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Optimal Control in Distribution System using Intentional Islanding Mode of Operation

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Abstract: In Grid connected distribution generation systems Islanding detection is a vital act for reliability and safeness. For islanding detection several methods were proposed, but under multi-source configurations most of them may fail. Islanding can be a possible solution with a properly harmonize and advanced control scheme, to ensure reliable power to the negative loads. An intentional islanding detection control scheme for operation of an inverter-based DG system has been proposed in this paper. An interface control was designed for providing the constant power under grid connected mode of operations. In the absence of the grid, the algorithm will make the inverter to work in voltage control mode. An load shedding algorithm is used to remove the deviations in the generation and load.

Index Terms: Islanding mode, Optimal control, Grid connected mode, Distributed generation (DG).

I. INTRODUCTION

The renewable energy sources like wind, bio-mass, bio-gas, hydel, geo-thermal, solar are eco-friendly, abundant in nature and available freely in the environment. The energy produced by these can be integrated with grid under deregulated environment with dynamic pricing(1) . The Distributed generation are lesser in cost, eco- friendly, versatile technology and offers more reliable power. The integrations of the DG's with grids leads to several problems for ensuring the economical grid operations. To resolve the above problems, Islanding technique can be solution for protecting the generators and consumer loads**.** An unintentional island due to break down of utility will leads to most seriously complicate the reconnection of utility network, also cause in failure of protection devices and may leads to safety hazards. Hence according to current protection practices, the distributed generating resource should detect the formation of islands and disconnect the DG from the utility grid within few seconds [3]. IEEE 1547 states that one has take care for future consideration in implementation of intentional islanding technique [4].

For implementing the intentional island mode of operation, there must a system to detect the islanding event, as soon as the utility system get disconnected from the Grid. Under this circumstance a well-organized islanding detection algorithm is required, which can be locally controlled and remote-controlled mode of operation. In remote controlled mode of operation, efficient communication system is required between local DG and utility grid. In local control mode of operation requires the voltage and frequency at the DG site to be monitored [5]-[6]. A numerous works has been reported about the interface and control of the DG systems in grid connected and islanding modes of operation in the literature [7]. The effect of different controllers in interface om islanding detection has been analyzed [8]. This paper presents a single control algorithm for both grid connected as well as islanding operating mode. The islanding detection algorithm makes the DG system work in voltage control mode, when the grid is disconnected from the load. A superiority based load shedding scheme has been proposed to neutralize the imbalance in the power generation and load at point-of coupling (PCC) .

2. SYSTEM UNDER STUDY

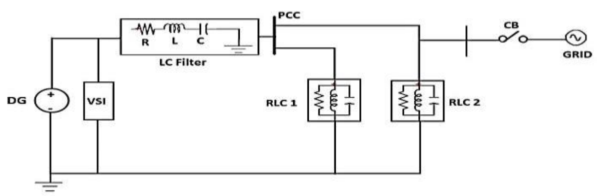

Fig. 1: Single line diagram of system under study.

A single -line diagram is shown in above Fig.1 for the system under investigation. It consists DG, which is represented as a dc source and three phase voltage source inverter, LC filter and a breaker to interact with grid. The inductor (L) and capacitor(C) value are used to design a filter. An PI controller is used to interface, the control parameters are defined in the synchronous frame. The frequency and angular reference are determined at the Point of common coupling (PCC) using phase locked loop.

2.1 Modelling of System:

With reference to the figure1. We get, $V_{ik}(t) = V_{gk}(t) + R_i i_k(t) + L_i \frac{d_{ik}(t)}{dt}$ (1)

where, *Ri*= resistance between DG and PCC, L_i= inductance between DG and PCC, V_{ik} & V_{gk} are voltages at the inverter and grid side respectively and k=a, b, c.

By applying parks transformation for equ.1 becomes,

$$V_{id}(t) = V_{gd}(t) + R_i i_d(t) + L_i \frac{d_{id}(t)}{dt} - \omega L_i i_q \qquad (2)$$

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$$V_{iq}(t) = V_{gq}(t) + R_i i_q(t) + L_i \frac{d_{iq}(t)}{dt} + \omega L_i i_d \qquad (3)$$

Where 'ω' is the angular frequency of the system

2.2 Grid Mode:

In this mode of operation, DG will supply the constant active and reactive powers to the system. The value of frequency and voltage at PCC are decided by the grid. The 3 phase PLL will carry out the synchronization process synchronization process to make the voltage Vgq as zero. Therefore, the real and reactive power are represented in dq frame as

$$P = \frac{3}{2} V_{gd} I_d \qquad (4)$$

$$Q = -\frac{3}{2} V_{gd} I_q \qquad (5)$$

Where V_{gd} represent the maximum grid voltage at the PCC and the currents i_d and iq are components of currents in dq axis. With respect the equation 4 and 5, active and reactive power are decoupled and can be controlled separately using i_d and i_q values.

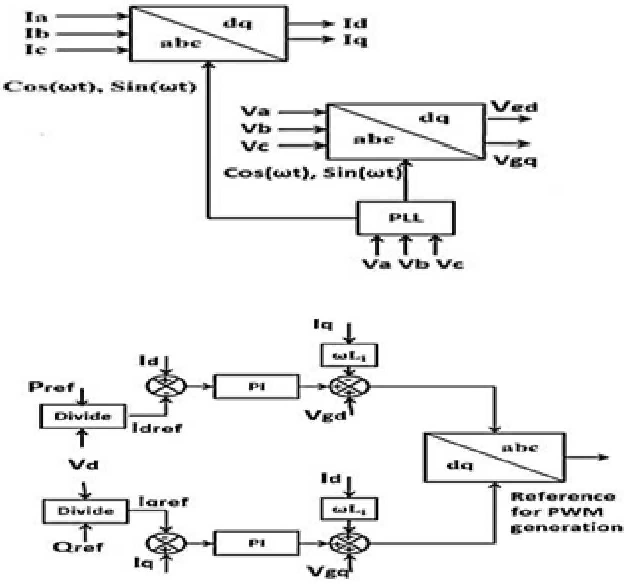

Fig. 2: Current controlled mode of operation

Equations2 and 3 can be rearranged

$$V_{id}'(s) = V_{id}(s) - V_{gd}(s) - \omega L_i i_q(s) \qquad (6)$$

$$V_{iq}'(s) = V_{iq}(s) - V_{gq}(s) + \omega L_i i_d(s) \qquad (7)$$

Therefore the transfer function of the system to be controlled in grid connected mode is

$$\frac{V_{id}'(s)}{i_d(s)} = \frac{V_{iq}'(s)}{i_q(s)} = G(s) = \frac{1}{R_i + sL_i} \qquad (8)$$

The relative error between reference value of current and the inverter current value is processed by propositional Integral (PI) controller. The input to the PI controller is dc quantities, since the control logic is implemented in synchronous frame theory. The controller is tuned by Ziegler Nicholas method to reduce the steady state error and generate modulating reference for the PWM switching.

2.3 Islanded Mode:

In this operating mode, in the absence of grid for maintaining the constant voltage and frequency at PCC, the above stated current controlled strategy cannot applicable. Hence the interface controller must be operated as voltage Control mode in the absence of the grid.

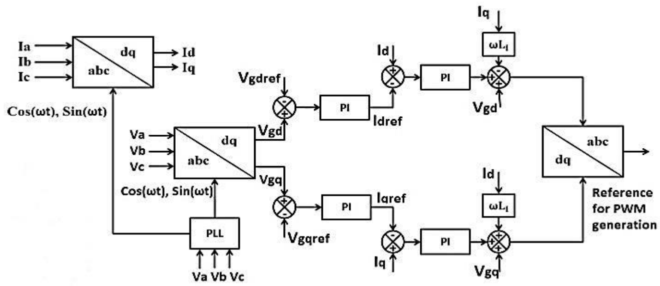

Fig. 3: Islanding mode of operation

3. Islanding Detection Algorithm:

For the current system a simple islanding detection method has been proposed which is works on frequency and voltage measurement to implement the intentional islanding operations. The various in voltage and frequency are based on the load- generation divergence.

Islanding will be detected when these parameters exceed the limits specified values by the algorithm. The algorithm should be secure and fast acting based on the mismatch of load-generation. It will help to prevent them is relate of other grid dynamics for islanding as shown in Fig.4. If the deviations in the load-generation is low, the proposed algorithm cannot detect islanding within specified time and leads to Non-Detection Zones [9].

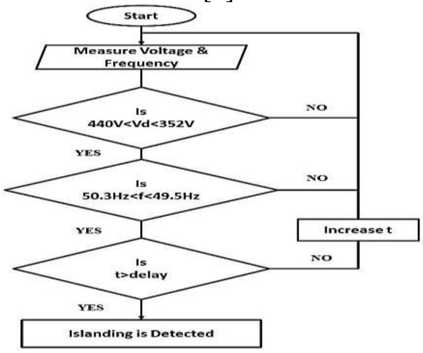

Fig. 4: Islanding Detection Algorithm

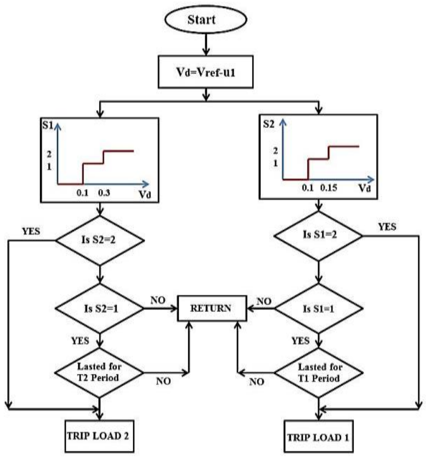

Fig. 5: Load Shedding Algorithm

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3.1Load Shedding Algorithm:

With the suggested islanding detection algorithm, sometimes it is required the load generation mismatch for transferring the control from grid connected to islanded mode of operation.

In such cases the system cannot sustains an island mode due to the extreme variation in voltage and frequency. Therefore, in case if the demand of load is more than the generation, few loads should be shutdown using load shedding algorithm to avoid the wild collapse in voltage and frequency. In this paper a priority-based load shedding has been implemented. When the voltage crosses the specified value, signal enables the circuit breaker and the load will be removed. If sustained voltage variations occur for longer period with grater magnitude, $load_2$ must have more importance than load 1[10]. Load $_1$ and load 2 are tripped at voltage levels of 0.15 pu and 0.3 pu respectively. The second voltage value 0.1puactivates a load shedding command only when the voltage is constant after some time delay. The delay time for load $_1$ and load $_2$ are T_1 and T_2 respectively, such that T2>T1.

5. Results

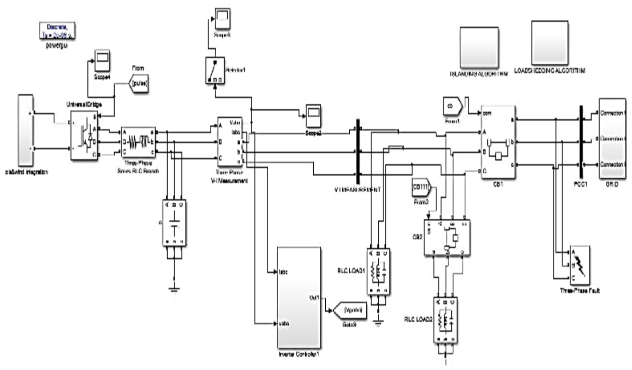
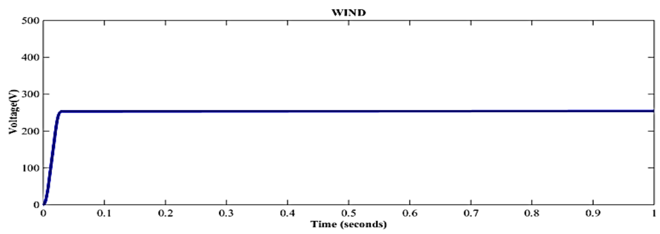
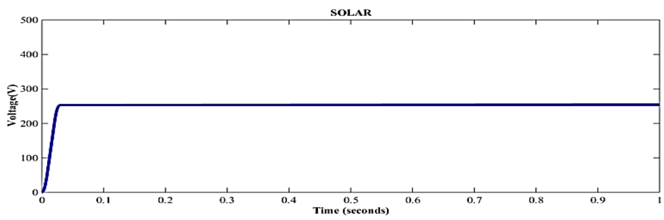


Fig. 6: Simulink Model

The simulated system is shown in Fig.6. The system parameters are given in table 1.Fig7 represents in DG integration both the Wind & Solar DG voltages are maintain constant and the Current and Power should maintain without any deviation.





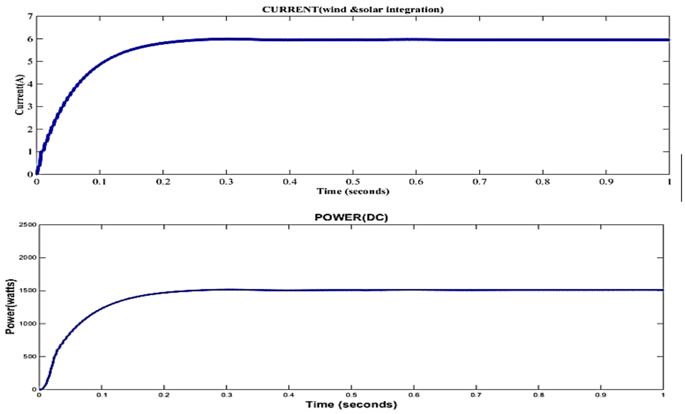


Fig. 7: (a) Wind Voltage, (b) Solar Voltage, (c) Wind & Solar Integrated Current, (d) DC Power

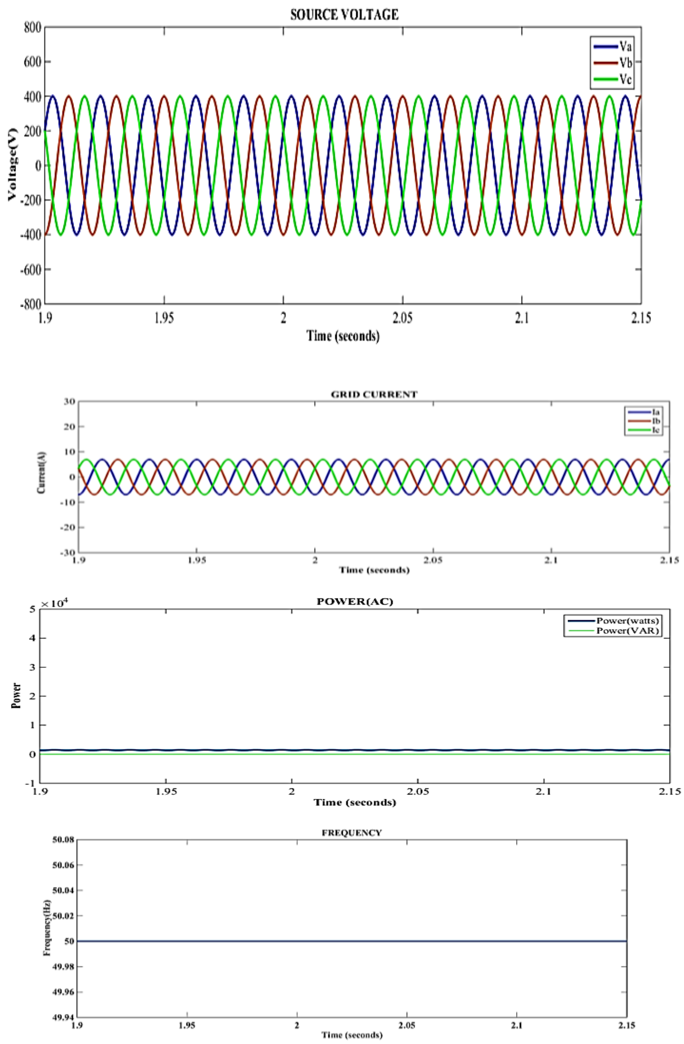


Fig. 8: Grid Connected Mode (a) Source Voltage, (b) Grid Voltage, (c) Source Current, (d) Grid Current,(e) Power in AC (f) Frequency.

At t= 2sec the Grid is disconnected from the load. To maintain the constant current after occurrence of the islanding, the power and voltage at PCC are the function of load.

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The variations of frequency and voltages are monitored continuously by Islanding detection algorithm. There is some delay time before giving the command signal to grid at t=2.06 sec.Both the Load Shedding and Islanded Detection algorithms works in parallel and check for the deviation in voltage. The system will operates in the voltages control mode from t=2 sec to t=2.6 sec, when the Load is shut down and simulation results are shown below.

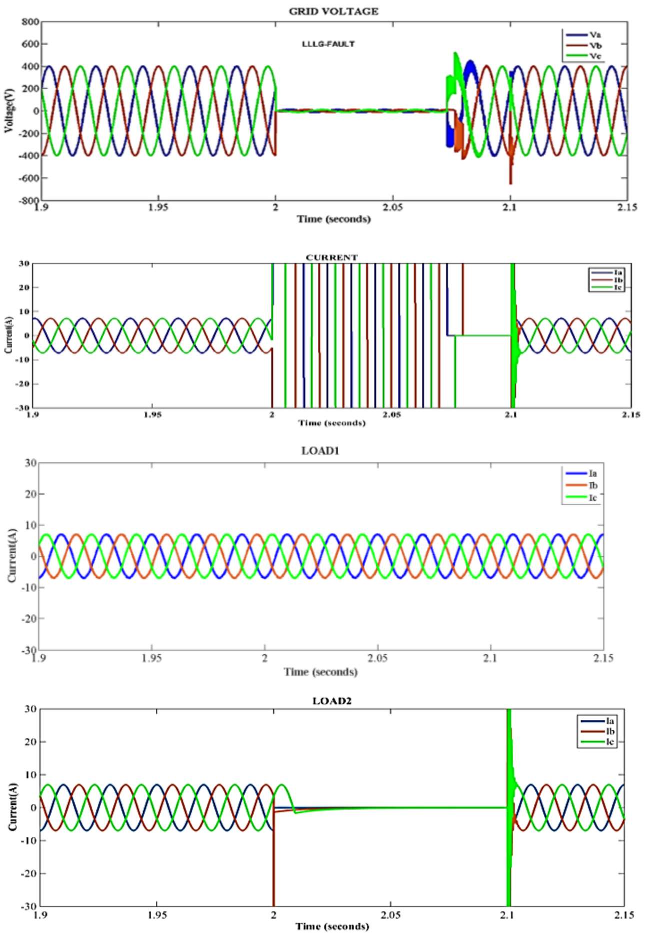

Fig. 11: (a) Power during Islanded Mode, (b) Frequency during Islanded Mode.

6.CONCLUSION

The potency of an Islanding detection method for multi DG system has been analysed. The research on the method indicates relatively precise detection for UVP/OVP and OFP/UFP condition. This Islanding detection method can be simply implemented without any alteration in the control strategy. The performance of the Load Shedding algorithm during the removal of mismatch between Load and Generation is secure.

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