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

Optimization of Switches by Using Ac Link Buck Boost Inverter with Space Vector Modulation

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Abstract:
This paper proposes a space vector pulse width amplitude modulation (SVPWAM) method for a sparse ac-link buck–boost inverter for the dc–ac power conversion, which reduces the number of switches without changing the principles of operation. This converter, which is named sparse ac-link buck–boost inverter, reduces the number of switches from20 to 18 and also reduce the switching losses with propose SVPWM technique. It is also verified that the output harmonic distortions of SVPWAM is lower than SPWM, by only using one-third switching frequency of the latter one. This paper proposes a modified configuration. An important feature of this inverter is that it can be fabricated by IGBT modules, which are more compact and more cost-effective, compared to the discrete devices.

Key words- ***space vector pulse width amplitude modulation (SVPWAM), sparse ac-link buck–boost inverter, THD***

I. INTRODUCTION

Currently, two existing inverter topologies are used for hybrid electric vehicles (HEVs) and electric vehicles (EVs): the conventional three-phase inverter with a high voltage battery and a three-phase pulse width modulation (PWM) inverter with a dc/dc boost front end. The conventional PWM inverter imposes high stress on switching devices and motor thus limits the motor's constant power speed range (CPSR), which can be alleviated through the dc–dc boosted PWM inverter. Fig. 1 shows a typical configuration of the series plug-in electric vehicle (PHEV). The inverter is required to inject low harmonic current to the motor, in order to reduce the winding loss and core loss. For this purpose, the switching frequency of the inverter is designed within a high range from 15 to 20 kHz, resulting in the switching loss increase in switching device and also the core loss increase in the motor stator. To solve this problem, various soft-switching methods have been proposed Active switching rectifier or a diode rectifier with small DC link capacitor have been proposed in . Varies types of modulation method have been proposed previously such as optimized pulse-width-modulation [improved Space-Vector-PWM control for different optimization targets and applications, and discontinuous PWM (DPWM). Different switching sequence arrangement can also affect the harmonics, power loss and voltage/current ripples. DPWM has been widely used to reduce the switching frequency, by selecting only one zero vector in one sector. It results in 50% switching frequency reduction.

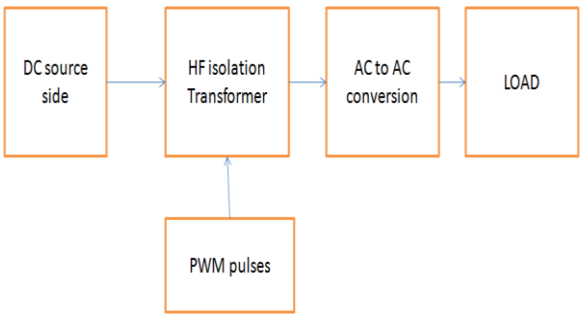

Fig 1.Propose system Block Diagram

II.SPACE VECTOR PULSE WIDTH MODULATION

Space Vector Pulse width Modulation (SVPWM) generates the appropriate gate drive waveform for each PWM cycle. The inverter is treated as one single unit and can combine different switching states (number of switching states depends on levels).

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The SVPWM provides unique switching time 27 calculations for each of these states [6]. This technique can easily be changed to higher levels and works with all kinds of multilevel inverters (cascaded, capacitor clamped, diode clamped). The three vectors that form one triangle will provide duty cycle time for each, giving the desired voltage vector (Vref). This can be described with the formula: V = (T1V1+T 2V 2+T3V3) /Tc

SVPWM also have good utilization of the DC link voltage, low current ripple and relative easy hardware implementation. Compared to the SPWM, the SVPWM has a 15% higher utilization ratio of the voltage [22][24]. This feature makes it suitable for high voltage high power applications, such as renewable power generation. As the number of level increase the redundant switching states increases and also the complexity of selection of the switching states [7]. So, deciding which level is right for a certain application it is important to find a balance between losses and specification of the positioning of the reference vector.

Modulation Technique	Line Voltage THD	Stator Current THD	Fundamental Voltage (Volt)
SPWM	44.3%	4.03%	269,9
Trapizoidal	40.08%	2.55%	299,8
Staircase	44.53%	2.55%	302,8
Stepped	36.68%	2.08%	317,6
Third Harmonic	35.62%	1.38%	332,6
Offset Voltage	34.84%	1.23%	346,3

Table 4: Different Modulation Techniques and their THD

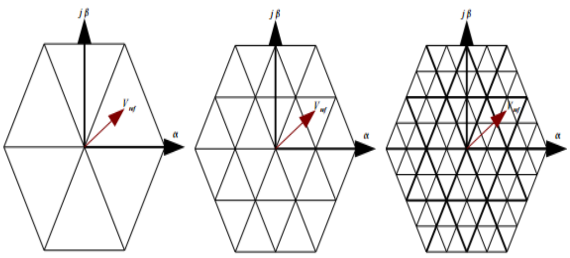

Figure 1: Space Vector diagram of a (a) two-level inverter (b) three-level inverter (c) five level inverter

III. PROPOSED CONVERTER

The essential working methods of the meager air conditioning connection buck–boost inverter and the pertinent waveforms are spoken to in Figs. 4 and 5, individually. Every connection cycle is separated into 12 modes, with 6 force exchange modes and 6 fractional resounding modes occurring then again. The connection is stimulated through the data stage sets amid modes 1 and 7 and is de-invigorated to the yield stage sets amid modes 3, 5, 9, and 11. Modes 2, 4, 6, 8, 10, and 12 are resounding modes amid which no force is exchanged and the connection resounds.

Modes 1–6 in the modified configuration are similar to those of the original converter, except other than turning on the proper switches on the output switch bridges; So7 and So8, on the output intermediate cross-over switching circuit, should be turned ON during modes 3–5. Although the output switch bridge contains unidirectional switches, So7–So10 (referenced above as intermediate cross-over switching circuit) enables the link to conduct both positive and negative currents. Therefore, during modes 7–12, the same output switches as modes 1–6 will be conducting; however, instead of So7 and So8, switches So9 and So10 conduct during modes 9–12.

Before the start of mode 1, the incoming switches, which are supposed to conduct during mode 1, are turned ON (S3 and S8 in Figs. 6 and 7); however they do not conduct immediately, because they are reverse-biased. Once the link voltage, which is resonating before mode 1, becomes equal to the voltage across the dc side, proper switches (S3 and S8) are forward biased initiating mode 1. This implies that the turn ON of the switches occurs at zero voltage as the switches transition from reverse to forward bias. Therefore, the link is connected to the dc source via switches which charge it in the positive direction. The link charges until the dc-side current averaged over a cycle time, meets its reference value. Input-side switches are then turned OFF. Fig.5. Behavior of the ac-link buck–boost inverter in different modes of operation: (a) Mode 1. (b) Mode 2, 4, and 6. (c) Mode 3. (d) Mode 5.

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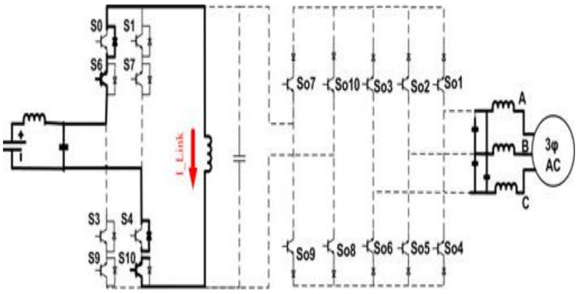
During mode 2 none of the switches conduct. The link resonates and the link voltage decreases until it reaches zero. At this point, the incoming switches that are supposed to conduct during modes 5 and 7 are turned ON (S13, S14, and S18 in Figs 6 and 7); however being reverse-biased they do not conduct immediately. Once the link voltage reaches VACO (assuming |VACO | is lower than |VABO |) switches S14 and S18 become forward biased and they start to conduct initiating mode 3.

During mode 3, the link is discharged into the chosen phase pair until the current of phase C at the output-side averaged over a cycle meets its reference. At this point S14 will be turned OFF initiating another resonating mode.

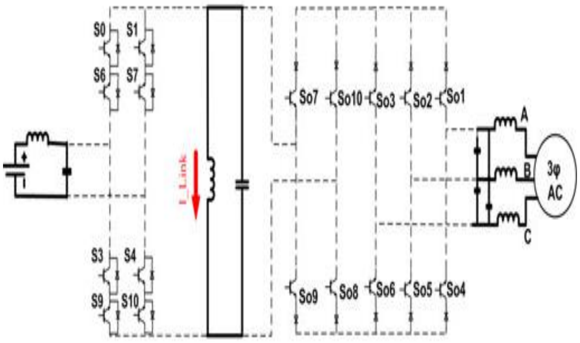
During mode 4, the link is allowed to swing to the voltage of the other output phase pair chosen during Mode 2. For the case shown in Figs. 6 and 7, it swings from VCAO to VBAO. Once the link voltage becomes equal to the voltage across the output phase pair AB, switches S13 and S18 become forward-biased, initiating mode 5.

During mode 5, the link discharges to the selected output phase pair until there is just sufficient energy remained in the link to swing to a predetermined voltage (Vmax), which is slightly higher than the maximum input and output line-to-line voltages. At the end of mode 5, all the switches are turned OFF allowing the link to resonate during mode 6.

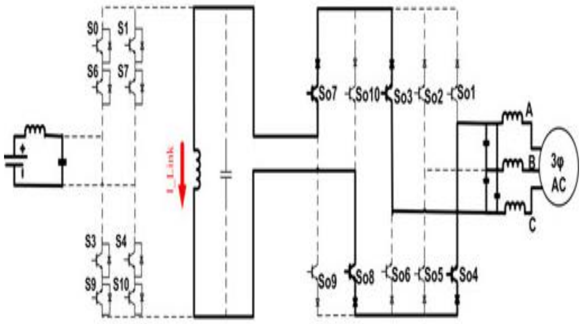
During mode 6, the link voltage swings to −Vmax , and then its absolute value starts to decrease.



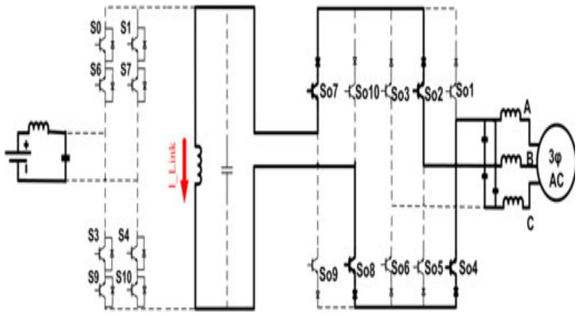
(a)



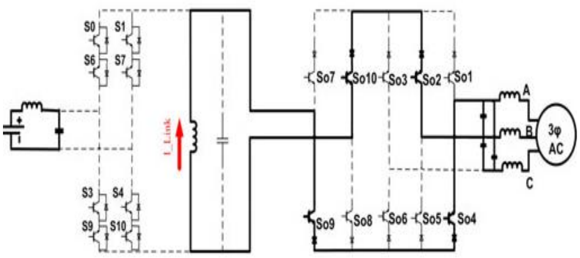
(b)



(c)



(d)



(e)

Fig. 8. Behavior of the sparse ac-link buck–boost inverter during different modes of operation: (a) Mode1. (b) Mode 2, Mode 4, and Mode 6. (c) Mode 3. (d) Mode 5. (e) Mode 11.

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By adding a single-phase, high-frequency transformer to the link, the sparse ac-link buck–boost inverter can provide galvanic isolation, as shown in Fig.59. In practice, due to leakage inductance of the transformer, the link capacitor needs to be split into two capacitors placed at the primary and the secondary of the transformer. Otherwise at the end of the charging or discharging mode, depending on which side the capacitor is located at, the current of the leakage inductance will have an instantaneous change, which results in voltage spike.

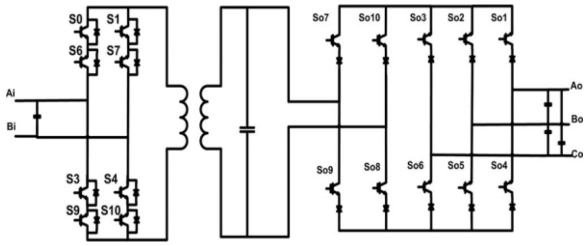
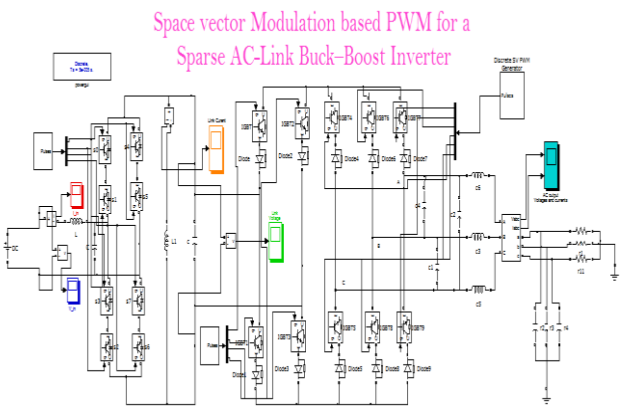


Fig 9. Sparse ac-link buck–boost inverter with galvanic isolation

IV. SIMULATION RESULTS

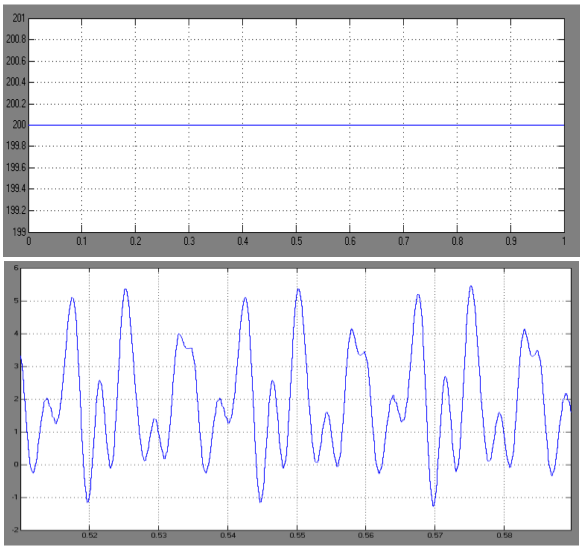
Simulation is performed using MATLAB/SIMULINK software. Simulink library files include inbuilt models of many electrical and electronics components and devices such as diodes, MOSFETS, capacitors, inductors, motors, power supplies and so on. The circuit components are connected as per design without error, parameters of all components are configured as per requirement and simulation is performed

Simulation Circuit

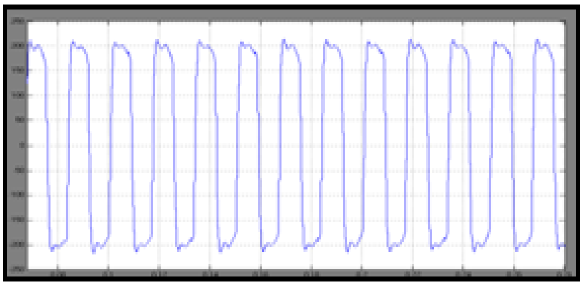


WAVEFORMS

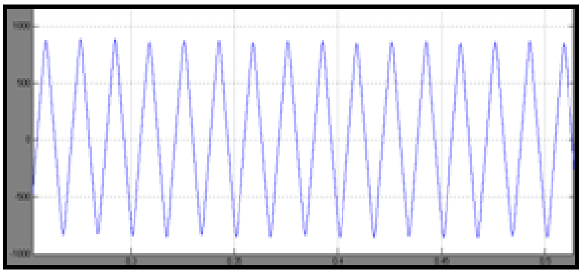
A) Input Voltage and Current



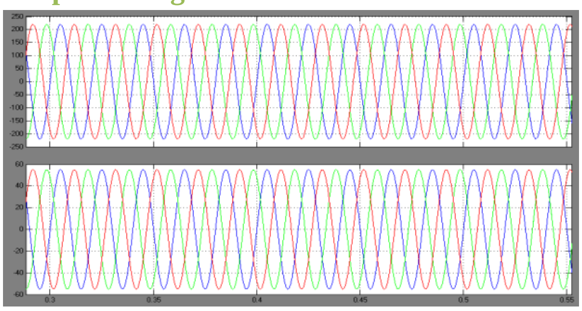
B) HF LINK VOLTAGE



c) AC LINK CURRENT



D) Output Voltages and Currents



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CONCLUSION

The THD in the inverter output with respect to different PWM techniques applied. The space vector PWM technique was found to give a better performance with less THD compared to other techniques. named sparse ac-link buck–boost inverter, reduces the number of switches from20 to 18 and also reduce the switching losses with propose SVPWM technique. It is also verified that the output harmonic distortions of SVPWAM is lower than SPWM, by only using one-third switching frequency.

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