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Simulation of Two Terminal Fault Combination Location Method in MMC-HVDC Transmission Line Model

Mr. Suraj D. Solanke and Prof. Harshal V. Takpire
G. H. Raisoni, University, Amravati

Abstract: *Due to the widespread use of renewable energy, multi-terminal flexible HVDC grids are required. However, the issue of security remains a significant obstacle. This is primarily because DC networks have a lower inductance than AC networks, which typically causes a sudden drop in DC voltage and a rapid rise in fault current that can reach dangerous levels in milliseconds. Distance protection and other steady state-based high voltage AC (HVAC) system protection algorithms are not suitable for MT-HVDC system protection. In the event of a fault, unit line protection devices must operate at a sufficient speed and isolate only the faulty section to prevent a short circuit from causing the entire system to fail. They are susceptible to direct and alternating current faults. Fast and selective protection schemes are required to guarantee their high reliability and continuous operation. Using modular multilevel converters, this project aims to investigate the transient voltages brought on by dc line faults in an HVDC grid. Utilizing MATLAB to model an MMC-based four terminal HVDC grid, extensive simulations are carried out to verify the scheme's efficacy.*

Keywords*:* DC line protection; Multi-terminal HVDC grid; Fault classification; Faulty pole selection; Fault transient voltage

I. INTRODUCTION

Modular multilevel converters (MMCs) are increasingly being utilized in flexible HVDC systems [1], [2], and [3] due to the advantages they offer over two-level voltage source converters (VSC), such as having lower switching losses and lower output voltage harmonics [1], [2], and [3]. In enormous scope multi-terminal HVDC frameworks, there will be an extraordinary open door soon to show MMC's benefits [4]. Multi-terminal HVDC frameworks offer more prominent adaptability and transmission overt repetitiveness than highlight point HVDC frameworks [5, 6]. Regardless, security structure confines the improvement of HVDC cross sections for the most part [7], [8].

Using an AC circuit breaker (CB) to isolate the damaged branch rather than a DC CB or fault-tolerant converter is the best way to protect against an ac fault in a multi-terminal HVDC grid [9]. because the first choice has the ability to guarantee that healthy branches will continue to function normally. However, due to the low impedance of the DC network, the fault current can reach more than ten times the rated value within milliseconds [10, 11], putting the converter equipment in danger and straining the AC CB. Quick assurance standards are therefore essential.

AC transmission systems frequently use distance and overcurrent protections. Due to the absence of a grid fundamental frequency impedance, distance protection cannot be directly utilized in a DC system [12]. Boundary assessment is utilized to address the shortcoming distance in [12] and [13]. However, a lumped-boundary circuit is used, and as a result, accuracy decreases with line length. Refs. [9],[14] apply an overcurrent plan to the HVDC lattice assurance, but significant shortcoming opposition has an impact on the unwavering quality and selectivity. Overcurrent assurance is combined with directional and undervoltage assurances in [14] to enhance security dependability, but this results in the confusing system of shortcoming ID.

After analyzing fault transient voltages under distributed-parameter AC line conditions, this paper presents a non-unit AC line protection scheme for the MMC-based multi-terminal HVDC grid. The nearby shortcoming transient voltage is all that is utilized in the shortcoming grouping technique. Its principal benefits integrate fast security

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speed (inside 1 ms), and high responsiveness even by virtue of tremendous issue check (for instance 400 Ω). Besides, as opposed to the standard voyaging wave-based insurance system, the limit for shortcoming not set in stone through hypothetical estimation instead of reproduction.

II. PROPOSED CONTROL METHOD

Two completely decoupled control stages—one for the MPPT dc-dc converter and one for the dc-MMC converter—make up the proposed control strategy. MPPT and controlling the PV string input voltage are the responsibilities of the first control stage. The second control stage is carried out by the dc-MMC, also known as a grid side converter. It aims to control power control, individual dc-link voltage control, grid current control, and total dc-link voltage control.

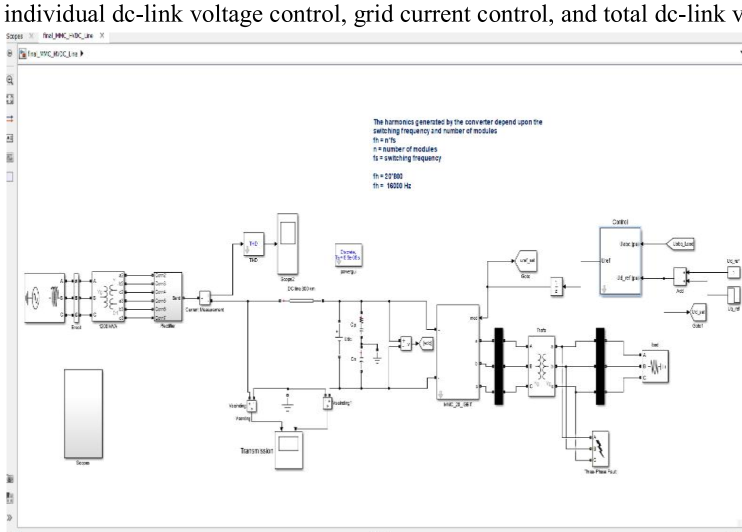

Figure 1 UNIPOLAR MMC BASED HVDC GRID

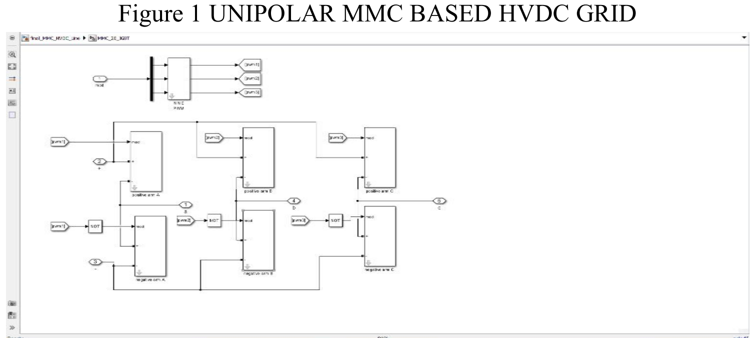

Figure 2 MMC SUBSYTEM MODEL

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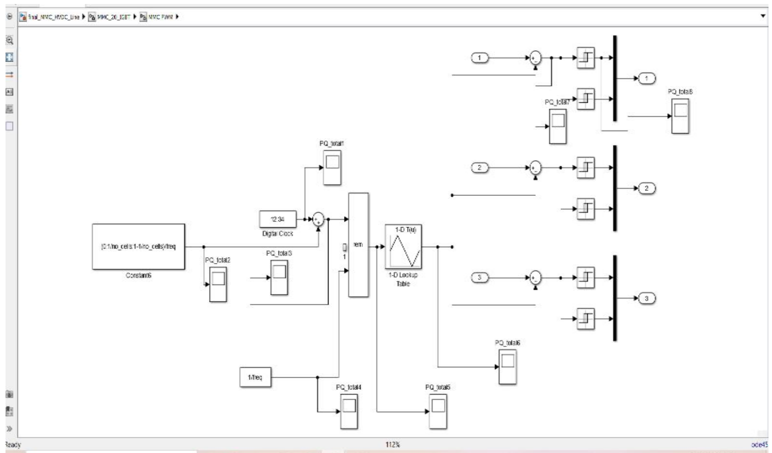

Figure 3 PWM SUBSYSTEM

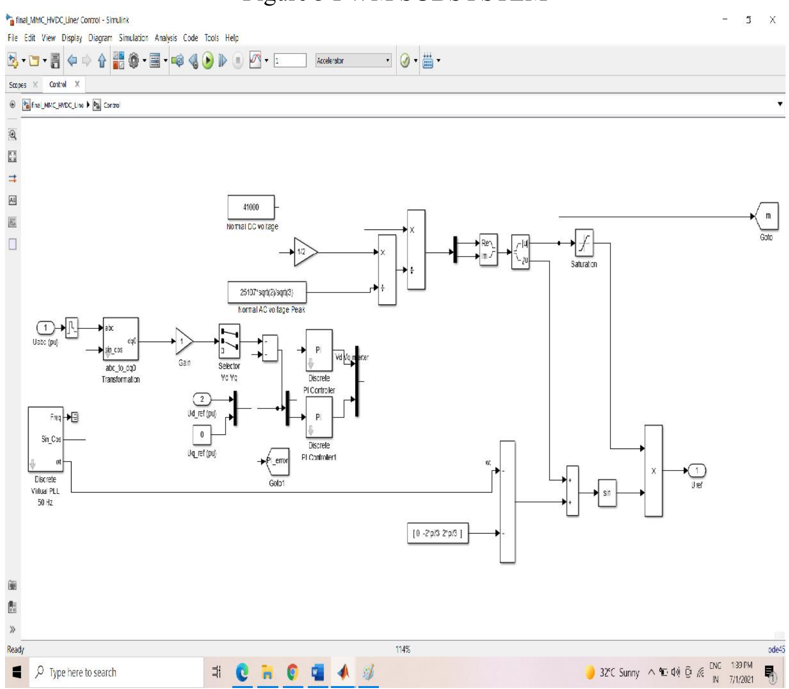

Figure 4 control circuit for generating reference voltage

Figure 1 portrays the total model of a MMC-based HVDC matrix, which incorporates a rectifier circuit and an inverter circuit, with an air conditioner load associated with the inverter. MMC is only connected to the inverter side in unipolar mode, whereas the standard 600 rectifier is connected to the sending end side. A reference voltage controlling circuit is designed to generate the reference voltage, and PWM generates a triangular waveform for the triggering signal. The PWM input receives a 1pu continuous reference voltage from the controlling structure.

A six-switch inverter is made up of 20 IGBTs in this MMC circuit, with three for the positive arm and three for the negative arm. After the whole model is finished, it is run briefly, and the shortcoming is associated with the inverter after 0.8 seconds.

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III. RESULT

NORMAL CASE

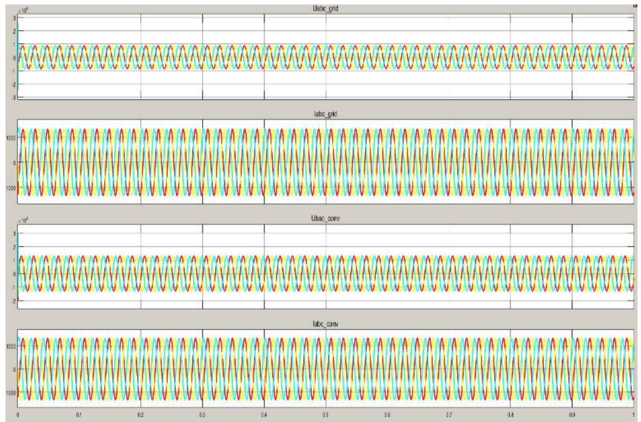

Figure 5 VOLTAGE AND CURRENT WAVEFORM

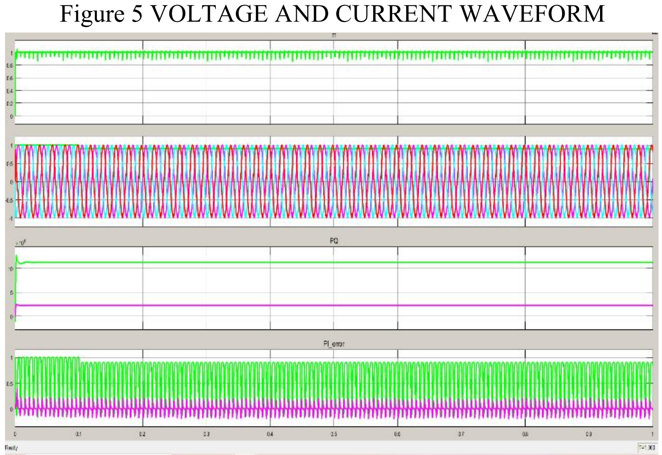

Figure 6 POWER AND MODULATION INDEX WAVEFORM

LG FAULT

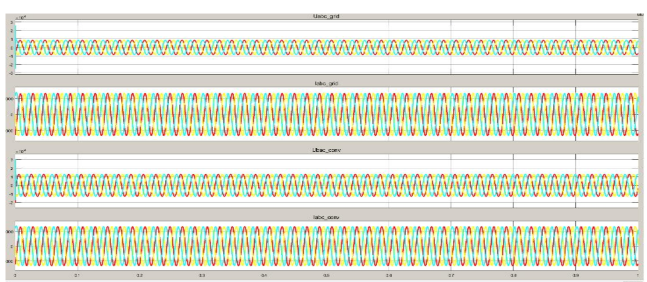

Figure 7 VOLTAGE AND CURRENT WAVEFORM

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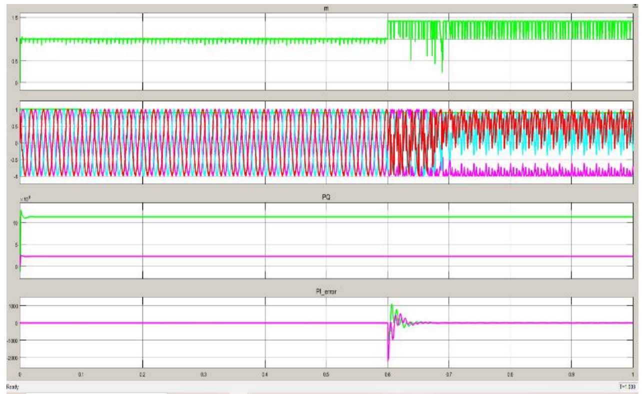

Figure 8 POWER AND MODULATION INDEX WAVEFORM

LLG fault

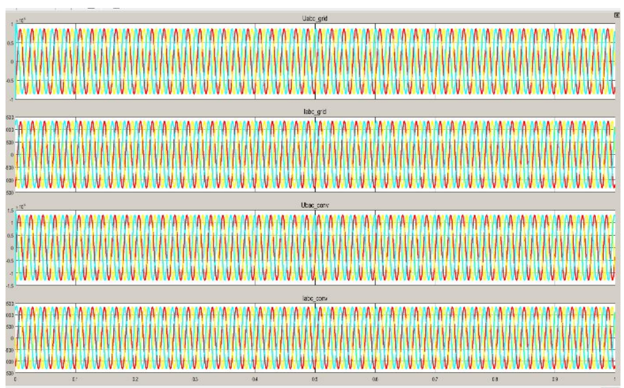

Figure 9 VOLTAGE AND CURRENT WAVEFORM

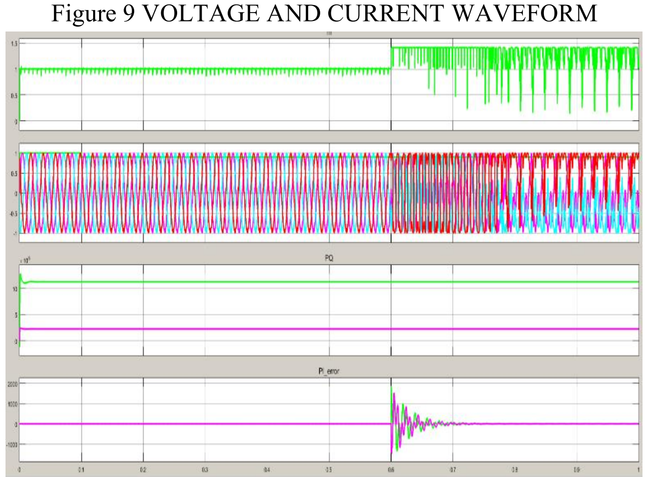

Figure 10 POWER AND MODULATION INDEX WAVEFORM

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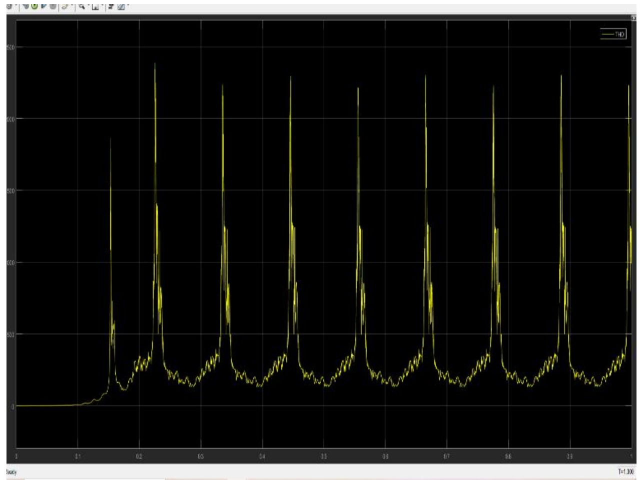

Figure 11 THD Of normal case

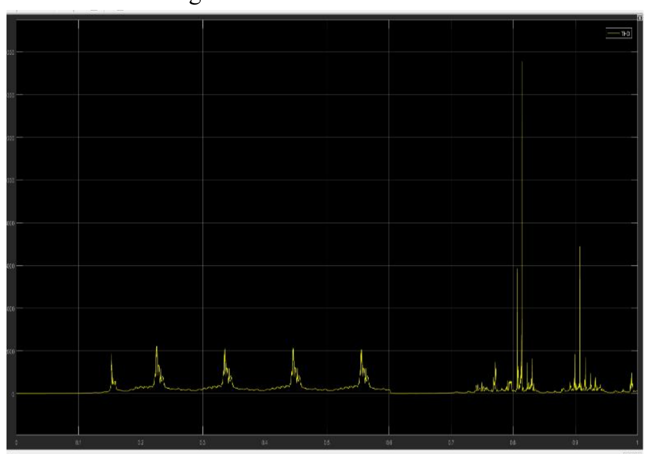

Figure 12 THD Of LG fault case

The result figure above demonstrates this. that voltage and current have no effect on distortion caused by faults and harmonics because an MMC-based inverter is used. Figures 5 and 6 show the normal situation, and it is evident that the fault has no effect on voltage or current when compared to figures 7 to 12.

IV. CONCLUSION

This paper incorporates enormous scope HVDC framework associated generator source energy transformation framework. The dc-ac stage is included in the two-stage ac-dc system that is being proposed. Reduced filter size and cost, decoupled active and reactive power, and multiport network capability are just a few of the benefits of MMC and HVDC operation that are incorporated into the systems. Additionally, compared to a dc-ac central inverter or a dc-dc/dc-ac two-stage inverter, a dc-dc central inverter or a dc-dc/dc-ac two-stage inverter, as well as an ac-dc HVDC power station, have fewer power electronics components. The framework plan and execution are profoundly measured, permitting the Power Gadgets Building Block idea to be used. Compared to ac systems, which require synchronization and coordinate transformations, control schemes are simpler and less complicated. Future research will need to address a few technical issues, such as the insulation requirements for the converter cells and how they affect the overall cost of the system.

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