MODES OF OPERATION OF AC MICROGRID

1R. K. Ambade, 2P. S. Shete

1Design Engineer, Nakshika Enterprise Vadodara, Gujrat,
2Assistant Professor, Department Electrical Engineering YCCE, Nagpur
Email: {rhlambade@gmail.com, pranay.shete85@gmail.com}

Abstract
The microgrid stability is always concerned, because of its dynamic nature of a load and its locally connected micro sources (Renewable). Depending upon applications, the microgrid types, system structure and control methodology varies. The paper succinct to take cognizance of stability aspects of remote, utility connected and facility microgrid in manner of the operation, types of micro source and network parameters. The voltage stability, transient stability and small signal facet in different type of the microgrid are discussed along with realm of reformations. The micro sources with optimal power converters are used for matching load characteristics and to maintain power stability in different modes of microgrid. For analysis purpose of the microgrid different digital computation platform are used.

Key Words : Microgrid, distributed generation(DG)

1. Introduction
THE restructuring of power system seizes the private players to actively participate in distributed energy generation from freely available local resources. The distributed power generation from renewable resources are always connected to load through power converter of optimal rating for matching load characteristics. The irregular availability of renewable sources gives rise to severe stability operation issues inside the microgrid. Each renewable resource are location specified sources which required one-off control topologies to extract maximum power. According to its availability of resources, load demand, future scope, its function, reliability, power quality, etc. classify different types and structure of a microgrid. Increasing the diffusion of distributed generation(DG) penetration in to a passive network which are integrate with voltage sources converters(VSC) in a classical power system for economical operation. The stability of DG with is concerned on the control of VSC only [2]. There is a significance of storage, sources, protection, compensation, etc. on stability of microgrid.

The small signal stability, transient stability and voltage stability are most concerned inside the power system. Each type microgrid have dissimilar immune response to different sequence issues of power system. The analysis and detailing is required, to find response and behaviour of microgrid. The complete detail literature, its effect and stability issues in different types of microgrid is analysed. For analysing of microgrid different power tool window are apply.

2. AC Microgrid

A. Types of AC Microgrid
The idea and detail concept of micro grid was introduced in 2001 by R. H. Lasseter [4]. An microgrid is a integrated energy system consisting of distributed energy resources (DERs) and multiple electrical loads operating as a single, autonomous grid either in parallel to or “islanded” from the existing utility power grid [2]. Basically, there are three types of microgrid. Remote or autonomous microgrid, Campus microgrid and Utility microgrid.

Remote microgrid is isolated from grid and never connected to grid. These microgrid are remotely located and thorny to reached by power utility. Campus microgrid is inside the campus or organization and as per requirement it is connected to grid. Utility microgrid have highest power rating from remaining all microgrid and always connected to grid.

Fig. 1 : Basic structure of AC Microgrid
Fig. 1. shows the basic structure of AC microgrid. The figure shows that microgrid sources or DER output is connected to input of inverter. The inverter output is connected to the load bus. In utility, connected microgrid supply to utility or utility may supply to load, microgrid have bidirectional flow of energy depend upon energy generation and consumption of source and load. If both the DER are of solar PV, then at night, DER output is off and utility grid will supply to load for without energy storage microgrid. The storage devices are very costly and required additional more 70% of total cost of project for storage of only 10% of generated energy. Sensitive load is supply through uninterruptable power supply(UPS).

3. Stability Issues of AC Microgrid

Fig. 1. shows the basic structure of AC microgrid. The figure shows that microgrid sources or DER output is connected to input of inverter. The inverter output is connected to the load bus. In utility, connected microgrid supply to utility or utility may supply to load, microgrid have bidirectional flow of energy depend upon energy generation and consumption of source and load. If both the DER are of solar PV, then at night, DER output is off and utility grid will supply to load for without energy storage microgrid. The storage devices are very costly and required additional more 70% of total cost of project for storage of only 10% of generated energy. Sensitive load is supply through uninterruptable power supply(UPS).

Stability and its Concern

Fig. 2 shows, the Small signal stability in a microgrid which is related to controller used for feedback, load switching, power limit of the micro sources, etc., A fault with subsequent island gives the transient stability issues in a AC microgrid. Reactive power limits, load dynamics and tap changers creates the voltage stability problems in a microgrid.

Fig. 3 shows, that the various stability improvement methods. While the supplementary control loops, stabilizers, coordinated control of the micro sources can recover the small signal stability, the transient stability improvement is realized through use of energy storage, load shedding etc., On the other hand, the voltage regulation with DGs, reactive compensation, advanced load controller and the modified current limiters of the DGs can ensure the voltage stability in AC microgrid. Depending upon the type of microgrid, different stability issues may be connected to most common problems as shown in Fig. 4.

The DG feedback controller with decentralized control methods generate most of the microgrid the most signal stability issues in the limiters. A remote microgrid, while in a utility common reason is the current. In a facility microgrid, the frequent load switching within a small area often creates the small signal stability problems.
4. Stability Improvement In AC Microgrid

A. Stabilizer
Small signal stability can be enhanced in VSC interfaced microgrid. The output power of the connected DG fed to the stabilizer.

B. Reactive Compensation With DSTATCOM
The reactive compensation in a microgrid is essential to uphold the voltage within suitable limits. The voltage regulation problems are more in utility and remote microgrid. The DSTATCOM is used for injecting reactive power in system during voltage sag.

C. Energy Storage System
Energy storage system provides the stability improvement in a microgrid by injecting active (sometimes also reactive power) power during power shortage, DG trip, islanding, load dynamics and ride through until the backup diesel genets come live.

D. Load Shedding for Stability Improvement
The most crucial role of load shedding in the microgrid stability takes place during islanding. A sudden loss of the grid creates power imbalance and the load shedding for the power balance is time critical in a microgrid.

Fig. 5 : Main Microgrid Simulation Diagram

5. Simulation Results and Parameters
This model is composed of two Di attributed Generating (DG) units, individual R-L load of DG, utility main R-L load and tie-lines for connecting DG to utility or grid. Single distribution transformer (step down) is connected at point of common coupling (PCC) between DG and the grid. Circuit breaker is used to isolate the DG for the grid during intentional or un-intentional state of affair rest. During transitions between modes of microgrid (Islanded or Grid connected), the system parameters changes. The main utility connected load is larger than individual DG loads. The power lines connected between DG and PCC are of optimum rated capacity to efficient power transfer to load as well as the grid support. The DG output power is always concerned because of above reasons stated in the Section-III. For the measurement of frequency, the Phase lock loop (PLL) is used. Both grid and load side frequency is measured by using PLL. The DG-1 and DG-2 are connected at PCC. The DG-1 and DG-2 both are 2.5 km away from the main load. Both the load (individual DG and Main grid load) are consist of R-L parameters. The system is simulated in powerful digital computation tool. All the system parameters used under the simulation are taken from standards made for distribution of energy, as the microgrid is connected at passive network.

6. Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase to Phase Voltage rms</td>
<td>7778.174 V</td>
</tr>
<tr>
<td>Phase to Phase Voltage value</td>
<td>11 kV</td>
</tr>
<tr>
<td>Power Frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Utility load</td>
<td>61.29 kW</td>
</tr>
<tr>
<td>Individual DG1 Load</td>
<td>1.29 kW</td>
</tr>
<tr>
<td>Individual DG2 Load</td>
<td>3.87 kW</td>
</tr>
<tr>
<td>Total Load</td>
<td>66.45 kW</td>
</tr>
<tr>
<td>Length of line</td>
<td>2.5 km</td>
</tr>
<tr>
<td>Line resistance</td>
<td>0.08 ohm/ km</td>
</tr>
<tr>
<td>Line inductance</td>
<td>1 m H</td>
</tr>
<tr>
<td>Power generation (DG-1 &amp; DG2)</td>
<td>16 kW</td>
</tr>
<tr>
<td>Operating Voltage (DC)</td>
<td>370 V</td>
</tr>
</tbody>
</table>
7. Result

Fig. 6: (a) Grid side voltage after transformer, (b) Zoom view of islanded plot, (c) Frequency variation (Grid side)

Fig. 6 shows the voltage and frequency variation on the grid side. The system nominal distribution operating parameters are 400 V, 50Hz. During preliminary period, up to 0.04 seconds, the deep variation in frequency and slowly increase in voltage are observed. The staring transients in voltage and frequency are observed up to the system 2 to 3 cycle. In Fig. 6 (c) it observed that, at starting when sudden heavy load is connected, the dip in frequency are observed. These dips in frequency are because of sudden increase in active power demand in system. The variation is settled down in 0.2 seconds. After, that complete system is tuned to system parameters. Fig. 6 (a) shows that period between 0.4 to 0.7 seconds is islanding, the grid is isolated from microgrid. These perhaps intentional or unintentional due to un availability of grid.

Fig. 7: (a) Load bus voltage, (b) Starting initial transients, (c) Frequency variation at load bus

Fig. 7 shows the voltage and frequency variation on the load side. During preliminary period, up to 0.2 seconds, the deep variation in frequency and slowly increase in voltage are observed. The staring transients in voltage and frequency are observed up to the system 2 to 3 cycle. In Fig. 7 (c) it observed that, at starting when sudden heavy load is connected, the dip in frequency are observed. The similar effect is observed in grid side. These dips in frequency are because of sudden increase in active power demand in system. The variation is settled down in 0.2 seconds. After, that complete system is tuned to system parameters. Fig. 7 (a) shows that period between 0.4 to 0.7 seconds is islanding, the grid is isolated from microgrid. As a primarily purpose of microgrid is to, fulfil load in unavailability of utility and to maintain system reliability. The system reliability is maintaining during intentional or un-intentional un-availability of utility.
8. Conclusion

There are different modes of operation of Microgrid. For analysis point of view we consider, here islanded and grid connected mode only. From the results, it can be said that, the variations in voltage and frequency w. r. to time is same and which is within tolerable limit. Here, controller acts in closed loop control manner, which will feed the power from the source (stiff AC system) during islanded mode only. It will remain idol during normal variation (before occurrence of islanded operation).

References


