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A Survey on Control of Solar Photovoltaic Integrated Universal Active Filter Based on Discrete Adaptive Filter

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Abstract

In this a novel technique based on adaptive filtering is proposed for the control of three phase universal active power filter with solar photovoltaic array integrated at its DC bus. two adaptive filter along with a zero-crossing detection technique are used to extract the magnitude of fundamental active component of distorted load currents, which is then used in estimation of reference signal for the shunt active filter. This technique enables extraction of active component of all three phases with reduced mathematical computation. The series active filter control is based on synchronous reference frame theory and it regulates load voltage and maintains it in-phase with voltage at point of common coupling under conditions of voltage sag and swell.

Keyword:- power quality, universal active power filter, adaptive filtering, photovoltaic system, maximum power point tracking, PI controller. Fuzzy logic controller.

Introduction

Due to increase in the demand of clean energy system based on solar and wind energy in the present distribution system. In this technique the model is based on adaptive filter is proposed for the control of three phase universal active power filter integrated DC Bus with solar PV array. Two adaptive filter with zero crossing detection technique are used to extract the magnitude of fundamental active component of the load distortion.

There's intermediate nature of voltage fluctuation has become a major issue in low voltage distribution system network [1]. In the modern era with development of semiconductor devices the use of sophisticated power electronic devices is gradually increased. Just like computed power supplies, variable frequency drives (VFD), switched mode power supply (SMPS), servers. Although all the electronic devices are consuming less power, so called energy efficient but they draw nonlinear current from the supply. Due to this there's increased in sensitivity of voltage disturbance. This non-linear current also effect the distribution transformer and common point coupling system (PCC). Here one thing been cleared that "the clean energy with best power quality are not demand of the upcoming future". It also reduced the dependency son fossil fuels for energy. That's may cause improvement of environment the renewable energy are being connected along with the flexible AC transmission systems (FACTS) for unified power flow control (UPFC) are being discussed in [5]. FACTS devices such as UPFC are used in transmission system along with large PV farms to improve the power system stability.

1.2. Power Quality Problems

The quality of power is affected when there is any deviation in the voltage, current or frequency [6]. The common problems that affect the sensitivity of the equipment are 1. Power Surges 2. Transients 3. Frequency Variation 4. Electrical Line Noise 5.

Brownouts or Blackouts 6. Power System Faults 7. Improper grounding affects the main affect caused by these problems is the production of harmonics. The presence of harmonics deteriorates the quality of power and may damage the end user equipment. These harmonics causes the heating of underground cables, insulation failure, reduces the life-time of the equipment, increases the losses etc.

1.3 Solutions to Power Quality Problems:
The most effective solution to improve the power quality is the use of filters to reduce harmonics. The basic idea of using a filter is explained in Fig. 1.1, where the filter injects a compensating current that compensates the harmonics in load current. There are different filter topologies in the literature such as- active, passive, hybrid. The passive power filters are used to filter out a particular order harmonic and has the problem of parallel resonance. The other solution is the use of Active Power Filter (APF). There are different types of APF like series APF, shunt APF. The shunt APF is costly and is not used for large systems. The series APF works as a harmonic isolator and used to reduce the negative-sequence voltage There is another filter topology which is a combination of passive filter and APF known as Hybrid Filter.

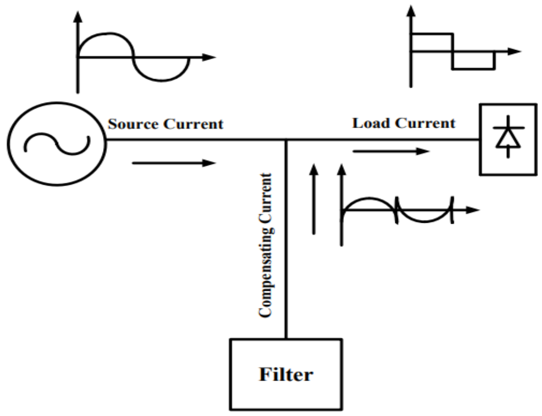

Fig.1: Basic Operation of Filter.

II. Literature Review
the literature review of various types of power quality improvement technique-based paper and PV Array Here we are studies different types of power quality improvement technique such as D-Statcom, Unified power quality controller, the benefits and limitations of these existing approaches are also explored and compared. States that small wind energy conversion systems (WECSs) are becoming an attractive option for distributed energy generation. WECSs use permanent-magnet synchronous generators (PMSGs) directly coupled to the wind turbine and connected to the grid through a single-phase grid-tie converter. The loading produced on the dc link is characterized by large ripple currents at twice the grid frequency. These ripple currents are reflected through the dc bus into the PMSG, causing increased heating and ripple torque. This paper depicts the use of PMSG inverter to control the dc-link voltage. In order to avoid reflecting the ripple currents into the PMSG, the feedback dc-link voltage is passed through a filter. The Butterworth filters, notch filters, anti-resonant filter (ARF) and moving average filter (MAF) are considered. For a fair comparison, formulas are provided to tune the filter parameters so that dc-link voltage control will achieve the selected bandwidth. The different filtering options produce different levels of torque ripple reduction. The notch filter, ARF, and MAF obtain the best results and there is a tradeoff between the filter implementation complexity, bandwidth, overshoot, and the torque ripple reduction [1].

A modified p-q theory-based control of solar photovoltaic array integrated unified power quality conditioner (PV-UPQC-S). The System incorporates clean energy generation along with power quality improvement thereby increasing functionality of the system. The fundamental frequ ency positive sequence (FFPS) components of voltage at the point of common coupling (PCC) are extracted using generalized cascaded delay signal cancellation (GCDSC) technique which is then used in p-q theory-based control to estimate reference signals for the PV-UPQC-S. This modification in p-q theory enables its application for PV-UPQCS control in conditions of distorted PCC voltages.

[2] Single-phase transformer-less hybrid series active filter (THSeAF) based on duo-neutral-point-clamped (D-NPC) converter to address distribution level power quality to investigate experimentally the efficiency of the hardware-in-the-loop (HIL) implementation for power electronics applications. This benchmark contributes to demonstrating the capability and efficiency of such real-time implementation for smart grid power quality (PQ) analysis which requires fast switching process with small sampling time. Such applications require the compensator to address major power quality issues related to a nonlinear load. This compensator presents an efficient and reliable solution for future grid applications to overcome voltage and current related issues as well as assisting the integration of renewable for a sustainable supply. The controller extracts voltage and current harmonics to be compensated. A proportional and resonant (P+R) regulator produces switching signals for the D-NPC converter [3].

A control scheme for single-stage solar photovoltaic (SPV) grid-interfaced system. The voltage-source inverter (VSI) is a power electronic interface between SPV array and the grid. The VSI provides power quality features, i.e., harmonics mitigation, power factor correction and perturb and observe maximum power point tracking for single-stage SPV grid-interfaced system [4]. Deals with the design and performance analysis of a three-phase single stage solar photovoltaic integrated unified power quality conditioner (PV-UPQC). The PV-UPQC consists of a shunt and series connected voltage compensators connected back-to-back with common DC-link. The shunt compensator performs the dual function of extracting power from PV array apart from compensating for load current harmonics. An improved synchronous reference frame control based on moving average filter is used for extraction of load active current component for improved performance of the PVUPQC. The series compensator compensates for the grid side power quality problems such as grid voltage sags/swells. The compensator injects voltage in-phase/ out of phase with point of common coupling voltage during sag and swell conditions respectively. The proposed system combines both the benefits of clean energy generation along with improving power quality [5].

III. Proposed Methodology

In the proposed model a novel technique are used whose working based on adaptive filter for the control of three phase universal active power filter of DC bus integrated with solar PV array. To extract the fundamental active component of the distorted load current magnitude the zero-crossing technique are being used. Further it is used to estimate the reference signal for the shunt active filter. It will extract the active component of all three phase. The series active power filter are uses here to regulate the load voltage and maintain it in phase are based on synchronous reference frame theory. A test system are taken and connected it to the universal active power filter for harmonics mitigation generated by non-linear load connected on three phase grid. The universal active power filter are consist of two VSC that is connected in series and parallel to the PCC grid. Further it connected with DC link capacitor. Power electronics switches are used with fuzzy controlled interface system. The fuzzy interface system has two input variables and one output variables being replaced by PI controller at DC voltage regulator. The total harmonic distortion is done comparison on source current using FFT analysis

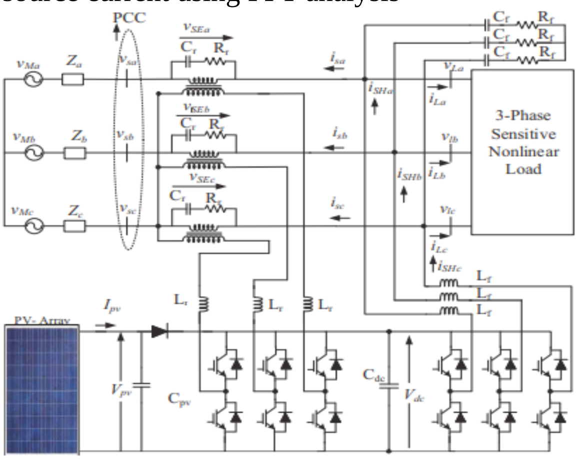

Fig. 2: Proposed system of Solar Photovoltaic Integrated Unified Active Power Filter.

3.1 PROPORTIONAL-INTEGRAL CONTROL SYSTEM

Proportional-integral (PI) controllers find wide application in industrial control systems due to the reduced number of parameters to be tuned. They also provide control signals that are proportional to the error between the reference signal and the actual output i.e., proportional action, to the integral of the error the consequent equation is given as:

$$u(t) = K_p e(t) + K_i \int_0^t e(t)dt$$

Where u(t) is the actuating signal, e(t) is the error signal, K_p is the proportional gain constant, K_i is the integral gain constant. The PI control provides the basic and efficient solution for most of the real-world control problems with the help of three-term functionality covering treatment for both the transient and steady-state responses. Fig. 3 shows diagram of PI proposed control system.

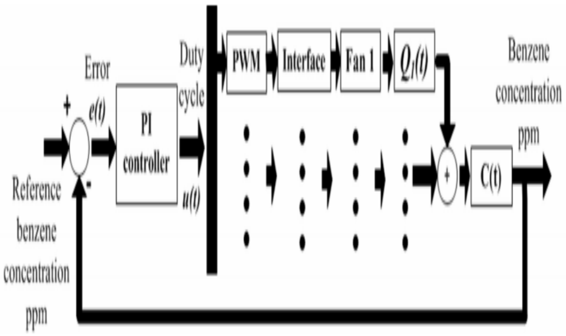

Fig. 3: Proposed PI control system.

3.2 FUZZY LOGIC CONTROLLER

Fuzzy logic or fu zzy set theory was given by Lotfi Zadeh, a computer scientist at the University of California, Berkeley, in 1965, for representing and manipulating data that is not precise and ratherfuzzy or vague. In the beginning he was criticized by the professional community, but progressively, Fuzzy logic (FL) gained importance in the professional society and in due course emerged as a new order of Artificial Intelligence. The FL became a attractive area of research because it worked really well between significance and precision, that for a very long time humans have been doing manually. The FL provides an inference that facilitates approximate human reasoning capabilities to be applied to knowledge-based systems. The FL theory provides mathematical strength to capture the uncertainties linked with information like thinking and reasoning. The classical set theory is based on Boolean logic, where a certain variable either absolutely belongs to a set $(\mu(x) = 1)$, or absolutely does not belong to the set $(\mu(x) = 0)$. Whereas, in fuzzy set theory based on FL, a particular object has a degree of membership in a given set that may be anywhere in the range of 0 (absolutely does not belong to set) to 1 (absolutely belong to set). This is the reason why FL is often defined as multi-valued logic (0 to 1), on contrast to bi-valued Boolean logic. Therefore, the approaches that are based on FL do provide an appropriate conceptual framework for dealing with the representation of common-sense knowledge.

Fuzzy logic has been utilized in a wide range of problem domains over a span of few decades. Although the fuzzy logic is relatively new, the areas of applications are wide. L.A. Zadeh in 1965, laid the fundamentals of fuzzy set theory [1] as an approach to deal with the imprecision of practical systems.

Bellman and Zadeh write: "Much of the decision making in the real world takes place in an environment in which the goals, the constraints and the consequences of possible actions are not known precisely". This "imprecision" or fuzziness is the base of fuzzy sets or fuzzy logic applications.

Fuzzy sets were developed as a generalization of conventional set theory. Due to this fact, fuzzy logic remains the highlight of highly expert and mathematical technical journals since years. In the late 1980s this scenario changed suddenly with the highly evident success of numerous control applications. Heuristics, intuition, expert knowledge and linguistic descriptions are visibly important to power engineers but virtually any practical engineering problem needs some “imprecision” in the problem formulation and successive analysis.

Fuzzy control gives a formal methodology to represent, manipulate and implement human’s heuristic knowledge regarding the control of a system. Figure 3 depicts the block diagram of a fuzzy logic controller, in which there is an embedded a closed-loop control system. The process outputs are denoted by y (t); its inputs are denoted by u (t); and the reference input to the fuzzy controller is denoted by r (t).
The fuzzy controller has four main components: The rule-base, that holds the knowledge in the pattern of a set of rules, that describes the finest way to control a system. The membership functions are used to quantify knowledge. The inference mechanism states which control rules are relevant next to the current time and then decides which input of the plant should be enabled. The fuzzification interface modifies the inputs, such a way that they can be interpreted and compared to the rules in the rule-base. The defuzzification interface transforms the conclusions reached by the inference mechanism into the inputs of the plant. Fig. 4.3 is shows the schematic diagram of fuzzy logic controller.

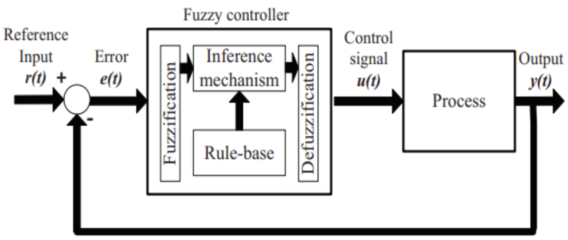

Fig. 4: Scheme of a fuzzy logic controller.

3.2.1 Description of fuzzy logic tools
Unlike Boolean or crisp logic Fuzzy logic, deal with vague, imprecise and uncertain problems and uses membership functions whose values vary between 0 and 1. Figure 4.4 shows a schematic block diagram of fuzzy inference system or fuzzy controller. It consists of following working blocks:

- Fuzzification Interface
- Knowledge base
- Decision making logic
- Defuzzification

Since it is a two-dimensional fuzzy control, a fuzzy logic controller must possess proportional integral control effects. An integral action is usually needed to achieve the best performance in practical situation.

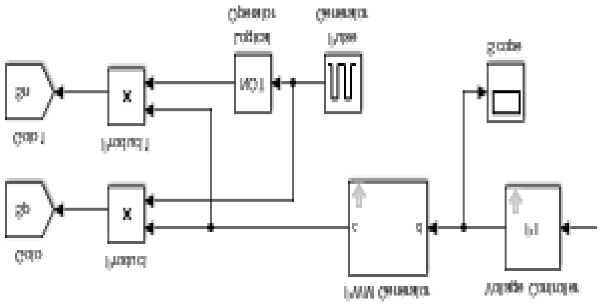

Fig. 5: PWM pulse generator.

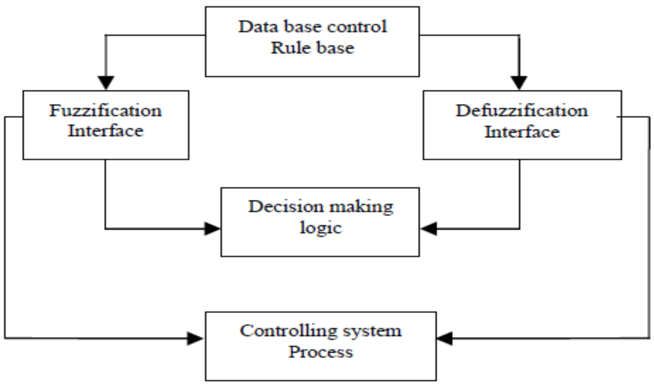

Fig. 6: Fuzzy Inference System.

3.2.2 Design of Control Rules
The fuzzy control rule design involves defining the rules that relate the input variables to the output model properties. Since fuzzy logic controller is independent of system model, the desin is majorly based on the intuitive feeling and experience of the process. The rules are expressed in English like language with syntax such as If {error e is A and change of error Δeis B} then {control output is C}. For better control performance finer fuzzy petitioned subspaces (NL, NM, NS, ZE, PS, PM, PB) are used.

3.2.3 Advantages of Fuzzy Control

The advantages of fuzzy control over the adaptive control can be summed as follows:

It relates output to input, without much understanding all the variables, permitting the design of system to be more accurate and stable than the conventional control system. The linguistic, not numerical; variables make the process similar to that of human thinking process

The fuzzy controller uses two input membership variables; error E and change in error dE. The fuzzy function has only one output. The function considered is 'mamdani' function with seven membership functions in each variable.

IV. Conclusion

We have research the different paper and study about the adaptive filter-based PV-UAPF system. The method of sampling the fundamental component of load current obtained through adaptive filter enables fast extraction of fundamental active component of nonlinear load currents for all phases in one sampling. Only two adaptive filters are required to extract magnitude of active component of three phase load currents. This technique requires reduced computational resources while achieving good dynamic and steady state performance in extraction of fundamental active component of nonlinear load current.

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