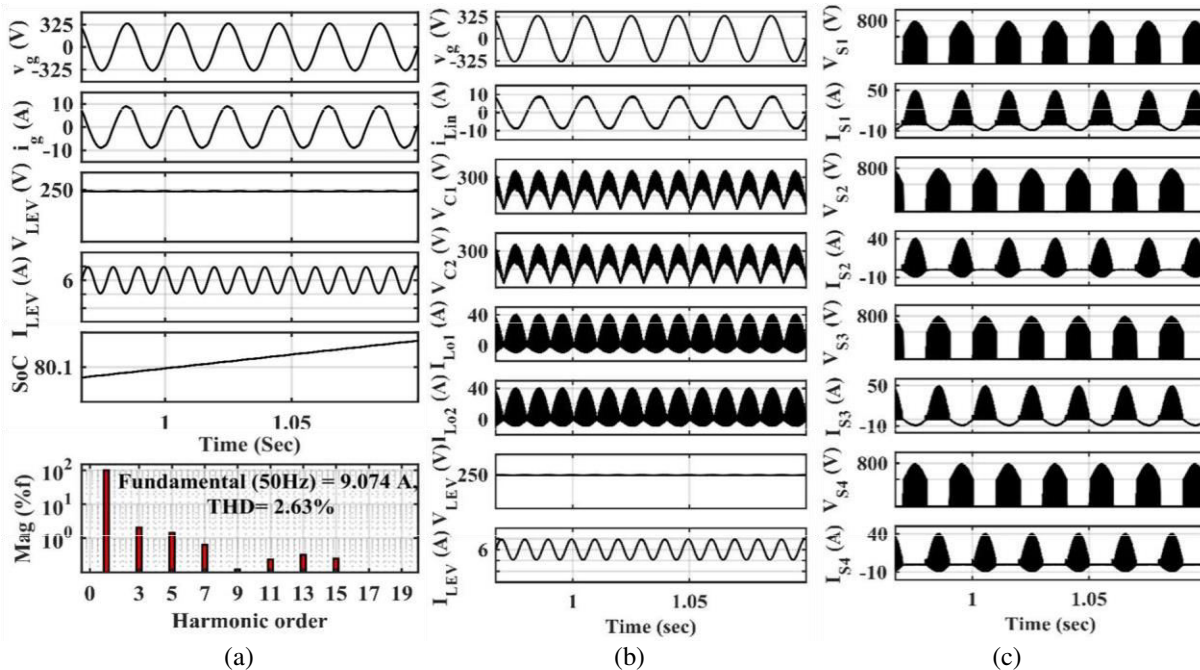


Fig6: Key waveforms of EV charger during charging of 72 V battery

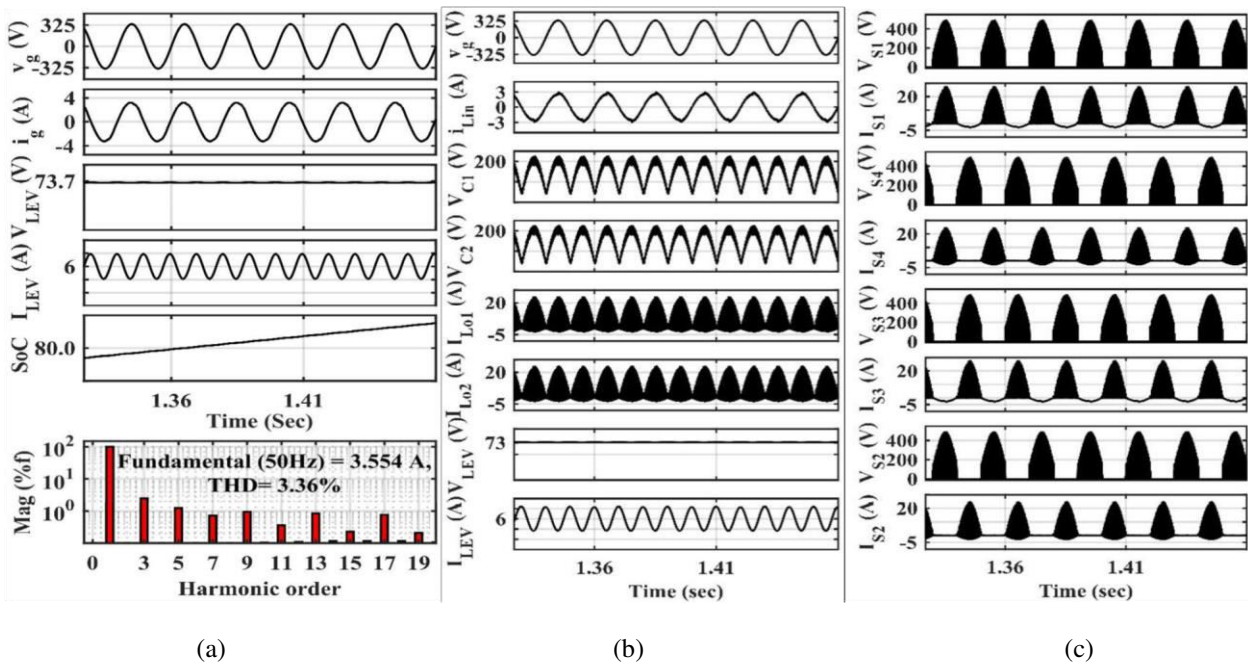


Fig7: Key waveforms of EV charger during charging of 240 V battery

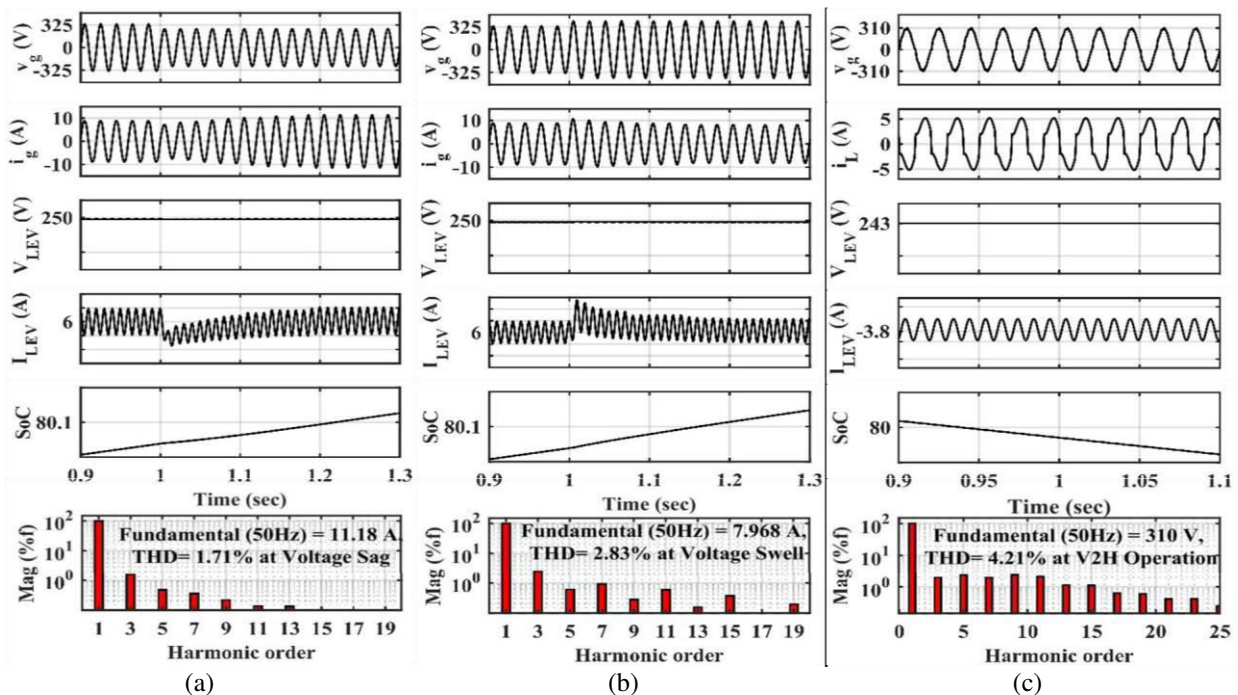


Fig8: Key waveforms of EV charger during charging of 240 V battery.

VII. CONCLUSION

This study realizes a singlestage bidirectional EV charger using a switching inductor-based Cuk converter. This EV charger's broad output voltage range is its key benefit. As such, it has the ability to charge both high voltage and low voltage electric vehicles (HEVs). Therefore, when batteries with nominal voltage ratings of 72 V and 240 V are being charged, the performance of the charger that is being offered is examined. Additionally, the effectiveness of the EV charger is evaluated to ensure that it complies with the IEC 610003-2 standard for power quality and the NEMA PE-5



standard for battery current bidirectional operation. Additionally, the demonstrated EV charger's dynamic and steady-state capabilities are evaluated in a variety of operating scenarios, including both ideal and variable grid voltage conditions.

REFERENCES

1. Khaligh and S. Dusmez, "Comprehensive Topological Analysis of Conductive and Inductive Charging Solutions for Plug-In Electric Vehicles," *IEEE Trans. Veh. Tech.*, vol. 61, no. 8, pp. 3475-3489, Oct. 2012.
2. M. Abbasi, K. Kanathipan and J. Lam, "An Interleaved Bridgeless Single-Stage AC/DC Converter with Stacked Switches Configurations and Soft-Switching Operation for High Voltage EV Battery Systems," *IEEE Trans. Ind. App.*, Early Access, Mar. 2022.
3. D. Zinchenko, A. Blinov, A. Chub, D. Vinnikov, I. Verbytskyi and S. Bayhan, "High-Efficiency Single-Stage OnBoard Charger for Electrical Vehicles," *IEEE Trans. Veh. Tech.*, vol. 70, no. 12, pp. 12581-12592, Dec. 2021.
4. P. Amiri, W. Eberle, D. Gautam and C. Botting, "A CCM Bridgeless Single-Stage Soft-Switching AC-DC Converter for EV Charging Application," *IEEE Energy Conv. Cong. and Expo. (ECCE)*, pp. 18461852, Oct. 2021.
6. Tausif, H. Jung and S. Choi, "Single-stage isolated electrolytic capacitor-less ev onboard charger with power decoupling," *CPSS Trans. Power Elect. and App.*, vol. 4, no. 1, pp. 30-39, Mar. 2019.
7. D. Patil and V. Agarwal, "Compact Onboard Single-Phase EV Battery Charger With Novel Low-Frequency Ripple Compensator and Optimum Filter Design," *IEEE Trans. Veh. Tech.*, vol. 65, no. 4, pp. 1948-1956, Apr. 2016.
9. R. Kushwaha, B. Singh and V. Khadkikar, "An Isolated Bridgeless Cuk- SEPIC Converter-Fed Electric Vehicle Charger," *IEEE Trans. Ind. App.*, vol. 58, no. 2, pp. 2512-2526, Apr. 2022.
10. Atseries, *Appl. Note JD5013-00*, Nov. 2006.
11. H. Kim, J. Park, J. Lee and S. Choi, "A Simple Modulation Strategy for Full ZVS of Single-Stage Electrolytic Capacitor-less EV Charger with Universal Input," in *IEEE Trans. Power Elect.*, Early Access, Apr. 2022.
12. K. Singh, R. Prasanna and K. Rajashekara, "Modelling and Control of Novel Bidirectional Single-Phase Single-Stage Isolated AC/DC Converter with PFC for Charging of EVs," *IEEE Intern. Conf. on Electro/Info. Tech. (EIT)*, pp. 0661-0666, May 2018.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details