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POWER CONTROLLER WITH BUILT IN ASIP FOR SOLAR POWERED APPLICATIONS

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Abstract : Solar photovoltaic (PV) systems are currently an important component of modern electrical power generation systems. Analyzing the effectiveness of Maximum Power Point Tracking (MPPT) is made easier by the precise and effective design of solar PV cells strategies. The highest output power is produced by an equivalent circuit model solar PV panel when relative to the solar PV panel with a single-diode comparable circuit model.In terms of tracking efficiency, settling time, and the number of iterations needed to find the MPPT, The ASIP is the best solution to have a efficient and predominant technology.

I. INTRODUCTION

Electricity has a significant role in our civilization, and its use will raise people's standards of living. Fossil fuels can be considered the primary sources for generating electricity in the modern world in order to meet load demand. Yet,the fact that they are naturally exhaustible, which has a significant negative impact toward environmental disasters that will still be felt in decades to come because they cannot be renewed.

In light of the detail that our civilization is heavily reliant on power, renewable sources are being considered as alternatives because they are both ecologically beneficial and abundant in nature. The numerous renewable sources found in nature are depicted in Fig. 1.

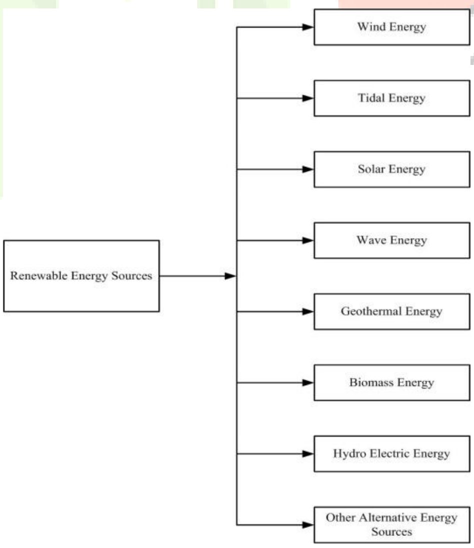

fig.1 block diagram of renewable sources

The most promising energies elements in the literature are photovoltaic (PV) and wind energy conversion systems (WECS). As of June 30, 2018, RES and its grid-tied cumulative installed capacity in India reached 71,187.12 MW. PV contributed 23,022.83 MW, or 33%, and wind contributed 34,293.48 MW, or 48%, together with hydro power and biomass. The cumulatively installed grid-tied renewable energy capacity in India during the previous four years by MNRE (2017).

MOTIVATION AND OBJECTIVES

Due to their abundance in nature and lack of pollution, RES have been the focus of research into electricity and generating up until this point. The disadvantage of RES is that it is quite challenging to produce the necessary amount of electric power in a short period of time. The availability of environmental/natural resources determines their ability to meet demand and produce sources that are inherently unexpected and uncontrollable. Recognizing the issue, the renewable sources exhibit erratic behavior throughout the day. Therefore, adopting renewable sources will not allow for the continuous and stable production of power. By combining a few uncontrolled sources with storage, a hybrid RES system might be created [1].

Knowingly, the accessibility of the natural world throughout the day has increased the generation using PV and wind systems. The total amount of output power created depends on sun's readiness and the wind's speed [2]. Typically, when the sun is shining, there is no wind, and when it is gloomy or nighttime, there is frequently a strong breeze. So that the load demand is satisfied when one of the sources is unavailable or insufficient to supply it, the other comes into being. PEC is required to progress the system's dependability and power transmission efficiency in order to integrate RES. The investigation and integration of PV systems with grid applications is the main goal of this research project. The available rated PV system, which is used for both stand-alone and grid-based applications, is the foundation of the study

Some of the most popular MPPT algorithms used on PV-based systems include the ones below. These algorithms have the ability to track MPP in real time under rapidly changing irradiance conditions with minimized MPPT oscillation, fast reaction, and ease of use.

P&O Technique

It has been noted that several researchers emphasized perturb and observe-based MPPT algorithms.,The P&O algorithm is depicted. Initial measurements of the PV voltage and current are made before calculating the related power, P. The operational point of a PV array is moved toward the MPP when the operating voltage is perturbed in a specific direction and $dP/dV>0$. This method keeps the PV array voltage fluctuating in the same direction.

Incremental Conductance Technique

Based on the immediate and incremental conductance values of the PV modules, this algorithm modifies the voltage of the PV array. The P&O method's drawback of being unable to track the peak control variable under quickly changing conditions is overcome by the rapid tracking of the control variable. The PV characteristic equation, When the operating point is to the left of the MPP, the slope of the PV array power curve is zero; it is positive when it is to the right of the MPP; and it is negative when it is to the left of the MPP.

INTELLIGENT MPPT TECHNIQUES

In addition to the soft computing methods in the MPPT control unit to track the MPP with minimal fluctuation and quick reaction. In the subsections that follow, the methods are explained.

1.FUZZY LOGIC CONTROL BASED MPPT

Rather than utilizing a mathematical model, membership functions are used to operate fuzzy logic controllers. As it is composed of three stages: fuzzification, inference mechanism, rule base table look up, and defuzzification. The input variables are fuzzified by converting them into linguistic variables based on the selected membership function. At the inference step, the controller's behavior is defined by the rules that govern how the language variables are changed. The FLC output is transformed from a linguistic variable to a numerical variable using a membership function during the defuzzification stage. Two inputs and one output make up an FLC-based MPPT (Kottas et al., 2006). As seen here, the typical inputs are tracking error (E) and change in error (delta E).

2.NEURAL NETWORK BASED MPPT

Applications of neural networks (NN) for nonlinear system modeling and system identification are growing in popularity. By approximating parameters, this method is utilized to tackle challenging issues. NN is made up of three layers: input, hidden, and output. Two neurons make up the input layer, which is supplied by the PV system's voltage and current variations (Bahgat et al., 2005). The duty cycle output is utilized to power converters that are run at or close to the MPP. Using a transfer function applied to it, the hidden layer is employed to transport the input signals to the output layer.

3.ANFIS BASED MPPT

Adaptive Neuro-Fuzzy Inference System (ANFIS) is the name of the hybrid approach that combines fuzzy logic and neural networks. According to Chekired et al. (2014), this system operates the fuzzy logic algorithm using external data, and the NN algorithm using internal data for training. The tracking error (E) and change in error (πE) are given into a neural network as inputs, and the fuzzy system will use the NN output as an input. Duty cycle, which is utilized to run converters within and outside of the MPP, is the output that the fuzzy system produces.

4.FL-GA BASED MPPT

A hybrid approach that combines fuzzy logic with genetic algorithms (FL-GA) is presented in (Larbes et al., 2009). MPPT efficiency will rise with appropriate choice of fuzzy inference rules, membership functions, and GA parameters. Tracking the maximum power point under quickly fluctuating irradiance circumstances is done using the FL-GA controller output duty cycle.

OTHER MPPT TECHNIQUES

The voltage approximation line MPPT, which models the PV system using its V-I characteristics, is proposed in (Liu and Huang, 2011). With analog circuitry serving as the controlling platform, this program tracks objects at a rapid speed. Low power photovoltaic systems employ it. The technique described in (Petrone et al., 2012) is based on the idea of equalizing the output operating points to align with the PV system's forced displacement of input (TEODI) operating pointing. Without memory, this paper needs less hardware. Since this method does not rely on perturbation stages, it employs load current as the input and does not exhibit power fluctuations at the operational point. That being said, partial shading makes it difficult to use this technique.

An MPPT for PV systems based on Extremum Seeking Control (ESC) is proposed in (Leyva et al., 2012). This study analyzes sinusoidal based PV system control using the Lyapunov function. Because of the nonlinear input-output mapping methodology used by the method, the MPPT exhibits less oscillation. The different intelligent MPPT strategies for PV systems that have been presented. This study of comparison also shows the hardware used, the methods used, and its benefits. This review indicates that the FL-GA based MPPT algorithm, when implemented in FPGA hardware, outperforms other methods for determining the PV system's peak power.

1. PARTIAL SHADING BASED MPPT TECHNIQUES

Due to partial shade and mismatch caused by buildings, trees, and cloudy conditions, photovoltaic systems have low power output. The generating power fluctuates due to changing environmental conditions, which also lowers efficiency. Under partial shading conditions, the PV system's maximum power can only be obtained by the use of an optimum maximum point track based technique. In this PV array's feature with a local and global maximum power point. The subsequent subsections examine the diverse approaches put forth by different scholars to monitor the MPP in situations with partial shade.

OVERALL ANALYSIS OF THE MPPT REVIEW

Given that there are various MPPT techniques accessible for a PV system with the intention. It can be challenging to determine which approach is superior when trying to maximize power production. Based on the hardware, application, and circuit complexity, a choice can be made. Also the availability, reaction time, and efficiency. It is also challenging to discuss the cost analysis of every technology that has been described.

Without really putting every algorithm into practice. Since digital circuitry requires processor boards for programming, analog circuitry-based systems are typically less expensive than digital circuitry. In comparison to the other systems, the system with fewer input sensors will also be less expensive.

Furthermore, in comparison to the other systems, the system with fewer input sensors will pay less. As was evident from the in-depth talks in the preceding sections, one of the key components of the PV power production module is the MPPT system, which will undoubtedly increase the power production's efficiency. The overall efficiency of the PV system will rise as a result of the MPPT-based system's relatively higher power generation compared to classical PV systems, hence lowering the cost of carbon neutrality. When power is produced using photovoltaic systems, carbon emissions are generally reduced and thus the cost of carbon abatement is decreased.

Several MPPT techniques for PV systems have been discussed in this area. evaluated, discussed, and their benefits and drawbacks included. Furthermore, the MPPT approaches have been roughly classified into the following categories: Incremental Methods of partial shading based MPPT, conductance, and intelligent MPPT. For each group the several approaches put out and applied by different researchers up until have been listed along with their benefits and drawbacks. The chart of comparisons detailed, goes over the technologies utilized, the converters used, and their hardware. the system model's implementation

Review of DC- DC Converters

Unfortunately, because of their low dc voltage by nature, PV sources are not appropriate for direct use in microgrids. Photovoltaic (PV) modules are typically connected in series to achieve high voltage levels. This calls for a sizable physical space and a high volume of PV modules. An effective DC-DC converter is needed to get around that and raise the low voltage to high voltage, which maximizes the use of renewable energy sources

1 BOOST CONVERTER

A single switch is used by the boost converter to function in step-up mode. Based on Fig. 2.8, the converter is made up of an inductor, a capacitor, a switch, and a diode. The current grows linearly and passes through the inductor and switch when the switch is turned on because the diode becomes reverse biased.

2 SEPIC CONVERTER

The boost converter has a single switch that it employs to work in step-up mode. As seen in Fig. 2.8, the converter is made up of an inductor, a capacitor, a switch, and a diode.. In the traditional boost converter, there is also a high level of switch stress and inrush current flow.

2.1 HIGH STEP-UP DC-DC CONVERTERS WITH COUPLED INDUCTOR

Using linked inductor, which produces high voltage gain and can be adjusted to produce a similar turn ratio to isolated converters (Zhao and Lee, 2003), can increase the high step-up converter efficiency (Khalilzadeh and Abbaszadeh, 2015). the linked inductor high step-up boost converter. Acting as a voltage source in series with the primary supply is the linked inductor secondary winding component. The connected inductor's leakage energy, however, causes severe voltage spikes and voltage stress to the main switch. The clamp diode Dc and capacitor Cc are used to absorb the leakage energy and inhibit the switch turn off voltage, which lowers the voltage

To achieve the soft-switching operation of the switch, a high step-up DC-DC converter with a connected inductor and auxiliary circuit.Zero voltage switching (ZVS) and zero current switching (ZCS) turn-on conditions from the auxiliary circuit are used by the switch to function. The duration of the auxiliary device's on Switching has a very brief duration to minimize further losses. Consequently, a complex in the converter framework and higher expenses. And also it displays a zero voltage transition with a significant step-up (ZVT) of an inductor-coupled boost converter (Wu et al., 2008). The main and clamp switches use the ZVT soft switching with resonant inductor LS. The leakage energy clamp circuit is utilized in order to limit voltage spikes and preserve it. The use of soft-switching boosts the converter's conversion efficiency at the expense of higher cost and size.

2.2 HIGH STEP-UP DC-DC CONVERTERS WITH SWITCHED CAPACITOR

"Using a capacitor as a voltage source is another technique for achieving a high step-up conversion. High conversion ratios can also be attained by adding switching capacitors to converters. (Chung et al., 2003) depicts the high step-up converter with N stage switching capacitor. Two switches, a diode, and a capacitor combine to produce each switched capacitor cell. Every capacitor can be viewed as a source of voltage that the switches recombine. When the switch is off, current flows across the circuit and the diode becomes forward biased. Series connection of N stages of switched capacitor cells is used in converters to increase the high voltage conversion".

2.3 HIGH STEP-UP DC-DC CONVERTER WITH INDUCTOR AND SWITCHED CAPACITOR

To achieve a voltage gain, a switching capacitor is integrated with the boost converter.(Ismail and others, 2008). a single switch DC-DC converter equipped with a capacitor-diode multiplier and a boost multiplier cell. The boost multiplier cell may produce voltage conversion in the same way as a traditional boost converter since it is made up of diodes Dx and Dy, an inductor Lx, and a capacitor Cx. Consisting of diodes D1 and D2, as well as capacitors C1 and C2, the capacitor-diode multiplier maximizes voltage gain and minimizes switch voltage stress. The two main drawbacks of this kind of high step-up converter are that it requires hard switching, which results in significant switching loss, and it has more magnetic components, which lowers power output. Thus, low power applications are the main use case for this sort of converter.

2.4 HIGH STEP-UP DC-DC CONVERTER WITH SWITCHED CAPACITOR AND COUPLED INDUCTOR

The boost converter's linked inductor and switching capacitor combination. Using the converter suggested by Wai and Duan (2005), a substantial voltage gain conversion can be accomplished. The semiconductor devices' reverse recovery problem is brought on by the connected inducer's leakage inductance. To lower the switching loss, employ the gentle switching technique. The switch voltage is suppressed and the leakage energy is recycled by the clamped diode DC1 and capacitor CC1. In order to transport the energy from capacitor CC1 to the load, the resonance circuit is made up of the inductor Lr and capacitor CC2. In the converter, lower switch voltage stress results in a higher voltage gain.

3. HIGH STEP-UP DC-DC INTERLEAVED BOOST CONVERTERS

For high power applications, the interleaved structure can be helpful (Li and He, 2011). To produce a high voltage gain, the switching capacitor is integrated into the traditional boost converter. This circuit is utilized to enhance high voltage conversion, reduce ripple current, and minimize the size of the component and the transient response. High voltage conversion gain is acquired using a switched capacitor cell. One of this converter's shortcomings is that it operates by arduous transitioning circumstances.

By combining two inductors that maximize the magnetic core and increase its magnetic usefulness, the linked inductor is created, The interleaved boost converter with a coupled inductor and switched capacitor is displayed. To minimize the magnetic components, a soft switching-based operation is employed. But notice the significant voltage gain. Switched capacitor cells are used to accomplish conversion. Interleaved boost converters are utilized in (Ling et al., 2015) to double transferable power while lowering input ripple current. In high voltage applications, however, switch control becomes complicated and conversion efficiency suffers. In collected works vast number of MPPT algorithms like perturb and observe P and O,

The following methods are easily accessible for MPP extraction from the RESs: incremental conductance, hill climbing, fuzzy logic controllers, neural networks, and hybrid based controllers. Every MPPT algorithm has unique advantages and disadvantages. Ram and associates (2017), Saravanan and Babu (2016), and Tiwari and Babu (2016). The most widely utilized MPPT techniques in PV and wind systems, out of all the available MPPT approaches in the literature, are P and O and hill climbing approaches. due to its straightforward construction and ease of usage, as noted by Saravanan and Babu (2016). Through the sense of voltage and current from the RESs, both methods operate on the principle of perturbation.

In P and O and in techniques involving hill climbing, respectively, the voltage and duty cycle are the perturbation elements. In order to obtain the MPP from the source, it computes the power change by

modifying the perturbation element and compares it to the previous values. However, in unstable weather conditions, it has limitations on effective MPPT.
In the P and O algorithm's the MPP is obtained by varying the PV array's terminal voltage in relation to PV power output.
In the next cycle, the terminal voltage will be stimulated in a positive direction if the power output is higher than it was previously, and vice versa. In 2016, Saravanan and Babu. Another method that is applied to both PV and wind systems is the incremental conductance methodology (Ram et al., 2017). This is because the technology can handle non-linear features and extract MPP.
By calculating the ratio of the prompt conductance to the incremental conductance, it tracks MPP and detects voltage and current from the RESs. Compared to other readily available MPPTs in written form, it is less versatile and straightforward to use.
According to Tiwari and Babu (2016), the Fuzzy Logic controller is one artificially intelligent MPPT approach that works with both wind and photovoltaic systems. To create fuzzy rules that extract MPP from the RESs, prior knowledge of the meteorological conditions is required. It goes through three steps to extract MPP from RESs using fuzzy logic controllers: The process of fuzzification involves using membership functions to turn real data into fuzzy. A fuzzy inference system is then used to identify the output regions. Finally, defuzzification is used to return the data to its original crisp state.
Among the several soft computing techniques, it is the best appropriate for rapid changes in environmental conditions and tracks MPP efficiently under partially shaded meteorological situations. Inspired by the human biological neuron, the artificial neural network (ANN) is an intelligent control technique that tracks MPP from RESs. In 2016, Saravanan and Babu. The neural network architecture comprises three layers: i) the input layer, which receives inputs from RESs like as voltage, current, irradiation, temperature, and wind speed. ii) Hidden layer for fine-tuning weights; this provides a healthy performance; and iii) Output layer for delivering the output variable, like duty cycle.

4. Review on Multi-Input DC-DC Converters

Different RES and storage devices should be integrated together to solve the aforementioned issues and provide more dependable, steady electricity to the grid or load. Renewable energy sources are discontinuous in nature, prone to outages, and create larger fluctuations in the generated power. 2015 saw Krishna and Kumar. The primary use of PECs is the integration of several sources. Integrating various energy sources by transforming them into the necessary form of integration, extracting MPP from the source, and maintaining power quality at the load side are the primary goals of PEC in hybrid power systems.
Kilic & Dursun (2012). Generally, two discrete inverters are used for the grid amalgamation of hybrid RESs using the common AC shunted method, This can be improved by using a single common inverter to integrate hybrid RESs using the common DC shunted method, It can also be modified by adding a MIC for hybrid RES integration and an inverter for grid amalgamation.

4. AC Shunt Coupled Hybrid System

The hybrid power system with grid connection and AC shunted coupled. Here, available PV and wind power are PEC-converted into AC. Both the AC-DC converter for WECS and the DCDC converter for PV are included. After being converted from DC to AC, this AC is then delivered to the grid or specific loads by means of separate DC-AC inverters that are integrated at the AC bus. The authors A foundational module of a grid-connected hybrid power system comprising photovoltaic (PV) and solid oxide fuel cell (SOFC) was created by Bayrak and Cebeci (2014). Using the actual DPS-160 PV module data sheet as a guide, a 160 Wp PV panel was created, These 800 Wp PV generators are linked to the grid through the use of panels. In the hybrid system, a 5 kW SOFC was constructed to support the DC bus. With MATLAB/simulink software, the full hybrid RES system is developed and analyzed.
In order to get a quicker actual power response in the hybrid RES system, Ou and Hong (2014) designed an intelligent controller.Effective power sharing and improved transient responsiveness under various load scenarios are demonstrated by the outcome. To verify the hybrid system's effectiveness under various load scenarios and disruptions, Hong et al. (2013) conduct a similar kind of study.

In this paper, the enhanced Elman Neural Network (ENN) controller and the Wilcoxon Radial Basis Function Network (RBFN) control method are utilized to extract MPP from wind and PV systems, respectively. In a variety of load scenarios and disturbances, the controller exhibits greater stability and efficiency.

In order to regulate the active, reactive, and dump power in a stand-alone hybrid system, Hirose and Matsuo (2012) designed an advanced power controller. By using a communication connection to check each source's power condition, the built controller will be able to tell the sources to turn on or off. Each source will use its specific inverter to supply the load once it receives the ON command.

In order to optimize the hybrid system's net present value, Dufo-Lìpez et al. (2009) suggest a control optimal technique. In this article, hydrogen is produced using an electrolyzer using extra electricity produced by the hybrid. The hydrogen that is produced is either consumed commercially or fuel cells are used to produce electricity.

Kalantar et al. (2010) created a supervisory control based on evolutionary algorithms to regulate the energy between generation and consumption in a hybrid renewable energy system that consists of a lead-acid battery (2.14 kAh), a micro turbine (230 kW), a PV array (85 kW), and a wind turbine (195 kW). Indirect space vector control (ISVC) is used to extract the maximum power point from the wind, while voltage source inverters (VSI) are used to manage the load's voltage and frequency. A comparison analysis between the PID and fuzzy logic controllers (FLC) and the proposed controller has been conducted.

Trifkovic et al. (2014) created a power management control approach for a hybrid system that combines fuel cells, photovoltaics, wind, electrolysis, and hydrogen storage tanks. It uses decision-based control at the supervisory level and decentralized adaptive model predictive control at the local control level to balance power between generation, hydrogen storage, and dynamically changing load demand. Wu et al. (2015) developed the coordinated smooth switching drop control (SSDC), which allows for flexible power control of energy storage systems and decentralized power management through the use of frequency bus-signaling.

Yamegueu et al. (2011) conducted an experimental investigation for a hybrid system that lacked battery energy storage and combined a diesel generator (9.2 kW) with photovoltaic (2.85 kWp) technology. The experimental result demonstrates how the performance of the diesel generator is impacted by the inclusion of PV at a certain load. Dummy loads are therefore used to monitor excessive power in order to increase system efficiency.

Yamegueu et al. (2013) conducted an experimental investigation for a hybrid system that included a diesel generator without BESS and photovoltaics (PV) and found that the PV increased harmonics in voltage and current. A top-notch sine wave inverter can be used to suppress this. In order to reduce variations in the power generated by the renewable energy source (RES), Li et al. (2013) designed an adaptive smoothing control technique for hybrid PV and WECS based on BESS. The status of charge and power level are efficiently regulated by the control technique that was created.The design of power converters, storage batteries, active and reactive power control, maintaining power quality, control strategies developed for power management, extracting MPP, and optimal utilization of energy sources and hybrid system protection have all been thoroughly reviewed in relation to AC shunt coupled hybrid systems.

2.5 OVERALL ANALYSIS OF THE CONVERTER REVIEW

A non-isolated high step up converter is suggested in order to get over the aforementioned problems and produce high voltage gain with just one switch. A voltage-doubler circuit in the SEPIC converter is used in the suggested converter 1 topology. This converter's benefits include easy control, fewer components, low voltage stress across the semiconductor devices, low conduction loss, and high voltage conversion. Another DC-DC converter with a single switch that is not isolated is suggested. In addition to using low voltage rating MOSFETs and low resistance (RDS-ON) diode-capacitor circuits in series, the proposed converter 2 lowers the voltage stress across MOSFETs and diodes. The suggested model's conversion efficiency rises as a result.

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