POWER ANALYSIS OF THE GRID CONNECTED PV FOR THE HYBRID ENERGY STORAGE SYSTEM WITH THE ARTIFICIAL INTELLIGENCE

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Abstract**—** The penetration of renewable energy sources (RESs) in the distribution system becomes a challenge for the reliable and safe operation of the existing power system. The sporadic characteristics of sustainable energy sources along with the random load variations greatly affect the power quality and stability of the system. An efficient energy management structure is designed in this project for a grid-connected PV system combined with hybrid storage of supercapacitor and battery. In this project, using artificial neural network (ANN) for tracking of maximum power point is discussed. Error back propagation method is used in order to train neural network. A neural network has advantage of fast and precisely tracking of maximum power point. In this method neural network is used to specify the reference voltage of maximum power point under different atmospheric conditions. By properly controlling of dc-dc boost converter, tracking of maximum power point is feasible. The combined supercapacitor and battery storage system grips the average and transient power changes, which provides a quick control for the DC-link voltage, i.e., it stabilizes the system and helps achieve the PV power smoothing. The average power distribution between the power grid and battery is done by checking the state of charge (SOC) of a battery, and an effective and efficient energy management scheme is proposed. Additionally, the use of a supercapacitor lessens the current stress on the battery system during unexpected disparity in the generated power and load requirement. The performance and efficacy of the proposed energy management scheme are justified by simulation studies**.**

Keywords**—** renewable energy sources (RESs), PV system, artificial neural network (ANN), maximum power point, DC-link, state of charge (SOC)

1. INTRODUCTION

TODAY'S power system emphasizes the growing adoption of green technologies due to the concern on energy saving and the fast penetration of renewable sources. The most commonly used environmental technologies nowadays are wind turbines and photovoltaic (PV). In terms of reliability and sustainability, the best choice is PV due to the advantages like low cost, high efficiency, low maintenance, and high consistency. However, due to the changing environmental operating conditions such as temperature, irradiance, effects of partial shading, and humidity, the stability and generation of the PV are affected up to a large extent, which adversely affects the stability of the connected system [1]. Energy storage systems (ESSs) are employed in the micro grids to provide continuous power from an intermittent source like PV, decrease the power mismatch between the generated and required power, i.e., the smoothing output power mode, and enhance the quality and stability of the system. The most popular and basic energy storage used is the battery because of its easy implementation. However, batteries have high energy density and small power density, which provide low charging/discharging rates. The super capacitors possess a small energy density and high power density in contrast to the batteries, which give high charging/discharging rates. Hence, hybrid energy storage systems (HESSs) are created by grouping the battery and super capacitor to get the bene- fits of both devices. In HESS, the life span of the batteries increases by distracting the battery momentary current to the super capacitors [2]. A strategy for proper power supervision is essential for the effective and smooth operation of the hybrid micro grid. The strategy should provide services like

① regulating the terminal power of each distributed generator (DG),
② controlling the frequency and voltage of the system,
③ keeping the power balance among generation and demand,
④ supplying cost-effective power,
⑤ regulating DC-link voltage,
⑥ enhancing power qualities,
⑦ transitioning the smooth and seamless operating mode, and

⑧ maintaining the state of charge (SOC) of energy storage devices within their limits [3].

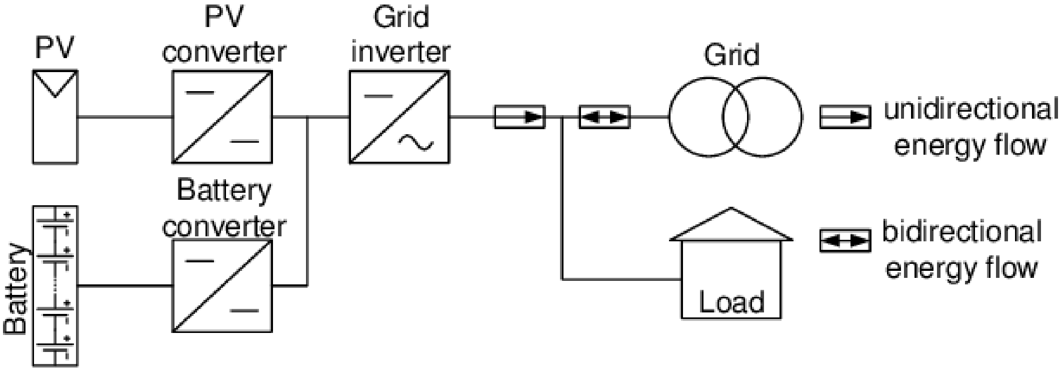


Fig 1 Block diagram of the proposed system

The features like reduction in current harmonics, improvement in power factor, and reactive power support are also realized from this scheme. In [8], a coordinated control approach for PV-wind-battery-connected hybrid system is suggested. A model predictive control scheme for both isolated and grid-connected modes is used for voltage source converter (VSC) control to keep the bus voltage stable and to enable smooth grid synchronization. A power management method based on multi-segment adaptive droop control is proposed in [9] for a PV and battery-connected islanded system. This method can track and provide the maximum PV power to the system as per the requirement and it can also change its operating point. A peak power management method is suggested in [10], which aims to reduce the burden during peak deficit power from the conventional power grid and to maximize the utilization of renewable energies. The suggested management scheme is developed by considering the peak demand, total demand, total generation, and the SOC of storage arrangements. A power management structure based on adaptive droop control is designed in [11]. In general, the adaptive droop control is designed for the optimum charging and discharging control of battery storages to ensure the longevity of the system with variation in power generation. In [12], control and power management techniques are discussed to track the operating point of the power converters at a faster rate for a better dynamic response along with the reduction of charging/discharging rate of the battery.

I. PROPOSED METHOD FOR POWER MANAGEMENT:

The PMA chooses the working condition of the system de- pending on the availability of the generated power and load power. By setting (8), three power modes PR of operation are recognized.

- Depending on the SOCs of battery and supercapacitor, each power mode is again classified as four operating ideas. The SOCs of battery and supercapacitor SOCb and SOCsc can be estimated by using the Coulomb counting method [9], [19],
- ib, isc, SOCb0, SOCSC0, and CN are the battery current, supercapacitor current, initial SOC of battery, initial SOC of supercapacitor, and nominal capacity of battery [20], respectively.

PV array

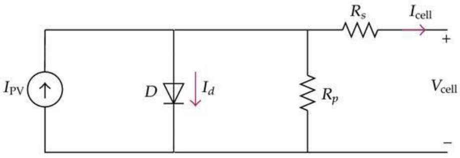


Fig: 7.1 Equivalent circuit of PV model

The equivalent circuit of the ideal PV cell. The basic equation from the theory of semiconductors [3] that mathematically describes the *I*-*V* characteristic of the ideal PV cell. All PV array datasheets bring basically the following information: the nominal open-circuit voltage (*V*oc,), the nominal short-circuit current (*I*sc,), the voltage at the MPP (*V*mpp), the current at the MPP (*I*mpp), the open-circuit voltage/temperature coefficient (*KV*), the short-circuit current/temperature coefficient

(KI), and the maximum experimental peak output power (Pmax).

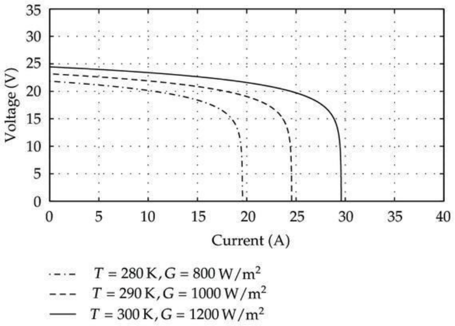


Fig: V-I characteristic of PV

This information is always provided with reference to the nominal condition or standard test conditions (STCs) of temperature and solar irradiation. Some manufacturers provide I-V curves for several irradiation and temperature conditions. These curves make easier the adjustment and the validation of the desired mathematical I-V equation. Basically, this is all the information one can get from datasheet of PV arrays [4].

MPPT by Using Neural Network

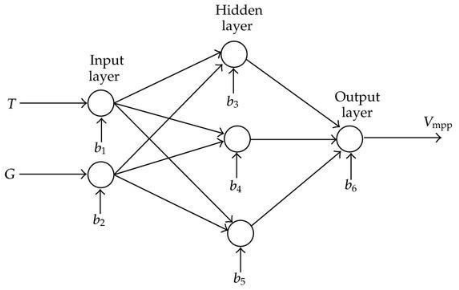


Fig: Neural network structure

In this paper for tracking maximum power point, an artificial neural network is used. A three-layer neural network is used to reach MPP. Temperature (T) and irradiance (G) are two input variables and voltage of MPP (Vmpp) is the output variable of ANN. It is necessary to obtain some data as input and output variable to train the neural network. Consequently, weights of neurons in different layers are acquired.

ANN Controller

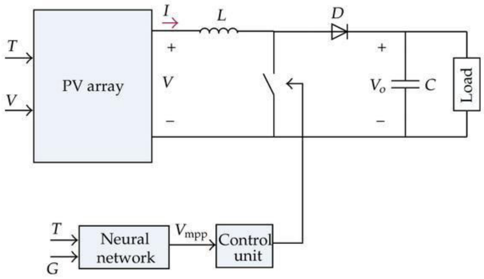


Fig: 7.4 Neural Network

DC-DC chopper includes PV as a input and its control units.

There are several methods to train ANN. In this paper error back propagation method is used to train the ANN. After training the ANN and specification of neuron weights, for any T and Gas inputs of ANN, output of ANN is the V_{mpp}. Now, current of maximum power point (Impp) can be obtained by using V-I characteristic of the modeled PV. Consequently, maximum power ($P_{\max}$) is reached by multiplying V_{mpp} and I_{mpp}. PV and maximum power point tracker system, which is composed of a dc-dc boost converter and neural network-based control unit. In every moment to control chopper with specified V_{mpp} and I_{mpp} duty cycle of chopper is obtained

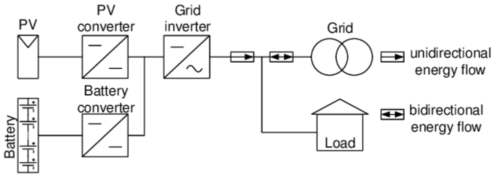


Fig: Block diagram

SIMULATION RESULTS

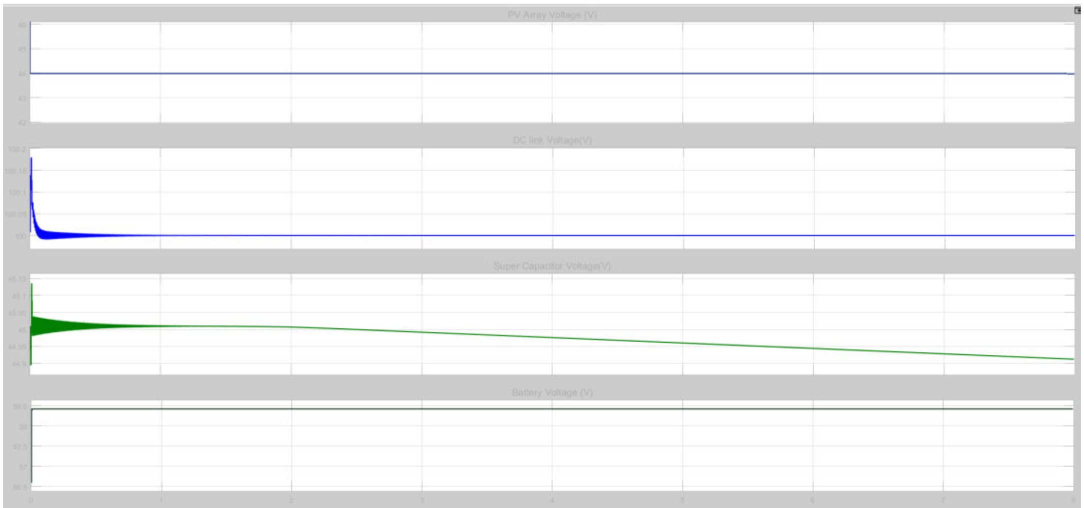


Fig: Voltages of the PV array, DC link, super capacitor and the battery energy storage system

Fig 8.1 presents the PV Voltage, the battery Voltage, and the supercapacitor Voltage on the DC-link side, where the scenario is verified. Another important parameter is the DC-bus voltage, which must be kept constant at 100 V. In Fig, the DC-bus voltage remains stable near 100 V during all different changes occurring in PV generation, exhibiting a maximum ripple voltage (peak-to-peak) of about 1.6 V (or ± 0.2%), which is absolutely acceptable. Moreover, the current controllers in the bidirectional converters of the battery and the supercapacitor provide the corresponding duty cycle for each converter.

Also, in Fig despite the several rapid variations occurred on the system, each controller responds extremely fast and provides the required duty cycle for the operation of the bidirectional converter. Specifically, the battery converter operates in boost-mode (battery discharging) during the first second, and in buck-mode (battery charging) during the rest period. As can be seen in the zoomed view of the duty cycle of the battery converter, during each rapid change, the controller acts extremely fast and provides the required duty cycle to the converter.

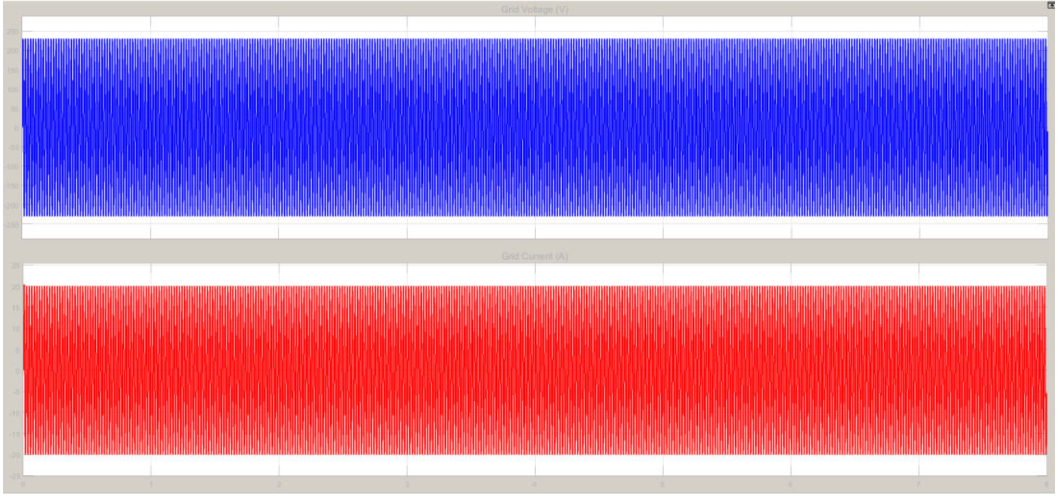


Fig: 8.2 Grid Voltages and the Current

Finally, Fig.8.2 shows the Voltages and currents on the AC side, where the inverter output current, the load current and the grid current are presented. Despite the solar irradiance variations, the output current of the inverter is constant, due to the constant load demand. Also, the current balance is verified during the chosen period of 8 s, as the output current of the inverter supplies the load, and no exchange between the grid and the PV system is observed.

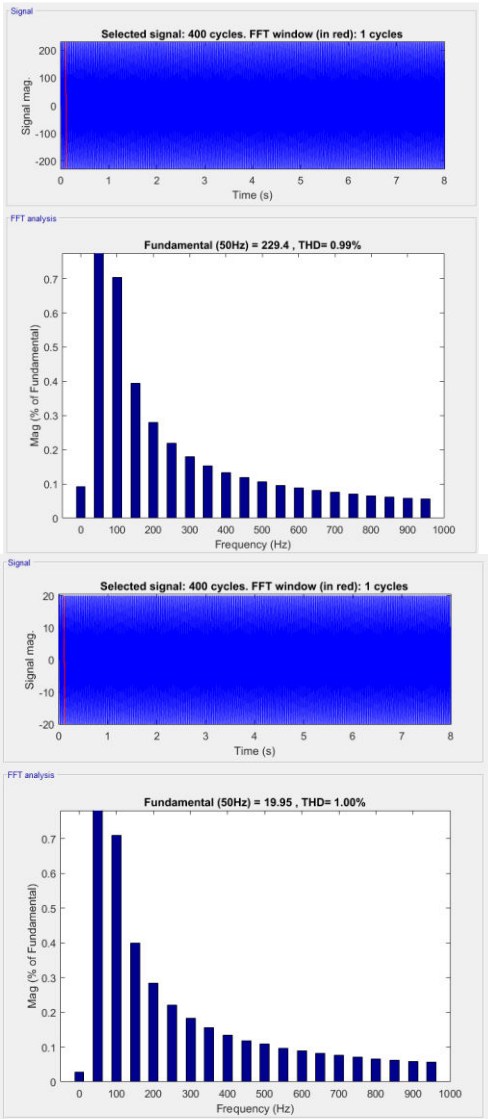
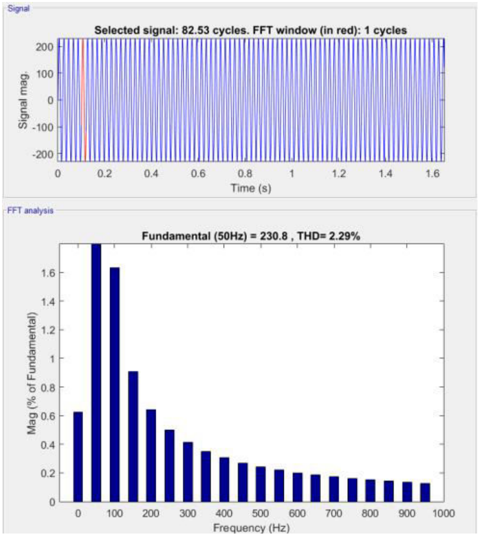


Fig: 8.3 THD percentage of the grid voltage and the current with the ANN controller



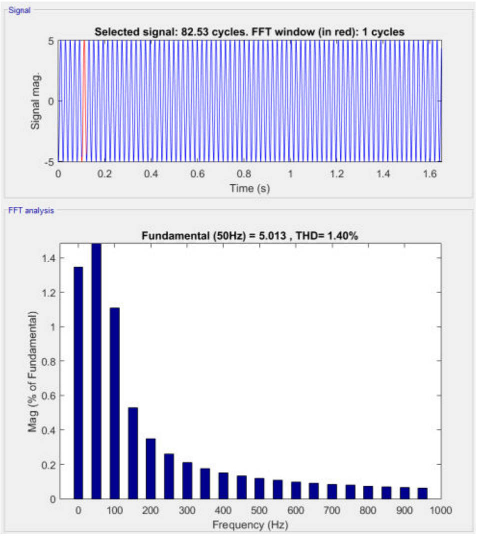


Fig: THD percentage of the grid voltage and the current with the PI controller

From the simulation results can be seen that the unsymmetrical passive load, the voltage, and current THD in grid especially during islanding when the difference between phase voltage and current magnitudes (Fig.8.4) is larger when compared with Fuzzy. The negative sequence filtering with PLL can be done to improve the stability of the converter-based unit, especially during unsymmetrical faults. From the simulation results can see that by using negative sequence filtering with PLL the voltage and current THD is slightly reduced with fuzzy. However, when the negative sequence is filtered from the current reference in the inverter control system (Fig.) the Voltage THD is reduced during normal operation and also during unsymmetrical fault before islanding the voltage and current THD. In addition, after islanding the distortions in voltage and current are notably lower. However, the negative sequence filtering from voltage and current reference does not remove the ripple from dc-link voltage during an unsymmetrical fault

CONCLUSION & FUTURE SCOPE

9.1 CONCLUSION:

This paper proposed a novel HESS power management strategy based on an Artificial Neural Network with the aim of mitigating Li-ion batteries stress under dynamic power exchange conditions, often experienced in standalone renewable microgrids. The proposed power management strategy is able to manage the power flow of the ESSs, managing their charging or discharging power depending on their SOC state, satisfying the system load throughout the system operation. A Simulink® model of a typical standalone photovoltaic microgrid, with a HESS composed by Li-ion batteries and SC, was developed to analyze the performance of the proposed system. With this method, there was a reduction in dynamic stress and peak current demand of the Li-ion batteries, without loss of efficiency in the supply of the load during all the performed tests. The potency of the discussed control technique is conveyed by comparing the power quality features like settling time, overshoot/under-shoot, and THD with other different schemes. The proposed scheme does not comprise the peak and off-peak hour demand, which can be further included for better power management. The proposed scheme is verified through simulation results for grid-connected applications. Hence, it can be applied to isolated microgrid systems. Small signal analysis can be done subsequently to look over the system stability.

FUTURE SCOPE:

As a future solar PV integrated battery energy storage system, to reduce the number of power conversion stages and obtain maximum energy transfer efficiency, a fundamentals-based algorithm and topology, without the integration of DC-DC converter, is proposed. Moreover, the voltage control issue in the DC microgrid is treated as an optimization problem to minimize the hardware complexity and the losses of high-frequency switching devices. The presented work validates the effectiveness of the proposed concept via the evaluation of the energy transfer efficiency in simulations and experimental measurements over a full daytime. The functionality of the proposed topology can provide benefits such as 1) cost-effective and high reliability due to lower electronic components, 2) resilience improvement of renewable-powered systems and 3) lower barriers toward more deployments of PV-powered microgrid systems.

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