REVIEW OF POWER SYSTEM DISTRIBUTION NETWORK

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Abstract – In power system "Distribution Network" is of the main part. Distribution network is directly connected to the load center. Nowadays, the concept of integrating renewable and distributed energy sources in the distribution level, has become a great concern to the power engineers. To improve power quality and stability of power system in the distribution network, further researches are going on by the power companies and the power engineers. A review of the Electrical Power Distribution System along with its architecture (i.e. Radial Network Architecture, Ring/ Loop Network Architecture and Mesh Micro-grid Architecture), principle of operation, control system, future growth, and also its advantages and disadvantages are presented in this paper.

Keywords: *Distribution Network, Power quality, Stability, Distributed energy*

1. INTRODUCTION

The design and implementation of a reliable and stable distribution network is the key of successful power delivery to the load center. Through a proper and efficient distribution system of electrical power, the power provision to individual customer can be enhanced. Natural disaster such as earthquake, flood, cyclone, etc. affects the distribution system. Every system is designed under natural disaster rated units. Though, the restoration of power network prolongs based on the design, control and management of that particular network, get affected [1]. Basically, a distribution network consists of substations, primary feeder, transformer, and distributor and service mains. Electricity is generated in a sine wave form. Which means, the parameters of power varies with the time.

Currently, to meet the energy demand, the sources of renewable energies are widely being used. But, the implementation of a various types developed and integrated related to renewable energy sources, makes the distribution network vulnerable [1-2].

Both the user and the electricity provider get benefitted by the energy generation in the distribution levels. The energy generation in the distribution network not only reduces the

transmission losses but also the power generation cost. The power generation from the renewable energy sources has less environmental impacts. So, in many countries power generation from the nonconventional sources is becoming an attractive solution.

2. DISTRIBUTED NETWORK ARCHITECTURE

2.1 Radial Network Structure

In the past electrical power distribution system, the primary of the distribution transformer get connected to the different, which comes radially out from the substation as shown in Fig.1
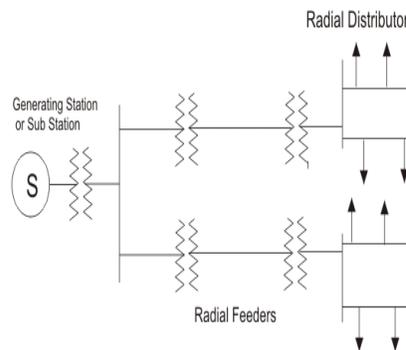

Fig 1

But, one major drawback of **Radial Network Architecture** is that, if any of the feeder get failure, the whole network will get affected and there is no alternative way-out to feed the transformer.[3],[4] The power supply will also get interrupted, when the transformer breaks down. Thus we can say that, there will be a complete blackout in the whole Radial Power Distribution Network.

Application of Radial Network

Radial Power Distribution System is only used when, the substation or a generating station is situated at the center of the locality. In this network architecture, the primary of the distribution transformer is connected to the different feeders,which comes radially out from the substation or a generating station. [5]Thus, the power flow in the radial network architecture is only one directional and it is the main characteristics of Radial Power Distribution System.

The Radial Power Distribution System as shown in Fig.2 is the simplest system with lowest initial cost. Though, the system is the simplest one and with lowest initial cost but, it is not highly reliable.

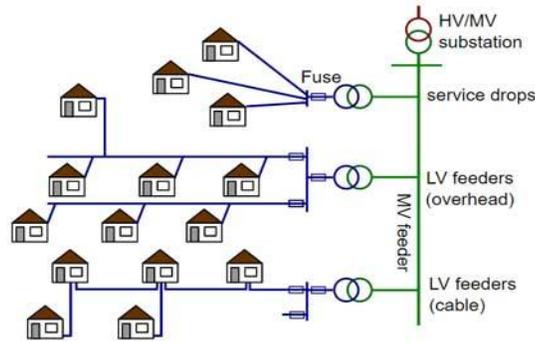A single line diagram of the radial network architecture is shown below -

Fig 2

Advantages of Radial Network Architecture

  • Simplest as fed at only one end.

  • The initial cost is low.

  • It is useful when the generating is at low voltage.

  • Preferred when the station is situated at the center of the locality (consumers).

  • More economical for some areas which have a low load requirement

  • Require less amount of cables

  • It has a low maintenance

Disadvantages of Radial Network Architecture

  •   The distribution transformer gets heavily loaded, which is near to the substation.

  •   Whenever the load on the distribution transformer changes, the consumers face serious fluctuations in voltage.

  •   As the power flow in the radial network architecture is only one directional and all the consumers are dependent on single feeder and distributor. Thus, any fault on any of the single feeder or the distributor, causes a full blackout in supply to all the consumers connected to that system.

2.2 *Ring/Loop Network Architecture*

By introducing Ring/Loop Network Architecture, we can overcome the drawbacks of the Radial Network Architecture. In this network architecture, by more than one feeder, one ring network of Distributor is being feed [6-8].

By this way, the whole network doesn't get hampered even, if any of the feeder gets failure as we can see from Fig 3. At various suitable points, this system is made more reliable with providing various isolator section. Thus, if any fault occurs on any section of the network, that section can be isolated easily by the help of the isolators.
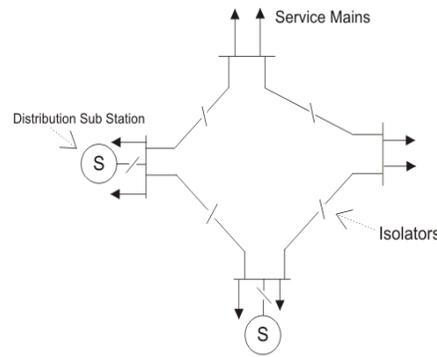

Fig 3

By this way, the rest of the healthy part of the System doesn't get hampered and have a continuous power supply. And also the maintenance of the faulty section can be done easily. Depending upon the following factors, the number of feeders which will be connected to the ring distributor, is determined-

1.   **Maximum Load Demand :** With the increase in the Maximum Load Demand, the no. of feeders to be connected to the ring distributor also increases.

2.   **Total Length of the Ring Distributor Network :** With the increase in the length, the no. of feeders to be connected will also increase.

3.   **Voltage Regulation Demand :** The number of feeders to be connected to the network also depends on the Voltage Regulation Demand [9].

Depending upon the location of the consumers, the sub-distributors and service mains may be taken off through distribution transformer at suitable points on the ring.Sometimes,

service mains are feed by the sub-distributors instead of connecting them directly to the ring. where access of ring distributor is not directly possible, this type of connections are made.

Advantages of Ring/Loop Network Architecture

- In ring power is supplied from both ends as compared to radial.
- If any fault occurs in the radial circuit the entire system goes off unlike in ring where by incase one end gets a fault the other end still keeps on supplying power.
- Compared to the radial system, the voltage drop is less along the distribution line
- More subscribers can be installed to the system than the radial system
- By using a tie line in high loaded areas voltage fluctuations can be reduced.

Disadvantages of Ring/Loop Network Architecture

- As it requires more materials than radial hence, this network architecture is quite expensive.
- Radial circuit is more economical.
- High maintenance cost.
- It is not usable when the client is situated at the center of the load.

2.3 Mesh Micro-grid Network architecture

Apart from radial and ring architecture, in mesh architecture also the electrical grid can be organized. The Mesh architecture normally implemented with high or medium voltage while radial used with low level voltage [10]. A mesh network structure follows the radial structure, including redundant lines and the main lines as shown in Fig.4. This configuration is organized as backup for rerouting power, when the main line gets failure.

Compared to Ring main and Radial architecture, Mesh grid has the most complex architecture. A mesh network structure includes many alternative connections between nodes. By this, the operation and protection of the distributed network, significantly made challenging. As mesh grid architecture is the most often architecture rather than ring configurations, it is less ideal pertaining to its complexity. Because, the configuration of the existing is utilized by the mesh distributed networks, instead of installing a new network.
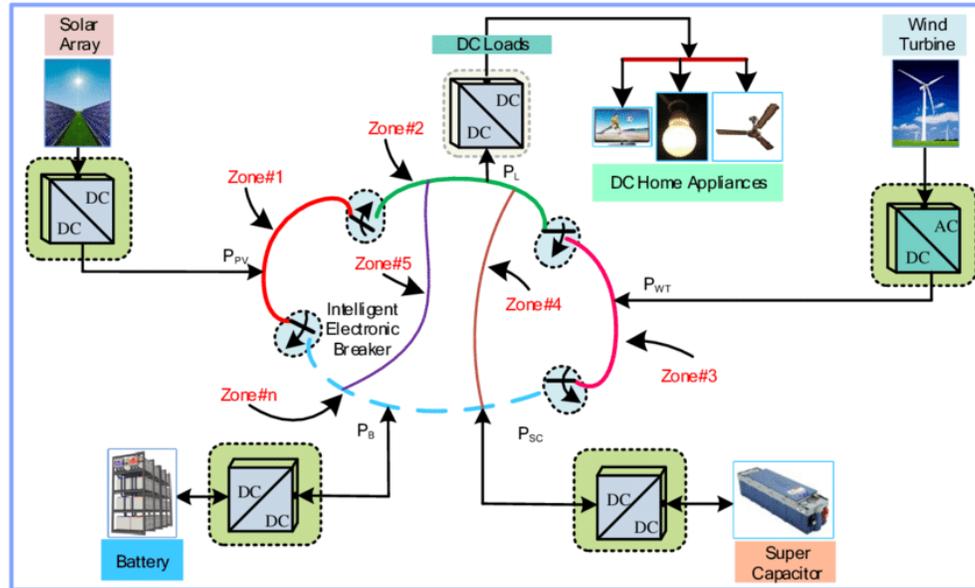
Fig 4

1) <u>Advantages of Mesh Micro-grid architecture</u>

- The load power sharing accuracy can be obtained accurately, when the DC output power of the converter is set as inversely proportional to the corresponding droop coefficient.

- If the droop coefficient and line impedance satisfy the relationship, power sharing error can also be eliminated.

- The mesh grid network architecture have a higher value of short circuit power.

- Through redundancy, this network architecture have high reliability and comparatively balanced voltage profile.

2) <u>Disadvantages of Mesh Micro-grid architecture</u>

- The stability of the system gets badly affected by the Communication delay in a mesh configuration.

- The results may not be applicable for distributed networks with heterogeneous and mixed R/X ratio lines, which is common in low voltage distributed networks.

- Transmission using Mesh architecture utilizes a nonlinear method, which follows the limitation of only focus on lossless distribution networks with purely inductive distribution lines.

- Only on droop control, reactive power sharing as a careful analysis is guaranteed.

3. DISTRIBUTION GENERATION PENETRATION INTO DISTRIBUTION NETWORK

As the quality of the power system is a very important issue for the power generation companies as well as for the consumers. Though our power system is mostly dependent of generating power from fossil fuel, now a days the renewable energy technologies are becoming more important in the power system in many countries[9-10]. Distribution Generation is nothing but a small generating unit, which generates electrical power near to the load center based on the renewable energy techniques available. Connecting a DG to the Distribution network provides a lots of benefits.

1) Advantages

- Reduces technical losses.
- Enhances power quality.
- Provides higher reliability to the distribution system.
- Reduces the emission of pollutants from the generating station.
- Improves voltage profile and power quality.
- It saves the investment cost in the transmission and distribution architecture by adverting the need.

2) Disadvantages

- In order to maintain the equilibrium condition for the exchange of power, a proper protection is needed for the Conventional Distribution System.
- The resource dispatchment signaling becomes extremely complicated.
- Establishment of connection and revenue contracts are quite difficult.

4. RELIABILITY ON THE FUTURE TREND

The reliability of a system is determined by the continuity of system to remain in operating condition during the duration of time cycle. Storms, rain, snowfall, falling tree branches, high

speed wind, brownouts, and many other environmental and technical aspects affects the operating system.[11-12] It is obvious that the less the distance of generation unit from the load center or the end user the more the reliability will be. The basic concept of distributed generation is that the generation is at nearby points to the load. Hence, with the reduction in distance the system-reliability will increase [13].

5. COMPARISON OF NETWORKS

For determining the best suitable network architecture, many factors have to be considered. Factors considering, voltage range, climate and environment, location of DG, load classification, generator types, grid structure, etc. helps in the determination of suitable network architecture among Radial, Ring and Mess-grid architecture.[14]

6.CONCLUSION

In this paper we have presented a review of the distributed network architectures i.e. radial distributed network structure, ring/loop distributed network architecture and mesh distributed network architecture. In this paper we have also stated. The advantages, disadvantages and applications of each type of network with details. In the entire world there are many projects running on the testing and the implementation of new technologies on the electrical distribution system. So, further research on developing the technologies should be considered for the future electrical power system.

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