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A HIGH-PERFORMANCE SPWM CONTROLLER FOR THREE-PHASE UPS SYSTEMS OPERATING UNDER HIGHLY NONLINEAR LOADS

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Abstract— This paper presents the design of a high-performance sinusoidal pulse width modulation (SPWM) controller for three phase uninterruptible power supply (UPS) systems that are operating under highly nonlinear loads. The classical SPWM method is not good enough in compensating the harmonics and the distortion caused specifically by the nonlinear currents drawn by the rectifier loads. This study proposes a new design strategy that overcomes the limitations of the classical RMS control. It adds inner loops to the closed-loop control system effectively that enables successful reduction of harmonics and compensation of distortion at the outputs. The simulations are done in the MATLAB/SIMULINK environment using the Simulink and PLECS model of the inverter. The results are evaluated based on steady-state error, transient response, and the THD of the output voltage. A THD equal to 3.8% at the output voltage is achieved even under the worst nonlinear load.

Keywords— SPWM, UPS, MATLAB, Simulink.

I. INTRODUCTION

In a UPS system, the inverter is responsible for synthesizing sinusoidal voltages from a dc source through the pulse width modulation (PWM) of the dc voltage [1-2]. The inductive element here is needed to remove the switching frequency harmonics from the current waveform that are generated by the PWM operation of the inverter. The inductance value can be reduced if the switching frequency is increased. But, in practice, it has an upper limit at high power inverters due to the efficiency concerns and the switching device limitations. So, for the selected switching frequency and the power level, an optimum filter with a smallest inductance can be designed, but the distortion cannot be completely avoided, and the regulations and the customer specifications may not be satisfied.

In this paper proposes a new strategy with a new design that overcomes the limitations of the classical RMS control. The controller is based on the multiloop SPWM method. In the controller topology all the loops are combined (instead of cascade connection) before they are applied to the PWM generator. This feature basically adds the relative benefits of each loop and creates a more effective multiloop strategy. It adds inner loops to the closed loop control system effectively that enables successful reduction of harmonics and compensation of distortion at the voltages. The proposed system was designed with a high performance SPWM controller for three-phase UPS systems powering highly nonlinear loads [3-4].

Table: 1 Unbalance Load and Neutral current

Load Condition	Neutral Current I_n
① $\lvert I_{LA} \rvert = I_m$; $I_{LB} = I_{LC} = 0$	$\lvert I_n \rvert = I_m$
② $\lvert I_{LA} \rvert = \lvert I_{LB} \rvert = \lvert I_{LC} \rvert = I_m$ $PF_A = 1$; $PF_B = 0.8$; $PF_C = -0.8$	$\lvert I_n \rvert = 1.24\, I_m$
③ $\lvert I_{LA} \rvert = \lvert I_{LB} \rvert = \lvert 2I_{LC} \rvert = I_m$ $PF_A = -0.8$; $PF_B = PF_C = 0.8$	$\lvert I_n \rvert = 1.47\, I_m$
④ $\lvert I_{LA} \rvert = \lvert I_{LB} \rvert = I_m$; $I_C = 0$ $PF_A = -0.8$; $PF_B = 0.8$	$\lvert I_n \rvert = 1.84\, I_m$

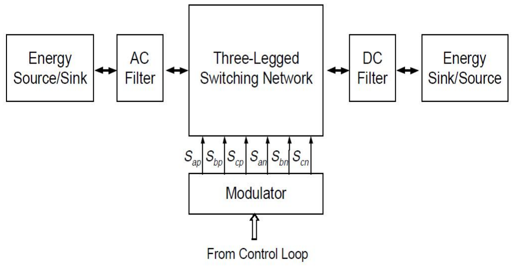

Fig 1: Block diagram

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Three-legged voltage source power converters include voltage source inverter (VSI) and boost PWM rectifier, as shown in Figure 1. They are the most popular power converter topologies used in motor drive applications and three-phase PFC rectifiers. A common switching network, consisting of six power switches, can be identified in both the voltage source inverter and the boost rectifier. The switching network has DC terminals – p and n, and AC terminals ¾ V_a, V_b, and V_c. To construct a voltage source inverter, an ideal voltage source is connected to the DC terminals, while a balanced three-phase L/C filter is connected to the AC terminals.

To construct a boost PWM rectifier, the load is connected to the DC terminals, while three boost inductors are connected to the AC terminals. It is normally assumed the three-phase load is balanced for a three-phase voltage source inverter. Ideally the voltage potential of VG would be the same as that of Vn, and there would be no ground current incurred [5]. Similarly a well balanced three-phase AC source is also assumed for the boost PWM rectifier. The switching network chops energy into chunks and dispatches the energy chunks by on/off actions. Each of the ideal switches in the switching network operates in the first and second quadrant of the V-I plane, and can be realized by a power switch is a unified representation of a three-legged power converter including an inverter and a rectifier[6].

A modulator controls the switching actions of the switching network. The modulator sends all the gate signals of the power switches. For an inverter used as an UPS, the modulator sends on/off control signals to the switching network such that the output voltage at the energy sinks terminal is a three phase sinusoidal voltage. For boost rectifier, the modulator sends on/off control signals to the switching network such that the current from the energy source is a three-phase sinusoidal current.

II. FUZZY LOGIC CONTROLLER

Fuzzy logic is a powerful problem solving methodology with a myriad of applications in embedded control and information processing. Fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions.

Fuzzy logic controller calculates the d-axile of 3rd harmonic voltage based on the dc voltage error. The inputs to the fuzzy controller are the dc voltage reference value and measured dc voltage. This controller use Min-Max operator (Mamdani implication) and Centroid defuzzification method. The output obtained is the 3rd harmonic voltage.

The degree of membership function used for fuzzification is shown in Fig.2 and Fig.3 and membership function for defuzzzification is shown in Fig.6.

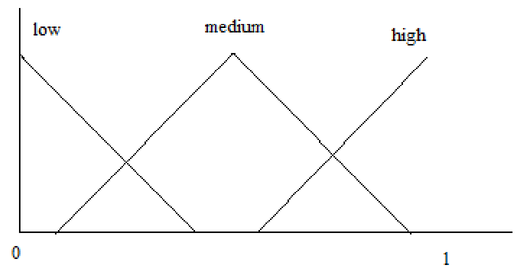


Fig 2 : Membership function for input 1

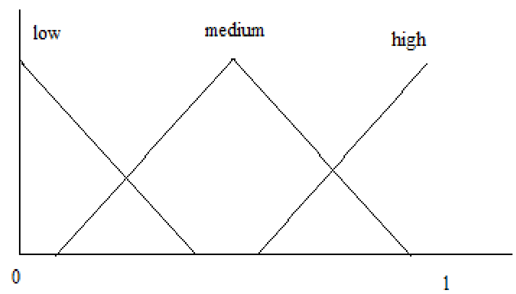


Fig 3 : Membership function for input 2

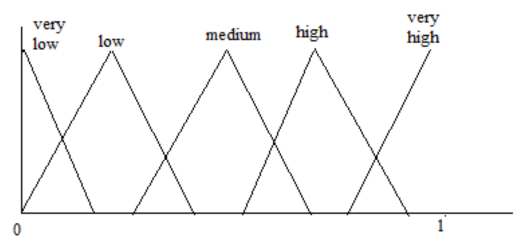
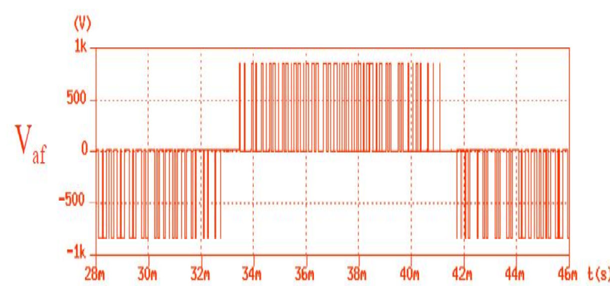


Fig 4 : Membership function for output

III. SIMULATION RESULTS



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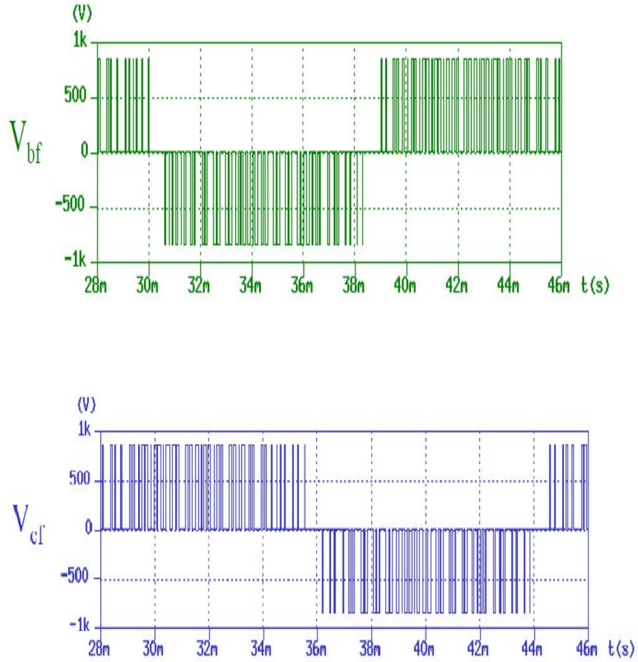

Fig 5 : Three Phase voltages

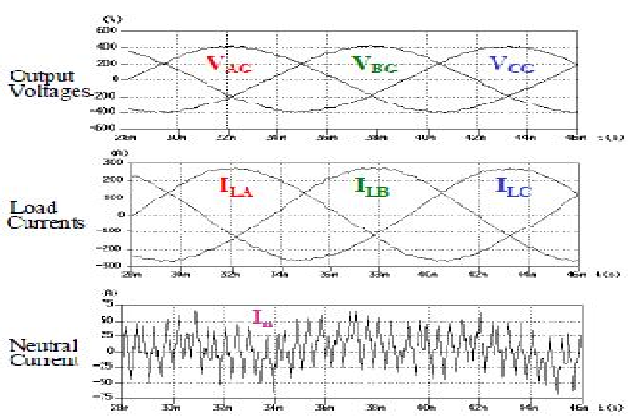

Fig 6 : Output Voltage

IV. CONCLUSION

This paper presents the analysis and design of a high performance SPWM controller for three-phase UPS systems powering highly nonlinear loads. Although the classical SPWM method is very successful in controlling the RMS magnitude of the UPS output voltages, it cannot effectively compensate for the harmonics and the distortion caused by the nonlinear currents drawn by the rectifier loads.

References

[1] Uninterruptible power systems (UPS)—Part 3: Method of specifying the performance and test requirements, First Edition 1999-03, International Standard IEC 62040-3.

[2] F. Botter´on and H. Pinheiro, "A three-phase UPS that complies with the standard IEC 62040-3," IEEE Trans. Ind. Electron., vol. 54, no. 4, pp. 2120–2136, Aug. 2007.

[3] Q.-C. Zhong and Y. Zeng, "Can the output impedance of an inverter be designed capacitive?" in Proc. 37th Annu. IEEE Conf. Ind. Electron., 2011, pp. 1220–1225.

[4] U. Borup, P. N. Enjeti, and F. Blaabjerg, "A new space-vector-based control method for UPS systems powering nonlinear and unbalanced loads,"IEEE Trans. Industry Appl., vol. 37, no. 6, pp. 1864–1870, Nov./Dec. 2001.

[5] Q.-C. Zhong, F. Blaabjerg, J. Guerrero, and T. Hornik, "Reduction of voltage harmonics for parallel-operated inverters equipped with a robust droop controller," in Proc. IEEE Energy Convers. Congr. Expo., Phoenix,AZ, 2011, pp. 473–478.

[6] S. Jiang, D. Cao, Y. Li, J. Liu, and F. Z. Peng, "Low THD, fast transient, and cost-effective synchronous-frame repetitive controller for three-phase UPS inverters," IEEE Trans. Power Electron., vol. 27, no. 6, pp. 2294–3005, 2012.

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