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Control for Grid Connected and Intentional Islanded Operation of Distributed Generation

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ABSTRACT

The Distributed Generations in Micro grids are tied to the Utility Grid. These Generators shall be synchronized only if the Grid supply is available. If the grid supply fails the synchronization shall be lost until the grid supply resumes. The IEE1547-2003 standard states to disconnect DG if the grid supply fails .When an outage of grid supply occurs a condition known as Intentional islanding occurs. In such a condition the Micro grid is isolated from the rest of the grid. It is essential for microgrid resume operation for reliable service. Energy sector is moving in to an era of DG and Micro grids. The IEEE 1547-2003 standard does leave open a section to take on a task for intentional islanding in future. The controls must identify the intentional islanding. DGs in Grid tied mode shall operate with Current source inverters (CSI).DGs in intentional islanded operation mode shall operate with Voltage source inverters (VSI). This paper proposes a control algorithm to detect grid supply failure and the intentional islanding operation of DGs. An algorithm for intelligent load shedding during islanded operation also proposed. The VSI and CSI modes are designed and presented in this paper .The results are simulated in MATLAB.

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1. Introduction

Energy sector is moving in to the era of Micro grids and DGs based on renewable energy sources is an alternate source to assist the main power stations[17].The interest in DG has led to the recent technological advances in electrical and mechanical power conversion[16].Customers expect a reasonable level of quality in supply from their utilities. The main advantage of DG is provide uninterrupted supply when operated in intentional islanded mode during main grid outages[8].During Grid connected operation mode each DG inject a predetermined power to grid. The power conversion system in this mode uses Current source inverter.

When the DG is isolated from the rest of the grid the DG has to change over to islanded operation to feed the critical loads. During islanded operation the non- critical loads must be disconnected to limit essential loads only, until the grid supply is resumed. Controls for VSI and CSI modes are described here**.** Àlso algorithm for intelligent load shedding and synchronization for grid reconnection are proposed

2. Controller

The Schematics of DG Inverter with controller shown in Fig.1. LCL filter can transfer and distribute energy to load. [1], [24], [25]. The controller provides a preset power from DG and maintain voltage at point of common coupling (PCC). During an outage after detection, the system reverts back to VSI mode and constant voltage maintained**.** Block diagram of controller shown in Fig.2.

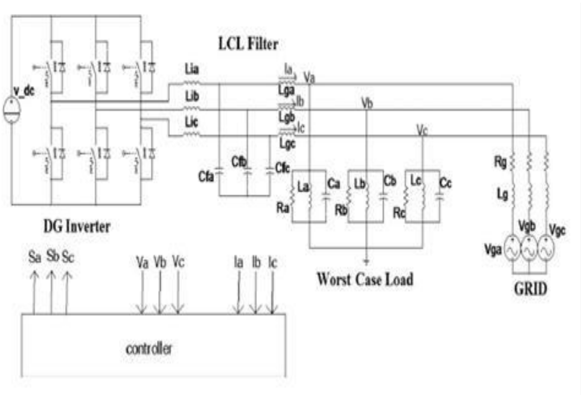

Fig.1 Schematics of DG inverter system

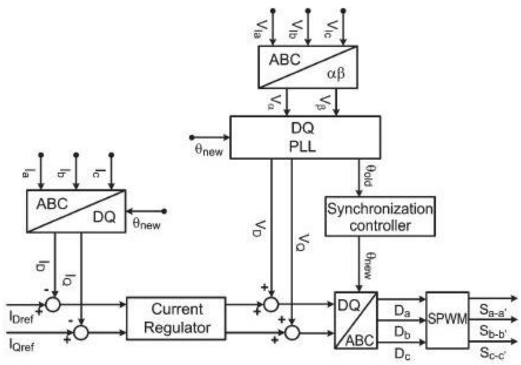

Fig. 2 Block diagram of current controller.

3. Grid Connected Operation

The controller in fig.1 is designed in grid connected CSI mode[10]**.**Frequency and phase angle reference at PCC is determined by Phase lock loop (PLL) and synchronization can be done in this mode. In grid connected operation mode power factor is unity. The grid current reference signal has to be in phase with Grid voltage [14]**.** When operating in the CSI mode the filter current undergo Parks transformation. The error signal passed to PID controller to generate inverter reference voltage .The voltage reference re-transformed in to inverse of Parks transformation. The voltage is used for generating high frequency PWM voltages [11]. The topology is shown in fig.2.

4. Grid Failure Detection

When the grid fails, islanding is detected in order to change between grid-connected and intentional islanding modes [12].Two parameter used are the magnitude of grid frequency and grid voltage .The algorithm in fig.3 cause to switch the invertor to the required inter face at PCC. When the grid voltage is either less than0 .88pu or greater than1.1 pu the main grid is deemed as an outage [26].Similarly when the grid frequency becomes less than 59.3Hz or greater than 60.5Hz the main grid is deemed as an outage [8].

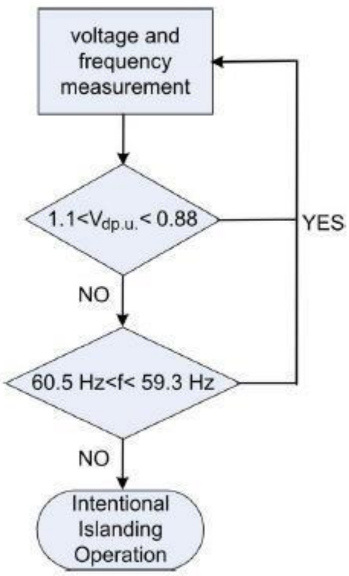

Fig. 3 Intentional islanding algorithm

When an outage of grid occur**s** voltage and frequency disturbances originate in the micro grid which supplies the local loads. The transient depends on the load in the local circuit. When the drifts in parameters reach a particular level it is presumed that islanding initiates. But for the intentional islanding operation rapid disconnection of non-critical loads must be made if the capacity of DG is less than the total load in micro grid. This process is intelligent load shedding. The load shedding system is shown in Fig.4.

The intelligent load shedding is defined as a process to reduce the system load on priority to safe guard the system from potential material damages and generation losses. Hence for the stable operation of intentional islanding, load shedding is essential.

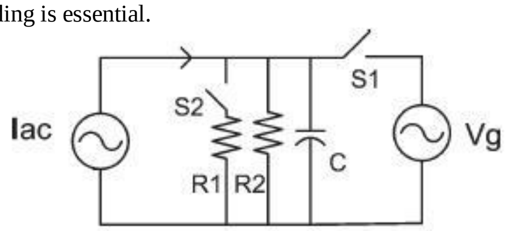

Fig. 4 Load shedding system

5. Slanding and Detection

The two types of Islanding modes are intentional or arranged islanding and unintentional or occurred islanding[18]-[20].Intentional islanding isolate the utility grid from the rest of the system to form power island when outage occurs. This condition enable Micro grid continue supply local load demands by Distributed generation(DG).Whereas the unintentional or occurred islanding is harmful to the system due to the voltage and frequency transients which leads to instability in system. Electrical system components in islanded section are liable for damages. Several methods available to detect state of islanding as classified in Fig.5.

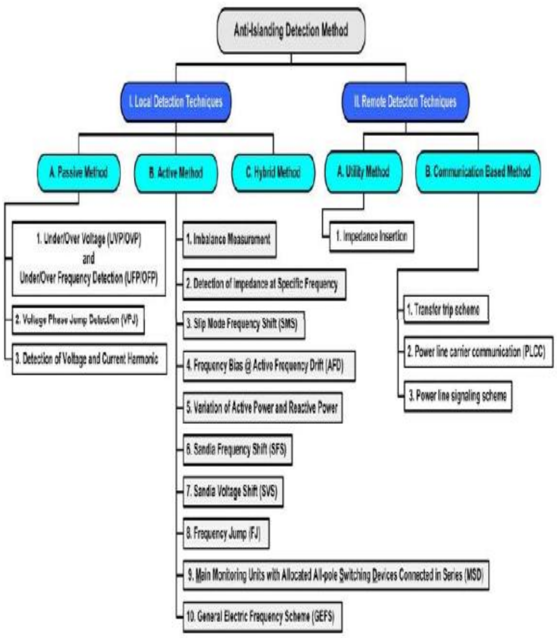

Fig. 5 General classification of islanding detection

6. Results and Discussion s

6.1 CSI operation

For CSI operation, inverter designed for supply constant current and power output. For unity power factor operation also ensured [21].The sine wave for pulse width modulation is generated from the filtered output voltage and power as feedback to switch the inverter in CSI mode generated by PWM of CSI sine wave with CSI carrier .The filtered inverter power output is fed to the control algorithm to generate CSI sine wave. The polynomial function does the comparison of inverter power output with the preset value of 10 KW for active power and 0 KW for reactive power. The error signals fed to modulation system after regulation of the error by PID. The pulse width modulated signal is used to switch inverter. The output active power is 10 KW and reactive power is set to 0KW. Power factor is unity. The inverter voltage and grid voltage are in phase. Inverter output current in phase with the voltage results in unity power factor. Simulated scope view and simulated system are shown in Fig.6 and fig. 7 respectively.

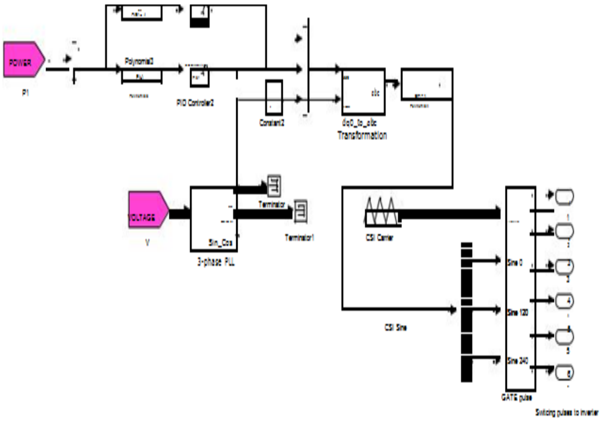

Fig. 6 Simulated system CSI mode

Fig.7 Simulated scope view Grid connected CSI mode

6.2 Auto Detection of Grid Failure and Switching in between VSI & CSI Mode

The grid voltage and frequency are continuously measured through a 3 phase phase lock loop(PLL).The measured signal will then undergo an interval test to monitor whether these parameters are within threshold limits. If grid voltage reach less than0 .88pu or more than 1.1 pu outage of grid is deemed occurred. Same way frequency transients also measured for detecting power outage. Threshold value for frequency are 59.3Hz and 60.5 Hz. \

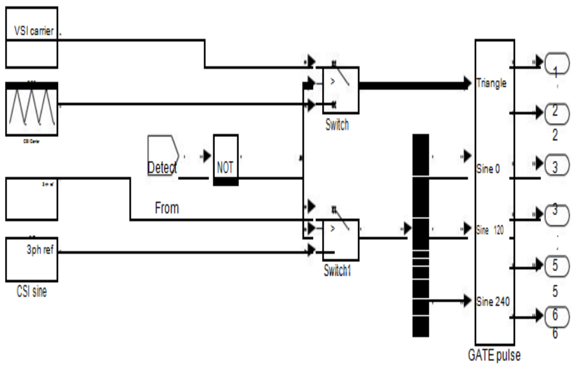

Fig.8 Simulated auto detection and switching in between VSI and CSI modes

The inverter will be in VSI mode in case the MG islanded. Intelligent load shedding of non-critical load and supply only the critical loads. when the external grid supply resumed the inverter will revert back to CSI mode. Grid synchronization done in this mode .The simulated scope view and simulated system are shown in Fig.8.And Fig.9 respectively

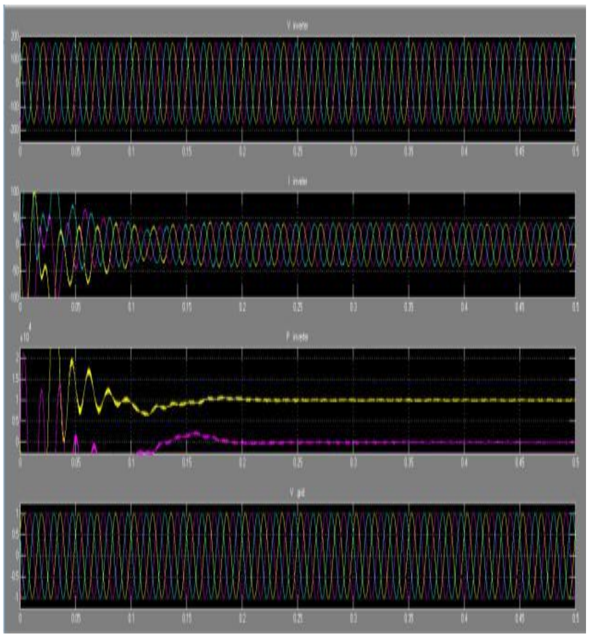

Fig.9 Simulated scope view of auto detection and switching in between VSI and CSI modes

7. Conclusion

Distributed generation is gaining more importance in recent years and predicted to inevitably lead to a new approach in the distribution system operation [16]. A micro grid is a cluster of interconnected DG, loads and intermediate energy storage units that co-operate with each to be collectively treated[22].Intentional islanding of distributed generation(DG) provide an uninterrupted supply to critical consumers and system reliability can be improved [16].Distributed generation, islanding detection methods, control topologies in grid connected operation &standalone operation, voltage behavior in transition during power outage, load shedding algorithms and synchronization methods in reconnection have been studied[2].The use of DGs to supply a portion of the network or critical loads can improve the quality of supply indices and reliability. Aside from that additional revenue to DG owners can be achieved due to the increased power supplied during network outages and customer satisfaction resulted due to reduction of the frequency and duration of interruptions from outages in the distribution network[16]. DG owners, DNOs and customers could potentially benifit due to intentional islanding of DG micro grids [23].

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