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Effective grid interfaced renewable sources with power quality improvement using dynamic active power filter

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ABSTRACT

The present modern power system is getting more complex and dynamic day by day. These Dynamic changes can be effectively handled by integrating renewable sources to the grid. The optimal usage of renewable sources will improve the overall performance of the electrical utility. Renewable energy sources and non-linear loads connected to grid have adverse effects on the power quality of the system. This paper presents I cosine ANFIS control based Dynamic Active Power Filter (DAPF) to improve the power quality of the grid at source side with effective integration of renewable sources. The model presents optimal usage of renewable sources and avoids the usage of battery by replacing with solar energy unit (SEU). DAPF fed by SEU and wind unit serves power to the load during power fluctuations from grid side. The performance of proposed model with I cosine ANFIS controller based DAPF is validated using MATLAB/SIMULINK.

Introduction

In the present modern world, power sector is one of the key factors which affect the economy of a country. Increasing population and living standards demands excessive power from the utility. These issues lead to developing new sources of energy which keeps pollution and global warming as the main criteria. To cope with these issues renewable Energy Sources are developed [1].

Integration of a renewable energy units to the grid has much effects on the power quality of the system [2,3]. The injected harmonics in the line are mainly due to nonlinear loads connected and wind energy units causes requirement of reactive power on the line. Utility and consumer equipment will be affected by power quality abnormalities. This makes the power quality more important at all levels of usage of electricity [1]. These power quality problems should be addressed so as to provide reliable and quality power, which eliminates these power quality issues while integrating renewable energy units (REUs). Different variety of control strategies are proposed and implemented [4,5]. Traditional passive LC filters have been used for harmonic suppression [6]. But due to resonance problem and poor dynamic performance of LC filters, active power filters are involved [7]. The model presented here uses I cosine ANFIS control [8,9] based DAPF for improving the power quality.

The proposed model performs (1) Reactive power compensation, (2) Unity power factor at Common connecting Line (CCL), (3) source current harmonic reduction at CCL, and (4) active power supply to the load during grid fluctuation.

The paper is organized as follows: the proposed model is described in Section 'Proposed system description', the control scheme is described in Section 'DC link', Section 'Control strategy' presents supporting simulation results and Section 'Conclusion' concludes the proposed model.

Proposed system description

The topology presents effective integration of wind and solar energy units to the grid. Here wind energy unit is integrated to the grid at CCL through the transformer. The solar energy unit (SEU) is used in place of battery [10] to maintain the DC link capacitor voltage and also to supply the active power to the load during power fluctuations. This makes the model to use REUs very effectively. Fig. 1 shows the general block diagram of grid integrated REUs. Here battery fed dynamic active power filter is used to improve the power quality [11]. Fig. 2 describes the proposed model, where REUs are integrated to the grid in optimum manner. Instead of connecting the SEU to the grid CCL, it is connected through the active power filter. This reduces the usage of battery and excess power is fed to the grid through the inverter. During night time except delivering the active power, active power filter

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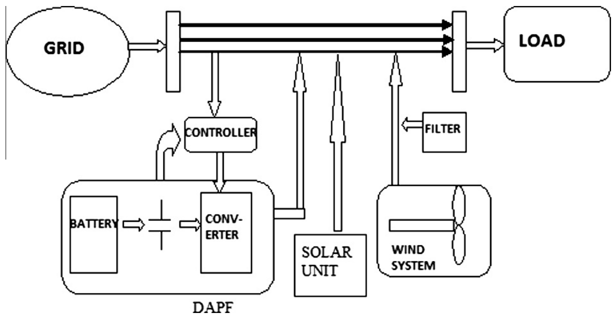

Fig. 1. Renewable source integrated to grid with DAPF at source side.

performs the reactive power compensation and harmonic reduction.

Solar energy unit

In literature variety of MPPT algorithms were proposed. Among them oftenly used techniques are Incremental conductance and Perturbation & Observation (P&O) [12]. The incremental conductance takes more time to track the maximum power which in turn leads to power loss [12]. Due to fewer parameters and simple feedback model, P&O method is widely used. Fig. 3 shows P&O based SEU. P&O involves periodical decrement and increment solar cell's voltage. Here, the solar unit consists of PV cell, Maximum Power Point Tracking unit (MPPT) [13] and DC–DC converter as power conditioning is required before connecting to DC link [14,15]. Here the solar unit is designed with MPPT which produces maximum output power.

$$P_P = V_P * I_P \tag{1}$$

The model of solar cell is shown in Fig. 4.

The terminal current and voltage of solar cell are given by,

$$I_p = I_{sc} - I_{sat}\left\{\exp\left[\frac{q}{AkT}(V_p + I_p R_{se}) - 1\right]\right\} - \frac{V_p + I_{sc}R_{se}}{R_{sh}} \tag{2}$$

$$V_p = \frac{AkT}{q}\ln\left\{\frac{I_{sc}}{I_p} + 1\right\} \tag{3}$$

Here series resistance is R_{se}, shunt resistance is R_{sh}, Boltzmann constant is k and Diode Ideality factor is A.

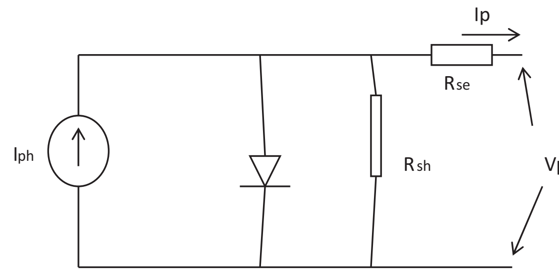

Fig. 3. Solar cell.

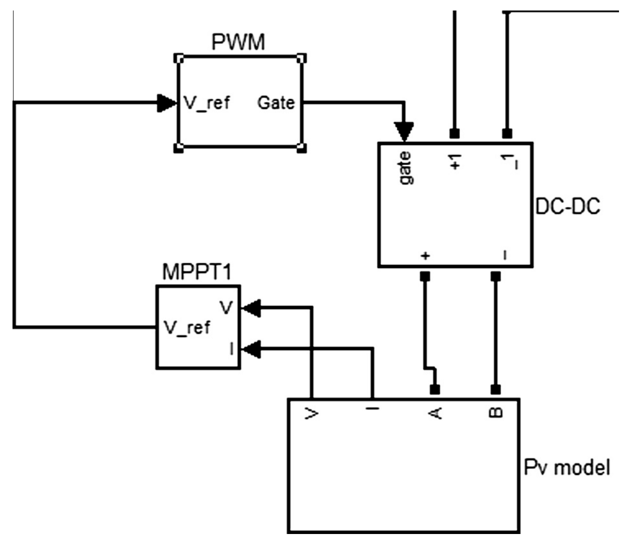

Fig. 4. Solar energy unit.

Wind energy unit

The wind energy system consists of induction generator and turbine. The power output of wind system depends on characteristics of wind turbine generator and speed of the wind [16]. The induction generator based wind system output power is

$$P_{\text{wind}} = \frac{1}{2}\rho\pi R^2 V_{\text{wind}}^3 \tag{4}$$

where V_{wind} – speed of the wind, R – radius of rotor, ρ – air density.

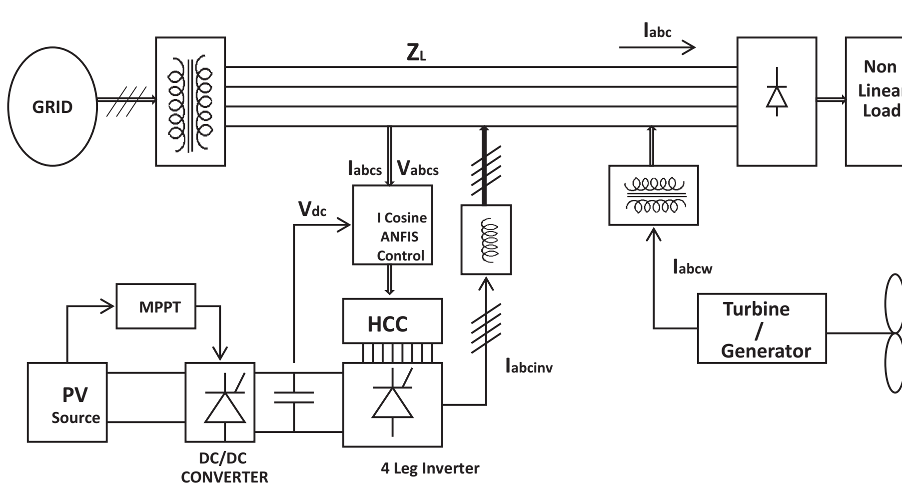

Fig. 2. Detailed diagram of proposed system.