IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, August 2024

STATCOM Based on Modular Multilevel Inverter Coupled with Smart Detection Technique-A Survey

Trishna Rajendra Gothe[1] and Prof. W. A Gavhane[2]
PG Scholar, Department of Electrical Power System[1]
Assistant Professor, Department of Electrical Power System[2]
Government College of Engineering, Aurangabad, Maharashtra, India

Abstract: *A static synchronous compensator (STATCOM) is reviewed along with Multilevel inverter in this study, which uses another secluded design with standard three-stage voltage source inverters to staggered activity. The inverters are linked to a transformer with three free DC joins and an open-end winding plan. The inverters in this development will be connected in a fountain design. Besides multi-facet working, the framework is recognized by low important impeding voltages for switch evaluations, as the proposed STATCOM might apply twofold the DC capacitor voltage to the transformer windings. The proposed geography's control framework advancement is likewise given. A few demonstrating and reasonable tests will be performed to assess the activity of the recommended geography and the presentation of the laid out control framework. Voltage regulation and maximum power transmission can be achieved via reactive power compensation in a power system. The reason for this audit article is to zero in on different elements of STATCOM, for example, various arrangements, regulation methods, the idea of new decreased switch count geographies, applications incorporating connection point with environmentally friendly power, engine drives, and Realities regulator.*

Keywords: STATCOM; Inverter; Multilevel; detection; smart

I. INTRODUCTION

In power production, transmission, and distribution systems, power grid instability and power quality are key challenges. These issues typically develop as a result of mismanaged power flow. The ramifications of interfacing nonlinear, uneven, or potentially receptive burdens to the lattice incorporate voltage unsettling influences like droops/grows, irregularity, drifters, motions, high consonant substance, and low power factor. Expanded coordination of sustainable and nonrenewable energy sources in Conveyed Age frameworks has likewise added to expanded unpredictability and power quality difficulties. To alleviate them a few adaptable ac transmission framework (Realities) regulators have been created and proposed in writing. Realities regulators are ordinarily separated into two primary gatherings:

- Thyristor Based Regulators and
- Voltage Source Inverter (VSI) Based Regulators.

SVC and TCSC, or Thyristor Controlled Series Compensators, are combined into Thyristor Based Controllers. VSI based regulators cover Static Simultaneous Compensators (STATCOM), Static Coordinated Series Compensators (SSSC) and Bound together Power Stream Regulators (UPFC).

An Inverter is an electrical device that converts direct stream power into subbing stream power at the destined result voltage and rehash. Staggered Converters have really arisen as a charming region in the area of current applications. Power electronic converters can make an outcome voltage which switches between two unmistakable voltage levels. The Staggered Inverter creates the ideal result voltage by consolidating different DC voltage levels into its feedback. By and large, the information side voltage levels are acquired from environmentally friendly power sources, capacitor voltage sources, energy components, etc. Several stunned inverter types include the following: Diode cut inverter, Flying capacitor staggered inverter, and Streamed H-ranges converter. Dazed inverters are used in medium voltage and high power applications these days. It can be used in a variety of fields, including siphons, ships, high-voltage DC transmission, variable recurrent drives, and UPSs. adaptable ac transmission framework (Realities) innovation for

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, August 2024

making/retained responsive power is a static simultaneous compensator (STATCOM) using a voltage source converter. Voltage regulation & maximum power transmission are possible using reactive power compensation in a power system. Different sorts of STATCOMs were tried and conveyed in various electrical frameworks during the most recent couple of many years. Numerous sorts of staggered converters, for example, -

diode-braced converter,

flying-capacitor converter,

flowed H-span converter measured staggered converter (MMC) substitute arm converter (AAC) can be utilized as STATCOM.

The staggered structure gives overt repetitiveness and adaptability. Be that as it may, it requires a genuinely enormous number of H-span sub-modules to decrease the music and each sub-module requires an enormous DC capacitor.

II. STATIC COORDINATED COMPENSATOR (STATCOM)

One shunt-related real-element device used primarily for responsive power control is the STATCOM. There are two possible consistent state functioning modes for the STATCOM: capacitive (driving) and inductive (releasing). In general, STATCOMs are thought to promote the growth of power frameworks even further. A single VSC and the shunt-related transformer that goes with it are found in the STATCOM. Similar to a static VAR compensator (SVC) or turning produced condenser, the STATCOM limit is a dependable means of providing responsive power compensation to voltage support (IEEE Power Arranging Society Genuine components Application Gathering, 1996). In order to accomplish this, the STATCOM draws—or embeds—a responsive current that is delivered into the line. The STATCOM could exchange dynamic power with the line through, instead of being a tiny bit like a typical static VAR generator.

In the electric architecture, the STATCOM might provide responsive power by quadraturing a variable degree stream as the line voltage. Rather than using reactor banks or capacitors to generate responsive power, the STATCOM uses a capacitor to help maintain a consistent DC voltage for the operation of the converter. Figure 1 shows one of the STATCOM's key circuits.

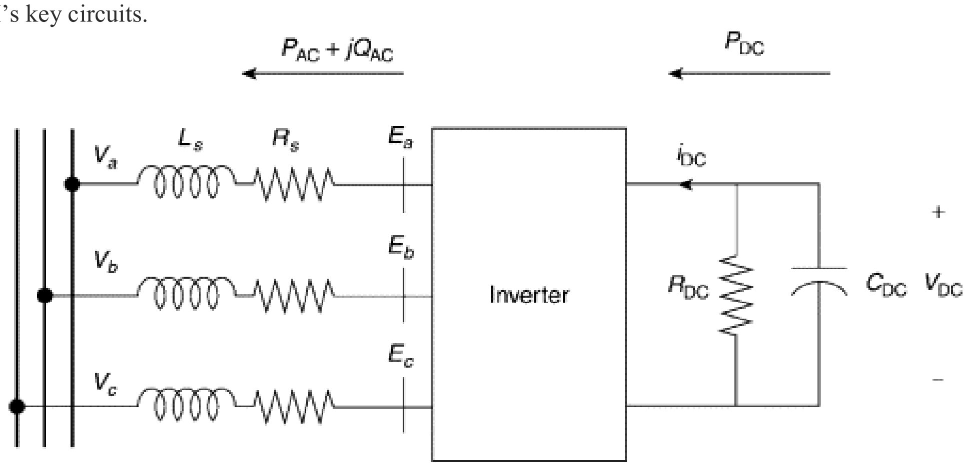

Figure 1- Comparable Circuit of STATCOM

A Static Simultaneous Compensator (STATCOM) is proposed in which new measured structure with regular three stage voltage source inverters is utilized to staggered activity. STATCOM is a power electronic gadget utilizing force drove gadgets MOSFET, IGBT and so on. STATCOM is a shunt gadget it can either retain or produce receptive power in synchronizing with the interest to balance out the voltage of force organization. The voltage of force framework Expands because of burden mislead, STATCOM will Decrease its result voltage V1 and the accordingly will ingest receptive ability to balance out the voltage to typical worth. The above method of activity of STATCOM is called voltage Guideline Mode.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, August 2024

III. LITERATURE SURVEY

By Yang et al[1], the challenges linked to the MMC are associated with submodule balancing control, circulating current control, control complexity, and transient performance. Significant level nonlinear and obvious control methods should additionally foster The management and implementation of standard control frameworks by the MMC. Finally, the impact events associated with the obvious level wide bandgap (WBG) influence devices, such as SiC and GaN, are studied using various frequency exchange schemes and change plans. Although the results show this, the stage-shifted transporter-based pound width change (PSC-PWM) has a greater impact on failures. It produces a dominant quality voltage with reduced firm symphonious mutilation (THD) when compared to the stage-demeanor heartbeat width rule (PD-PWM) and the attempted run-of-the-mill balance pound width change (SAM-PWM). Furthermore, devices using WBG switches, such as those made of silicon carbide (SiC) and gallium nitride (GaN), offer fewer impact losses and increased productivity, especially when swapping MMC applications at high rates.

Du et al. propose a passive cross-connected MMC (PC-MMC) [2] and an active cross-connected MMC (AC-MMC) [2] whose single-phase configurations, respectively. Similar recommendations are made for the PC-MMC and the flying-capacitor MMC. The circuit designs of PC-MMC and AC-MMC are identical. It's crucial that additional submodules in the air conditioner MMC are moved in place of the flying capacitor in the PC-MMC. Similar control ideas have been put out by Du et al. The flying capacitor in the PC-MMC is ready to switch power between the upper and lower arms and cover voltage growth on the submodule capacitors at low/zero repeat movement. Strong regulated submodules pertaining to AC-MMC do this. The materials used in medium-voltage motor drives are PC-MMC and AC-MMC.

For star/delta-organized MMCs, the two main designs in the subfamily are single-star and single-delta. There are three submodule series that are connected in a delta or star pattern. In applications such as battery energy limit structures and power compensators (STATCOM), a single star MMC is recommended. Two-star or delta-planned packs connected by a DC source or load are consolidated into twofold star and twofold delta. They are able to determine the bidirectional DC-AC or AC-DC current change. In MMC projects like as motor drive structures and HVDC transmission, a double star is extensively employed. Nine branches, or three star-connected clusters, make up a triple-star MMC [3]. The term "modular multilevel matrix converter" (M3C) is widely recognized.

A novel architecture for multimodal communication, known as hexagonal MMC or Hexverter, was created by researchers recently [4]. Each of the six arms of the Hexverter is connected to one of two three-stage AC associations once more. The arms are arranged in a hexagonal circuit. When differentiated and triple-star MMC or M3C, this astute geology can effect direct AC change with an even smaller number of branches and parts. When used in applications like as low-repeat wind turbines, this converter is helpful.

A nonlinear decoupling control based on feedback linearization [5] is proposed for MMC converters with the remaining linearized variables and linear controller to achieve desired transient responses and stability. Another nonlinear control method based on sliding mode control [6] is investigated with the faster dynamic response by splitting the state space into several subspaces, which are further controlled in an individual control structure. Passivity-based control [7,8], belonging to the nonlinear control strategies is applied to the MMC system based on an energy function to acquire a better dynamic and steady-state performance. The passivity-based control and sliding mode control are further combined in the MMC control system to improve the transient performance and robustness to system changes [9]. A nonlinear back-stepping control scheme [10], based on energy equations, is explored for single- and three-phase MMC by using Lyapunov theory with a simplified control structure in the *abc* frame. The back-wandering method is enhanced by the organic element of flowing current disguising and bolstered by reenactment and preliminary work that exhibit remarkably robust responsiveness and vitality.

IV. MMC TOPOLOGIES

A. Submodule *Geographies*

As seen in Figure 2, the condensed configuration of a three-stage MMC consists of a DC terminal, a forced air system terminal, and a changing over piece with three phase legs. Two symmetric arms—the upper arm and lower arm—are proposed for each leg/stage. An assembly of ambiguous submodules connected in series with a chock inductor is present in the upper and lower arms to cover high-repeat portions of the arm current. An MMC can achieve bidirectional power conversion[11].

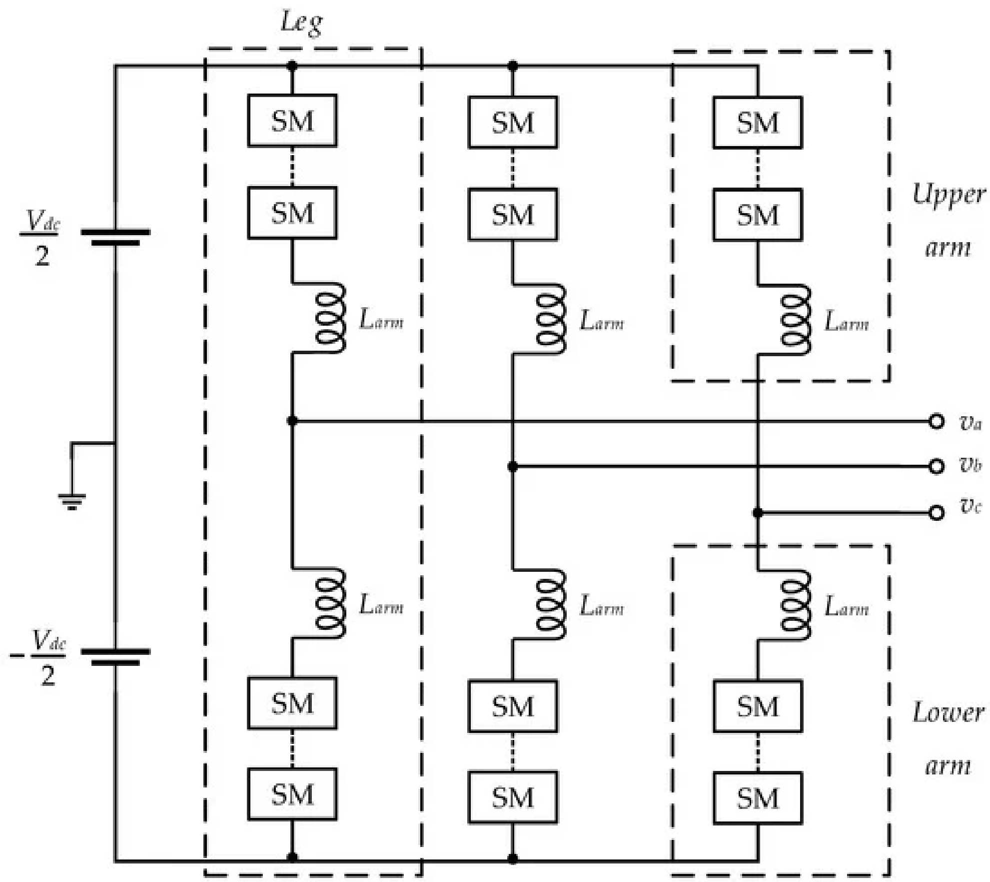

Figure 2- Generalized configuration of a three-phase MMC[1]

B. Two-Level Submodule Topologies

The SM is the fundamental component of an MMC. Over the past twenty years, a range of submodule topographies have been proposed by scholars. According to the output voltage level, these submodules can be classified into two categories: two-level submodule topologies with a single source and multilevel submodule topologies with multiple sources[12].

Among all the SM topologies, the half-bridge submodule (HBSM) [13] is the most popular configuration thanks to its simple structure together with a low system cost. The HBSM is comprised of two power switches with anti-parallel diodes and a floating capacitor[14], as shown in Figure 3. Depending on whether the capacitor is implanted or evaded, the submodule voltage can be adjusted to either Vc1 or nothing.. As needs be, the HBSM is in like manner named as the chopper SM.. One apparent disadvantage of an HBSM is its vulnerability to DC fault current[15].

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 2, August 2024

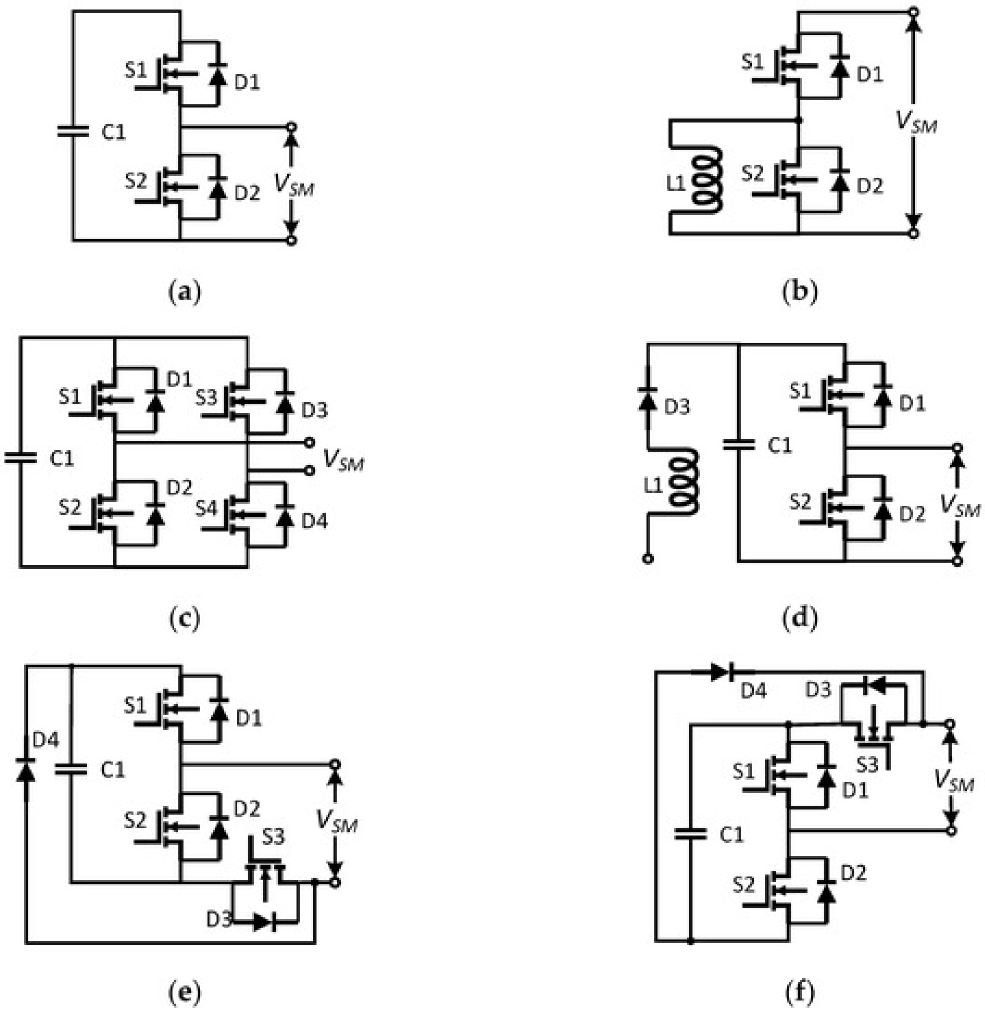

Figure 3- Two-level submodule topologies: (**a**) half-bridge submodule (HBSM); (**b**) current source HBSM; (**c**) full-bridge structure (FBSM); (**d**) self-balancing submodule (SBSM); (**e**) clamp-single submodule (CSSM) type-Ⅰ; (**f**) CSSM type-Ⅱ; (**g**) Single-thyristor HBSM; (**h**) Double-thyristor HBSM.[1]

C. *Staggered Submodule Geographies*

Traditional staggered converter layouts include the flying capacitor (FC) and impartial point clipped (NPC) concepts. In MMCs, they were similarly displayed as three-level submodules[16]. Figure 4 introduces the NPC submodule (NPCSM) and FC submodule (FCSM) circuit layouts individually. NPCSM is made up of four IGBT devices with two clipping diodes, two capacitors, and hostile-looking diodes. FCSM includes similar components except for the clamping diodes[17,18].

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 2, August 2024

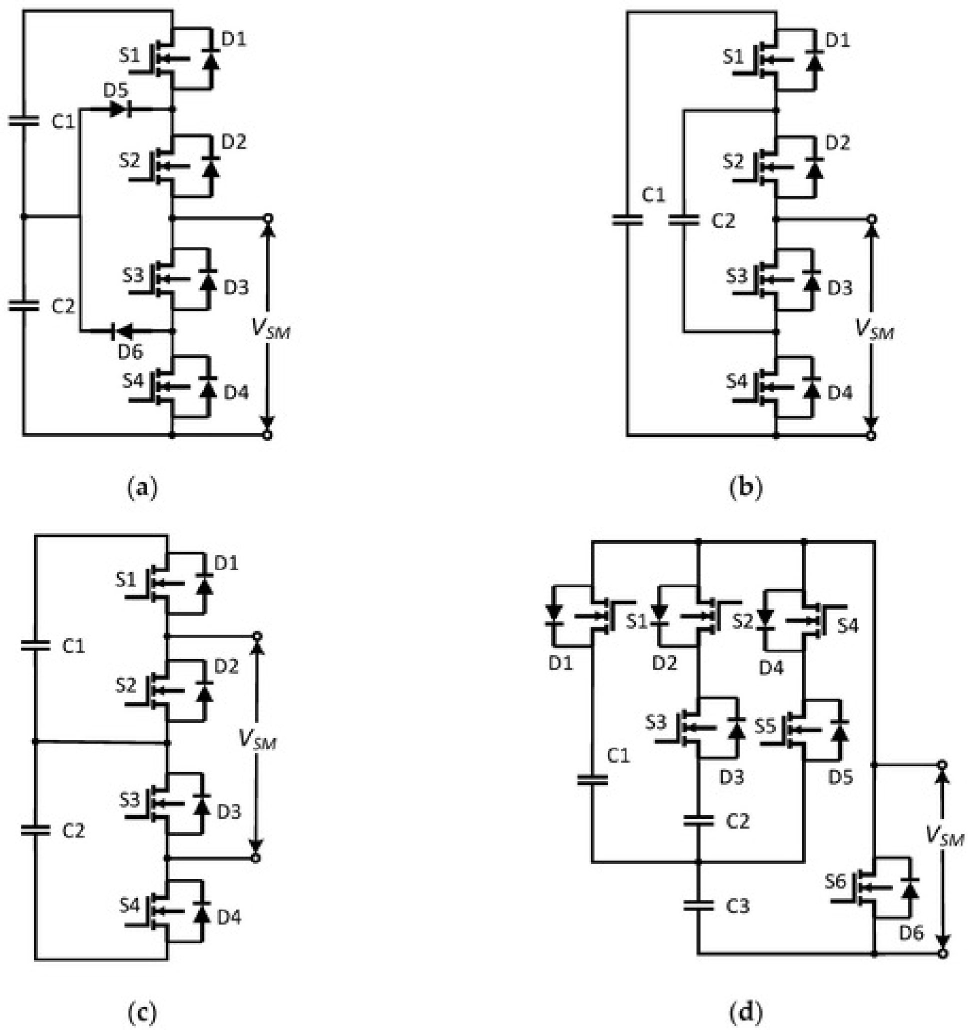

Figure 4- Multilevel submodule topologies: (**a**) neutral point clamped submodule (NPCSM); (**b**) flying capacitor submodule (FCSM); (**c**) cascaded half-bridge submodule (CHBSM); (**d**) stacked switched capacitor submodule (SSCSM); [1]

V. DISCUSSION

Figure 5 depicts the close-up of the result output The total harmonic distortion (employing various equilibrium approaches while taking into account semiconductor effects setbacks and MMC performance. As can be observed from Figures 5a,b, SiC modules provide lesser influence disasters and higher impact capabilities for all three change procedures, while appearing differently than Si contraptions.

Furthermore, as Figure 5a illustrates, the PSC-PWM has greater influence setbacks than the PD-PWM and SAM-PWM for both Si and SiC switches. This results in a decreased MMC capability, as Figure 5b illustrates. Even with reduced influence errors and efficiency, Figure 5c demonstrates that PSC-PWM is visible in providing exceptional voltage quality at a lower tumor necrosis factor compared to the other two techniques.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 2, August 2024

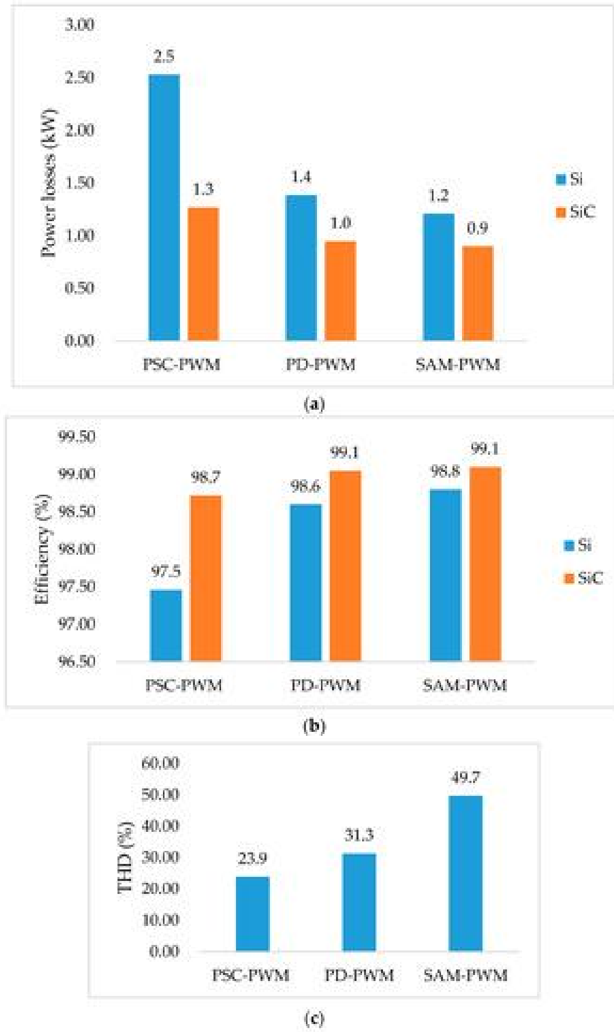

Figure 5- Relative execution of utilizing Si and SiC semiconductors with various tweak strategies and burden and information voltage per MMC: - (a) Semiconductor power misfortunes; (b) MMC productivity; (c) Result voltage all out symphonious mutilation (THD).

VI. CONCLUSION

With features like flexible staggered yield voltage, low symphonious substance of result voltage and result current, estimated and versatile arrangement, further created capability, and unmistakable dreariness, the STATCOM-MMC should be a great option for medium and high-voltage power applications. It is evident that the STATCOM-MMC, being an application-arranged geology, will be coordinated to be more changed and generally about modified in the particular application area with regards to drive transmission and quality improvement. In relation to the submodule and common geologies, mathematical demonstrating and control methodologies, change systems, and the connection between WBG advancement and disasters, this study reviews the STATCOM and MMC. The HBSM maintains awareness of the control in business use among a collection of submodule configurations for submodule topography, as deduced from its basic design and insignificant cost. Recent developments in submodule circuits could be investigated in conjunction with a comparative analysis of the impact of module size and cost variations, trade events, and the shift from basic to non-basic dissatisfaction. In particular, under varying or uneven load, new irrefutable level geologies might be investigated to produce better execution and satisfy various weight needs with the overall design of the

MMC.Submodule changing control, flowing current control, and outcome voltage and current control under various system conditions are all examined in relation to MMC control. The problematic problems include the submodule altering control, the flowing current control, the simultaneous control of several variables, and the complexity of the control process.

REFERENCES

[1]. Yang Wang,Ahmet Aksoz, et al, "A Review of Modular Multilevel Converters for Stationary Applications", ***Appl. Sci.*** 2020, ***10***(21), 7719; https://doi.org/10.3390/app10217719

[2]. Du, S.; Wu, B.; Tian, K.; Zargari, N.; Cheng, Z. An Active Cross-Connected Modular Multilevel Converter (AC-MMC) for Medium-voltage Motor Drive. *IEEE Trans. Ind. Electron.* 2016, *63*, 1.

[3]. Kawamura, W.; Hagiwara, M.; Akagi, H. Control and Experiment of a Modular Multilevel Cascade Converter Based on Triple-Star Bridge Cells. *IEEE Trans. Ind. Appl.* 2014, *50*, 3536–3548.

[4]. Blaszczyk, P. Hex-Y—A New Modular Multilevel Converter Topology for a Direct AC-AC Power Conversion. In Proceedings of the 2018 20th European Conference on Power Electronics and Applications (EPE '18 ECCE Europe), Riga, Latvia, 17–21 September 2018; pp. P.1–P.10.

[5]. Leng, P.; Li, Y.; Zhou, D.; Li, J.; Zhou, S. Decoupling Control of Maglev Train Based on Feedback Linearization. *IEEE Access* 2019, *7*, 130352–130362.

[6]. Yang, Q.; Saeedifard, M. Sliding Mode Control of the Modular Multilevel Converter. In Proceedings of the 2018 IEEE Applied Power Electronics Conference and Exposition (APEC), San Antonio, TX, USA, 4–8 March 2018; pp. 1036–1043.

[7]. Liu, X.; Huang, J.; Sun, Y.; Gao, S.; Tong, X. Passive Control for the MMC-HVDC System Based on the Energy Function. In Proceedings of the 2019 14th IEEE Conference on Industrial Electronics and Applications (ICIEA), Xi'an, China, 19–21 June 2019; pp. 2232–2237.

[8]. Bergna-Diaz, G.; Zonetti, D.; Sanchez, S.; Ortega, R.; Tedeschi, E. PI Passivity-Based Control and Performance Analysis of MMC Multiterminal HVDC Systems. *IEEE J. Emerg. Sel. Top. Power Electron.* 2019, *7*, 2453–2466.

[9]. Ke, S.; Zhu, M.; Chen, Y.; Zheng, C.; Hu, C. Passive Sliding Mode Variable Structure Control For MMC-UPFC. In Proceedings of the 2019 IEEE Innovative Smart Grid Technologies—Asia (ISGT Asia), Chengdu, China, 21–24 May 2019; pp. 2184–2189.

[10]. Ahmadijokani, M.; Mehrasa, M.; Sleiman, M.; Sharifzadeh, M.; Sheikholeslami, A.; Al-Haddad, K. A Back-Stepping Control Method for Modular Multilevel Converters. *IEEE Trans. Ind. Electron.* 2020, *3*, 1.

[11]. Halli U.M., "Nanotechnology in E-Vehicle Batteries", International Journal of Nanomaterials and Nanostructures. 2022; Vol 8, Issue 2, pp. 22–27

[12]. Pankaj R Hotkar, Vishal Kulkarni, et al, "Implementation of Low Power and area efficient carry select Adder", International Journal of Research in Engineering, Science and Management, 2019, Vol 2, Issue 4, pp. 183 - 184.

[13]. Karale Nikita, Jadhav Supriya, et al, "Design of Vehicle system using CAN Protocol", International Journal of Research in Applied science and Engineering Technology, 2020, Vol 8, issue V, pp. 1978 - 1983, http://doi.org/10.22214/ijraset.2020.5321.

[14]. K. Kazi, "Lassar Methodology for Network Intrusion Detection", Scholarly Research Journal for Humanity science and English Language, 2017, Vol 4, Issue 24, pp.6853 - 6861.

[15]. Mrunal M Kapse, et al, "Smart Grid Technology", International Journal of Information Technology and Computer Engineering, Vol 2, Issue 6

[16]. Waghmode D S , et al, "Voltage Sag mitigation in DVR based on Ultra capacitor", Lambart Publications. 2022, ISBN – 978-93-91265-41-0

[17]. Dr. B. D. Kadam et al, "Implementation of Carry Select Adder (CSLA) for Area, Delay and Power Minimization", Telematique, 2022, Vol 21, issue 1, pp. 5461 – 5474

[18]. K. Kazi, "Smart Grid energy saving technique using Machine Learning" Journal of Instrumentation Technology and Innovations, 2022, Vol 12, Issue 3, pp. 1 – 10.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 2, August 2024

[19]. Nida N. Shaikh, Milind D. Chavan, V.G. Shirshikar,(2023). PV Penetrations in Conventional Power System and Generation of Harmonic and Power Quality Issues: A Review. *International Journal of Power Electronics Controllers and Converters*. 2023; 9(2): 12–19p

[20]. Prashant K Magadum (2024). Machine Learning for Predicting Wind Turbine Output Power in Wind Energy Conversion Systems, Grenze International Journal of Engineering and Technology, Jan Issue, Vol 10, Issue 1, pp. 2074-2080. Grenze ID: 01.GIJET.10.1.4_1

[21]. K. K. S. Liyakat, "Detecting Malicious Nodes in IoT Networks Using Machine Learning and Artificial Neural Networks," *2023 International Conference on Emerging Smart Computing and Informatics (ESCI)*, Pune, India, 2023, pp. 1-5, doi: 10.1109/ESCI56872.2023.10099544.