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UNIFIED SPACE VECTOR PULSE WIDTH MODULATION TECHNIQUE FOR REDUCTION OF HARMONICS DISTORTION

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ABSTRACT

A unified space vector pulse width modulation (USVPWM) and Alternate inverter pulse width modulation technique for a dual two-level inverter system with two isolated DC voltage sources is used for reducing the total harmonic distortion. The Unified SVPWM can obtain good performance for a wide speed range as compared to alternate inverter PWM. Unified SVPWM technique gives less Total Harmonic Distortion as compared to SVPWM and alternate inverter PWM technique. The gate pulses for the dual inverter are generated by the concept of one unified SVPWM in accordance with the voltage-second integral principle the ratio of the two DC-link voltages can be an arbitrary positive value also simplifies the region identification in sectors and reduces total switching frequency is reduced by 1/3 of the dual inverter SVPWM. PMSM motor with dual inverter is used in military application, electric vehicles, and aerospace, due to their excellent performance such as high power density, high efficiency and good controllability; because the fault tolerant capability is improved by open end winding phenomenon and it prevent the circulation of zero sequence current.

Keyword: Area-Efficient, Binary to Excess One Converter, CSLA,Dual-Inverter, Switching Frequency.

I INTRODUCTION

Open winding system has been widely investigated in the field of motor driving and power generation in the last few decades. By employing different combination of converters, the open winding system shows advantages over the conventional star or delta connected structure in many aspects, such as, reducing the DC bus voltage, achieving multilevel modulation effect, improving the operation performance of motors. However, a large amount of switch devices have to be used in the open winding system and resulting a complex converter structure, which will not only increase the system expense but also make it complex for the control implementation. In order to avoid the above drawbacks, a semi-controlled open winding system, by integrating a diode bridge and a voltage source converter (VSC), could take the advantages of the less active switch devices, the simpler system configuration and control complexity.

Two isolated DC buses are usually employed in the open winding system to control two converters. Nevertheless, a single DC bus supplied open winding system can take a simpler structure compared with isolated DC bus structure, which is also more convenient for the practical applications. However, a zero

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sequence current loop will occur open winding system when supplied by a common DC bus. The zero sequence currents owing through the stator windings will increase the system conduction losses and decrease the operation efficiency. Meanwhile, the heavier switch device burden and unexpected DC voltage fluctuation will occur furthermore, due to that the triple back electromagnetic force (EMF) usually exists in the phase windings of permanent magnet synchronous generator (PMSG). The zero sequence current also willing introduces six times frequency torque ripple. As a result, it is necessary to suppress the zero sequence current in the open winding PMSG system supplied by a single DC bus.

The SVPWM strategy employing those switching combinations that do not contribute to the zero-sequence is also introduced introduce the zero-sequence voltage. And also a carrier-based PWM algorithm is used in dual two-level inverters and dual matrix converters to eliminate common-mode voltage. However, due to the voltage drops on the power semiconductor devices and switching dead time, the zero- sequence voltage cannot be eliminated although these selected switching combinations are employed. Common-mode chokes and dead-time compensation strategies are proposed to suppress the zero-sequence current in.

II UNIFIED SPACE VECTOR PULSE WIDTH MODULATION

2.1 Problem Identification

High power non-linear and time varying loads, such as rectifiers, office equipment's like computers and printers, and also adjustable speed drives cause undesirable phenomena in the operation of power systems like harmonic pollution and reactive power demand. The highly nonlinear currents drawn especially by high-power single-phase rectifier loads greatly distort the outputs of Nonlinear Loads. So the permanent magnet synchronous motor drive fed by the dual inverter with dc supply is used. Potential zero sequence current in the open end winding drive system has to be considered since it causes circulating current in the winding and leads to high current stress of power semiconductor devices and high losses. Zero sequence switching combinations do not produce zero sequence voltage are used to synthesize the reference voltage in existing method. In order to suppress zero sequence current in the open end winding Nonlinear Loads drive unified SVPWM is used. In addition the total switching frequency reduced by 1/3 of that of the dual SVPWM. In addition the alternate inverter PWM is used to reduce the total harmonic distortion in power electronic drive.

2.2 Unified SVPWM

The configuration of a dual two-level inverter system with two isolated dc voltage source Vdc1 Vdc2 is shown in _g. where the ratio of two isolated DC voltage sources DC voltages, k=Vdc1 /Vdc2 , is an arbitrary positive value. The relationship between the reference voltage vector Vs and the vector outputs of the dual inverter Vinv1 and Vinv2 is represented as,

$$Vs = Vinv1 - Vinv2 \qquad \text{------ (1)}$$

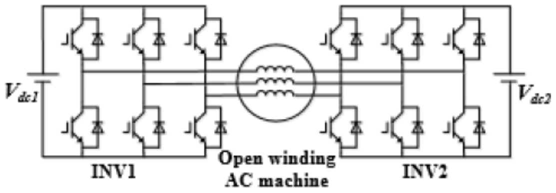

Fig.1: Configuration of dual inverter with two isolated DC sources

2.3 PWM Scheme

The open-end winding PMSM drive fed by the dual inverter is depicted in fig. The neutral point of motor windings is opened, and two inverter feed the windings from each end. The DC links of the two inverters can be isolated or connected together, as shown in fig 2(a) and (b) respectively, As to the dual inverter with isolated DC link dual inverter, the circuit can be reduced since only a single DC power supply is needed. But unfortunately, the DC bus can provide a potential path for the zero-sequence current. So, in this paper mainly discussion on the open-end winding PMSM drive fed by the common DC-Link dual inverter.

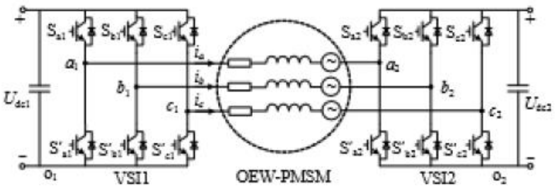

Fig. 2: The open-end winding PMSM fed by dual inverter with isolated DC link

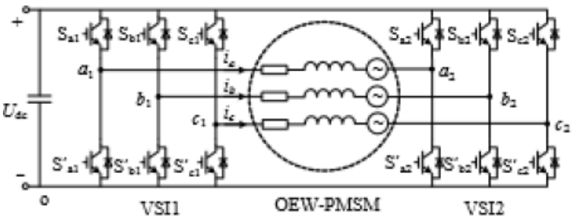

Fig. 3: The open-end winding PMSM fed by dual inverter with common DC link

Model of open-end winding PMSM Each phase model of a PMSM can be construct by a resistance, an inductance and the EMF in series. For a non salient open-end winding PMSM, the equivalent circuit is shown in Fig. 2, in which the model for each phase is the same with that of the star-connected motor.

In this paper, the space-vector-based PWM scheme presented for the conventional two-level inverter is extended for the dual-inverter scheme. The switching timings for the switching inverter are calculated, which depend only on the instantaneous phase reference voltages. The clamping states of the clamping inverter (be it inverter-1 or inverter-2) also depend on the instantaneous phase reference voltages. Thus the inverters change their roles as clamping and switching inverters depending on the SHC for every 360 of the cycle.

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III EXPERIMENTAL STUDIES

In order to verify the effectiveness of the proposed unified SVPWM algorithm, experiments are implemented on a dual two-level inverter system based on an open winding PMSM. The parameters of the PMSM are listed in below table 1. The sum of two DC-link voltages Vdc1 and Vdc2 is set to 140 V for all experiments.

Table 1: Parameters of the PMSM

SYSTEM PARAMETERS	VALUE
Stator Resistance	1.35Ω
Pole Pairs	4
d-axis inductance	7.76e-3 H
q-axis inductance	17e-3 H

When the running speed 500 r/min, the results for the Alternate inverter PWM switching strategy are shown in below figure. It can be seen that both algorithm exhibit good performance when k=1.However, the current and the torque outputs are distorted even with small difference between two DC voltages (k = 15:13) for the algorithm proposed as shown in fig. The performance keeps a good state no matter how much the voltage difference is k = 15:13 as shown in fig or k = 3:1.

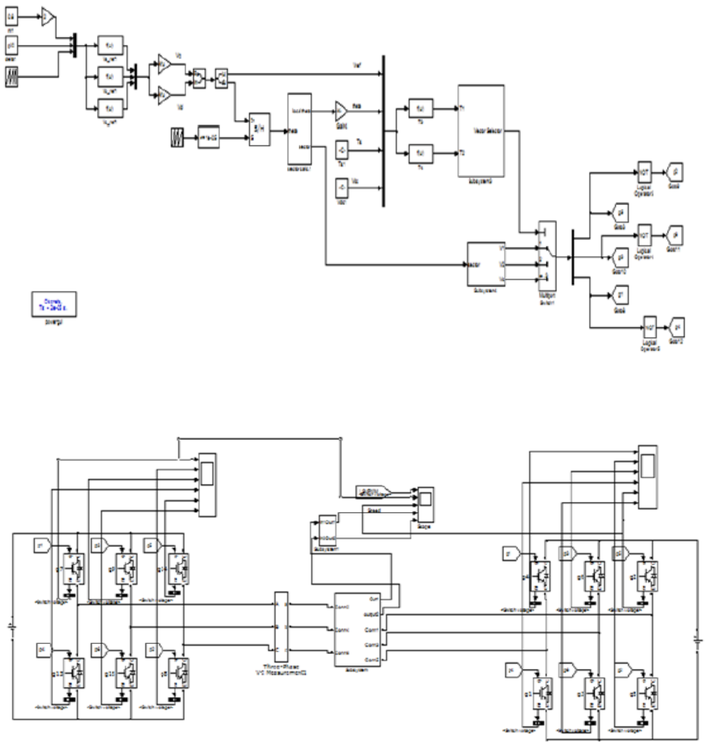

Fig. 4: Alternate inverter PWM switching strategy

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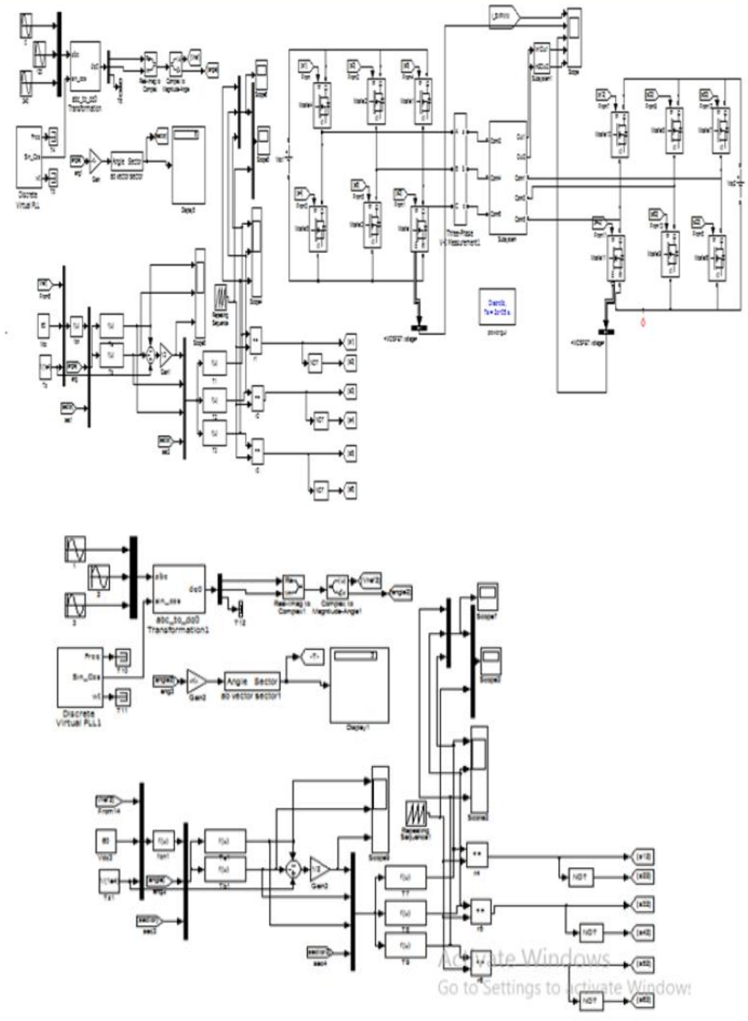

Fig. 5: Alternate inverter PWM switching strategy

IV PROPOSED METHOD

4.1. Unified SVPWM at 500 r/min:

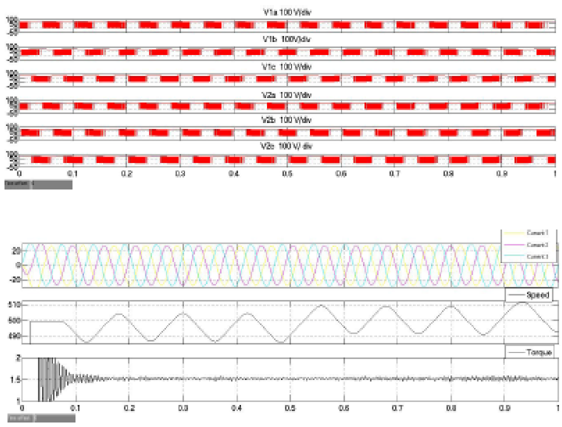

Fig. 6: k = Vdc1: Vdc2 = 70V: 70V = 1

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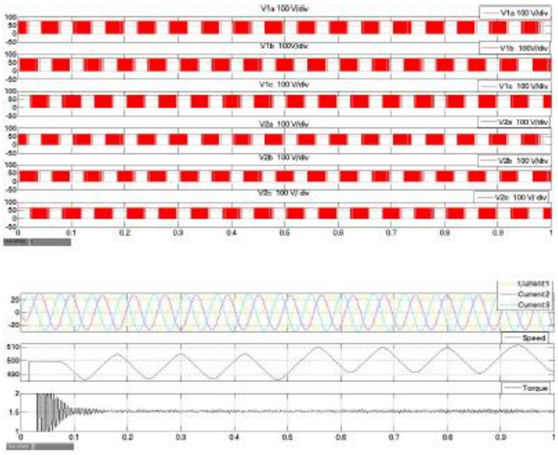

Fig. 7: k = Vdc1: Vdc2 = 75V: 65V = 15: 13

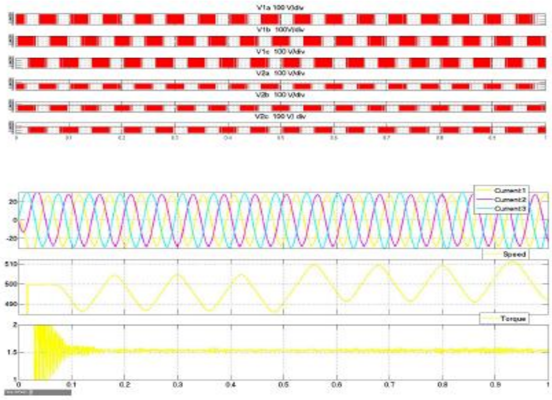

Fig. 8: k = Vdc1: Vdc2 = 94V: 46V

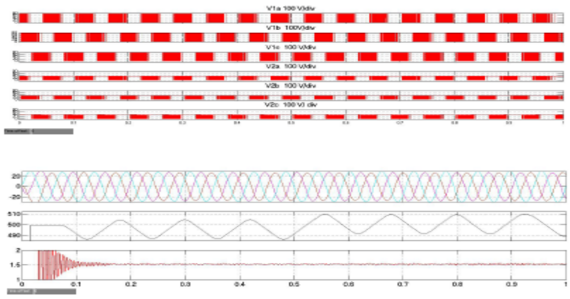

Fig. 9: k = Vdc1: Vdc2 = 105V: 35V

4.2. Unified SVPWM at 1000 r/min:

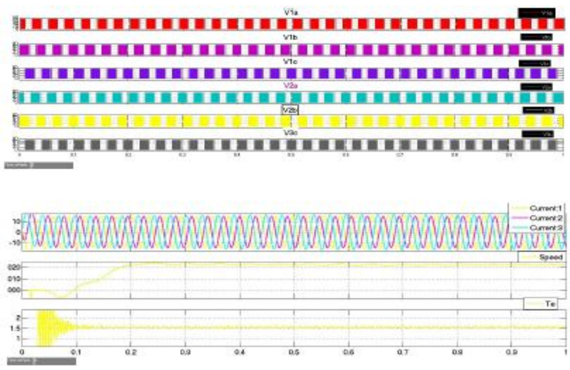

Fig. 10: k = Vdc1: Vdc2 = 70V: 70V = 1

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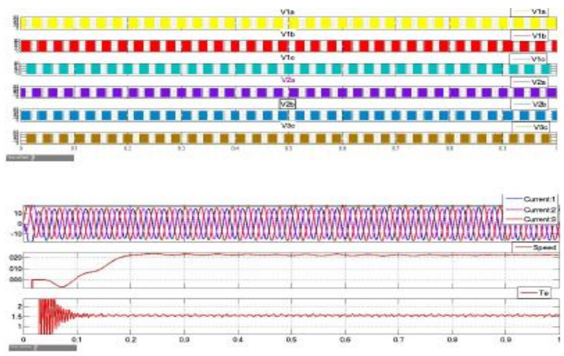

Fig. 11: k = Vdc1: Vdc2 = 75V: 65V = 15: 13

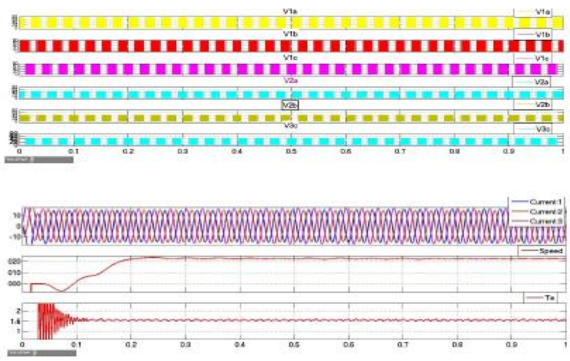

Fig. 12: k = Vdc1: Vdc2 = 94V: 46V

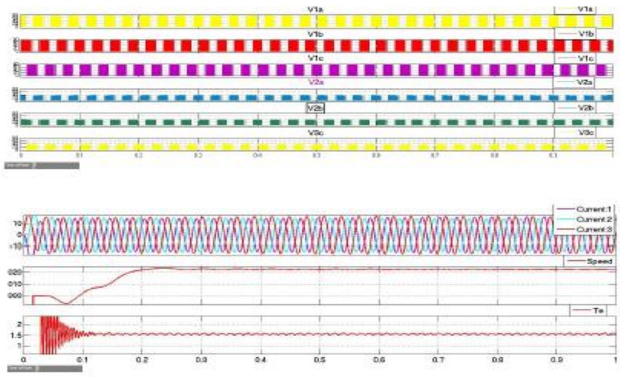

Fig. 13: k = Vdc1: Vdc2 = 105V: 35V

4.3. Unified SVPWM at 1500 r/min

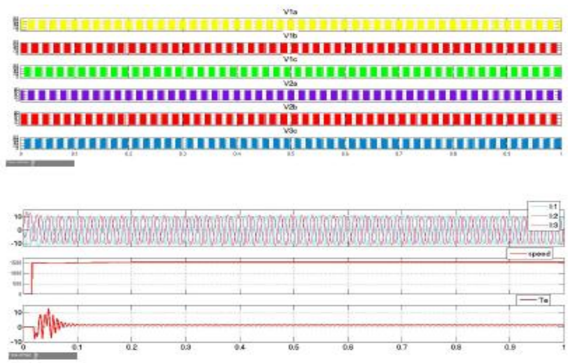

Fig. 14: k = Vdc1: Vdc2 = 70V: 70V = 1

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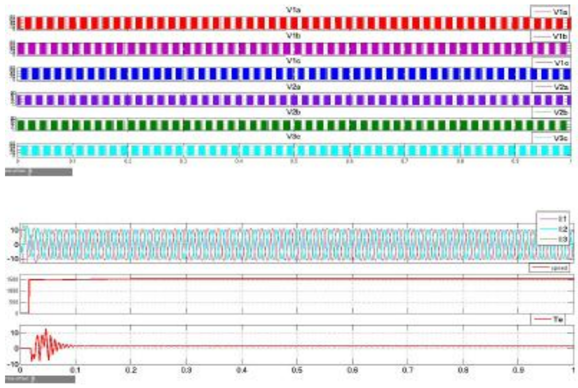

Fig. 15: k = Vdc1: Vdc2 = 75V: 65V = 15: 13

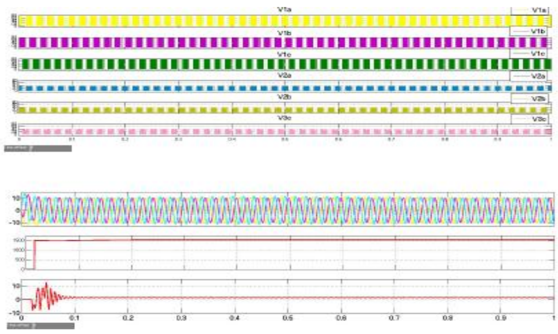

Fig. 16: k = Vdc1: Vdc2 = 105V: 35V

V SIMULATION RESULTS

In this paper Simulink models for two techniques have been developed and tested in the MAT-LAB/SIMULINK environment. The simulation results are compared for nonlinear loads and then it analyzed by computing their total harmonic distortion (THD). Therefore it has been observed that Unified SVPWM is better in reducing harmonics in non-linear load. The current distortion is analyzed for different switching frequencies. Also it has been observed that Unified Space vector is better in reducing THD as compared to Alternate Inverter pulse width modulation for a wide speed range.

When speed is increased to 1500 r/min as shown in above figure, the output performance is still good under different values of k. It can be concluded that the unified SVPWM algorithm can be obtain good performance for a wide speed range and the ratio of two DC voltage supplies can be flexible.

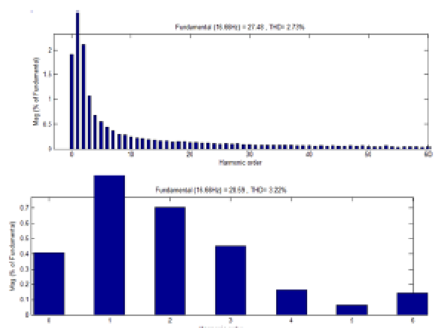

Fig. 17: Current harmonic profiles for three different methods at 500r/min

Table 2: Alternate Inverter PWM under different DC link voltages

K = Vdc1:Vdc2	70:70	75:65	94:46	105:35
Harmonics of ia(%)	3.22	3.10	2.75	2.66

Table 3: Unified SVPWM under different DC link voltages

K = Vdc1:Vdc2	70:70	75:65	94:46	105:35
Harmonics of ia(%)	2.66	2.73	2.72	2.72

VI CONCLUSION

In this paper two different PWM techniques, namely Unified Space vector PWM and Alternate inverter PWM has been evaluated. Then Simulink models for two techniques have been developed and tested in the MATLAB/SIMULINK environment. The simulation results are compared for nonlinear loads and analyzed by computing their total harmonic distortion (THD).It has been observed that Unified SVPWM is better in reducing harmonics in non linear load. The current distortion is analyzed for different switching frequencies. It has been observed that Unified Space vector is better in reducing THD as compared to Alternate Inverter pulse width modulation for a wide speed range. In future the simulation study can be performed in SVPWM with neural networks and the Network toolbox in MATLAB as Neural network implementation is very fast and also it can increase the switching frequency of power switches in the inverter.

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