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Enhanced Control of Chopper based PV Array using Fuzzy Logic Control System

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ABSTRACT: As we know that solar radiations are nonlinear and vary according to the different weather conditions as well as locations. Maximum power point tracking is very important factor to enhance the outputs in Solar PV array. Now a days many research is going on to enhance the output of solar PV array irrespective of the nonlinear conditions. In this work a fuzzy logic control system has been designed for the gate pulse with the predefined rules and try to achieve the desired outputs. Simulation results are shown and discussed with the Matlab/Simulink simulation software to validate the proposed control strategy. This control strategy has a good performance in terms of dynamic response and output.

KEYWORDS: Maximum power point tracking system (MPPT), Pulse Width Modulation (PWM), Insulated gate bipolar transistor (IGBT), Total harmonic distortion (THD), static synchronous compensator (STATCOM),), and fuzzy logic control (FLC),Perturbation & Observation (P&O)

I. INTRODUCTION

Energy not only plays an important role in our life but also in the overall economy of the country. The requirement for energy is increasing in our daily life due to the industrial revolution. In the most developing country like India, the large share of energy generation mainly depends upon non-renewable energy sources. The gradual depletion of these sources such as fossil fuels, oils, etc. leading the developing countries towards the un-sustainability of civilization. Along with that, the generation of energy through conventional sources is also a reason for greenhouse gases. It has become a global challenge to reduce the emission of greenhouse gasses like CO2 and CO3 to ensured secure, clean, and affordable energy. Whereas clean and sustainable energy is perfectly generated through renewable energy sources [1].

According to the U.S. Department of Energy, the demand for electricity is expected to increase 30% by 2035 as a result of new consumption models, e. g. smart plug-in electric vehicles and smart homes [2]. To decrease the greenhouse gas emission, the attention has been drawn to the electricity generation of renewable energy resources as ecofriendly and non-polluting power generation units [3].

Now As per the financial terms electricity generation using renewable sources have higher price as compared to the non-renewable resources. But now a days the major challenge is to generate a good quality power with lesser incremental cost as much as possible and with lesser carbon emission. In that case we use renewable sources to generate power with good quality. So we should adopt the most convenient and cheapest way for generation transmission and distribution. In order to get an optimum power generation hybrid electricity is used so that increase in price may get compensated by the use of renewable assets.

Many government schemes are running for the incentives in installation of renewable sources worldwide that will also be considered in planning of incremental cost of the project as well as payback period from the savings of electricity bills revenue. [4]





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Fig -1: Electricity consumption increasing pattern

India is a developing country and construction takes place in a very rapid rate. Electricity consumption should be in a limited range in every sector that may be industrial, agricultural and commercial as well as residential buildings.

So Government has taken so much initiatives in this field like amendments in the National building code and launches new building codes to reduce the energy consumption in building sector. In Various sectors the loads according to consumption can be seen in the above figure.

Mostly in buildings if some percentage of auxiliary consumption can be taken from the solar energy then this will be very helpful in reduction in consumption.

Many researches are going in this field to increase the output with suitable waveforms of voltage, current so that may be easily supply to the grid or load.

II. MODELLING OF PV ARRAY

Electrical Model of photovoltaic cell Implements a PV array built of strings of PV modules connected in parallel. Each strings consists of strings connected in series. Parallel strings 40 and series connected modules per strings 10. With open circuit voltage 37.14V and short circuit current 8A.







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 $I = I_{D-} I_{RP-} I_{ph} \dots (1)$ $I = I_{ph-} I_{0-} \left[exp\left(\frac{V + IRs}{V_T}\right) - 1 \right] - \left[\left(\frac{V + IRs}{R_p}\right) \right] \dots (2)$ $I = n_p I_{ph-} n_p I_{rs-} \left[exp\left(\frac{q}{KTA} * \frac{V}{n_s}\right) - 1 \right] \dots (3)$ $I_{rs} = I_{rr} \left[\frac{T}{T_R} \right]^3 exp\left(\frac{qE_G}{KA} \left[\frac{1}{T_r} - \frac{1}{T} \right] \right) \dots (4)$ $E_{G=} E_G (0) \frac{\alpha T^2}{T + \beta} \dots (5)$ $I_{ph} = \left[I_{scr} + K_i \left(T - T_r \right) \right] \frac{s}{1000} \dots (6)$

Where, Iph is the Insolation current, I is the Cell current, I0 is the Reverse saturation current, V is the Cell voltage, Rs is the Series resistance, Rp is the Parallel resistance, VT is the Thermal voltage (KT/q), K is the Boltzmann constant, T is the Temperature in Kelvin, and q is the Charge of an electron. [3]

In this paper a review of major MPPT techniques used in major PV standalone system are presented and gives a detailed review on various MPPT techniques used in this work. The I-V and P-V characteristics with different irradiation and temperature variation are shown in figure below



Fig -3: I-V and P-V Characteristics

V. BOOST CONVERTER

The PV system generates DC voltage in all the variable conditions of solar radiations. The generated voltage is low and variable and it must be somewhat high and constant at the input of inverter. So we need a boost converter device to boost the voltage as well it try to maintain constant boosted voltage.





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Fig -4: Subsystem Of boost converter



Fig -5: Circuit diagram of boost converter

The Fig. 5 shows a step up or PWM boost converter. This consists of a dc input voltage source VIN; boost inductor L controlled switch T, diode D, filter capacitor C and load resistance RL. When the switch S is in on state, the current in the boost inductor increases linearly and the diode D is off at that time, when the switch s is turned off, the energy stored in the inductor is released through the diode to the output RC circuit. The transfer function for the boost converter is [4]

MAXIMUM POWER POINT TRACKING

The MPPT control is a fundamental in order to obtain a good performance on the overall system. The MPPT techniques can be categorized as direct and indirect methods. The direct method includes perturbation and observation method, fuzzy logic method, neural network method and incremental conductance method. In this work we review two different fuzzy logic control methods and trying to achieve optimum output by comparison in the overall installed system of such rating.





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III. FUZZY CONTROL SYSTEM



Fig -6: Fuzzy control logic



Fig -7: Surface view of initial system



Fig -8: Rule View of initial control system





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Fig -9: Surface View of final control system



Fig -10: Rule View of final control system





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Fig -11: Input membership function 1



Fig -12: Input membership function 2





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Fig -13: Output membership function Theta

Fuzzy logic is a powerful tool since it allows the control of the system whose parameters are unknown or incomplete and as a result difficult to model mathematically. Fuzzy logic control consist of three main stages: input, processing and output. At the input stage membership functions are used to fuzzify the input values. The now fuzzified input is fed into the processing stage where an inference mechanism applied the appropriate rule from the knowledge base to come up with a set of fuzzy outputs. This output is then defuzzified using an appropriate technique. [14]

In this model this fuzzy logic controller is initially connected to the MPPT controller. This fuzzy controller stores the MPPT file which contains the membership functions as input and rules to obtain the maximum output voltage from the solar PV module. The output of the fuzzy logic controller is given to the gate drive of the buck boost converter. The output of the fuzzy logic controller depends upon the membership function and rules designed.



Fig -14: MPPT based on fuzzy logic system





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|DOI: 10.15680/IJIRSET.2025.1405299| **IV. RESULT AND DISCUSSION** ▲ Scope4 X File Tools View Simulation Help (④ ▼) (⑤ ⑤ ⑥ ⑥ ⑧ ⑧ ◎ ⑤ ▼) (○ ♥) (○ ♥) (○ ♥) (○ ♥) (○ ♥) (○ ♥) (○ ♥) (○ ♥) (○ ♥) (○ ♥)</td o last' from the Configuration Properties Logging tab ng. Try ur ng 'Limit data p Data 🗅 26°C Cloudy ^ 🖻 📴 🦟 如) Fig -15: Initial Output Voltage 💰 Scope2 File Tools View Simulation Help ⊚ • | ⊗ • | ▶ | ■ | ≫ • | ⊙ • | ⊙ • | ♪ • | ↓ 🔊 🥅 🔝 26°C Cloudy へ い (20) ENG 18: 19-08-0 🚽







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Fig -17: Output Voltage

V.CONCLUSION

A model has been designed of solar PV array with maximum power point tracking system with two different fuzzy logic control strategy. The model is designed using Matlab/Simulink. Previously many researches has been already done in the perturbation and observation and now a day's research based on the rules as well as future prediction of weather according to analysis for the maximum output of the PV arrays installed in the station. A fuzzy control system is designed initially with rules and membership functions and the voltage came across nearby 4200 V but later on the the control system with another rules and membership function in Mamdani type fuzzy control strategy has been designed and applied over the model and the result shows that Voltage output is lesser as compared to initial one nearby 2300 V. Different models with different rule sets behave accordingly so it is necessary to apply the research process to know the better control system with desired output. In the next level research will be done by converting this DC voltage into AC with the help of inverter configuration and connect this to the load or grid.

VI. FUTURE APPLICATIONS

Let us consider a practical project in which the enhancement is possible. According to government the buildings designed in the future should comply all the codes with respect to energy conservation like green building codes or energy conservation building codes. In many states and union territories of India this code is notified and the codes to be comply in the buildings are mandatory. In respect to this code if any building is constructed the solar panel should be installed as per the roof area or according to the total expected energy consumption of a year.

For example if the roof area is 100 square meters then the 25% of the roof area should be covered with the solar panel or if the total energy consumption of a year is near about 10,000 Kwh per year than 1% of connected load like 100 Kw capacity of solar Panel should be connected to meet the auxiliary demand.

Solar Panels capacity is also decided depending upon the weather. For example if we consider a city, like Dehradun, the weather is composite and various simulation software's work with the weather files to get the best output and the load required of solar panels.





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Fig -18: Sun path of a building





The graph shows the monthly number of sunny, partly cloudy, overcast and precipitation days. Days with less than 20% cloud cover are considered as sunny, with 20-80% cloud cover as partly cloudy and with more than 80% as overcast. The methodology used in this paper basically depends upon the predetermined values of inputs and outputs. If the Solar Panels to be installed anywhere in the world the weather files are available in the government websites and the detailed analysis of the weather is also available. According to these analysis we can design the membership functions, rules and outputs. So in the form of PVB (positive very big), NB (Negative big), NS (Negative small) like this. So we can design an intelligent maximum power point tracking system by using fuzzy logic system with the predetermined set of rules and outputs. Now a days the efficiency of solar PV array are near about 15 to 20 %. We can increase this efficiency by using this maximum power point tracking system. We have taken an example from a site from the north India. We can do this analysis anywhere in the world and enhance the outputs.





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