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Synchronisation of Microgrid without Effect on the Power Sharing Capabilities of Distributed Generation

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Abstract**: This paper presents different synchronisation strategies for the purpose of seamless transfer between the two modes of operation of Microgrid. Microgrid has emerged as great evolution in the power system. This paper analyse the synchronization strategies of microgrid to have a smooth switching between the two modes of operation of microgrid i.e islanded and grid connected modes of operation. Synchronisation of the voltage at the point of common coupling(pcc) should be done to achieve smooth switching. Different control strategies for synchronization are summarized and a new methodology based on space vector modulation is defined and simulation results are presented.
Keywords: Synchronisation, point of common coupling, Microgrid, Distributed generation, Droop control, Space vector pulse width modulation.

I. INTRODUCTION

Nowadays Distributed generation(DG) has gained much importance because of the effects of environment and economical issues. A Microgrid(MG)[1] is a small scale power generation mostly consisting renewable energy sorces which are integrated together with loads, monitoring units and energy storage system and all these are interfaced through power electronic devices. A microgrid can be operated in both islanded and grid connected modes of operation. But in order have high reliability it is always recommended to have a seamless transfer between two modes of operation. In case of critical loads like elevators, refrigerators uninterrupted supply is required or in case of utility grid maintainence continous supply is needed to supply to the localized loads.

The modes of operation of microgrid are grid connected mode where the static switch is closed and in this mode microgrid allows bidirectional flow of power i.e when MG has excess of generation it is delivered to grid and if there is deficiency it will utilize from the main grid.In Islanded mode of operation the static switch is closed and the MG is suppling the local loads.In this mode there may be two possibilities.

Case a) Over generation: When the load demand is less than the generation capacity of MG, the excess generation is stored by the battery storage system.

Case b)Under generation: When the load demand is more than the generation capacity of the MG ,the battery storage system is used and also the DGs are asked to deliver the maximum capacities. However this is only limited period of operation and is not recommended.

The control strategies defined are master slave control and Droop based control. In Master slave control the master DG is operated as voltage controlled source in islanded mode of operation. In droop based method all DGs are controlled with droop control scheme which derives the required amplitude of voltage and frequency deviating from the rated values.

To make a perfect synchronization during the operational mode changes of MG, the voltage of the point of common coupling (Vpcc) should be matched with the voltage of the main grid (Vgrid) in terms of amplitude, frequency and pahase sequence. However, there are some issues by using the control strategies defined. In this paper the basic structure of microgrid with two DGs connected in parallel along with a load is given and the control strategies are applied on this basic structure.

II. MICROGRID STRUCTURE

Figure 1 shows the basic structure of a microgrid with two DGs in parallel along with a load connected to the main grid with the help of a static switch through point of common coupling(PCC).In Islanded mode static switch is open.In grid connected mode static switch is closed and the DG is controlled as current source.

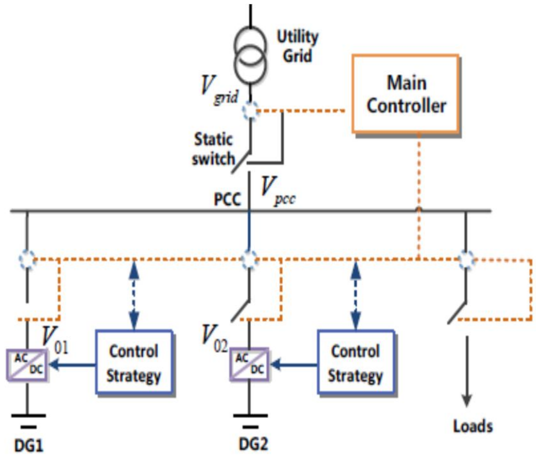

Fig.1 Basic structure of Microgrid Synchronisation.

III. SYNCHRONISATION STRATEGIES

To ensure synchronization the difference between the amplitude of voltage,frequency and phase sequence of point of common coupling (Vpcc,fpcc,Ɵpcc) should be same as that of the utility grid(Vgrid,fgrid,Ɵgrid) or should be maintained in a range of small limits.The synchronization strategies are described as below

A. Master slave control

Master slave operation consists of upper master control and bottom slave control. The upper master send instruction to the slaves for voltage, setting point of active and reactive powers. In the bottom slave control one or more DGs operate as slaves and provide the reference of voltage and frequency.

In this situation one DG is operated as voltage controlled source to provide voltage reference while the other DG is operated as current source to provide the reference power. To match the Vpcc with Vgrid, can be done by adjusting Ɵpcc and fpcc.

1) *Adjusting Ɵpcc only*: As most of the DGs are renewable energy sources and not involved with speed governer system the frequency is almost constant and hence the phase difference is constant and so is the amplitude. So if this difference of phase and amplitude is detected we can compensate the difference and achieve synchronization as shown in fig2

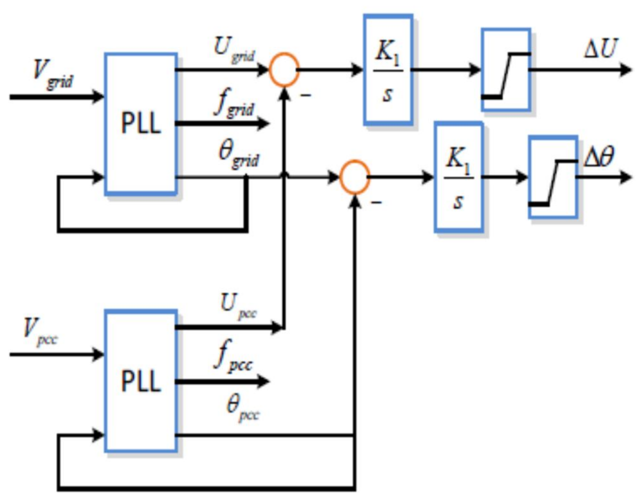

Fig.2 control structure for phase angle control.

The difference of amplitude and phase obtained from integrator are added to DG1 for compensation. The time of synchronization is decided by the value of the coefficient of the integrator. As integrator defines the solution over a sweep of period, larger values of the coefficient indicate short time for synchronization.

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B. Droop control

Droop method is based on locally collected data and does not require much communication as in case of master slave control. It has its assumption of high line impedance and the constraint that the maximum droop should not be less than the nominal voltage. This method is used to control the inverters of the DGs to make them operate in parallel with proper power sharing between them.

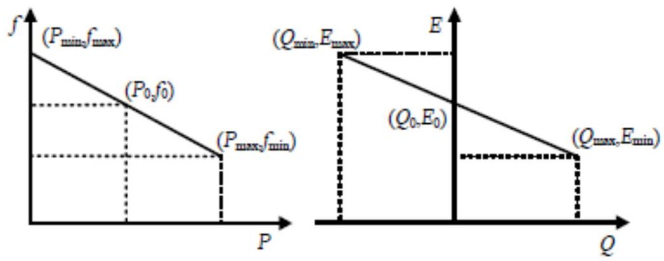

Fig.3 Droop characteristic line

Droop control method is based on simple basics of power system that as the load demand increases it draws more active power which drops the frequency. Similarly voltage drops with effect of reactive power. Based on this concept droop characteristics of the inverters are adjusted by adjusting the the working points of p-f and Q-E characteristics in order to obtain the required voltage and frequency for the purpose of synchronization. This can be implemented through the following:

1) *Adjusting the droop characteristics of both inverters simultaneously:* Here the droop characteristics of both the inverters are taken to be the same and the primary working lines are p-f and Q-E with set points taken as (Po,fo) and (Qo,Eo) while the working points are taken as (P,f) and (Q,E).When the set points are adjusted to (Po’,fo) and (Qo’,Eo) such that the working points are obtained as (p,f’) and (Q,f’) , so that the voltage and frequency are changed for the purpose of synchronization while the power sharing capabilities of DGs are being remaining same.

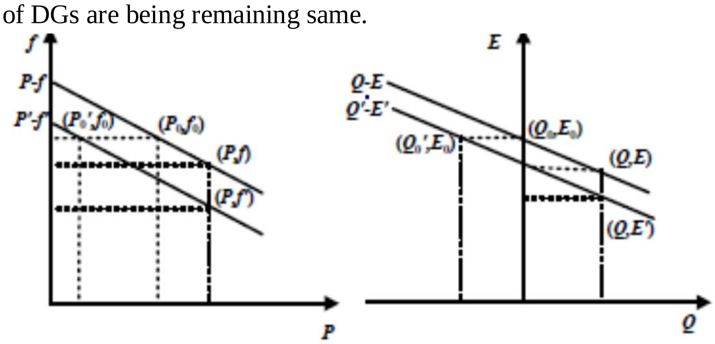

Fig.4 Adjusting droop characteristics of both inverters.

2) *Adjusting droop characteristic of only one inverter:* Here also the primary lines are same and when the set point of one inverter adjusted as (po’,fo) and (Qo’,Eo) then the working points of both the inverters are changed as (P1,f’), (p2,f’) and (Q1,E’) (Q2,f’).Here we see that voltage and frequency are changed along with a change in power sharing capabilities of the DGs

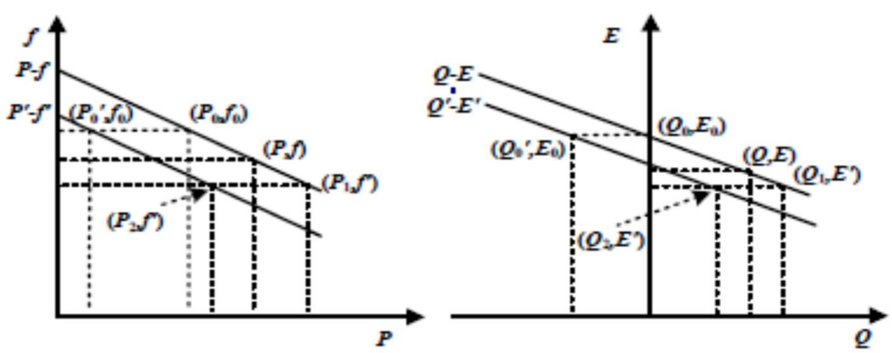

Fig.5 Adjusting droop characteristic of one inverter.

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So we can see that by adjusting Po and Qo we can vary the amplitude of voltage and frequency, can be changed as per requirement for the purpose of synchronization. In order to adjust voltage at PCC signals are sent to the controllers of the DGs. Linear integration method which uses only 5 bits of data for communication is implemented for this purpose is shown in fig 5.This linear integration is used to linearly increase or decrease the Po and Qo as per the synchronization commands.

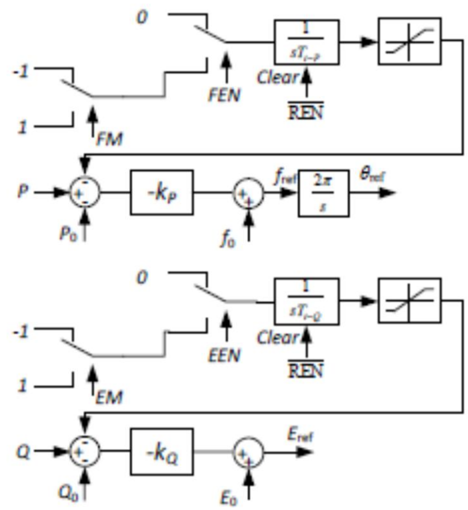

Fig.6 Linear integration method based on droop control

7	6	5	4	3	2	1	0
×	×	×	EM	EEN	FM	FEN	REN

Table1: The synchronization command

REN	FEN	FM	EEN	EM	Adjusting way	Results
0	×	×	×	×	×	×
1	1	0	×	×	$P_0\downarrow$	$f\downarrow$
1	1	1	×	×	$P_0\uparrow$	$f\uparrow$
1	0	×	×	×	P_0-	f-
1	×	×	1	0	$Q_0\downarrow$	$E\downarrow$
1	×	×	1	1	$Q_0\uparrow$	$E\uparrow$
1	×	×	0	×	Q_0-	E -

Table2:Meaning of synchronization command

IV. A NEW SYNCHRONISATION METHOD

By using the control strategies used above, however synchronization is achieved but it has its own limitations. A new method using Space Vector Pulse Width Modulation (SV PWM) is used to achieve synchronization. Space vector modulation is based on the concept of representing three phase quantities as vectors.

V. CONCLUSION

In this paper different control strategies and a new synchronization method based on space vector PWM is defined. In master slave control there may be chance of communication failure while in droop based method the power sharing capabilities are being changed. Simulation is conducted for the strategy defined in section IV and the obtained results are presented.

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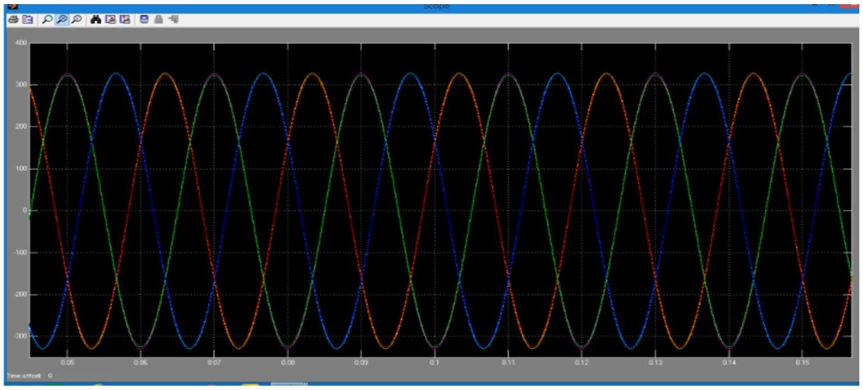

Fig7.Synchronised output voltage.

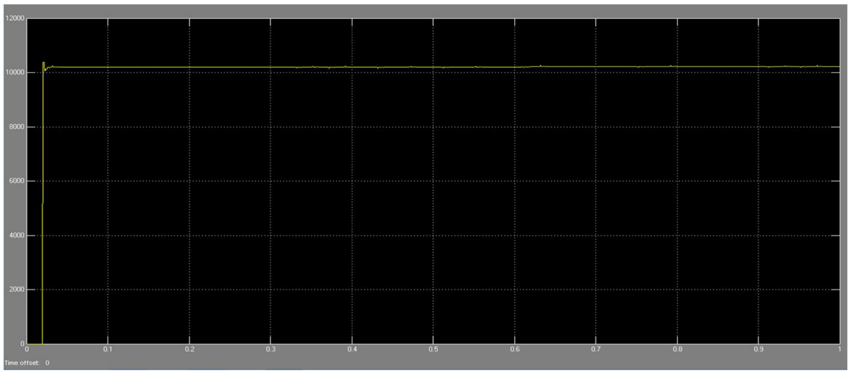

Fig8: Active power of DGs.

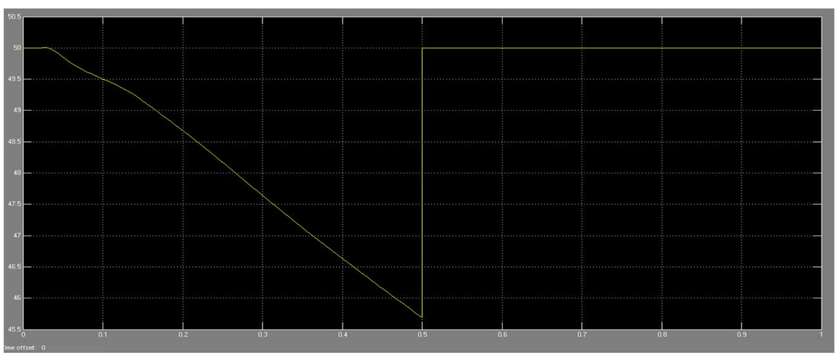

Fig9: Frequency at time of synchronization.

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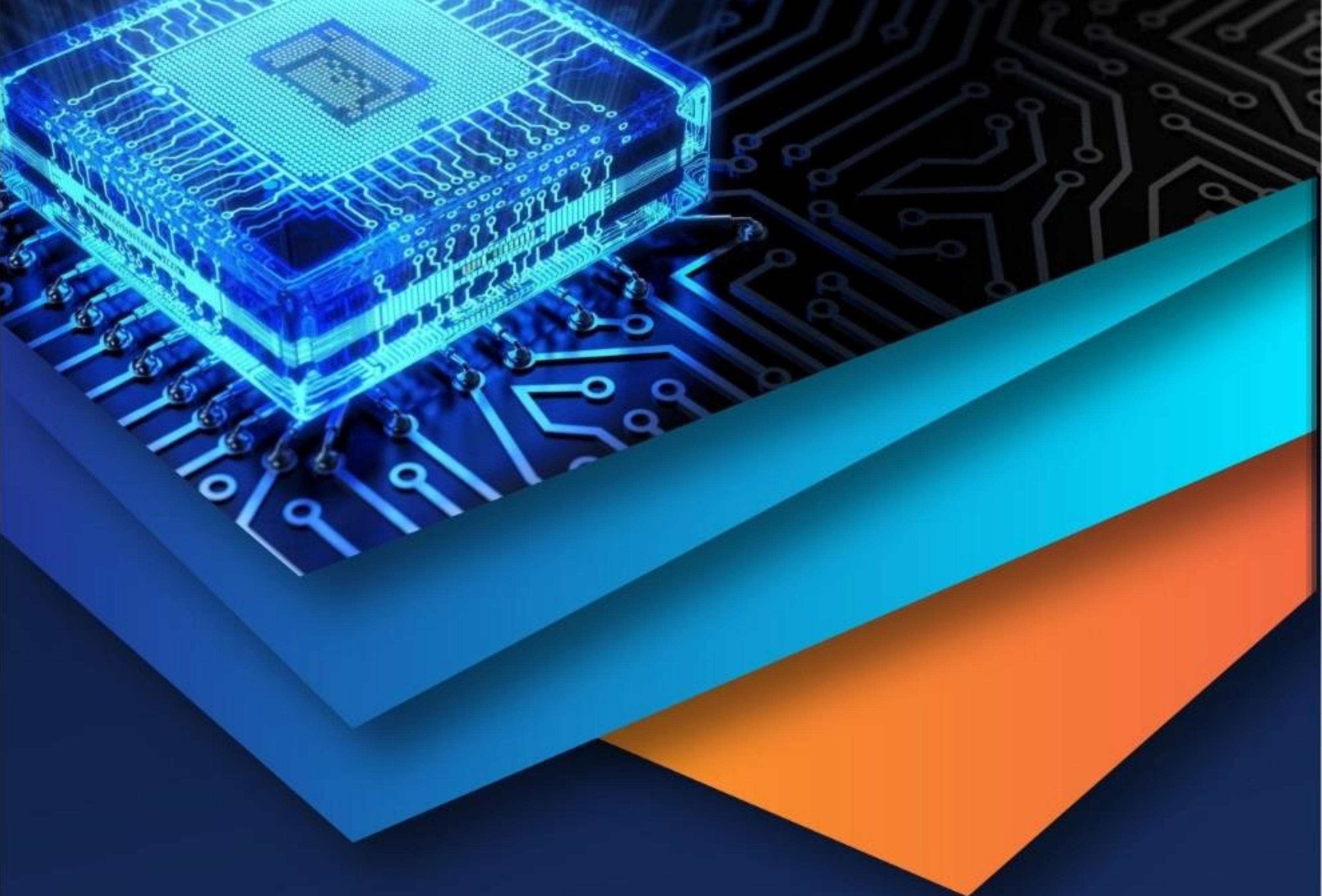

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