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A Unified Control and Power Management in Hybrid Microgrids

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Abstract: - Battery storage is usually employed in Photovoltaic (PV) system to mitigate the power fluctuations due to the characteristics of PV panels and solar irradiance. Control schemes for PV-battery systems must be able to stabilize the bus voltages as well as to control the power flows flexibly. This paper proposes a comprehensive control and power management system (CAPMS) with fuzzy logic for PV-battery-based hybrid microgrids with both AC and DC buses, for both grid connected and islanded modes. The proposed CAPMS with fuzzy logic is successful in regulating the DC and AC bus voltages and frequency stability, controlling the voltage and power of each unit flexibly, and balancing the power flows in the systems automatically under different operating circumstances, regardless of disturbances from switching operating modes, fluctuations of irradiance and temperature, and change of loads.

Key Words: — Solar PV System, Battery, Fuzzy Logic Controller, Control and Power Management System CAPMS.

I. INTRODUCTION

Continually increasing demand for energy and concerns of environmental deterioration have been spurring electric power experts to find sustainable methods of power generation. Distributed generations (DG) in the form of renewable resources, such as solar energy, are believed to provide an effective solution to reduce the dependency on conventional power generation and to enhance the reliability and quality of power systems [1]. Photovoltaic (PV) power systems have become one of the most promising renewable generation technologies because of their attractive characteristics such as abundance of solar and clean energy. Rapid PV technology development and declining installation costs are also stimulating the increasing deployment of PV in power systems. However, due to the nature of solar energy and PV panels, instantaneous power output of a PV system depends largely on its operating environment, such as solar irradiance and surrounding temperature, resulting in constant fluctuations in the output power [2], [3]. Therefore, to maintain a reliable output power, battery storage systems are usually integrated with PV systems to address the variability 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).

II. 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.

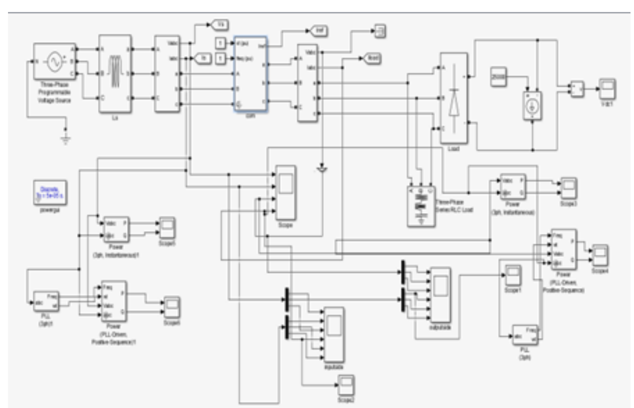

Figure.1. System Block Diagram

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

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A. Fuzzy Logic Controller

A fuzzy control system consists of the following components:

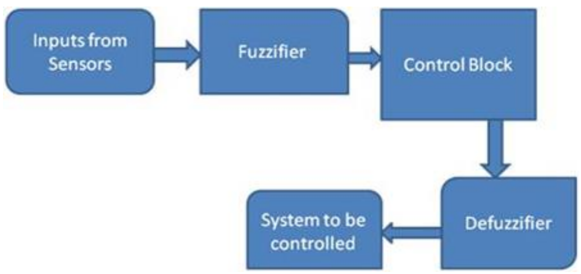

Figure.2. Fuzzy control system

A Fuzzifier which transforms the measured or the input variables in numerical forms into linguistic variables.

A Controller performs the fuzzy logic operation of assigning the outputs based on the linguistic information. It performs approximate reasoning based on the human way of interpretation to achieve control logic. The controller consists of the knowledge base and the inference engine. The knowledge base consists of the membership functions and the fuzzy rules, which are obtained by knowledge of the system operation according to the environment.

The Defuzzifier converts this fuzzy output to the required output to control the system.

B. 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.

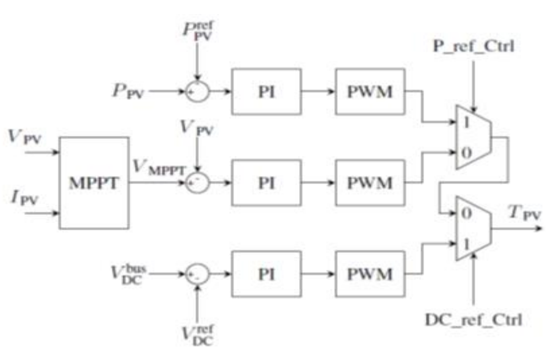

Figure.3. PV Array Controller [7]

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].

C. Battery Controller

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

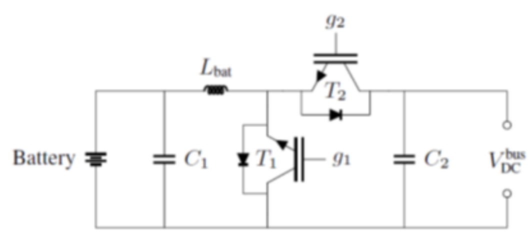

Figure.4. Bidirectional DC/DC Converter for Battery Bank

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, $T1$ and $T2$, that regulate the charging/ discharging procedure [7].

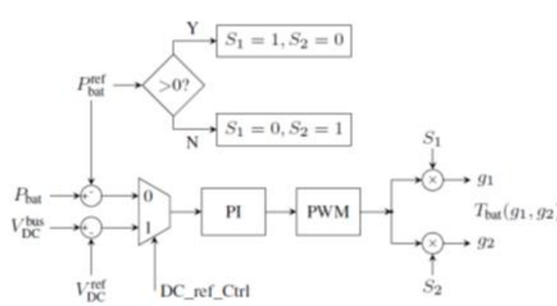

Figure.5. Battery charging/discharging controller [7]

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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 $Pbat$ > 0 and a charging occur when $Pbat$ < 0. $Tbat$ ($g1$, $g2$) 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].

D. 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 (ea); 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].

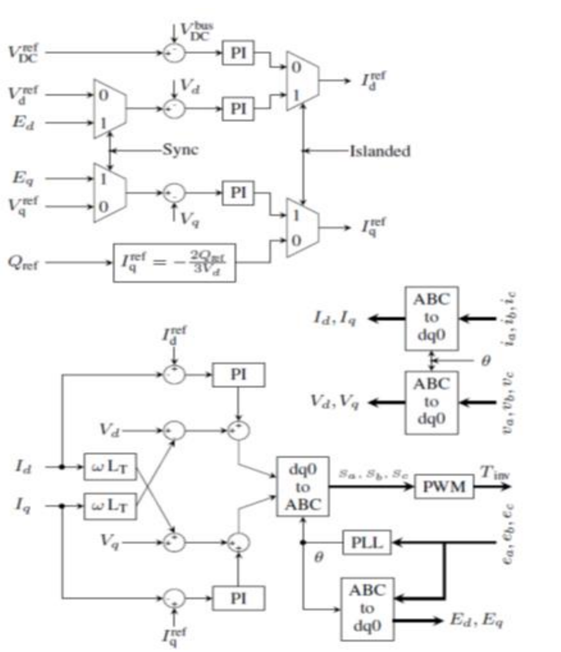

Figure.6. Control Scheme of Inverter [7]

III. 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 6 where the MPPT controller had a fuzzy logic added to achieve an increased voltage at the output. The output value of Vdc can be seen at the simulation outcome depicted in the figure 9 which shows the betterment of the scheme when compared to the approach made by Yi and others in the same perspective without using the fuzzy logic controller.

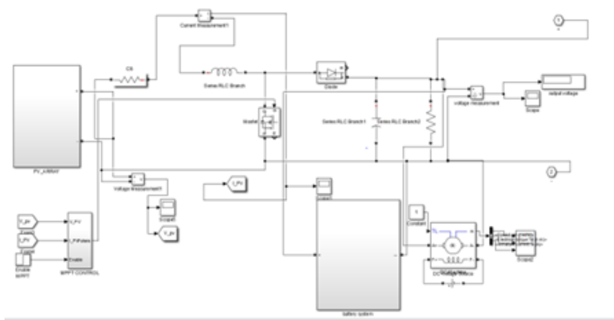

Figure.7. System Implementation

The figure below shows the regulation achieved through the system execution.

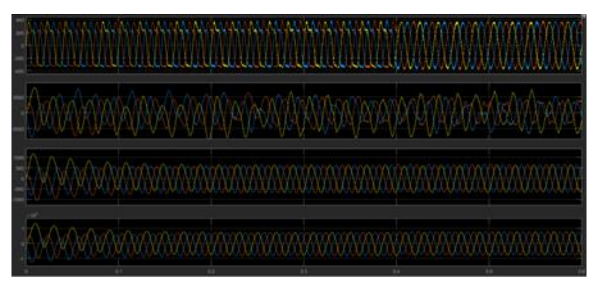

Figure.8. Output from System

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.

IV. Conclusions

This paper proposes a control and power management system (CAPMS) with fuzzy logic for hybrid PV-battery systems with both DC and AC buses and loads, in both grid-connected and islanded modes. The presented CAPMS is able to manage the power flows in the converters of all units flexibly and effectively, and ultimately to realize the power balance between the hybrid microgrid system and the grid.

Furthermore, CAPMS with fuzzy ensures a reliable power supply to the system when PV power fluctuates due to unstable irradiance or when the PV array is shut down due to faults. DC and AC buses are under full control by the CAPMS in both grid-connected and islanded modes, providing a stable voltage environment for electrical loads even during transitions between these two modes. This also allows additional loads to access the system without extra converters, reducing operation and control costs.

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