PROTECTION SCHEME FOR UNIPOLAR MMC-BASED MULTI-TERMINAL HVDC GRID

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Abstract:

Multi-terminal flexible HVDC grids are required due to the high penetration of renewable energy. However, protection issue remains a major challenge. This is largely due to the low inductance in DC network compared to AC interconnection which usually results in a sudden collapse in the DC voltage and rapid rise in the fault current thus reaching damaging levels in few milliseconds. Therefore, faults in MT-HVDC system must be detected and cleared quickly before it reaches a damaging level; typically, 4 – 6ms (including circuit breaker opening time) following the inception of the fault. For this reason, transient based protection techniques are ideal. The protection scheme must be reliable and dependable. Transient based protection algorithms utilize the higher frequency components of the fault generated signal to detect a fault, therefore making it possible to detect the fault while the fault current is still rising and well before the steady state. The traditional protection algorithms developed for conventional high voltage AC (HVAC) systems such as distance protection are steady state based and as such not suitable for the protection of MT-HVDC systems. Non-unit line protection devices which will operate at a sufficient speed and which will isolate only the faulty section in the event of a fault are therefore required to avoid a total system failure during short circuit. They are vulnerable to dc faults. To ensure their high reliability and continuous operation, fast and selective protection schemes are indispensable. This project analyses the transient voltages in the case of dc line faults in modular multilevel converter (MMC)-based HVDC grid. A MMC-based four terminal HVDC grid is modeled using MATLAB, and extensive simulations are conducted to validate the effectiveness of the proposed scheme.

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

Introduction:

Modular construction convertor (MMC) is bit by bit employed in versatile HVDC systems thanks to its blessings over twolevel voltage supply convertor (VSC), like less change losses, lower harmonics in output voltage, and easier to realize high voltage and huge capability [1–3]. there'll be a good likelihood within the close to future to point out the su- priorities of MMC in giant scale multi-terminal HVDC grids [4]. Compared to point-to-point HVDC systems, multi-terminal HVDC grids supply higher transmission redundancy and adaptability [5,6]. However, protection system limits the event of HVDC grids to an oversized extent [7,8]. When a dc fault happens in multi-terminal HVDC grid, the most effective protection alternative is to isolate the faulty branch by dc fuse (CB), instead of victimization ac CB or fault-tolerant convertor [9]. as a result of the primary alternative will guarantee the traditional operation of healthy branches. How- ever, thanks to the low electrical resistance of dc network, the fault current will reach over 10 times of the rated worth inside few milliseconds [10,11], that endangers the convertor instrumentality, and results in stress on dc CB. Therefore, quick protection principles area unit indispensable. In ac transmission systems, distance and overcurrent protections get wide utilization. However, it's laborious to use distance protection in dc system directly, for no grid first harmonic electrical resistance may be outlined [12]. In [12] and [13], parameter analysis is applied to re- gift the fault distance. However, lumped-parameter circuit is employed, and as a result the exactness deteriorates with the rise of line length. Refs. [9,14] apply overcurrent theme to the HVDC grid protection, however, the dependability and property area unit suffering from giant fault resistance. In [14], to enhance the protection dependability, over- current protection is combined with directional and undervoltage protections, however which ends up within the advanced method of fault identifiion. In typical line commutated convertor (LCC)-based HVDC system, traveling wave, voltage or current spinoff and voltage level area unit used as main protection, whereas current differential protection is applied as back-up protection. The said protection criteria also can be accustomed the dc line protection in HVDC grid, except this differential protection for its long-time delay. supported the boundary impact of current-limiting reactor, use voltage modification rate to discriminate internal fault from external fault. Reference combines the protection strategies of current modification rate with voltage level. These protection strategies will meet the need of protection speed, whereas, the sensitivity and dependability can decrease within the case of enormous fault resistance. In, travelling-wave-based fault location strategies area unit pro- expose for dc line protection, that area unit supported single- or two-terminal measurements. once solely native data is employed, the time of arrival of each the initial and mirrored waveforms from the fault purpose has to be obtained. However, the detection of the mirrored traveling wave is tough for its attenuation within the propagation method and confusion with alternative mirrored waveforms. though the two-terminal fault location theme doesn't have to be compelled to live the time of arrival of the mirrored wave shape, the signal transmission between 2 terminals results in communication delay. After analyzing fault transient voltages underneath condition of dis- tributed-parameter dc line, this paper presents a non unit dc line protection theme for MMC-based multi-terminal HVDC grid. The fault classification technique solely uses the native fault transient voltage. Its main blessings embody quick protection speed (within one ms), and high sensitivity even in the case of large fault resistance (e.g., 400 Ω). In addition, unlike the conventional travelling-wave-based protection method, the threshold of the fault classification is set by theoretical calculation rather than simulation

III. PROPOSED CONTROL METHOD

The proposed control method is composed of two control stages completely decoupled from each other, one for the MPPT dc-dc converter and one for the dc-MMC converter. The first control stage is in charge of performing MPPT and controlling the input PV string voltage. The second control stage, performed by the dc-MMC or grid side converter, has several control goals, including: total dc-link voltage control (power control), individual dc-link voltage control (to adjust the power imbalance among cells) and grid current control.

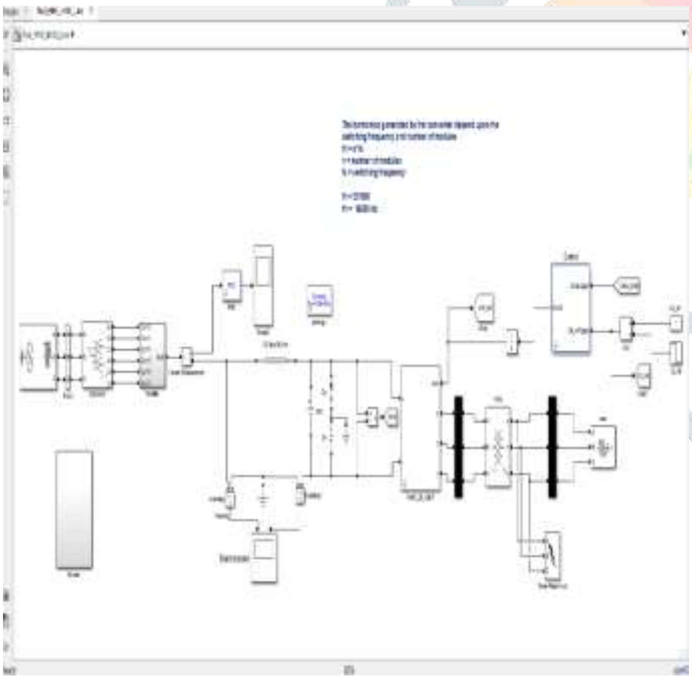

Fig.1 UNIPOLAR MMC BASED HVDC GRID

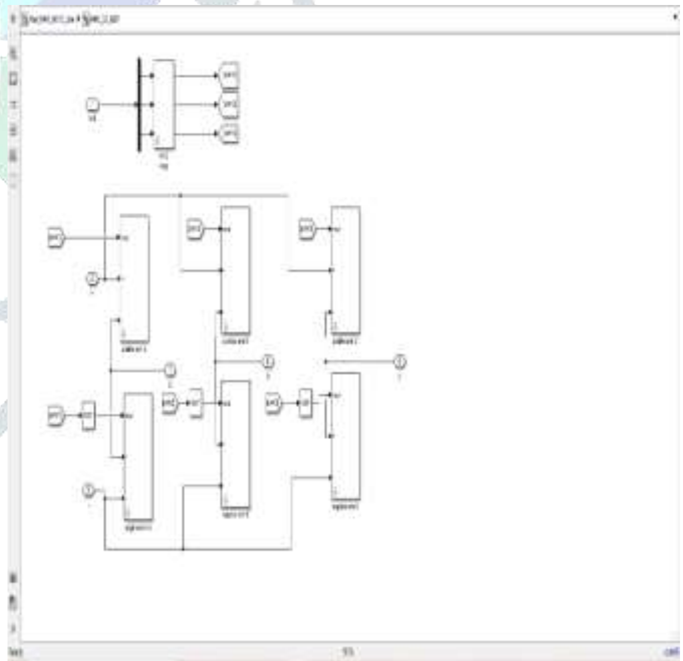

FIG.2.MMC SUBSYTEM MODEL

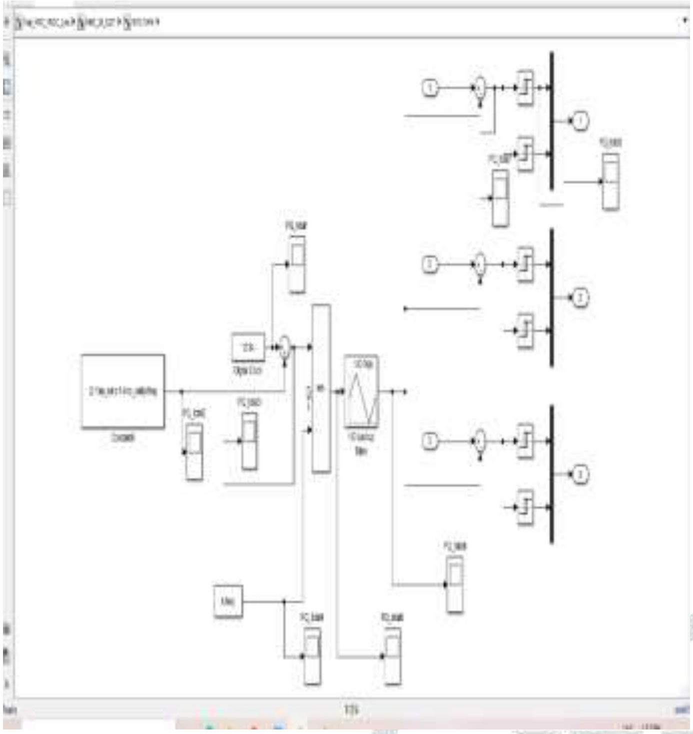

FIG.3 PWM SUBSYSTEM

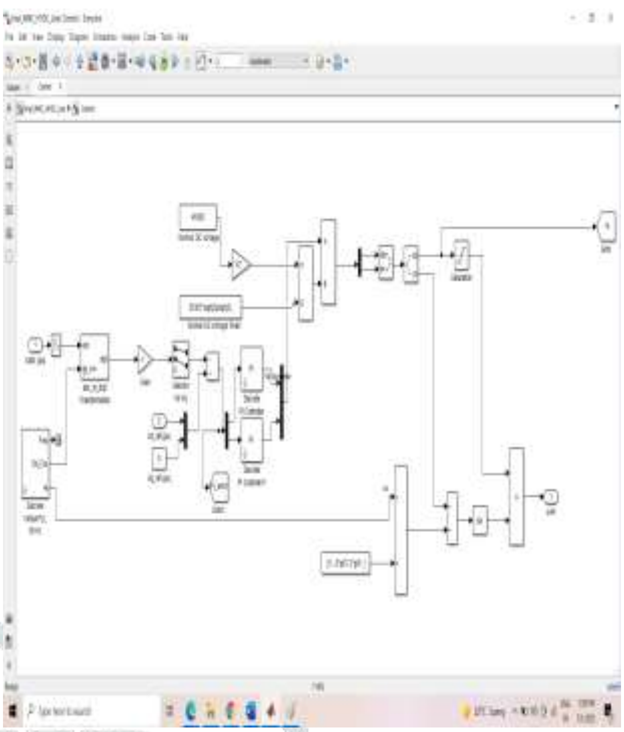

fig.4 control circuit for generating reference voltage

Fig.1 shows the complete model of MMC based HVDC grid, which consist of rectifier ciruit and inverter circuit and AC load is connect at inverter side. In unipolar MMC is connected at inverter side only and normal 60^0 rectifier is connected at sending end side. To generate triggering signal, triangular waveform is generated by PWM and to generate reference voltage controlling circuit is design. in controlling structure continues reference voltage of 1pu is produce which is given to input of PWM.

Here in MMC circuit 20 IGBT is used to make a 6 switch for inverter (3 for positive arm and 3 for negative arm). after complete model is ready, it is run for 1 sec and fault is connected after 0.8 sec on inverter side.

Result:

NORMAL CASE

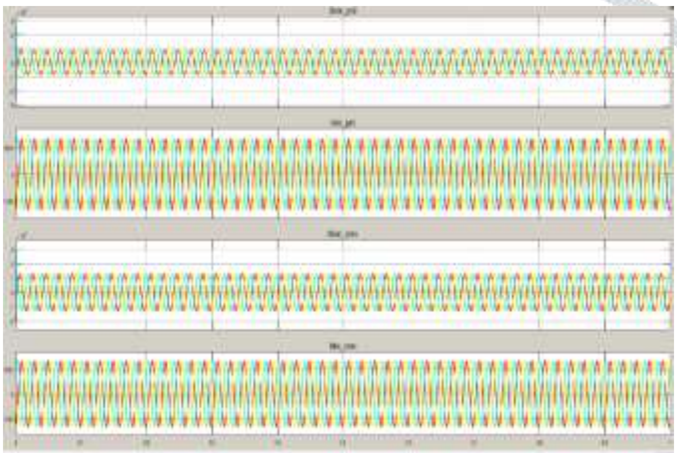

FIG.5 VOLTAGE AND CURRENT WAVEFORM

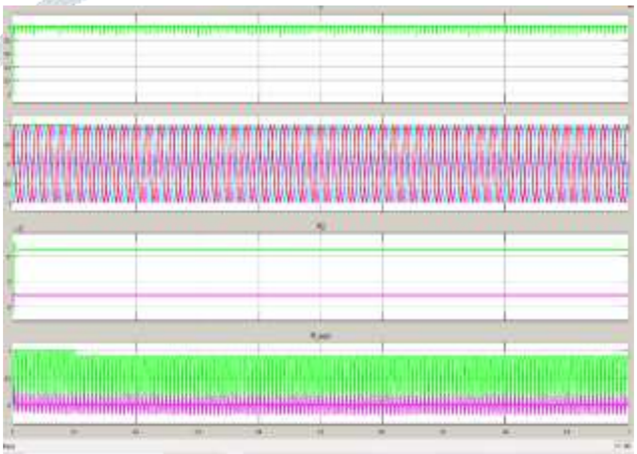

FIG.6 POWER AND MODULATION INDEX WAVEFORM

LG FAULT

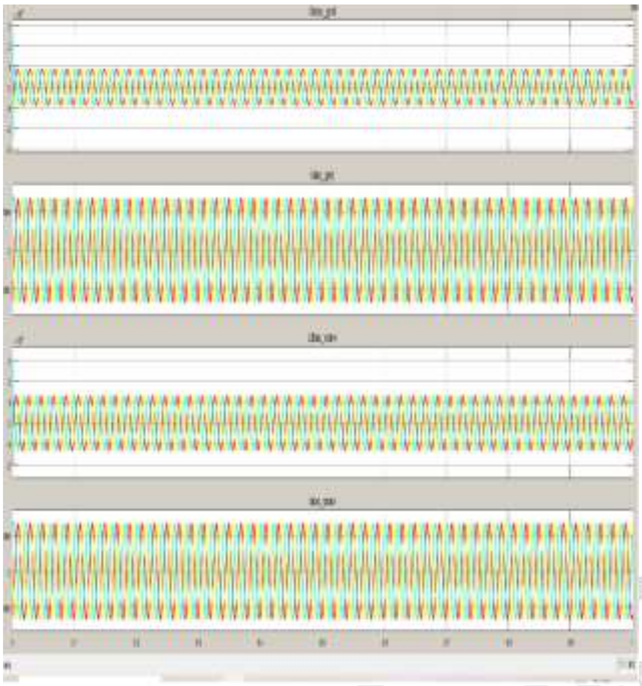

FIG.5 VOLTAGE AND CURRENT WAVEFORM

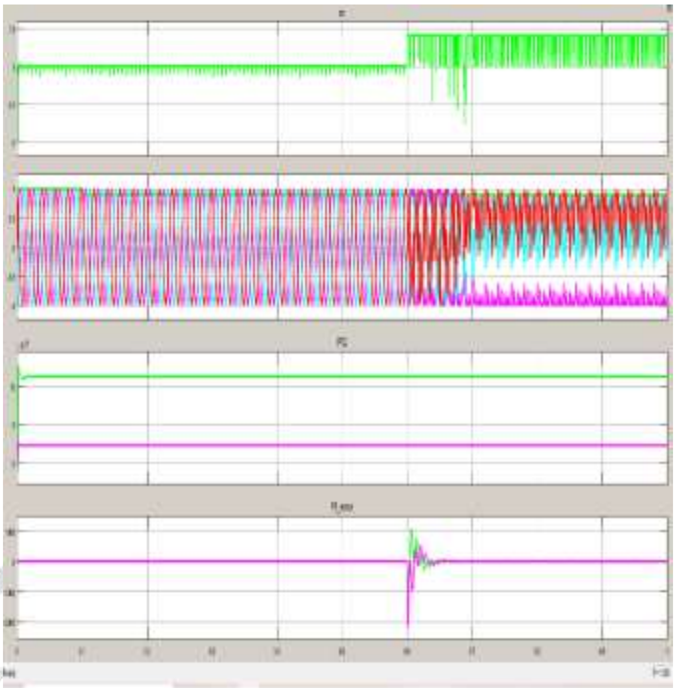

FIG.6 POWER AND MODULATION INDEX WAVEFORM

LLG fault

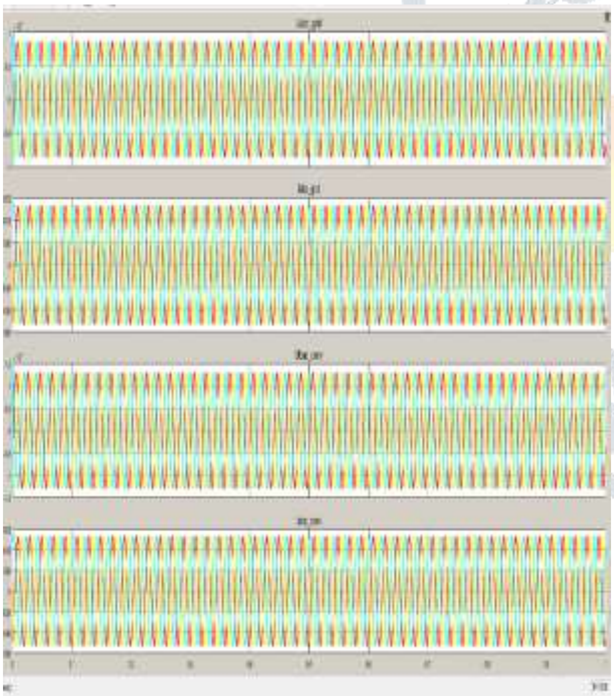

FIG.7 VOLTAGE AND CURRENT WAVEFORM

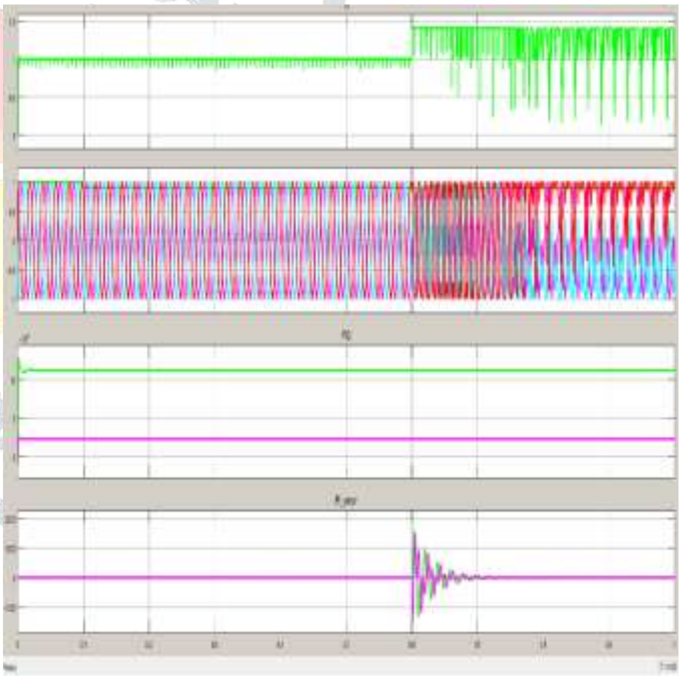

FIG.8 POWER AND MODULATION INDEX WAVEFORM

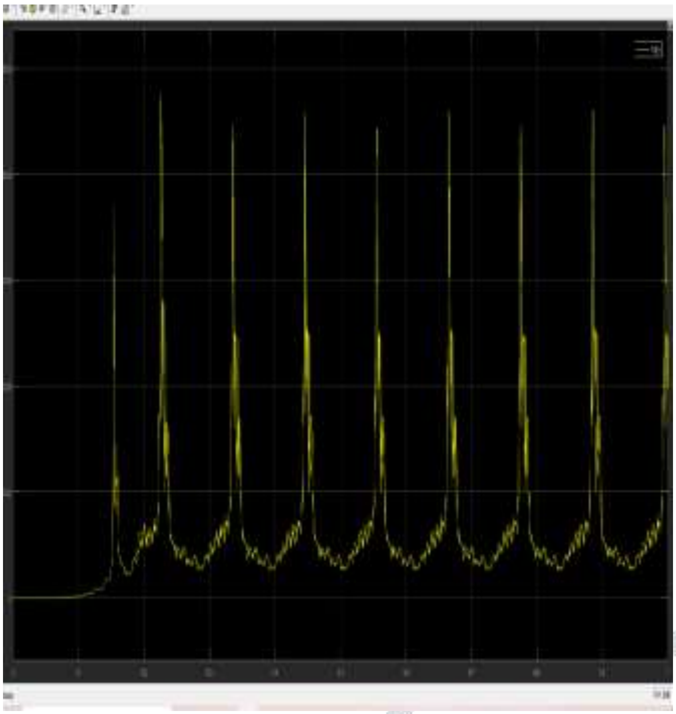

FIG.9 show THD Of normal case

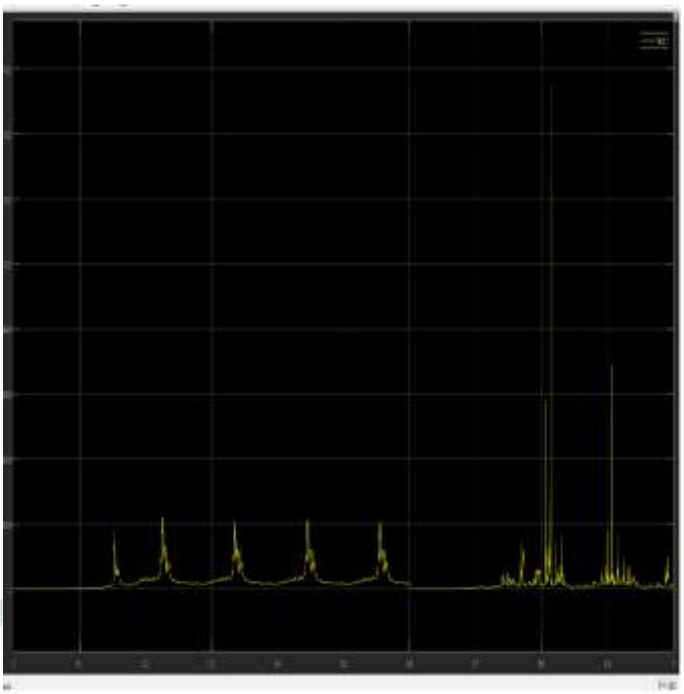

FIG.9 show THD Of LG fault case

From above result fig. Is is clear that due to the use of MMC based inverter, voltage and current has no effect of fault and harmonics distortion. fig .5 and 6 shows normal case and comparing with fig.5,6,7,8 it is clear that fault has no effect on voltage and current.

Conclusion: A large-scale HVDC grid-connected generator source energy conversion system has been presented. The proposed configuration consists of a two-stage ac-dc system combining the dc-ac stage. The distances and remoteness for the feasibility of the HVDC line can be relaxed if underwater cabling is part of the system. The systems incorporate all advantages of the MMC and HVDC operation: reduced size and cost of filter, decoupled active and reactive power and multiport network possibility. In addition, the two dc-dc stages per power cell have less power electronics components than a dc-ac central inverter or a dc-dc/dc-ac two-stage inverter, followed by a ac-dc HVDC power station. The system design and implementation are highly modular, enabling use of the Power Electronics Building Block (PEBB) concept. The control schemes are very straightforward and are less complex than ac system which require synchronization, and coordinate transformations. Some technical challenges remain for future research: insulation requirements for the converter cells and its impact on the cost of the overall system.

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