Design of Hybrid Fuzzy-PI Controller in Power Management System for PV Battery Based Hybrid Micro Grids Operations

K. Swetha, D. Vijay Kumar, P. Ravi Kiran

Abstract: ***Distributed generation is an important method to accumulating the energies from different sources. It has not impacted the environmental conditions along with to mitigate the transmission losses. In this regard, battery banks are performance very imperative role in the solar system for suppressing the power fluctuations and enhance the power quality. Moreover, various control techniques are essential to the PV-battery system because of rendering the continuous power flow during random load variation. This paper mainly focused on complete control and power organization system (CAPMS) with a hybrid fuzzy-PI controller for PV battery bank based on AC and DC buses in micro-grid operations. The proposed CAPMS improve the dynamic response of the system under extensive operating conditions. Also, it has controlled the DC and AC bus voltages and eccentricity of the frequency of the system. The proposed hybrid fuzzy PI system has an ability of improving the system stability compared with conventional PI controller. The simulation is approved out by Matlab/Simulink as well as compares the performance of the proposed approach with other conventional controllers.***

***Index Terms*: PV battery banks, solar system, control and power management system, distributed generation, Micro grid,hybrid Fuzzy-PI controller.**

I. INTRODUCTION

Distribution generation (DG) is more useful in present days because of it has tolerable the number of energy sources in the form of renewable sources. The nonconventional sources are solar, wind, tidal,etc. Presently, thenumber of governments throughout the world encourages the solar systems and provides subsidies to install solar plants. Since usage of renewable energy sources, render the efficient and reliable power supply to consumers without interruptions. Besides, by using renewable energy sources to reduce the transmission losses and impact of bad environmental conditions[1]. Mostly, the important and lucrative renewable energy generation is photovoltaic (PV) electrical systems. It has lot of benefits such as plenty of solar energy and pollution free.The maximum amount of electric power is obtaining mainly depends on the solar energy and PV panels. But the entire PV systems completely build upon environmental conditions namely solar irradiance and weather conditions so if the fluctuations and flickers are occurred in output power flows[2,3].

Revised Manuscript Received on June 01, 2019.

K Swetha, Department of Electrical and Electronics Engineering, SRKR Engineering College, Bhimavaram, India.

D Vijay Kumar, Department of Electrical and Electronics Engineering, SRKR Engineering College, Bhimavaram, India.

P Ravi Kiran, Department of Electrical and Electronics Engineering, SRKR Engineering College, Bhimavaram, India.

So, battery banks are used often for overcoming those problems as well as to sustain the quality and reliable in power. Normally, the number of PV panels and battery banks are incorporated to the micro grid system.These battery banks are giving the continuous and efficient supply to the consumers. The bidirectional inverter is set up in the middle of the system and which is interfacesthe DC to AC power systems[5,4]. Since installed the DC/DC converter in the power management system, it is easy to control the power flow in PV-arrays. And, the bidirectional converter has placed near to battery banks in the system then it has controlling the battery bank charging and discharging. The DC and AC power is transfer to destination through the different buses and equipment. In this way, the demand of DC power is transfer through the DC bus and transmitting the AC power for require load over Point Of Common Coupling (**PCC**). When transmuting the breaker characteristics at PCC then PV-battery bank merely able to operate in grid connected and islanded modes[6–8]. Moreover, the power management algorithm is quite essential to PV-battery bank system for retain the power generation and consumption at large random load varying circumstances.Since 1980's, number of researchers were disclosed the various power management methods for PV-batterysystem.Merabet*etal*.[9]Implemented the control system in wind based micro gridsystem with PV-battery. However, the control algorithm is introduced in single phase inverter even though it has not regulated the reactive power properly. In addition, the innovative control algorithm has penetrated in wind based PV-battery bank system[10]. By using this algorithm, the cost of PV array and battery bank were optimized favorably, these advantages are absent in merabet*et al.*[9].

In this paper, hybrid fuzzy-PI controller is proposed in control and power organization system for improving the performance of PV-battery bank systems. Which is control the fluctuations, flickers, random load changing and power flow transfer among micro grid. Furthermore, it has stabilized the voltage in both AC and DC buses as well as transmitting the efficient power between grid connected and islanded modes in terms of balance the production and load demand.

II. THE STRUCTURE OF CONTROL AND POWER MANAGEMENTSYSTEM

Fig.1 The specification of PV-battery bank system is demonstrated in proposed micro grid based control and power organization system with figure 1.The PV array has attached to DC bus by

DC-DC boost converter as well as bidirectionalconverter is located at vicinity of battery bank. Thereupon, it has protected the battery bank in the presence of charging and discharging modes.
The PV-battery bank based micro grid system has looked into similar specifications[11–13]. The power management system comprises of different modules. These modules would use to check the realistic parameters in the PV-battery system of the converters.In fact, the PV-battery system able to operate either grid-connected or islanded mode when it has directly connected to the grid through circuit breaker. Control and power management system always monitor the circuit breaker working and find the voltage levels. If any differences occur in voltage levels then promptly the control scheme has imposed to converter operations. When consider the grid connected mode, the converter (inverter) has regulate the reactive power (Q_{AC}) and DC bus voltage (V_{bus}) level of the system. For AC side, PV and battery system has different converters for controlling the output power in PV array and charging and discharging in battery bank.

On the other hand, the circuit breaker has opened when large load variation so if the control method is to protect the system. Itwould sustain the scheduled AC frequency and to balance the generation and load demand during disturbances.

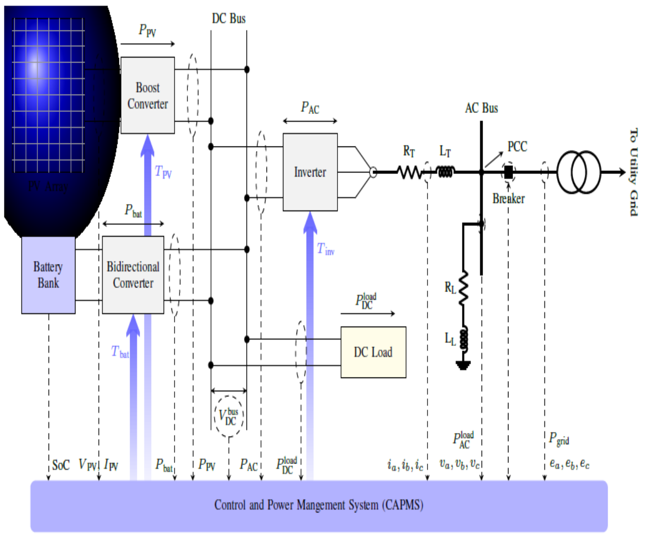

Figure 1.Schematic diagram of power management system

As transmuting the mode of grid connected to island, control the AC bus voltage (V_A, V_B, and VC) and Frequency of the system by using the inverter switches. At the same time, the DC-bus voltage regulates by battery converter as well as both modes are supervision under state of charge (SoC) of the battery bank. The power management equations in both modes are,

For

grid connected, $P_{PV} + P_{bat} = P_{DC}^{load} + P_{AC}^{load} + P_{Grid}$ (1)

For

Islanded mode, $P_{PV} + P_{bat} = P_{DC}^{load} + P_{AC}^{load}$ (2)

Where, PV array output power is $P_{PV}$and$P_{bat}$is the power flows in battery converter. In this regard, charging and discharging of the battery is represents with different conditions. For charging mode the condition is $P_{bat}<0$ and $P_{bat}>0$ for discharging mode.Also, P_{DC}^{load} and P_{AC}^{load} Are DC and AC load demands. Basically, P_{Grid} is identified with interchange of power between main grid and micro grid associated with circuit breaker.

III. DESIGN OF SYSTEM CONTROLLERS

A. PV Array:

The PV array would use to store the solar energy after that it has converted into DC power.The boost DC-DC converter to boost the DC power through DC bus. The greatest power point following (MPPT) is actualized to PV array system for stabilizing the fluctuations and output power flow due to solar irradiance and various temperature conditions[14]. Likewise, the PV array is controlled by three methods namely MPPT technique, control reference control and DC transport voltage dependent on the condition of the PV-battery bank framework. Fig.2 demonstrates the structure of PV cluster,

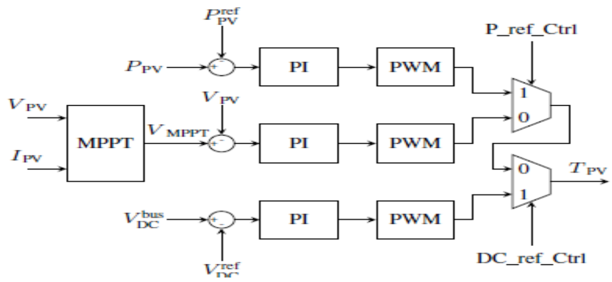

Fig.2 Structure of PV array

B.Design of battery converter:

The battery bank is very noteworthy in PV frameworks as a result of adjusting the power age and burden. As a matter of fact, the bidirectional DC/DC converter controls the battery bank through DC transport. The schematic chart of the battery bank is represented in Fig.3,

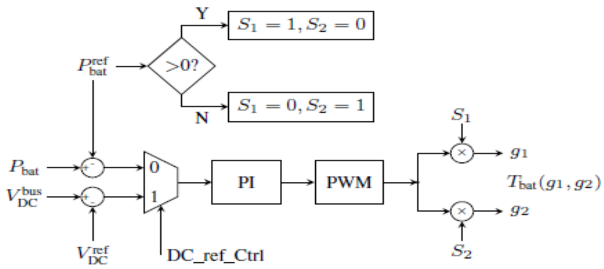

Fig. 3 Arrangement of battery controller.

The battery bank system has two switches such as T_1 and T_2. Furthermore, the charging and discharging modes are controlled by these two switches. If consider the grid connected mode, the power flow is controlled either in or out of the battery by different commands. In islanded mode, the DC bus load voltage must be stabilized with commands in power management system.

C.Three phase Inverter :

A three phase inverter is designed in this system, which converts DC power to AC power at different firing angles.

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Moreover, the control technique of three phase inverter depends on the various modes of operation of e system namely grid connected and islanded mode. The design of three phase inverter is shown in Fig.4,

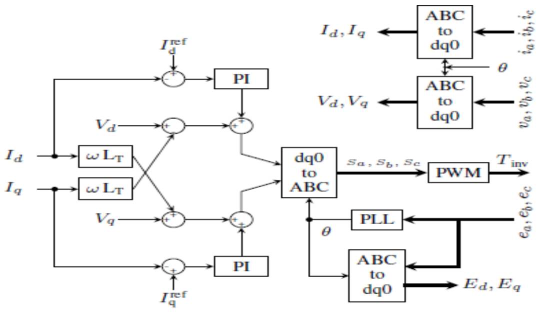

Fig.4 Design of three phase inverter

When the system is in grid connected mode, accurate angle θ of phase-A voltage is obtained with phase locked loop (PLL). But in islanded mode, the angle θ is produced within the inverter which is varying with the frequency from 0 to 2π as periodic ramp signal. In this paper, proposed the hybrid fuzzy-PI controller for to mitigate the fluctuations, unnecessary oscillations and disturbances in the output power. Besides, the hybrid controller render better dynamic response in the modes of grid connected and islanded modes.

IV. SIMULATION RESULT ANALYSIS

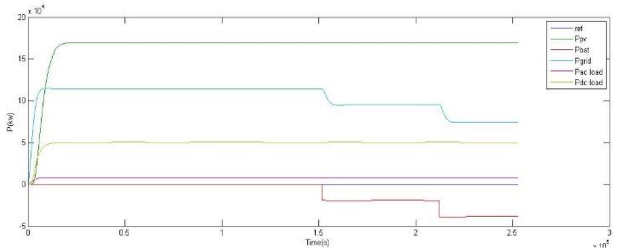

Fig.Case-1(a)Power streams of the PV-battery framework.

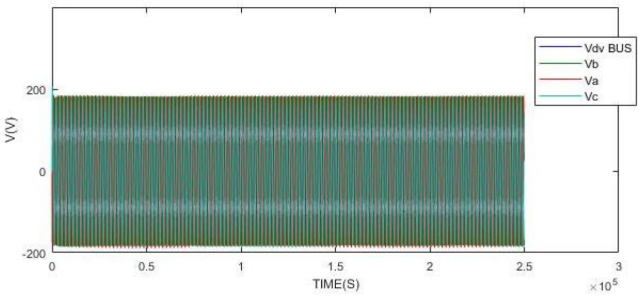

Fig.Case-1(b)Voltage estimations of the PV-battery framework

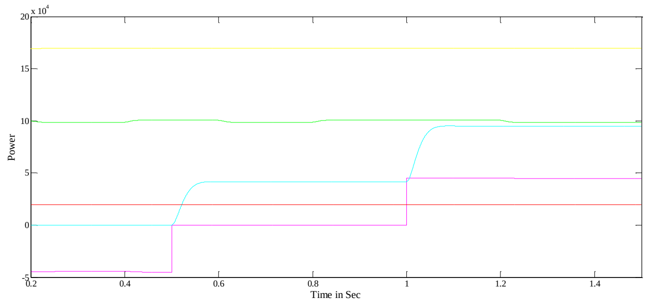

Fig. Case-2 power

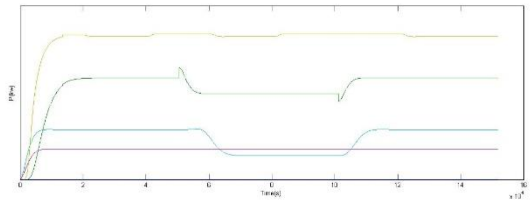

Fig.Case-3 PV-array in power-reference mode

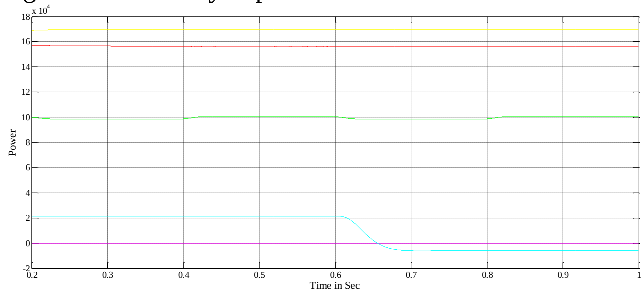

Fig. Case-4receving power

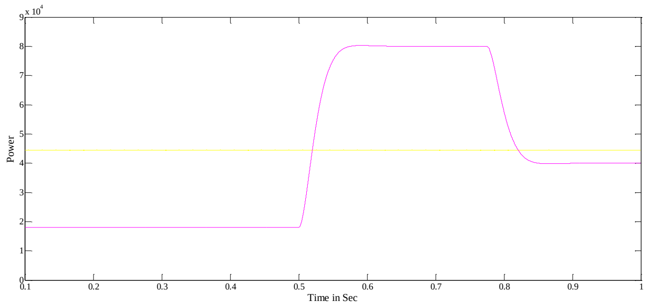

Fig. Case-5 Reactive power control of the inverter

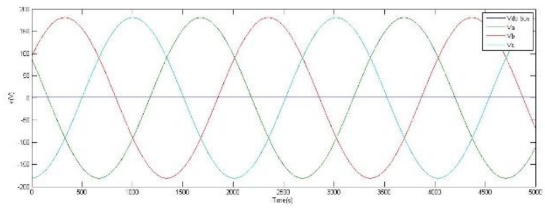

Fig.Case-6 transition

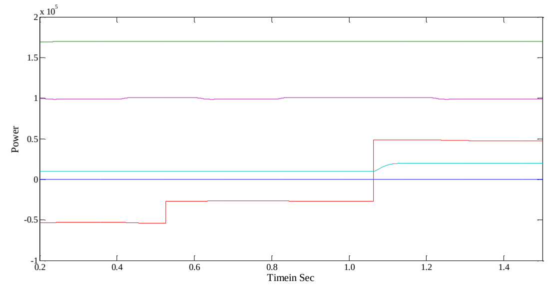

Fig. Case-7 control streams of the PV-battery framework with changing burdens

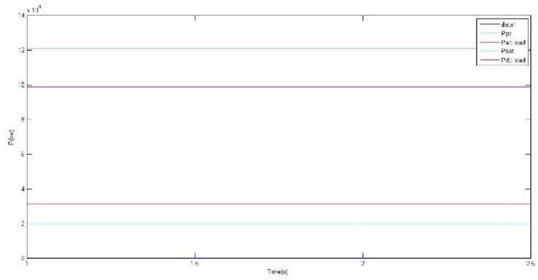

Fig.Case-8 power changes with PV system generation.

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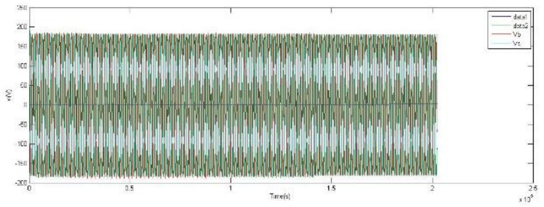

Fig.case-9 bus voltages

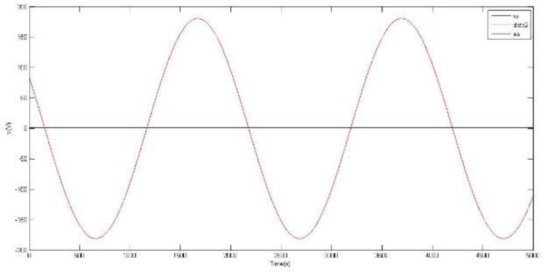

Fig.Case-10 AC bus voltages(unsynchronized)

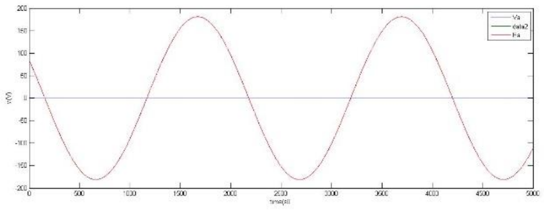

Fig.Case-11 AC bus voltages(synchronized)

V.CONCLUSION:

The proposed hybrid fuzzy-PI controller performed effectively in hybrid PV- battery bank system of power management in the presence of DC and AC loads. The proposed controller has regulated the power flow between converters in the operation ofgrid connected and islanded modes.The control method to balance the power generation and consumption of power in between hybrid micro grid and grid system at varying of random loads.Moreover, the control and power management system ever behaves supervisory and keep AC and DC buses within limits during the transients occur in two modes of grid-connected and Islanded mode.The system to tolerable the number of loads without using supplementary converters. Eventually, the hybrid fuzzy-PI controller gave better responses rather than the conventional controllers.

APPENDIX:

System investigated with specified parameters,

TABLE I
BASIC PARAMETERS OF THE PV-BATTERY SYSTEM UNDER STC

Parameters	Values
PV Maximum Power (P_{PV}^{MPPT})	170 kW
PV Maximum Power Voltage (V_{MPPT})	122 V
Battery Capacity	45 kAh
Battery Fully Charged Voltage	412.5 V
Battery Nominal Voltage	400 V
Battery Max Charge/Discharge Power	150 kW
DC Bus Voltage (V_{DC}^{ref})	450 V
AC Bus Voltage (line to line)	208 V
Transformer Voltage Ratio	208 V : 1.2 kV

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AUTHORS PROFILE

Completed my M Tech in high voltage engineering from jntu Kakinada and published 15 research articles in various international conferences and national and international journals, a member of IEI.

Completed my doctorate in control systems from AU Visakhapatnam and published 54research papers in various national and international conferences and journals, a member of ISTE.

Completed my B.Tech Degree in Electrical and Electronics Engineering from Sir CR Reddy Engineering College under Andhra University. Presently working as Research Scholar in Sagi Rama KrishnamRaju (S.R.K.R.) Engineering College.

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