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Novel Technique For The Reduction in Wind Power Generation

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Abstract:

This This paper presents a compensating system for the harmonic currents, the reactive power and source neutral conductor current in three-phase four-wire distribution system fed by non renewable source in wind by using a five-level cascaded H-bridge voltage source inverter (CHB-VSI) based shunt active power filter (SAPF). A controller based on the d-q-0 theory (synchronous reference frame) and in-phase disposition (IPD) modulation technique is introduced for the SAPF. The distribution network which supplies mixed non-linear loads and employing CHB-VSI based SAPF is simulated by MATLAB/SIMULINK software. The performance of SAPF is analyzed by using the proposed control technique on the total harmonic distortion of source current, power factor and reactive power. Besides, it is illustrated by extensive simulation results, the effectiveness of five-level SAPF on source neutral conductor current.

Keywords:
CHB-VSI; harmonic currents; reactive power compensation; source neutral conductor current; THD

I.INTRODUCTION :

Today, more than 28 000 wind generating turbines are successfully operating all over the world. In the fixed-speed wind turbine operation, all the fluctuation in the wind speed are transmitted as fluctuations in the mechanical torque, electrical power on the grid and leads to large voltage fluctuations. During the normal operation, wind turbine produces a continuous variable output power.

These power variations are mainly caused by the effect of turbulence, wind shear, and tower-shadow and of control system in the power system. Thus, the network needs to manage for such fluctuations. The power quality issues can be viewed with respect to the wind generation, transmission and distribution network, such as voltage sag, swells, flickers, harmonic etc.

However the wind generator introduces disturbances into the distribution network. One of the simple methods of running a wind generating system is to use the induction generator connected directly to the grid system. The induction generator has inherent advantages of cost effectiveness and robustness. However; induction generators require reactive power for magnetization. When the generated active power of an induction generator is varied due to wind, absorbed reactive power and terminal voltage of an induction generator can be significantly affected.

A proper control scheme in wind energy generation system is required under normal operating condition to allow the proper control over the active power production. In this paper we Introduce a novel technique to reduce the Total Harmonic Distortions in wind power generation. Here we using five level cascaded H- Bridges (CHB).The major merits of the CHB-VSI over the other two types are introduced in [13]-[15]. This paper proposes a compensating system based on five-level CHB-VSI. As the five-level CHB-VSI based SAPF with in-phase disposition (IPD) modulation technique which is considered as an effective compensator in a four-wire distribution network, and there it is essential to establish the compensating performance of SAPF.

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This paper is organized as follows. The IPD modulation technique is discussed and the modeling of the five-level CHB-VSI based SAPF is introduced in Section II. Section III reports SAPF connection to the distribution network and the proposed controller based d-q-o theory. The simulation model and the results are presented in Section IV. Section V presents the conclusions.

II.IN-PHASE DISPOSITION (IPD) MODULATION TECHNIQUE:

The IPD modulation technique uses carriers of same frequency, amplitude and phases, but just differs in DC offset to occupy contiguous bands as shown in Fig. 1.

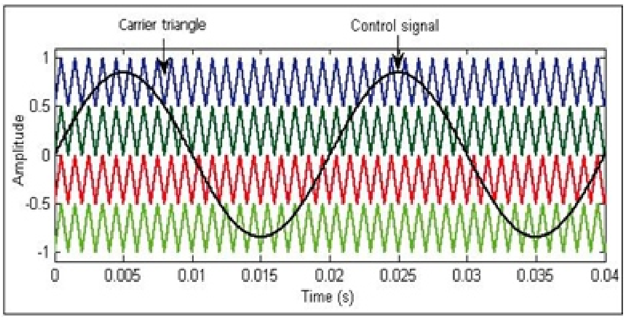

Fig. 1. IPD modulation for five-level CHB-VSI

for five-level VSI. The carriers are in phase across all the bands.In this technique, four triangular carriers are selected for five-level VSI based on the formula M-1 where M is the number of levels, i.e 5-1 = 4 [15]. By comparing these 4 triangular carrier signals with the sinusoidal modulation signal, the PWM gating signals for the IGBTs of five-level CHB-VSI will be generated. The simulated output phase voltage and line-to-line voltage of the five-level CHB-VSI and the corresponding harmonic spectrum and total harmonic distribution (THD) are shown in Figs 2 and 3, respectively.

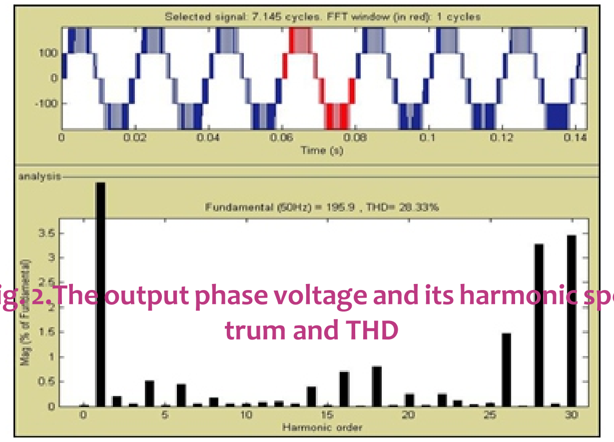

Fig 2.The output phase voltage and its harmonic spectrum and THD

III.PROPOSED FPGA CONTROLLER FOR SAPF:

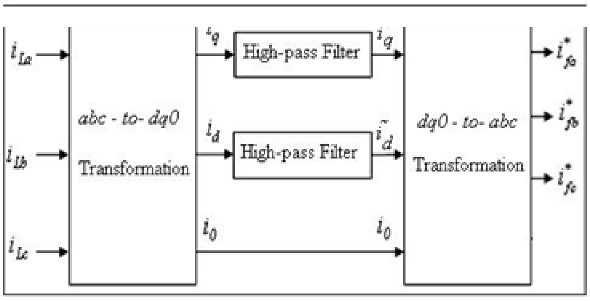

Fig. 3. Proposed controller based on the d-q-o theory

Here we Using dqo theory and FPGA technique SPWM is based on the comparison of a sinusoidal control signal with a triangular carrier. The switches on a single branch are turned on or off depending on whether the control signal is greater or smaller than the carrier. A detailed analysis of the circuit topology, the modulation method, and simulations can be found in [11]. Space vector modulation can be an alternative, although it requires some higher computing efforts [29], [30].

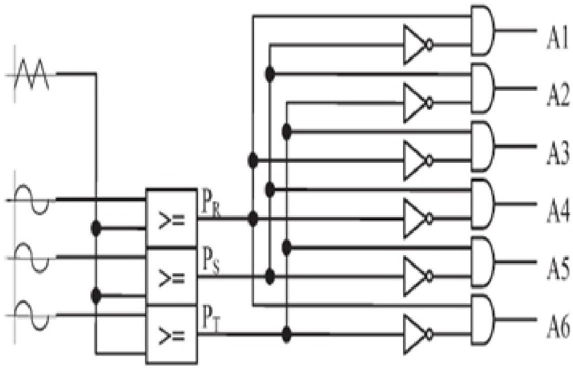

Fig. 4. FPGA Technique

TABLE II
DIRECT SPWM GATE SIGNALS

State	A1	A2	A3	A4	A5	A6	I_R	I_S	I_T
1		1				1	0	I/3	- I/3
2	1				1		I/3	- I/3	0
3	1					1	I/3	0	- I/3
4			1	1			- I/3	0	I/3
5		1		1			- I/3	I/3	0
6			1		1		0	- I/3	I/3

In FPGA for VSIs, the signals PR, PS, and PT are generated by the comparison of one triangular with three sine waves and they directly drive the switches of each leg of the VSI.

To generate the desired current level at the load while assuring current continuity in all the inductors, the driving signals for a need more logic manipulation [28]. The signals Pi are logically subtracted (unsigned) two at a time to generate the firing signal of each switch (A1–A6), according to the logic diagram shown in Fig. 4. The combination of the valid conditions of all the switches form a set of six active valid states that are shown in Table II.

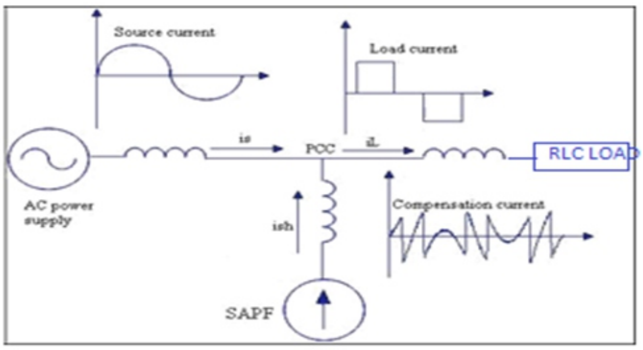

Fig. 5. Main power circuit (SAPF in a four-wire distribution network).

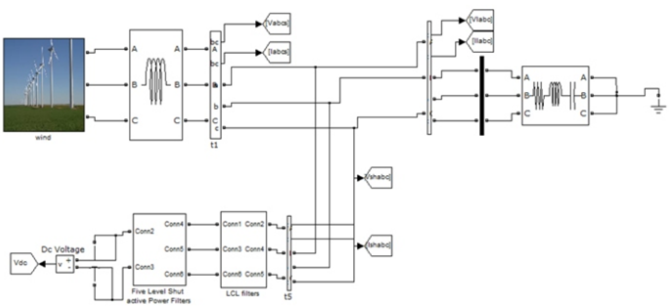

Fig. 6. Simulation model of distribution network with five-level SAPF

IV. SIMULATION MODEL AND RESULTS:

In order to validate the proposed scheme employing thefour-wire CHB-VSI based SAPF, a simulation model using the proposed controller in a three-phase four-wire distribution network supplying mixed non-linear loads i.e. a three-phase thyristor bridge rectifier with a firing delay angle of 300 and three single-phase diode bridge rectifiers, is developed by MATLAB/SIMULINK as shown in Fig. 6.

Table 1. Simulation Parameters

Parameter	Value
3- AC source voltage (RMS)	415 V
Source frequency (f)	50 Hz
Source resistance (R_s)	2 m
Source inductance (L_s)	0.002 mH
3- diode rectifier AC side inductance (L_{L1})	6 mH
3- diode rectifier DC side impedance (R_{dc1}, L_{dc1})	12 , 20 mH
1- diode rectifier AC side inductance (L_{L2})	3 mH
1- diode rectifier DC side inductance (R_{dc2}, L_{dc2} & C_{dc2})	15 , 1 mH, 470 µF
Interface inductance at AC side of SAPF (L_{sh})	6 mH
DC storage capacitor of SAPF (C_{dc}) per cell	100 µF

A. Effect of non-linear loads on distribution system:

To analyze the effect of mixed single-phase and three-phase non-linear loads on the distribution system when the SAPF is not introduced, a separate simulation model is developed by considering the data of the system and non-linear loads as in Table 1. Fig. 7 to Fig. 13 report the simulation results of voltage, current, THD, active and reactive powers and power factor at supply end.

Fig. 7 shows the simulation waveform of the phase 'a' source line-to-neutral voltage, which is observed to be pure sinusoidal with a peak value of 338.85 V and the corresponding THD as in Fig. 8 is equal to 0.02 % which is less than 5 % the IEEE-519 standards. Similar results are obtained for the phases 'b' and 'c'.

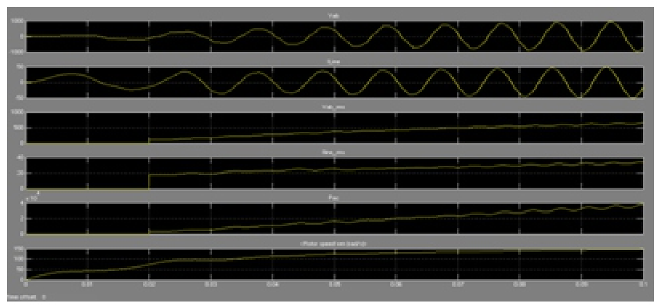

Fig 7: Source phase to phase voltage (Vab), Line current (Il) , Voltage RMS, Current RMS, Total power and Rotor speed.

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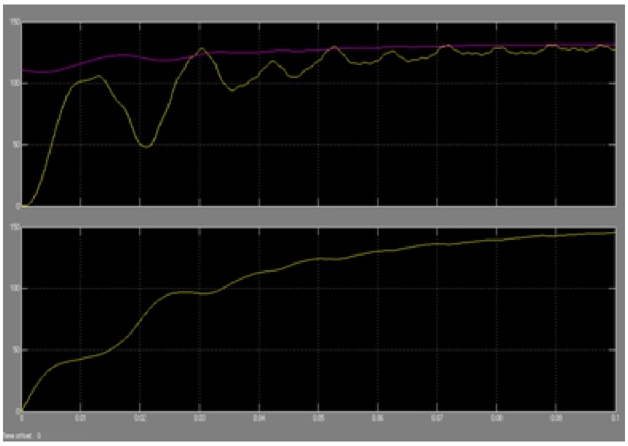

Fig 8 Electrical torque and Mechanical torque.

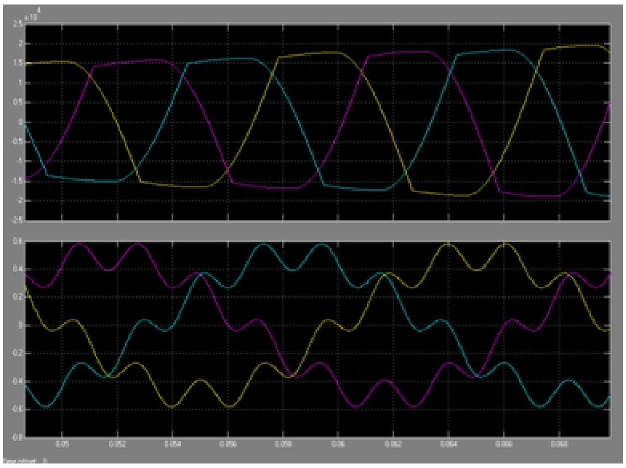

Fig 9 Shunt injected voltage and currents.

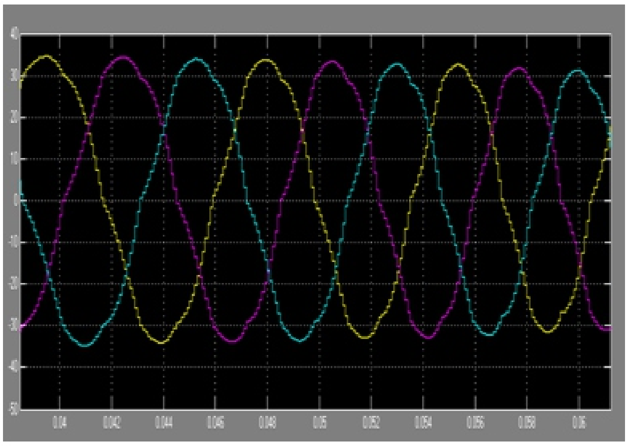

Fig 10: load current without controller.

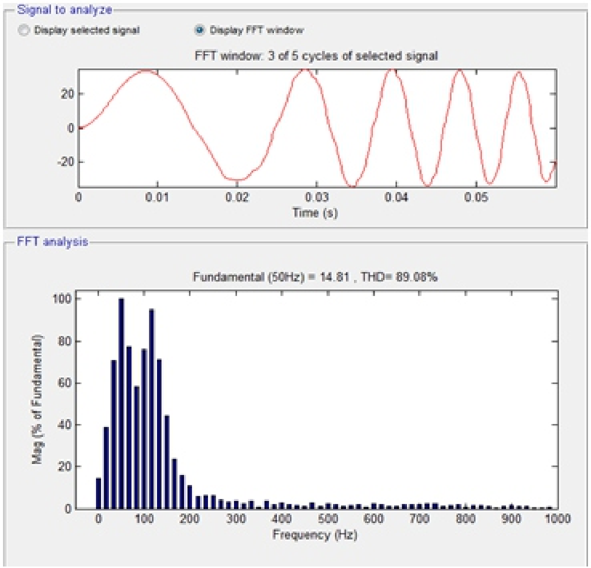

Fig 11. THD of load current with out controller.

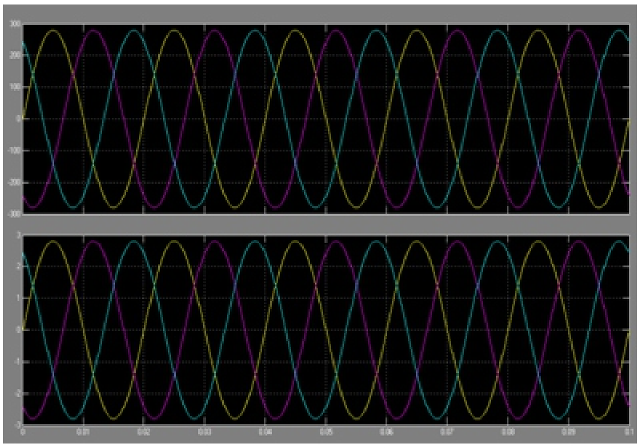

Fig 12 : Load voltage and load current with controller

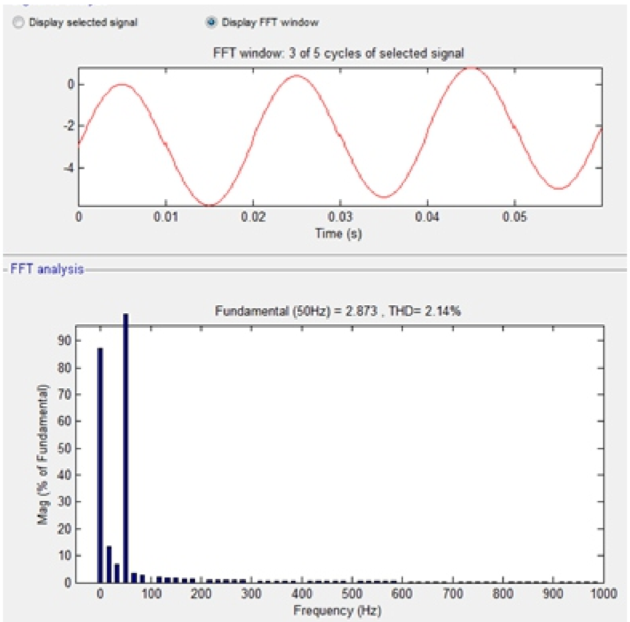

Fig 13. THD of load current with controller

By observing fig 11 and fig 13 we can justify that THD level was decreased in load side upto 2.14%.

VI. CONCLUSIONS:

In this paper MATLAB/SIMULINK model is developed for the proposed five-level CHB-VSI based SAPF by using proposed d-q-0 theory based controller and IPD modulation technique. The performance of five-level CHB-VSI based SAPF with proposed controller is analyzed. It is established from the extensive simulation results that the SAPF is effective to minimize the source harmonic currents and reduce the THD within the prescribed limits of IEEE-519 standards i.e. less than 5 %. The source end power factor is improved closed to unity and the neutral conductor current is also well minimized by the compensating performance of SAPF. The proposed control strategy and modulation technique ensured efficient operation of five-level CHB-VSI based SAPF for power quality improvement of three-phase four-wire distribution systems.

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