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An Advanced Power Flow Control in Small Scale DC Power Structure by Using Multilevel Converter

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Abstract:** Because they combine outstanding harmonic performance with low switching frequencies, multilevel transforms are attractive options in Small-Scale DC Power Ne2rks. High dependability can also be obtained by including redundant submodules into the cascaded transform chain. DC microgrids are developing as the next generation of small-scale electric power structures, with very low line impedance. This phenomena creates high currents in microgrids even with little voltage changes; hence, a power flow controller must have quick transient reaction and accurate power flow management. Multi-level transforms are used as power flow controllers in this work to provide high speed and high accuracy power flow management in a dc microgrid. Because a multi-level transform is employed, the output filter can be tiny. The linear controller, such as PI or PID, is established and widely used in the power electronics sector, but its performance degrades as system parameters change. In this paper, a neural structure (NN) based voltage management technique for a DC-DC transform is developed. This project also shows how to construct the output LC filter of a multi-level transform to meet a current ripple requirement. In comparison to typical 2-level transforms, we can demonstrate that a multi-level transform with a smaller filter may provide high-speed and high-precision power flow management for low line impedance situations. MATLAB/Simulink Simulation results are used to evaluate the control performance of each output current in the step response while accounting for transient variations in the power flow.

***Keywords:** Microgrid, Power flow control, PWM, DC-DC transform.*

1. INTRODUCTION

Renewable energy sources have become increasingly popular in recent years as society and the economy have progressed. They are now more cost-effective than traditional energy

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sources. New energy sources, on the other hand, have the drawback of a wide selection of output voltages. As a result, it is required to build a DC/DC transform with excellent ability across a wide voltage range. High voltage direct current (HVDC) transmission systems are a well-established and proven technology for transferring huge amounts of energy over long distances with minimal power losses and reactive power requirements. Large-scale offshore wind generation is expanding, making connectivity across different farms more difficult. Medium voltage direct current collection structures are a potential technique for such integration, with the goal of eliminating superfluous conversion stages and improving system dependability. The primary enabler for the dc grid is high-voltage, high-power DC/DC transforms. In the literature, several transform topologies have been explored and described, which may be roughly characterised as mixed (containing of numerous transform modules) and modular multilevel topologies.

In many applications nowadays, the use of high-frequency power transforms is unavoidable. High frequencies are preferred because they result in smaller and lighter circuits as well as quicker transient responses. Switching losses and electromagnetic interferences, on the other hand, are key difficulties with these transforms. These constraints can be circumvented by employing zero current and/or voltage switching in soft switched transforms. Because of these characteristics, as well as the growing demand for higher power density, higher ability, and lower electromagnetic interference, resonant transforms are now widely used in a variety of industrial applications, including high voltage power supply for industrial magnetrons, RE applications, LED driver, automotive E/BHPG, and driver of SRM. When compared to standard 2-level transforms, multilevel transforms used for high and medium voltage applications greatly reduce the harmonic content of the output voltage. Due to the success of this strategy in dc-ac conversion, multilevel transform systems for dc-dc conversion will become popular in applications in renewable energy. Many new varieties of multilevel transforms have been created that may be utilised either directly or as step-up dc-dc transforms. However, none of these multilevel topologies are more appealing than the modular multilevel transform. Diode clamped transforms require a high number of diodes, making the system prohibitive to build. The outline technique of a power flow controller for a dc small scale grid is examined in this paper by addressing the number of levels as one of the outline factors. This work contributes to the thorough outline of transforms and LC filters for the dc micro grid depending on the number of levels. Furthermore, simulations are carried out by building a dc structure with much multi-level transforms.

Multilevel Converter

Multilevel transforms, being an essential component of high power energy applications, have long been the subject of study. The specific objective of MLCs is to overcome difficulties with semiconductor device voltage limit capability, and they are appealing for high-power energy control because of their better performance in power semiconductor technology. Power electronic transforms are an important component of contemporary electric circuits that employ electronic switching components to convert electric energy from one amount of voltage, current, or frequency to another. Diverse power transforms with optimal modulation techniques should be utilised in various electric applications to supply the needed electric

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energy to the load with greatest ability and minimal cost. The multilevel inverter is one of the most recent major breakthroughs in power electronic transforms. In addition, numerous multilayer transform topologies have been devised. Figure 1 depicts the most typical multilevel power transforms as well as the traditional 2-level transforms. The basic idea behind a multilayer transform is to do power conversion by collecting a staircase voltage waveform using a series of power semiconductor switches with numerous lower voltage dc sources. Multiple dc voltage sources can be capacitors, batteries, or renewable energy voltage sources.

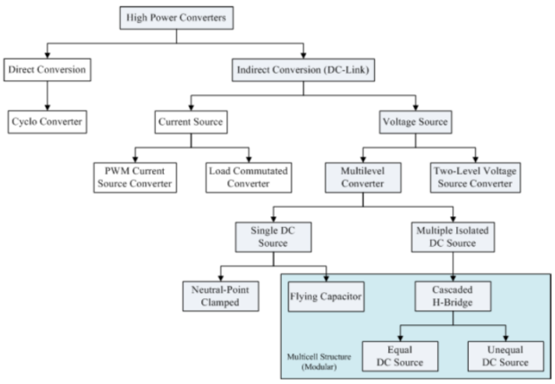

Fig.1: configuration of multilevel transforms.

When compared to ordinary 2-level transforms, multilevel transforms have substantial advantages. High-power quality waveforms, low switching losses, high-voltage capabilities, and low electromagnetic compatibility are among the benefits (EMC).

Power Flow Control in Distribution Structure

Because of energy depletion and environmental concerns, distributed generation has been extensively advocated and developed in recent years. Due to improved dispersed power access capability and larger power supply dependability, DC distribution structures may become the development path of future distribution structures as compared to AC distribution structures. With the fast expansion of the DC grid, power flow computation is receiving a lot of attention right now. The Newton-Raphson technique, like the AC grid, is still the most often used method for computing power flow. create a DC grid power flow model using the PQ decomposition approach, suggested an algorithm that keeps the Jacobian matrix constant and increases the speed of power flow computation. Voltage source convert (VSC) and DC-DC transform are both critical components of a DC grid, and their control modes have a significant impact on power flow computation. Because of its versatile control capabilities, VSC is frequently utilised for the connectivity of AC and DC grids. suggest a power flow calculation approach that takes into account the VSC's droop control mode as well as the system's controller outline It examines the features of parallel operation of multi-transforms with varied droop curves in depth and presents a technique for calculating power flow. Another significant component is the DC-DC transform, which is used to connect to various voltages in the DC grid and is analogous to transformers in the AC grid.

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The rising proliferation of distributed generators and e-vehicles in the energy market necessitates the development of innovative solutions for the electric energy distribution grid that allow for multi-directional power flow. A meshed low voltage direct current (LVDC) structure is one of the proposed alternatives. Meshed grid topology has several advantages over regular ring topology. Nonetheless, meshed systems pose issues in terms of protection and power flow controllability. For many years, multi-terminal high voltage DC (HVDC) transmission has been a well-established study area. The major reasons for implementing a multi-terminal HVDC are improved availability and lower costs. The power flow through all lines in a multi-terminal structure is not easily managed, which can lead to substantial overloads. Emerging research topics include meshed LVDC distribution structures for secondary consumers and the accompanying equipment. Power flow regulation is difficult to implement in LVDC structures, as it is in multi-terminal HVDC structures.

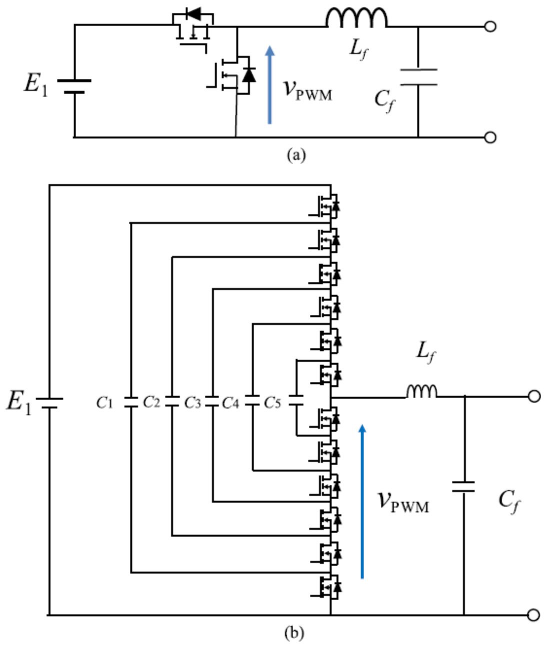

Fig.2: Power flow controller circuit configurations, (a) 2-level transforms, (b) 7-level transforms.

The circuit arrangements of the 2-level and multi-level schemes are shown in Fig. 2. A flying-capacitor type multi-level structure is provided as an example in this study. Table I lists the quantities of the system components in each transform. In the primary circuit of a flying capacitor type m-level transform, there are (2m2) switches and (m2) flying capacitors. Despite the fact that the number of series-connected switches rises in terms of the number of levels, the overall conduction loss stays almost the same as in 2-level transforms. Because the voltage stress for each switch is reduced, a switch with a lower voltage rating and smaller on-state resistance can be used in multi-level transforms.

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Table-I: no. of levels

The number of levels	2-level	7-level	*m*-level
Switching device	**2**	**12**	**2*m*-2**
Flying Capacitor	**-**	**5**	***m*-2**
Output PWM switching frequency f_{PWM}	f_c	$6 f_c$	$(m-1) f_c$

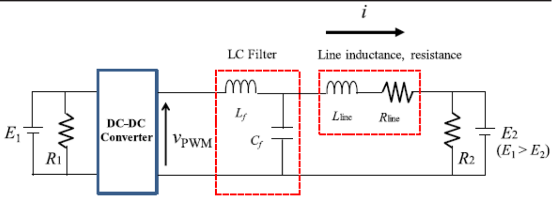

Fig.3: Power flow control circuit between 2 nodes.

Figure 3 depicts a circuit for investigating power path between 2 nodes as the smallest component of a dc microgrid. A dc microgrid consists of 3 sorts of parts in terms of power flow: a unidirectional power source such as PV or wind, a bidirectional supply/load such as a battery bank, and unidirectional loads. These components are linked in one-to-one, one-toplural, or plural-to-plural relationships. E1, R1, E2, and R2 depict the power suppliers and loads connected by a distribution line and a power flow controller in Fig. 3.

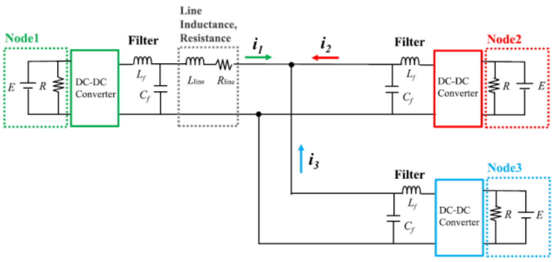

Fig.4: system configuration,

A simulation is used to validate the current control capacity of the 2-level and multi-level transforms. In this study, a distribution structure with 3 nodes and 3 transforms is studied as part of the anticipated dc microgrid, as seen in Fig. 4. The batteries are supposed to be 3 bidirectional power supply in this circuit. They are linked together by power flow controllers and transmission system, the length of which determines the stray inductance and resistance. There are 2 types of distribution structures: one with 3 2-level transforms and one with 3 7-level transforms.

Neural structure controller:

Multi-level voltage-fed inverters have lately gained popularity in industry for high-power applications. Multi-level inverters outperform 2-level inverters with the same component switching frequency in terms of output spectrum. PWM generation, on the other hand, is more complicated. Voltage sharing of power electronic switches in multi-level inverters is simple to implement. Furthermore, voltage stress on every switching state is decreased using

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multi-level inverters. Multi-level inverters are gaining popularity due to intrinsic benefits such as minimal switching losses and less voltage stress, which translates in lower filter costs.

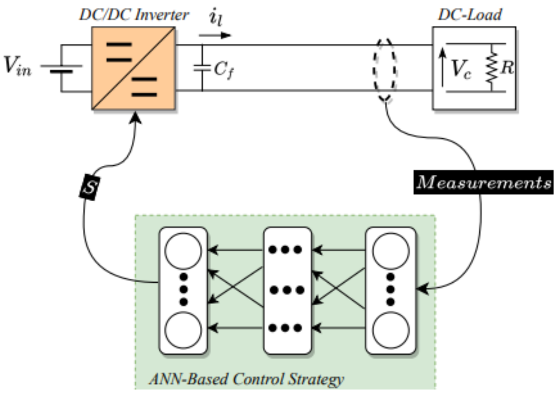
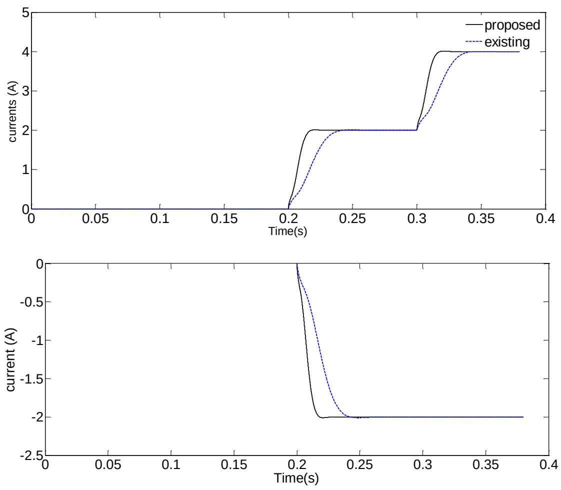


Fig.5: proposed control strategy.

Figure 5 depicts an overview of the suggested control strategy: the training phase combines to predict the transform output voltage transforms and data collecting under full-state observation. The data collected is utilized to train the ANN. The suggested control strategy's simulation results are also compared to the standard PI Controller.

2. SIMULATION RESULTS

For validation of the system is composed of 3 nodes and 3 transforms, simulations of 2-level and 7-level transforms with filters were planned and built, as shown in Fig. 4.
Case-1: 3 2 level transforms (fpwm =500 kHz).



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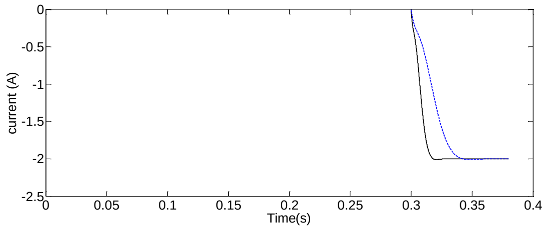

Fig.6: comparison waveforms of proposed and existing methods for 3 2 level transforms (fpwm =500 kHz).

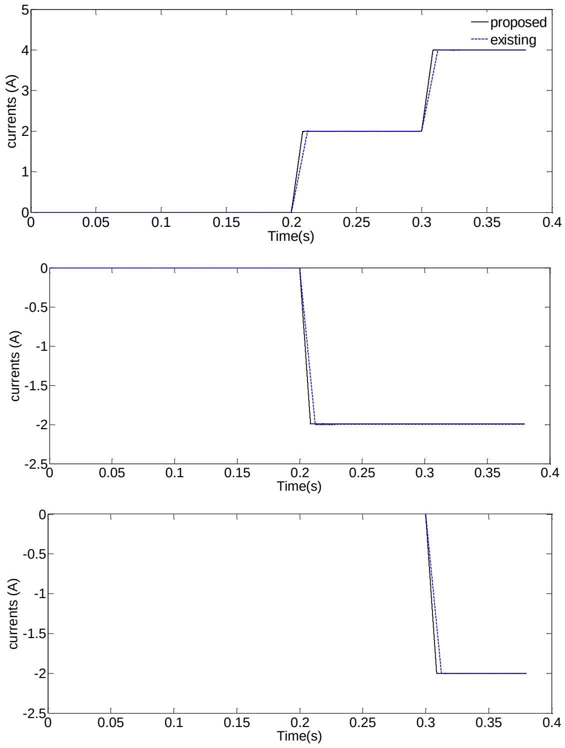

Fig.7: comparison waveforms of proposed and existing methods for 3 7 level transforms (fpwm =500 kHz).

To begin, all currents are generally set to zero, implying that the output voltages of all 3 transforms are set to the same value. Second, a current of 2.0A is obtained from Node1 to Node2 by adjusting the output voltage of the transforms, hence keeping current i3 constant. Third, a current of 2.0A passes from Node1 to Node3, keeping current i2 constant at 2.0A. As a consequence, Node1's current of 4.0A is spread evenly (2.0A) to Nodes 2 and 3. Each transform's current-control system is based on a PI controller that uses feedback information from each inductor current. The settling time of the proposed 2 & 7-level transform is roughly one-fifth that of the existing 2 & 7-level transform, which is owing to the reduced time constant of the proposed 2 & 7-level transform's filter. Furthermore, the response values of i2 and i3 do not follow the reference values at the corresponding instants of the step shift (0.2 and 0.3 s); this is owing to the transform's response bandwidth constraint.

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3. CONCLUSION

We examined multi-level transforms in this work to provide quicker current management in a dc microgrid with highly low-impedance links. The technique for outlineing the power flow controller's output filter took into account the number of output levels, steady-state ripple, and gradient of the transient range of output current. The suggested control strategy outperforms traditional linear controllers in terms of overall performance, according to simulation data. The suggested technique's implementation would be advantageous in DC microgrid scenarios where DC boost transforms demand high accuracy for tweaking controller settings.

4. REFERENCES

1. H. S. Khan, M. Aamir, M. Ali, A. Waqar, S. U. Ali, and J. Imtiaz, "Finite control set model predictive control for parallel connected online UPS system under unbalanced and nonlinear loads," Energies, vol. 12, no. 4, p. 581, 2019.
2. Z. Zhang and K. Chau, "Pulse-Width-Modulation-Based Electromagnetic Interference Mitigation of Bidirectional Grid- Connected Transforms for Electric Vehicles," IEEE Trans. Smart Grid, vol. 8, no, 6, pp. 2803–2812, 2017.
3. M. Naden and R. Bax, "Generator with DC boost and split bus bidirectional DC-to-DC transform for uninterruptible power supply system or for enhanced load pickup" US Patent, US7786616B2, 2003.
4. R. T. Naayagi, A. J. Forsyth and R. Shuttleworth, "High-Power Bidirectional DC–DC Transform for Aerospace Applications," IEEE Trans. Power Electron., vol. 27, no. 11, pp. 4366–4379, 2012.
5. K. Chao and C. Huang, "Bidirectional DC-DC soft-switching transform for stand-alone photovoltaic power generation systems," in IET Power Electron., vol. 7, no. 6, pp. 1557–1565, 2014.
6. K. Jin, M. Yang, X. Ruan and M. Xu, "3-Level Bidirectional Transform for Fuel-Cell/Battery Hybrid Power System," in IEEE Trans. Ind. Electron., vol. 57, no. 6, pp. 1976–1986, 2010.
7. Viswanatha, V. "Microcontroller based bidirectional buck–boost transform for photo-voltaic power plant." Journal of Electrical Systems and Information Technology 5.3 (2018): pp.745–758, 2018.
8. M. Forouzesh, Y. P. Siwakoti, S. A. Gorji, F. Blaabjerg and B. Lehman, "Step-Up DC–DC Transforms: A Comprehensive Review of Voltage-Boosting Techniques, Topologies, and Applications," IEEE Trans. Power Electron., vol. 32, no.12, pp. 9143–9178, 2017.
9. K. Tytelmaier, O. Husev, O. Veligorskyi and R. Yershov, "A review of non-isolated bidirectional dc-dc transforms for energy storage systems," Proc. YSF 2016, Kharkiv, pp. 22–28, 2016

