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"A Review on Distributed Generation Control and Power Sharing In Islanded Microgrid"

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Abstract:

The micro-grid in islanded operation is unable to share reactive power accurately due to variation/mismatch in line impedance. This paper includes various approaches for implementing distributed power generation and power sharing in islanded Microgrid. It also includes the methodology for automatic recovery of system frequency. Most of the methods are mainly dependent on two important operations: error identification and voltage recovery operation. The increase in sharing accuracy is enhanced by sharing the error reduction operation. The activation of error reduction operation is done by synchronization signals of lower bandwidth. Since the output voltage amplitude is decreased by error reduction operation thus in order to compensate the decreased voltage amplitude a voltage recovery operation is implemented. The conventional dropped control method can be more effective in controlling the inverters in microgrid when the microgrid is disconnected from main grid but bears certain lacuna in transient response. This paper presents various controlling strategies and comparative approach between various methods of power sharing in islanded Microgrid.

Keywords -- **Microgrid, Drooped Control, Distributed Generation, Power sharing.**

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I. INTRODUCTION

The dependency on centralised power generating system is widely replacing by distributed generation (DG) of power. The distributed generation bears several advantages such as, high efficiency of energy utilization, flexibility in installation, less pollution, lowest transmission losses. Almost all the DG sets are connected via power electronic switching devices that introduce interference in the system. In order to overcome such disturbances the concept of Microgrid was proposed by Consortium for Electrical Reliability Technology Solution [1]. Microgrid may offer flexible power management compared to single DG unit. It can also operate in islanded or grid connected mode thereby satisfying the financial need/assistance of utility as well as consumers [2]. Basically, microgrid is made up of low to medium ranges of voltages that includes various loads and distributed energy resources. It has CC (Central Controller) and LC (Local Controller), various load sources, static switches and loads [3]. The microgrid is found to be operative in two modes namely, grid-connected operating mode and islanded mode. These mode of operation is selective that depends on state of connection with main grid. In previous mode of operation i.e. grid-connected operation the microgrid is connected to main grid that bears high system inertia thereby the frequency of microgrid is identical to the main grid [4]. Thus when desired output power of DG set is inserted to the system the frequency of microgrid may vary and that is compensated by main grid. Whereas in case of islanded mode of operation the microgrid has to maintain its own frequency and need to maintain its supply and demand of its own using DG sets only. Several studies have been put up by different scholars claiming active power sharing and frequency control strategies for microgrid. The p-f droop control method considered as the most common method of power sharing have been developed that eliminates the conventional power sharing concept using synchronous generators [5]. A tunable droop control method bearing two degrees of freedom acts adaptive transient droop controller in contrast to conventional droop controller [6]. In order to have frequency recovery in islanded Microgrid two modes of operation namely, single-master & multi-master mode is introduced that focuses on secondary load frequency control in islanded Microgrid [7]. In order to enhance the power sharing capability and frequency control stability in the system a concept of virtual impedance control is developed that helps in decoupling the active/reactive power [8]. A battery energy storage system can be actively control the power sharing ability of system instead of droop control method by using constant frequency control method adds the advantages but gains in capital cost [9]. In this paper we have tried to include most common methods and best method for power sharing and frequency control in islanded microgrid.

II. CONFIGURATION OF AC MICROGRID

Microgrid consists of several DG units and diverse load. The main components are a static switch, a central controller (CC), LC filter, DGs and loads. Fig. 1 depicts the configuration of microgrid. Each of the DG unit is connected to the AC bus via static switches whereas the Microgrid is connected to the main grid through smart switch. If the smart switch is closed the system is grid-connected on the other hand when the smart switch is open the system is islanded. In case of grid connected mode the DGs and utility involves in power sharing by absorbing and compensating the reactive power in the system thereby fulfilling the need. On any circumstances when the microgrid is islanded the voltage source inverters are responsible for maintaining the stability of microgrid. Fig 2 indicates the DG unit model for microgrid configuration.

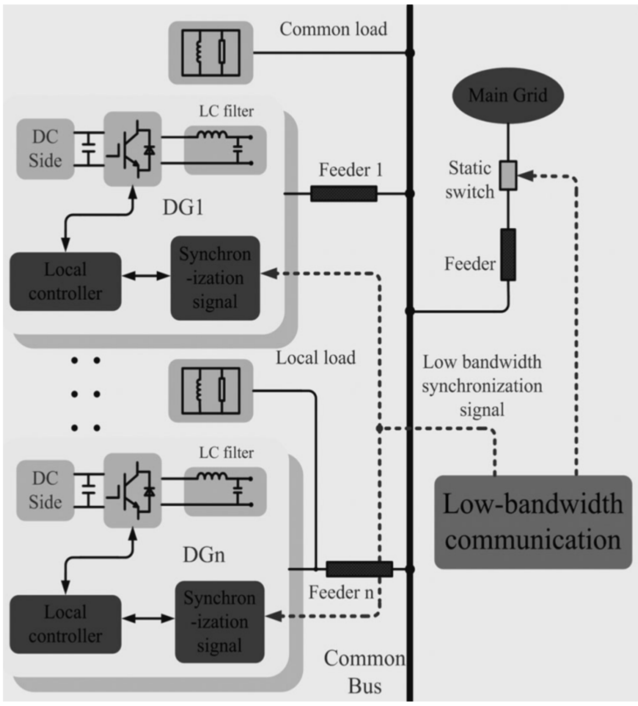

Fig. 1: AC microgrid configuration

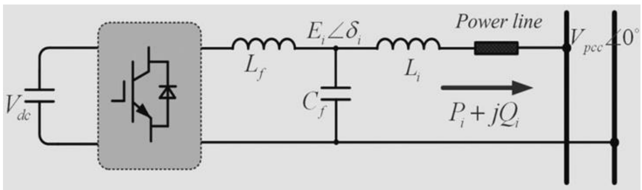

Fig. 2: DG unit model

The various parts of microgrid has their own importance in the system, the main function of CC is to maintain the voltage and frequency to a specified level. It also controls the voltage of DG. Generally DG is either dis-patchable or non-dis-patchable. Fuel cells, micro-turbines can produce controllable active power as per demand that in-turn maintains the power sharing during islanded operation whereas when PV cells, wind turbines are used as DG units, since their output is dependent on weather condition (instead of load) thus are not to be dispatched. The sustainability of islanded microgrid can be observed by controlling the DG output or opting the frequency control methods. Each of these is summarised in following manner.

III. DG CONTROL METHOD

The DG controller in islanded microgrid must be properly commanded in order to maintain the frequency and satisfy the require need for the same a multi-agent approach plays an important role.

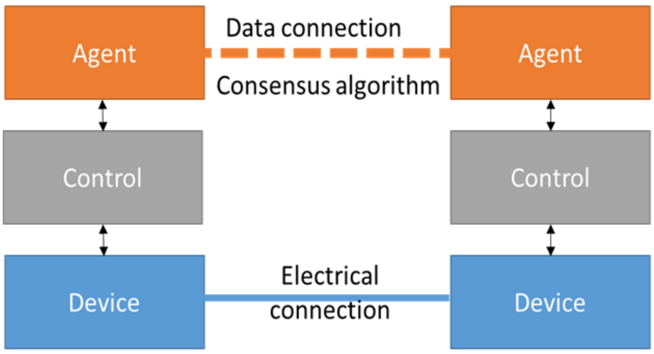

Fig. 3: layer control structure for DG

The working condition of DG controllers are broadly divided into three layers namely, device layer, control layer and agent layer as depicted in fig 3. The device layer consists of physical components basically the measurement devices that sense the signal and pass the sensed signal instantaneously to the consecutive layers. The output values (current, voltage) of device layer is fed to control layer which calculates the active and reactive power and act accordingly to build feedback control system. Similarly, the frequency deviation observed at the DG output is sent to agent layer which further forwards the data received and that makes the inverters to adjust the value of DG output.

IV. FREQUENCY CONTROL METHOD

The developed feedback control system for determining the reference frequency in order to maintain system frequency is broadly categorise in three different forms that are summarised below.

A. Droop control Method: The conventional *P-f* droop control method plays an important role in controlling of active power sharing. CC helps in determining the deviation of active power from the amount already dispatched. This deviation is used to calculate the output reference frequency (f_{out}) i.e. given by,

$$\boldsymbol{fout = fnom + mi\,(Pi\,dip - Pi)}$$

Where, mi is droop co-efficient. Above equation suggest that, the output reference value of frequency calculated is directly proportional to the *p-f* droop co-efficient or in other word the exact sharing of load among the several DGs is proportional to the droop coefficient.

B. Self-recovery control: The main aim of self-frequency recovery method is to provide the corrective measures to DGs to maintain frequency during power sharing. The change in frequency during power sharing happens due to differences in the impedance of the DG set during transient state or swift in the location of load leads to differences in the output frequency of DGs. The automatic/self-frequency restoration of DGs dependent on *kf* (frequency restoration factor) which is expressed as,

$$\Delta f_{i,\mathrm{res}} = k_f \int (f_{\mathrm{nom}} - f_i)\, dt$$

Every DG has same restoration factor which indicates that the change in frequency at any one of the DGs due to transient can restored by sharing the burden equally on every DGs.

C. Compensation control: The lacuna observed during self-recovery control can be minimised using compensation control. This method works on reducing the power sharing error instead focusing on reducing the frequency error cause during transients. As the active power is dependent on magnitude of impedance as well as frequency difference, the small change in frequency in the system can have large power difference thus compensation of active power is main area of focus in this method. During transients the communication system is established for communicating the CC and DGs that helps in switching action. The operation of switches provides the compensation of active power for smaller time duration but adds reliability and instantaneous action is performed for equal power sharing.

V. CONCLUSION

We have described the control methods for DG and various frequency control methods for islanded microgrid. Since islanded microgrid bears low inertia thus it is vulnerable to the frequency disturbances and hence frequency recovery is very much essential. The various methods studied are workable at high voltage level thereby a novel technique has to be established that will consider equal power sharing of DGs and frequency restoration in islanded microgrid at low voltage level also. This paper presents a brief review on various methods for maintaining power/frequency in islanded microgrid.

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