GRID INTERFACED SOLAR ENERGY SOURCE WITH POWER QUALITY IMPROVEMENT USING SHUNT 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 PI control based Active Power Filter (APF) 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). The performance of proposed model with PI controller based APF is validated using MATLAB/SIMULINK.*

Keywords—Renewable Energy, Distributed Generation, Power quality, PhotoVoltaic, shunt Active filter, control Algorithm

1. 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 .Integration of a renewable energy units to the grid has much effects on the power quality of the system. 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 . 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 . Traditional passive LC filters have been used for harmonic suppression . But due to resonance problem and poor dynamic performance of LC filters, active power filters are involved . The model presented here uses PI control based APF 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.
Earlier works different control methods are used for inverter control to generate reference current. In [1] Bert Renders, Koen De Gusseme, et. al discussed the mitigation of voltage sag by injecting reactive current at PCC using a distribution FACTS device known as Distribution Static Compensator. In [2], G.Sundar et.al presented a methodological approach to power quality problems associated with renewable based distributed generation systems and control strategy for attaining greatest reimbursement from these grid-interfacing inverters. The inverter is controlled incorporating with active power filter functionality. Due to the control, the combination of grid interfacing inverter and the unbalanced load appears as balanced linear load to the grid. In [3], Fu-Sheng Pai et.al proposed a unified current-regulated controller is used such that the converter can be served as a power conditioner for the grid-connected operation or provided as an emergency generator for stand-alone operation. The paper has extended the circuit to include the capacity expansion capability to enhance the system with a higher capacity.In [4], Dusan Graovac et.al proposed a universal power quality conditioning system as a combination of a unified power quality conditioner and shunt active filter at the load side. It can compensate at the same time for sags, swells, interruptions, unbalance flicker, harmonics, reactive currents, and current unbalance. Active rectifier control system keeps constant dc bus voltage necessary for proper operation of the filters. Series filter provides sinusoidal load voltages and parallel filter compensates power factor of non-linear loads. Converter power level and price is somewhat higher than in conventional systems, but the compensation characteristic is superior. In [5], Josep M. Guerrero et.al proposed control technique, based on the droop control method, uses only locally measurable feedback signals. This method is usually applied to achieve good active and reactive power sharing when communication between the inverters is difficult due to its physical location. However, the conventional voltage and frequency droop methods of achieving load sharing have a slow and oscillating transient response. Hence, better controllability of the system is obtained and, consequently, proper transient performance can be achieved. In [6], Uffe Borup et .al proposed a new control concept that provides sharing of harmonic load currents between parallel-connected. In a parallel connection, these controllers will fail to ensure a proper sharing and lead to instability. In

order to provide harmonic load sharing with the harmonic controllers applied, a new control concept is derived from the well-known concept of sharing linear load by droop coefficients converters without mutual communication. This method can be applied in most solid-state ac power converter topologies supplying nonlinear load.

2. PROPOSED MODEL

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 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. shows the general block diagram of grid integrated REUs. Here battery fed dynamic active power filter is used to improve the power quality 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 performs the reactive power compensation and harmonic reduction.

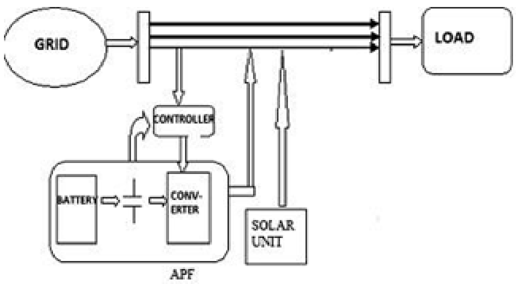

Fig 1. Block Diagram of Proposed system

A.SOLAR ENERGY UNIT

Modeling this PV necessarily requires taking weather data (irradiance and temperature) as input variables. The output can be current, voltage, power, which are used to trace the characteristics of IV or PV curve. Any change in the input immediately implies changes in outputs. That is why, it is important to use an accurate model for the PV module. The chosen model is the single diode model with both series and parallel resistors for greater accuracy.

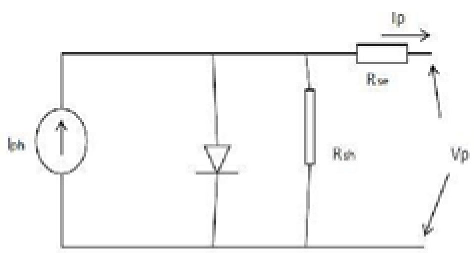

Fig 2. Solar cell

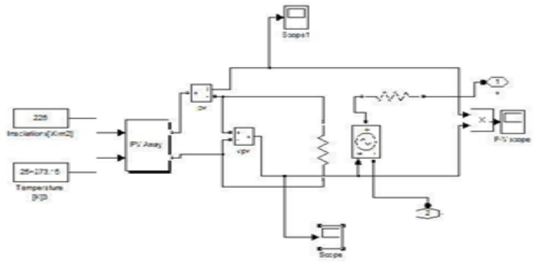

Fig. 3 Simulation of PV Module

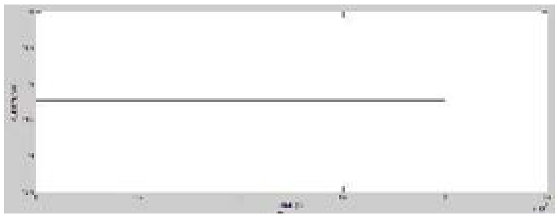

Fig. 4 PV Module (Current)

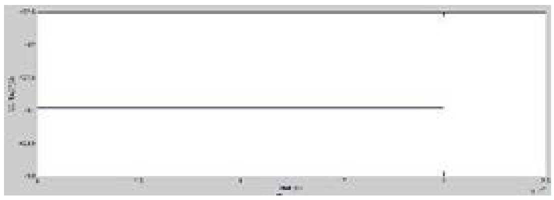

Fig. 5 PV Module (Voltage)

The proposed model is a 3 phase 3wire system. The 3 Leg inverter operates such that it absorbs or delivers active power from or to the grid.The switching operation of inverter is varied such that the inverter and load power combinedly acts like a resistive to the grid. The SEU replaces the battery usage. From Fig. 2, the solar unit is connected to the DC link of the APF. This APF is connected to grid line at CCL where wind system and non linear loads are connected. The power quality is maintained by the APF which is controlled by PI controller. The APF injects the currents based on the control strategy. This current cancels the harmonic part of source current and compensates the required amount of reactive power. Here, inverter acts as inductor and absorbs the current harmonics. The connected SEU at DC link of APF provides the required amount active power during fluctuations.

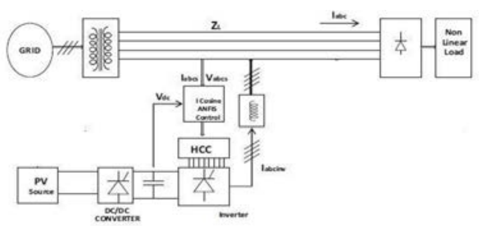

Fig 6 Block diagram of proposed system

B.Grid Interfaced Inverter rule

In a three phase balanced system, the source RMS value can be computed from the phase voltages (Va, Vb, Vc) and is denoted as Vm.

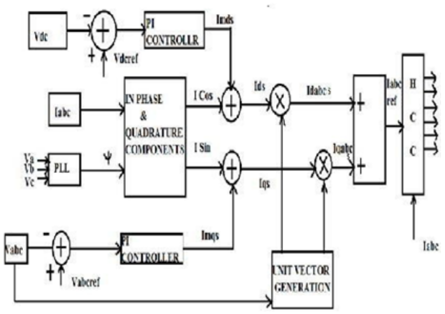

Fig 7 control technique

From the source currents (Iabcs) and source voltages (Vabcs), cosine and sine components of source currents (IacosΘ, IbcosΘ, IccosΘ, IasinΘ, IbsinΘ & IcsinΘ) are generated. The control algorithm performs the DC link voltage regulation as well as source voltage regulation. The active power transfer in between grid and SEU will be carried by Vdc regulation, which results as a current Im. This Im is combined with in phase component of source current, which generates Ids. This Ids will be multiplied by unit vectors Wa, Wb & Wc to generate the direct component Idabcs of reference current. Similarly after the regulation of source voltage and multiplying with the unit vectors, quadrature component Iqabcs of reference currents are generated. Further the reference currents Iaref, Ibref & Icref are generated by the addition of Idabcs & Iqabcs of source currents.

Now the difference between reference and actual currents is fed hysteresis current controller (HCC). HCC develops the pulses to APF based on the difference between reference and actual source currents.

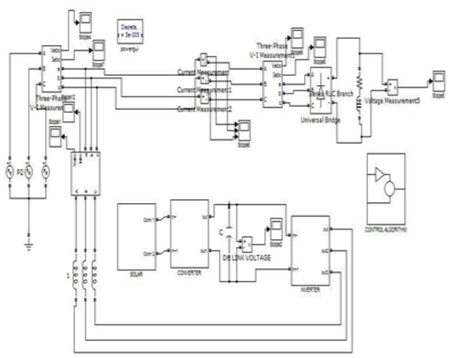

Fig. 8 Simulation model of proposed model

3. RESULT & ANALYSIS

In order to verify the proposed control approach of Grid Interfaced Renewable Energy Source (Solar)with Hysteresis Current Controller to the Inverter are summarized, the simulation study is carried out using MATLAB/Simulink software. The simulation of proposed method, is carried out (without Filter) shown in fig.7

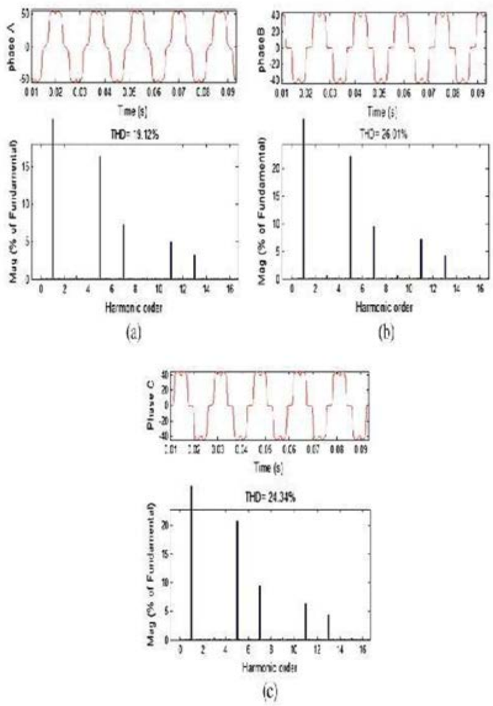

Fig. 9 (a-c) Harmonics distortion of source current(without filter)

The simulation of proposed method, is carried out (with Filter) shown in fig.8 using MATLAB /Simulink.

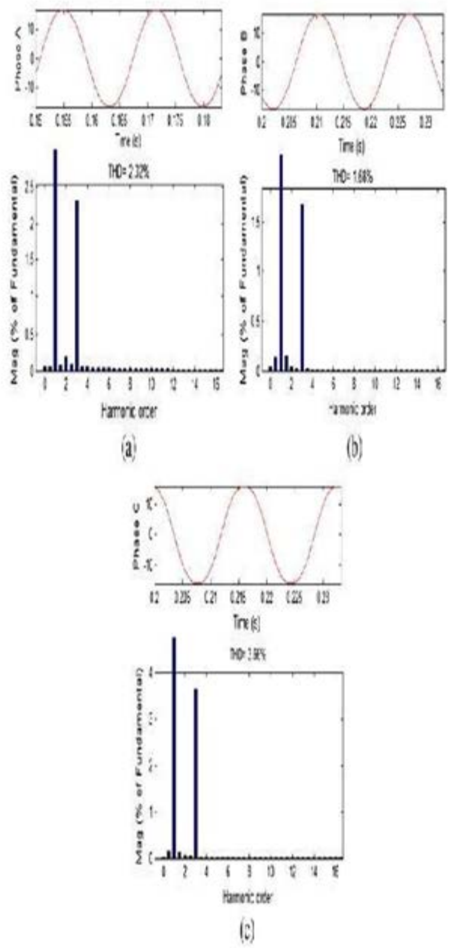

Fig. 10 (a-c) Harmonics distortion of source current(with filter)

4. CONCLUSION

This Paper has proposed a control algorithm of grid interfacing inverter to improve the quality of power. From this it is observed that the current harmonics is reduced, power factor is improved, active power injected to grid and the Reactive power demand of the grid is compensated. The required amount of active power is supplied to the load.

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