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Hybrid Energy Conversation System Connected To Grid Using Integration of PV with Power Quality Improvement

Sirpa Abhilash
B.Tech,
Department of EEE,
Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad.

Bandari Anil
B.Tech,
Department of EEE,
Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad.

Annadi Mrudula
B.Tech,
Department of EEE,
Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad.

ABSTRACT:

Grid integration of photo voltaic (PV)/Battery hy-brid energy conversion system with (i) multi-functional features of micro grid-side bidirectional voltage source converter (µG-VSC) (ii) tight volatge regulation capability of battery converter (iii) MPPT tracking performance of high gain integrated cas-caded boost (HGICB) dc-dc Converter with quatratic gain and less current ripple are presented in this paper.

The PV side HGICB Converter is controlled by P&O MPPT algorithm to extract the maximum power from the variable solar irradiation. This paper proposes a modified Instantaneous symmetrical components theory to the µG-VSC in micro-grid applications with following intelligent functionalities (a) to feed the generated active power in proportional to irradiation levels into the grid (b) compensation of the reactive power, (c) load balancing and (d) mitigation of current harmonics generated by non-linear loads, if any, at the point of common coupling (PCC), thus enabling the grid to supply only sinusoidal current at unity power factor.

The battery energy storage system (BESS) is regulated to balance the power between PV generation and utility grid. A new control algorithm is also proposed in this paper for the battery converter with tight DC link voltage regulation capability. The dynamic performance of battery converter is invistegated and compared with conventional average current mode control (ACMC).

A model of a hybrid PV Energy Conversion System is developed and simulated in MATLAB/SIMULINK environment. The effectiveness of the proposed control strategies for HGICB converter and µG-VSC with battery energy conversion system are validated through extensive simulation studies.

PROSED SYSTEM:

Public interconnected power grids are composed of complex combinations of generation plants, substations, transformers and transmission lines, which supply electricity to cities, businesses and industry. In addition, there are smaller independent power grids that provide power to islands or remote areas, which have limited or no access to public interconnected grids. Connecting these areas and regions to the public grid is a time and money consuming process or in some cases physically impossible. Traditionally, small stand-alone grids are electrified by diesel generators. However, the renewable energy resources are attractive sources of power, since they can provide sustainable and clean power. Hybrid plants can be an integration of diesel generators with renewable energy resources such as photovoltaic. In addition, integrating a battery energy storage system (BESS) with the hybrid plant provides significant dynamic operation benefits such as higher stability and reliability of power supply. Hybrid plants are outlined as an optimum approach for off grid power supply options for remote areas applications.

TECHNOLOGY :

The following technology is used in the paper:

- Micro grid-side bidirectional voltage source converter
- Tight volatge regulation capability of battery converter
- Mppt
- High gain integrated cas-caded boost (hgicb)
- Dc-dc converter with quatratic gain
- Battery energy storage system
- Average current mode control (acmc)

WORKING PRINCIPLE:

In order to analyze the operation of the plant, the dynamic operation is run in the software Power Factory.

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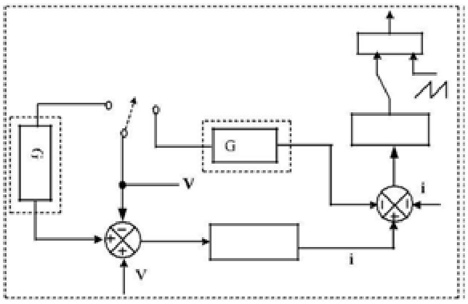
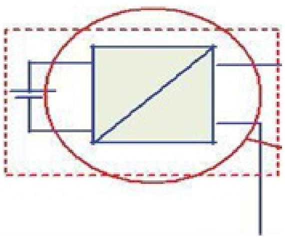
Firstly, a model of diesel plant is implemented by integrating built-in models of diesel generator with its controllers and a load model, and then the models of three diesel generators are integrated with the load. Moreover, a model of fuel consumption measurement is developed in the thesis and integrated. Then, a model of battery energy storage system is integrated with the diesel plant and load, and then a model of PV field is integrated with the plant. After that, the model is integrated with supplementary components such as lines and transformers. Finally, a model of secondary controller is developed in this thesis and integrated with the model of the plant. Four control strategies in relation to primary and secondary control of active power are proposed. Each control strategy leads to different performance and variations in the output power of the diesel generators and the BESS. The operation of the hybrid plant is analyzed according to each control strategy according to the results of the simulations.

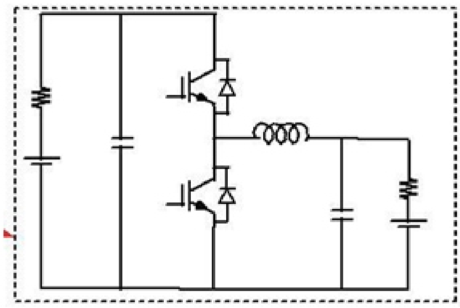


Block Diagram



Storage

Block diagram is shown in below



MODELING AND CONTROL:

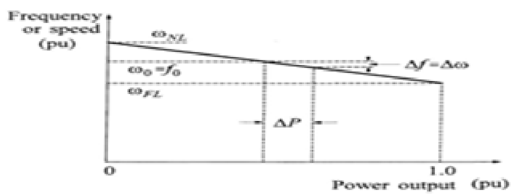
The MPPT algorithm for HGICB Converter, control approaches for battery converter and μG-VSC are discussed in the following :

ACTIVE POWER - FREQUENCY CONTROL:
PARALLEL OPERATION WITH DROOP CONTROL

The frequency of a grid is dependent of active power and the voltage of the grid is dependent of reactive power. For the satisfactory operation of power systems, it is important to keep the frequency and voltage close to their nominal values. In the simple case of one source of power in an island grid (i.e. one generator), the automatic voltage regulators (AVR) suffice to keep the voltage on target. For the frequency control, the speed governor of the generator suffices to keep the frequency close to the nominal value by accommodating changes in load demand as needed. For multiple sources of power in parallel, it is important to recognize that there are two essential control loops; the frequency control loop, which controls the active power sharing and the voltage control loop, which controls the reactive power sharing.

Droop:

when a prime mover has a droop governor, the speed of the prime mover decreases asmore load is applied. The droop value is the rate of frequency decrease to the load increase.



Ideal characteristics of a governor with speed droop.

Isochronous:

when a prime mover has an isochronous governor, the prime mover maintains itsspeed at the set value throughout the entire range of load. An isochronous governor has a zero droop

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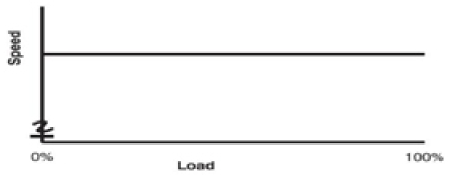
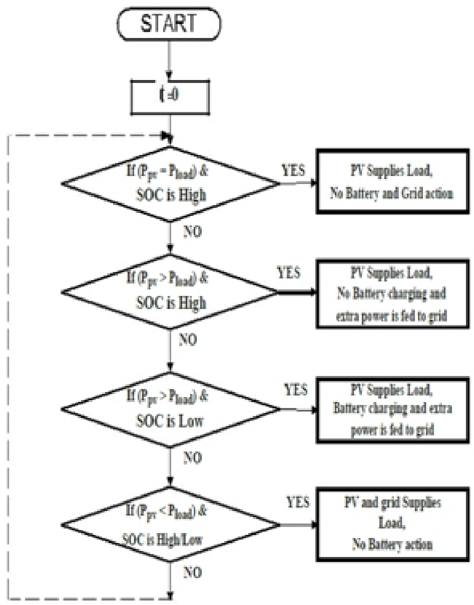


The averaged model is nonlinear and time-invariant because of the duty cycle, d(t) . This model is finally linearized about the operating point to obtain a small-signal model is shown in Fig. 4. The following are the important transfer functions used to design the compensators and to analize the system behaviour under small signal conditions (i) the duty-cycle-to-output transfer function Gcv (s), carries the information needed to determine the type of the voltage feedback compensation,(ii) the duty-cycle-to-inductor current transfer function Gci(s), is needed to determine the current controller structure.



Flow chart of power flow in hybrid system

Proposed Control for Battery Converter:

If AC side of µG-VSC has constant power appliances (CPAs), in the small-signal sense, CPAs nature leads to negative incremental input-conductance which causes desta-bilization of the dc-link volatge [10]. On the microgridgener-ation side, the inherent negative admittance dynamics of their controlled convertion stages challenges the dc-link volatge control and stability. This effect is more with reduced dc-link capacitance. Therefore, in both cases, fast and effective control and stabilization of the dc-link voltage is very crucial issue.

To address this problem, many methods are reported in the literature like

(i)by large DC link capacitance
(ii)by adding passive resistances at various positions in DC LC filter
(iii)by loop cancellation methods.

Voltage Loop Design Steps:

i) Place one zero as high as possible, yet not exceeding resonating frequency of the converter.
ii) Place one pole at frequency of output capacitor ESR to cancel the effects of output capacitor ESR.
iii) Adjust, gain of compensator to trade-off stability margins and closed-loop performance.
iv) Another pole should be place at origin to boost the dc and low frequency gain of the voltage loop.

Generation of reference currents for µG-VSC:

The main aim of the µG-VSC control is to cancel the effects of unbalanced and harmonic components of the local load, while supplying pre-specified amount of real and reactive powers to the load. Upon successfully meeting this objective, the grid current ig will then be balanced and so will be the PCC voltage vp provided, grid volatge vg is balanced.

Battery Converter Modeling:

The battery converter goes through two topological stages in each switching period, its power stage dynamics can be described by a set of state equations.

$$\frac{di_L}{dt} = \frac{v_{c1} d_{(t)}}{L} - \frac{v_{c2}}{L} - \frac{(r_s + r_L) i_L}{L}$$

$$\frac{dv_{c1}}{dt} = \frac{v_{dc,Bus} - v_{c1}}{C_1 R1} - \frac{i_L d_{(t)}}{C_1}$$

$$\frac{dv_{c2}}{C_2} = v_B - v_{c2} - i_L\,dt\,C_2R2$$

The averaged model is nonlinear and time-invariant because of the duty cycle, d(t) . This model is finally linearized about the operating point to obtain a small-signal model is shown in below. The following are the important transfer functions used to design the compensators and

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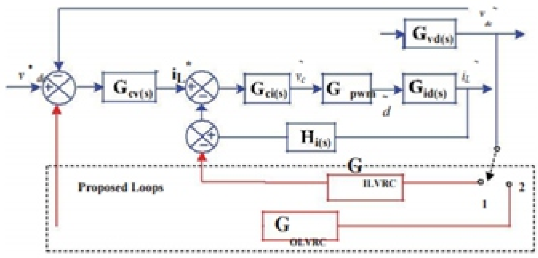
(i) the duty-cycle-to-output transfer function Gcv (s), carries the information needed to determine the type of the voltage feedback compensation.

(ii) the duty-cycle-to-inductor current transfer function Gci(s), is needed to determine the current controller structure.



Inner and outter loops of battery converter with MACMC.

RESULTS AND DISCUSSION:

The proposed control strategies for PV hybrid generating system is developed and simulated using Matlab/SIMULINK under different solar insolation levels. In order to capture the transient response of the proposed control system, PV insolation is assumed to increase from 200 to 1000 W/m2 at 0.3 s, and decreases from 1000 to 200 W/m2 at 0.5 s. This abrupt increase or decrease is assumed in this work in order to test the robustness of the proposed control algorithm. As a result, the inductor current of the HGICB converter is varied to track the maxmum power accordingly and the power flow.

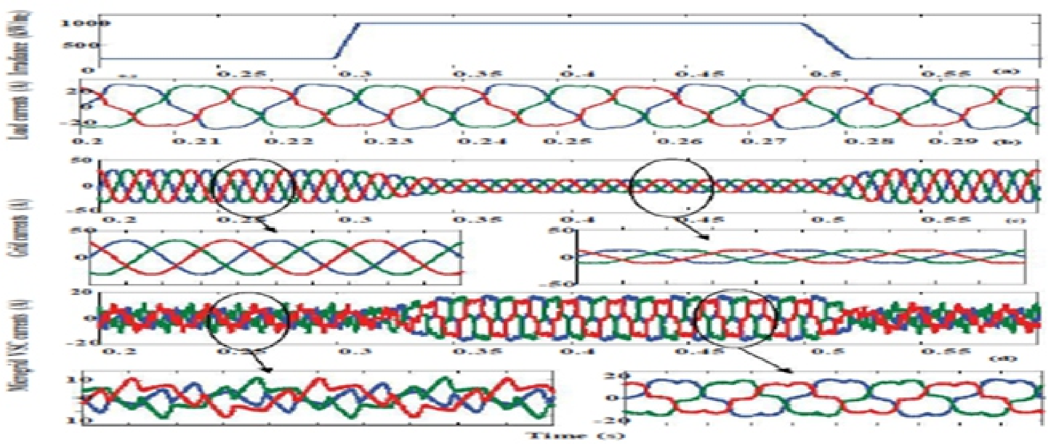
MPPT Tracking Performance of HGICB Converter:

The dynamic performance of HGICB converter with P&O MPPT algorithm at two different insolation levels are shown in Fig. 5. A variable PV volatge and current in proportion to insolation levels are applied to HGICB converter and as a result, the duty cycle is calculated using the MPPT algorithm. The PV characteristics at two insolation levels are shown in below (a)-(b).

From below (a), the maximum power, current and voltage are 2.6 kW, 14 A and 190 V respectively and these values are tracked by HGICB converter which are shown in below (d)-(f). Tracked values of PV power, voltge and currents are given in Table II for the above operating insolation levels.From these results it can be concluded that, HGICB converter is tracking maximum power closely at all operating conditions.SIMULATION OF PRIMARY CONTROL OF BESS AND DIESEL

GENERATORS AND PV FIELD IN PARALLEL:

The model of PV field is integrated with the grid of a diesel generator and the BESS, and a load step of 10% increase is simulated. The dispatch power of the diesel generator is the nominal power (0.816 [kW]), the dispatch value of the PV field is 2 [MW], and the dispatch value of the BESS is zero.



The diesel generators are not always connected to the grid, especially during sunny days. If the PV field receives high irradiation during the day so that enough energy is generated, the diesel generators are usually disconnected.

For this reason, the diesel generators cannot be configured to provide all the primary or secondary control of the plant.

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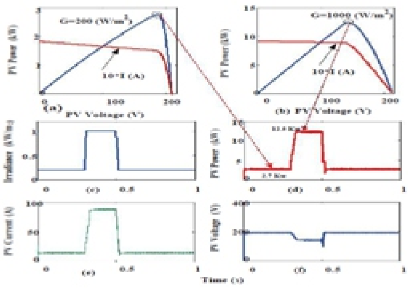
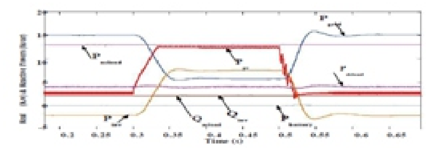
CONTROL STRATEGY (1):

This control strategy represents the operation of the plant when the primary control is provided by the diesel generators and the BESS in parallel, and the secondary control is provided by the BESS.

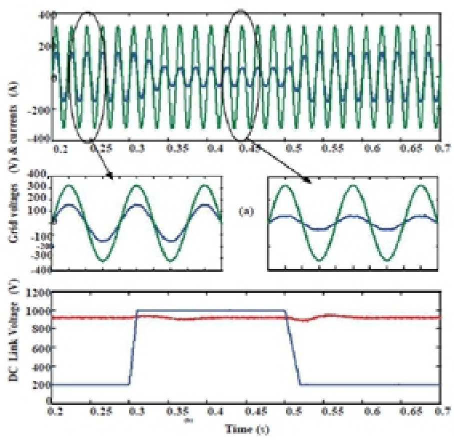


CONTROL STRATEGY (2):

This control strategy represents the operation of the plant when the primary control is provided by the diesel generators and the BESS in parallel, and the secondary control is provided by the diesel generator and the BESS in parallel.



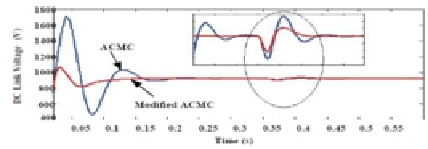
Real and Reactive Power flow waveforms of PV hybrid generating system.

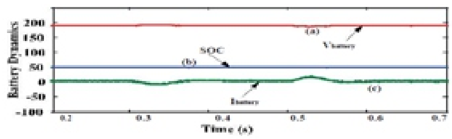


Simulation results: performance of proposed control approach (a) Grid Voltages and currents (b) Dc Link Voltage Dynamics with different insolation

CONTROL STRATEGY (3):

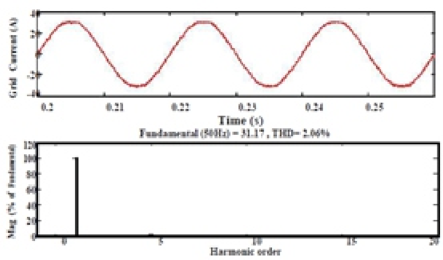
This control strategy represents the operation of the plant when the primary control and secondary control are provided mainly by the BESS shows that the frequency drops directly after the load increase, and then it retrieves the nominal value after about 85 seconds. The output power of the diesel generators increases slightly according to primary control because of the relatively high value of droop.





CONTROL STRATEGY (4):

The output power of the diesel generators increases slightly according to primary control, because of the relatively high value of droop, and then it increases according to secondary control until the frequency stabilizes. On the other hand, the output power of the BESS increases instantaneously as the load increases according to primary control, and then it decreases slightly until it reaches the steady state at the nominal value.



SOFTWARE TOOLS:
(Matlab Simulation)
» Simulink

•It is a commercial tool for modeling, simulating and analyzing multi domain dynamic systems.
•Its primary interface is a graphical block diagramming tool and a customizable set of block libraries.
•Simulink is widely used in control theory and digital signal processing for multi domain simulation and Model based design.

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» APPLICATIONS:

1.Technical computing
2.Engineering and sciences applications

•Electrical Engineering
•DSP and DIP
• Automation
•Communication purpose
•Aeronautical
•Pharmaceutical
•Financial services.

» Other Features:

•2-D and 3-D graphics functions for visualizing data
•Tools for building custom graphical user interfaces
•Functions for integrating MATLAB based algorithms with external applications and languages, such as C, C++, Fortran, Java, COM, and Microsoft Excel .

ADVANTAGES:

A parallel dc-linked multiinput converter with a half-bridge bidirectional DC/DC cell topology is chosen to link the battery/ultra capacitor storage unit with the dc-link.These advantages as well as the fast torque response make PMSMs good candidates for use in HEVs.