ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Solar based Simplified Multilevel Converter with Space Vector Modulation

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Abstract:
This paper proposes a simplified space vector modulation (SVM) scheme for multilevel converters. Compared with earlier SVM methods, the proposed scheme simplifies the detection of the nearest three vectors and the generation of switching sequences, and therefore is computationally more efficient. Particularly, for the first time, the proposed scheme achieves the same easy implementation as phase-voltage modulation techniques. Another superior characteristic of the proposed scheme over earlier methods is its potential for multiphase multilevel applications.

The proposed scheme also offers the following significant advantages: 1) independence of the level number of the converter; 2) more degrees of freedom, i.e., redundant switching sequences and adjustable duty cycles, to optimize the switching patterns; and 3) no need for lookup tables or coordinate transformations. These advantages make the proposed scheme well suited to large levelnumber applications, such as modular multilevel converters and high voltage direct current systems. Simulation and experimental results verify this new concept.

Keywords:
High voltage direct current (HVDC), modular multilevel converter (MMC), multilevel converter, multilevel inverter, multiphase converter, orthogonal unit-vectors, space vector modulation (SVM), space vector pulse width modulation (SVPWM).

INTRODUCTION:

Multilevel power conversion was initial introduced twenty years a gone [1]. The general concept involves utilizing a better variety of active semiconductor switches to perform the ability conversion in tiny voltage steps. There are many blessings to this approach when put next with ancient (two-level) power conversion. The smaller voltage steps lead to the assembly of upper power quality waveforms and also scale back the dv/dt stresses on the load and scale back the magnetic force compatibility (EMC) considerations. Another important feature of construction converters is that the semiconductors ar wired in a series-type association, which permits operation at higher voltages. However, the series connection is usually created with clamping diodes, which eliminates overvoltage considerations.

Furthermore, since the switches are not really series connected, their switching will be staggered, which reduces the switch frequency and so the switch losses. One clear disadvantage of multilevel power conversion is the larger variety of semiconductor switches needed. It should be pointed out that lower voltage rated switches will be employed in the construction convertor and so the active semiconductor value isn't appreciably inflated when put next with the two level case. However, each active semiconductor extra needs associated gate drive electronic equipment and adds any quality to the convertor mechanical layout. Another disadvantage of multilevel power converters is that the little voltage steps area unit usually made by isolated voltage sources or a bank of series capacitors.

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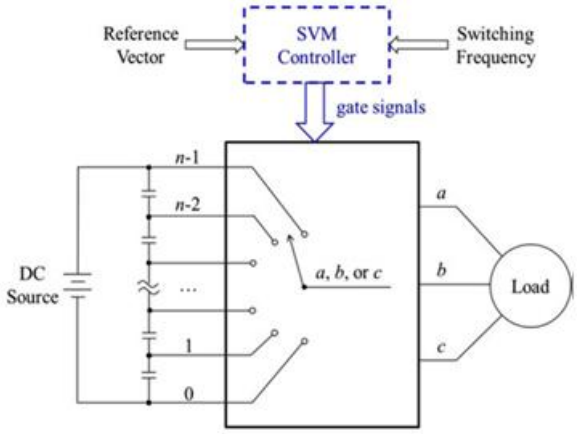
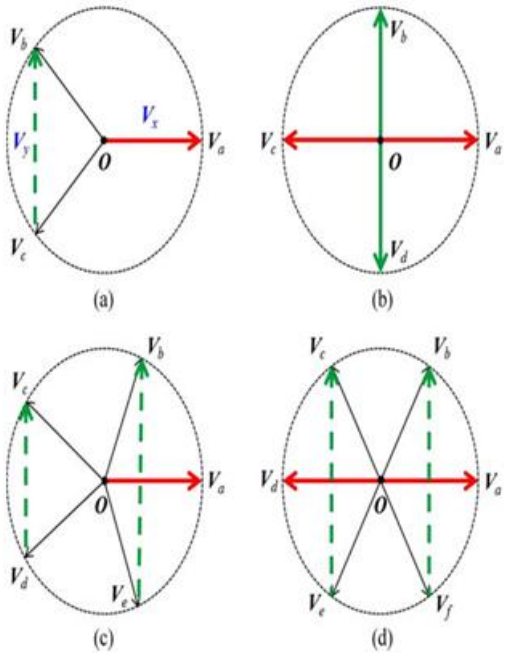
Isolated voltage sources may not continually be pronto offered and series capacitors need voltage balance. To some extent, the voltage balancing will be addressed by exploitation redundant shift states, which exist due to the high variety of semiconductor devices. However, for a complete solution to the voltage-balancing drawback, another multilevel device could be needed [2–4]. In recent years, there has been a substantial increase in interest in multilevel power conversion. This is evident by the very fact that some Institute of Electrical and Electronic Engineers (IEEE) conferences are Keith Corzine University of Wisconsin–Milwaukee © 2002 by CRC Press LLC currently holding entire sessions on construction converters. Recent research has concerned the introduction of novel device topologies and distinctive modulation methods. Some applications for these new converters include industrial drives [5–7], flexible AC transmission systems (FACTS) [8–10], and vehicle propulsion [11, 12].

One area unita wherever construction converters are notably appropriate is that of medium-voltage drives [13]. This chapter presents an summary of construction power conversion ways. The first section describes a general multilevel power conversion system. Converter performance is discussed in terms of voltage levels without regard to the specific topology of the semiconductor switches. A general method of multilevel modulation is described that may be extended to any number of voltage levels. The next section discusses the switching state details of fundamental multilevel converter topologies. The concept of redundant switching states is introduced in this section as well. The next section describes cascaded multilevel topologies, which involve alternative connections of the fundamental topologies. The final section shows example multilevel power conversion systems including laboratory measurements.



SIMPLIFIED SPACE VECTOR MODULATION SCHEME FOR MULTILEVEL CONVERTERS:

This paper proposes a new SVM scheme for multilevel converters. Both the detection of the nearest three vectors and the generation of switching sequences are extremely simplified.



SVM INTRODUCTION:

Considering an electric drive system as shown in Figure, the controller generates a reference voltage, us , represented with voltage space vector, In order to apply this voltage on the motor, it is required to convert this reference voltage to the switching signals for the inverter. To do this, several PWM strategies are available.

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In the sub-oscillation methods, the three phase voltages are firstly calculated and they are compared with a high frequency carrier signal to generate the pulses to control the inverter switches. Besides such methods, it is possible to generate the switching signals directly using the space vector of the reference voltage, without having to convert the space vector to the three phase values at first. This method is called space vector modulation (SVM).

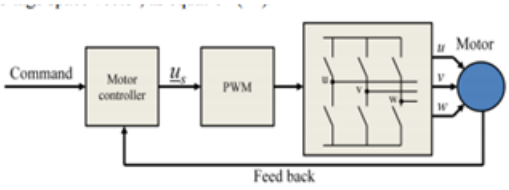
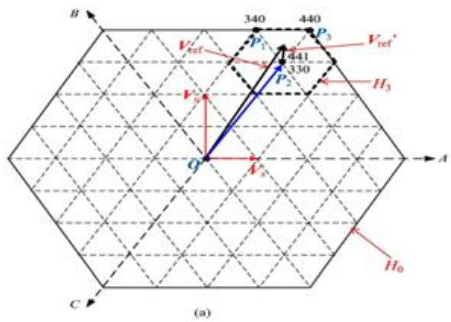
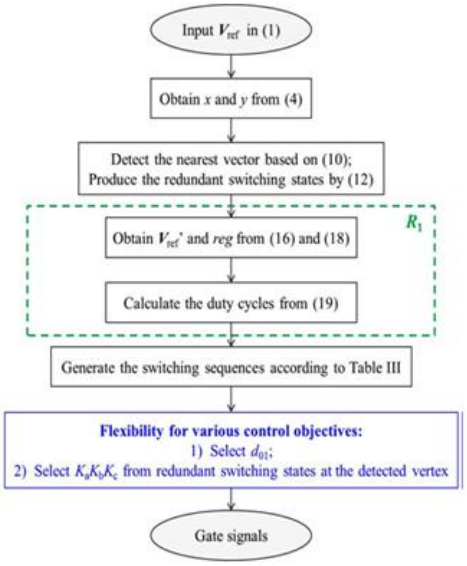


Figure 1. Structure of an electric drive system

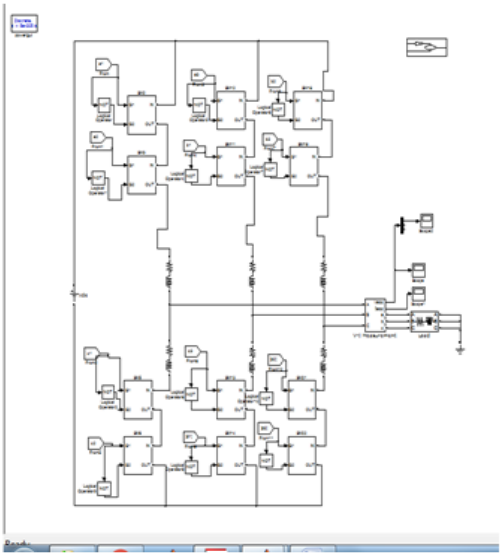




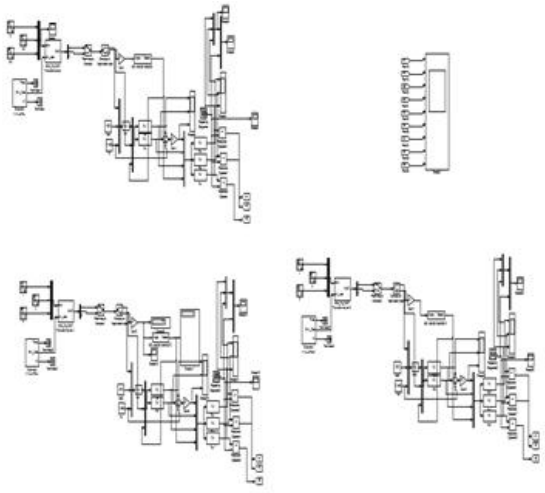
SIMULATION RESULTS:

To demonstrate the two degrees of freedom (i.e., the redundant switching sequences and the adjustable duty cycles) of the proposed new scheme, a simulation is implemented in MATLAB/ Simulink for a three-phase five-level converter. In the simulation, the switching frequency is 5 kHz (fundamental frequency is 50 Hz), the modulation index is 0.6 (i.e., a low-modulation region in order to produce redundant switching states), and the switching sequence mode is changed (alternately from the ascending mode to the descending mode) after every switching cycle.

Main Circuit:



Subsystem of Circuit Diagram:



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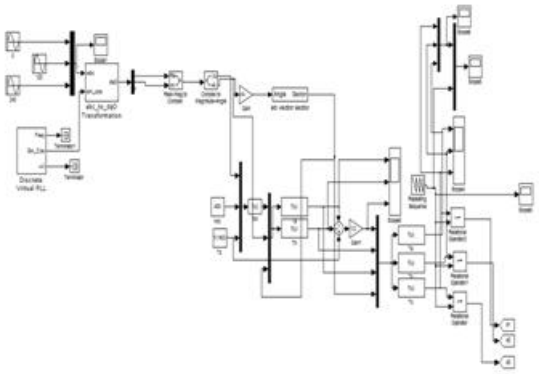
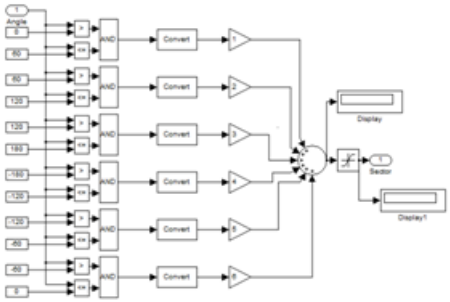
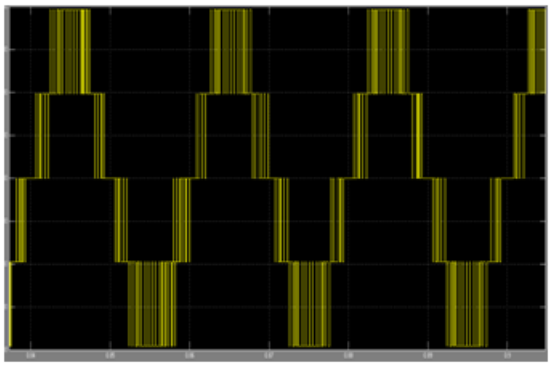
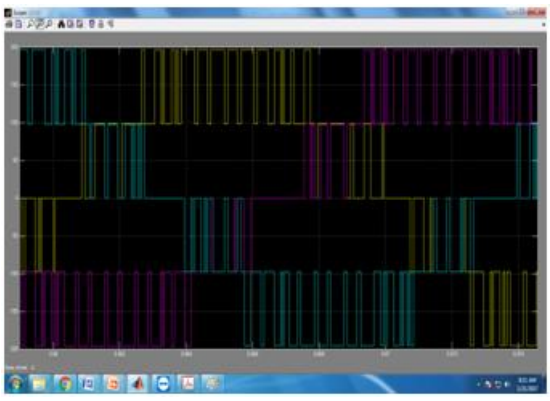


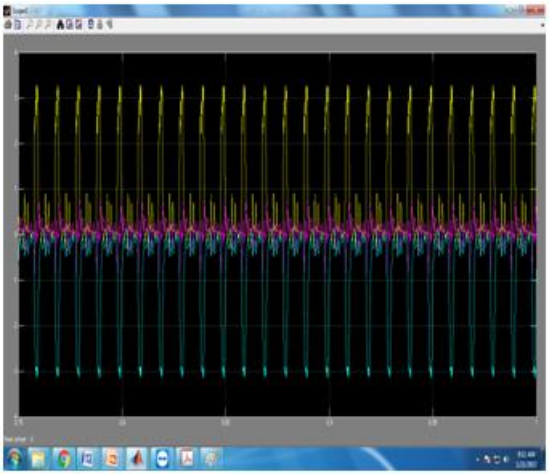
Angle vector



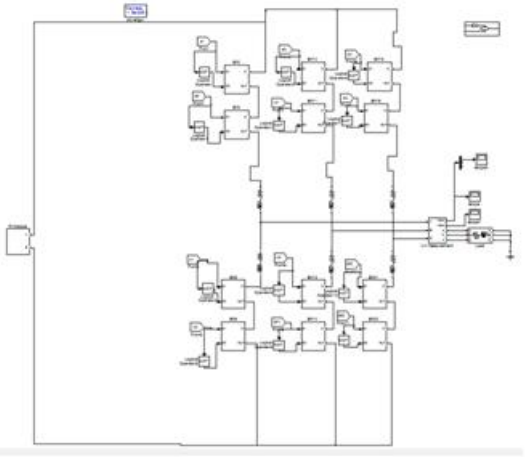
Output Waveforms :



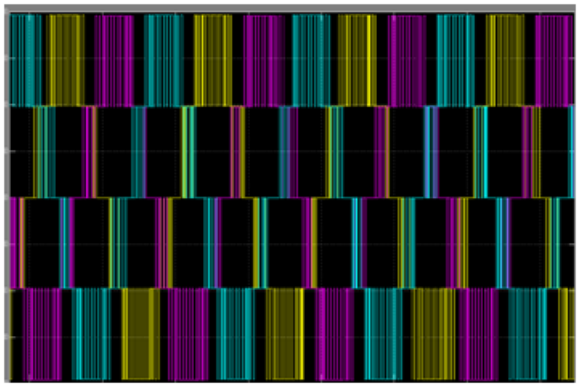




EXTENSION SIMULATION RESULTS



Source wave forms:



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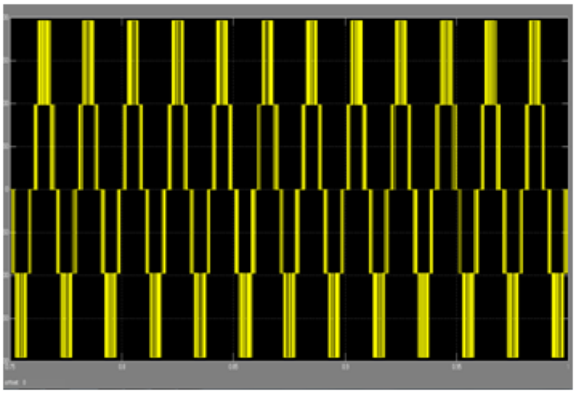

PID CONTROL:

The PID controller, which consists of proportional, integral and derivative elements, is widely used in feedback control of industrial processes. In applying PID controllers, engineers must design the control system: that is, they must first decide which action mode to choose and then adjust the parameters of the controller so that their control problems are solved appropriately. To that end, they need to know the characteristics of the process. As the basis for the design procedure, they must have certain criteria to evaluate the performance of the control system. The basic knowledge about those topics is summarized in this article.

CONCLUSION:

This paper proposes a simplified SVM scheme, for any three-phase multilevel converter. Based on two orthogonal unit vectors that decouple the three-phase components, the proposed scheme is independent of the level number of the converter. Simulation and experimental results verify this new concept. The proposed scheme is computationally extremely efficient. It achieves the same easy implementation as the phase-voltage modulation techniques, while maintaining the significant flexibility (i.e., redundant switching sequences and adjustable duty cycles) for optimizing the switching patterns. Therefore, it is well suited to large level-number applications. Compared with earlier SVM methods, the proposed scheme significantly simplifies the detection of the nearest three vectors and the generation of switching sequences. No lookup table or coordinate transformation is required. This paper also introduces a general approach to construct the orthogonal unit-vectors for any other multiphase system. Therefore, the proposed scheme can potentially be extended to simplify the SVM for multiphase multilevel converters.

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