MMC BASED HYBRID SWITCHED CAPACITOR DC-DC CONVERTER

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ABSTRACT

The purpose of this study is to suggest a development strategy that can support the growing integration and expansion of electronic loads as well as renewable energy sources. Beginning with a medium frequency isolated Modules Multilevel Converter, a number of other dc-dc topologies that have features that are targeted to the end user have been made available. The simulation validation and theoretical analysis of an AC DC with PFC based on MMC converter applications are the topics that are covered in this research. The ideas of the interleaving converter and combined power stage are utilized in this design, which is founded on the flexible multilevel conversion (MMC) methodology. Galvanically insulated and connected by a single magnetic core operating at a medium frequency, the grid-side and load-side conversions are both operated by the same magnetic core.

I INTRODUCTION

Developing DC–DC converters that are based on multilayer structures and are capable of reliably connecting medium/high voltage dc grids (MVDC/HVDC) and low/medium current dc power loads, such as data centers, electrified transportation, and electrical vehicles, has been the objective of this research. A Modular Multilevel Structure In this architecture, the converter, also known as the MMC, is an essential component because of its modular design and its capacity to make use of well-known electronic technology. In this regard, medium frequency isolated direct current-direct current topologies that are based on MMC have been created. It is possible to use the transformer spins ratio to improve the interface between the rectifier stages and the inverter. This is in addition to the fact that it can improve fault protection. An additional benefit of the medium frequency operation is that it results in a reduction in both the volume and weight of the converter. The higher frequency, on the other hand, has a tendency to raise the dv/dt that is placed on the windings. This might potentially limit the medium inverter's ability to reduce its volume and weight, which would make its design highly challenging. Nevertheless, the transformer is required to be traversed by the entirety of the power that is processed by the converter. Reducing the amount of power that is produced by the transformer is the goal of the dc auto-transformer converter that has been presented. This topology, which is likewise based on MMC with Half-Bridge (HB) sub modular (SM), enables some power to flow directly from the input dc voltage source to the load, hence reducing the transformer power rating. This is made possible by the fact that there is a direct electrical connection between the inverter unit and the rectifier stages. In spite of this, the configuration in question leads to a reduction in the converting fault blocking capabilities as well as the galvanic isolation across the dc terminals. This is the case unless more complex SM topologies are applied in place of HB. The voltage balancing of both the lower and upper arms is often accomplished by these topologies by the utilization of either an MMC arm inductor or a capacitive route. In situations when there is a significant variation in both the input and the output voltage, it is necessary to have a high alternating current current and/or large arm passive components in order to accomplish this balance. Because of this, the efficiency of the component is low, and the capacity of the component is not utilized properly under these circumstances. This drawback can be circumvented by employing a number of different current source modules to act as mediators for the energy that is transmitted to the DC terminals. Due to the fact that an increase in the number of SMs leads in a decrease in the maximum output voltage, these topologies are suitable for applications that require a high voltage ratio across the dc input and output.

II LITERATURE SURVEY

The isolated DC/DC structure that was proposed by S. Kenzelmann et al. (2015) [1] was created with the help of a modular multilevel converter. For the year 2018, Sharon Sanjeev George Make an effort In electric vehicles, also known as EVs, clean energy is utilized in a significant, vital way. What makes these vehicles viable for mass transit is the power pack's capacity to make efficient use of the energy that it has stored [2]. Gagandeep Singh and Shalki Srivastava's recommendation from 2019 [3] suggests that a non-isolated large-gain DC-DC converter should be utilized for photovoltaic (PV) applications whenever possible. With a high step ratio, X. Xiang et al. (2018) [4] proposed a DC-DC converter that is compact, modular, and multilayer in design. A transformer-less bipolar multistring DC-to-DC converter that makes use of series-connected voltages was introduced by N. R. Zargari and colleagues in the year 2017. During the year 2017, S. Du and B. Wu came up with the idea of a wide voltage ratio bipolar modular multilayer DCDC converter that did not require a transformer [6]. They proposed an adjustable multilayer high-voltage direct current (HVDC) buck-boost converter [7] based on its switched-mode equivalent. S. H. Kung and G. J. Kish (2018). For the purpose of high-voltage direct current (HVDC) connections, G. J. Kish et al. (2015) suggested a modular multilayer DC to DC converter that allowed for defect block capability [8]. A three-tier modular DC/DC converter that is capable of being utilized in a high-voltage DC grid was proposed by You and Cai X. in the year 2018 [9]. A modular multilayered DC–DC converter that offers characteristics that are comparable to those of a flying capacitor converter was proposed by P. Gray and its colleagues in the year 2022 [10]. When it came to the inverter application, [11] investigated the use of a limited number of switches in their research. An effort was made by Kish and others to develop a multilayer DC to DC conversion that is capable of fault blocking. I am [12].

III METHODOLOGY

The suggested article describes an ac-dc converter that is based on the MMC and incorporates power factor corrections. Additionally, the converter does not require a transformer. It is composed of an output LC filter that is composed of Lo and Co, a flying capacitor (Cf), and four sets of N SMs that are connected in series and are now referred to as arms (Aa, Ab, Ac, and Ad). vLC is the definition of the input voltage of the LC filter, and it is equal to vLo plus power. In spite of the fact that the research being conducted for this project is centered on topology functioning in Buck mode, it is possible to use it in a manner that is analogous to derive the equations regarding Boost mode as well. It is possible to specify particular features in order to establish the configuration of the SM. An example of this would be that HB SMs will provide a low semiconductor account, which will reduce the complexity of the converter as well as the losses it experiences.

The operational block diagram and pin connections of the prototype system are depicted in Figure 1. This diagram exhibits the concept of implementing power factor correction owing to fluctuating current. In recent years, a significant amount of research has been conducted on dc-dc converters that are based on multilevel structures. The objective of this research is to achieve the reliable integration of medium/high electricity dc grids (MVDC/HVDC) and low/medium electricity current (dc) loads. These loads include things like electric vehicles, electric transportation, information centers, and other similar applications. Because of its modular design and its capacity to make use of well-known electronic technologies, the Modular Multilevel Converter (MMC) is an essential component in this scenario. In this regard, dc-dc topologies that are based on medium frequency isolated MMC have been created. An improvement in the interface between the inverter and the rectifier stages can be achieved through the utilization of the transformer turns ratio, and the capacity for fault protection can be increased through the utilization of galvanic isolation. Because of the medium frequency operation, the converter's volume and weight are also reduced, which is another advantage of the converter. However, due to the fact that the transformer is responsible for handling all of the power that is processed by the converter, as well as the fact that higher frequencies have a propensity to increase the dv/dt that is placed on the windings, the volume/weight reduction of the medium transformer may be limited, which makes its design more complex. It has been suggested that the dc auto-transformer converter may be used as a means of reducing the amount of power that the transformer processes.
This architecture, which is also based on MMC in addition to Half-Bridge (HB) submodules (SM), enables some power to flow directly from the source of the input dc voltage to the load, hence reducing the power rating of the transformer. In order to accomplish this, it maintains a direct electrical connection between the inverter and the rectifier stages. However, unless more complex SM arrangements are used in place of HB, this design comes at the cost of losing the galvanic isolation of the dc terminal as well as a portion of the converter's fault blocking capabilities. This is the case unless the HB is replaced with a more complex arrangement. It is also possible that the transformer will still be quite massive, particularly in the event that there is a significant voltage difference between the input and the output. In response to the issues that have been occurring with medium speed transformers, a few transformer-less MMC-based direct current to direct current converters have been investigated. In many cases, these topologies are able to provide voltage balancing between the upper and lower arms by utilizing either the MMC arms inductors or a capacitive route. Nevertheless, in order to accomplish this equilibrium when the voltage variations at the input and the output are both substantial, a high alternating current current and/or big arm passive elements are required respectively. In these kinds of circumstances, the capacity of the components is being exploited, which results in a decrease in efficiency. A number of different current source modules are utilized in order to mediate the transmission of power between the DC terminals, which allows this disadvantage to be addressed. Due to the fact that an increase in the number of SMs results in a decrease in the maximum output voltage, these topologies are suitable for applications that call for high voltage ratios between the dc input and output. Another category of transformer-less direct current to direct current converters is comprised of the Switched Inductor (SL), Hybrid Switched Capacitor (HSC), and Switched Capacitor (SC) topologies. When it comes to the processing of energy, these converters function by connecting groups of capacitors and/or resistors in either parallel or series. Consequently, converters with a high power density and a high voltage ratio capacity are produced during this process. Furthermore, self-voltage clamping and component balancing are both activities that are carried out on SC and HSC converters. However, such topologies may be restricted or made more complicated due to the fact that their efficiency is dependent on the working duty cycle, the enormous number of components, the voltage ratio changing with the number of cells, and the concern over current/voltage spikes. There are also potential limitations. The purpose of this study is to provide a topology that is based on MMC and is a bidirectional dc-dc hybrid switching capacitor (MMC-HSC-DC). This transformer-less converter is one

of a kind in terms of its structural design because it does not contain any arms inductors. The flying capacitor Cf automatically clamps the total voltages of the arms, which represents a novel technique to balancing the voltages of the arms as a whole. Consequently, in contrast to the topologies that were discussed earlier, it is not necessary to supply an alternating current (AC) power flow through the arms in order to achieve the desired voltage balance. In addition to this, the converter generates an operational characteristic that is comparable to that of a switched capacitor.
In the next part, the components that were used to construct the prototype that was recommended are described. Conversion Based on MMC A modular multilayered converter, often known as an MMC, is an enhanced voltage source converter that can accommodate a wide range of medium and high-voltage voltage requirements. In addition to having minimal voltage and current rating requirements for the power switches, it also has excellent modularity, straightforward scaling, and strong output performance. These are some of the competitive advantages it offers. A DC fatal, an AC terminal, and a converter kernel with three phase legs are the components that make up the generalized configuration of a three-phase MMC. In each leg or phase, the two arms that are observed to be symmetrical are the arm that is raised and those that are lower. In order to suppress the high-frequency elements that are present in the arm voltage, the upper and lower arms are composed of a collection of submodules that are comparable to one another and are coupled in series with a chock circuit. The most important things that MMCs are interested in include topologies, mathematical modeling, modulation approaches, sub module balance control, output voltage as well as current control, and circulating current control.

IV RESULTS

There are a number of design and functional qualities that are improved when compared to a converter that is fully powered. These improvements include the AC-DC conversion efficiency being higher and the converter being able to meet its small power rating. In spite of the fact that the power sources differ from those of an existing converter, the system that has been presented achieves higher levels of performance, fewer losses as a result of conversion, and enhanced efficiency.

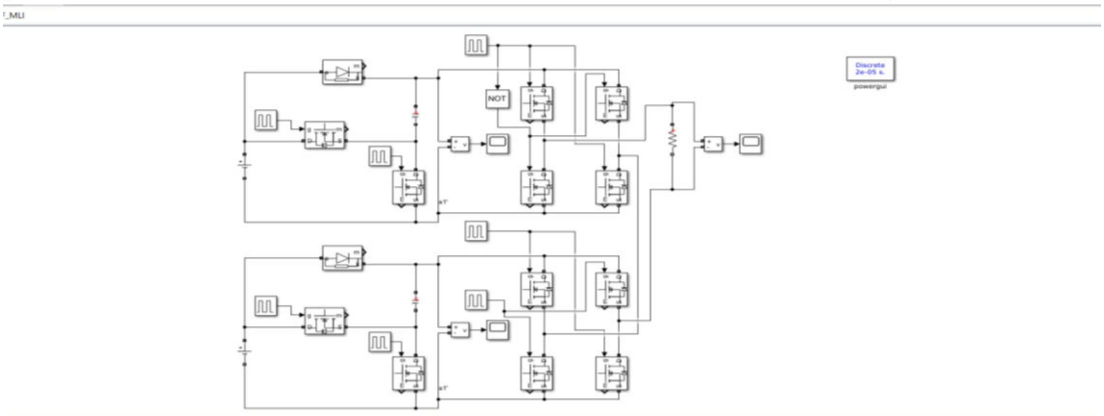

Fig1. Simulation diagram

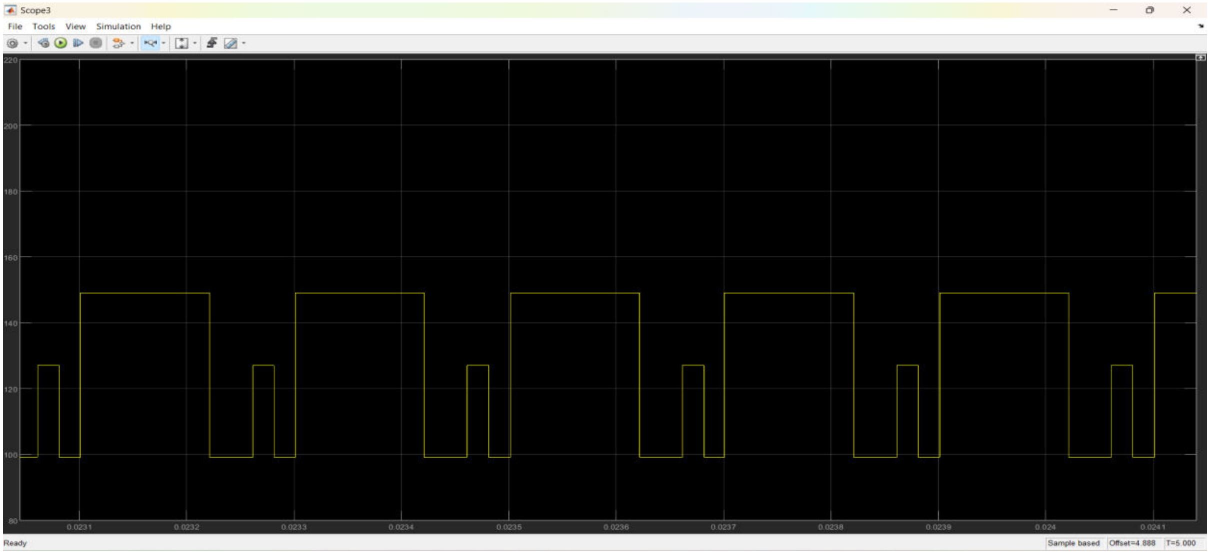

Fig.2 Output Waveform of DC Voltage/Current/Power

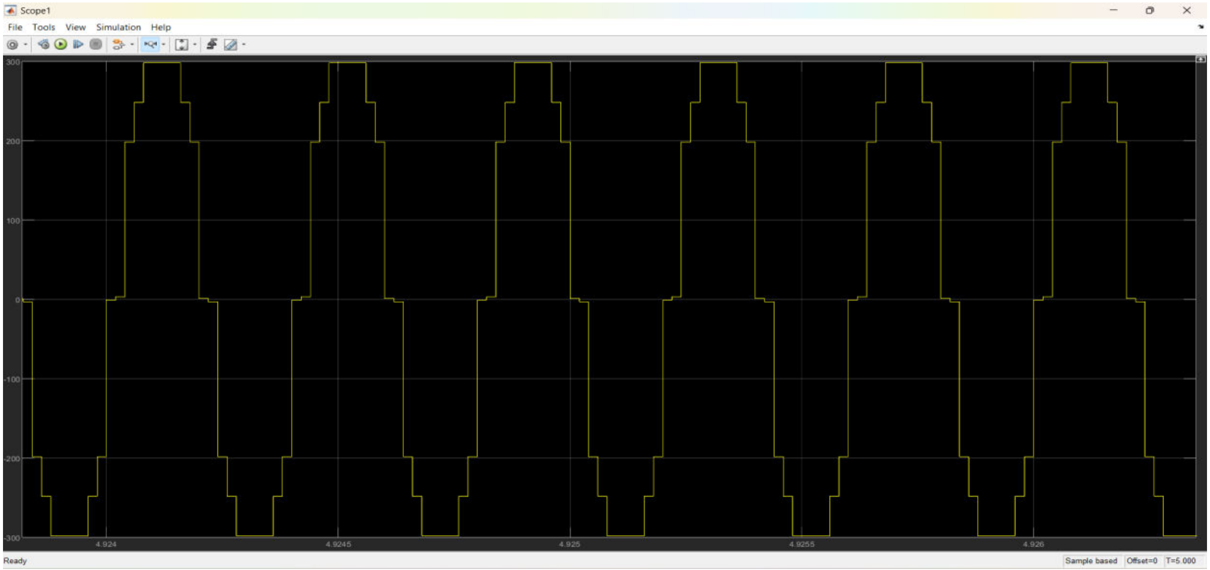

Fig.3 Output Waveform of Switched Voltage/Inductor Current

CONCLUSION

We propose the topology of an AC DC PFC that is based on an MMC converter. Its composition can vary across different SM configurations to meet the demands of the application. To overcome the semiconductors' blocking voltage restriction, the number of SMs in each arm is adjusted. The mathematical analysis, design procedures, and simulation findings have all been presented and examined to ensure that the proposed topology performs as expected. When the power factor is high, they demonstrate the functionality of the proposed converter. Achieving high efficiency while reducing voltage stress was made possible by disregarding the losses connected with the passive components and semiconductors connected to the secondary side of the converter. This converter works as expected thanks to the PWM modulation system, average current mode control technique, and circulating current control loops that balance the voltage. In addition to reducing the converter's weight and volume, the modulation technique enables the magnetic elements to operate at a higher frequency.

REFERENCES

[1] S. Kenzelmann, A. Rufer, D. Dujic, F. Canales, and Y. R. de Novaes, “Isolated DC/DC structure based on modular multilevel converter,”IEEE Trans. Power Electron., vol. 30, no. 1, pp. 89–98, Jan. 2015.

[2] G. Lambert, M. V. Soares, P. Wheeler, M. L. Heldwein, and Y. R. de Novaes, “Current-fed multipulse rectifier approach for unidirectional HVDC andMVDC applications,” IEEE Trans. Power Electron., vol. 34, no. 4, pp. 3081–3090, Apr. 2019.

[3] X. Xiang, X. Zhang, T. Lüth, M. M. C. Merlin, and T. Green, “A compact modular multilevel DC-DC converter for high step-ratio MV and HV use,” IEEE Trans. Ind. Electron., vol. 65, no. 9, pp. 7060–7071, Sep. 2018.

[4] S. Milovanovic and D. Dujic, “High-power DC– DC converter utilizing scott transformer connection,” IET Electric Power Appl., vol. 13, no. 10, pp. 1441–1452, Apr. 2019. [Online]. Available: https://digital-library. theiet.org/content/journals/10.1049/ietepa.2018.5746

[5] A. Schön and M.-M. Bakran, “A new HVDC-DC converter for the efficient connection of HVDC networks,” in Proc. Europe Int. Exhib. Conf. Power Electron. Intell. Motion Renewable Energy Manage. Nürnberg: VDE Verlag GmbH, 2013, pp. 525–532.

[6] S. Du, B. Wu, K. Tian, D. Xu, and N. R. Zargari, “A novel mediumvoltage modular multilevel DCDC converter,” IEEE Trans. Ind. Electron., vol. 63, no. 12, pp. 7939–7949, Dec. 2016.

[7] S. Du, B.Wu, D. Xu, and N. R. Zargari, “A transformerless bipolar multistring DC/DC converter based on series-connected modules,” IEEETrans. Power Electron., vol. 32, no. 2, pp. 1006–1017, Feb. 2017.

[8] S. Du and B. Wu, “A transformerless bipolar modular multilevel DCDC converter with wide voltage ratios,” IEEE Trans. Power Electron. vol. 32, no. 11, pp. 8312–8321, Nov. 2017.

[9] S. Du, B. Wu, and N. R. Zargari, “A transformerless high-voltage DC– DC converter for DC grid interconnection,” IEEE Trans. Power Del., vol. 33, no. 1, pp. 282–290, Feb. 2018.

[10] S. H. Kung and G. J. Kish, “A modular multilevel HVDC buck-boost converter derived from its switched-mode counterpart,” IEEE Trans. Power Del., vol. 33, no. 1, pp. 82–92, Feb. 2018.

[11]G. J. Kish, M. Ranjram, and P. W. Lehn, “A modular multilevel DC/DC converter with fault blocking capability for HVDC interconnects,” IEEE Trans. Power Electron.

[12]D. Rajmadhan, A.Kuppuswamy, P. Mariaraja, “Three Phase 11-Level Single Switch Cascaded Multilevel Inverter, The International Journal of Engineering and Science, Vol.3, No.3, pp: 19-25, 2014.