Microgrid Control and Protection

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***Abstract*- Microgrids are Small- scale version of traditional large power grids functioning either autonomously or with inter connection to the main grid. Microgrid provides efficient, low cost, clean energy and improve the stability of the regional electric supply it also has no transmission system. Primary function of micro grid is to serve power at distribution level. DERs connected to the micro grid enable reliable and efficient operation of micro grid. This paper addresses operation of microgrid voltage control and protection. The main aim of this paper is three- fold. First, a control strategy for inverter based solar panel is purpose to control voltage during islanded operation. Secondly, a protection scheme is proposed to protect both the lines and solar panel during islanded operation. Lastly, both the control scheme and protection scheme and coordinate and synchronized with each other to avoid malfunction.**

***Index terms*- Microgrid, Distributed energy resources, Transmission System, Islanded Operation, Solar Panel, and Voltage Control**

I.INTRODUCTION

A microgrid refers to distributed energy resources and loads that can be operated in a controlled, coordinated way; they can be connected to the main power grid or operate in "islanded" mode during fault condition. Microgrids are low-voltage or medium-voltage grids located at or near the consumption sites. They can generate power from both renewable and conventional sources and although they are mainly electrical systems, they can also incorporate a thermal energy component, such as combined heat and power. Microgrids are increasingly being implemented with energy storage systems, as batteries become more cost competitive. The system is controlled through a microgrid controller comprising demand-response so that demand can be matched to available supply in the safest and most optimized manner. A flywheel or battery-based grid stabilizing system can be incorporated to offer real and reactive power support.

Allowing the solar panel to operate during an islanding situation could potentially bring benefits to the owner, DNO and the customer. The owner benefits from the additional revenue since it is selling power during utility outage. As for the DNO, an improvement in the overall security of the supply could be achieved. Lastly, the customers are satisfied due to the reduction in the frequency and duration of interruptions resulting from outages in the distribution network. Solar panel should be equipped with an islanding detection algorithm during both grid connected and islanded operation. Fault currents in the islanded region might change and this can cause disoperation to the currently installed protective devices. Inverter based solar panel do not provide the levels of short circuit current sufficient to operate current sensing protective devices such as over current relays. If the protective relays were designed for small fault currents to satisfy the micro-grid operation, this might lead to unwanted tripping.

The protective devices should be capable to accurately determine when a micro-grid should be operated especially with the numerous abnormal conditions that might occur in the system. Besides that, sufficient co-ordinate fault protection should be provided to assure safe operation of the micro-grid. Safe operation and control of voltage during islanded operation of solar panel is another major challenge. The solar panel interface consist of single phase two wire grid interfacing to mitigate power quality

within microgrid. A much more changeling task is to operate more than one solar panel on the islanded mode. A hybrid control scheme for multiple inverters operating in islanded is proposed. The controller includes a synchronization algorithm for restoring the microgrid to the grid once the fault is cleared.

2. PROPOSED CONTROL SCHEME

In this paper only centralized control is discussed
A CCB is necessary in this scheme in order to set the reference current for each module. The measured load current is driven in CCB where is divided by the number of modules in parallel, forming the reference of each module. Subsequently, the reference current is subtracted from the current of each module. The error is processed through a current loop. An outer control loop in the centralized control adjusts the load voltage. The main drawback of this method, apart the central controller, is the need to measure the total load current, so the application the scheme in a large distribution system is difficult.
ACS712 a current sensing module is use to measure the current in the microgrid. This current sensing module sends data (electrical values and status) to MCC. MCC reads this data and as per status and algorithm in the microcontroller operates the relay to make the microgrid work properly.

3. PROPOSED PROTECTION SCHEME

An example of microgrid system is shown in figure 3.1. Here MCC is monitoring system is included in protection system.MCC is carried out by Arduino Mega 2560, located at central substation. The function of communication electronics is to make each circuit breaker with an integrated over current relay capable of exchanging information with an MCC. The main goal of MCC is to periodically check and updates the relay settings.
MCC can read data (electrical value, status) from circuit breaker if necessary it can modified relay settings. When an abnormal condition is detected a tripping condition is checked, if tripping condition is reached CB is open. Let us assume that fault occurs between SWB1 and SWB2 in a microgrid.

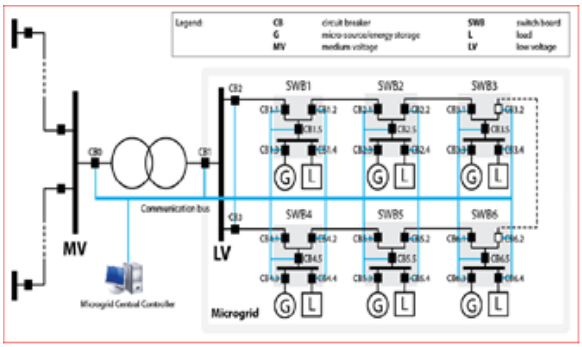

Fig. no. 3.1: Micro grid protection system infrastructure.

GEN4 and GEN5 are taken out for maintenance, and hence load at SWB5 and SWB6 are supplied through SWB3 by closing CB 3.2 and CB 6.2 which is shown in figure. Two identical distributed generators are connected with SWB1 and SWB6. So the fault occurring between SWB1 and SWB2 is feed by generators GEN 1 and GEN 6. As the fault occurred is near to GEN 1 so the maximum fault current is fed by GEN 1 and GEN2 feeds less current as compared to GEN 1.

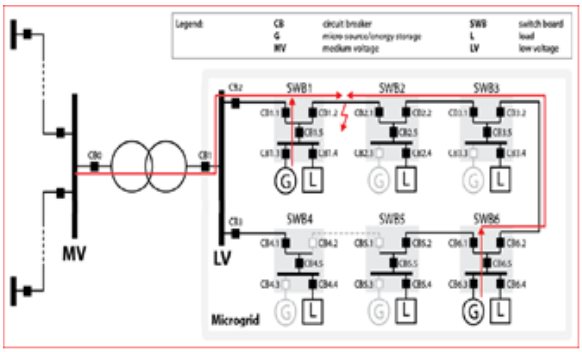

Fig. no. 3.2: Micro grid protection system with central controller unit.

The fault detected by CB1.2 is more and current detected by CB2.1 is less. So by the following function of CB1.2 and CB2.1 is opened and isolate the fault. If CB 1.2 and CB 2.1 fails to operate the fault is isolated by opening the CB 1.1, CB 1.5,CB 2.2,CB2.5 this protection is known as time graded protection (also known as “follow- me” system). If CB 1.1 operates faster than CB 1.2 it will cause a sensitivity problem for CB 1.2 so for this reason we use follow me system in which the time setting is adjusted so that CB 1.2 (near the fault) has less tripping time than CB 1.1.
Let us consider second fault occurs at generator and load bus, this fault is fed by the generator present at bus hence by opening the CB 2.3, CB 2.4, CB 2.5

we can isolate the fault. Let us consider the third fault occurs on the feeder or the load side, in this case there is fuse which is rated such a way that the fuse operates before the CB, if fuse fails to operate CB trips and isolate the fault by disconnecting the load from the grid this fault can be isolated.

4. POWER MANAGEMENT IN DC MICROGRIDS

A microgrid is connected into the utility grid through a bidirectional power converter that consistently monitors both sides and manages power flow between them. If there is a fault in the utility grid, the power converter will disconnect the microgrid from the grid, creating an islanded energy system. The microgrid can continue to operate in the islanded mode, that is primarily intended to increase system reliability and service continuity, and it is typically unplanned. However, it can also be introduced intentionally for maintenance purposes through the main switch. In some cases, islanded operation is the only mode of operation, e.g. in off-grid remote electrification system. As a result, there are two operation modes for a microgrid: (i) grid-connected and (ii) islanded mode.

i) Grid-Connected Mode

In the grid-connected operation mode, the grid-tied power converter has control over the AC link voltage level. If the sum of the output power of the distributed generation systems is sufficient to charge the storage devices, any excessive power is supplied to the utility grid. If the sum of the output power of the distributed generation and storage systems is deficient with respect to the load demand, the required power is supplied from the utility grid. In the grid-connected mode, power management is performed in a complementary manner between storage devices and as a result a AC microgrid can 3 operate safely and efficiently.

ii) Islanded Mode

When a AC microgrid must be separated from the utility grid and switch to the islanded mode, the grid-tied power Inverter releases control of the AC link voltage level, and one of the converters in the microgrid must take over that control. Since each converter of distributed generation sources is used for desire control of its belonging source, only the converters of the energy storage elements are free to regulate the AC link voltage level. During the islanded mode, the battery plays the major role in regulating the AC link voltage level, and the super capacitor plays a secondary role in responding of the sudden power requirement as an auxiliary source/sag, i.e. for peak shaving during transients.

5. CHALLENGES IN MICROGRID

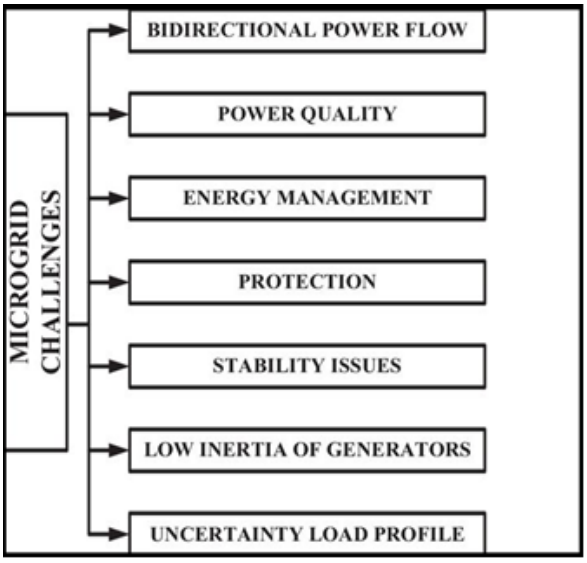

Fig. no. 5: challenges in microgrid

5.1) Bidirectional Power Flow

When the grid is connected to the main grid the flow of current may be bidirectional i.e. when the load requirement is more the current flow will be from main grid to microgrid and when the load is less the microgrid will supply the main grid. Hence the bidirectional relay protection is not possible.

5.2) Power Quality

Power Quality issues are most significantly occurs issue. As the renewable energy resources like solar panel we use so that it's maximum behavior depend on nature hence power quality issues are occurred. Also due to presence of harmonics in inverter circuit and other power electronic devices.

5.3) Energy Management

Energy Management involves all controllers like MCC, DNO, and MO which controls the performance of whole microgrid. So due to their behavior also issues are occurred in microgrid.

5.4) Protection

Microgrid protection is the most significant challenges facing the implementation of microgrids. Once a microgrid is formed, it is important to satisfy

the loads, lines and the distributed generations on the island are protected

5.5) Fault Current Contribution

Fault current inside in grid connected AC microgrid are varied because of fault current contribution of the main grid and microgrid resources (solar panel) are different from each other due to various fault locations, fault types, and high penetration of IBDGs. A FCL is equipment with small impedance in normal working condition, turn to the state of huge impedance if the current exceeds a given threshold limit due to a fault. Such a component is capable to raise the short circuit power of system in minimal condition without threat for equipment in the case of fault. The sudden gust in the microgrid causes rise in fault current which surpasses the short-circuit limit of network equipment by microgrid connection and also the increase in penetration of DG into the grid, the fault current level is also increased simultaneously. In order to overcome this problem, FCL could be arranged between the main network and microgrid. There are various types of FCLs, which have different designs and are made of various superconducting materials. SFCL is revolutionary protective device which has the capacity to lower the fault current level within the fault current first cycle.

5.6) Stability Issues

In operation of the microgrid, a challenging task is to operate more than one distributed generation on the island; it is no possible to use the active and reactive power control. It is mandatory to regulate the voltage during microgrid operation by using a voltage versus reactive power droop controller for local reliability and stability.

5.7) Low Inertia

The low inertia in the system can lead to critical frequency deviations in stand-alone operation if a proper control mechanism is not implemented. Low inertia of microgrid is also significant issue. As with low inertia, MGs faces the frequency control stresses and also some transients in MGs during islanded mode of operation.

5.8) Uncertainty Load Profile

Due to uncertainty of load profile disturbance in whole microgrid system is occurred. So because of this stability and reliability also affected.

6. RESULT

Fig. no. 6.1: Hardware of testing circuit

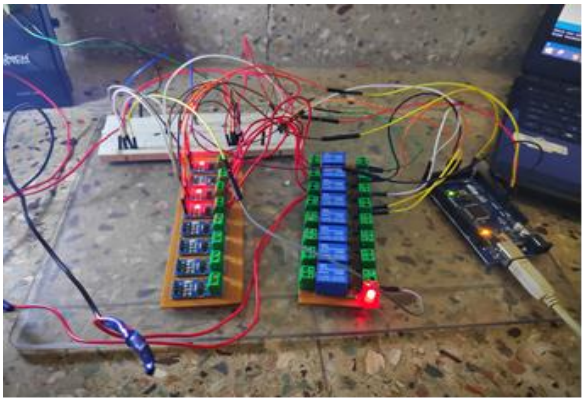

Fig. no. 6.2: Protection circuit

Figure 6.1 shows the testing circuit of microgrid. In this project, a power system network is modeled system with the different assets such as PV, battery, loads, cables, etc.

Figure 6.2 shows protection circuit for microgrid. Here we use overcurrent protection relay with the primary function of control logic used for connecting/disconnecting loads. The different loads like fan, bulb, AC etc that we can use in model.

7. CONCLUSIONS

Microgrid is an extension of main grid providing on-site generation capable of fulfilling its local load demand. Microgrid architecture requires to be added to the main grid to increase the reliability, improve power quality, avoid the use of depleting fossil fuels, improve the technical performance and reduce the greenhouse gases emissions. The microgrid can be connected in an islanded or isolated or autonomous and grid connected modes. Depending on the requirement these renewable energy sources are connected in the main grid or operate separately. Because of these reasons, operation, control and grid

integration of renewable resources is a task of fundamental importance in modern power system. Thus, it is desirable to develop reliable microgrid operation and effective energy storage algorithms which would enhance the performance of hybrid power systems.

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