Educational Administration: Theory and Practice
2024, 30(11), 970 - 976
ISSN: 2148-2403
https://kuey.net/
Research Article

Development of a Bidirectional Dc-Dc Converter for Electric Vehicle Charging

Rajesh Boddepalli[1*] , Dr. Bibhuti Bhusan Rath[2] , Sri Karudumpa Suneel Goutham[3]

[1*]Electrical and Electronics Engineering, Aditya Institute of Technology and Management, An Autonomous Institute, K.Kotturu, Tekkali-532201, Srikakulam Dist. A.P 2023 Email ID- boddepallirajesh9398@gmail.com
[2]M.Tech, PhD, Associate Professor of EEE Department, Aditya Institute of Technology and Management, An Autonomous Institute, K.Kotturu, Tekkali-532201, Srikakulam Dist. A.P 2023
[3]M. Tech, PhD, Asst. Professor of EEE Department, Aditya Institute of Technology and Management, An Autonomous Institute, K.Kotturu, Tekkali-532201, Srikakulam Dist. A.P 2023

Citation: Rajesh Boddepalli et al , (2024), Development of a Bidirectional Dc-Dc Converter for Electric Vehicle Charging, *Educational Administration: Theory and Practice*, 30 (11) 970 - 976
Doi: 10.53555/kuey.v30i11.8932

ARTICLE INFO

ABSTRACT

Over the last few centuries, discussion of electric vehicles (EVs) has evolved within the automobile industry. The rise of EVs is significantly aided by their charger. This study suggests an integrated DC/DC converter for use in second-level electric car chartering. So, the suggested converter is bidirectional, capable of providing electricity from batteries directly to the grid is dubbed Vehicle to Grid (V2G) utilisations. Also, the DC-DC converter is created by combining boost and buck converters, and as a result, it can operate in both boost and buck techniques for charging and discharging. The DCDC converter steps down the voltage (Dc-link) while charging Grid to Vehicle (G2V) to battery voltage and provides the necessary charging current through CC. This is the charging step in the buck process. The DC-DC converter's function throughout the V2G procedure is to increase the battery voltage in order to supply the dc link voltage. It is foreseeable for the converter to achieve high efficiency.

Key words: DC-DC Bidirectional Converter; Electric Vehicle Charging; Current Control (CC)

INTRODUCTION

As well recognized, electric vehicles (EVs) are known for their higher power conversion efficiency, lower emissions of exhaust pollutants, and reduced levels of noise and vibration, as compared to cars powered by internal combustion engines (Phillips et al., 2000). The battery plays a pivotal role in the progress of EVs. In contemporary society, the prevalence of electric cars has increased significantly. Consequently, there is a pressing need to priorities the establishment of EV charging infrastructure in order to meet the growing demand for electrical energy from the substantial fleet of EVs. EVs are powered by electricity, in contrast to the primary conventional sources of energy derived from fossil fuels. EVs may acquire energy from external sources via off-board charging and store it in a battery, or generate electricity on board using fuel cells. The development of EVs may be traced back to 1835, when Thomas created the first battery-powered EV (Lü et al., 2020).

The Battery Electric Vehicle (BEV) has garnered significant attention in recent years as a subject of interest for both automotive industry professionals and scientific academics. The schematic representation of the hybrid electric vehicle/electric vehicle (HEV/EV) system is shown in Figure 1,

The suggested arrangement efficiently mitigates the negative effects of circulating current, while simultaneously lowering conduction loss and switching stress. Furthermore, the experimental findings provide assurance that the suggested arrangement effectively mitigates the occurrence of voltage spikes during the operation of the converter.

The suggested converter demonstrates the capability to efficiently include a soft-switching feature via the use of the precharging technique. This approach successfully mitigates the negative impact of inrush current during the beginning condition.

The suggested arrangement mitigates the voltage and current strain experienced by the semiconductor components of the low-voltage inverter and As a consequence, the efficiency of the isolated BDC is enhanced.

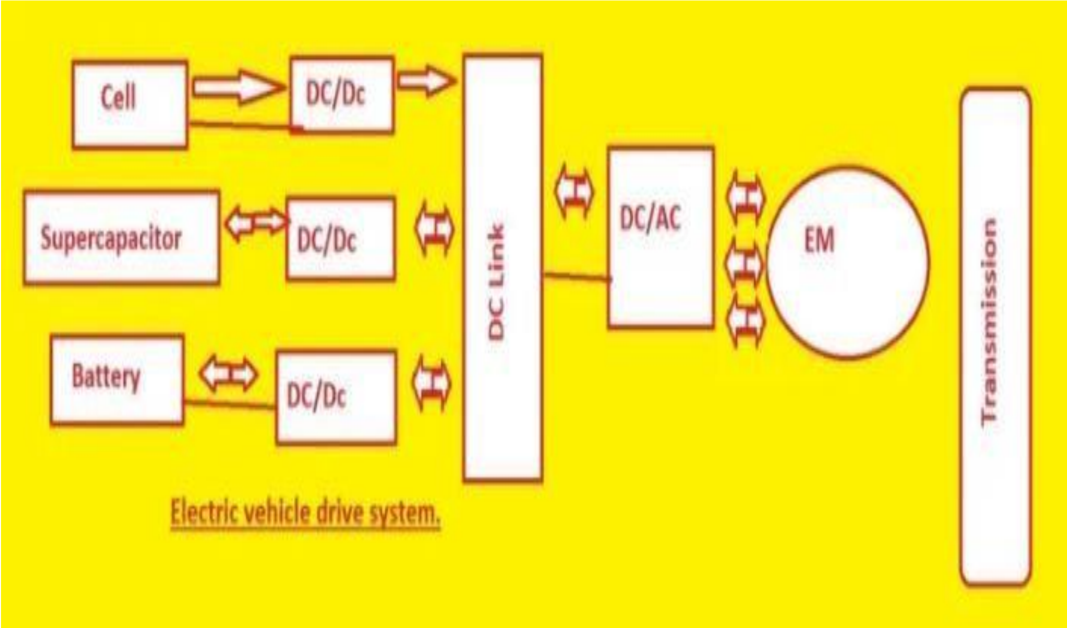


Figure.1 Scheme construction of EV (Mohammed et al., 2020)

The globe is increasingly moving towards green technology as a result of worries about the negative environmental impacts of using fossil fuels. EV utilization is one of green technology's promising aspects. By the end of 2021, there were expected to be 16.5 million EVs—both plug-in hybrid electric vehicles (PHEV) along with battery electric vehicles (BEV)—on the planet's roads. According to the Stated Policies scenario (IEA, 2022) this count will increase even further, with the predicted worldwide EV stock reaching approximately 200 million by 2030. As seen in Figure 1, there is a rise in two- or even threewheeled light electric vehicles (LEVs). This is due to their manageable size and suitability for usage in public transit in nations looking to lower their carbon footprint (Will et al., 2021).

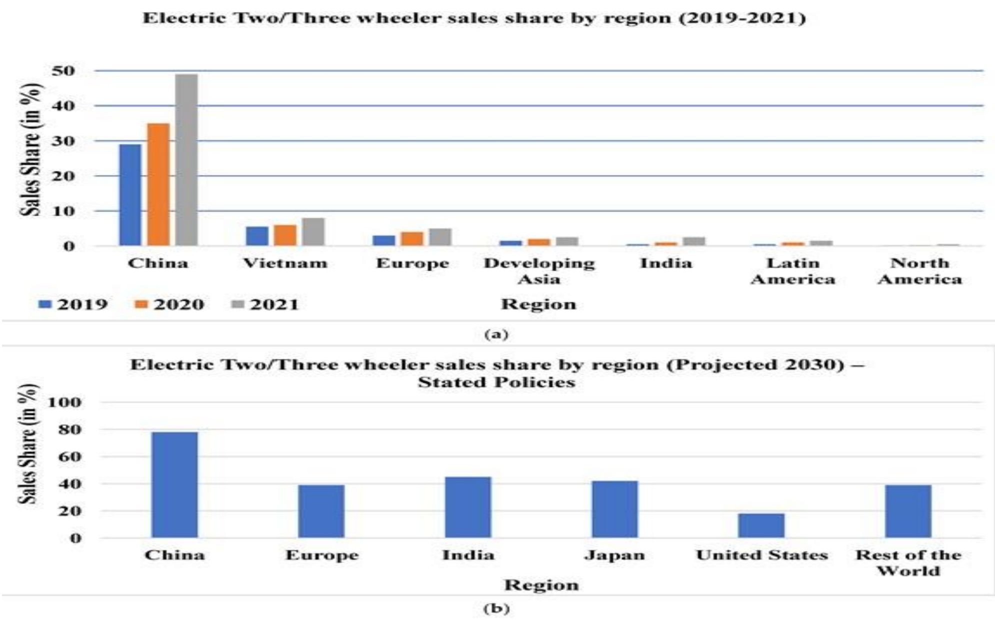


Figure.2 Electric Vehicle sales trend in various regions. (a) Growth from 2019 to 2021 (b)

LITERATURE REVIEW

In this section Table 1 shows the review of previous study on comparison of different converter based on their performance. Comparison between converters are based on their maximum conversion efficency, high side voltage and low side voltages.

Table.1Performance Comparison among a variety of converters

Switching control structure		Bidirectional Power Flow	Out put rippl e	Number of PWM Controlled switches	Passive Compo nents	Realized prototype power rating	Maximum conversion efficiency	High-Side Voltag es	Low side Voltages
Hint teal., 2015	Single phase	Yes	Medi um	6	5	5KW	91.50%	300V	VES1: 125V VES2: 144V
Lin and Chao, 2013	Single phase	No	High	5	7	1KW	94%	400V	VES1: 30~50 V VES2: 50~100V
Chen and Huang, 2013	Single phase	No	Low	4	15	90 W	93%	540V	VES1: 240~300V VES2: 240~300V
Wai and Chen 2014	four phases	Yes	Low	8	4	5KW	95%	200V	VES1: 42~63 VES2: 48V

Research Gap

The researchers have been driven by the scarcity of resources and growing environmental consciousness to pursue the development of energy systems with enhanced efficiency. The EV has appealing characteristics, such as its ability to provide enhanced efficiency throughout both accelerating and braking phases. BEVs are renowned for their environmentally friendly nature, since they produce no pollution during operation. However, one notable drawback of BEVs is the significant amount of time required for charging their batteries. The process of choosing DC-DC converters poses a significant challenge in order to get an improved and more efficient solution. The progress in energy harvesting and technological advancements has garnered the attention of researchers in EVs along with HEVs. The use of unidirectional DC-DC converters has been considered for energy storage applications; however, it has been shown that bidirectional DCDC converters provide a more optimal option.

OBJECTIVE

1. To study design and analysis of modified bidirectional DC-DC convertor topologies for EV charging.
2. To design along with evaluate modified soft-switching technique to overcome the switching losses and improve overall efficiency of EV.

MATERIAL METHODOLOGY

Since the inception of the first electric cars, there have been several distinct charging methods devised (Pesaran, et al., 2009). The charger must be classified based on various public strategy and application architectures due to its several components. In accordance with the study conducted by Zhang and Xie (2009), Table 1 provides an elucidation of the six methodologies used for the categorization of charges, as outlined by Ahmed et al. (2020).
For electric cars, there aren't really three unique charging levels (Mohammed, 2020). The normal charging modes that will take effect if the vehicle is left to stand for a long period of time are either Level 1 or Level 2 (Botte et al., 2000).

Table.2 The Categorization of Electric Vehicle (EV) Chargers

Cataloguing form	Alternatives
The Construction	Dedicated and Integrated
Place	On-Board ad Off-Board
Connective form	1. Conductive
	2. Inductive
	3. Mechanical
Input Power	Ac and Dc

The Power flow	Unidirectional and Bidirectional
Levels of charging	Level 1
	Level 2
	Level 3

Table.3 The Levels of Charging for Electric Vehicles

The Level of Charging	**AC Input Voltage(V)**	**Maximum Current (A)**	**Maximum Power (KW)**
Level 1	110-120	16-18	2
Level 2	240-260	80-90	20
Level 3	300-500	200-400	250

The longevity and charging duration of the battery have a significant impact on the characteristics of the battery charger. Numerous manufacturers are now engaged in worldwide operations focused on the development of various battery components for EVs (KURNAZ and Mohammed, 2020). However, the manner in which battery segments are presented is influenced not only by the approach of components, but also by how the modules are used. According to Sahib et al. (2020), the chargers were vital in the progress of this particular skill set.

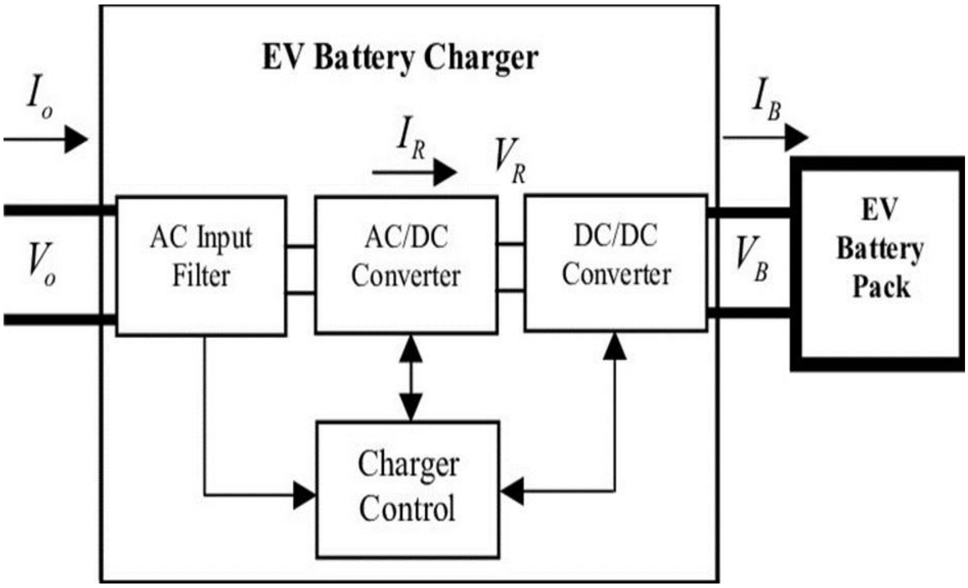


Figure.3 Battery charger system

The schematic representation of the battery charger architecture is shown in Figure 2. Given that batteries possess a limited energy capacity, EVs need periodic recharging, often accomplished by connecting to the power grid. Also, the EV charger consists of an AC/DC diode rectifier that converts AC power into a DC link voltage (Mushref, et al., 2020). This is then followed by a DC/DC converter that generates the required DC link voltage for the battery.

The traditional bidirectional EV charger has two main components: the first being an active grid that incorporates a bidirectional AC-DC rectifier responsible for power factor correction, and the second being a bidirectional DC-DC converter used to regulate battery current. The chargers may be classified into two system configurations: non-isolated DC/DC converters along with isolated DC/DC converters. Also, non-isolated converter offers many benefits, including the reduction of ripple in the output current, increased system efficiency, enhanced power density, and improved heat dissipation capacity. The reduction in the number of switches leads to a decrease in conduction losses due to the existing shunt in the parallel route. By using the interleaving method inside the dc-dc converter, it is possible to mitigate the ripple present in the input current and output voltage, while avoiding any additional burden on switching loss. Consequently, this approach leads to an enhancement in the overall efficiency of the system. When operating in the charging mode, it is necessary to generate a sinusoidal current waveform that exhibits a distinct phase angle in order to regulate reactive power along with power. During the discharge mode, any charger is required to restore the current inside a similar sinusoidal waveform. Also, a bidirectional charger is capable of both receiving charge from the network-grid and returning excess battery power back to the grid. This procedure is often called the V2G mode and is associated with maintaining energy balance (Mohammed et al., 2020).

The circuit presented in Figure 3a is a bidirectional two-quadrant charger that operates without isolation. The proposed circuit consists of two switches that greatly simplify the control of the motherboard. However, it should be noted that this circuit incorporates two inductors that tend to possess significant size and expense. Furthermore, its functionality is limited to bucking in a single direction and boosting in the opposite way. The proposed modification of the circuit, as seen in Figure 3b, entails an isolated bidirectional dual-active bridge charger.

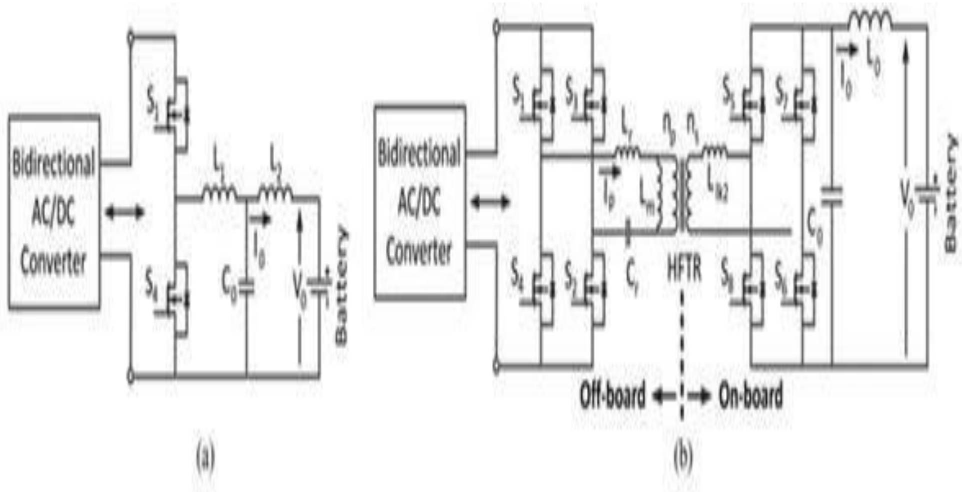
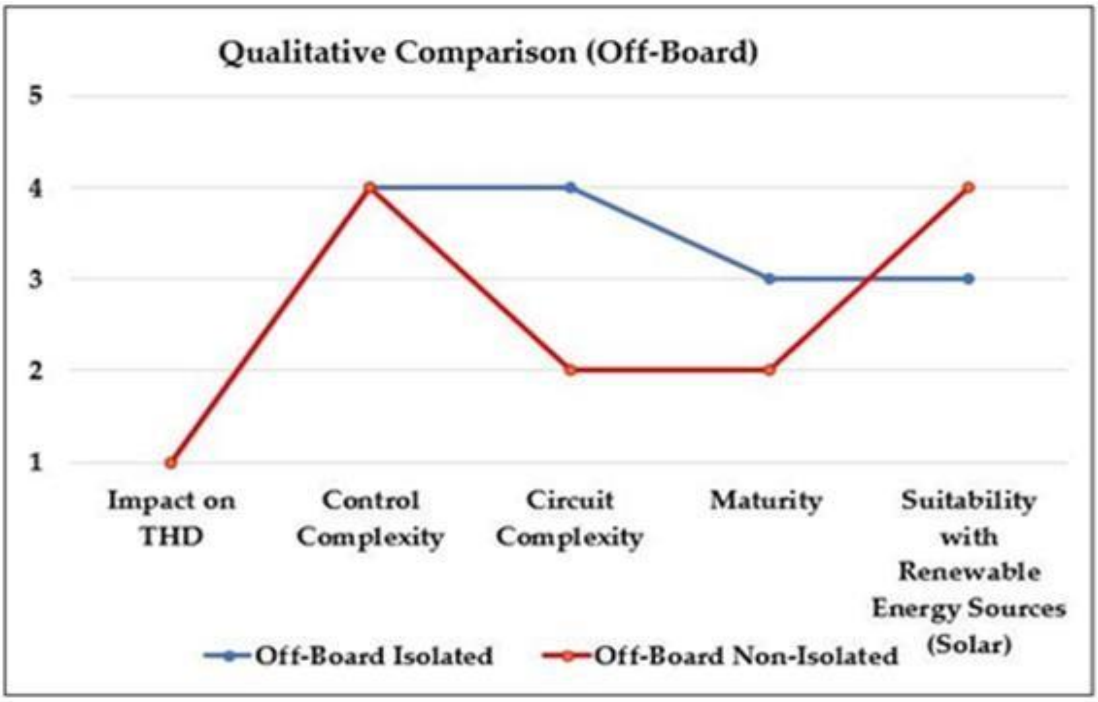


Figure .4 (a)Non-Isolated Bidirectional Two-Quadrant Charger (b) Isolated Bidirectional dual active Bridge Charger

RESULT AND DISCUSSION

The figure presents a qualitative contrast of on-board along with off-board DC-DC converter topologies based on the literature that were read. Characteristics including the effect on supply THD, along with control and also circuit intricacy, technological maturity, along with appropriateness for PV incorporation are included in this comparison. Additionally, work must be done to maximize the V2G capability of LEV charges. Using a bidirectional converter in place of the DBR stage is one approach to do this. In addition to the apparent benefit of V2G potential, they differ from multistage converters that employ a DBR stage in that they have fewer components and a higher power density. For non-isolated topologies, bidirectional functionality is very advantageous. This converter was distinguished by its straightforward operation, minimal component count, and shared ground between the power source and the battery.

(a)



(b)

Figure.5 Qualitative Comparison of (a) On-Board and (b) Off-Board DC-DC Converters. On a scale of 1 to 5,1 = lowest and 5 = highest

CONCLUSION

An evaluation of non-isolated based high gain bidirectional DC-DC converters for supercapacitor interface in EV vehicles has been completed in this paper. Non-isolated topologies are taken into consideration in this evaluation due to their inherent benefits, which include lower cost, weight, and size compared to their isolated counterparts, as well as improved efficiency, all of which are desirable for the aforementioned application. The best converters for these applications have a high capacity for stepping up and down, less stress on the switches, and a small number of overall components. As a result, the voltage gain in the boost and buck modes of both groups of converters have been compared. This study examines the proposition of a level 2 electric car charger, as well as the design along with execution of a DC/DC converter for the battery charger's charging power. The proposed circuit has exceptional power density and rapid control capabilities.

REFERENCES

1. Phillips, M., Jankovic, M., and Bailey, K. E. (2000). Vehicle system controller design for a hybrid electric vehicle. in Proceedings of the 2000. IEEE International Conference on Control Applications. Conference Proceedings (Cat. No. 00CH37162), pp. 297–302.
2. Lü, X et al., (2020). Energy management of hybrid electricvehicles: A review of energy optimization of fuel cell hybrid power system based on genetic algorithm," Energy Convers. Manag., vol. 205, p. 112474.
3. Mohammed, A. H., Shantaf, A. M., and Khalaf, M. (2020). The Probe into Reflection Mobile Radio Propagation. International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA), pp. 1–
4. International Energy Agency. *Global EV Outlook 2022*; IEA: Paris, France, 2022.
5. Will, S.; Luger-Bazinger, C.; Schmitt, M.; Zankl, C. (2021) Towards the future of sustainable mobility: Results from a European survey on (electric) powered-two wheelers. *Sustainability*, *13*, 7151.
6. Hintz, A., Prasanna, U. R., and Rajashekara, K. (2015). Novel modular multiple-input bidirectional DC–DC power converter (MIPC) for HEV/FCV application. IEEE Transactions on Industrial Electronics, vol. 62, no. 5, pp. 31633172.
7. Lin, B. R., and Chao, C. H. (2013). Soft-switching converter with two series half-bridge legs to reduce voltage stress of active switches. IEEE Transactions on Industrial Electronics, vol. 60, no. 6, pp. 2214-2224.
8. Chen, Y. M., Huang, A. Q., and Yu, X. (2013). A high step-up three-port dc–dc converter for stand-alone PV/battery power systems. IEEE Transactions on Power Electronics, vol. 28, no. 11, pp. 5049-5062.
9. Wai, R. J., and Chen, B. H. (2014). High-efficiency dual-input interleaved DC–DC converter for reversible power sources. IEEE Transactions on Power Electronics, vol. 29, no. 6, pp. 2903-2921.

10. Pesaran, A. A., Markel, T., Tataria, H. S., and Howell, D. (2009). Battery Requirements for Plug-in Hybrid Electric Vehicles--analysis and Rationale. National Renewable Energy Lab.(NREL), Golden, CO (United States).
11. Li, S., Zhang, C., and Xie, S. (2009). Research on fast charge method for lead-acid electric vehicle batteries. International Workshop on Intelligent Systems and Applications, pp. 1–5.
12. Ahmed, A. H., Al-Heety, A. T., Al-Khateeb, B., and Mohammed, A. H. (2020). Energy Efficiency in 5G Massive MIMO for Mobile Wireless Network. International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA), pp. 1–6.
13. Mohammed, A. H., Hamdi, M. M., Rashid, S. A., and Shantaf, A. M. (2020). An Optimum Design of Square Microstrip Patch Antenna Based on Fuzzy Logic Rules. International Congress on Human- Computer Interaction, Optimization and Robotic Applications (HORA)pp. 1–7.
14. Botte, G. G., Subramanian, V. R., and White, R. E. (2000). Mathematical modeling of secondary lithium batteries. Electrochim. Acta, vol. 45, no. 15–16, pp. 2595–2609.
15. KURNAZ , S., and Mohammed, A. H. (2020). Secure Pin Authentication in Java Smart Card Using Honey Encryption. International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA), pp. 1–4.
16. Sahib, Z. A., Uçan, O. N., Talab, M. A., Alnaseeri, M. T., Mohammed, A. H., and Sahib, H. A. (2020). Hybrid Method Using EDMS & Gabor for Shape and Texture," in 2020 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA), pp. 1–6.
17. Mushref, A. G., Mohammed, A. H., and Bayat, O. (2020). Rayleigh Leistungs Relation and Rician Fading Channels in Qam Using Simulink Environment. International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA), pp. 1–5.