International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Power Management in Hybrid Microgrids Using Fuzzy Logic

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Abstract: ***Batteries installed in Photovoltaic Systems for extensive storage of energy has been demanded for a better administration of the same in terms of equilibrium of voltages across the bus and to govern the current of power further malleably. Battery utilized in PV scheme of working will alleviate the power vacillations owed to the physiognomies of PV panels and solar irradiance. This paper makes use of a fuzzy logic controller in the MPPT section accompanied by the inclusive Control and Power Management System (CAPMS) reaching for an ultimate outcome of increase in V_{DC} as well as compliantly monitoring approach for voltage and current, both AC and DC, along with involuntary balancing of power transfer within the system whether it is on island-mode or grid-mode.***

Keywords: Solar PV System, Battery, Fuzzy Logic Controller, Control and Power Management System CAPMS

1. Introduction

Constantly expanding interest for electricity and worries of natural crumbling have been prodding electric force specialists to discover manageable techniques for power age. Distributed generations (DG) as sustainable assets, for example, sun oriented vitality, are accepted to give a successful answer for diminish the reliance on traditional force age and to upgrade the unwavering quality and nature of power schemes [5]. Photovoltaic (PV) power frameworks have gotten one of the most encouraging inexhaustible age advancements on account of their alluring attributes, for example, bounty of sunlight based and clean vitality. Fast PV innovation advancement and declining establishment costs are likewise invigorating the expanding arrangement of PV in power frameworks.

Be that as it may, because of the idea of solar based power and PV boards, momentary force yield of a PV framework relies to a great extent upon its working condition, for example, irradiance of sun and encompassing temperature, bringing about steady vacillations in the yield power [1], [4]. In this manner, to keep up a dependable yield power, battery stockpiling frameworks are typically incorporated with PV frameworks to address the changeability issue.

A fuzzy control framework is a control scheme dependent on fuzzy rationale—a numerical framework that breaks down simple information esteems as far as intelligent factors that take on constant qualities somewhere in the range of 0 and 1, as opposed to old style or computerized rationale, which works on discrete estimations of either 1 or 0 (valid or bogus, separately) [3].

An energy management and system is introduced in [7] that provides stable operation for a wind-PV-battery system. The management formula is intended for single-phase electrical converter and it's powerless to manage the reactive power. A scheme introduces another management technique for a wind-PV-battery system, that focuses on optimizing the sizes and prices of the PV array and battery rather than dynamic power leveling. Moreover, the projected technique needs large historical information of thirty years to estimate the facility generated by the turbine and PV array. Similarly, in a technique to optimize the wind-PV-battery system is projected which concentrate on size improvement rather than elaborate management strategies for individual power supply. an influence management strategy for a PV-battery unit is mentioned is supported droop management for load sharing between the PV-battery unit and another power supply [7]

An improved version, that considers multiple power units, has been bestowed; though these methods with success manage the ability demand and production, each of them chiefly specialise in the ability management between the PV-battery unit and different generation units. to boot, these ways don't take into account systems with DC bus and masses. A stratified management algorithmic rule for a PV-battery-hydropower system regulates the AC bus voltage by the hydropower generator and manage the active and reactive power by the PV-battery unit, and another reference introduces an identical technique for a hybrid PV-battery-diesel system. However, each these algorithms fail to contemplate the voltage management for the case wherever the hydropower or diesel generator is out of service [7].

The paper here presents the system prepared by Yi et. al with an additional fuzzy logic controller attached to the MPPT controller section.

2. System Design

The system here will manage the batter system of Photovoltaic framework for backup in both island as well as grid mode, to achieve a stronger outline and betterment in voltage outcome. The schema will have controllers for PV array, Battery and Inverter which is been explained here to understand the design concepts of the system; MPPT controller will have a fuzzy logic controller connected to achieve an enhancement in voltage output. The diagram below depicts the system to show various blocks.

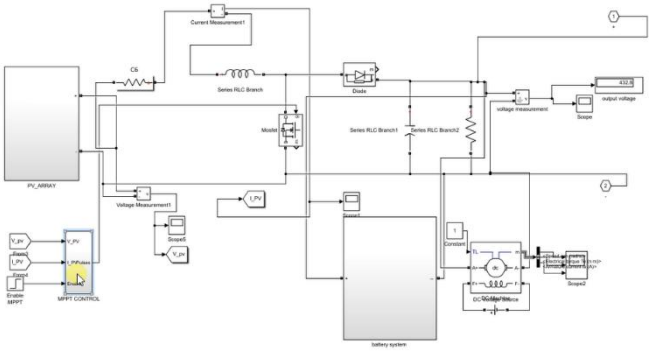

Figure 1: System Block Diagram

The maximum power point tracking from the above figure maybe be dissected for following more explanatory diagram that shows the addition of fuzzy logic controller.

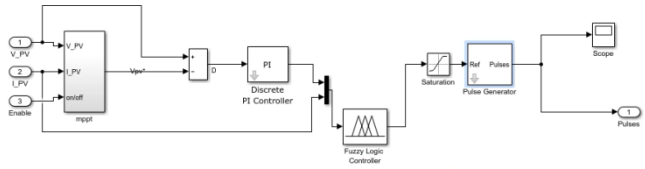

Figure 2: Fuzzy Logic Controller in MPPT Controller

The following sections will explain the different parts of the system which has helped out to achieve the outcome.

2.1. Fuzzy Logic Controller

Fuzzy control regulation can be considered as the information on a specialist in any related field of use. The fuzzy standard is spoken to by a grouping of the structure IF-THEN, prompting calculations portraying what activity or yield ought to be taken as far as the presently watched data, which incorporates both information and criticism if a shut circle control framework is applied. The law to plan or assemble a lot of fuzzy standards depends on a person's information or experience, which is reliant on each unique real application.

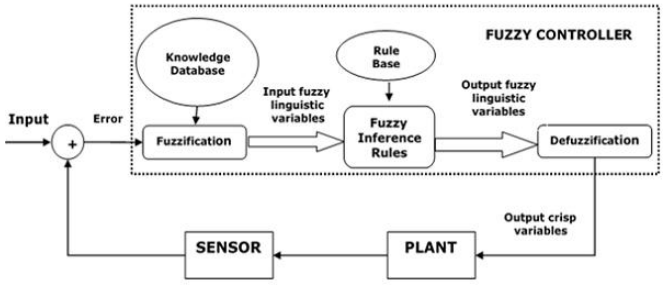

Figure 3: Fuzzy Logic Controller –Working [3]

A fuzzy IF-THEN principle relates a condition portrayed utilizing etymological factors and fuzzy sets to a yield or an end. The IF part is for the most part used to catch information by utilizing the versatile conditions, and the THEN part can be used to give the end or yield in phonetic variable structure. This IF-THEN principle is generally utilized by the fuzzy surmising framework to process how much the info information coordinates the state of a stock.
The procedure utilizes an assortment of fuzzy enrollment capacities. Fresh qualities are first changed into fuzzy qualities to have the option to utilize them to apply rules planned by etymological articulations. At that point, the fuzzy framework changes the semantic determination back to a fresh worth.

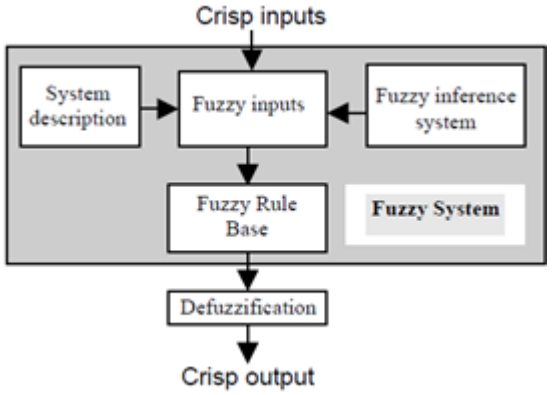

Figure 4: Fuzzy Logic Controller - Block Diagram [3]

These means are depicted as follows:

1) Fuzzification: Crisp information esteems are changed over to degrees of enrollments, and match them with the states of the standards to decide how well the state of each standard matches that specific info.
2) Fuzzy rule base: The assortment of rules is known generally speaking base. Reality esteem for the reason of every rationale rule is figured and applied to the end some portion of each standard. This outcomes one fuzzy set to be relegated to each yield variable for each standard.
3) Inference System: Inference from a lot of fuzzy guidelines includes fuzzification of the states of the principles, at that point spreading the participation estimations of the conditions to the results of the standards.
4) Defuzzification: Fuzzy ideas engaged with the finish of the fuzzy guideline set are made an interpretation of go into object terms before they can be utilized by and by. To do this a set of enrollment capacities must be characterized. [3]

2.2. PV Array Controller

The PV cluster changes over sun based vitality into DC power, and is associated with the DC transport by means of a lift DC/DC converter.

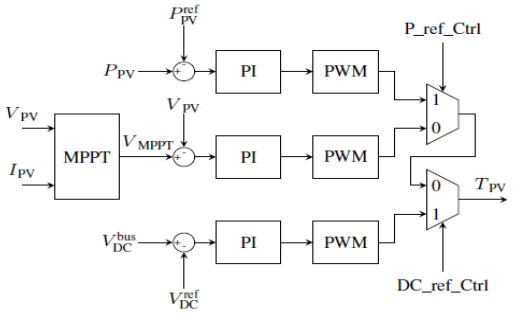

Figure 5: PV Array Controller [7]

Be that as it may, because of nonlinear qualities of PV boards and the stochastic variances of sun based irradiance, there is consistently a most extreme force point (MPP) for each particular working circumstance of a PV exhibit. Hence, most extreme force point following (MPPT) calculations are ordinarily executed in PV framework to

remove the greatest force a PV cluster can give [28]. The proposed CAPMS utilizes one of the most mainstream techniques, the Incremental Conductance MPPT, which gives a reference voltage V MPPT that the PV exhibit will track to produce the greatest force under different activity conditions (various blends of irradiance and temperature). There are three potential control plans for the PV cluster: MPPT control, power-reference control, and DC transport voltage control, contingent upon the circumstance of the PV-battery framework [2], [7].

2.3. Battery Controller

Being an energy buffer, batter bank is compulsory in PV systems aimed at power harmonizing.

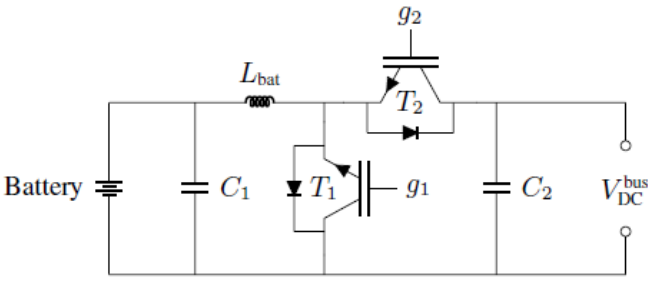

Figure 6: Bidirectional DC/DC Converter for Battery Bank

The battery bank of this coordination is allied to the DC bus, as presented in the diagram above, and is meticulous by a bidirectional DC/DC converter which encompassed two switches, T_1 and T_2, that regulate the charging/ discharging procedure [7].

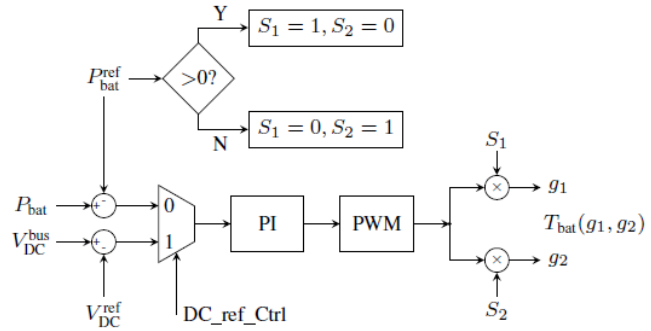

Figure 7: Battery charging/discharging controller [7]

Comprehensive control practice can be evident from figure 6. When the mode on grid connected, the facility DC_ref_Ctrl $= 0$ will regulate the inward as well as outward movement of power within a battery; we can have a discharge during $P_{bat} > 0$ and a charging occur when $P_{bat} < 0$. $T_{bat}\,(g_1, g_2)$ will become the ultimate outcome which turns out to be a 2-D toggling signal. But when an Island mode is being utilized, DC_ref_Ctrl $= 1$ through the support from CAPMS thereby making the converter to operate in a voltage reference approach. The finally flowing voltage will therefore within the reference, which would be in DC mode, due to the action of converter to steady the same; in fact, CAPMS observes and limits the upper and lower values of the battery features [2], [7].

2.4. Inverter Controller

A 3∅ inverter is made use of to achieve the conversion of power from Direct Current to Alternating Current with the help of the interfacing of both the ends. This converter as well will look into the mode in which the scheme of PV is working. While in grid approach, a phase locked loop section takes up the responsibility to pull out θ that is the angular measurement of phase A following the breaker (e_a); but during the islanded situation of operation, θ can be determined locally that turns out to be periodical slope indication ranging from 0 to2π having a frequency f [7].

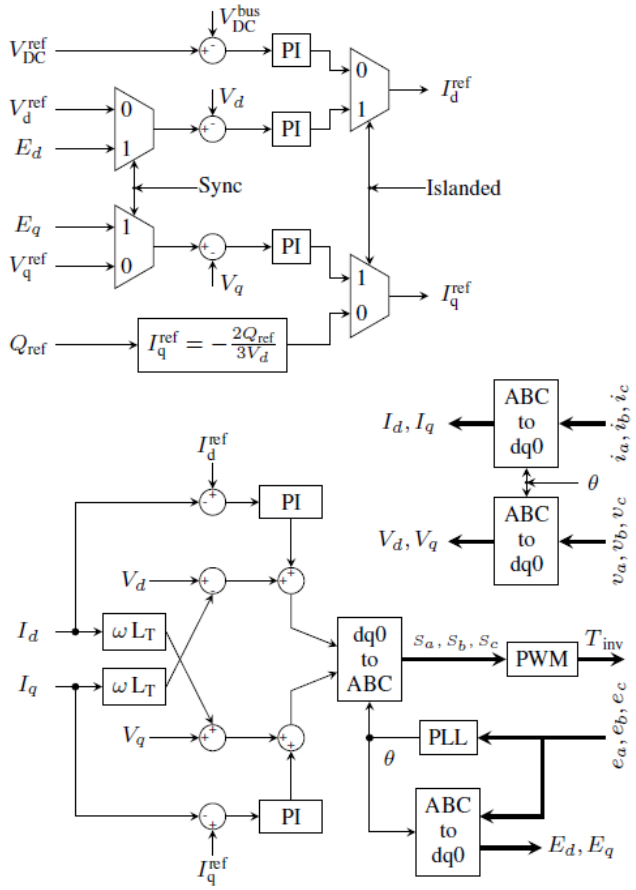

Figure 8: Control Scheme of Inverter [7]

3. System Implementation and Results

The power administration in the battery array connected to a PV system of power has been implemented as shown in Figure 8 where the MPPT controller had a fuzzy logic added to achieve an increased voltage at the output. The output value of V_{dc} can be seen at the simulation outcome depicted in the figure 9 which shows the betterment of the schemewhen compared to the approach made by Yi and others in the same perspective without using the fuzzy logic controller.

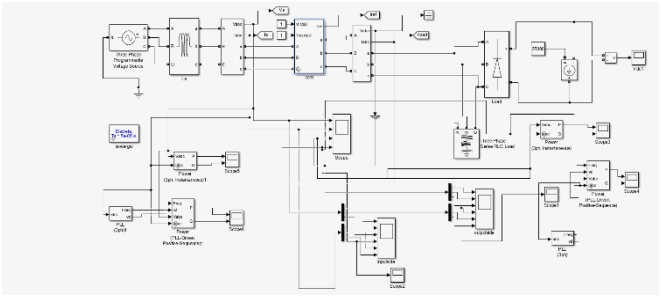

Figure 9: System Implementation

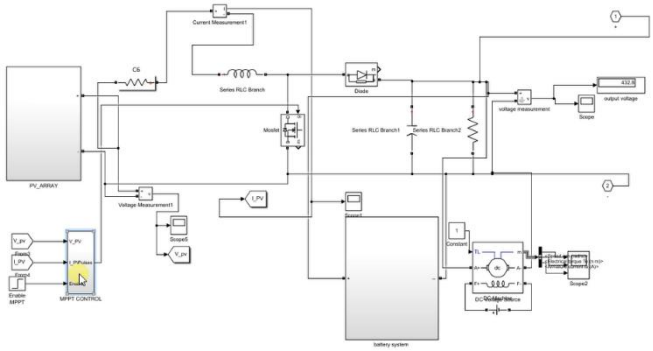

Figure 10: Simulation Result - V_{dc} = 432.8 v

The input and output values of power has been shown here below in figure 10 and 11 which shows the regulation achieved through the system execution.

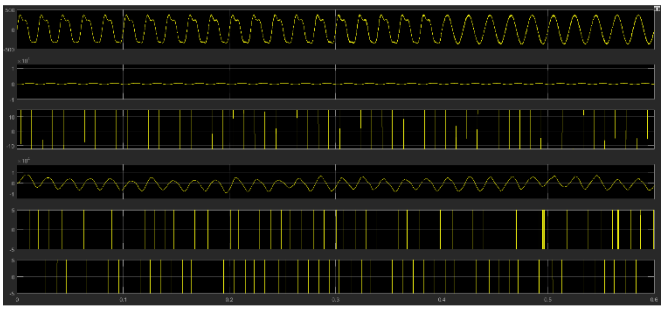

Figure 11: Input to System

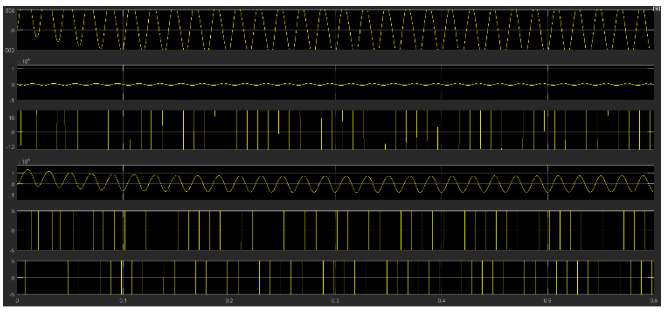

Figure 12: Output from System

The waveform above obtained by the simulation of the circuit can inevitably explain the final possible utility of the approach adopted here thereby getting it done positively.

4. Conclusion

Power management in battery included Photo Voltaic systems made use of solar energy industry has been a very crucial feature witnessed more alertly. Here an approach for regulation has been implemented with an inclusion of fuzzy logic to increase the output direct current voltage considerably. A more robust and capable system in terms of efficacy as well output voltage is achieved.

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