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Power Quality Improvement In Renewable Power Generation System Using Active Power Filter

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Abstract

A predictive control mechanism for current control employing four-leg voltage source inverter is discussed in this paper. This voltage source inverter uses the shunt active power filter which is incorporated for the balancing of non-linear loads, minimisation of current harmonics, adjusting the power factor to the normal value and the compensation of unbalanced current which is produced via non-linear loads. In order to forecast the upcoming performance of the variables to be controlled, predictive control algorithm is used. The behaviour of the suggested active power filter along with their relative control strategy are proposed for both the transient condition and the steady state conditions which is evaluated and validated through simulations in MATLAB/SIMULINK.

Keywords: Four-leg inverter, predictive control, active power filter, current control.

Introduction

The quality of the power have been weakened in the power system mains which are due to the growth of power electronics converters, renewable energy sources which causes the non-linearity in the system. Because of the nature of nonlinearity, the solar power and wind powerare to be interfaced to the grid through static converters such as PWM converters for the improvement of power quality[1].As the power generation is constantly varying, it exactly disturbs the voltage regulation and builds voltage fluctuations in power systems. More classic compensation techniques are needed for the improvement of the power distribution systems. It is seen that the four-leg inverter structure is chosen to incorporate a three-phase four-wire active power filter. The active power filters are realized using three- phase four-leg inverter is presented in [2] –[6]. A predictive control algorithm is designed and applied for this application. In this paper, an improved method of predictive control algorithm is recommended to minimize the complexity for the selection of the ideal voltage vectors which is done by takingasubgroup of voltages for this algorithm.

Conventionally, active power filters aremeasured using modified controllers like PI controller or adaptive controller, for the current and the voltage circles of DC [7], [8].PI controllers are implemented using linear model whereas the predictive control uses the non-linear model which is similar to unique operating condition. This model is attained by means of the predictive controllers by which the performance of the active power filter is improved, predominantly in the course of transient operating conditions. The active power filter promptly follows the reference signal of current while maintaining the constant dc-voltage. The power converters which uses the predictive control algorithm is incorporated in induction and synchronous motor drives [9]–[12].Predictive control is an appropriate control mechanism which permits the presence of system constraints and non-linearities which is designed for the different stages of the controller. In the applications of drives in the motor, predictive current control scheme demonstrates a very spontaneous mechanism which is used for switching multivariables and the time for dead-zone is accomplished. On the other hand, these kinds of applications will have so many drawbacks which are linked to fluctuations and instability generated due to the parameters of the load which are unknown. The main advantage of the projected algorithm is that it fits well in the applications of active power filter. The widespread report of the selected current reference generator is implemented in the active power filter. The shunt active power filter and the efficiency of the related control scheme compensation are established through simulation. Shunt active power filters have been introduced as a way to overcome the power quality problems caused by nonlinear and reactive loads.

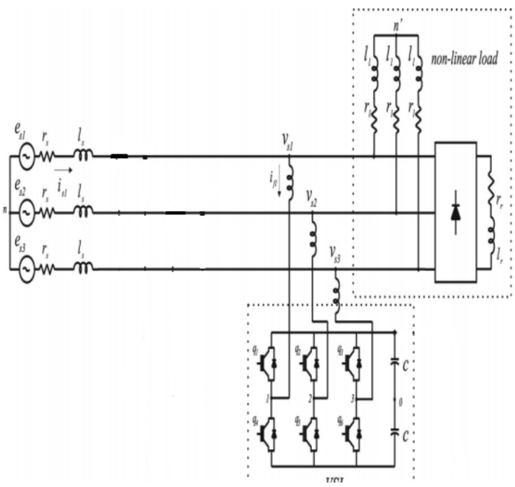

Figure 1: Three-phase equivalent circuit of the proposed shunt active power filter

Four Leg Inverter and Predictive Current Control

The four leg inverter topology is shown in Fig.2.It is related to the conventional three-phase voltage source inverter but the former has the fourth arm attached to the neutral point of the system. The switching states are increased in the fourth arm so that the flexibility and the quality of the voltage obtained can be enhanced and the compensation of unbalanced current can be rectified.

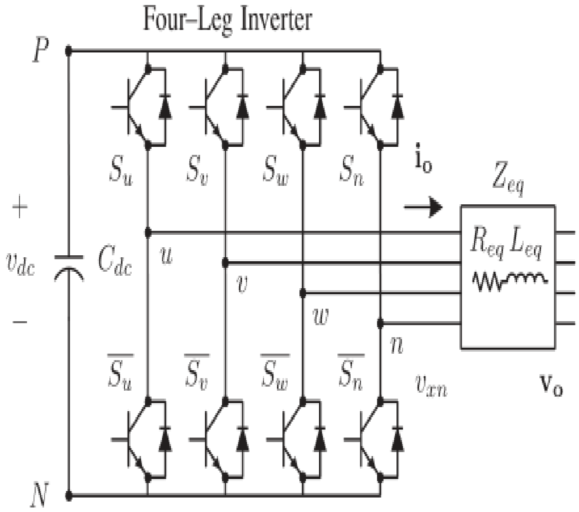

Figure 2: Four leg Voltage source inverter

The schematic illustration of the predictive current control scheme shown in figure.3.is an optimization algorithm. Only the fixed number of switching states can be created in this algorithm and the main function is to calculate the performance of the variables for each switching state. A selection criteria must be well-defined for the selection of the suitable switching state. This selection criteria is stated as a objective function that will be calculated for the predicted values of the variables to be controlled.

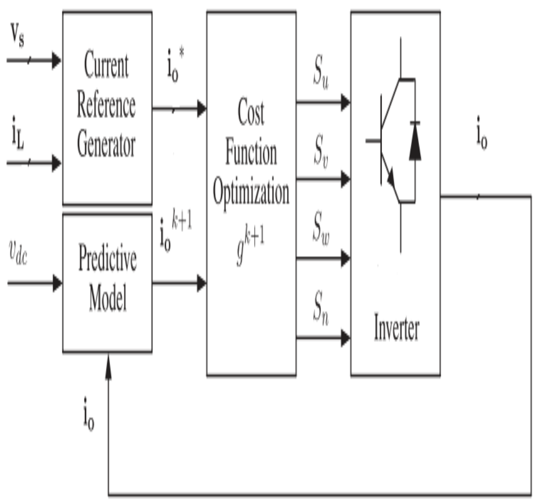

Figure 3: Predictive current control block diagram.

Current Reference Generator

This is considered to produce the required current reference that is used to compensate the unwanted load current components. A dq-based current reference generator arrangement is used to obtain the active power filter current reference signals. This scheme generates a fast and accurate signal which avoids voltage changes that weaken the current reference signal produced by their respective load current. This segment calculates the reference current signal which is necessary to compensate the reactive power, current harmonic, and current discrepancy. The displacement power factor(sin$\emptyset_L$) and the maximum total harmonic distortion(THD) of the load describes the interactions concerning the apparent power and the load, as shown

$$\frac{S_{APF}}{S_L} = \sqrt{\frac{\sin\emptyset_{(L)} + THD_{(L)}{}^2}{1 + THD_{(L)}{}^2}}$$

Where the value of THD_L includesthemaximumharmonic current. The frequency of the maximum current harmonic component that can be compensated is equal to one half of the converter switching frequency. The current which is flowing through the neutral of the load is remunerated by inserting the same instantaneous value.

Simulation Results and Discussions

Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. MATLAB/SIMULINK is a part of Math works, which is used for determining the flow of data in graphical manner and is it also used for simulating and modelling of the components of the systems. Simulation is one of the best ways to study the system or circuit behaviour without damaging it. It is now essential for an electrical engineer to understand the concept of simulation and learn its use in various applications. The performance of proposed concept of power quality improvement in renewable power generation system using active power filter has been evaluated by using Matlab/Simulink environment.

Figure 4(a) shows the open loop circuit of solar system without the control of voltage source inverter.

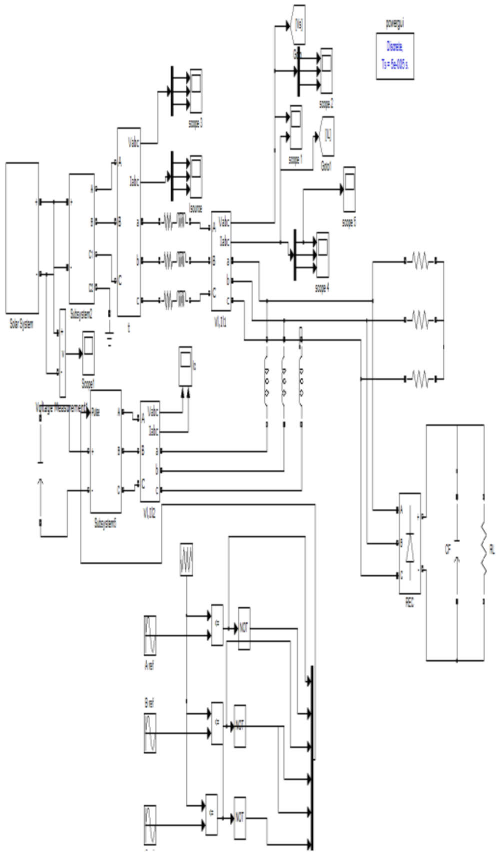

Figure 4(a): Open loop circuit of solar system using non-linear load without the control of VSC

Figure 4(b) shows the simulation model of the solar system which uses PS-Simulink converter and the output obtained is in DC which is then inverted to AC.

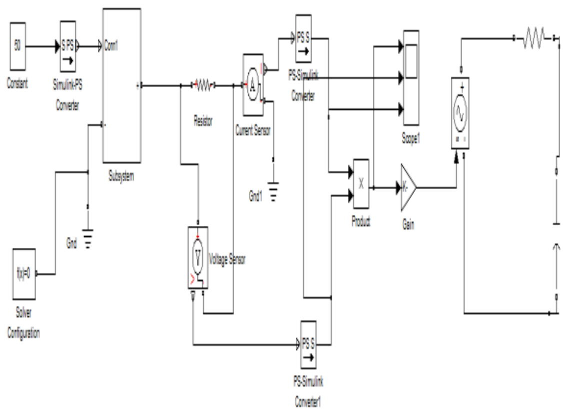

Figure 4(b): Simulation model of Solar system

Figure 4(c) shows the solar cells which is used for the simulation modelling of the solar panel.

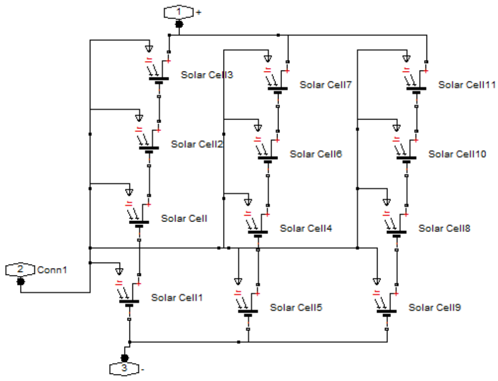

Figure 4(c): Solar cells employed for the simulation of solar system.

Figure 4(d) shows the THD value of the open loop configuration of the solar system.

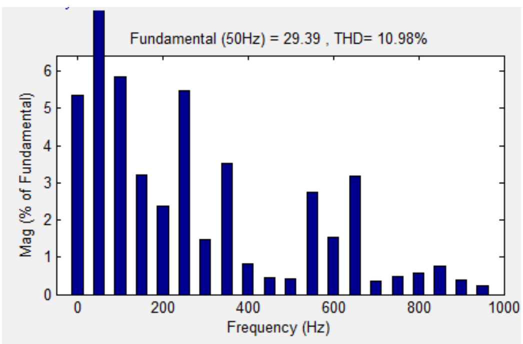

Figure 4(d): THD value of the solar system in open loop

Figure 4(e) shows the DC output of the solar system which is 415V.The inverter circuit is used to convert the DC output in AC which uses the sinusoidal pulse width modulation technique for switching pulses.

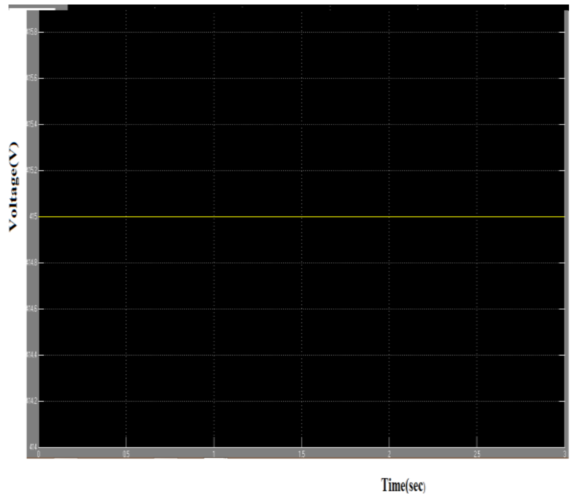

Figure 4(e): DC output waveform of the solar system

Figure 4(f) shows the Output waveform of the open loop configuration of the solar system without control circuit. Harmonics are present in the system which has to be reduced using the active filters.

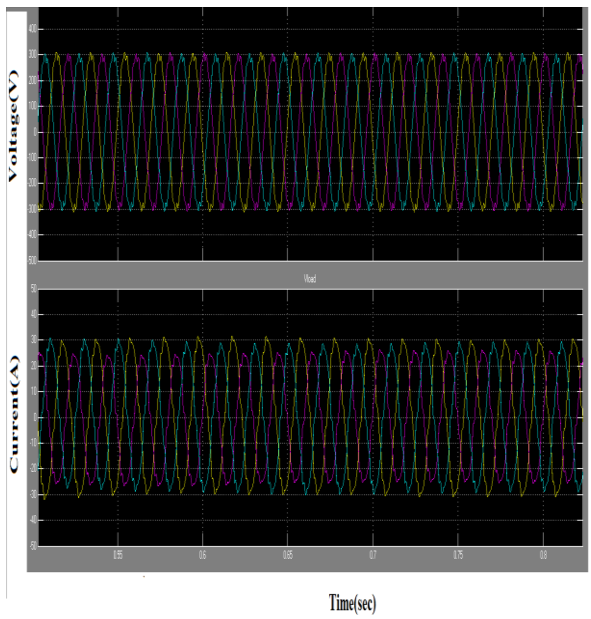

Figure 4(f): Output waveform of solar system in open loop mode

Figure 5(a) shows the simulation model of the solar system which uses predictive control circuit and the control of the voltage source inverter has been performed using active filters for minimising the harmonic distortion in the system.

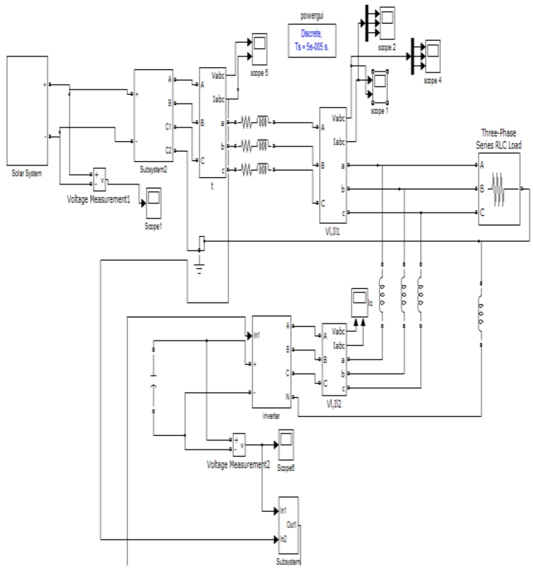

Figure 5(a): Closed loop configuration of solar system

Figure 5(b) shows the control circuit which uses predictive control method and the active filters are employed for minimising the harmonics in order to make the system to be stable.

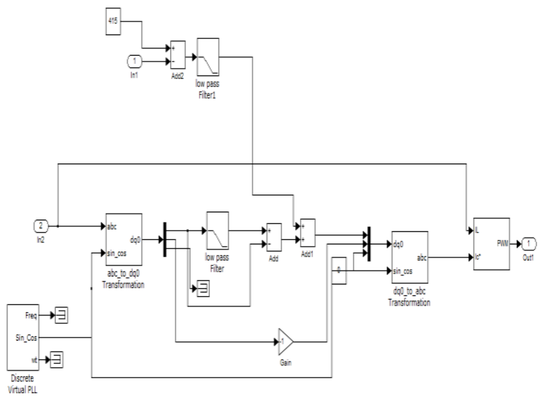

Figure 5(b): Simulation model of Predictive control circuit.

Figure 5(c) shows the THD value of the solar system which uses the control circuit in which the harmonics has been reduced on comparison with THD value of open loop configuration.

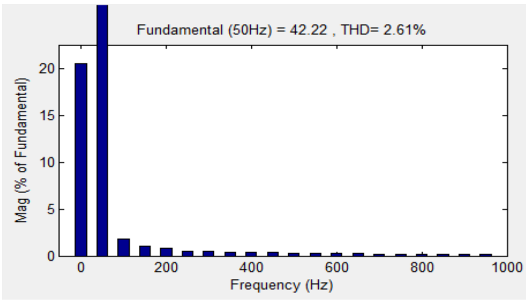

Figure 5(c): THD value of solar system in closed loop

Figure 5(d) shows the output waveform of the closed loop configuration of the solar system which uses the control circuit in which the harmonic distortion has been reduced.

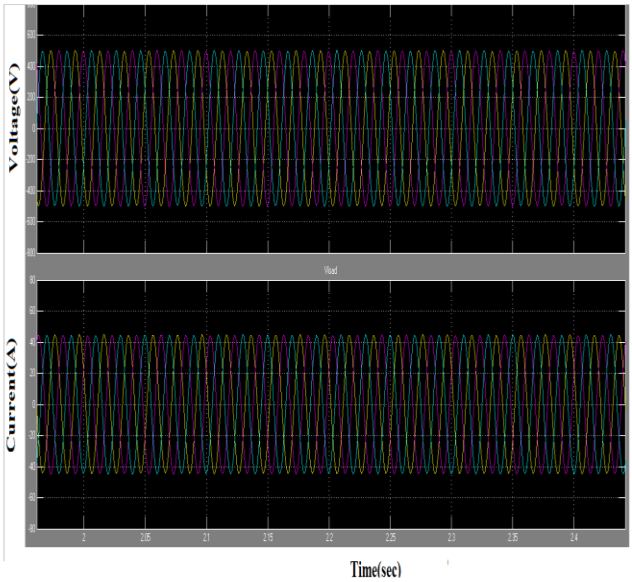

Figure 5(d): Output waveform of closed loop configuration of solar system

Conclusion

The current quality in the distribution systems has been improved by using the predictive control method. Once the compensation has been employed, the currents in the unbalanced load perform as near to ideal balanced currents. The Total Harmonic Distortion in load currents has been substantially decreased, which is observed to be below five percent. Simulation results has shown that the Transient response has been improved and the application of active power filters is performed by using the predictive control scheme. Active power filters are proven to be well effective for the linear and non-linear loads.

References

[1] J. Rocabert, A. Luna, F. Blaabjerg, and P. Rodriguez, "Control of power converters in AC microgrids," IEEE Trans. Power Electron., vol. 27,no. 11, pp. 4734–4749, Nov. 2012.

[2] Pablo Acu na, Luis Morán, Marco Rivera, Juan Dixon, José Rodriguez, "Improved Active Power Filter Performance for Renewable Power Generation Systems", IEEE Transactions on power electronics, vol. 29, no. 2, February 2014.

[3] S. Naidu and D. Fernandes, "Dynamic voltage restorer based on a four-leg voltage source

[4] converter," Gener. Transm. Distrib. IET, vol. 3, no. 5,pp. 437–447, May 2009.

[5] R. Vargas, P. Cortes, U. Ammann, J. Rodriguez, and J. Pontt, "Predictive control of a three-phase neutral-point-clampedinverter," IEEETrans.Ind. Electron., vol. 54, no. 5, pp. 2697–2705, Oct. 2007.

[6] F. Wang, J. Duarte, and M. Hendrix, "Grid-interfacing converter sys-tems with enhanced voltage quality for microgrid application; concept and implementation," IEEE Trans. Power Electron., vol. 26, no. 12, pp. 3501–3513, Dec. 2011.

[7] S. Ali, M. Kazmierkowski, "PWM voltage and current control of four-leg VSI," presented at the ISIE, Pretoria, South Africa, vol. 1, pp. 196–201,Jul. 1998.

[8] Z. Shen, X. Chang, W. Wang, X. Tan, N. Yan, and H. Min, "Predictive digital current control of single-inductor multiple-output converters in CCM with low cross regulation," IEEE Trans. Power Electron., vol. 27,no. 4, pp. 1917–1925, Apr. 2012.

[9] M. Preindl and S. Bolognani, "Model predictive direct speed control with finite control set of PMSM drive systems," IEEE Trans. Power Electron., 2012.

[10] J. T. Bialasiewicz, "Renewable energy systems with photovoltaic power generators: Operation and modeling," IEEE Trans.Ind.Electron.,vol.55,no. 7, pp. 2752–2758, Jul. 2008.

[11] M. I. M. Montero, E. R. Cadaval, and F. B. Gonzalez, "Comparison of control strategies for shunt active power filters in three-phase four-wiresystems," IEEE Trans. Power Electron., vol. 22, no. 1, pp. 229–236, Jan.2007.

[12] R. de Araujo Ribeiro, C. de Azevedo, and R. de Sousa, "A robust adaptive control strategy of active power filters for power-factor correction, harmonic compensation, and balancing of nonlinear loads," IEEE Trans. Power Electron., vol. 27, no. 2, pp. 718–730, Feb. 2012.

[13] C. A. Quinn and N. Mohan, "Active filtering of harmonic currents in three-phase, four-wire systems with three-phase and single-phase nonlinear loads," in APEC'92—Applied Power Elec. Conf., 1992, pp.829–836.