A MICRO GRID PROTECTION SYSTEM WITH CENTRAL CONTROL AND MONITORING

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Abstract-

Micro grids are modern, small-scale versions of the centralized electricity system. They achieve specific local goals, such as reliability, carbon emission reduction, diversification of energy sources, and cost reduction, established by the community being served. Micro grid also ensures power quality of grid. It is a localized grouping of electricity generation, energy storage, and loads that normally operate connected to a traditional centralized grid. Micro grid consists of low voltage distribution systems with distributed energy resources, such as wind turbine and photovoltaic power systems, together with storage devices. This paper describes micro grid protection and safety concept with central control and monitoring unit where multifunctional numerical relay could be used.

Keywords- Distributed Generator (DG), Micro Grid (MG), Micro Grid Central Control.

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Introduction: A *micro grid* is a localized grouping of electricity generation, energy storage, and loads that normally operate connected to a traditional centralized grid (macro grid). This single point of common coupling with the macro grid can be disconnected. The micro grid can then function autonomously. Generation and loads in a micro grid are usually interconnected at low voltage. From the point of view of the grid operator, a connected micro grid can be controlled as if it were one entity

- Have much smaller financial commitments.
- Use renewable resources hence are more environmentally friendly with lower carbon footprints.
- Require fewer technical skills to operate and rely more on automation.
- Are isolated from any grid disturbance or outage.
- Place the consumer out of the grip of large corporations that run the generation networks.

Micro Grid an overview: A micro grid is a small-scale power grid that can operate independently or in conjunction with the area's main electrical grid. Any small-scale localized station with its own power resources, generation and loads and definable boundaries qualifies as a micro grid. Micro grids can be intended as back-up power or to bolster the main power grid during periods of heavy demand. Often, micro grids involve multiple energy sources as a way of incorporating renewable power. Other purposes include reducing costs and enhancing reliability. The modular nature of micro grids could make the main grid less susceptible to localized disaster.

Modularity also means that micro grids can be used, piece by piece, to gradually modernize the existing grid. The practice of using micro grids is known as distributed, dispersed, decentralized, district or embedded energy generation.

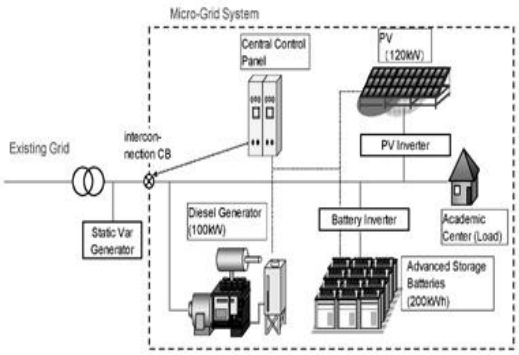

Figure 1- Schematic diagram of Micro grid system

Protection Issues: Fault currents for grid connected and islanded operation of micro grid are different. The short-circuit power varies significantly. Faults also causes loss of sensitivity, over current, earth leakage, disconnection of generators, islanding, reducing reach of over current relays, single phase connections and loss of stability. Depending upon location of faults with respect to distributed generators and existing protection equipment, problems like bidirectional power flow and change in voltage profile occurs. The power output of distributed generators like synchronous generators, induction generators and inverter interfaced protection units is unpredictable due to which whenever there is a fault, power output of these DG sources changes. Modification in fault current level, device discrimination, reduction in reach of impedance relays, reverse power flow, sympathetic tripping, islanding, single phase connection, selectivity are the key protection issues.

Protection Scheme for Micro Grid: Micro grid protection system must be able to face this challenge that it must respond to both, island and grid connected faults. In island mode, when it is clearing the fault, it must isolate the smallest part of Micro Grid. In grid connected mode, it should isolate the Micro Grid from Main Grid as fast as possible. Micro Grid consists of various Distributed Energy Resources. When various types of Distributed Resources connected to Micro Grid and Utility grid, the Distributed Resources contribute fault current to the system and this level of contribution depends on the type of Distributed Resource.

So, for such a dynamic structure of Micro Grid, here is a protection scheme shown in figure-2. Here central control unit communicate with all relays and distributed generators in the micro grid to record their status as ON/OFF, their rated current and their fault current contribution. Communication with relay is required to update the operating current and to detect the direction of the fault currents and thus mitigate the fault properly. The control unit also records the status of utility grid as connected or micro grid is islanded for adaptive protection.

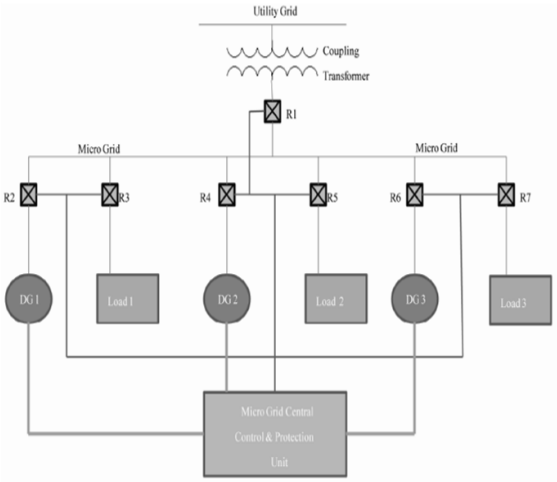

Figure 2-Micro grid protection system

Safety Design Concept in Micro Grid protection

This is very important part in Micro Grid protection scheme. So there must be a suitable model for this purpose. Central control and protection system should be designed to ensure required safety. Micro Grid hazard analysis is very important for this purpose and based on hazard level different safety thresholds is settled.

For Micro Grid safety design following three parameters need to be considered.

- Sensitivity - It must be able to sense any abnormal condition.
- Selectivity – To minimize fault consequences, it should disconnect only faulty part.
- Speed – Protective relay should operate as fast as possible.

It should have the capability to distinguish between fault, transients and abnormal conditions. It should operate when there is an occurrence of fault. It also has the capability to avoid misoperation. The protection strategy should also have redundant functionalities of relays to improve reliability. It is essential that this safety model can protect a Micro Grid in both modes of operation- grid connected and islanded mode against all types of faults.

Based on safety analysis a modern micro grid operational model for different relay settings is shown in Figure 3. Here, the central unit communicates with every single relay and distributed generator in the micro grid on interruption basis. The central control and monitoring unit record the instantaneous status of the distributed generator and utility grid as connected/disconnected, their rated currents and their fault current contributions.

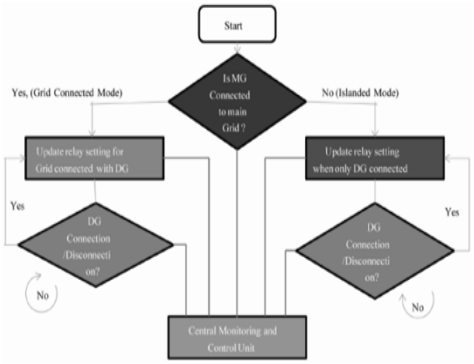

Figure 3- Operation model of Micro Grid regarding different relay settings strategy

To overcome protection problem of islanded and grid connected system different relay settings are required. Once a distributed generator connected/disconnected in system, based on island or grid connected, new relay settings are updated, new fault currents are updated in relays. Relays operate independently to open the connections. Once the current flowing over the relay exceeds the operating current, relays send signals to set the fault detection bit.

Fault Analysis (Micro Grid)

Faults in Micro Grid are of mainly two types-

- External faults- Main Grid- (could be in MV bus or distribution transformer)
- Internal faults- Micro Grid- (could be in LV feeder or transformer)

As Micro Grid need to operate in both modes (islanded and grid connected), Micro Grid Protection System faces the major problem due to large difference between fault current in main grid connected and islanded mode. Also there are problems related to sensitivity and selectivity. Conventional protection system is not capable of handling such a situation, so we need an advanced protection scheme.

Adaptive protection system for Micro Grid

We are considering an adaptive protection system for Micro Grid as shown in Figure. This Protection System can effectively help us in better performance. Due to the contribution of Main Grid connected mode, fault currents are large. In islanded mode fault current may be significantly small compared to grid connected mode. This is due to limited current contribution

of distributed resources. So, conventional over current protection is not appropriate in islanded mode of operation.

The new adaptive protection system can modifies the preferred protection response to a change in system conditions in a timely manner by means of externally generated signal or advanced control actions.

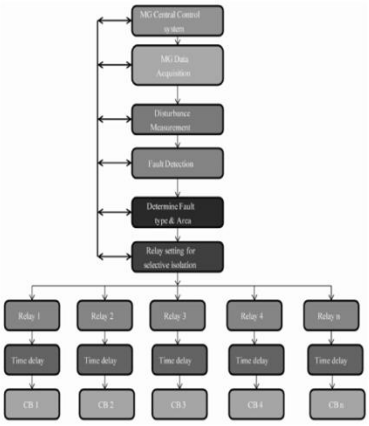

Figure 4- Centralized protection system for micro grid

Requirements and suggestion –

We can practically implement Adaptive Micro Grid Protection System; there are some requirements and suggestion as follows-

- There would have a micro grid central controller and monitoring system in modern micro grid protection system. Communication electronics make each CB with an integrated directional OC electronic trip unit (relay) capable of exchanging information with micro grid central controller.
- Use of numerical directional OC relays/microprocessor based relay/digital relay because fuses or electromechanical and standard solid state relays are inapplicable—they do not provide the flexibility for changing the settings of tripping characteristics and they have no current direction sensitivity feature.
- Numerical directional OC relays/microprocessor based relays must dispose of possibility for using different tripping characteristics (several settings groups) that can be parameterized locally or remotely automatically or manually.
- Introduce modern control infrastructure and data acquisition protocols so that individual relays can communicate and exchange information with micro grid central

controller. With this instantaneous settings for different fault scenario which will reliably to guarantee a required application performance.

This modern Micro grid protection system with micro grid central control and monitoring system is an important thing to discuss to overcome challenge of conventional protection system. Instantaneous relay settings, current, voltage and power directions are sent to central control unit through micro grid monitoring and data acquisition unit.

So with micro grid central controller and monitoring unit any abnormal condition or disturbance can be monitor and measure. Based on disturbance data analysis the fault could be detected, when any fault is detected it is important to find fault type based on current state of micro grid and the fault affected area/zone.

The main goal of intelligent protection system is to maintain relay setting of each relay with current micro grid scenario. There would be a special module in micro grid central control (MCC) unit which is responsible for periodic check and update of relay settings. The Micro grid central control (MCC) can read data (direction, electrical value, status) of individual relays from each CB and if required it can modify subset of relay settings (tripping characteristics).

So tripping decision can perform by MCC to each in- dividable relay, in case of any abnormal situation is detected tripping condition is checked and the direction of current is measured compared with actual relay settings.

Fault Mitigation Technique of Micro Grid

In micro grid protection system the fault analysis done based on data acquisition from control unit based on data acquisition disturbance is measured and fault detection alarm rings based on disturbance value.

In step one fault should be determined by detecting the variation in voltage at the bus. Based on power direction the fault location is detected. The fault point is in the utility grid if the power direction of the common connection point of utility grid and point of micro grid is positive. According to the power directions of the lines connected to bus bar, the system can determine whether there is a short-circuit fault at bus.

The fault is a short circuit fault of bus and breakers of each side of bus operates, if the power directions of all lines are negative. Inner fault, bus fault, line fault is determined on the basis of power direction. Fault is removed by tripping signal from relay if the fault zone is detected.

Conclusions

In this paper, we have considered the problems related to Micro grid protection system and their appropriate solutions. A micro grid protection system using digital relaying with control and monitoring units is presented. This protection system allows automatic adaptation of protection settings according to the actual type of grid structure and the interconnection of micro grid. These digital relays permits for continuous monitoring of analog and digital signal produced from the system. This automatic control and protection system can potentially solve the problems related to Micro Grid.

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