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Hybrid Technique for Inverter Using PWM

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Abstract:
A hybrid pulse width modulation (PWM) theme for the grid electrical converter is investigated, which combines the deserves of space-vector PWM (SVM) and elite harmonic elimination PWM (SHEPWM). SHEPWM is adopted at steady state, while SVM is adopted to reach higher dynamic performance at grid fault. A transition strategy between these two PWM schemes is projected, which achieves sleek and fast transition by optimizing the switch state throughout transition. Finally, the proposed transition strategy for the hybrid PWM theme is valid by the simulation and the experiment.

Keywords:
Hybrid pulse width modulation (PWM) scheme, selected harmonic elimination PWM (SHEPWM), space-vector PWM (SVM), switching state, transition strategy.

INTRODUCTION:

In this paper, a hybrid PWM scheme for the grid inverter is investigated, which combines the merits of both SVM and SHEPWM. SHEPWM is adopted at steady state, while SVM is adopted to achieve better dynamic performance. A transition strategy between these two PWM schemes is proposed, which achieves smooth and quick transition by optimizing the switching state during transition. Finally, the proposed transition strategy for the hybrid PWM scheme is verified by the simulation and the experiment. In high-speed drives and in aircraft applications fundamental output frequencies of up to 1 kHz are common and high control bandwidths are required. Here, the switching frequency can be increased up to 50 kHz in order to obtain acceptable waveforms and control performance. Again, the efficiency suffers and bulky cooling systems are necessary.

PULSEWIDTH modulation (PWM) scheme is one of the key technologies for a grid-connected inverter. The commonly used PWM schemes include sinusoidal PWM (SPWM) [1]–[5], space-vector PWM (SVM) [6]–[10], and selected harmonic elimination PWM (SHEPWM) [11]–[15]. Different PWM strategies have different applications with each intrinsic characteristic. SPWM and SVM have been widely used in the grid inverter for photovoltaic (PV) application [4]–[7]. Compared with SPWM and SVM, SHEPWM has lower equivalent switching frequency with respect to the given power quality requirement [8]. Therefore, it has less switching loss. However, SHEPWM is generally realized by a lookup table, and its dynamic is slower, which is not suited to the grid fault ride-through condition. Low-voltage ride-through (LVRT) ability for the grid inverter has become the standard and has been required in many regions and countries .

In this paper, a hybrid PWM scheme for the grid electrical converter is investigated, which combines the deserves of each SVM and SHEPWM. SHEPWM is adopted at steady state while SVM is adopted to win higher dynamic performance. A transition strategy between these two PWM schemes is projected, which achieves swish and fast transition by optimizing the shift state throughout transition. Finally the proposed transition strategy for the hybrid PWM theme is verified by the experiment.

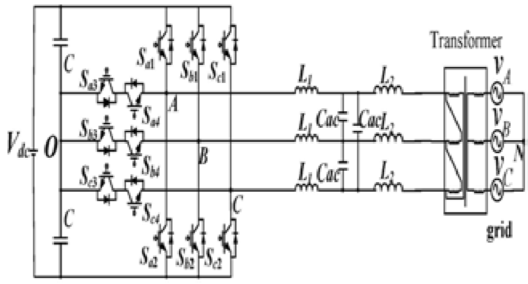

Fig. Main circuit of T -type three-lever inverter.

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PULSE-WIDTH MODULATION:

INTRODUCTION:

A power inverter, or inverter, is an electronic device or electronic equipment that changes DC (DC) to electrical energy (AC). The input voltage, output voltage and frequency, and overall power handling depend on the look of the particular device or electronic equipment. The inverter will not turn out any power; the facility is provided by the DC supply. A power inverter are often entirely electronic or is also a mix of mechanical effects (such as a rotary apparatus) and electronic electronic equipment. Static inverters do not use moving parts within the conversion method.

Hybrid PWM Scheme:

A hybrid pulse width modulation (PWM) theme for the grid electrical converter is investigated, which combines the deserves of space-vector PWM (SVM) and chosen harmonic elimination PWM (SHEPWM). SHEPWM is adopted at steady state, while SVM is adopted to come through higher dynamic performance at grid fault. A transition strategy between these two PWM schemes is planned, which achieves sleek and fast transition by optimizing the shift state throughout transition. Finally, the proposed transition strategy for the hybrid PWM theme is valid by the simulation and the experiment. The proposed PWM strategies for a three-level NPC converter are mainly classified into the carrier-based PWM (CB-PWM) and the space-vector modulation (SVM) strategies. The CB-PWM strategies are mostly based on pure sinusoidal PWM (SPWM) or a SPWM strategy in conjunction with a zero-sequence voltage injection [16]–[19]. Compared with the SPWM strategy, inclusion of a zero-sequence voltage extends the linear-modulation range of the converter. The existing CB-PWM strategies do not provide natural voltage balancing; therefore, additional control effort is required to achieve the voltage balancing [16], [17]. The additional control effort imposes relatively high-switching frequencies in the switching devices and also distorts the ac-side voltage spectra [20]–[24].

In the technical literature, a CB-PWM strategy with a proper zero sequence voltage that: 1) autonomously carries out the voltage ebalancing task, with no requirement for additional control effort; 2) reduces the switching frequency; and 3) mitigates the low-frequency voltage oscillations of the NP, has been neither proposed nor investigated.

INTRODUCTION:

Pulse width modulation (PWM) theme is one of the key technologies for a grid-connected electrical converter. The commonly used PWM schemes embrace curved PWM (SPWM), space-vector PWM (SVM) , and selected harmonic elimination PWM (SHEPWM). Different PWM ways have completely different applications with every intrinsic characteristic. SPWM and SVM have been widely employed in the grid electrical converter for electrical phenomenon (PV) application. In this paper, a three-level T-type grid-connected inverter with LCL filter is investigated

TABLE I
PARAMETERS OF GRID-CONNECTED INVERTER

Parameter	Symbol	Value
Rated power	P	10KW
DC bus voltage	U_{dc}	500V
Grid line voltage	U	270V
Grid frequency	f	50Hz
Inverter side inductance	L_1	0.68mH
Grid side inductance	L_2	0.68mH
Filter capacitance	C_{ac}	6uF

In order to require advantages of the 2 modulation methods, a hybrid PWM scheme is planned in this paper, It is seen that the outputs of current regulator ud∗ and uq∗ are used to drive the pulsewidth modulators. In case of the grid fault, the SVM is adopted, while SHEPWM is most popular at traditional condition with higher power conversion potency. The bandwidth of SHEPWM is abundant shorter than that of SVM. Both the steady-state and the dynamic performances of the hybrid PWM theme square measure higher compared with either SVM or SHEPWM scheme, which makes the hybrid PWM theme appropriate for the grid electrical converter.

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Pulse-width modulation:

Pulse-width modulation (PWM), as it applies to control, is a way of delivering energy through a succession of pulses instead of a incessantly varied (analog) signal. By increasing or decreasing pulse width, the controller regulates energy flow to the motor shaft. The motor's own inductance acts like a filter, storing energy during the "on" cycle whereas emotional it at a rate corresponding to the input or reference signal. In other words, energy flows into the load not so abundant the switch frequency, but at the reference frequency. PWM is somewhat like pushing a playground-style merry-go-round. The energy of each push is keep within the inertia of the serious platform, which accelerates bit by bit with tougher, more frequent, or longer-lasting pushes. The riders receive the kinetic energy in a very very totally different manner than however it's applied.

SIMULATION RESULTS:

Simulation of the proposed transition strategy on Simulink is done with its parameters the simulation results of the dynamic performance of the SVM and the SHEPWM. The proposed transition strategy is verified on a 10-kW three-level T-type grid-connected inverter prototype, as shown in Fig. 16. Parameters of inverter are shown in Table I. SVM is used with the switching frequency of 7.6 kHz, while quarter-wave symmetric SHEPWM is used with 29 switching bangles in quarter fundamental cycle (i.e., N = 29).

Pulse Width Modulation (PWM):

The Pulse Width Modulation (PWM) is a technique which is characterized by the generation of constant amplitude pulse by modulating the pulse duration by modulating the duty cycle. Analog PWM control requires the generation of both reference and carrier signals that are feed into the comparator and based on some logical output, the final output is generated.

The reference signal is the desired signal output maybe sinusoidal or square wave, while the carrier signal is either a saw tooth or triangular wave at a frequency significantly greater than the reference. There are various types of PWM techniques and so we get different output and the choice of the inverter depends on cost, noise and efficiency.

Advantages of PWM Technique:

- The output voltage control with this method can be obtained without any additional components.
- With the method, lower order harmonics can be eliminated or minimized along with its output voltage control. As higher order harmonics can be filtered easily, the filtering requirements are minimized.

Disadvantages of PWM technique:

- Increase of switching losses due to high PWM frequency
- Reduction of available voltage
- EM1 problems due to high-order harmonics

Sinusoidal Pulse Width Modulation:

In this modulation technique are multiple numbers of output pulse per half cycle and pulses are of different width. The width of each pulse is varying in proportion to the amplitude of a sine wave evaluated at the centre of the same pulse. The gating signals are generated by comparing a sinusoidal reference with a high frequency triangular signal.

- The rms ac output voltage,

$$V_o = V_s\sqrt{\frac{p\delta}{\pi}} \rightarrow V_s\sqrt{\sum_{m=1}^{2p}\frac{\delta_m}{\pi}}$$

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- Where p=number of pulses and δ= pulse width.

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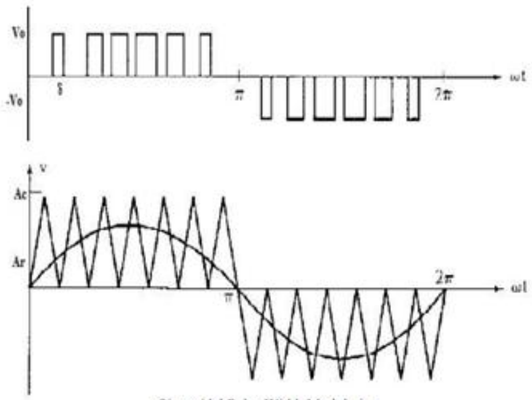
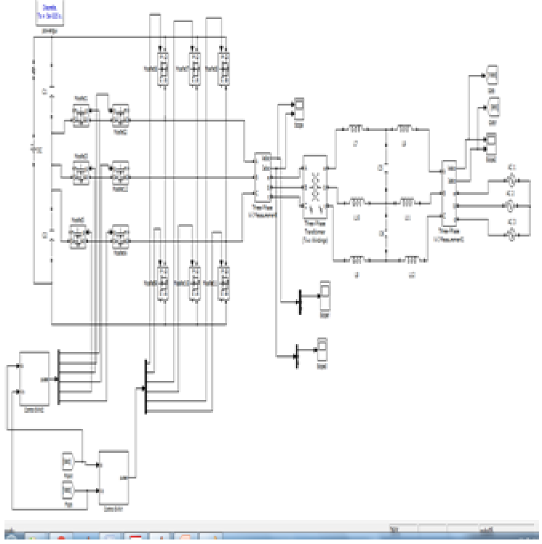
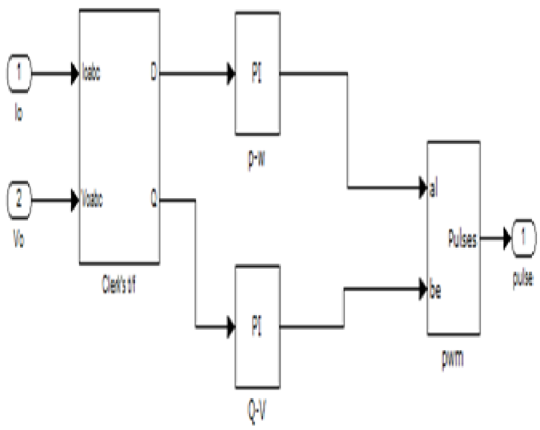


Sinusoidal Pulse Width Modulation

Main Circuit

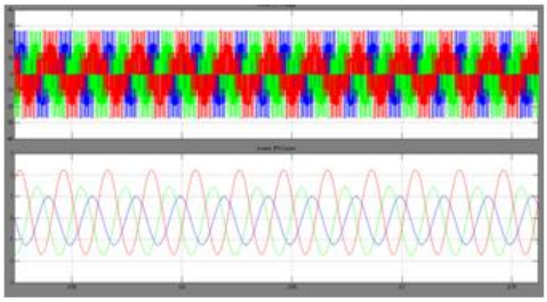


Control Circuit Diagram

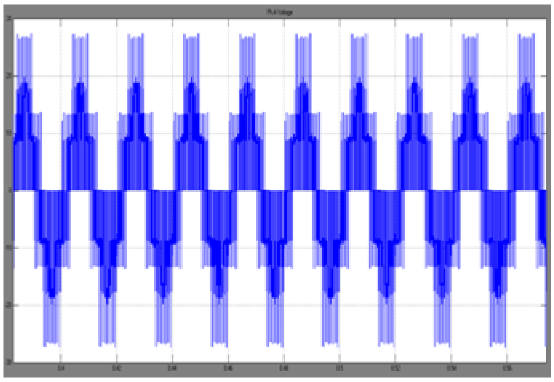


Output Waveforms:

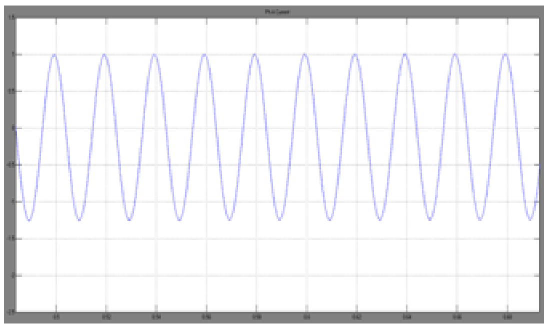
3-Phase Inverter Voltage &Current



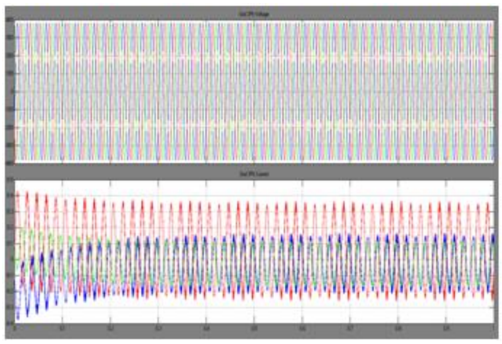
Phase A Voltage



Phase A Current



3-Phase Grid Voltage & Current



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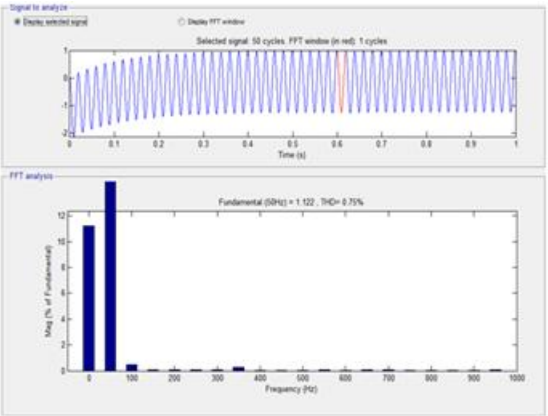
THD Calculation



CONCLUSION:

This paper proposed a smooth and quick transition strategy of a hybrid PWM scheme for PV inverter. By rearranging the sequence of the SVM, the extra switching counts can be avoided during transition. It ensures smooth transition within one switching frequency cycle. Consequently, the hybrid PWM scheme is suitable for the grid inverter application, which has high efficiency at steady state and can respond quickly in LVRT condition. The control scheme is verified by both the simulation and the experiment.

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