ENHANCEMENT OF POWER QUALITY OF SOLAR INVERTER BY USING PV CONNECTED SAPF WITH ANFIS CONTROLLER

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ABSTRACT

This study provides a three-phase three-wire solar generating inverter grid-connected operation and harmonic elimination hybrid system using an Adaptive Neuro Fuzzy Inference System (ANFIS) controller. The hybrid system consists of solar array batteries, a photovoltaic output filter, a three-phase voltage-type inverter, an inverter output filter, and passive filters. The suggested hybrid system's working principle and operational characteristics are used to develop a composite control approach for active power, reactive power, and harmonic suppression. The composite control method consists of a single closed-loop control slip of active power and reactive power, as well as a double closed-loop control slip of harmonics. Hybrid systems that use the ANFIS results have an effective improvement in power factor, deliver active power to loads, and suppress micro-grid harmonics.

Keywords: PV system, eliminating the harmonics, Shunt Active Power Filter (SAPF), Adaptive Neuro Fuzzy Inference System (ANFIS) controller.

INTRODUCTION

In recent years, globalization and industry have increased electricity demand. Compact fluorescent lights (CFLs), televisions, laptops, inverters, and a number of other electronic devices are examples of domestic loads. Non-linear loads, such as variable frequency motors and convertors, are employed in industry. The existence of a nonlinear load causes load current distortion, which affects power quality. The switching action introduces the delay effect in power electronics equipment. This results in harmonic distortion and a decrease in power factor. To minimize harmonics on the load, several compensation mechanisms are used, such as a passive or active filter to enhance line side power quality and, as a consequence, lower selected harmonics and THD. Passive filters are used to overcome power quality issues, but their disadvantages include high cost, reliance on source impedance, and parallel or series resonance. Active power filters are abundant, occupying many areas of control theories, harmonic extraction methods, and reference current production methods of active power filters. Akagi introduced the theory of instantaneous active and reactive power (PQ). We can convert three phase quantities into two phase quantities for systems with active and reactive components using this theory [1]. The usage of PQ theory, dq theory for current and voltage harmonics extraction, and managing the reference current PI controller for shunt active filter (SAPF) and series active filter [2] was covered. Based on the synchronous reference frame (dq) theory, the author presents ANFIS and hysteresis control [3].

Many systems have been developed to improve power quality by addressing current distortion restrictions for nonlinear loads. This work includes a harmonics reduction and reactive power compensation analysis and simulation of PV systems connected in SAPF. To compensate for the source current, the SAPF injects the same amplitude and reverse phase of the load current. Figure 1 depicts the suggested system, which is based on a three-inverter three-phase SAPF system. The shunt APF is intended to be used in conjunction with a nonlinear load.

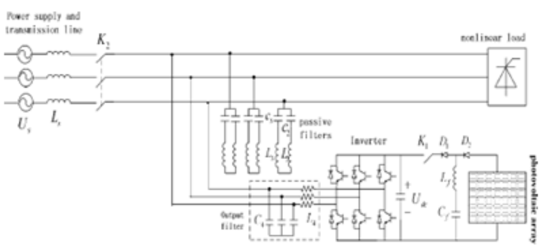

Fig.1 Proposed system configuration

It is linked to the PCC's distribution network. We used the P-Q Theory to calculate the reference current for the Shunt Active Filter. A DC/DC converter can also be used to modify the value of the PV system's output voltage. MPPT uses Fuzzy Logic Control (FLC) as a robust controller. The fuzzy interference system (ANFIS) method issuitable for rapidly changing irradiation and partial shading, but it can also be used with systems that have sufficient processing power. This paper proposes an ANFIS-based MPPT to compute the optimal duty cycle of a DC-DC boost converter and compares it to IC-based techniques. The output power of photovoltaic (PV) panels is well known to have a very non-linear characteristic. There will be a certain maximum power at a specified voltage for a certain temperature and irradiation, so (MPP).The voltage of MPP varies with irradiation and, in particular, temperature variations. As a result, no matter how much irradiance, temperature, or other variables exist, the system must run at the MPP of the PV array by managing the inverter. Furthermore, the generated system, which is primarily supplied to the utility grid, must not only be of sinusoidal current, but must also meet the requirements of the power grids, such as no DC component in the inverter output current, harmonic minimization as a result of no harmonic pollution on the power grids, and so on. These requirements necessitate a high-control inverter. The issue for themajority of designers is to achieve the following goals while keeping costs to a minimal. To get the most power out of a solar array, a maximum power point tracking controller is frequently required (MPPT). To determine the highest power point, the perturb and observe (P&O) approach requires calculating dP/dV. (MPP). When the irradiance fluctuates rapidly, it is unable to monitor the MPP and instead oscillates about it rather than trackingit. The incremental conductance approach can quickly track MPP, but it adds to the complexity of the a, which uses the dI/dV computation. The constant voltage approach, which utilises 76 percent open circuit voltage as the MPP voltage, and the short-circuit current approach are both straightforward, although they don't always monitor MPPs precisely. The most suited strategies for increasing the dynamic performance of maximum power point tracking are AI-based methods. The AIapproaches give a rapid, versatile, and computationally expensive solution for the MPPT problem, taking into account the non-characteristicsof solar PV modules. MPPT uses two basic AImethods: fuzzy logic and c networks. The design and implementation of an ANFIS-based MPPT scheme are discussed in this study. ANFIS combines the benefits of neural networks and fuzzy logic to effectively deal with nonlinear solar PV module behaviour. As a result, given changeable solar irradiation and temperature circumstances, this research employs ANFIS algorithms to determine the maximum power of a PV module.

PROPOSED SYSTEM CONTROLLER

The ANFIS reference model uses irradiance level and operating temperature as inputs. At a given temperature and irradiance level, the ANFIS reference model outputs the exact value of maximum usable power from the PV module. The actual output power from the PV module is determined using a multiplication method on detected operational voltage and currents at the same temperature and irradiation level. To generatecontrol signals, two powers are compared, and the error is fed into a proportional integral (PI) controller. The IGBT receives a pulse from the control signal provided by the PI controller for triggering purposes. The resulting signals regulate the duty cycle of the quasi-z-source inverter, allowing the PV module's operating point to be adjusted. The suggested control system will achieve the following goals: 1. Maximum power point tracking. 2. Grid power output stability was desired. In the case of the Grid, the inverter's outputpower should be regulated and adjustable based on user demand.

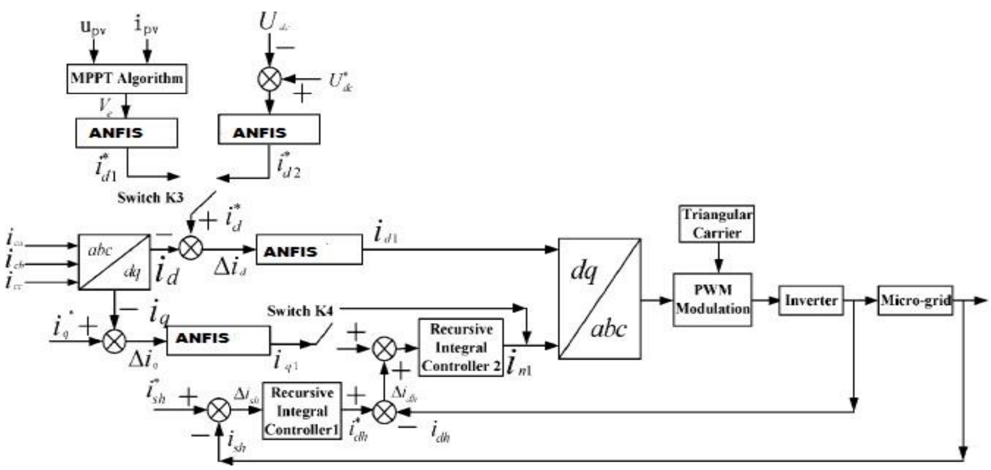

Fig2. Proposed controller diagram

Regardless of changes in the input conditions, the output voltage, magnitude, and frequency remain constant. Weather transmitters are used to collect solar irradiance, temperature, and other weather information. The current/voltage signals produced by the sun irradiance and temperature transducers are logged in real time using ordinary data loggers. These data are then sent to a PC for further processing or actual system deployment utilising the ANFIS controller.

Model of a PV array

The incident solar irradiance, cell temperature, and reference values all affect the nonlinear equations. Manufacturers of PV modules typically supply these reference values for certain working conditions such as STC, where the irradiance and cell temperature are known. Mismatch effects can also alter the true values of these meat parameters because real operating conditions are never the same as the norm.

ANFIS for MPPT tracking

This is the ANFIS reference model's training data set. When trained with a sufficient number of epochs, ANFIS is capable of establishing the input-output mapping of training data sets. ANFIS develops a set of fuzzy rules by modifying the values of membership functions in order to produce acceptable output for various input values. The parameters of membership functions are tweaked oraltered till the error is minimized.

Figure 5 shows a five-network neuro-fuzzy structure. The structures display two solar irradiance and cell temperature inputs, which are translated into appropriate membership functions, three solar irradiance functions in Fig.6 and three temperature functions. The ANFIS controller generates these membership functions based on prior information gained from the training data set.

System Development

Some conditions must be met for utility grid and grid connected PV system synchronisation, such as voltage level, frequency, and phase sequence matching. PV inverters with advanced power electronics technologies perform this synchronization. These parameters are directlyinfluenced by the power-voltage relationship or irradiance on the cell, as well as the cell temperature. To transform changes in temperature and radiation into generated voltage and current of PV arrays, a good simulation model is required. So that the dynamic performance of the PV systemmay be analysed under various weather situations. The electrical characteristics of a PV unit can be represented by the current-voltage relationship of the cell. Changes in solar activity The solar cell is aphotovoltaic cell with a p-n junction. When exposed to sunlight, it absorbs more energy thanthe band-gap allows. This results in the formation of some hole-electron pairs that are proportionate to the incident radiations. Internal electric fields of the p-n junction alter these carriers, resulting inphoto current proportional to solar insulation. PV cells have nonlinear features that change with the amount of light they receive and the temperature they are exposed to.

PV Shunt Active Power Filter(SAPF) model.

The boost converter raises the inverter's voltagelevel and controls the MPPT. The boost converter's output voltage is higher than the input voltage. In a boost converter, the input current is the same as the inductor current, therefore it is not as discontinuousas in a buck converter, and thus the input filter requirements are less stringent. If high-efficiency solar panels are used, the need for a boost convertercan be reduced, and switching losses in theconverter can be reduced. PV panels create DCvoltage, which must be converted to AC powerbefore being connected to the grid. Before connecting to the grid, we need an inverter to convert DC to sinusoidal AC. The voltage and frequency of the output should be the same as the voltage and frequency of the grid. There are numerous inverter topologies to choose from. The PWM (pulse width modulated) Voltage Source Inverter is chosen using the d-q theory with phasein the suggested method. The inverter's output is nearly sinusoidal. The toggling of the 6 switches is controlled by individual PWM impulses.

RESULTS

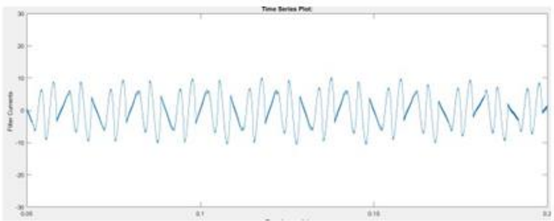

Fig.-(3) Simulation results of SAPF for Filter current.

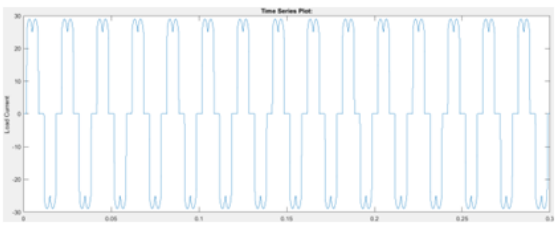

Fig.-(4) Simulation results of SAPF for Load current.

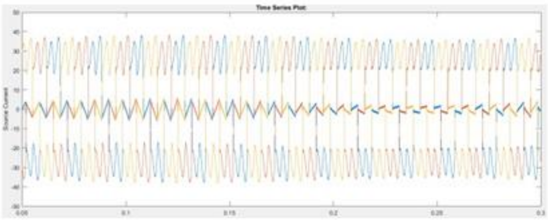

Fig.-(5) Simulation results of SAPF for Source current.

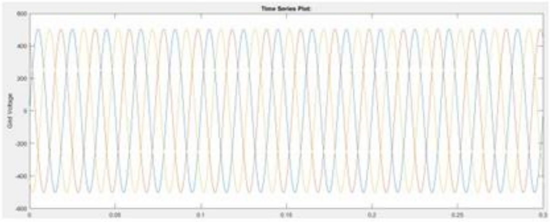

Fig.-(6) Simulation results of SAPF for Source Voltage.

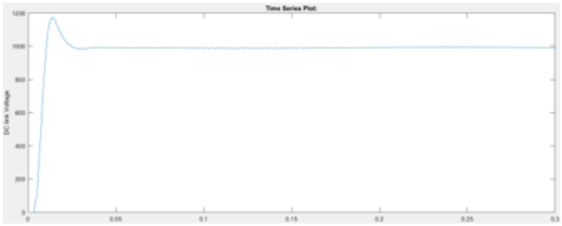

Fig.-(7) Simulation results of SAPF for DC linkVoltage.

CONCLUSIONS

The paper proposes an ANFIS-based Grid integration PV power generating system. An active filter acts as a conduit between the producing source and the Grid. In order to get the most out of the PV system, ANFIS is employed to regulate the shoot through duty ratio. The modulation index of the filter's interface is used to adjust the voltage and frequency on the grid side. Controlling both the shoot through duty ratio and the modulation index ensures that the control objectives are accomplished. Simulation and experimental data back up the proposed control approach. The hybrid wind and solar system with ANFIS-MPPT operation proposed for the project will be reported in the future. It has been considered a wide range of irradiation levels, both constant and rapidly changing. This technology is used to adjust for reactive power generated by nonlinear loads and reduce harmonics. The active filters' performance is linked to the quality of the current references. This method is crucial because it allows for the simultaneous adjustment of harmonic currents and reactive power. The purpose of this study is to offera control system for a shunt active filter (SAPF)that may be used to remove current harmonics caused by non-linear loads. The instantaneous reactive (pq) theory is employed to generate the reference current.

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