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A Nearest Level Modulation technique for Modular Multilevel Converter for Fewer Submodule

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ABSTRACT

A simpler nearest level control balancing solution for modular multilevel converters is described in this research. The proposed solution does not necessitate individual submodule voltage sorting or switching state redundancy. Once the submodules have been sorted by the number of submodules to be turned on, the submodules can be identified at any time during the method's implementation. In the gate pulse generation stage, the suggested method likewise does not require the individual submodule status. The switching states of the input voltages can be used to build the gate logic in the described technique. This paper mainly based on switching pattern of submodules , and according to the switching pattern submodules produces the scaled output for modular multilevel converter. Model consist of 4 submodule in upper arm and 4 submodule in lower arm which produces the upper and lower arm voltage. And we are getting 5 levels for 4 submodules. For simulation purpose we uses a MATLAB SIMULINK.

Keywords : MATLAB SIMULINK, Modular Multilevel Converter, Total Armonic Disturbance, Modular Multilevel Converter, APOD-PWM

I. INTRODUCTION

The integrated multilayer converters can be immediately connected to medium voltage (2.3–4.16 kV) power systems, according to the researchers. Furthermore, in order to run at the increased operating voltage, these topologies necessitate a greater number of output voltage levels, which increases the complexity of the converter's control and assembly. Furthermore, in order to run at the increased operating voltage, these topologies necessitate a greater number of output voltage levels, which increases the complexity of the converter's control and assembly. On the other hand, multi-cell converters are modular and are easier to scale up to higher voltages.

One of the most promising topologies in the multi-cell converter family is the modular multilevel converter (MMC). The following are the main characteristics of MMC

- It has a modular design that allows the voltage and power rating to be scaled.
- It has the ability to generate output currents and voltages with lower dv/dt and ripple.
- Typically, a very reduced total harmonic distortion (THD) output voltage can be produced.

- MMC can generate a huge number of voltage levels in the output voltage waveform. As a result, the submodules can be operated at a very low switching frequency.
- To ensure fault tolerance, it can use redundant submodules in each arm.

II. METHODS AND MATERIAL

MODULAR MULTILEVEL CONVERTER

The MMC topology has sparked a lot of attention in high-voltage applications recently. Marquardt and Lesnicar suggested it first, and it is considered one of the next-generation high-voltage multilevel converters without line-frequency transformers. MMC topology is preferred for high-voltage applications due to its modularity, voltage scalability, and common dc bus.

The following are some of the advantages of a modular multilevel converter:

- Continuities of operation: The sub-modules of a modular multilevel converter are connected in a chronological order. The MMC as a whole can keep running even if only a few sub-modules fail.
- Modular structure: MMC may be scaled to different voltages and power levels.
- Converters or standards machines that are connected to the grid: It's a filterless setup with minimal total harmonic distortion (THD) and a theoretically high voltage level. However, a normal transformer or no transformer can be used for grid-connected applications.
- Significantly improved productivity.

The following are some of the disadvantages of using a modular multilevel converter:

- There are an excessive number of high-power semiconductor devices connected.
- Capacitors have a lot of energy stored in them.

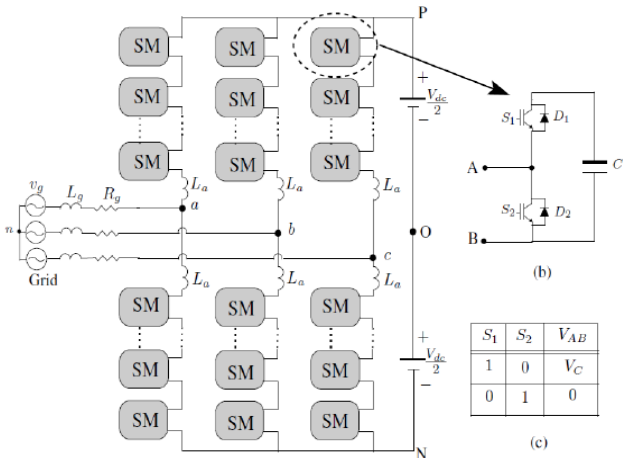


Figure 1. Schematic representation of MMC : Topology, (b) Sub-module, (c) Switching states

DIFFERENT MODULATION SCHEME

The following are some of the modulation techniques available for manipulating signals and producing desired output

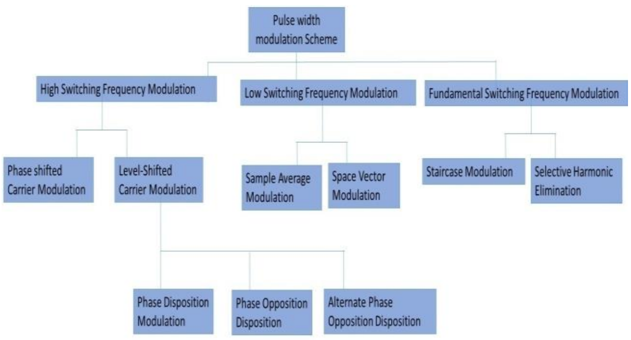


Figure (2) Different Modulation Technique

Pulse width Modulation (PWM)

PWM systems are intended to reduce output voltage harmonic distortion while increasing output voltage magnitude at a given switching frequency. The PWM schemes for a modular multilevel converter are divided into three categories based on the switching frequency: high switching frequency, low switching frequency, and fundamental switching frequency modulation schemes.

Multi-carrier modulation schemes are subdivided into phase-shifted (PSC-PWM) and level-shifted (LSC-PWM) carrier modulations, depending on the type of carrier arrangement.

- **Phase-Shifted Carrier Modulation :**

This modulation has the advantage of utilising all modules equally and producing low harmonics considering the low number of sub-modules. The level of the carriers is the same, but they are level shifted so that they are equally spaced in one cycle (n-number of identical triangular carriers are present, with one carrier for every sub-module displaced at an angle of 360°/N.)Each arm has its own carrier set. In fact, n+1 or 2n+1 voltage levels can be obtained at the phase terminal by adjusting the phase of carrier sets between the upper and lower arms.

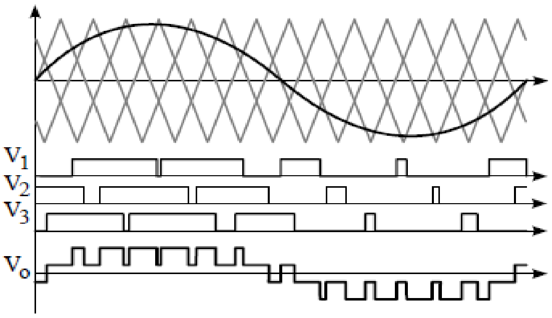


Figure (3) Phase shifted Pwm

Level-Shifted Carrier Modulation:

This system likewise requires an n-number of triangular carriers that are identical. Carrier waves are placed one on top of the other in this arrangement. Each carrier is assigned a separate sub-module. When compared to a reference signal, the module must either be applied or bypassed. When the number of modules is large enough, a comparatively low switching frequency with low harmonic output is created.

The LSC-PWM has three versions depending on the phase relationship between nearby carriers: I phase-disposition (PD), in which the triangular carrier signals are vertically aligned in phase, as shown in Figure (a); (ii) phase-opposition-disposition (POD), in which triangular carrier signals above the sinusoidal reference zero are in phase and those below the sinusoidal reference zero are out of phase, as shown in Figure (b); and (iii) alternate phase-opposition-disposition (APOD), in which all triangular carrier signals are disposed alternately in phase-opposition, as shown in Figure (c)

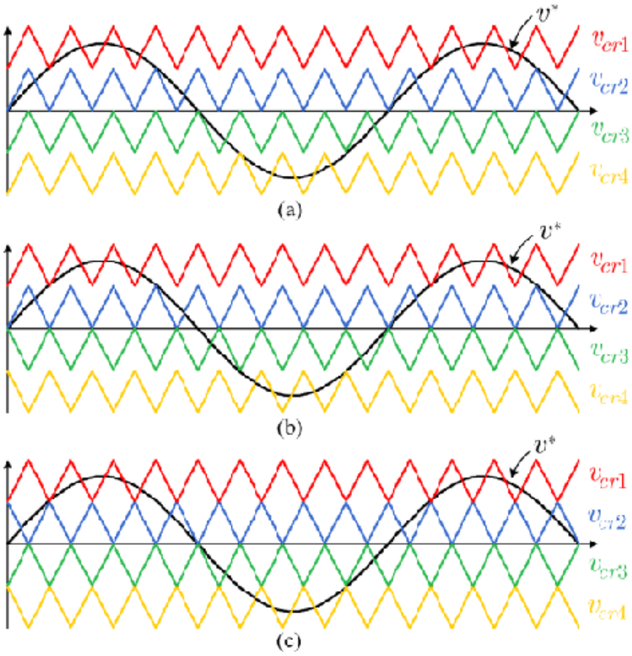


Figure (4) (a)PD, (b)POD, (c)APOD

Nearest Level Modulation

The number of sub-modules inserted is determined by the amplitude of the reference modulating signal. This approach generates the desired reference phase voltage by using the nearest voltage level; thus, it is also known as near-est level modulation (NLM). The NLM is a fundamental switching frequency modulation that avoids the usage of triangular carrier signals, unlike the sine-triangle PWM approach. This modulation technique is suitable for modular multilevel converter systems with a large number of sub-modules because output voltage quality is less likely to deteriorate with small voltage steps. Furthermore, nearest-level modulation is simple to implement in large modular multilevel converter systems.

Assuming that the MMC has N SMs per arm or there are (N+1) levels in the output voltage.Vc represents the average capacitor voltage of all the SMs in each phase.

$$Vdc = \frac{\mathrm{Vdc}}{\mathrm{N}}$$

The number of SMs in the on-state in the upper and lower arms can be calculated

$$Non\_ju = int\left(\frac{0.5Vdc - Vref\_j}{Vc}\right)$$

$$Non\_jl = \mathrm{int}\left(\frac{0.5\mathrm{Vdc} + \mathrm{Vref\_j}}{\mathrm{Vc}}\right)$$

Where j =a,b,c. int(y) will grt the nearest integer of y. At any time, total of SMs in the on state in each phase is equal to the number of SMs per arm as given by

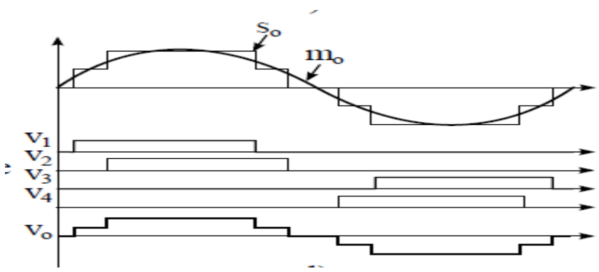
$$N = Non\_ju + Non\_jl$$

Thus, the number of SMs in the off-state in the upper and lower arms is expressed as

$$Noff\_ju = N - Non\_ju$$

$$Noff\_jl = N - Non\_jl$$

The output voltage waveform of this modulation technique is shown in fig



Figure(5) nearest level modulation

III. RESULTS AND DISCUSSION

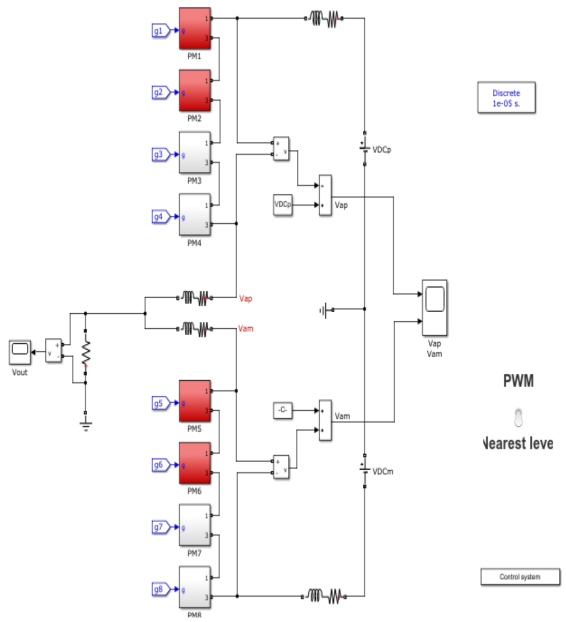
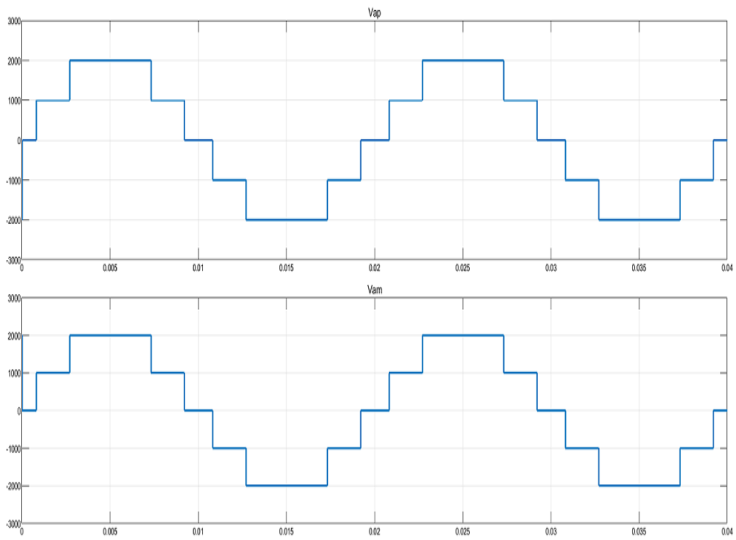


Figure (6) Simulation model of mmc using PWM and Nearest level modulation performed in MATLAB

This model consist of 4 submodule in each arm ie. Upper and lower arm , and the submodules implements the half-bridge modular multilevel converter.Each submodule consist of one half- bridge and one capacitor on the dc side.

OUTPUT BY NEAREST LEVEL MODULATION TECHNIQUE



Figure(7) Upper and lower submodule voltage of nearest level modulation

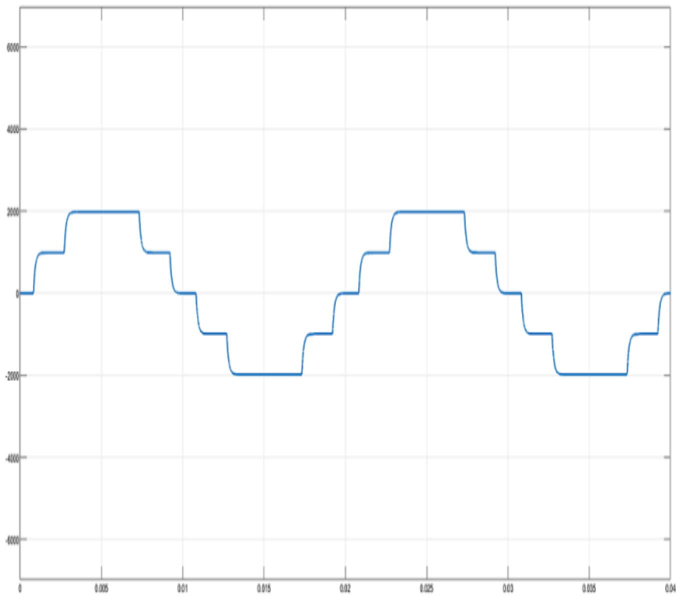


Figure (8) Output Voltage waveform of NLM technique

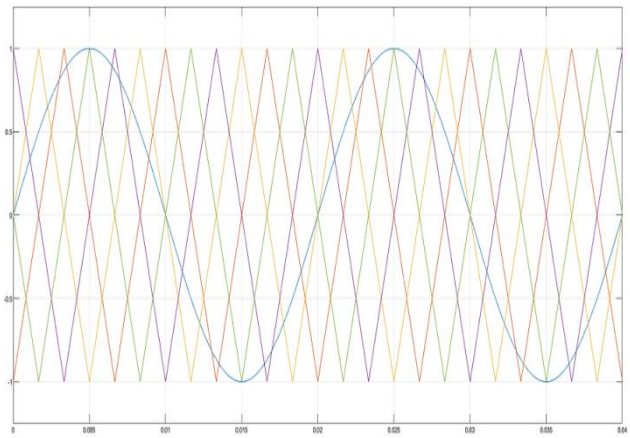


Figure (9) Waveform of carrier and reference voltage

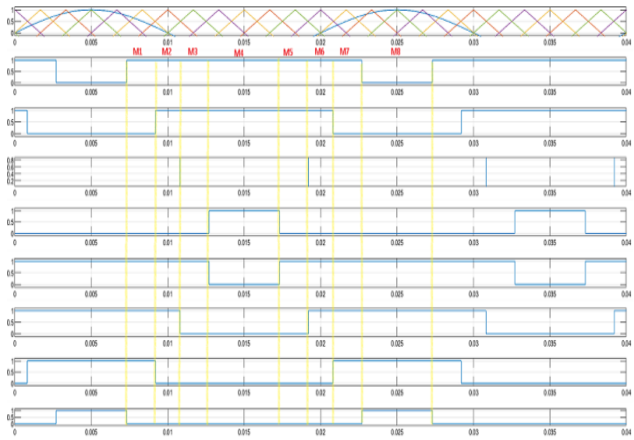
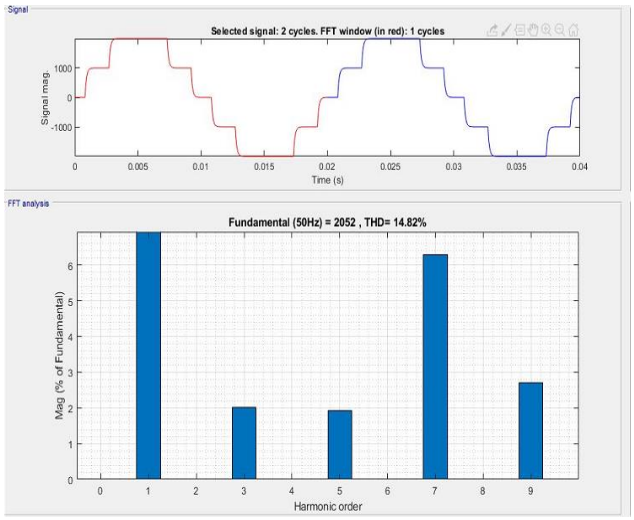


Figure (10) Formation of gate pulses

Table 1 Modes of Operation

Modes	S1	S2	S3	S4	S5	S6	S7	S8
M1	ON	ON	ON	ON	ON	ON	ON	OFF
M2	OFF	ON	ON	ON	ON	ON	OFF	OFF
M3	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
M4	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
M5	ON	ON	ON	OFF	ON	ON	ON	ON
M6	ON	ON	OFF	OFF	OFF	ON	ON	ON
M7	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
M8	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON



Figure(8) THD analysis of Nearest Level Modulation

IV. CONCLUSION

This paper mainly focuses on how different modulation technique is used to decrease the total harmonic disturbance (THD) present in the output voltage of Modular Multilevel Converter (MMC). Several modulation technique is in use we majorly working on APOD-PWM modulation and Nearest Level modulation technique.

After observing the output of NLM we found that for 4 set of submodule we are getting the 5 level output. Therefore for n submodule we get n+1 output.

So to reduce the harmonics present in output we perform the modulation technique ie nearest level modulation , we obser the flat levels with low harmonics. In NLM method the THD is reduce to 14.82%.

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