International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Comparison of Voltage Droop Control Techniques in a DC standalone Microgrid

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ABSTRACT

This paper represents the different control techniques like mppt and droop control techniques for the dc micro grid in standalone mode. The mppt is used for the open loop control mode and droop control mode is used for the close loop control mode. The droop control mode is also known as the constant voltage control mode. The droop control technique is also used for the accurate load sharing in island or standalone mode. This paper represents mppt control technique and different droop control technique with pv and battery with dc-dc convertor and DC load. In this paper conventional droop control technique is introduced firstly and then introduced the adaptive droop control technique for the batter voltage regulation. This paper presents the matlab simulation of dc micro grid in standalone mode.

Keywords—pv with mppt and droop control method, battery with bi directional convertor, adaptive droop control technique.

I. INTRODUCTION

Now a day the Microgrid is the more efficient and economical part of the distribution generation. The microgrid consisting the distribution sources like the photovoltaic array, battery fuel cell and wind turbine. The microgrid has two types ac microgrid and DC mcrogrid. The dc microgrid is easier and economical as compared to the ac microgrid because of the absence of the frequency and reactive power. Because of that control of the dc microgid is also easier than the ac microgrid[1]. Dc microgrid consisting of the sources like the pv with buck/boost convertor according to their application and battery with bidirectional DC-DC convertor for the charging and discharging capacity for powermanagerment and energy storage purpose[2]. The wind cam be used with the rectifier to convert the ac voltage in to dc. The DC voltage may be 46v,110v, 220v, 380v and 400v taken.

The dc microgrid consisting of the different architecture and control scheme like centralized control, de centralized control and hybrid control with and without communication link. In this paper we are considering the decentralized control technique without communication link[3].

According to the feature of pv generating unite the pv is operated in to the two operating control mode like maximum power transfer theorem mode[11] and droop control[4]-[8] mode which is also known as constant voltage control mode. The mppt mode is used when the load required the more power or the battery required the power for

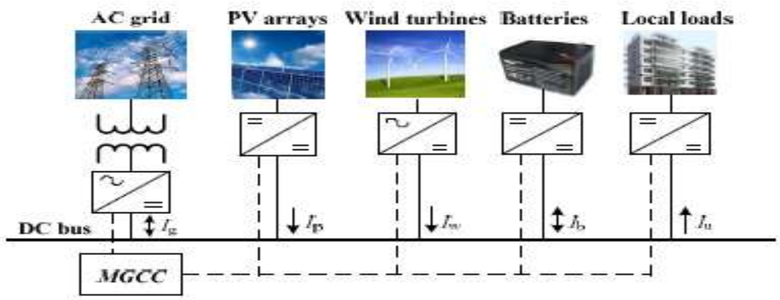


Fig. 1. low voltage dc microgrid.

charging purpose. So the battery is in charging mode when the pv is operating into the mppt mode when the

generation is greater than the demand. When the battery is fully charged the pv is operated in to constant voltage control mode or droop control mode to avoid the battery overcharging and also for the dc bus voltage regulation. Here we are considering the conventional droop control technique and compare it by the adaptive droop control technique.[10]

The low voltage dc microgrid is shown in to the fig.1.it is consisting of the distribution generation unites like pv, battery and wind. Also shown Fig1. it is in grid connected mode or islanding mode.

The following section of paper is like section (II) DC microgrid architecture. Section (III) Control scheme of DC Microgrid and section (IV)Simmulink result and conclusion and references.

II. ARCHITECTURE OF DC MICROGRID

In this paper we are addressing the pv generating unite with Battery storage system. Here 10 kw PV is used with dc-dc boost convertor with mppt and droop control mode and also the 300v and 6.5Ah energy storage unite is used with bi directional dc dc convertor with droop control technique. Fig 2 shows the block diagram of pv and battery storage unite with control strategy.

The two operation mode of control is discussed in this paper like mppt and droop control.

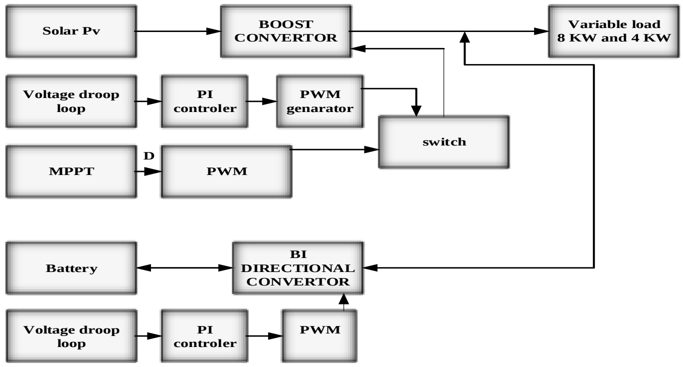


Fig. 2. block diagram of pv and battery unite.

III. control methdo of dc dc convertor

A.Convesional droop control method

In this method we are using the conventional droop control method and mppt mode of control. Droop control is employed to achieve current sharing of participant PV units while operating at CVC mode. The principle of droop control is to add a current feedback loop to the voltage-current inner loops of PV units, which is regarded as artificially expanding the output impedance of each converter. As a result, the output impedance of each PV unit's converter is much larger than the impedance of cables connected to the DC bus. The principle of DC droop control. [9] can be expressed as follows.

$$V^* = V_{ref} - Ki_d$$

where *v*ref is the reference value of PV units output voltage, K is the droop gain, *i*d is the output current and *v** is the new reference value of voltage after droop control implemented.

K can be seen as an equivalent resistance, it can be designed by the parameters of DG's capacity and the DC bus voltage level.[10]

$$K_{Droop} = \frac{\Delta V_{DC} * (V_{DC} - \Delta V_{DC})}{P_R}$$

Where Δ*V*DC is the DC bus voltage *V*DC allowed floating value. *P*R is the rated power of the voltage source.

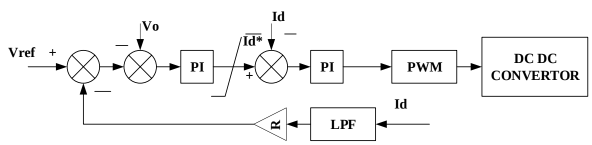


Fig. 3. Droop control storages for pv and battery storage unite.

Fig. 3 shows the CVC control diagram of PV and battery converters. It contains the droop control, an outer voltage control loop and an inner current control loop in.

B.MPPT Control technique.

According to the characteristics of PV and WT, there exists a maximum power point (MPP) when the PV/WT and the converter's impedance are matched. Taking PV generating unit for example, V_{PV} and I_{PV} are sent into the maximum power point tracking (MPPT) module as shown in Fig. 2. It outputs the PV's reference voltage V^*_{PV} and a voltage control loop regulates the boost type converter to make V_{PV} reach V^*_{PV}. Perturb and observe MPPT method [11] can be adopted to track the PV MPP in real time. Fig. 4. shows the mppt control structure.

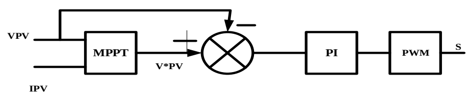


Fig. 4. MPPT control of pv array.

C.control method of battery storage unite.

As shown in Fig. 2. BS units are connected to the DC bus and each BS unit is controlled as a voltage source to realize the redundancy in CVC mode when the BS status is discharging.

Fig. 5. shows the control diagram of the bidirectional DC/DC converter at discharging status. The difference between V_{DC} and V^*_{DC} is sent to the voltage PI regulator and the output is sent to the PWM generator to drive S_2. S_3 is always off and the converter operates at boost type.

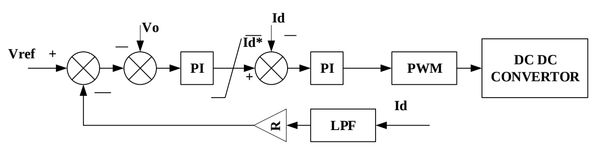


Fig. 5. battery discharging control strategy.

Fig. 6 shows the control diagram of the bidirectional DC/DC converter at charging status. There are two control loops, an inner current control loop and an outer voltage control loop. A current limiter was insert in the current loop to limit the charging current. S_2 is always off and the converter operates at buck type.

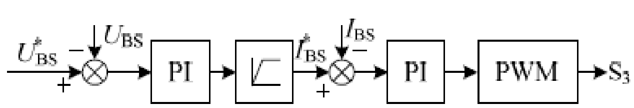


Fig. 6. charging control of Battery storage unite.

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

A.Adaptive droop control method

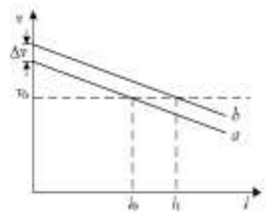
The conventional droop control technique is the easy to implemented. The different pi regulator is used so there is transient of pv output unite so to minimize the transient phenomena we are using the adaptive droop control method and also a little batter voltage regulation in it.

This paper proposed a droop-controlled MPPT scheme based on voltage-shifting method. An offset Δv is added to the conventional droop control loop to change the output current value of PV units. The voltage-shifting droop equation can be expressed as follows.

$$V^* = V_{ref} - ri_d + \Delta V$$

Now the voltage-shifting method changes output current of PV unit. In Fig. 7(a), PV unit operates at MPPT mode, and DC bus voltage is stabilized at *V0* by other units. After adding Δv, the droop curve is shifted from *a* to *b*, and the output current of PV unit is changed to $i1$.

The corresponding current adjusting during DC bus voltage fluctuations are depicted in Fig. 7(b). If the DC bus voltage changes from v_0 to v_1 (v_2), the output current will change from i_0 to i_1 (i_2), but after voltage shifting, the droop curve is shifted from *a* to *b* (*c*), and the output current of PV unit is maintained at i_0.



Fig[a]

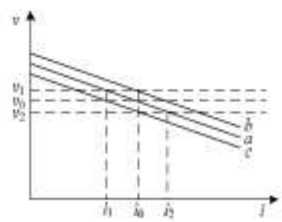


Fig [B]

Fig. 7. Droop Cherecteristics of Voltage shifting.

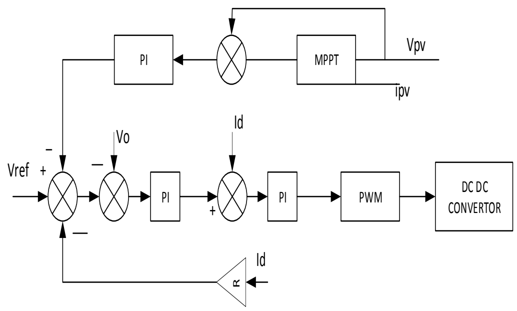


Fig. 8. adaptive droop Control technique.

As shown in Fig. 8. the corresponding control strategy of PV units consists of inner loops (voltage and current loops), droop control loop and MPPT module. The reference value of PV voltage *v**pv that generated from MPPT module is compared with the sample value of PV voltage *v*pv, and the result is sent to a PI regulator. The output value of PI regulator is then added to the output of droop control and the reference value of voltage *v*ref, and products *v**. Finally, *v** is sent to the inner loops and generates PWM signals to the boost converter of PV unit.

IV. SIMMULINK RESULT

The simulation is constructed in MATLAB/Simulink environment to verify the proposed DC micro-grid and control scheme in to block diagram. The simulation parameters are set below:

The DC bus voltage is 400V, the DGs maximum power is 12kw, the load maximum power is 12kw, each BS unit is 300V/6.5Ah.

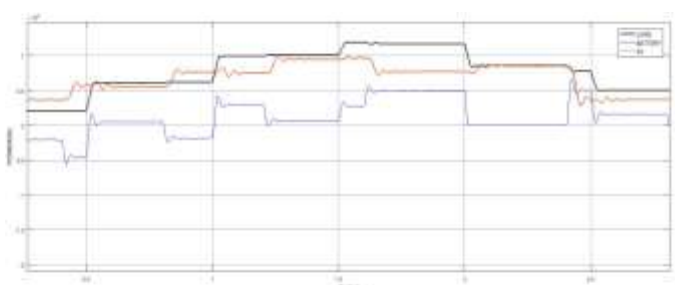


Fig. 9. mppt and conventional droop control method

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ISSN: 2319-8354

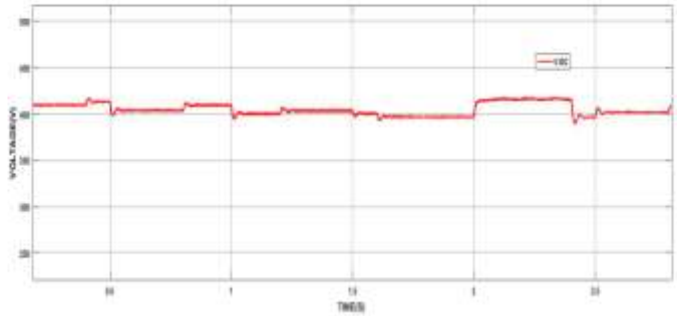

Fig. 10. DC Bus voltage

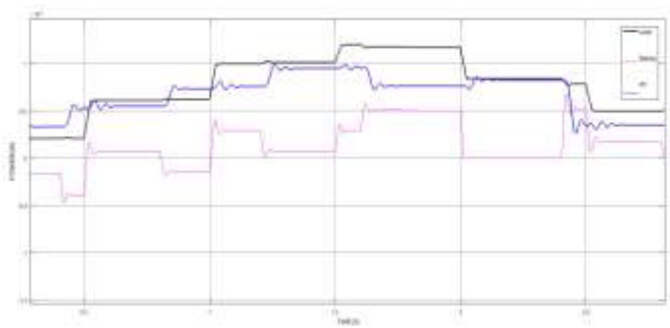

Fig. 11. Adaptive control stratage for o/p power

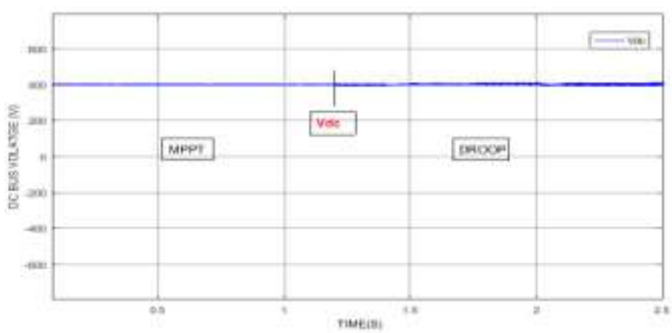

Fig. 12. DC Bus voltage after adaptive droop control strategies.

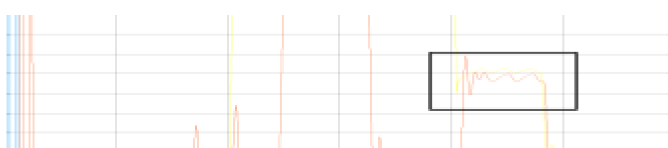

Fig. 13. Conventional droop control mode.

Fig. 14. Adaptive droop control mode.

Fig. 9. shows that when the generation power of pv is more than the load, the remaining power is used as the charging power for battery. And the generation is less than the demand the the battery supplies the remaining power.

Fig. 9. shows that the output power of the convention voltage droop control mode and mppt mode. Here before 1.2 sec. the pv is working on mppt mode and after 1.2 sec the battery is fully charge and disconnected from the charging switch. And pv is working on the droop control mode.so, battery is stopped charging in to the droop control mode. And as shown in the Fig. 10. dc bus voltage is stable nearer at the 400v.

Now as shown Fig.11 in to the fig output power waveform is shown for adaptive droop control system and also Fig.12 shows that the dc bus voltage is regulate at the 400v constant. And Fig.13 and Fig. 14. shows that the comparison of the conventional and adaptive droop control mode. And we compare that the transient oscillations of pv are minimized.

V. CONCLUSION

After simmulink result, we conclude that the adaptive droop control storage is better than the conventional droop control technique and we are getting the batter voltage regulation result of the dc microgrid. And DC bus voltage is stable at 400v constant.

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