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PV-APF Based Distribution Unit for Power Quality Control in Grid under Non-Linear Load Effects

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ABSTRACT
In this paper, a three-phase three-wire system, including a detailed PV generator, dc/dc boost converter to extract maximum radiation power using maximum power point tracking, and dc/ac voltage source converter to act as an APF, is presented. Grid tied solar power generation is connected to nonlinear loads based on Active Power Filter (APF) by providing predictive control scheme. The dc/ac VSC integrated by an APF function should providethe harmonic elimination and reactive power compensationand simultaneously inject the maximum power generated by PV units. The dc output voltage of PV arrays is connected to a dc/dc boost converter using a Ripple Co-relation controller to maximize their produced energy. Performance analysis is done by simulate by MATLAB/Simulink.

INTRODUCTION
As nonlinear loads, these solid-state converters draw harmonic and reactive power components of current from ac mains. In three-phase systems, they could also cause unbalance and draw excessive neutral currents [1]. The injected harmonics, reactive power burden, unbalance, and excessive neutral currents cause low system efficiency and poor power factor. Solid-state control of ac power using Thyristors and other semiconductor switches is widely employed to feed controlled electric power to electrical loads, such as adjustable speed drives (ASD's), furnaces, computer power supplies, etc. Such controllers are also used in HV dc systems and renewable electrical power generation [2]. They also cause disturbance to other consumers and interference in nearby communication networks Extensive surveys have been carried out to quantify the problems associated with electric power networks having nonlinear loads.

Distributed generation (DG) based on renewable energy sources are basically small scale power generation units (typically ranges from 20 kW to 20 MW) and they are located at the end user without long distance transmission line [3]. As a result, it reduces the transportation cost of generation and consumption points are close to each other. It is feasible to implement interfaces having ability to operate in grid connected as well as in isolated mode without grid connection which is called micro grids [4]. The basic structure of a Distributed Power Generation System (DPGS) is illustrated in Fig.1.

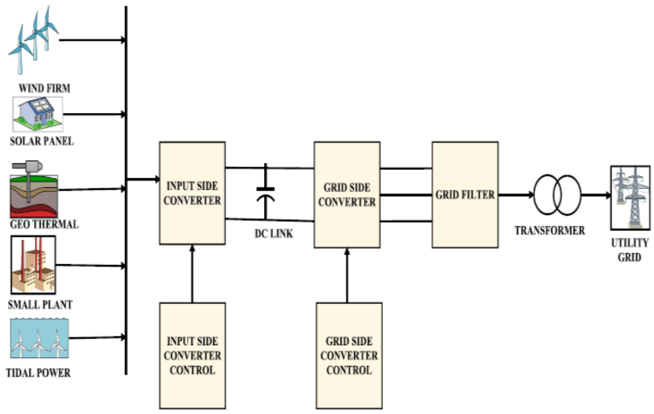

Fig 1: Distributed Generation system

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PV-APF

Power supply and power quality has been critical issues in power system recently. The grid-connected photovoltaic (PV) generator has nowadays become more popular because of its reliable performance and its ability to generate power from clean energy resources. The dc output voltage of PV arrays is connected to a dc/dc boost converter using a maximum power point tracking (MPPT) controller to maximize their produced energy [5]. Then, that converter is linked to a dc/ac voltage source converter (VSC) to let the PV system push electric power to the ac utility. The local load of the PV system can specifically be a non- linear load, such as computers, compact fluorescent lamps, and many other home appliances, that requires distorted currents [6]. Development of a means to compensate the distribution system harmonics is equally urgent. In this case, PV generators should provide the utility with distorted com-compensation capability, which makes currents injected/absorbed by the utility to be sinusoidal. Therefore, the harmonic compensation function can be realized through flexible control of dc/ac VSC.the power quality of the utility.

PV-APF

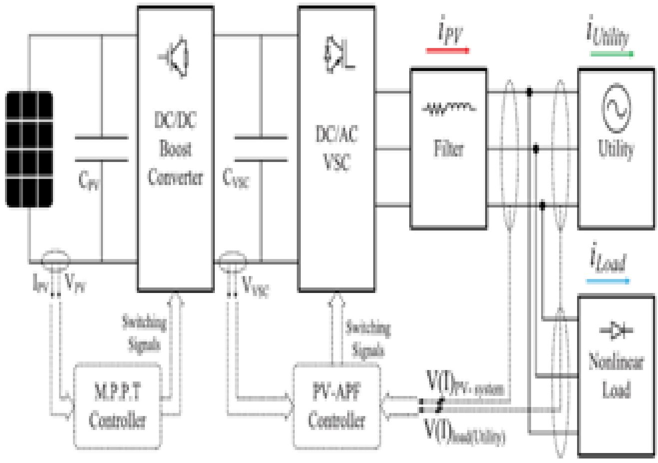

Fig 2: pv-apf system

Predictive Control based PV-APF

The complete description of the selected current reference generator implemented in the active power filter is also presented. This proposed model presents the mathematical model of the 4L-VSI and the principles of operation of the proposed predictive control scheme, including the design procedure [7]. Finally, the proposed active power filter and the effectiveness of the associated control scheme compensation are demonstrated through simulation.

Converter design

The converters will perform maximum power point tracking to extract the maximum energy possible from wind and sun.

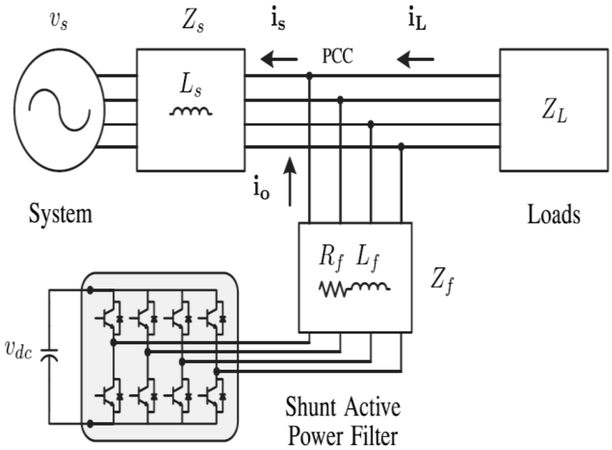

Fig 3: shunt active power filter.

This circuit considers the power system equivalent impedance Z_s, the converter output ripple filter impedance Z_f, and the load impedance Z_L. The four-leg PWM converter topology

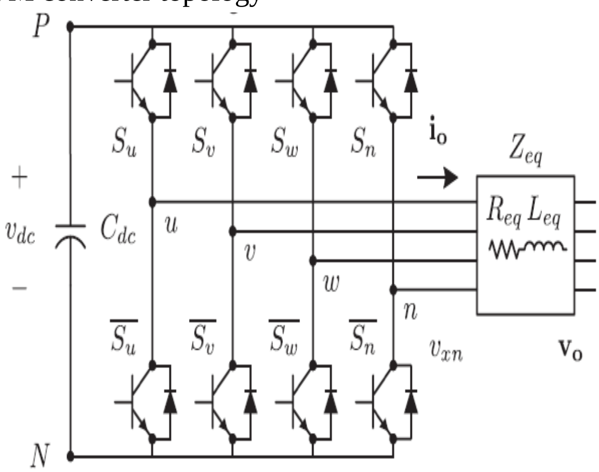

Fig 4: VSI topology

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Model Predictive Current Control

The block diagram of the proposed digital predictive current control scheme is shown in Fig. 5. This control scheme is basically an optimization algorithm and, therefore, it has to be implemented in a microprocessor [8]. Consequently, the analysis has to be developed using discrete mathematics in order to consider additional restrictions such

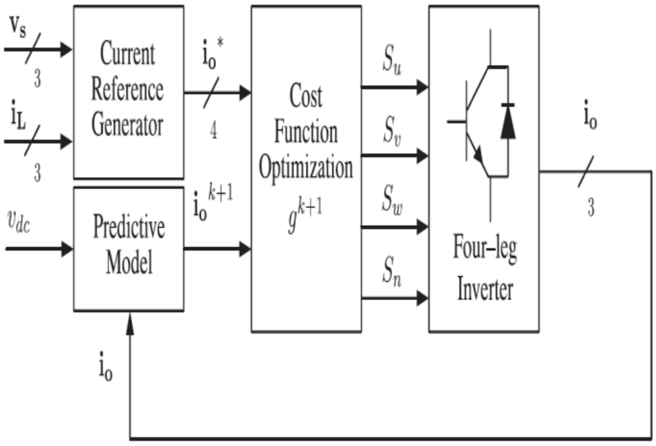

Fig 5: Proposed Predictive Digital Current Control Block Diagram

Current Reference Generation

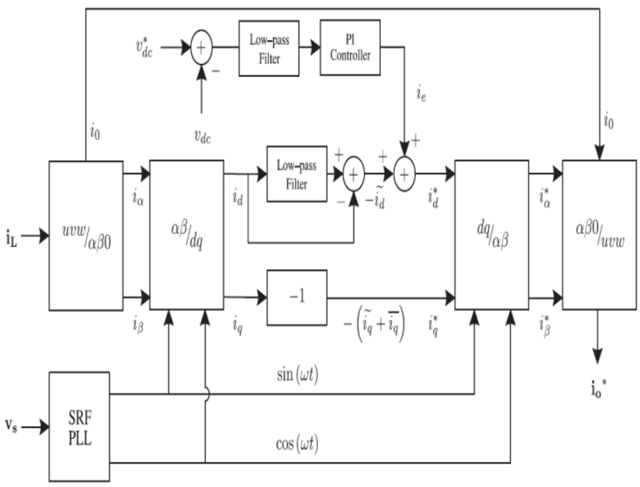

Fig 6: dq-based current reference generator

Where the value of $THD_{(L)}$ includes the maximum compensable harmonic current, defined as double the sampling frequency fs. The frequency of the maximum current

PV-APF with model predictive control technique

A simulation model for the three-phase four-leg PWM converter with the parameters shown in Table I has been developed using MATLAB-Simulink. The objective is to verify the current harmonic compensation effectiveness of the proposed control scheme under different operating conditions.

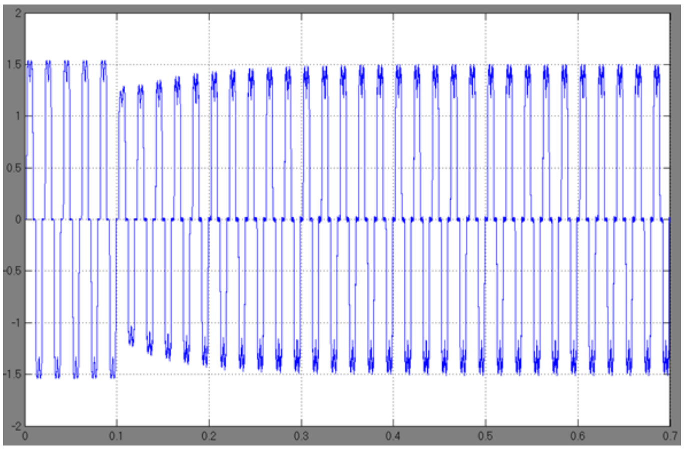

Fig 16: Load Current

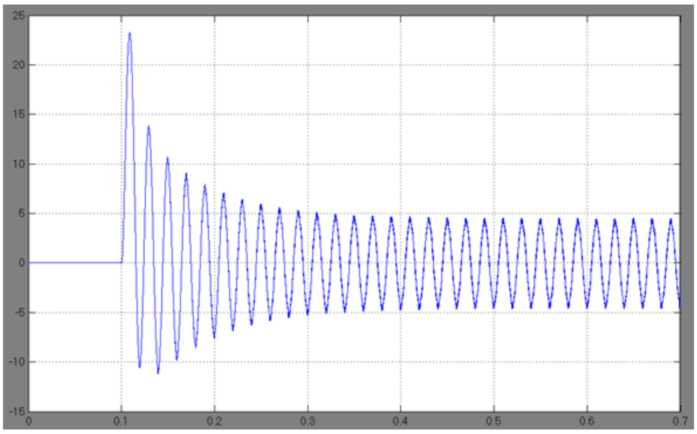

Fig 17: Active power filter output current.

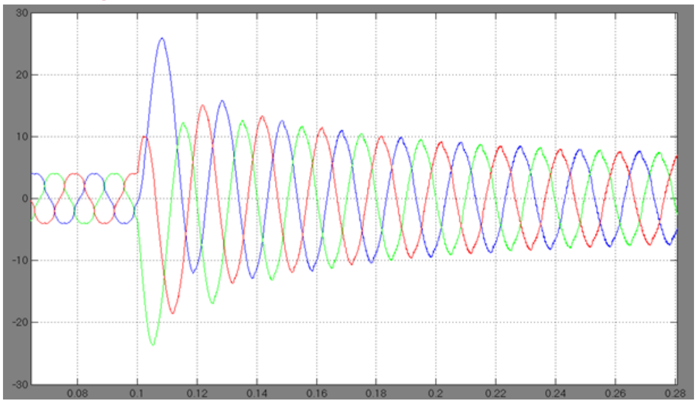

Fig 18: Three-phase currents

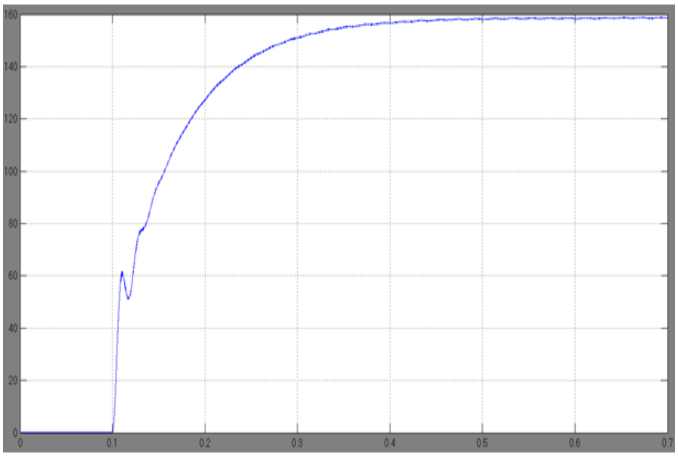

Fig 19:DC voltage converter

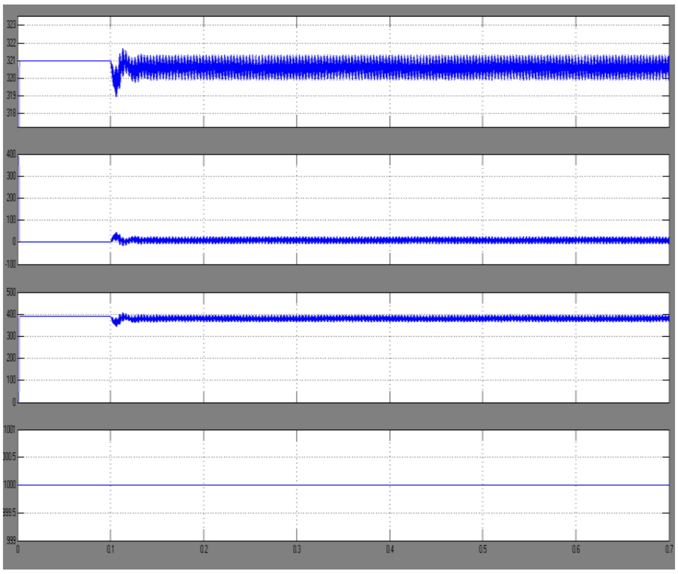

Fig20: PV-Array Characteristics (Voltage, Current, Id, S)

CONCLUSION

While a PV unit is deactivated, the APF function can still operate. It is, therefore, technically feasible for these power electronics-interfaced DG units to actively regulate the power quality of the distribution system as an ancillary service, which will certainly make those DG units more competitive. The new controller based on instantaneous power balance has been explained accordingly. The positive influence of MPPT on maximizing PV power output is also validated. .The switching among three controllers to dc/ac VSC brings different current waveforms. As a result, the conventional dq-current controller should not be applied when PV is connected to a local nonlinear load regarding power-quality viewpoint. Preferably, the PV-APF controller compensates the utility currents successfully. Simulation analysis shows better performances of this controller.

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