MODULAR MULTILEVEL CONVERTER CONTROL FOR MEDIUM VOLTAGE APPLICATIONS

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ABSTRACT

Recently, the Modular multilevel converters (MMCs) are rising in Medium and High Power Applications. In MMCs we use Aluminium electrolytic capacitors (AECs) in MMCs as floating capacitors because of their high volumetric efficiency and economical cost. But as time passes the capacitance of AECs will reduce and electrolyte is vaporized. The equivalent series resistance (ESR) of AECs increases which can result in an increase of sub-module (SM) capacitor voltage ripple, power loss, and could damage the operation of the MMC if used for a longer period. To avoid such harm, observing the wellbeing of capacitors is a significant advance to upgrade the dependability of the MMC by prescient support. This paper displays a failure prediction scheme for SM capacitors in the MMC by observing the SM capacitor voltage deviations. Extended simulation studies are done for a five-level MMC in PLECS stage and checked tentatively. The assessed capacitance through simulations and tests are in close consent to that worth estimated utilizing the LCR meter.

Keyword: - *PIC Micro Controller, Driver Unit, Multi Modular Converter , Capacitor & Inductor, DC Battery, Crystal Oscillator , DC to DC Converter, etc…*

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1. INTRODUCTION

N medium and high-power applications, such as high voltage DC-current (HVDC) transmission, static synchronous compensator (STATCOM), active power filters and medium-voltage motor drives (MVMD), the modular multilevel converter (MMC) is becoming a more favorable topology . It provides low harmonic content, modularity, voltage scalability, high efficiency, fault-tolerance and the capability of multi-motor operation. Due to its simple construction and easy assembling, MMCs draw considerable attention to electric ship propulsion systems , battery electric vehicles , electric railway traction systems, railway power conditioner, energy storage systems and battery charging infrastructure. However, the reliability of an MMC is an important issue due to high component count which may degrade over time. The most fragile components in the converter are the active switches and capacitors . Therefore, fault diagnosis and fault-tolerant control strategies are necessitated to achieve reliable operation of the MMC. Through prior studies and research, researchers have focused on improving the reliability by increasing the redundancy of SMs, performing reliability modeling, implementing fault detection and by using isolation and reconfiguration strategies. An open and short-circuit of the power switching device in an MMC distorts the output waveforms, shoot in capacitor’s voltage and may interrupt the operation of the converter. Therefore, fast detection, location and reconfiguration methods are imperative under the device failures. Usually, the protection and diagnosis of the active device under the short-circuit fault are integrated into the gate drivers. Numerous fault diagnosis studies including active switch and diode faults have been reported in the literature. A sliding mode-observer (SMO), state observer and Kalman filter-based fault diagnosis methods are applied to the MMC based on the information of SM capacitor voltage measurements and arm current. An accurate clustering and calculated capacitance-based fault detection algorithms are introduced for the MMC to detect the open-circuit of the active switch and have the ability to locate the faulty SM . A supervisory algorithm and a post-fault restoration method are established to assist the normal operation of an MMC under internal and external fault conditions. A new SM configuration of MMC is introduced in to detect open-circuit diode faults. Several redundant and fault-tolerant reconfiguration strategies have been applied to MMCs with a seamless transition and faster recovery time include carrier reconfiguration methods and the injection of zero-sequence voltage schemes. Most of these studies are limited to open circuit and short circuit faults of the power switching devices. Due to the high capacitance per volume requirement, in order to reduce capacitor voltage ripple in the MMC, aluminum electrolytic capacitors (AECs) are usually employed. The AECs gradually deteriorate while aging due to the vaporization of the electrolyte. Furthermore, the prolonged use of deteriorated capacitors increases SM capacitor voltage ripple, circulating current (CC) and could damage the normal operation of an MMC. Therefore, health monitoring and failure prediction of SM capacitors are imperative for detecting failing components, so they may be replaced before a fault occurs. The capacitance or equivalent series resistance (ESR) value is an indication of the health status and degradation level of a given capacitor.

1.1 Existing System

A sliding mode-observer (SMO) , state observer and Kalman filter-based fault diagnosis methods are applied to the MMC based on the information of SM capacitor voltage measurements and arm current. An accurate clustering and calculated capacitance-based fault detection algorithms are introduced for the MMC to detect the open-circuit of the active switch and have the ability to locate the faulty SM. A supervisory algorithm and a post-fault restoration method are established to assist the normal operation of an MMC under internal and external fault conditions.

1.2 Objective

Over the past years, studies on monitoring the health of AECs used in DC/DC, AC/DC and DC/AC power converters have been reported. In DC/DC converters, these schemes utilize the information of capacitor voltage ripple and/or inductor current to estimate C and ESR of AEC. In single/three-phase AC/DC converters, condition monitoring schemes are presented mainly using modeling approaches or recursive algorithms. An external current/voltage signal is injected in the control loops with complex algorithms such recursive least square (RLS) and state vector machine (SVM), are used to estimate ESR and/or C. Several capacitor health monitoring methods in dc link capacitors in single-phase/three-phase DC/AC converters for solar and motor drive applications are presented in. However, research on the techniques for monitoring the health of SM capacitors used in an MMC is very limited. In, condition monitoring of SM capacitors based on RLS algorithm is introduced to estimate the capacitance. However, this approach requires the injection of an external CC in the control loop of the MMC to estimate capacitance, which further increases the capacitor voltage ripple and power losses. Moreover, the magnitude of external CC injection in the control loop is to be calculated either off-line or on-line, which complicates the controller design and signal injection. Kalman filter algorithm is employed for an MMC to estimate the capacitance of the SM capacitors. However, these approaches utilize the integral computation to estimate the SM capacitance of all capacitors in an arm, it would complicate the algorithm and increase the computational burden. The summary of aforementioned capacitor health monitoring schemes used in different power converters

1.3 Contribution

In this paper, a simple failure prediction technique for SM capacitors of an MMC is proposed by monitoring the second harmonic impedance utilizing the ripple in SM capacitor voltage and current. The proposed approach does not require any complicated algorithm and an external current/voltage signal injection in the control loop. Therefore, the proposed scheme offers easier implementation in digital controllers in comparison with the aforementioned approaches. The proposed scheme is validated by detailed simulation and experimental studies on a half-bridge sub module (HB-SM) based single-phase MMC (four SMs per arm). The presented results are in good agreement with the capacitance value measured using the LCR meter

2. LITERATURE SURVEY

Modular multilevel converter (MMC) can be considered as a promising candidate for modern electric ship medium-voltage direct current (MVDC) power system due to its high-voltage quality, low switching loss, good expansibility, and good redundancy. As the voltage level in MVDC is much lower than that in high-voltage direct current case, the number of sub modules (SMs) of MMC in MVDC system is also much less. Therefore, the SM failure will have more significant effect on the safety operation. Since uninterrupted operation is one of the most important requirements in electric ship application, the special redundancy design for MMC is required. This paper thus proposes an MMC system with hierarchical redundancy ability, aiming to guarantee the ride-through operation under SM failure. The "hot-reserved" and "cold-reserved" SMs are prepared in the MMC by compromising the faulty SM number, voltage and current stress of SMs, SM power loss, and so on, and the hierarchical redundancy strategy is divided into several progressive layers to ride through the SM failure in different cases. The pre treatment units are designed to realize the proposed hierarchical redundant strategy smoothly, and without changing the existent modulation and sort-and-selection strategies designed for normal condition. The proposed design is explained in this paper, and verified by a three-phase MMC simulation and a single-phase MMC prototype.

Modular multilevel converter (MMC) is one of the most promising topologies for medium to high-voltage high-power applications. The main features of MMC are modularity, voltage and power scalability, fault tolerant and transformer-less operation, and high-quality output waveforms. Over the past few years, several research studies are conducted to address the technical challenges associated with the operation and control of the MMC. This paper presents the development of MMC circuit topologies and their mathematical models over the years. Also, the evolution and technical challenges of the classical and model predictive control methods are discussed. Finally, the MMC applications and their future trends are presented.

3. PROPOSED SYSTEM

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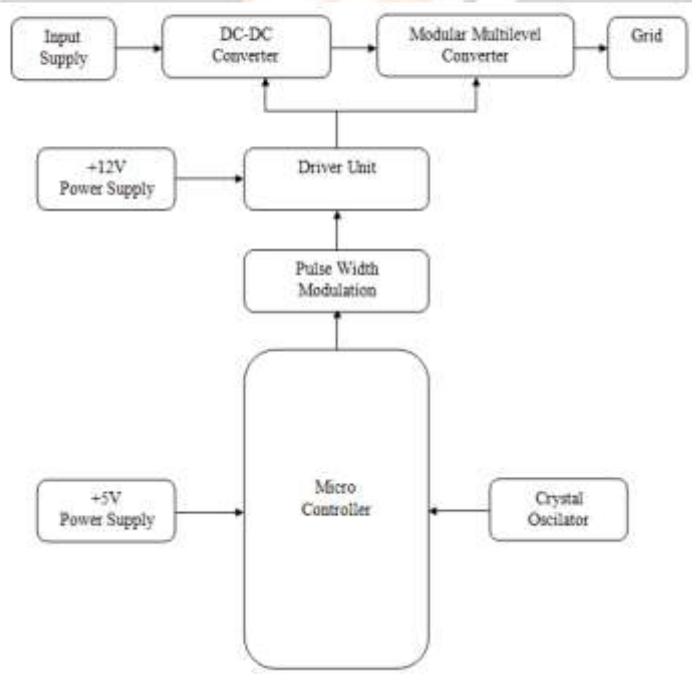

Fig.No. 1 Block Diagram For Proposed System

3.1 Advantages of Proposed System

1) It does not require an external signal injection in the current/voltage control loop.

2) Less computationally burden as it does not require complex algorithms for capacitance estimation.
3) Implementation with any type of modulation scheme is possible.

4) Easily extended to MMCs employing hybrid combination of aluminium electrolytic and film capacitors as

well.

5) This method will be a desirable solution for MMC to enhance reliability by predictive maintenance instead of corrective maintenance.

4. RESULT & DISCUSSION

The experimental results of hybrid MMC at 5Hz. In contrast to traditional MMC, capacitor voltage ripple was reduced to 18.5V (12%). Fig. 18 further presents the experimental waveforms of hybrid MMC at 2Hz. Under this very low frequency, the hybrid MMC can still operate with rated output current and the capacitor voltage ripple was 26.5V (18%). These results again proved the hyrbid MMC inherently has lower capacitor voltage ripple. But it should be noted that, the voltage ripple in experiments was much larger than the theroretical value. Because voltage rating of the experimental prototype was too small compared to an actual medium-voltage converter, thus the voltage needed for circulating current control and the voltage drops on SM IGBTs and parasatic resistances were not negligible. As a result, the dc voltage component in (12) has to be higher to make allowance for these voltage drops, which leads to larger capacitor voltage ripple, current amplitudes were around 5A and the common mode voltage was small, within ±100V. Neither overcurrent nor overvoltage problems existed.

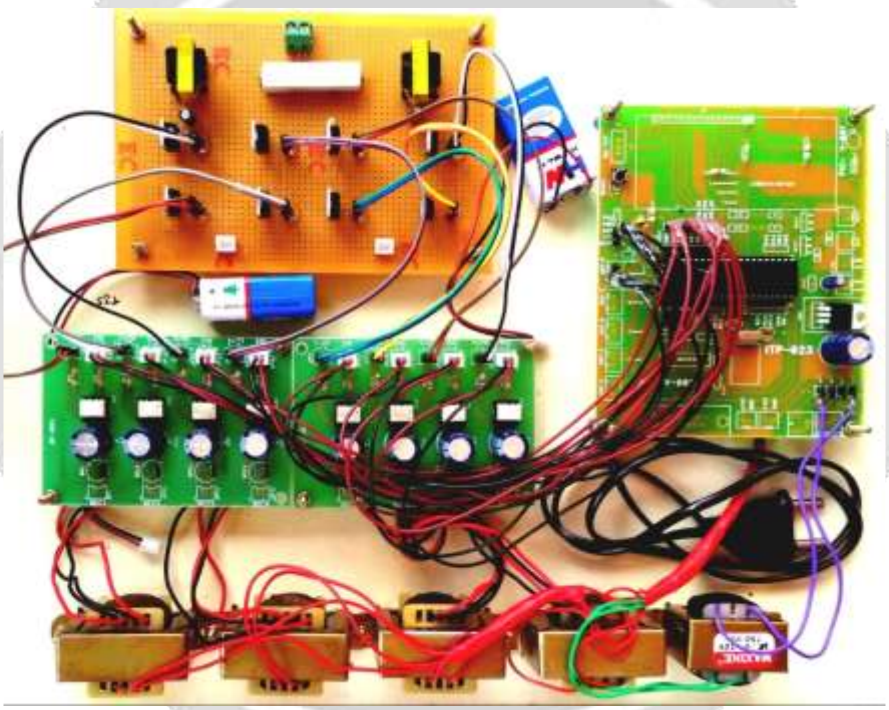

Fig.No. 2: Snapshot of Hardware Prototype

5. CONCLUSIONS

This paper presents a simple failure prediction technique for SM capacitors in the MMC with available hardware used for converter control. This method utilizes the inherent second- harmonic oscillations in SM capacitor voltage and current to estimate the capacitance of AEC. The simulation and experimental results confirm the efficacy of the proposed scheme under various operating conditions and the maximum error is found to be around 2.50%. The estimated capacitance from experimental results is in agreement with the direct measurement of capacitance using the LCR meter. Since the proposed scheme is based on utilizing inherent second-harmonic voltage oscillations, it can be extended to the MMC employing film capacitors or a hybrid combination of capacitors. This method will be a desirable solution for MMC to enhance reliability by predictive maintenance instead of corrective maintenance

6. REFERENCES

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