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A PV BESS SUPPORTED SERIES ACTIVE FILTER WITH POWER QUALITY IMPROVEMENT FEATURES

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ABSTRACT

To reduce sag, swell, and harmonics brought on by nonlinear power electronic loads, a three-phase series hybrid active filter (SEHAF) linked with a photovoltaic (PV) system and dc-dc boost converter is suggested. A capacitor is interconnected across a voltage source inverter (VSI) in the SEHAF to consistently control and compensate for unstable power. As a result, the overtones, droop, and swell in the source and load voltages are reduced. The voltage across the dc-link capacitor of the VSI is successfully regulated with PV incorporation, aiding in improved compensation. It is advised that a battery-supported sheaf be used to power the DVR's fallback support, increasing the DVR's effectiveness in low light conditions. In order to reliably regulate and account for unstable power, a capacitor is linked across a voltage source inverter (VSI) in the SEHAF. The voltages at the source and the load experience less harmonics, droop, and spike as a consequence. Improved rectification is made possible by the PV incorporation's effective regulation of the voltage across the VSI's dc-link capacitance. The reference current is produced using the recommended robust extended complex Kalman filter (RECKF) technique. The effectiveness of the PV-integrated-HAF is assessed using a synchronous reference frame with proportional-integral (PI) and fuzzy logic controller (FLC), and the outcomes are compared to the RECKF technique that has been proposed. To back the simulation findings, real-time digital simulation using OPAL-RT OP5142 is also conducted. It has been found that the suggested control system offers superior harmonic correction to traditional PI and FLC.

INTRODUCTION

The power quality, abbreviated as PQ, is an issue that must be addressed in order for commercial and industrial businesses to provide their customers with a reliable and economical supply. When switch mode power supply (SMPS) devices are used, there is a significant increase in the likelihood of power quality issues occurring. These loads contribute to the maintenance of non-linearity, cause harmonic generation, and reduce the effectiveness of the utility network. PQ is contingent on the supply system as well as the category of loads present in the distribution system. When conducting a PQ analysis, distortions and harmonics in the voltage and current are considered to be major concerns.

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Compensating strategies can be used to reduce the amount of harmonics that are present in the utility network. This helps ensure that the total harmonic distortion (THD) stays within the allotted range.

In recent years, a multitude of researchers have put up a wide variety of ideas, strategies, and theories designed to enhance the quality of power. By using active filters to dampen the harmonics, the PQ can be significantly enhanced (AFs). However, due to the presence of distortions at high frequencies, AFs are unable to adjust for current or voltage harmonics that are higher than the 25th order. The configurations of hybrid autonomous vehicles (HAF) are able to overcome the constraints of autonomous vehicles (AFs) while simultaneously providing superior performance and more cost-effective alternatives. In order to compensate for voltage and current harmonics in the utility system, different configurations of HAF, most commonly of the series and shunt types, are utilized in respective ways. In addition to bringing about a drop in the rating, HAF brings about an effective improvement in the compensatory efficiency of the passive filter. In recent days, it has come to everyone's attention that grid integrated PV systems have proven to be amazing in maintaining continuity of power supply in fault scenarios. This has led to widespread praise for these systems. Yet, one of the difficulties is in harvesting the maximum amount of electricity that a PV system is capable of producing in the face of variable environmental conditions that affect the amount of solar radiation that is received. In order to optimize the performance of the PV system, it is recommended that an efficient Maximum Power Point Tracking (MPPT) technique be created. A number of control algorithms for MPPT, including the Perturb & Observe (P&O), Incremental Conductance (INC), and Ripple Correlation Methodology, have been given by the authors of (RCT). Adaptive step size and adaptive perturbation frequency with load current based MPPT controller are explored in where it is needed to just use one sensor for the control of the circuit. Using the information about the load current allowed us to successfully complete the MPPT.

POWER QUALITY PROBLEMS

Power distribution system s, ideally, should provide their customers with an uninterrupted flow of energy at smooth sinusoidal voltage at the contracted magnitude level and frequency.

However, in practice, power systems, especially the distribution systems, have numerous nonlinear loads, which significantly affect the quality of power supplies. A s a result of the nonlinear loads, the purity of the waveform of supplies is lost. This ends up producing many power quality problems.

While power disturbances occur on all electrical systems, the sensitivity of today’s

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sophisticated electronic devices makes them more susceptible to the quality of power supply. For some sensitive devices, a momentary disturbance can cause scrambled data, interrupted communications, a frozen mouse, system crashes and equipment failure etc.

A power voltage spike can damage valuable components. Power Quality problems encompass a wide range of disturbances such as voltage sags/swells, flicker, harmonics distortion, impulse transient, and interruptions.

The SEMI International Standards Program is a service offered by Semiconductor Equipment and Materials International (SEMI). Its purpose is to provide the semiconductor and flat panel display industries with standards and recommendations to improve productivity and business. SEMI standards are written documents in the form of specifications, guides, test methods, terminology, and practices. The standards are voluntary technical agreements between equipment manufacturer and end-user.

The standards ensure compatibility and interoperability of goods and services. Considering voltage sags, two standards address the problem for the equipment.

SEMI F47-0200, Specification for semiconductor processing equipment voltage sag immunity‖. The standard addresses specifications for semiconductor processing equipment voltage sag immunity. It only specifies voltage sags with duration from 50ms up to 1s. It is also limited to phase-to-phase and phase-to-neutral voltage incidents, and presents a voltage-duration graph. SEMI F42-0999,Test method for semiconductor processing equipment voltage sag immunity‖

This standard defines a test methodology used to determine the susceptibility of semiconductor processing equipment and how to qualify it against the specifications. It further describes test apparatus, test set-up, test procedure to determine the susceptibility of semiconductor processing equipment, and finally how to report and interpret the results.

Storage systems can be used to protect sensitive production equipments from shutdowns caused by voltage sags or momentary interruptions. These are usually DC storage systems such as UPS,

batteries, superconducting magnet energy storage (SMES), storage capacitors or even fly wheels driving DC generators .The output of these devices can be supplied to the system through an inverter on a momentary basis by a fast acting electronic switch. Enough energy is fed to the system to compensate for the energy that would be lost by the voltage sag or interruption.

Though there are many different methods to mitigate voltage sags and swells, but the use of a custom Power device is

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considered to be the most efficient method. For example, Flexible AC Transmission Systems (FACTS) for transmission systems, the term custom power pertains to the use of power electronics controllers in a distribution system, specially, to deal with various power quality problems. Just as FACTS improves the power transfer capabilities and stability margins, custom power makes sure customers get pre-specified quality and reliability of supply.

PROPOSEDSYSTEM CONFIGURATION

It is suggested that a battery-supported sheaf be used to supply the backup support for the DVR, improving its efficiency in low light settings. A capacitor is interconnected across a voltage source inverter (VSI) in the SEHAF to consistently control and compensate for unstable power. As a result, the overtones, droop, and surge in the source and load voltages are reduced. The voltage across the dc-link capacitance of the VSI is successfully regulated with PV incorporation, aiding in improved correction. The suggested resilient extended complex Kalman filter (RECKF) method is used to generate reference current. A synchronous reference frame with proportional-integral (PI) and fuzzy logic controller (FLC) is used to evaluate the performance of the PV-integrated-HAF, and the results are compared to the RECKF method that has been suggested.

Among the power quality problems (sags, swells, harmonics…) voltage sags are the most severe disturbances. In order to overcome these problems the concept of custom power devices is introduced recently. One of those devices is the Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks. DVR is a recently proposed series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC). Other than voltage sags and swells compensation, DVR can also added other features like: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations.

The proposed configuration consists of solar PV, DC-DC boost converter, VSI with non- linear loads. The input to DC-DC boost converter is given by PV in which fuzzy logic is used to track MPP and improve the output voltage of PV. In general, the boost converter with FLC defines a suitable duty cycle which regulates the voltage and power output. Usually, the input voltage is variable with the voltage output while maintaining constant duty cycle. So, to maintain constant output voltage, the duty cycle is varied by the help of voltage input and

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condition of the load. The dc link bus voltage of VSI is controlled by the integration of solar PV along with a PI/ FLC. VSI are employed along with SEHAF configuration with PI/FLC/proposed RECKF for better reactive power compensation, improvement in power factor and suppression of harmonics. The details of the parameters used in the proposed system are provided.

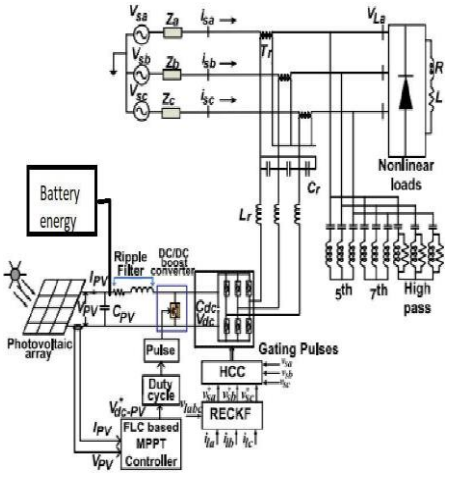
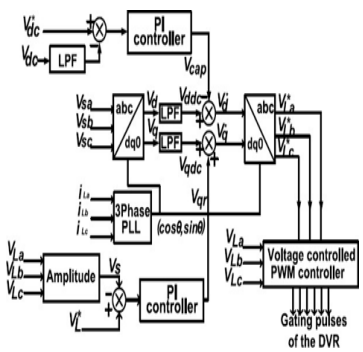


Fig 1. Proposed circuit and control architecture

In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection.



To understand why use of fuzzy logic has grown, you must first understand what is meant by fuzzy logic.

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, whichis an extension of multivalve logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of fl. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multivalve logical systems.

In fuzzy Logic Toolbox software, fuzzy logic should be interpreted as FL, that is, fuzzy logic in its wide sense. The basic ideas underlying FL are explained very clearly and insightfully in Foundations of Fuzzy Logic. What might be added is that the basic concept underlying FL is that of a linguistic variable, that is, a variable whose values are words rather than numbers. In effect, much of FL may be viewed as a methodology for computing with words rather than numbers. Although words are inherently less precise than numbers, their use is closer to human intuition. Furthermore, computing with words exploits the tolerance for imprecision and thereby lowers the cost of solution.

SIMULATION RESULTS

The simulation results and the corresponding discussions for harmonic

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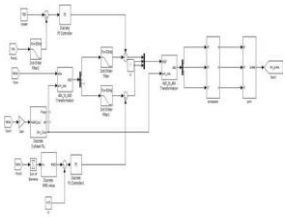
analysis is presented in a grid connected PV system. A solar PV with grid interconnection is designed using three phase VSI and is modeled using MATLAB/SIMULINK and the parameters of the system are presented in Table IA. A comparative analysis between different



controllers is presented under different operating conditions. In this analysis, the SRF with FLC is compared with conventional PI controller. Further, the performance of the test system is finally analysed with RECKF using SEHAF and being compared with the other two controllers. At PCC, the ripple voltage gets filtered using SEHAF and the technique for controlling DC-DC boost converter and VSI is modeled in MATLAB/SIMULINK environment.

In real-time PV systems, the MPPT controller plays a vital role for tracking [24], [25] the variable time dependent maximum power point of the solar array. This depends on the solar insolation and temperature. Here, MPPT with FLC is proposed under variable weather conditions. Real-time implementation of MPPT algorithm using FLC provides numerous advantages with better performance and it does not require the data of the PV system.

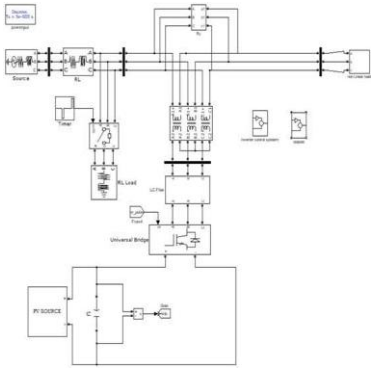
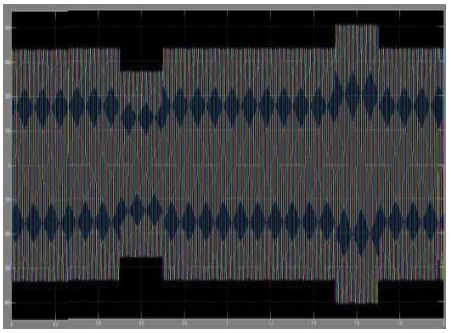


Fig 1 simulation circuit

Fig2. Control circuit



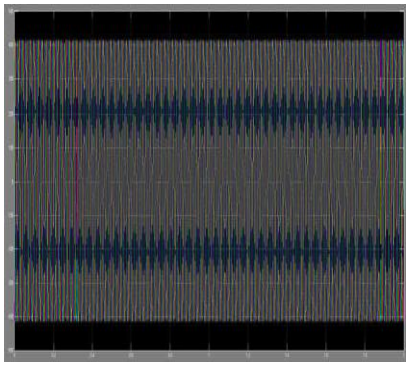


Fig 2 grid voltage with sag swell

Fig 3. Load voltage

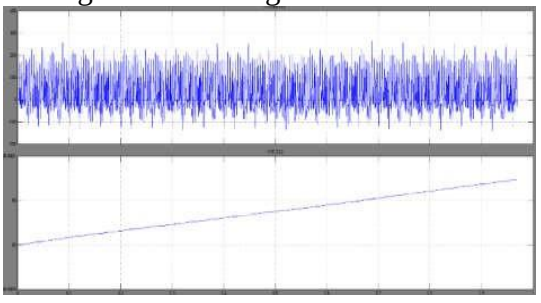


Fig 4. Battery voltage and current

CONCLUSION

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It is observed from the power quality analysis that in case of FLC based SEHAF, the THD value is improved significantly as compared to that of the conventional PI controller. But, with incorporation of RECKF, the reactive power management as well as improvements in THD value is much better in comparison to that of FLC and PI controller. In addition, real-time digital simulation in OPAL-RT OP5142 is also carried out to support the simulation results. Based on the simulation and real-time results, it is analyzed that the proposed SEHAF with RECKF control scheme provides much better harmonics compensation as compared to the conventional controllers. In the future study, the MPPT can be designed with grid interactive DC–AC inverter to achieve further improvements in the power quality and reactive power compensation. In addition, real-time hardware based power quality improvement will be carried out in our future study under different operating scenarios.

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