



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 4, April 2025

Artificial Neural Network-Based Controller for Electric Vehicle-To-Vehicle Energy Transfer

Mr. C. Somasankarappa, Sayali Kachhwah , T.Ganga Pratap , M. Sandhya Reddy

Assistant Professor, Dept of EEE, CMR College of Engineering & Technology, Hyderabad, India

UG Student, Dept of EEE, CMR College of Engineering & Technology, Hyderabad, India

UG Student, Dept of EEE, CMR College of Engineering & Technology, Hyderabad, India

UG Student, Dept of EEE, CMR College of Engineering & Technology, Hyderabad, India

UG Student, Dept of EEE, CMR College of Engineering & Technology, Hyderabad, India

ABSTRACT: The current research work addresses the design and development of Artificial Neural Network (ANN)-based controllers for Electric Vehicle-to-Vehicle (EV-to-VV) energy transfer via On-Board Converters (OBCs). The focus is to make efficient and reliable of electric vehicle-to-vehicle energy transfer. The research incorporates the design and implement of ANN controllers to improve the power flow and effectively regulate the transfer process. Extensive performance analysis is done to study the conduction of the prefer controllers in terms of overall efficiency and reliability enhancement of EV-to-VV energy transfer. The outcomes of the current research work give the development of electric vehicle technologies and efficiency enhancement of energy transfer mechanisms to enable sustainable transportation systems, tested through a MATLAB/Simulink simulation study.

KEYWORDS: Electric vehicle (EV), on-board type-2 ac charger, vehicle-to-vehicle (V2V) charging, battery, DC-DC Converter, NN controller.

I. INTRODUCTION

EVs are conventionally charged by onboard Type-1 and Type- 2 chargers of 3.3 kW to 19.4 kW power rating using single- phase or three-phase AC power. Electric vehicle are charged within less than an hour with off-board DC fast chargers of power rating greater than 50 kW for quick charging. In spite of such advancements, few available charging points have existed, and this has generated range anxiety in EV users. V2V charging has been proposed as the second mechanism in order to charge two EVs with no available grid power or DC fast- charging point to transfer energy from one EV to another.

Two areas exist for V2V: communication, which decides on the energy receiver and provider with game theory-based algorithms to calculate preferences and intersection points, and power transfer, which is power control using buck or boost conversion based on voltage levels of the EV battery. Current V2V solutions consist of off-board bidirectional power converters, which are inefficient via redundant stages of conversion, or off-board commercial equipment like the Andromeda Power 50 kW V2V charger, which provide additional space and hardware requirements. An alternative solution exists in the direct connection to the DC-link of EVs, but this cannot be implemented in the absence of tailoring.

The paper provides a novel V2V charging method with onboard Type-2 chargers in which the two EVs' power inlet ports are directly connected without extra hardware or extra ports. Active rectifier stages serve as the interface of connection, and conversion stages are reduced to the minimum to restrict losses and maximize efficiency. The system also includes mode selection logic to switch between buck and boost modes based on battery voltage levels and power flow direction to allow the users to play the roles of energy providers or receivers.

II. LITERATURE SURVEY

The rapid development of electric vehicles (EVs) has immense potential to make cleaner energies a reality in the automotive sector. OBCs have extensive applications in EVs due to ease of installation and affordability. Minimal

vehicle space and reduced recharging time are required for an OBC to be power- dense and highly efficient. Apart from this, the emergence of EVs to supply power back to the grid has boosted the demand for bidirectional power flow solutions in the automotive sector. This paper provides an in-depth overview and study on the state-of-the-art solutions of bidirectional OBCs. This paper provides the current status, including configurations and architectures, intelligent operating modes, industry standards, key components, and existing commercial products. An in-depth review of the promising topologies of bidirectional OBCs, including two-stage and single-stage configurations, are discussed.

Integrated OBCs utilize the existing propulsion equipment to charge the battery without additional bulky hardware and/or special infrastructure compared to traditional off-board and on- board battery chargers OBCs are commonly classified as three- phase and single-phase topologies with unidirectional or bidirectional power flow. This paper begins by presenting the most appropriate topologies recently proposed in the literature, which utilize either induction or permanent magnet motors to support fully integrated slow (single-phase) and fast (three- phase) on-board EV battery charging systems and with special focus on those topologies with zero or negligible hardware reconfiguration. Although traditional double-layer distributed winding structure permanent magnet (PM) motors have been applied in most commercial EV motors, non-overlapped fractional slot concentrated winding (FSCW) has been the dominant topology in recent permanent magnet motor design designs due to its very promising operating characteristics.

III. PROBLEM STATEMENT

With rising popularity of electric vehicles (EVs), there is a growing need for advanced solutions to counter challenges of energy efficiency, range anxiety, and efficient use of on-board energy storage devices. The existing infrastructure of EV energy recharging is through charging stations, which, in all circumstances and geographical locations, can be suboptimal, especially in rural settings or in the event of emergencies. In addition, traditional energy transfer methods are rigid and inefficient under dynamic operational conditions.

The proposed project involves the development of an on-board converters-based V2V energy transfer system with controllers based on artificial neural networks. The aim is to enable efficient and intelligent energy exchange between EVs in real time with optimal energy distribution possible without impacting the stability of the system. The project aim is to solve some of the most important technical challenges such as precision in energy flow regulation, scalability of the system, and the capacity to handle variation in vehicle mix and energy requirement.

ANN-based controllers shall be utilized to create decision- making enhancements within the energy transfer, utilizing machine learning software to learn across various scenarios to achieve optimal operations. The project will transform EV energy sharing systems into an effective and solid EV ecosystem.

IV. METHODOLOGY

The method for Electric Vehicle-to-Vehicle (V2V) energy transfer relies on the utilization of on-board converters and Artificial Neural Network (ANN)-based controllers to enable efficient and smooth energy transfer. System architecture is first developed with bidirectional on-board converters capable of controlling energy exchange among EVs.

Mathematical models of on-board converters and battery systems are derived to model energy transfer dynamics, utilizing MATLAB/Simulink to examine system performance under various conditions. Data from simulation are gathered, such as battery State of Charge (SoC) and load levels, to train the ANN with supervised learning techniques. The ANN controller is deployed to optimize converter operation by forecasting parameters to ensure efficient energy transfer. A hardware prototype is developed, including the on-board converters, ANN-based controllers, and communication modules. Experimental trials are conducted under various conditions to evaluate transfer efficiency, speed, and controller stability. ANN performance is compared with conventional control techniques, examining critical parameters such as energy efficiency, response time, and system robustness. Scalability is also examined to determine the system's capability for multi-vehicle energy transfer. Experimental verifications eventually confirm the reliability of the proposed method in real applications.

V. PROPOSED V2V POWER TRANSFER CONTROL FLOW

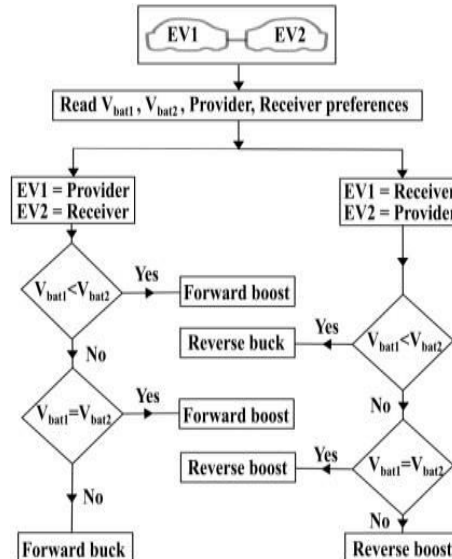


Fig . 1 Power transfer control flow

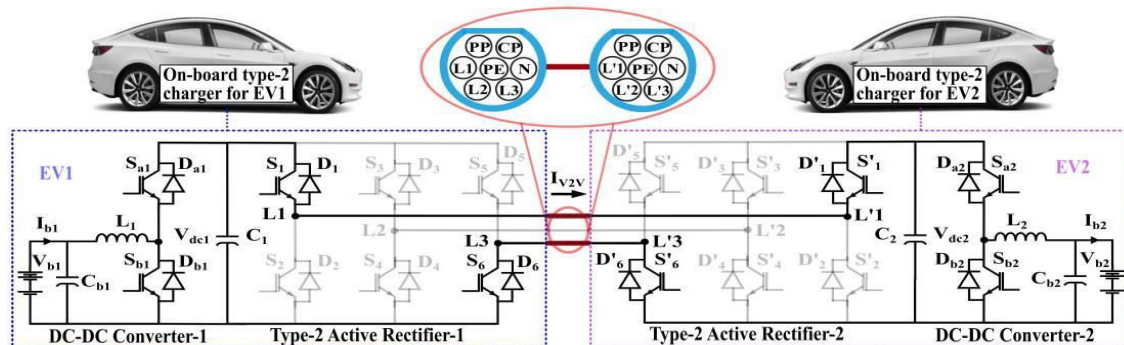


Fig. 2 Proposed topology for v2v operation

VI. CURRENT CONTROL STRUCTURE IN FORWARD BOOST AND REVERSE BUCK MODES ($V_{BAT1} < V_{BAT2}$)

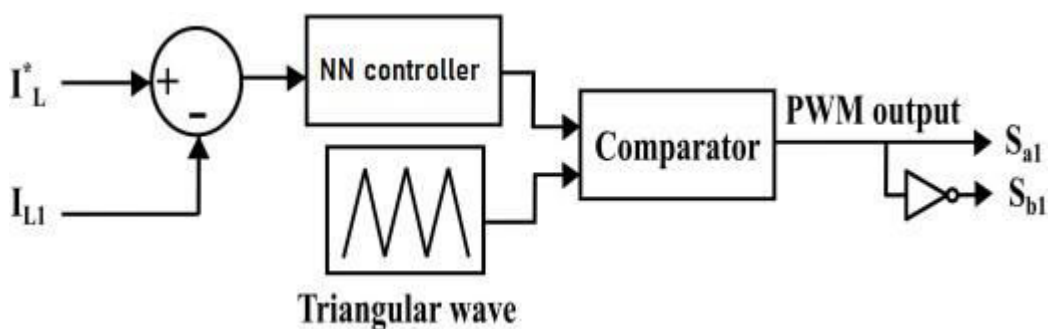


Fig. 3 Control structure

Bidirectional V2V power conversion interface is possible Realistic deployment of the envisioned commercial EV V2V approach expects that there is a communication link between EVs and controllers/instrumentation sensor access as discussed in [10]–[12] and suggests giving an efficient interface to the real power transfer in V2V through the hardware on the on-board type-2 charger. The provider EV and receiver EV are directly connected by utilizing the available on-board type-2 charging terminals for V2V energy transfer. Based on the battery voltage levels, provider, and receiver selection, obtained through the on-board instrumentation sensors and EV user inputs, the V2V mode is decided, as depicted in Fig. 6. Based on the selected mode of operation (e.g., forward boost), the power flow direction and the amount of energy transfer required are commanded by the on-board DSP controllers. Both the on-board chargers' active rectifiers are commanded to operate as an interface by enabling the top and bottom switches of any two legs. Upon the pairing of dc-links of the on-board chargers, based on the selected V2V mode the on-board chargers' battery side dc–dc converter is commanded in current-mode, to transfer the required charge to the receiving EV as described in the early parts of this section.

VII. BENEFITS OF USING ANN CONTROLLER

The requirement for an ANN controller occurs where conventional control methods cannot be used because the system to be controlled is too complex or operating conditions are too unpredictable. Here, an ANN controller can be of numerous benefits: Learning and adaptation capability: ANNs have the capability to adapt and change according to data and under changing conditions, which is beneficial for dynamic or variable systems. It is a process of continuously adapting in real time, an attempt to enhance performance and reduce errors. Nonlinear control: Real-world systems are mostly nonlinear and their output is not directly proportional to the input. ANNs are easily manageable by nonlinear systems because they are capable of learning any function to any degree of accuracy. Fault tolerance: ANNs are fault tolerant, i.e., it work for some of their components fail Parallel processing: ANNs can do parallel processing, i.e., they can do many calculations simultaneously. This can result in faster and more efficient control of complex systems. Generally, an ANN controller must be used whenever traditional methods of control cannot cope with the complexity, nonlinearity, or uncertainty of a system. ANNs offer a powerful and versatile tool of control that may learn and adapt to changing circumstances and maximize system performance

SIMULATION PARAMETRS

TABLE I
SIMULATION PARAMETERS OF THE PROPOSED V2V APPROACH

Parameter	Value
Battery-1 capacity (E_{bat1})	40 kWh
Battery-2 capacity (E_{bat2})	100 kWh
Battery-1 nominal voltage (V_{bat1})	350 V
Battery-2 nominal voltage (V_{bat2})	450 V
Switching frequency (f_{sw})	20 kHz
Filter inductor (L_1)	0.5 mH
Filter inductor (L_2)	0.6 mH
L_1 Internal resistance (R_1)	0.005 Ω
L_2 Internal resistance (R_2)	0.006 Ω
DC-link capacitor (C_1)	1000 μF
DC-link capacitor (C_2)	1100 μF
DC-DC converter-1 capacitor (C_{b1})	5.6 nF
DC-DC converter-2 capacitor (C_{b2})	5.8 nF

Fig. 4: Simulation parameters of the proposed V2V approach

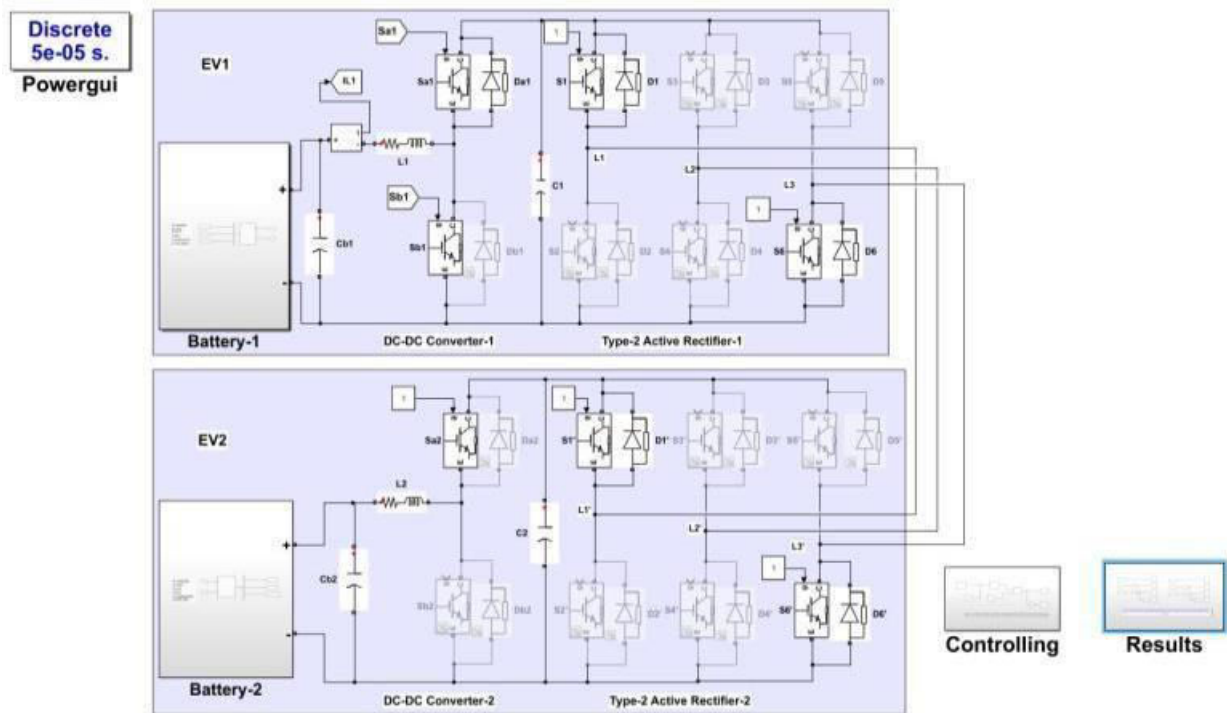


Fig. 5: Proposed V2V operation

VIII. RESULTS AND DISCUSSION

During this operational mode, the energy transfer from ev-1 to ev-2 battery done by controlling inductor current $IL1$. Starting with an initial reference inductor current IL^* set at 30A, it is incrementally raised in 10A steps up to 50A, controlling the discharge current $Ib1$ of the EV-1 battery. This control influences variations in EV-1's state of charge (SoCb1), voltage ($Vb1$), and discharged power ($Pb1$), depicted in Fig. 8a. Concurrently, the EV-2 battery undergoes a charging current $Ib2$, resulting in an increase in SoCb2, $Vb2$, and charged power ($Pb2$), displayed in Fig. 8b. Positive battery currents represent discharging, while negative values indicate battery charging, with both currents

Simulink Model of Results

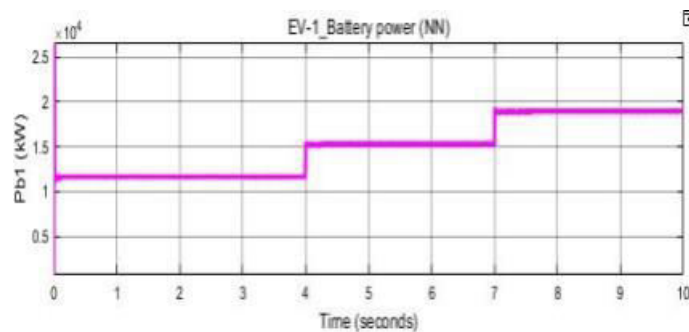


Fig. 6: Power of battery 1

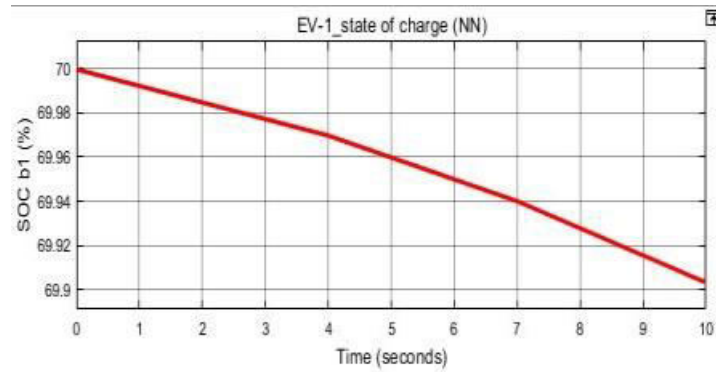


Fig. 7: State of charge of battery 1

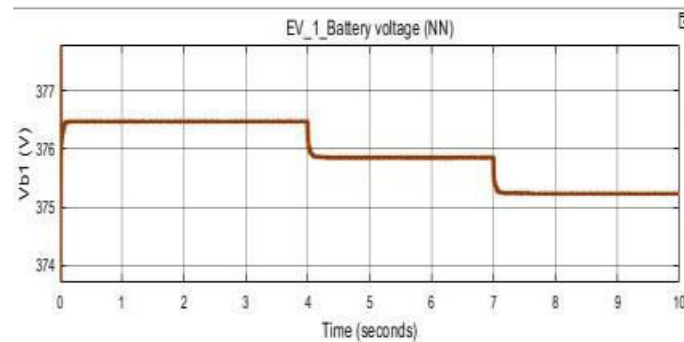


Fig. 8 : Voltage of battery1

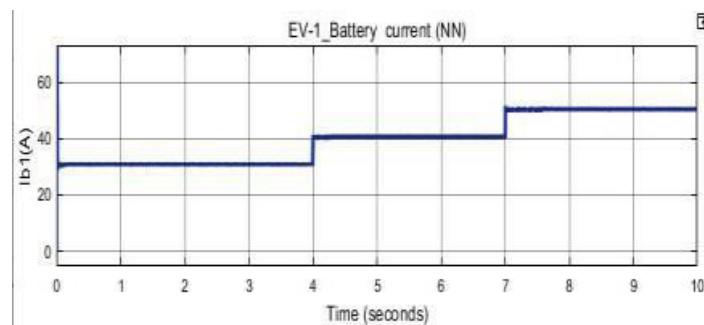


Fig. 9: Current of battery1

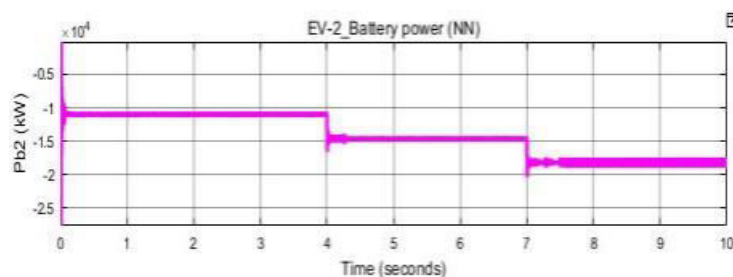


Fig. 10: Power of battery 2

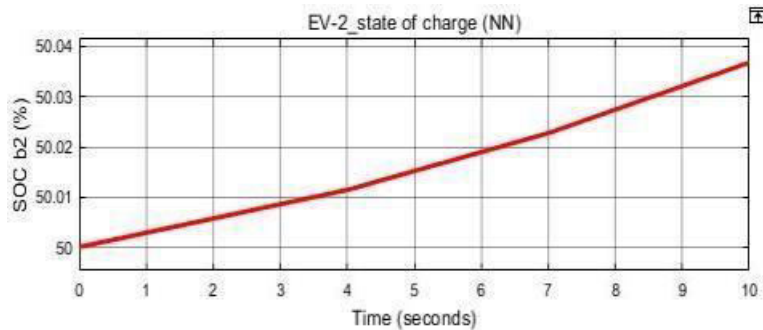


Fig. 11: State of charge of battery 2

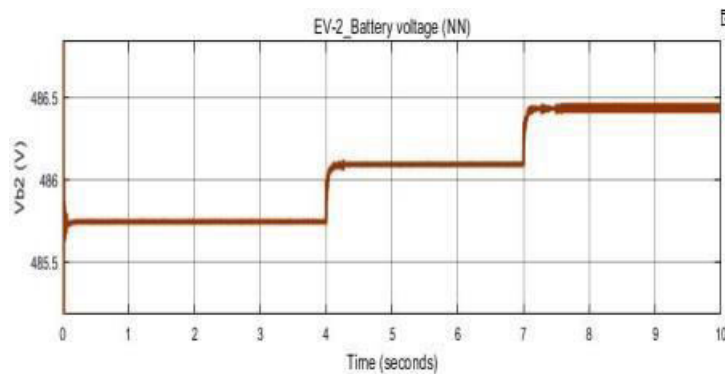


Fig. 12: Voltage of battery 2

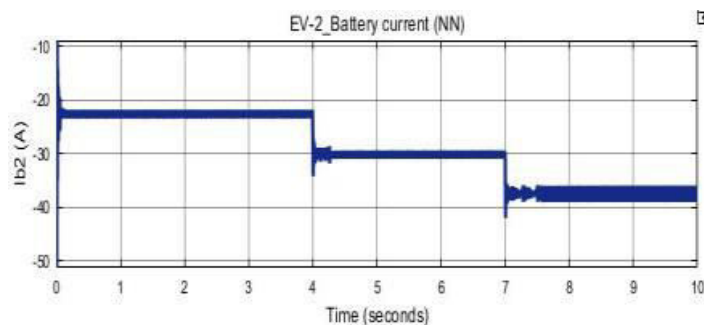


Fig. 13: Current of battery 2

IX. CONCLUSION

In conclusion, the implementation of Artificial Neural Network (ANN)-based controllers for Electric Vehicle-to-Vehicle energy transfer through On-Board Converters has proven to be a highly effective approach. Utilizing MATLAB Simulink, the controllers demonstrated significant improvements in power flow optimization and overall efficiency during simulated scenarios. The adaptability and robust performance of the ANN controllers were evident across diverse operational conditions, highlighting their potential for practical application. This research contributes to the advancement of electric vehicle technologies by providing a concrete and efficient solution for optimizing energy transfer mechanisms. Future work may focus on real-world validation and further refinement of the neural network models to ensure seamless integration into evolving electric vehicle systems. Overall, the study establishes ANN controllers as a promising tool for enhancing the sustainability and performance of electric vehicle-to-vehicle energy transfer systems.

REFERENCES

- [1] M. R. Khalid, I. A. Khan, S. Hameed, M. S. J. Asghar, and J.-S. Ro, "A comprehensive review on structural topologies, power levels, energy storage systems, and standards for electric vehicle charging stations and their impacts on grid," *IEEE Access*, vol. 9, pp. 128069–128094, 2021.
- [2] M. Yilmaz and P. T. Krein, "Review of battery charger topologies, charging power levels, and infrastructure for plug-in electric and hybrid vehicles," *IEEE Trans. Power Electron.*, vol. 28, no. 5, pp. 2151–2169, May 2013.
- [3] G. Li, L. Boukhatem, L. Zhao, and J. Wu, "Direct vehicle-to- vehicle charging strategy in vehicular Ad-Hoc networks," in *Proc. 9th IFIP Int. Conf. New Technol., Mobility Secur. (NTMS)*, Jan. 2018, pp. 1–5.
- [4] R. Q. Zhang, X. Cheng, and L. Q. Yang, "Flexible energy management protocol for cooperative EV-to-EV charging," *IEEE Trans. Intell. Transp. Syst.*, vol. 20, no. 1, pp. 172–184, Jan. 2019.
- [5] E. Bulut and M. C. Kisacikoglu, "Mitigating range anxiety through vehicle to-vehicle social charging system," in *Proc. IEEE 85th Veh. Technol. Conf. (VTC Spring)*, Jun. 2017, pp. 1– 5.
- [6] P. You and Z. Yang, "Efficient optimal scheduling of charging station with multiple electric vehicles via V2V," in *Proc. IEEE Int. Conf. Smart Grid Commun. (SmartGridComm)*, Nov. 2014, pp. 716–721.
- [7] A.-M. Koufakis, E. S. Rigas, N. Bassiliades, and S. D. Ramchurn, "Towards an optimal EV charging scheduling scheme with V2G and V2V energy transfer," in *Proc. IEEE Int. Conf. Smart Grid Commun. (SmartGridComm)*, Nov. 2016, pp. 302–307.[7] E. Ucer et al., "A flexible V2V charger as a new layer of vehicle-grid integration framework," in *Proc. IEEE Transp. Electrific. Conf. Expo (ITEC)*, Jun. 2019, pp. 1–7.
- [8] P. Mahure, R. K. Keshri, R. Abhyankar, and G. Buja, "Bidirectional conductive charging of electric vehicles for V2V energy exchange," in *Proc. 46th Annu. Conf. IEEE Ind. Electron. Soc. (IECON)*, Oct. 2020, pp. 2011–2016.



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