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Implementation of a Bidirectional Converter to Stand Alone LVDC Nano Grid by MPPT Control Strategy

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ABSTRACT:

The objective of this paper is to improve an energy management system (EMS) and provide uninterrupted power supply to the DC loads and also achieve self sufficiency by minimizing the grid power consumption. This is achieved by the control strategy for a cascaded two stage bidirectional converter interface between the nano grid and AC distribution network. An empirical relation for power flow through the converter is obtained and optimal capacitor link voltage is derived to achieve power transfer between rated limits. In this paper the proposed method is Rippel correlation contro(RCC)l method which is used to maintain the battery voltage constant. The experimental results are verified by using MATLAB simu link.

Index Terms-Low voltage DC(LVDC), battery storage, energy management, bidirectional converter, DC bus, PV panels.

1. INTRODUCTION

AC Power is very dominated by DC power systems because of their limited applications. Now a days increasing concentration on the energy savings has led to the evolution of DC systems being used in distribution or transmission. Today everyone using LED based loads like lights, laptops, chargers, systems etc work on the basis of lowvoltage DC. Commercial structures like data centers some software offices, hospitals, departmental stores these are all requires uninterrupted DC power source. Renewable sources like photo voltaic panels fuel cells and wind generators are DC in nature. For avoiding DC-AC conversion stage photo voltaic panels are directly connected to the DC bus. variable wind generators requires an AC-DC-AC conversion stage before they can be interfaced with the power grid. Here DC distribution system is preferred only single conversion stage that is AC-DC. When compared to AC transmission DC transmission is more efficient with improved controllability and reduced cost.

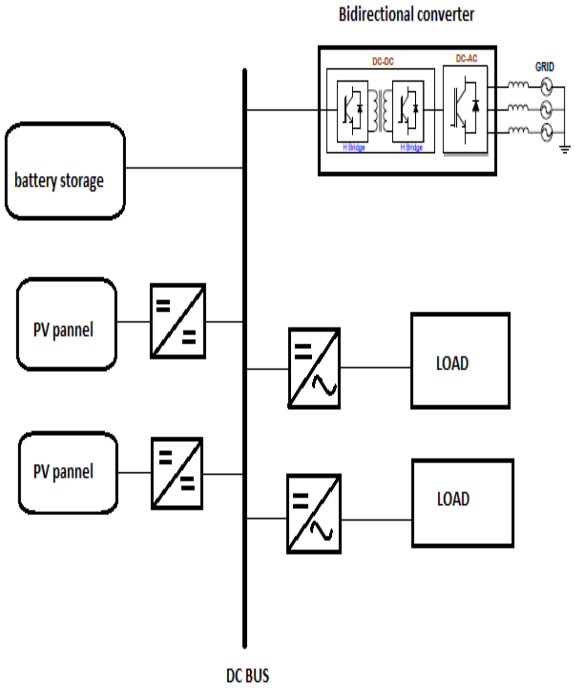


Fig1. Architecture of LVDC nano grid with bidirectional converter

The local DC distribution system within residences and commercial structures is called a DC nanogrid. The evolution of DC nano grid has also facilitated the process of energy management. future commercial buildings and residential and hospitals etc will be self sufficient by generating the necessary power renewable energy sources and also minimize the power consumption from the grid .The nano grid is typically designed such that renewable sources supply the average load demand, while storage and nonrenewable generation are used to ensure that the loads enjoy a continuous supply of power in the presence of the stochastic renewable sources. In this system batteries are backbone of the nano grid. low voltage dc power can be directly supply to the loads /home appliances/office appliances/hospitals etc and among these, it has been found that a 48v DC distribution system with its cable area optimized has minimum losses and maximum energy saving.

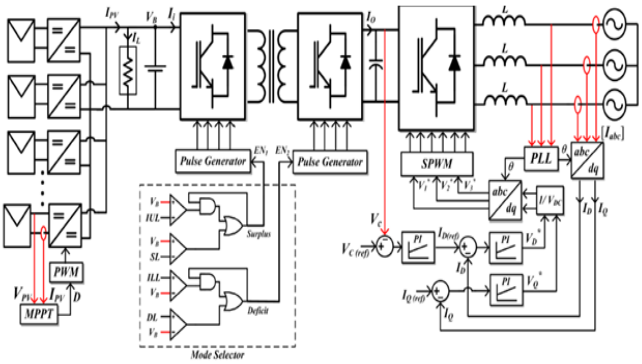
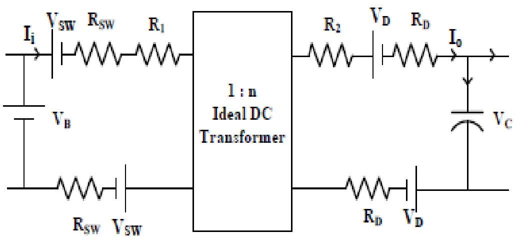


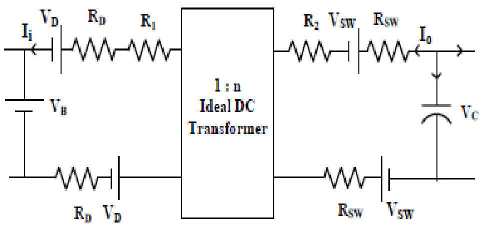
Fig 2. Control scheme for a bidirectional converter

The block diagram of low voltage DC nano grid along with the bidirectional converter. A low voltage dc bus (48V)allows flexibility during an installation of photo voltaic panels. here low voltage says that very few panels are needed in the series string. Maximum Power Point Tracking which increases the power output and proves practical for installation in residential and commercial areas. The DC nano grid having bidirectional converter which is used to transfer between low voltage DC network side to AC grid network and vice versa. Bidirectional converter is a combination of dual active bridge converter and three phase inverter. Dual active bridge converter allows the power transfer by using open loop control method and it operates in three different modes to control the direction of power flow. Power surplus mode, Power deficit mode and idle mode. Bidirectional converter having DC-DC converter with high frequency transformer that facilitates efficient operation at high power densities. And three phase inverter allows the interface between dc-dc source to AC grid.

The main aim of this paper is to develop the energy management system and also provide uninterrupted power supply to the home appliances such as computers ,fans, lights etc. With the help of battery or storage element we can supply the power to loads in the absence of sun light. Various modulation techniques and control strategies has been used to control the power flow through dual active bridge converter. in this paper open loop controller is used by choosing the capacitor DC link voltage power flow control between rated limits can be achieved. Direction of power flow is decided by energy management system. power flow is defined in three modes that is 1)surplus mode,2)deficit mode,3)idle mode. In power surplus mode power transfer from DC bus to power grid in this mode converter acts as an inverter. In deficit mode condition power flow from power grid to the DC bus. Idle Mode is employed where the nano grid is isolated and no power exchange occurs between the DC bus and the utility.



a) Power Surplus mode



b)Power Deficit mode

fig 3 : power surplus mode power deficit mode

Three phase inverter having double loop controller that is inner current loop has a fast dynamics and regulates the grid current and outer voltage loop used to regulate the DC capacitor link voltage. the three phase voltages and currents are transformed into their equivalent d-q variables using abc - dq (Clarke-Park) transformation. This conversion of the three phase time varying AC quantities into DC quantities allows effective control and helps achieve zero steady state error using PI controllers.

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2. MAXIMUM POWER POINT TECHNIQUE

Maximum power point tracking (MPPT) is a technique used photovoltaic (PV) solar systems to maximize power output. MPPT algorithms are designed in order for the photovoltaic system to adapt to environmental changes so that optimal power is delivered. solar panel that generates power according to the irradiation levels. The MPPT algorithm calculates the duty cycle for the converter corresponding to the maximum power point. The variation of the power and voltage of a solar panel is given in figure.

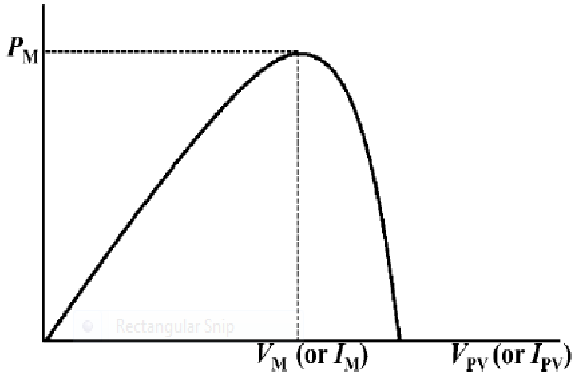

Fig 4: Power–voltage characteristics of PV systems

PV cells shows nonlinear V-I characteristic which is dependent on solar irradiation and temperature there is a need to track the maximum power point (MPP).

The aim of MPPT is to regulate the actual operation voltage of PV panel to the voltage at MPP. For this purpose, MPPT adjusts the output power of inverter or DC converter. If the PV output voltage is higher than MPP voltage, then transferred power to the load or network is increased, otherwise, it is decreased. This paper proposes a Rippel correlation control method for maximum power point tracking (MPPT) in photovoltaic systems. MPPT technologies have been used in photovoltaic systems to deliver the maximum available power to the load under changes of the solar insolation and ambient temperature.

3. RIPPEL CORRELATION CONTROL METHOD IN MPPT TECNOLOGY

Maximum power point trackers (MPPT) are frequently used to extract maximum power from a photovoltaic panel. Ripple correlation control (RCC) was introduced as a dynamic optimization technique that can be used as the basis for a MPPT or for motor efficiency maximization [2-16]. RCC uses ripple that exists in all switching power converters to extract information about the operating point. In this paper rippel correlation control (RCC) method is used to make the constant battery voltage. Ripple correlation control (RCC) is a fast, robust online optimization technique. RCC is particularly suited for switching power converters. The most common of these algorithms is the perturb and observe (P&O) method . This control strategy requires external circuitry to repeatedly perturb the array voltage and subsequently measure the resulting change in the output power. The RCC unit then calculates the duty cycle of the system, $d(t)$, to deliver the maximum available power to the load in the steady state. The Rippel correlation control method is an advance method of perturb & observation method.

The RCC is based on the observation that the product of the time-based derivatives of the array voltage Vpv and power Ppv will be greater than zero to the left of the MPP, less than zero to the right of the MPP, and exactly zero at the MPP see fig 4.

$$\frac{dPpv}{dt}\frac{dVpv}{dt} > 0 \qquad \text{when} \quad V_{pv} < V_m$$

$$\frac{dPpv}{dt}\frac{dVpv}{dt} < 0 \qquad \text{when} \quad V_{pv} > V_m$$

$$\frac{dPpv}{dt}\frac{dVpv}{dt} = 0 \qquad \text{when} \quad V_{pv} = V_m$$

if Vpv increases and there is a resulting increase in Ppv, the system's operating point is to the left of the MPP (see Fig. 4). if Ppv decreases after an increase in Vpv, then the system's operating point is to the right of the MPP (see fig4). RCC is advantageous due to its simple implementation as well as its low cost. When a PV array is connected to a power converter, the switching action of the power converter imposes voltage and current ripple on the PV array. As a consequence, the PV array power is also subject to ripple. Ripple correlation control (RCC) makes use of ripple to perform MPPT. RCC correlates the time derivative of the time-varying PV array power p& with the time derivative of the time-varying.

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4. SIMULATION RESULTS

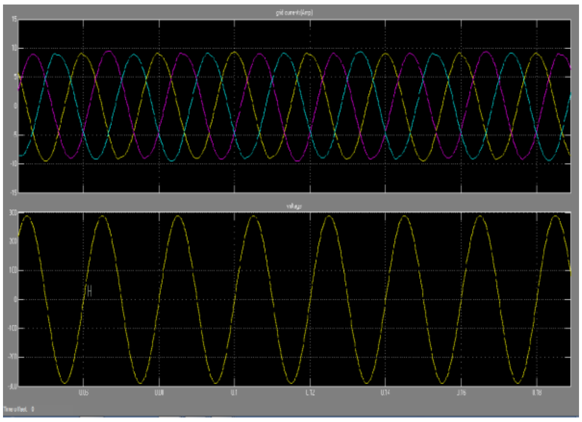

Fig 5: scale: Voltage V: 100v/div, Currents *Ia, Ib, Ic*: 5amp/div, time t: 0.1sec/div. Current & Voltage wave forms of surplus mode and deficit mode.

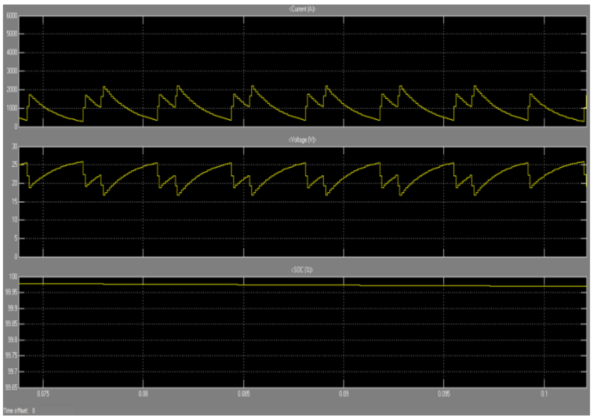

Fig6: (scale: Voltage V: 5v/div current:1*10^3 amp/div: SOC 99.98%) Current ,Voltage wave forms and state of charge of battery.

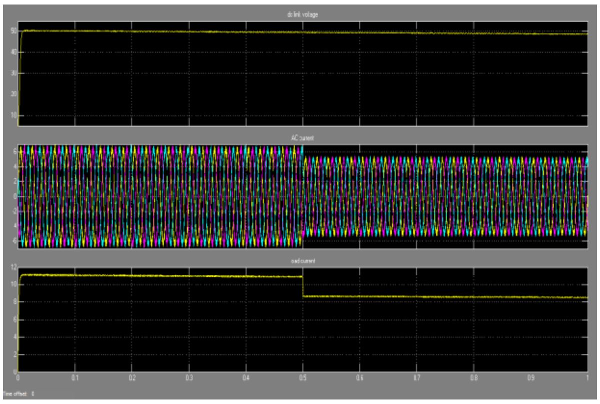

Fig7: System response during step decrease in load (scale: dc link voltage: 10v/div, AC line current: 2amp/div, load current: 2 amp/div).

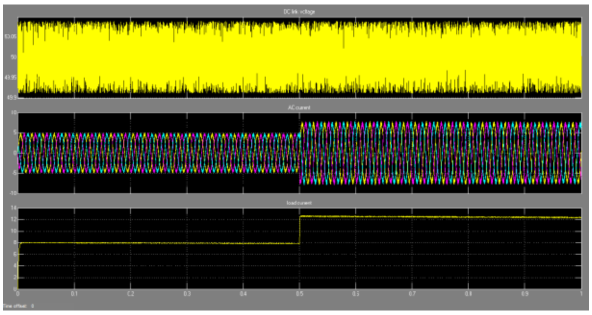

Fig8: System response during step increase in load (scale: dc link voltage: 50v/div, AC line current:5amp/div, load current: 2amp/div).

5. CONCLUSION

Rippel correlation control method is one of the methods of maximum power point tracking system. RCC is advance method than the p&o method. In this MPPT technology Rippel correlation method is used to maintain the constant battery voltage. The algorithm can be easily implemented in at low-cost. The MPPT block uses the product of voltage and power ripple to drive the operating point towards MPP. Here bidirectional converter facilitates the power transfer between DC nano grid and AC distribution network.

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