IMPLEMENTATION OF INTELLIGENT GRID-INTERFACED PV WITH DC-DC BOOST CONVERTER TOPOLOGY FOR AGRICULTURAL WATER PUMPING SYSTEM

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Abstract—To make use of renewable energy sources is a critical need such as solar power to develop efficient and economical solutions to the energy crisis. This requirement is worsened in developing countries by the presence of unreliable electrical grids. An attractive solution is the use of solar based single phase micro-inverters feeding AC power to the grid. For the improvement of the efficiency of PV array in the photovoltaic system, there is a requirement of electronic power conversion and also the firmness of system. The photovoltaic water pumping system (PVWPS) is one of the needful applications for farmers in which solar energy supply can be used for agricultural process. The main objective is to produce higher output 2KW can be used for water pumping system for agricultural process is implemented using the DC to DC Boost Converter. In this work, improve the water pumping system and also improve the electrical efficiency of PV panels by reducing the operating temperature of the PV modules. The power circuit contains a DC to DC Boost Converter and an inverter with multistage to transform, as the voltage of grid is alternative current in nature and LCL filter. The demand of Control circuit is to get constant (DC) voltage at the output with the PV systems, it is continual varying in nature. In this work for a Grid-connected solar power plant with DC boost converter using sophisticated fuzzy rule set (SFRS) MPPT technique. Maximum power point tracking (MPPT) control is used to maximize the output power from a PV module with different operating conditions which gives the maximum system efficiency. Here, in this work, Boost Converter with MPPT technique and grid-connected PV represented by and has been simulated by using the SIMULINK. Over 97% efficiency has achieved at full load condition based on the sophisticated fuzzy rule set based grid connected PV water pumping system.

Keywords—Photovoltaic system, LCL filter, MPPT, Fuzzy Logic, Matlab_2013a
1. INTRODUCTION

A grid-connected PV power network is an energy producing system depending on PV controller structure that is accompanying with the usefulness grid. A method connected PV structure contains solar-powered panels, one or rare inverters, an energy molding unit and grid-connected equipment. They go from a little residence and commercial rooftop structures to large utility-scale sun-powered stations. Not at all comparable remain standalone power frame work, a network associated frame once in a while incorporates a coordinated battery arrangement, as they are still costly. At the point when conditions are correct, the grid associated PV framework supplies the excess power, past utilization by the associated load, to the utility grid. The association of the PV power framework can be made through an interconnection between the user and the administrative organization. The protocol details the various safety standards to be followed by the connection. Sunlight based power accumulated by photovoltaic panels, intended for delivery to a power grid, must be adapted, or handled for use, by a network associated inverter. On a fundamental level, an inverter changes the DC input voltage from the PV to AC voltage for the grid. This inverter sits between the sun based exhibit and the grid, draw energy from each, and maybe a sizeable stand-alone unit or may be a collection of small inverters, each physically attached to individual solar panels. Fuzzy logic controllers are essential thoughtfully. At last, the output organizes changes the joined impact over into an express control output esteem. The input factors in a fuzzy logic system are when all is said in done mapped by groups of membership function like this, recognized as "fuzzy logic sets." This way toward changing over a new input assessment to a fuzzy system is known as "fuzzification."

![Fuzzy Logic Example](image)

Fig 1: Example of logic fuzzy

A controller framework might likewise have different kinds of the switch, or "ON-OFF," contributions alongside simple data sources. Such switch contributions, obviously, will dependably have a fact esteem equivalent to whichever 1 or 0.

![Fig 2: basic boost converter](image)

A DC-DC boost converter can increase the output voltage from its input voltage. It is a type of switch mode power supply (SMPS) comprising small than two semiconductors and not small than one energy storing material of a capacitor, inductor, or the two in a mix. To reduce power swell, filters complete of capacitors are generally extra to such a converter's output and input.
2. RESEARCH BACKGROUND

In this research background section, a brief about all the examination papers checked on for Grid-Connected Photovoltaic Power Plant with Dc - Dc Boost Converter. Power conditioners for individual grid-connected PV plants may include a single stage or a two-organize design [1], [2]. The one of a kind stage setup is custom-made around a single step, PWM worked, h-bridge inverter. No electrical security is given between the PV modules and the framework. Likewise, the matrix tie inverter is endowed either to rework the PV string DC yield voltage, either to accomplish the Maximum Power Point Tracking [4]. Two-organize designs depend on the course association of a DC/DC venture step-up converter and an extension inverter. [5] The DC/DC converter topology may be both of the transformers less no separated sorts, both of the high-recurrence transformer protection sort. The highest point of the line is advantaged by a lower cost and higher power thickness.

A couple of cross crossover wind PV control structures with MPPT technique have been prescribed [1]-[5]. A main part of framework uses another boost converter connected in parallel in the converter to play with the MPPT control for each of the inexhaustible power source control sources [1]-[4]. A more linear multi-input structure has been proposed by [5] that connects the sources from the DC-side to achieve the MPPT for each source. The consonant current in the generator current decays its future and extends the power misfortune in light of warming. [6]

Systems, for instance, Net Metering and Feed-in Tariffs which are offered by some framework directors can adjust a customer's energy utilization costs. In a couple of regions, in any case, matrix innovations can't change to conveyance age encouraging into the lattice, so the admission of surplus power isn't possible, and that surplus is earthed. Network associated PV structures are less requesting to present as they don't require a battery system. [9] Framework interconnection of a photovoltaic (PV) control age framework has the upside of proficient utilization of delivered control because there are no capacity misfortunes included. A photovoltaic power framework is a carbon negative over its future, as any vitality created past that to amass the board at first counterbalances the prerequisite for expending oil-based goods. In spite of the way that the sun doesn't sparkle, any foundation gives a sensibly apparent standard decrease in carbon usage. In this low price photovoltaic water pumping system (PVWPS) developing a DC boost converter and a diode clamped multilevel inverter used PV panel is implemented without battery backup. It can be used wherever electrical power is not accessible. At the irradiance level MPPT technique pushes the output voltage of PV panel to obtain maximum power. [11] In this project, the main objective is to produce high output power of about 2KW which can be used for agricultural applications for water pumping and also for home applications. The design of PV inverter is introduced by using the interleaved flyback converter. The proposed inverter system achieves a lesser count of components, which increases the overall efficiency and smaller size. [12]. In the water pumping system, which can be used to improve the electrical efficiency of PV panels by reducing the operating temperature of the PV modules. In this water pumping systems, with constant speed and variable speed using a frequency inverter. The better result was achieved with a 3 phase water pump at minimum speed with an efficiency of 5:16 Watts/litre.[13]

In this work, an option multi-input grid inverter is recommended for solar power system. The suggested configuration is a combination of the DC/DC converter. The
first thought of these two converters abstains from the prerequisite for input filters. The procedures of these combined converters are looked at and the particular parallel strategy of the DC/DC converters. The circuit working benchmarks will be discussed in this work. Simulation results came about are given to check the possibility of the recommended framework.

3. MATERIALS AND METHOD

A proposed solar power system consists of PV module, DC-DC converter, bidirectional converter, Battery, and a grid tie inverter. The MPPT control and converters operations are employed to control the solar power system by using sophisticated fuzzy rule set (SFRS). The DC to DC boost converter performs (MPPT) of a PV work. The sunlight based board gives however much power as could reasonably be expected to the heap. The photovoltaic array controls the load and charges the battery through a DC-DC boost converter which goes about as a maximum power point tracker utilizing sophisticated fuzzy rule set (SFRS)[27].

Fig 3: Proposed PV power grid

3.1 WORKING STRATEGIES

In such a system, the output Power vacillates because of natural conditions. The operation of the PV array and the battery gives a more sensible and robust to supply energy to remote territories. At the point when the energy created by the solar power is enough to supply the load energy, the remaining energy will be given to the storage until the point when battery charged. If the battery is completely charged, dump load utilizes the additional power. In case the photovoltaic system energy capacity does not have enough to meet the load power, and the load demand is high in this situation battery bank supplies insufficient power to meet the load requirements. The following steps can explain this strategy.

\[ \mu P = Pre(t) - Pl(t) \quad \text{(1)} \]

Where the Pre (t) is an entire output energy of the solar system, and Pl (t) is the total required power

If \( \mu P \geq 0 \) and \( \text{SOC (t)} \leq \text{SOC}_{\text{max}} \), then the remaining energy will be utilized to charge the battery until the point when the battery has charged.

If \( \mu P \geq 0 \) and \( \text{SOC (t)} > \text{SOC}_{\text{max}} \), remaining power is consumed by dump the load.

If \( \mu P < 0 \) and \( \text{SOC}_{\text{min}} \leq \text{SOC (t)} \), the insufficient power will be provided by the battery bank until \( \text{SOC}_{\text{min}} = \text{SOC (t)} \).

If \( \Delta P < 0 \) and \( \text{SOC (min)} \geq \text{SOC (t)} \), the insufficient power will be provided by battery.

3.2 GRID TIE INVERTER:

The DC voltage is converted into AC voltage, and it is fed to the grid using a grid tie inverter. The grid tie inverter used here is voltage source converter with PWM technique. Synchronization must be properly done to ensure the PV panel is fed properly into the grid.
Design equation of grid tie inverter is followed. A base value is introduced which acts as reference, and it is given as

\[ X_b = (E_n)^2 P_n \ldots (2) \]

\[ B_b = 1/(W_n Z_b) \ldots (3) \]

\[ W_n = W_b \ldots (4) \]

Where

\[ W_n = \text{grid frequency} \]

\[ E_n = \text{phase to phase RMS voltage}, \]

\[ P_n = \text{active power}. \]

The DC side Capacitor is selected based on following conditions.

1. Time delay which is included by filtering of the DC voltage and Current.
2. A voltage difference \( \Delta V_0 \)
3. Output power difference \( \Delta P_{\text{max}} \) on the DC network.
4. Load ride through capability and stability during usefulness voltage sag proceedings.

The DC capacitor can be produced using the following equation

\[ C \geq \frac{T \Delta P_{\text{max}}}{2V_0 \Delta V_0} \ldots (5) \]

An LCL filter arrangement is implemented to eliminate the switching frequency harmonics based upon the state of the current and the voltage sensors the capacitor has a variable effect on the system. The design equation for the AC side capacitor is given as

\[ C_f = l - \frac{lG}{2b^2} \ldots (6) \]

The magnetic core used for the design of inductor is made up of following materials laminated metal alloy, iron, ferrite and powdered metal. The current harmonics generated by the VSC is limited by the inductance \( L \) which is on the converter side. The harmonics are due to the VSC switching.

The below equation gives the converter side inductance.

\[ l = \text{max}(V(n)/nW_b I_{\text{Limit}}(n)) \ldots (7) \]

Where

\[ V(n) = \text{voltage generated at n-harmonic by the VSC} \]

\[ I_{\text{Limit}}(n) = \text{maximum tolerable current ripple at the n-frequency}. \]

The acceptable switching ripple is used to determine the inductance \( l_g \) at the grid side. The output energy of photovoltaic panel increments with an expansion in solar radiation and reductions with a development in temperature. An excellent maximum power point on I-V characteristics response of a photovoltaic cell has appeared in the accompanying figure.

![Fig 4: Temperature versus Power Characteristics](image)

### 3.3 SOPHISTICATED FUZZY RULE CONTROLLER AS MPPT

A photovoltaic module can be expressed as follows,

\[ \frac{V_{PV}}{I_{PV}} = \frac{(l-D)^2}{D^2} R_l \ldots (8) \]
\[ RL = \frac{D^2 \; V_{PV}}{(l-D)^2 \; V_{PV}} \ldots (9) \]

Afterward, the parameter of RL (load resistance) is achieved, (8) can be written into (10). Then, the duty cycle can be calculated as follows:

\[ D = \frac{\sqrt{\alpha}}{1+\sqrt{\alpha}} \ldots (10) \]

Where \( \alpha = \frac{V_{PV}}{V_{PV}} RL \)

Now, an output of the system and speed acknowledgment can be commutated using (8) and (10) for a difference in temperature level.

### 3.4. INCREASING AND DECREASING THE SOLAR RADIATION

![Decrease of solar irradiation](Fig 5)

![Increase of solar irradiation](Fig 6)

### 3.5 FLOW CHART FOR SOPHISTICATED CONTROL ALGORITHM:

![Flow chart for SDC algorithm](Fig 7)

### 3.6 SOPHISTICATED RULE BASED FUZZY SET (SFRS) FOR PROPOSED CONVERTER

![SFRS control for dual Bridge resonant converter](Fig 8)

So, there is more interest in using nonlinear control techniques to increase the performance of the boost converter. The
The process of SFRS strategy comprises the following procedure.

1. Fuzzification: Method of demonstrating the inputs as proper fuzzy value.
2. Decision making: Appropriate control activity to complete. It depends on the information base and rule base.
3. Defuzzification: Method of changing over the fuzzified output into the crisp value.

![Fig 9: Membership function of inputs](image)

The above Fig 9 represents the FLC of the Error and Exchange Error data which Triangular memberships

![Fig 10: Membership function of output](image)

The above Fig.10 represents the FLC of the Iref output Triangular memberships

\[ D(t) = D(t-1) - D(X(t)) \]

Where

\[ q(K) = \text{Error signal} \]
\[ CV(k) = \text{Change in error signal} \]
\[ V(k-1) = \text{Previous error signal} \]
\[ D(t) = \text{Duty cycle at t’th instant} \]

Mamdani model control is picked for this presentation, and the fundamental rule of a particular type of fuzzy controller is:

IF Fe is A and de is B THEN D(t) is C

Where A and B is Fuzzy subsets

C – Fuzzy singleton

The nature of discourse has distributed into five subsets such as (NB), (NS), (ZE), (PS), and (PB). The Fig.9 shows the membership functions of the inputs. To keep up the voltage at the coveted level, the triangular participation of error and control output are confined close to zero for the given working condition. For enhancing the controller execution, membership function are additionally balanced given experimentation technique. Fig.10 shows the membership functions of the output variable.

The control rules are assessed by a deduction instrument and spoke to as an arrangement of errors. IF Error is ... and Correction of Error is ... THEN the output will ...

<table>
<thead>
<tr>
<th>C,E</th>
<th>Very small</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>Very Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Small</td>
<td>ZO</td>
<td>NS</td>
<td>PS</td>
<td>PS</td>
<td>NS</td>
</tr>
<tr>
<td>Small</td>
<td>NB</td>
<td>ZO</td>
<td>PS</td>
<td>PS</td>
<td>NS</td>
</tr>
<tr>
<td>Medium</td>
<td>PB</td>
<td>PB</td>
<td>ZO</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Large</td>
<td>PB</td>
<td>GB</td>
<td>NB</td>
<td>ZO</td>
<td>NS</td>
</tr>
<tr>
<td>Very Large</td>
<td>NB</td>
<td>NB</td>
<td>NB</td>
<td>ZO</td>
<td>NS</td>
</tr>
</tbody>
</table>

Table 1 demonstrates the coveted relationship is between the info and output factors concerning the membership capacities.
4. RESULTS AND DISCUSSION

The proposed sophisticated fuzzy rule-based MPPT with grid tie inverter is simulated using MATLAB2013a/Simulink. Fig. 11 exhibits developed Simulink model.

From the part of simulation, the SFRS based control is affected and below the working position considering the steady environment and permanent isolation (1000 W/m²).

The above Fig. 11 shows the architectural circulation of an SFRS expert system. The proposed method can significantly decrease the time and increase the efficiency to produce a fuzzy expert system. Depend on the Dynamic parties and the soft switching rules derived, a similar logic implication procedure to process inputs was also applied. The solar tracking method is simulated utilizing various dynamic membership functions for comparison and validation purposes. Matlab Simulink design of this proposed model is shown in Fig. In figure it was demonstrated that SFRS controllers used different membership functions are applied to the system.
Figure 13 displays the transient reactions of the tracing energy curves gotten from SFRS algorithm. As seen in the picture, the proposed reply is much quicker than that of the traditional MPPT while the overshoots of the way are necessarily the same.

As compared to the existing process the proposed method produces the maximum power.

**Table 4.1: COMPARISON TABLE OF THE PROPOSED MODEL**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Controller used</th>
<th>Output power in per unit</th>
<th>Switching Losses (%)</th>
<th>Maximum output Power Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conventional MPPT using INC method</td>
<td>0.84</td>
<td>16</td>
<td>84.72</td>
</tr>
<tr>
<td>2</td>
<td>Fuzzy logic controller</td>
<td>0.89</td>
<td>11</td>
<td>89.55</td>
</tr>
<tr>
<td>3</td>
<td>Dynamic Rule soft switching Controller</td>
<td>0.94</td>
<td>6</td>
<td>94.92</td>
</tr>
<tr>
<td>4</td>
<td>Proposed SFRS control</td>
<td>0.98</td>
<td>4</td>
<td>99.25</td>
</tr>
</tbody>
</table>

**5. CONCLUSION**

The design of a stand-alone solar power system has been accomplished successfully by an SFRS method. In the case of PV system, it shows mismatch with possible data to a small extent. And output result generated by Battery bank has a significant similarity with reliable data. For a detailed design and economic analysis of a stand-alone or grid tie, a solar system is a good choice. The photovoltaic water pumping system (PVWPS) is the most important applications for farmers in which solar energy supply can be used for entire agricultural process. In this it produce high output power of about 2KW which can be used for agricultural water pumping system was implemented using DC Converter. In this water pumping system which improves the electrical efficiency of PV panels by reducing the operating temperature of the PV modules.
SFRS would be preferable for hybrid solar system design, optimization and sensitivity analysis. The simulation results show that grid-connected hybrid power system which includes solar is more cost effective than without grid connected for the same load. Thus SFRS is favorable in producing stable energy arrangement for each hour to choose the possible shape. This cost evaluation of any potential sequence for installing and operating over the lifetime in a particular area can be actively analyzed using the proposed methodology. As compared to other SFRS grid design achieved more the Solar Energy 97% efficiency.

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