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SREELEKSHMI R S
National Institute of Technology Calicut, Kerala – 673 601, lakshmilal2006@yahoo.co.in

Sunitha R
National Institute of Technology Calicut, Kerala – 673 601, rsunitha@nitc.ac.in

ANALYSIS OF INVERTER FED MICROGRIDS FOR DIFFERENT MODES OF OPERATION IN MATLAB/SIMULINK

SREELEKSHMI R S[1] & SUNITHA R[2]

[1,2]Dept. of Electrical Engineering, National Institute of Technology Calicut, Kerala – 673 601
E-mail : lakshmilal2006@yahoo.co.in, rsunitha@nitc.ac.in

Abstract - This paper presents analysis of control techniques of a converter fed microgrid in grid connected mode and islanded mode of operation. Here two control strategies are discussed , one for grid connected mode and the other for islanded mode of operation. In grid connected mode of operation the DG inverter system works in constant current control mode, and provide preset power to the grid, while in islanded mode of operation the DG inverter system goes to voltage control mode. Voltage control mode is simple and has a low number of control loops.

Keywords - *Islandingoperation, Distributed Generation, Micro-grid.*

I. INTRODUCTION

Distributed generation is now becoming a popular power scenario in a de-regulated environment. Integration of distributed generation and incorporation of controllers lead conventional power network to operate as active power networks. Under disturbances these power network split and if a split part contains generators and loads and if the load demand can be matched with supply a power island is established[1]. Recently more renewable power conversion systems are connected in low voltage ac distribution systems as distributed generators or ac micro grids due to environmental issues caused by conventional fossil fuelled power plants. Due to the expected high penetration of DGs in the distribution system, and the increasing competition amongst energy suppliers to secure more and more customers, intentional islanding of DGs becomes a valuable option . AC micro grids have been proposed to facilitate the connection of renewable power sources to conventional ac systems. DG interface control will be responsible for maintaining both the voltage and frequency on the islanded part of the network within the permissible operating levels[2,3]. Here active method is used which directly interact with power system by varying inverter output. The output power of DG and voltage at PCC are compared with set values and are passed to a PI controller. The output of PI controllers are then used to calculate the modulation index and angle of modulating signals. The frequency is measured using a PLL. The on-off switching signals are obtained using SPWM.

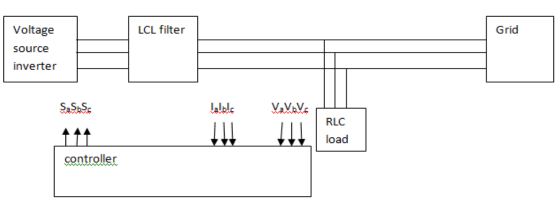

Fig. 1: Inverter fed microgrid with grid connected modelled in MATLAB/Simulink

II. CONTROL OF VSC IN DQ-FRAME

In the dq frame control of a grid imposed VSC system instantaneous decoupled control of the real and reactive power exchanged between the VSC system and the AC system is possible[11-14].

In addition to that the control variables are DC quantities in steady state. There are two main methods for controlling real and reactive power in the VSC system. The first approach is known as voltage-mode control and the second approach is known as current-mode control.

In a voltage controlled VSC system the real and reactive power are controlled , respectively by the phase angle and amplitude of the VSC AC-side terminal voltage relative to the PCC voltage[4-6]. The voltage mode control is simple and has a low number of control loops. In current mode control the VSC line current is regulated by a dedicated current control scheme, through the VSC AC-side terminal voltage. Then the real and reactive power are controlled by the phase angle and the amplitude of the VSC line current with respect to the PCC voltage.Thus due to the current regulation scheme ,the VSC is protected against overcurrent conditions[15-19].

III. CONTROLLER

A) Current Controller

The block diagram of the controller for grid connected mode is shown in fig 2.The output power of DG and the voltage at the PCC is measured and compared with reference values and fed to PI controllers. The output of the PI controllers are used to calculate the modulation index and angle of modulating signal. The real and reactive power is controlled by the current controller and it is performed in dq frame. The real and reactive power is controlled by the line current components. The feedback and feed forward signals are first transformed to the dq - frame and then processed by compensators to produce the control signals in dq-frame Finally the control signals are transformed to the abc-frame and fed to the VSC[7-10,20,21].

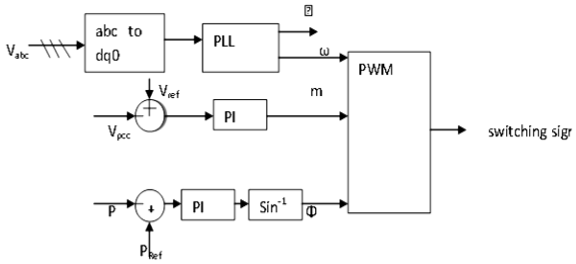

Fig. 2 : Controller for grid connected mode of operation

B) Voltage Controller

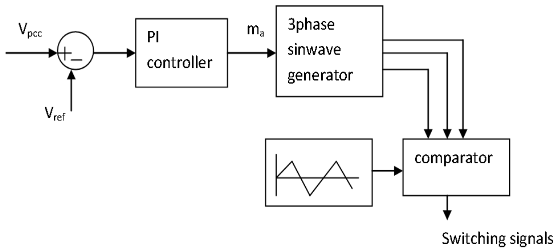

Fig. 3 : Shows block diagram of controller for islanding operation

In islanded mode of operation the control strategy changes from current controlled mode to voltage controlled mode. When a fault occur in the main grid the voltage and frequency deviates from its permissible values. During this condition the control mode changes .The frequency is set fixed at particular value. The voltage at the PCC is measured and compared with the set values. The error is passed to a PI controller to determine the modulation index value. Three sinusoidal waveforms shifted by120 degrees are generated using the modulation index and are compared with a high frequency triangular waveform to determine the on-off signals of the inverter switches[22].

IV. GRID SYNCHRONIZATION AND ISLANDING DETECTION

Grid synchronization and islanding detection is achieved usimg a dq0-PLL structure. The voltage angle is generated by PLL .The grid frequency and phase angle is tracked by the PLL[11-14] . When the voltage and frequency varies beyond permissible limits, islanding occurs.

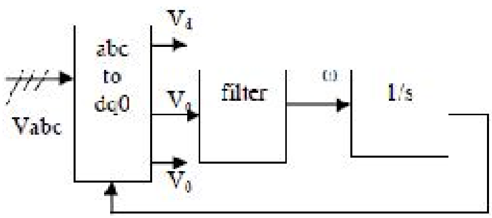

Fig. 4 : Block diagram of DQ-PLL structure

V. SIMULATION RESULTS

The converter fed microgrid consisting of a dc source, LCL filter and RLC load is modelled and analysed in MATLAB/Simulink. The dc source voltage is 400V. The RLC load is modeled so as to consume 10kW active power and zero reactive power. Under normal condition the DG inveter system will be in grid connected mode and will deliver 10kW active power to grid. The reactive power will be maintained at zero. The control scheme is analysed for different conditions.

Case 1: In normal operating conditions

Fig 7 shows the inverter current.at .2 sec the inverter is connected to the grid .From 0.2 to 0.3 sec the microgrid and the grid will be in a floating mode. After synchronization with the grid the microgrid will deliver 10kW of active power to grid. Hence from 0.3 sec onwards the inverter current is increased to 80A.

Fig 8 shows the active and reactive power from 0.2 to 0.3 sec the microgrid and the grid will be in a floating mode. After synchronization with the grid the microgrid will deliver 10kW of active power to grid. from 0.3 sec onwards the active power is increased to 20 kW and the reactive power is maintained at zero.

Case 2 : In islanding mode of operation

Fig 11 shows the inverter current during islanded operation. After synchronization the inverter current is increased to 80A. At 0.8 sec the DG detects the islanding condition and the control mode changes .From 0.8 sec onwards the current is decreased which indicates the disconnection from grid.

Fig 12 shows the active and reactive power after disconnecting DG from the grid. At 0.2 sec the DG is connected to grid and after synchronization the total active power delivered by the DG becomes 20kW. At 0.8 sec the DG detects the islanding condition and goes to islanding mode so that the active power delivered is decreased to 10kW.

VI. CONCLUSIONS

This paper presents control techniques in grid connected and islanded operations of microgrid ,voltage behaviour during outage and active and reactive power flow under various conditions .The analysis have been done for different operating conditions and change from one mode of operation to the other mode with the help of islanding detection is also used in this paper.

Case 1: In normal operating conditions

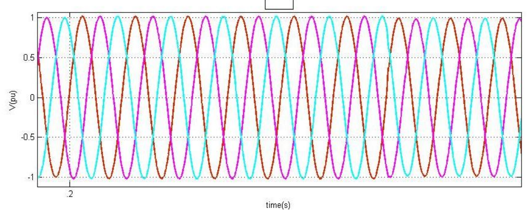

Fig. 5 : Grid voltage

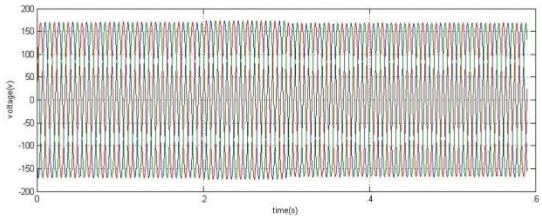

Fig. 6 : Inverter voltage

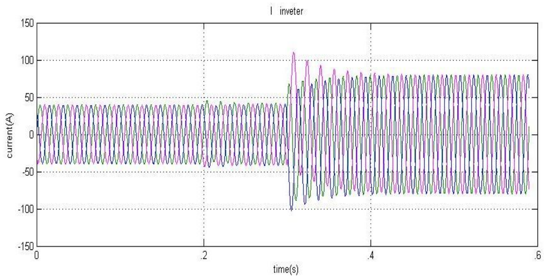

Fig. 7: Inverter current

Case 2 : In islanded operation

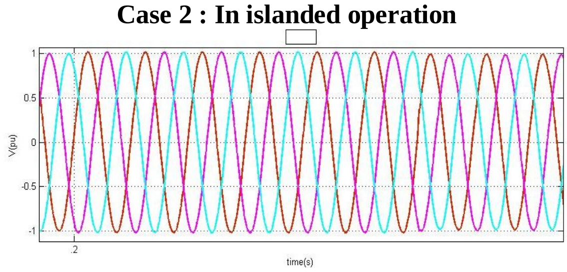

Fig. 9 : Grid voltage

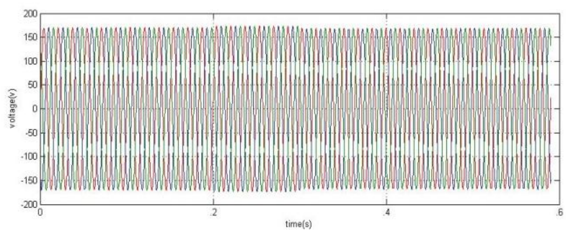

Fig. 10 : Inverter voltage

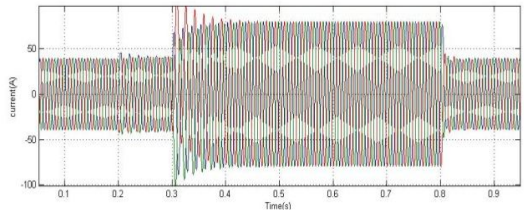

Fig. 11: Inverter current

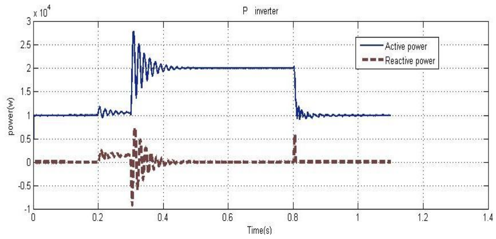

Fig. 12 : Active and Reactive power

Case 3 : When the DG is in outage condition

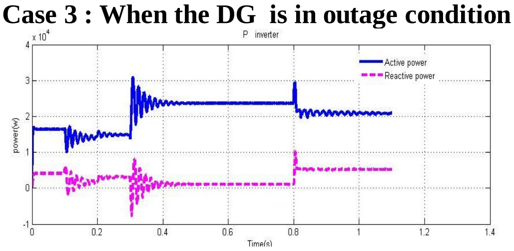

Fig. 13 : Active and Reactive power

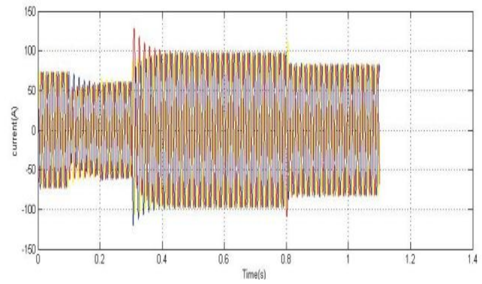

Fig. 14 : Inverter current

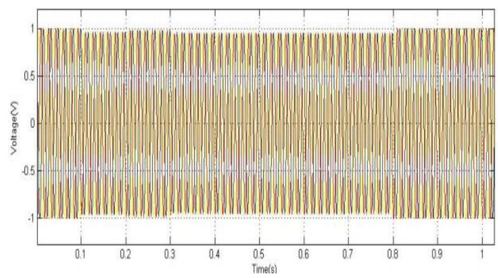

Fig. 15: Grid Voltage

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