Load frequency control in Microgrid
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Abstract-- The objective of this paper is to design a Load Frequency Control (LFC) mechanism using a Battery Storage System (BSS) and Diesel Generation (DG) units for an isolated microgrid system. Load frequency control is important in power sector & want to be maintain. They were tested under different scenarios; random load variations, and loss of one of the DG units. In this we also explain the objective and reasons of load frequency control.

Index Terms-- Microgrid, Real time load frequency control, BSS, Diesel Generation(DG).

I. INTRODUCTION
A micro-grid can be considered as a small grid based on distributed generators (DGs). Generally, the micro-grid consists of renewable energy based DGs and combined heat and power plants. It can supply power to small/medium sized urban housing communities or to large rural areas. It can be an economical, environment friendly and reliable way to supply power at distribution levels. The sources in a micro-grid can be mainly classified as dispatch-able or non-dispatchable in terms of power flow control [1,2]. The output power of dispatchable sources such as micro turbines, fuel cells and bio-diesel generators can be controlled to maintain the desired system frequency and voltage in an isolated micro-grid. However, non dispatchable sources such as wind and PV, in which the output power depends on the environmental conditions, are expected to be mainly controlled on the basis of maximum power point tracking (MPPT).

The sources in a micro-grid can also be classified as inertial and non-inertial depending on the way they are connected to the system. For example, a diesel generator and a hydro generator are inertial sources since they include synchronous generators with their rotating inertial masses. On the other hand, the sources connected through converters such as PV, fuel cell and batteries are non-inertial since power output through these DGs can be changed instantaneously. A micro-grid can operate either in grid connected or islanded mode. The available power of all DG units should meet the total load demand for islanded operation; otherwise load shedding need to be implemented.

Fig.1.Schematic diagram of a micro-grid

The control of real and reactive power output of the sources is essential to maintain a stable operation in a micro-grid, especially when it operates in the islanded mode. The frequency and voltage in an islanded (autonomous) micro-grid should be maintained within predefined limits. The frequency variations are very small in strong grids; however, large variations can occur in autonomous grids [3]. Thus power management strategies are vital for an autonomous micro-grid in the presence of few small DG units, where no single dominant energy source is present to supply the energy requirement [4]. Also, fast and flexible power control strategies are necessary to damp out transient power oscillations in
an autonomous micro-grid where no infinite source available [5].

II. OBJECTIVE OF LOAD FREQUENCY CONTROL
In an interconnected power system, as a power load demand varies randomly, both area frequency and tie-line power interchange also vary. The objectives of load frequency control (LFC) are to minimize the transient deviations in these variables (area frequency and tie-line power interchange) and to ensure their steady state errors to be zeros.

Frequency does not change in an Interconnection as long as there is a balance between resources and customer demand (including various electrical losses). This balance is depicted in Fig.2.[6]

![Fig. 2 — Generation / Demand Balance](image)

III. REASONS FOR LIMITS ON FREQUENCY
1. The speed of a.c motors are directly related to the frequency. Even though most of the a.c drives are not much affected for a frequency variation of even 50±1.5 Hz but there are certain application where speed consistency must be of high order.

2. The electric clocks are driven by synchronous motors and the accuracy of these clocks is not only a function of frequency error but is actually of the integral of this error.

3. If the normal frequency is 50 Hz and the turbines are run at speed corresponding to frequency less than 47.5 Hz or more than 52.5Hz the blades of the turbine are likely to get damaged.

4. The under frequency operation of the power transformer is not desirable. For constant system voltage if the frequency is below the normal value the flux in the core increases .As a result the magnetising current even exceeds the normal full load current .The sustained under frequency operation of the power transformer result not only in low efficiency but it may even damage the transformer winding due to overheating.

5. The system operation at subnormal frequency and voltage leads to loss of revenue to the suppliers due to accompanying reduction in load demand.

6. The most serious effect of subnormal frequency is on the operation of thermal power plants. With reduced frequency the blast by ID and the FD fans decrease as a result of which the generation also decreases and thus it become a cumulative action and may result in complete shut-down of the plant if corrective measures like load shedding is not resorted to.

7. The overall operation of power system can be better controlled if a strict limit on frequency deviation is maintained.[7]

IV. LOAD FREQUENCY CONTROL (SINGLE-AREA CASE)
To understand the load frequency control problem, let us consider a single turbo-generator system supplying an isolated load.[8]

![Fig.3.functional diagram of real power control mechanism of Generator](image)
1. **Fly ball speed governor**: This is the heart of the system which senses the change in speed (frequency). As the speed increases the fly balls move outwards and the point B on linkage mechanism moves downwards. The reverse happens when the speed decreases.

2. **Hydraulic amplifier**: It comprises a pilot valve and main piston arrangement. Low power level pilot valve movement is converted into high power level piston valve movement. This is necessary in order to open or close the steam valve against high pressure steam.

3. **Linkage mechanism**: ABC is a rigid link pivoted at B and CDE is another rigid link pivoted at D. This link mechanism provides a movement to the control valve in proportion to change in speed. It also provides a feedback from the steam valve movement.

4. **Speed changer**: It provides steady state power output setting for the turbine. Its downward movement opens the upper pilot valve so that more steam is admitted to the turbine under steady conditions.

**VI. SYSTEM DESCRIPTION AND CONTROL DESIGN**

**System Description**: The micro-grid system under consideration is comprised from two Diesel Generation (DG) units, two PV systems, and a Battery Storage System (BSS). The two DG units are 100 and 20 KVA. The two PV systems are 14.8 KW each, and the BSS is 30 Kwh. The micro-grid system has no means of connecting to any other power grid i.e. isolated system.

![Micro-grid system under study](image)

**Control Design**: The control objective is to minimize a performance index (J) associated with the frequency error $\Delta f (\Delta f = f - f_s)$, and

Furthermore the micro-grid system, in normal operation conditions experiences random demand fluctuations and possibly emergency conditions if one of the system’s primary generation units is suddenly lost. Hence it is crucial to have an automated and robust LFC mechanism implemented to ensure a stable system operation under all conditions.

Load Frequency Control (LFC) mechanism using a Battery Storage System (BSS) and Diesel Generation (DG) units for an isolated micro-grid system. The micro-grid system under consideration is comprised from two DG units, a BSS unit, and two solar panels. They were tested under different scenarios; random load variations, and loss of one of the DG units.[9]
defined by (1).

\[
\text{Minimize } J = \int |\Delta f|^2 \, dt
\]

(1)

Where \(f_s\) and \(f\) are the scheduled frequency of 60 Hz and the system’s measured frequency respectively. The objective is to minimize \(J\) under both normal operation conditions, where the power demand fluctuates, and contingency situations, where one of the system’s generation units is suddenly lost.

1) **Diesel Engine Control System:** The diesel engine model gives a description of the fuel consumption rate as a function of speed and mechanical power at the output of the engine, and is usually modelled by a simple first order model relating the fuel consumption (fuel rack position) to the engine mechanical power. As a prime mover it is crucial that the diesel engine equipped with a robust control system to ensure stable operation and foster disturbance rejection. The objective of the control system is to maintain the system’s frequency at the desired reference value i.e. drives the frequency error \((f_m - f_r)\) to zero where \(f_r\) is the reference frequency (60 Hz or 1 p.u.) and \(f_m\) is the measured frequency.

![Fig. 5. Diesel engine model with control system](image)

2) **Battery Storage Control System:** Fig.6 shows a block diagram of a battery storage system hooked up to a micro-grid. The control system developed for LFC is the DC/AC inverter control system. In order to utilize the BSS in LFC it is crucial that the inverter control system track the system’s frequency error signal and control the active power injected or absorbed by the BSS. The necessity to save on the amount of energy stored in the BSS to secure the maximum amount of reserve. Hence the BSS should not contribute much in LFC when the system’s DG units are available.

![Fig.6. Schematic diagram of a micro-grid connected battery system.](image)

V. CONCLUSION

This paper is presented the detail about the necessity of load frequency control and different type of control with its importance. This paper presented a decentralized LFC mechanism to control a BSS and DGs incorporated in an isolated microgrid system to regulate the system’s frequency. The mechanism was tested under three different scenarios; fluctuating demand which represents the normal operation conditions of a power system, and two emergency scenarios where one of the DG units was lost in each scenario.

VI. REFERENCES


2008.


VIII. BIOGRAPHIES

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