An Efficient Control of DC Microgrid with Variable Generation and Energy Storage System in Standalone or Grid Integrated Mode

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Abstract— This paper represents a hybrid system implant of Solar (PV) Energy storage device (Battery) and Supercapacitor (SC) and fuel cell to obtain isolated DC load demand. The solar (PV) is the preliminary energy source, where battery and Supercapacitor both are considered for their discrete power density to supply transient and static load consecutively. All source are joined to DC link bus by different DC-DC converters. A power flow control scheme modify theirfluctuate DC voltage to bus voltage by means of these converters. In this work, SC is taken to work for a limited period where fluctuation in load demand. Battery and FC are used for energy storage purposes. Battery is eligible to supply long term energy demand and Fuel cell used for backup source of energy which is used absence of solar energy and battery. Fuel cell charged the battery if it goes his minimum soc. SC is essential to meet temporary load demand. After that fault analysis will take place at different point of micro grid. The flawless energy management concept has been validated in MATLAB/SIMULINK with irregular load demand and solar radiation profile.

Keywords: PI Controller, Hybrid Power System, Super Capacitor, Nickel Metal Hydride Battery, Fuel Cell

I. INTRODUCTION

Recently, renewable energy sources are more popular for production of electricity and its increases day by day. Solar energy mostly used for generate electricity. PV is one of the most useful renewable energy sources. In hybrid system of pv battery and SC FC where battery and SC used for storage purpose. The main advantage of battery over SC is its high energy density. They can store energy at the minimum 3- 30 time beyond charge than SC. where, SC are able to deliver hundred to thousand time more power than a similar sized battery.so battery used for long term energy demand and SC are used for transient load demand. The major challenges are to take continuous power to variation in load demand so many scientists and engineers to focus on control of hybrid system.

In this paper hybrid PV-Battery-SC-FC system has chosen for the application of separate DC load isolated from the dc micro grid with distributed generation. This system used for telecom load, ATM, hospital and military establishment etc. Battery and SC both as the storage device make the system capable to supply continuous power in variation in load demand. PV the main source of energy which are connected to battery and SC are try to keep the storage devices charged to desired level.

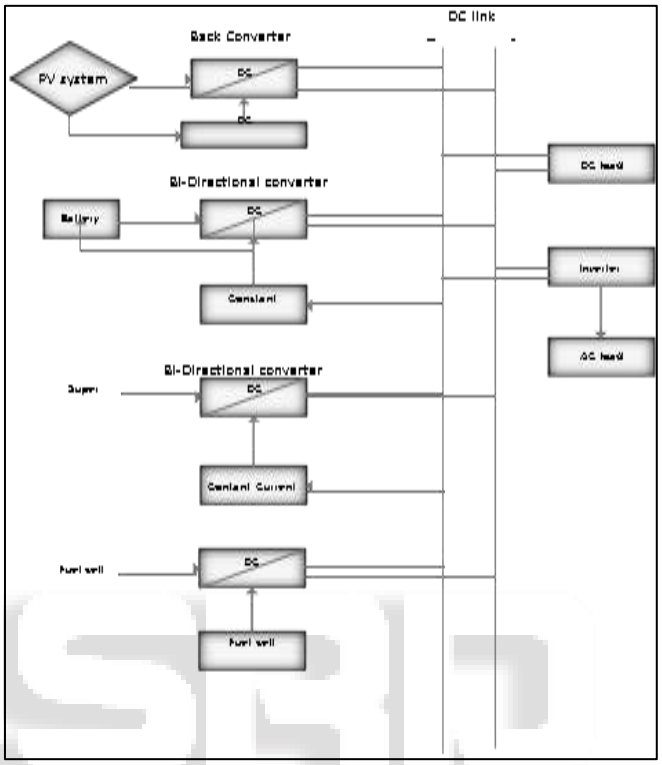


Fig. 1: Energy management

In this study, new control scheme has been suggested for PV system. PV is main energy sources which are used for DC load demand and also charged battery and super capacitor when load demand less than generated power. Battery controller charged battery at its maximum SOC and also discharged min SOC level which are link together to PV and SC controller and FC controller.

Section II solar system modeling followed by control objectives of system in section III and section IV the energy management strategy has been described with individual controller model. In section V system description is presented comparison of objectives with result It is followed by the conclusion in section VI.

II. MODELLING OF SOLAR SYSTEM

In this paper are used at primary sources. PV array are interfaced with the DC load by means of buck converter connecting with maximum power point tracking to always extract extreme available solar power. Its production varies with fluctuating irradiance and temperature. Fig 3 describes the model of PV controller.it has two operational modes; maximum power point tracking and content DC link bus voltage controller. The pv controller always works in MPPT mode which is show in fig 2.

In this paper, applied incremental conduction method used for extreme power from PV array which

operates by sensing the PV voltage (Vpv) and PV current (Ipv).MPPT always regulates PV power to its maximum power. Pv power sources given to load demand and extra power charged battery and super capacitor. If both of storage elements are at maximum limit then PV panel is connected in series DC/DC buck converter is used to control pv current.in this configuration 10 modules in 2 strings (each string with 5 modules in series) are connected to the DC bus.

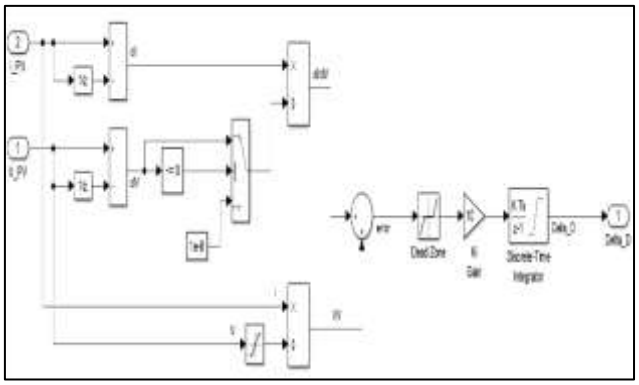


Fig. 2: Control strategy of MPPT

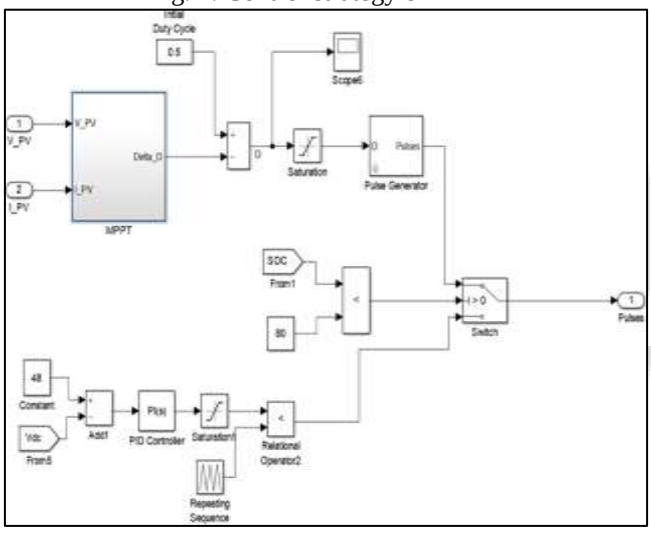


Fig. 3: Control strategy of Solar System

III. CONTROLLER OF BATTERY

To make the system more secure and use full for different load condition operational purposes have been decided. The energy commutation between DC bus and various source can be established by considering following control specifications.

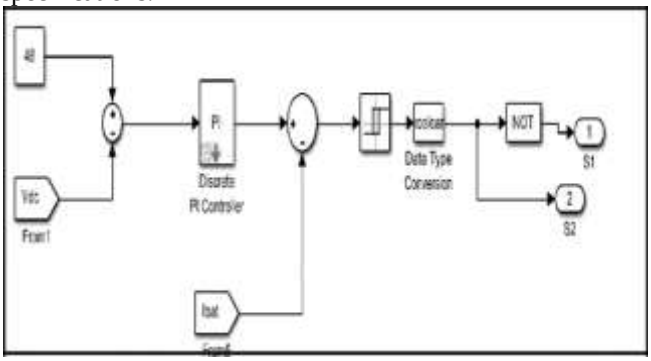


Fig. 4: Controller of Battery

- Maximum power point tracking of PV power depends on solar irradiance and temperature which is primary control parameter.
- Load input among all the energy sources in energy management strategy.
- Charging -discharging cycle of battery. Battery is allowed to discharge up to certain limit and then get charged by PV power and in case pv power source not allowable these time fuel cell charge the battery his maximum SOC.
- Operation of SC near to its fully charged voltage being fast response axillary source.
- Battery controller used to battery charged and discharged by buck-boost converter which is charged by pv power and discharged by dc load demand.
- DC link voltage equilibrium with safe operation of SC by preventive its charging and discharging current limit.

Based on the above objectives, hybrid system has been fill full load demand by pv power which is connected to hybrid control strategy. And also charged energy storing elements. This system has been designed in MATLAB SIMULINK with charging load condition with system dependability.

IV. CONTROLLER OF SC

SC has been chosen for unexpected changes in load demand and absorb transient power due to fast charging discharging cycle, and it has good efficiency and long life time.

The Supercapacitor's are join to DC link by means of a two quadrant DC-DC Converter. This converter is directed by the balancing pulses applied to two switches S1 and S2.This converter is operating in three modes: off, charging mode and discharging mode. The SC current can be positive or negative depending on its charging or discharging mode. At the time of discharging, SC current is conceived to be positive and at the time of charging, it is negative.

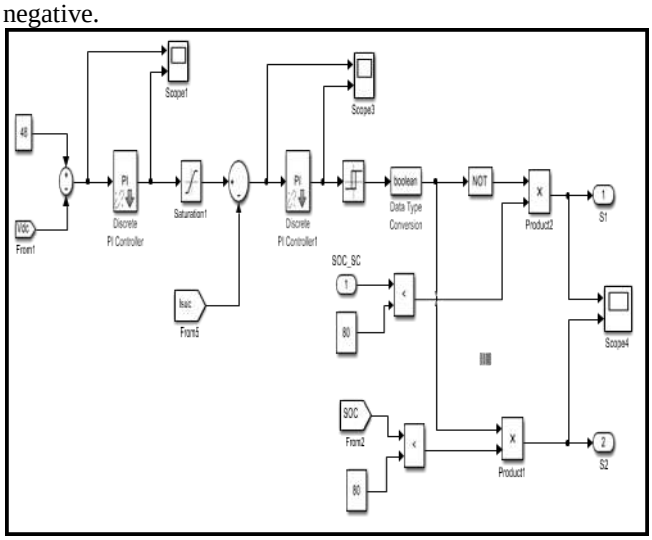


Fig. 5: Controller of Super Capacitor

Figure.5 shows the control strategy of the SC converter. Here, SC converter is controlled by two cascaded PI controller comprises of external voltage by means of internal current control. DC link voltage (Vdc) is sensed and associated with the DC link voltage reference (Vref) to

produce the error. This error is diminished by the PI controller and SC current reference (Isuc) is generated. This Isuc must be restricted to extreme allowable charging discharging currents by means of SC current directive function.

V. SYSTEM DESCRIPTION

A control plan of hybrid system has been taken for study with adjustable load demand and variable solar irradiance. The system should always be able to satisfy the desired load demand. In table 1,the rating of the system components including converter specifications are listed. Three sources are port with standalone DC load by means of three different converters is the major source .their size have been taken consequently, so that it can supply the load, as well as keep the storage devices charged .more over,battery and SC are sized such that they can meet the load demand when PV is unobtainable.

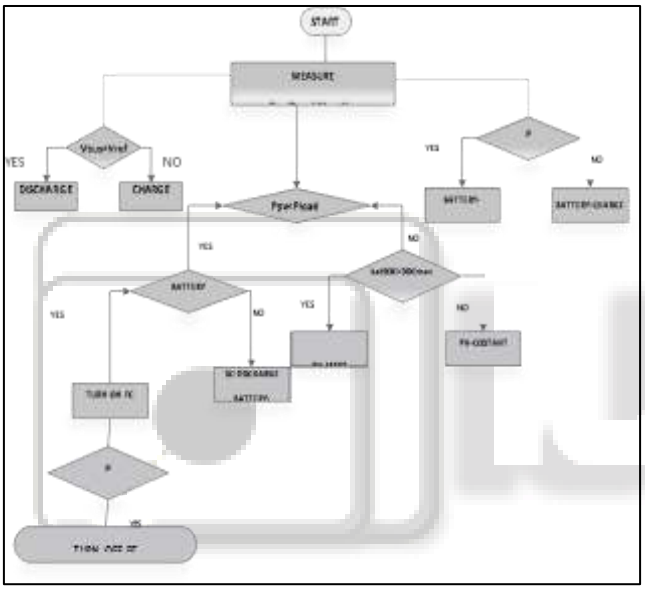
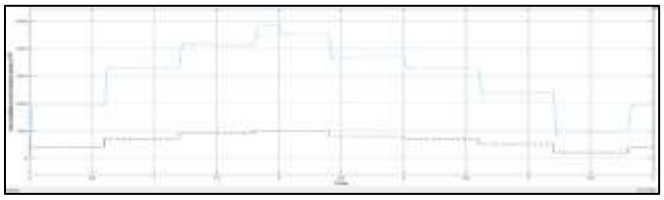


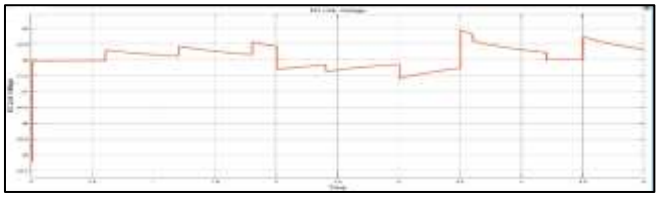
Fig. 6: Energy Management System

System component	Ratings
PV module	Voltage at MPP=30.7V, Current at MPP=8.15A, Power at MPP=250.205Wp,at STC
PV Array	Power at MPP=5 KW, at STC
Battery	Nickel metal hydride 24V,400Ah, Bat SOC min=20%, Bat SOC max=80%
Super Capacitor	Csc=300F, ESR=0.00004Ahm , Rated Voltage=30v, ,Iscmax=50, Iscmin=0,
Fuel cell	PEMFC-6KW-45Vdc
Dc-Dc converter	L1= 0.0477mH
Bidirectional converter	L2= 2.7429 e-5 H
Bidirectional converter 2	L3= 1.7429e-5 H
Dc link voltage	48V
Load	1500 w (average load)

Table 1: Specification of Hybrid System Components

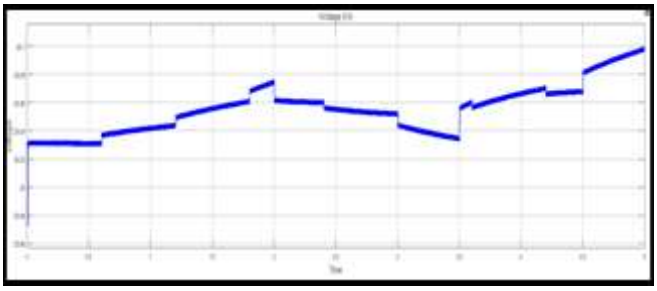


MAXIMUM POWER OUTPUT OF PV AT VARIABLE IRRADIANCE

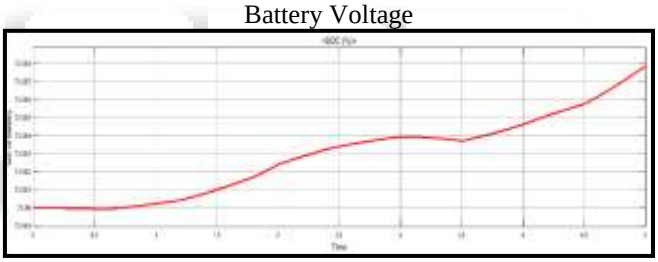


DC LINK VOLTAGE OF PV SYSTEM

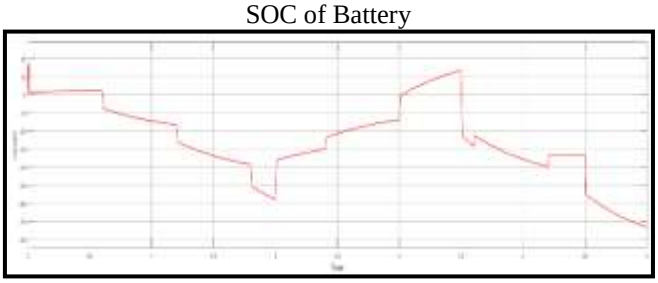
VI. RESULT



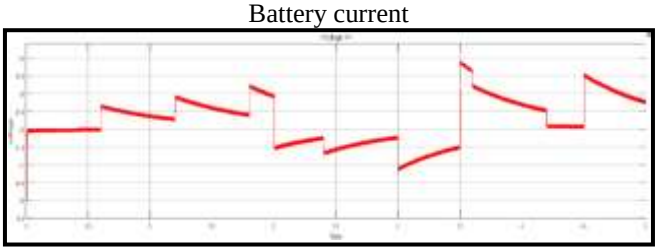
Battery Voltage



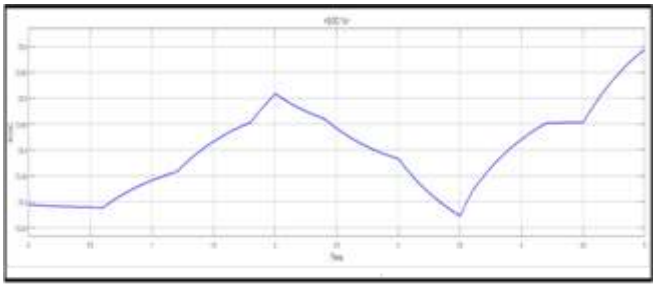
SOC of Battery



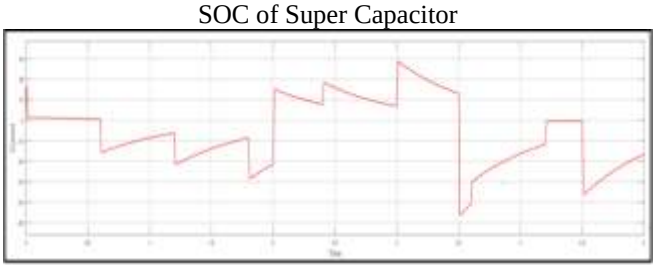
Battery current



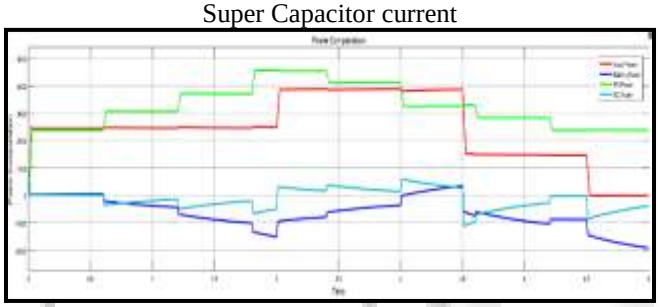
Super Capacitor Voltage



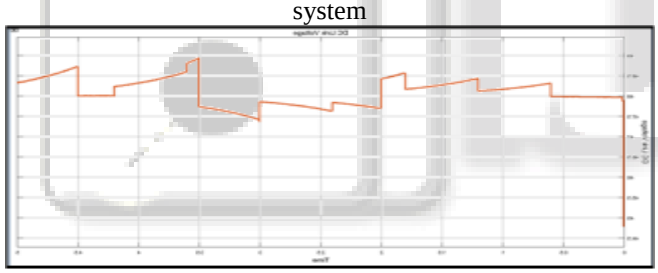
SOC of Super Capacitor



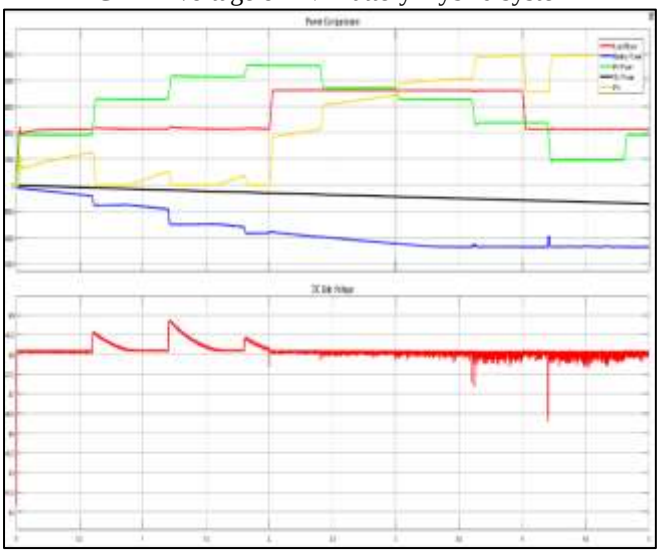
Super Capacitor current



Power comparison waveform of PV-Battery SC Hybrid system



DC Link voltage of PV-Battery Hybrid system



Simulation Results of PV-Battery with SC-FC Hybrid System

VII. Conclusion

In this paper we studied a most appropriate energy management control strategy of PV-Battery-SC-FC hybrid system. Our analysis here for continuous load condition here PV and fuel cell used as source and SC used for transient load condition because SC given fast response then battery. And battery used for back up source for fluctuation in load demand. Battery charge by fuel cell so this system given continues power given to various load condition. The simulation shows that classical PI controller-based control system for hybrid system which supplies the DC load, also keep battery and SC virtually fully charged and decreases FC usage by minimize FC running period. The simulation outcome shows the dependability of power supply and decreased fuel usage.

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