Modeling and Analysis of a Micro Grid for Effective Energy Management System

S. Sam Karthik

DhanalakshmiSrinivasan College of Engineering, Coimbatore, Tamilnadu, India

Dr. A. Kavithamani

Assistant Professor, Coimbatore Institute of Technology, Coimbatore, Tamilnadu, India

Abstract-Electrical energy need to be utilized in an optimal way to satisfy the demand. The demand of electrical energy will also be fulfilled by increased generation. Thoughthere are many new innovations in generating an electrical energy one has to think about micro grid systems. A growing interest has been shown by industries and energy markets in the development of micro grids. Various micro sources can be interconnected and be operated in grid connected mode as well as isolated mode of operation. While operating these two modes controllability and stability are the major issues. The instability occurs with imbalance operating condition. In this system a control strategy is provided for producing healthy energy to the micro grid. The micro grid helps in reducing the expenditure by reducing network congestion & line losses and line costs and thereby providing higher energy efficiency. This paper analyze the different characteristics in various operating mode based on the control strategy.

Keywords*-Micro grid, Stability, Controllability, Distributed Energy Generation.*

I. INTRODUCTION

Various methods have been introduced to produce electrical energy. A method that consists of various Distributed Energy Generation (DEG) systems has become the recent technological development due to its lower cost and high reliability [4]. Though it has many merits there are few demerits based on the stability. While using distributed energy generationsystem, voltage and frequency regulation are likely to be affected due to the change in generation level. By organizing these micro sources properly in a micro network these problemscan be reduce. The best way to mention the application and advantages of a DEG system into an electrical network system is by group of interconnected loads and micro energy generation sources, called as a micro grid. A DEG system can act as a controllable operating unit when connected to a grid or even when isolated [3]. There exist various micro grid management patterns that can be classified into three groups [1]. The first one deals with the physical construction and the parts involved in the system. The second group of management is about the control units that are involved as a communication between the operating units. The third one is about the distributed system which does not need any external communication units [2, 5].

II. DISTRIBUTED ENERGY GENERATION MODELING

There are two different types of generation that can be applied in a micro grid based on the type of source that is used by considering the renewable and non renewable sources. In this system various sources are interconnected and modeled such as Photovoltaic (PV), Wind and battery which is shown in fig.1. The integration of battery and super capacitor offers a complementary scheme due to their different power and energy densities [8].

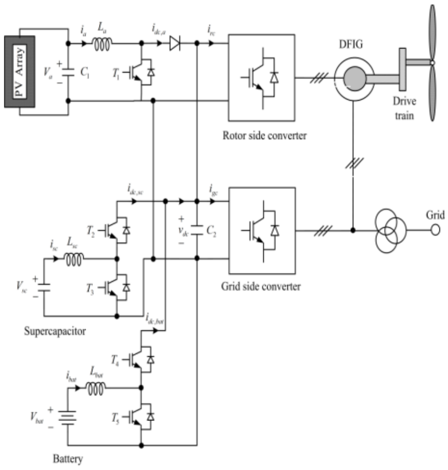


Fig.1.Microgrid Model Representation

A. PV Model

The equivalent circuit of a solar cell representation is shown in Fig.2. The model contains a current source G, diodeD, shunt resistance R_{sh} and series resistance R_s.

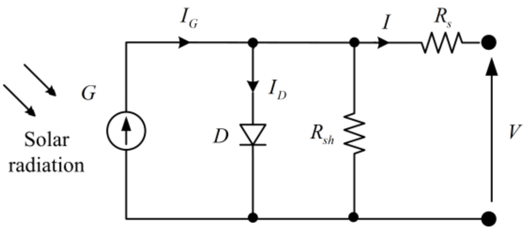


Fig.2.Equivalent circuit of a solar cell.

The diode current I_D, and the current through the shunt resistance I_{sh} are evaluated using

$$I_D = I_o \left\{ \exp\left[\frac{q}{mkT_c}(V + IR_s) \right] - 1 \right\} \qquad \text{--- (1)}$$

$$I_{sh} = \frac{V + IR_s}{R_{sh}} \qquad \text{--- (2)}$$

where, m is the idealizing factor, k is Boltzmann's gas constant, Tc is the cell absolute temperature, q is the electronic charge, V is the voltage imposed across the cell, and Io is the cell reverse saturation current. The current supplied to the load, I, is given by

$$I = I_G - I_o \left\{ \exp\left[\frac{q}{mkT_c}(V + IR_s) \right] - 1 \right\} - \frac{V + IR_s}{R_{sh}} \qquad \text{--- (3)}$$

The developed model is used to implement the PV array.

B. Battery Model

The CIEMAT battery model is used in this study. The model is able to predict charge and discharge characteristics of lead-acid batteries produced by different manufacturers eliminating the need for more costly and time consuming effort of developing parameters for each brand of battery. The battery dynamics are described by modeling the state of charge (SoC), voltage equation, and temperature effects. The instantaneous battery state of charge is given by

$$SoC(t) = SoC(t_0) - \frac{1}{C_{10}} \int_{t_0}^{t} I_{bat} \cdot dt \qquad \text{--- (4)}$$

Where $SoC(t_0)$ is the initial state of charge, C_{10} represents the battery capacity over a discharge regime at constant current I_{10}, in a time span of 10 hours.

C. Super Capacitor

A simplified model that consists of an ideal capacitor and an equivalent series resistance (ESR) is used. The ESR is static and is used to account for resistive losses in the dielectric, plate material, and electrolytic solution. The actual capacitance and ESR values vary with the terminal voltage, charging rate, current, and temperature.

IV. VOLTAGE AND FREQUENCY CONTROL

To control the frequency and voltage droop control system is adopted. The generalized characteristic equation is given as

$$f = f^* - m(P - P^*) \qquad \text{------- (5)}$$

$$U = U^* - n(Q - Q^*) \qquad \text{------- (6)}$$

Where U*and f*are the voltage magnitude and frequency at no load respectively. The m and n are the droop frequency and amplitude coefficients, and P* and Q* are the reference signal of the active power. The strategy of droop control is that each DG shares the power demand according to its own droop characteristic functions the flow of real power is linearly dependent on the phase angle difference, and the reactive power flow is linearly dependent on the voltage magnitude difference. The measured P and Q, reference P* and Q*, nominal f* and V* are considered as the input to calculate the reference $f_{ref}$and v_{ref}in ‘droop control’ block.

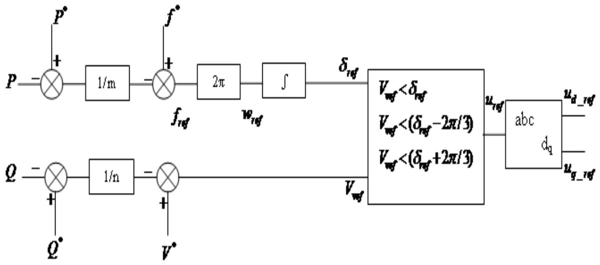


Fig.3.Voltage and frequency Controller

$u_{d_ref}$and u_{q_ref} are reference voltage at d and q axis respectively after ‘voltage formation’ block. f* and V* are grid rated frequency and voltage magnitude of the grid respectively. f_{ref}, and V_{ref} are reference frequency and voltage magnitude, and they are obtained by droop control characteristic. Three-phase u_{ref} is obtained by voltage formation device and then converted into u_{d_ref} and u_{q_ref}

V. RESULTS AND DISCUSSION

The major problem that occur in a micro grid is that the voltage stability and frequency stability. A coordinated control methodology is applied to control and monitor the operation of micro grid when connected in a grid and also when they are isolated. To maintain the frequency, the real power generation of micro grid is increased to match the demand. Similarly, to maintain the voltage level the reactive power is decreased. Initially two DEG of same voltage level and similar structural parameter are used to find the instability that is occurring in the system.Two distributed energy generator (DEG) are used with the generating voltage of 400. Four loads were used in which two loads are resistive and two inductive loads. The distributed energy generating system configuration is mentioned in the Table I.

TABLE I PARAMETERS OF THE SYSTEM

COMPONENT	PARAMETER
Main grid	Voltage = 400 VSource resistance = 0.8929 ohmsSource inductance = 16.5e-3 mH
Distributed energy generation (DEG) 1	DC voltage 400V
Distributed energy generation (DEG) 2	DC voltage 400V
Load 1	Active load = 40KWReactive load = 20KW
Load 2	Active load = 20KWReactive load = 10KW
Load 3	Active load = 60KWReactive load = 30KW
Load 4	High active and reactive loads

To verify the effectiveness of the micro grid, simulation is done to test the operation when connected to the grid and operating in isolated mode. The frequency analysis depends on real and reactive loads. The simulation with real load as 40KW and reactive load as 20 KVAR is tested and later on the test is done with change in loads which results in unstable frequency changes, but using PI controller it comes again to stable state.

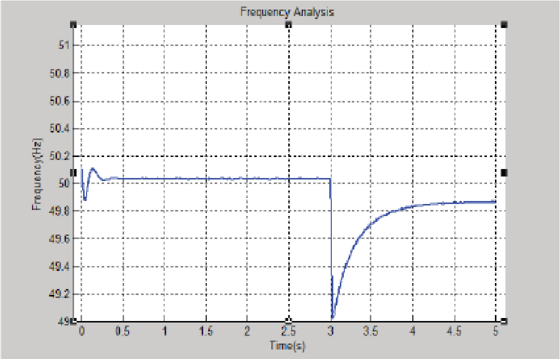


Fig.4.Frequency analysis grid connected mode

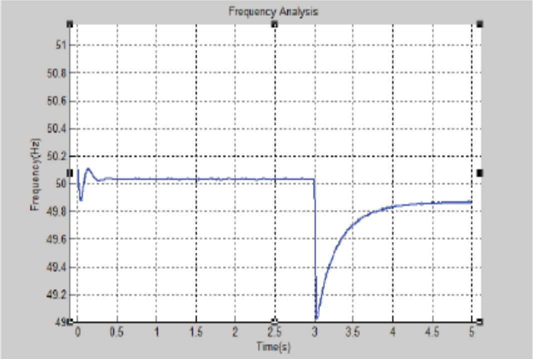
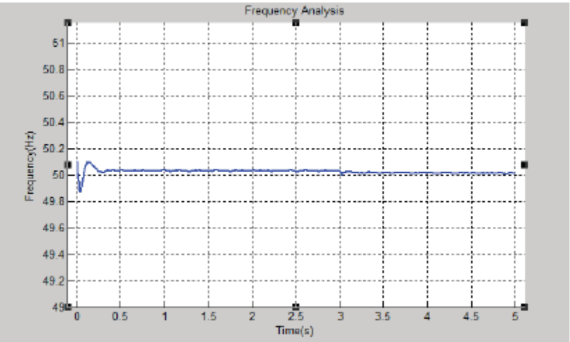


Fig.5.Frequency analysis isolated mode

The fig.4 and fig.5 shows the frequency of micro grid, when the load is very high the distributed energy system became unstable. The instability is overcome by droop controller. The result obtained after implementing controller is shown in fig.6 and fig.7.



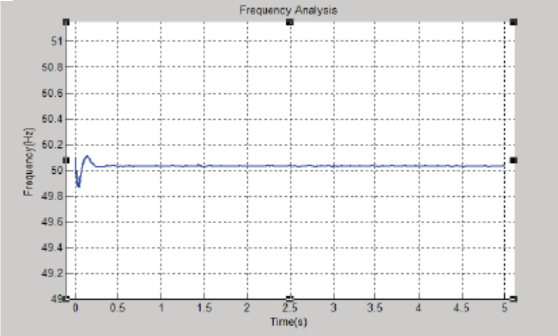


Fig.6. Frequency analysis grid connected mode
Fig.7. Frequency analysis isolated mode

The power analysis of the grid connected mode and isolated mode is presented in fig.8 and fig.9. This represents both active and reactive power.

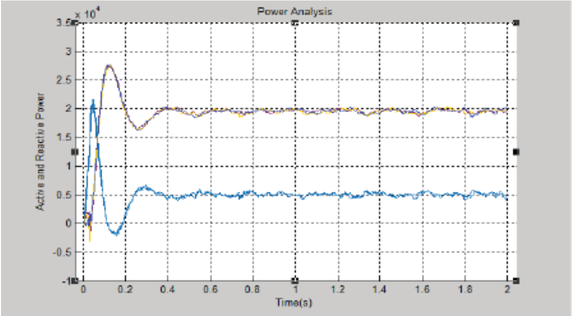


Fig.8.Power analysis Grid connected

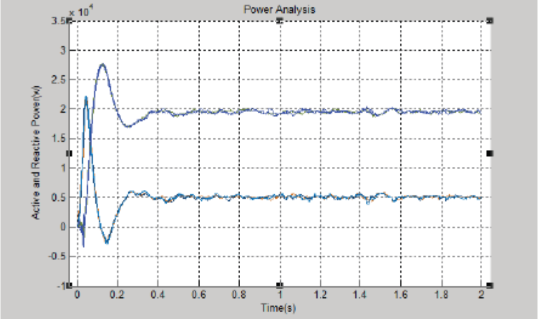


Fig.9. Power analysis isolated mode

VI. CONCLUSION

The recent power generations focuses on reducing transmission loss and reducing the stability issues. In this paper the frequency stability and voltage stability analysis is presented with implementation of droop control methods. To analysis this operation two distributed energy sources are considered. The power sharing between the grids is important hence coordinated control is also required to avoid losses and stability.

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