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Control for Grid Connected and Intentional Islanding Operation of Distributed Generation System

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Abstract:
This paper presents a complete model of a typical micro-grid and identification of the required control strategies in order to operate this new type of power system. Many problems solve the using of individual distribution generation. A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a "micro-grid". The micro-grids are new concepts of electrical power consist of Distribution Generation, Renewable Energy Resources and Sensitive as well as Non-sensitive load. These sources are operating in parallel to the grid and it can operate in islanding mode. During the disturbances the generation and load are not match then the load and generation separating islanding mode without harming the transmission line or grid. Intentional islanding describes the condition in which a micro-grid or a portion of the power grid, which consists of a load and a distributed generation system, is isolated from the grid system. In this situation, it is important for the micro-grid to continue to provide adequate power to the load. Under normal operation, each DG inverter system in the micro-grid usually works in constant current control mode in order to provide a preset power to the main grid. When the micro-grid is isolate from the main grid, each DG inverter system must detect this islanding situation and must switch to a voltage control mode. In this mode, the micro-grid will provide a constant voltage to the local load. This paper describes a control strategy that is used to implement grid-connected and intentional-islanding operations of distributed power generation. The control strategies have proven their robustness and effectiveness in controlling the operation of micro-grid while maintaining system stability.

Index Terms: Distribution Generation, Grid Connected Operation, Islanding Operation, Result and Discussion

I. INTRODUCTION

Distributed Generations comprises large amount of prime mover technologies. The mainly distributed generations are using renewable and non-renewable energy resources. Distributed energy resources are part of micro-grid system. The choice of distributed energy resources are depending upon fuel availability and locating area. The simple definition of the DG is "a renewable energy resources of electrical power connected to the distribution network consumer side. But originally power system developing the generation supplying local demand. The DG is producing small amount of power. The some country saving/defined the DG in depending upon voltage level and it in load directly connected to the consumer's demands or load. The IEEE defined the DG is not directly connected to the large amount of transmission line. The micro-grids are increasing overall efficiency, power quality etc. The IEEE definition of micro-grid as a group of interconnected load and DER within clearly defined an electrical boundary that acts a single controllable with respect to grid. The micro-grid operated parallel to the utility grid or island. When any type of events such as voltage collapse or fault occurs in the system then the micro-grid is operating islanding and it is isolate to main grid without any harming of transmission line. The micro-grid as combination of generation sources, energy storage and local. This combination unit is connected to the distribution network with the help of PCC. Some technical issues are power flow balancing, voltage control and behavior during the disconnection from the PCC. When micro-grids are operated islanded its characteristics different compare with conventional electrical system and it required different operation and control. The micro-grid controlling depending upon the inverter control. It is divided into two part (1) Current Controller and (2) Voltage Controller.

II. MICRO-GRID CONFIGURATION AND FEATURES

The basic micro-grid architecture diagram as shown in figure1. As shown in this figure consists of four feeders and distribution system. The A , B and C feeders are sensitive load and it required local generation but some of non-sensitive ad it do not required any type local generation. In this system consist of four micro-sources at node 8, 11, 22, and 16. When the problem arises in the utility grid then the static switch is open and isolated the sensitive loads from the main grid. When the micro-grid is grid connected power flowing the non-sensitive loads. The micro-grid consists of master controller or central controller. It is controlling the operation of micro-grid. This system is classified into three categories.

Unit Power Control:

In this diagram DG generating the voltage at a point and injected active power (P). This power flow from micro-source. When the increasing load demand in the micro-grid the extra power comes to grid because the all DG unit operate to constant output power. This system using CHP because of the power production depending on the heat demand.

Feeder Flow Control:

In this system every DG regulated the voltage at the connecting point and power. It is flowing to feeder A, B, C and D. When the system islands the local feeder flow or frequency droop function insures that the power is balanced.

Mixed Control:

If the system load demand is increasing that time the extra power taken from the distribution generation. The utility power and DG generating power mixed and its flow to load demand side.

MICRO-GRID FEATURES

Micro-grid is connected to the main system through the point of common coupling PCC. The inter connection static switch is connection between the micro-grid and distribution system. A main feature of micro-grid is to stable operation during the faults and various network disturbances. If the static switch will be open the autonomous mode operates and disconnects the micro-grid from the main grid. The DG and corresponding load can be autonomously separate from the distribution network to isolate the micro-grids load from the disturbance during any fault.

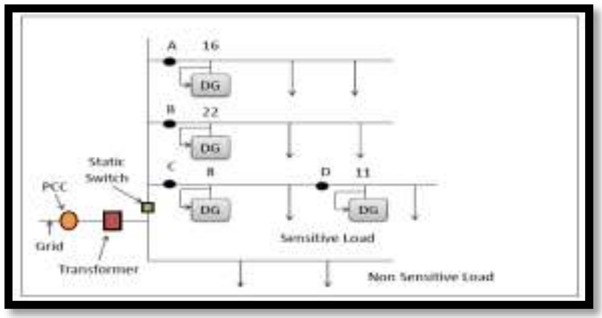

Fig.1 Basic Micro-grid Architecture

Micro-grids desired features are following:

- It enable to local power generation for the local load.
- It compromises various power generations that makes highly flexible and efficient.
- Its services provided for industrial, office, residential area, commercial etc.
- It provides good solution for any emergency case and shorting power in the grid during disturbance and fault.

III. CONTROL STRATEGY

The system consists of a micro source that is represented by the dc source. Under normal operation each DG inverter system in the micro-grid usually works in constant current control mode in order to provide adequate power to the main grid. If any problem arrived in grid side then the system will disconnect to main grid and it’s operate intentional islanding mode. In this mode it operate voltage control mode and provide constant voltage to the local load.

Mode 1: Grid Connected Operation

The control structure for grid connected DG system implemented in Matlab/Simulink is shown in Figure 3.1. The grid side converter operates as a controlled power source and standard PI controller are used to regulate the grid current in the dq reference frame in the inner control loops. The converter does not take an account to maintain DC link voltage constant by regulating i_d and i_q. The *id* represents the active power component injected current into the grid and i_q is reactive component. In this work i_d and i_q reference values are given and they will fallowed by the actual values by the DG system. In order to obtain only a transfer of active power only a transfer of active power, the i_q current reference is set to zero. The decoupling terms are used to obtain independent control of i_d and i_q. A PLL is used to synchronize the converter with the grid frequency. The philosophy of the PLL is that, the difference between the grid phase and inverter phase angel can be reduced to zero using PI controller and locking the line side inverter phase to grid [8].

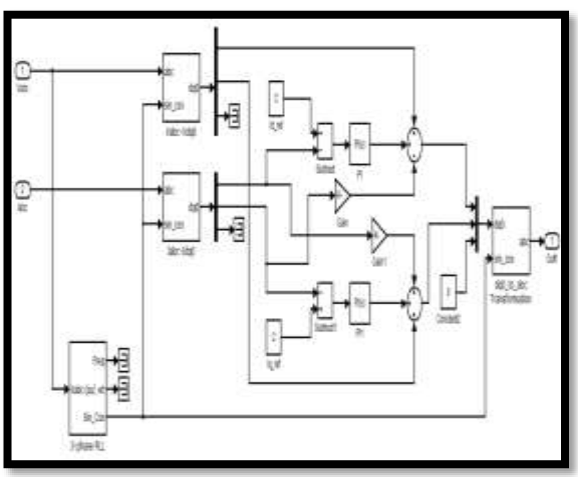

Figure 3.1: Current Control Block Diagram

Mode 2: Intentional Islanding Operation

For this mode of operation of DG system, the power conditioning unit consists of a three phase diode rectifier and voltage source inverters (VSI) with LCL filter are used. The control system for a voltage source inverter implemented using Matlab/Simulink is shown in Figure 3.2. DC voltage feeds 400 volts with 50Hz, 10kW load through an AC/DC/AC converter. The high frequency AC power is first rectified by six pulse diode bridge rectifier and filtered. A DC link voltage is given to an IGBT two level inverter generating 50Hz. The IGBT inverter uses Pulse Width Modulation (PWM) with 1.5 kHz carrier frequency. The voltage is regulated at 1p .u. (400 Vrms) by a PI voltage regulator using abc and dq to abc transformation. The conventional converter regulates the output voltage by a vector containing the three modulation signals used by the PWM generator to generate six IGBT pulses [8]. In this work the output voltage is regulated by the DG system.

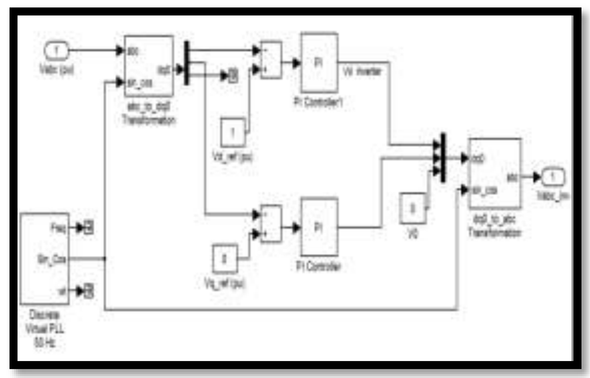

Figure 3.2: Constant Voltage Control Block Diagram

IV. SIMULATION RESULTS

The performance of the proposed control strategies was evaluated by computer simulation using MATLAB. Fig.4.1 shows the simulated system. This system was tested under the following conditions:

1. Switching frequency fs : 1.5 kHz;
2. Output frequency: 50 Hz;
3. Filter inductor Li: 3 mH;
4. Filter inductor L_l : 1.5 mH;
5. Filter capacitor C_f : 8.5 µF;
6. Dc-link voltage Vdc : 400 V;
7. Output phase voltage $V_{o1\phi}$: 120 Vrms;
8. Output capacity: 10 KW.

The *RC* load was adjusted to be resonant at 50 Hz and to consume 10 KW. The DG system was designed to supply 10 KW and 10 KVAR reactive powers. The system was operated initially in grid-connected operation. The grid was disconnected at 0.3 s, and this event was detected at 0.102 sec. After 0.102 sec, the control mode was changed from current- to voltage controlled operation. Fig. 4.2 shows the voltages and currents at the PCC before and after grid disconnection.

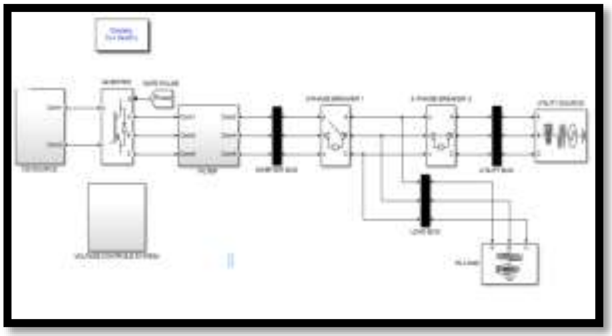

Figure 4.1: Simulated System in Matlab

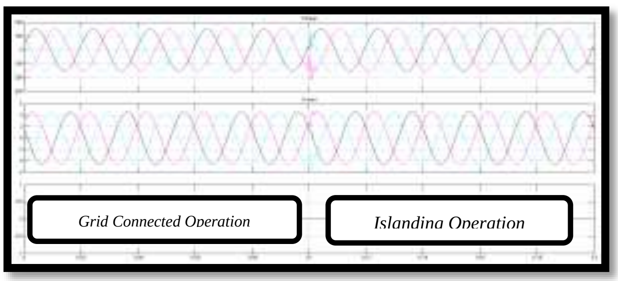

Figure 4.2: From grid connected to intentional-islanding operation

V. CONCLUSION

This paper intended to examine the micro-grid concept and to suggest control strategies that can reliably and efficiently operate a balanced 3 phase low-voltage micro-grid in grid -connected and islanded modes. At the first stage of this paper, and in order to study and analyze the behavior of a micro-grid, the essential components in a typical micro-grid system were simulated. A controller was designed with two interface controls: one for grid-connected operation and the other for intentional islanding operation. For the operation of a micro grid during grid-connected mode, constant current control schemes were introduced. For the operation of a micro grid during islanding mode, constant voltage control schemes were introduced. Both operations are simulated and shown results.

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