CHAPTER 1

INTRODUCTION

In recent years, electric power systems are experiencing the integration of a large number of low medium voltage distributed energy sources into distribution networks. Modern DER's are interfaced with the network through power electronic converters as they utilize renewable energy resources such as PV arrays, wind turbines and fuel cells. The increasing proliferation of EC-DERs has challenged the operating principles of traditional distribution systems. Therefore, the concept of micro grid has been introduced to resolve some of the technical issues associated with DER's. The practice of operating micro grids however recently disturbs the protection schemes which expected to operate independently as well as in conjunction with rest of a grid.in grid connected mode, fault current are fairly large due to this conventional over current relay is possible.

This paper proposes a strategy for protection of LV micro grids, in both modes of operation, based on programmable microprocessor-based relays and directional elements. The proposed strategy aims to detect and isolate the faults that impact the host micro grid, in a selective (coordinated) manner. The paper also presents the concept and structure of a new relay that enables the proposed protection strategy. The salient features of the proposed strategy (and the relay) are that it does not require communications, and is fairly independent of the fault current magnitudes and the mode of operation.

CHAPTER 2

MICROGRID

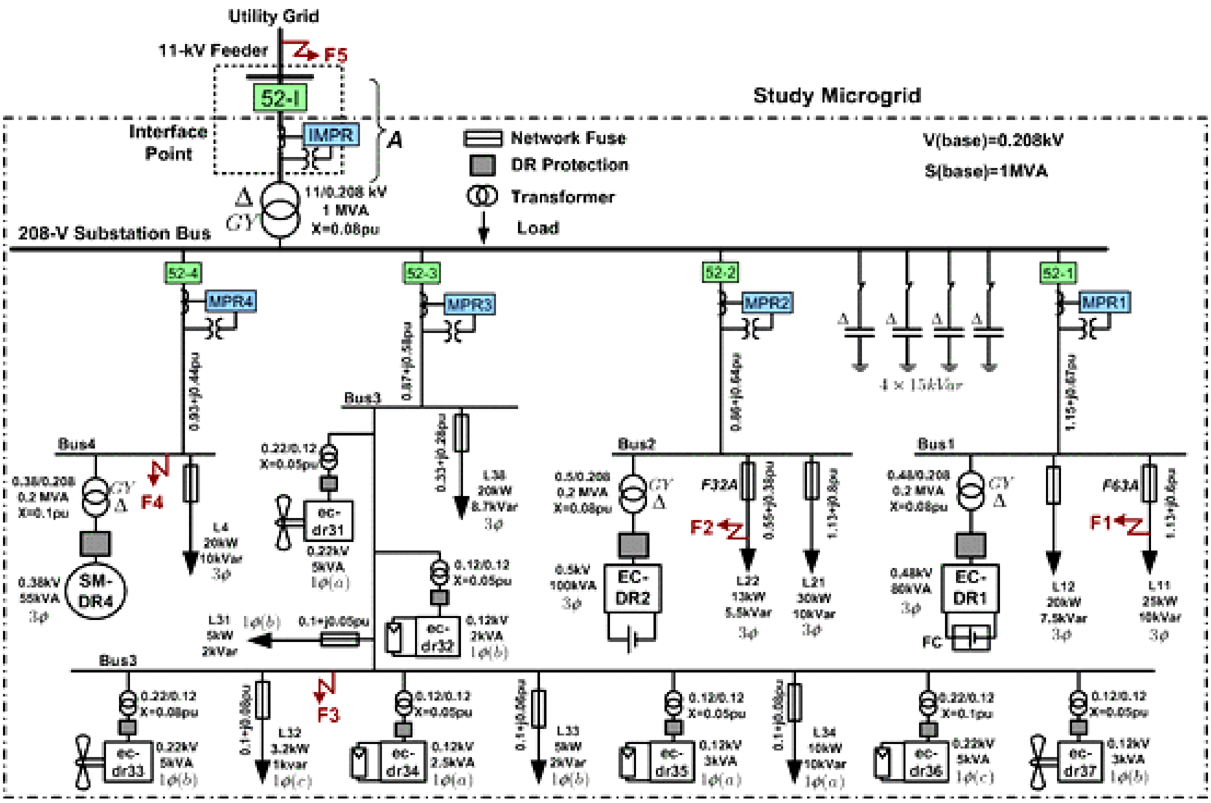

Fig 2.1 layout of micro grid

A micro grid is a localized grouping of electricity generation, energy storage, and loads that normally operates connected to and synchronous with the traditional centralized grid but can disconnect and function autonomously. 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.

Micro grid generation resources can include fuel cells, wind, solar, or other energy sources. The multiple dispersed generation sources and ability to isolate the micro grid from a larger network would provide highly reliable electric power. Produced heat from generation sources such as micro turbines could be used for local process heating or space heating, allowing flexible tradeoff between the needs for heat and electric power.

Most countries generate electricity in large centralized facilities, such as fossil fuel, nuclear, large solar power plants or hydropower plant these plants have excellent economics of scale but usually transmit electricity long distances and can negatively affect the environment. Distributed generation allows collection of energy from many sources and give lower environmental impacts and improved security of supply.

- It provide highly reliable electric power
- The multiple dispersed generation sources and ability to isolate the micro grid from larger network would provide highly reliable electric power produced heat from generation sources. such as micro turbines could be used for local process heating
- It is a localized grouping of electricity generation energy storage and loads that normally operates connected to a traditional centralized grid(macro grid).This single point of common coupling with the macro grid can be disconnected
- Micro grid can then function autonomously. generation and loads in a micro grid are usually interconnected at low voltage

2.1 BENEFITS OF MICROGRID

- Increase in reliability and stability of power supply

- Reduction of green-house gases emission as a result from utilization of renewable energy sources
- Reduction of line losses and deferral of investment in new construction and up- gradation of infrastructures.
- Provide excess power and assist voltage support to the utility grid during interconnected mode of operation.
- Cost efficient electricity infrastructure replacement.
- Improved energy efficiency, improve power quality, minimized overall energy consumption.

  Micro grid does not only tender its benefits but also adverse effects due to the interconnection of distributed generators (DG s)

- The increasing penetration of DGs in power systems will deeply affect the distribution of short circuit in the existing distribution network and consequently it affects the operation and control of distribution networks.

CHAPTER 3

DISTRIBUTED RESOURCES

Distributed generation, also called on-site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy, distributed energy or district energy, generates electricity from many small energy sources. Most countries generate electricity in large centralized facilities, such as fossil fuel (coal, gas powered), nuclear, large solar power plants or hydropower plants. These plants have excellent economies of scale, but usually transmit electricity long distances and can negatively affect the environment. Distributed generation allows collection of energy from many sources and may give lower environmental impacts and improved security of supply.

Distributed generation reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used, perhaps even in the same building. This also reduces the size and number of power lines that must be constructed.

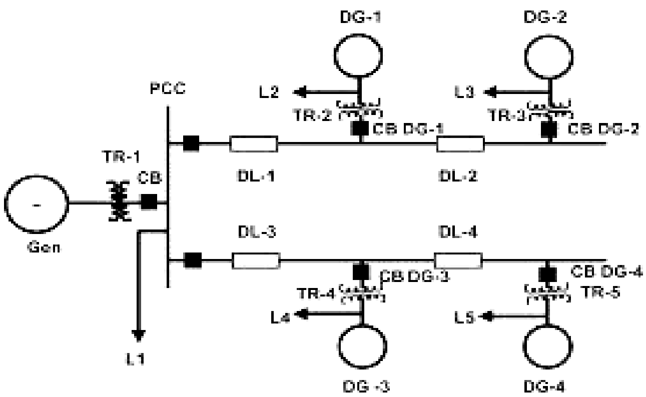

Fig 3.1 Distributed resources

CHAPTER 4

CHARACTERISTICS OF LOW–VOLTAGE DISTRIBUTION NETWORKS

4.1 STRUCTURE

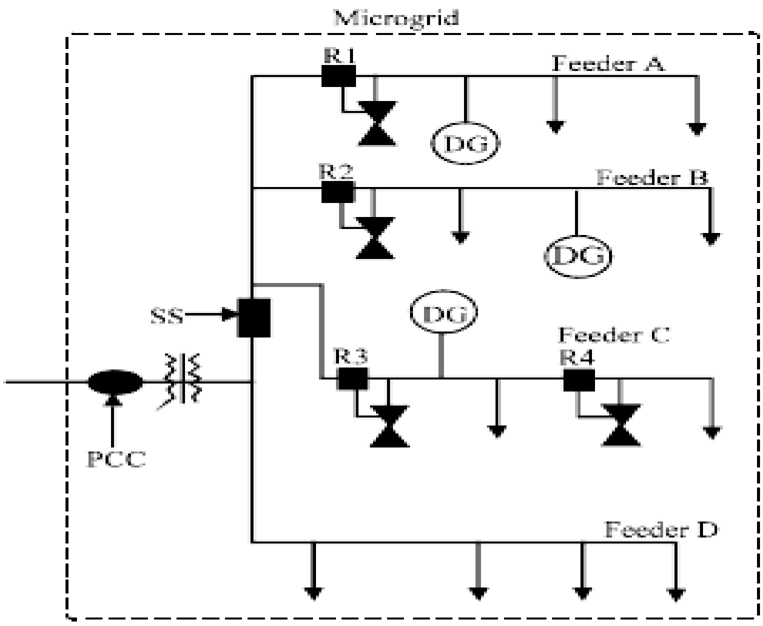

Fig 4.1 Distribution network

An LV micro grid is based on a designated area of a secondary distribution network which is supplied by a step-down transformer. By assumption, the designated area embeds sufficient amount of generation and is thus able to operate in isolation from the rest of the network. The rating of the step-down transformer, which connects the primary (MV) network to the secondary (LV) network, is typically from a few hundred kilovolt amperes to several megavolt amperes; thus the peak power demand of an LV micro grid is assumed to be limited to a maximum of several megavolt amperes. It is further assumed that micro grid loads are supplied by a number of radial secondary mains (SMs), which may be branched by one or more laterals, and that the presence of single-phase loads and or DRs makes the LV micro grid an inherently unbalanced network.

4.2 CONVENTIONAL PROTECTION

In general, simple overcurrent devices, most commonly in the form of fuses, are employed in secondary distribution networks to protect equipment and ensure safety. Secondary network conductors are typically protected by the so-called limiters. A limiter is a high-capacity fuse that is installed on each phase conductor of the SMs at each junction point. The step-down transformer is protected by a network protector, which is an LV air circuit breaker with a tripping/closing mechanism controlled by a self-contained relay. In addition, the network protector has fuses that provide backup protection for the step-down transformer. Since the fault should be rapidly isolated by the limiters, before the network protector operates, the time-current characteristics of the limiters must be coordinated with those of the network protector. This practice ensures that the smallest possible area of the secondary network is de-energized in response to a fault incident. The secondary side of the step-down transformer may not necessarily be protected by dedicated equipment, as the SMs are commonly equipped with corresponding dedicated network fuses. Hereafter, due to its more common usage, the term “network fuse” or “fuse” is used instead of limiter.

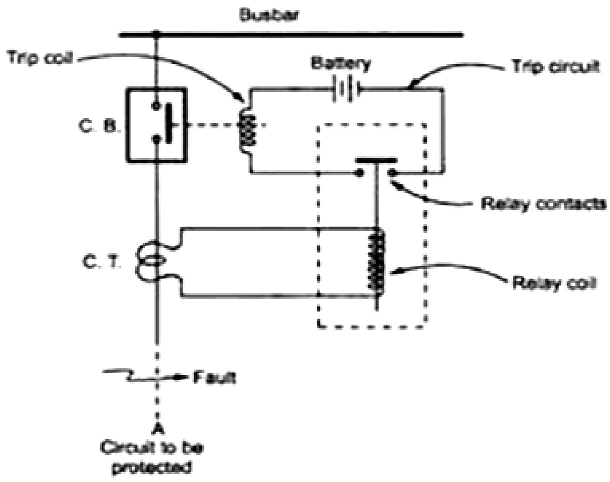

Fig 4.2 Conventional protection relay

A protective relay is a device that detects the faults and initiates the operation of the circuit breaker to isolate the defective element from the rest of the system.

The relay detects the abnormal conditions in the electrical circuits by constantly measuring the electrical quantities which are different under normal and fault conditions. The electrical quantities which may change under fault conditions are voltage, current, frequency and phase angle. Through the changes in one or more of these quantities, the fault signal their presence, type and location to the protective relays. Having detected the fault, the relay operates to close the trip circuit of the circuit of the breaker. This results in the opening of the breaker and disconnection of the faulty circuit. A typical circuit in Fig: 4.2 this relay divided into the three parts.

1. First part is the primary winding of a current transformer (CT).which is connected in series with the line to be protected.

2. Second part consists of secondary winding of CT, relay operating coil.

3. Third part is the tripping circuit which may be either a.c. or d.c. it consists of a source of supply, trip coil of the circuit breaker and the relay stationary contacts.

When a short circuit occurs at a point A, the current flowing in the line increases to an enormous value. This results in a heavy current flow through the relay coil, causing the relay to operate by closing its contacts. This in turn closes the trip circuit of the breaker, making the circuit breaker open and isolating the faulty section from the rest of the system.in this way, the relay ensures the safety of the circuit equipment from damage and normal working of the healthy portion of the system.

4.3 GROUNDING

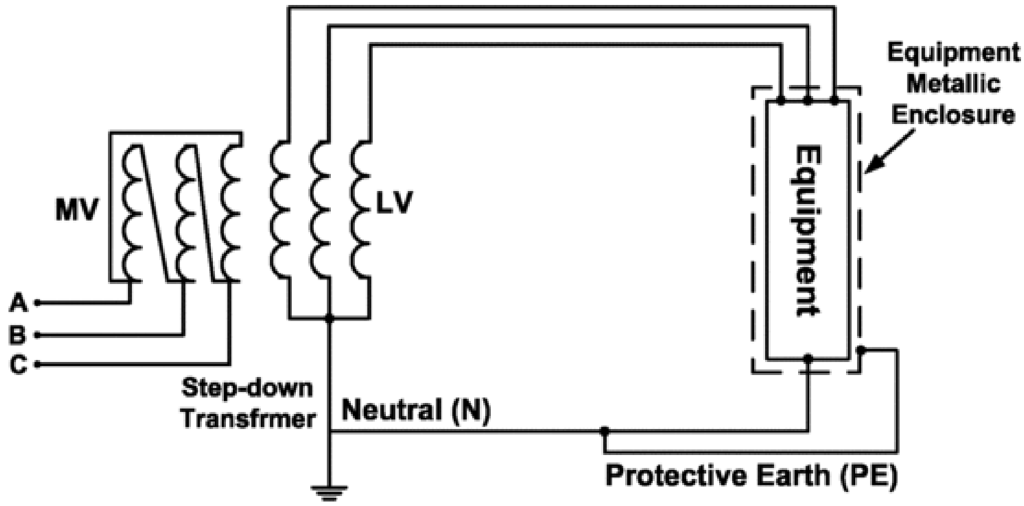

Fig 4.3 Grounding technique

An LV micro grid is subject to the same safety requirements and standards as those set for a Conventional secondary distribution network. In a micro grid, a fault incident may result in a substantial ground voltage, even if the DRs operate at low voltages. Moreover, the neutral grounding practice in a micro grid can affect protection. Therefore, the grounding strategies of the equipment in an LV micro grid must be adopted judiciously. Typically, a (delta/grounded wye) winding configuration is used for the step-down transformer. Thus, either of the two grounding strategies TT and TN can be adopted, since the ground will be available at the LV side of the step-down transformer, even if the micro grid is islanded. However, compared to the TT method, fault currents are higher in the TN approach, due to the low-impedance return path (neutral or protective earth conductor) that exists in the TN method. The reason is that, in the TN approach only a small fraction of the fault current is diverted to the ground, but the rest flows through the neutral path. This characteristic enables the use of ground-fault relays in the TN approach, for the neutral conductor of an SM. For the reason mentioned above, the popularity of TN method. And the system safety requirements, the TN-C-S grounding configuration.

4.4 D R INTERFACING MECHANISM

The DRs of an LV micro grid can be of the single-phase or three-phase type, based on rotating machines or interfaced through power-electronic converters of the voltage-sourced converter (VSC) types. A single-phase DR is connected between a phase conductor and the neutral conductor, typically through a single-phase isolation transformer. Thus, the TN-C-S grounding strategy ensures that the DR can contribute to a line-to-ground fault current, through the low-impedance path of the fault current loop. The TN-C-S grounding configuration can also be adopted for a three-phase DR for which an interconnection transformer is employed.

4.5 D R CONTROL STRATEGIES

The droop-based voltage/frequency regulation strategy has been employed for the DR’s. It is also assumed that the control scheme of each DR embeds a respective synchronization mechanism for safe reconnection of the islanded micro grid to the utility grid. To ensure that traditional basic protection functions, more specifically the directional function, can also be employed here, the built-in controls of DRs are designed in such a way that the DRs behave similarly to the conventional synchronous machines, in the sense that they more or less maintain the balance of their terminal voltages when an asymmetrical fault strikes the network; in an EC-DR, of course, the magnitude of the terminal voltage drops to limit the fault current contribution.

CHAPTER 5

PROPOSED PROTECTION STRATEGY

5.1 MAIN PROTECTION

The main protection scheme, which is based on the existence of a communication medium, employs directional elements to detect and isolate all network faults. According to the proposed protection strategy, the loop-forming lines are protected based on the instantaneous differential protection scheme. In the differential protection scheme, a relay measures the current magnitude and sends the measured value to the remote relay (on the other end of the line), through a communication link. If the magnitude of the line differential current exceeds its trip threshold for a pre-specified period of time, the corresponding relays detect and isolate the fault immediately; this can be ensured through the operation of the corresponding circuit breakers. On the other hand, the protection strategy proposes that the micro grid is divided into a desired number of sub networks so that each can be protected by a set of microprocessor-based relays; the structure and features of these relays, referred to as the “micro grid protection relay” (MPR). Therefore, it is required to replace some of the protective devices of the original distribution network by MPRs, each protecting a corresponding sub network. It should be noted that although it is hypothetically possible to divide the distribution network into any number of sub-networks, the division of the entire micro grid into the sub networks depends on the system requirements, constraints, and configuration. The proposed strategy also suggests that once a subnetworkgets islanded, for example, due to a fault within its jurisdiction, it is dropped out; this is due to the fact that there may not exist a generation-load balance in each sub network, or it may not be possible/economical to provide each sub network with additional protection. It should, however, be mentioned that the looped connection of the feeders improves the network reliability in such a way that the loss of a sub network will not necessarily result in service disruption in the entire micro grid. Moreover, if there is a generation-load balance in a sub network such that it can operate as an island, the corresponding sub network can additionally be protected based on this method.

According to the proposed communication-assisted protection strategy, each MPR sends two signals to the DCC: (i) the fault detection signal (FD) which indicates whether or not the MPR has detected a fault within the sub networks and (ii) the fault direction signal (D) which indicates the direction of the fault from the MPR viewpoint. The faulty sub network is detected through a suit-able logic mechanism, which analyzes the data provided by the above mentioned signals of each MPR; the logic algorithm will be explained. Once a fault is recognized by the DCC, the trip signals are sent to the appropriate circuit breakers to isolate the impacted sub network. The trip signals are sent after a time delay (greater than 0.1 s, but less than 0.15 s) in order to give a chance to the downstream protective devices to operate first (especially, in the grid-connected mode where the fault currents are fairly large).It should be pointed out that depending on the fault location, one of the circuit breakers associated with the loop-forming lines may also be required to open, through a trip command. In case of a circuit breaker failure, a breaker failure trip signal is sent to the adjacent circuit breakers to isolate the fault. The breaker failure signal, however, is sent after a delay (greater than 0.3 s, but less than 0.4 s) if the fault is still alive. The backup protection mode in all MPRs is enabled after about 0.4 s from the fault inception to make sure that the breaker failure trip signal has already been sent; hence the coordination between the main and backup protections is hold. Moreover, if the communication link fails (MPRs do not receive any signal for some time), all MPRs are automatically switched to the backup protection mode. Fig. 5.1 provides a flowchart of the proposed protection algorithm. To implement the proposed protection strategy, one can utilize wireless communications that offers several advantages including low installation cost, rapid deployment, and high mobility.

5.2 BACK UP PROTECTION

This section briefly describes the backup protection strategy, which does not require communications; it is considered to protect the network if the communication system fails. Therefore, as explained in the previous section, the MPRs automatically switch to the backup protection mode once the communication network fails. In the backup protection mode, all Fig. the relays are separately coordinated for the islanded and grid-connected modes. It should also be pointed out that, compared to the main protection, the backup protection strategy may take a relatively longer time to detect and isolate a fault in the micro grid, due to the employed grading technique for the protection coordination

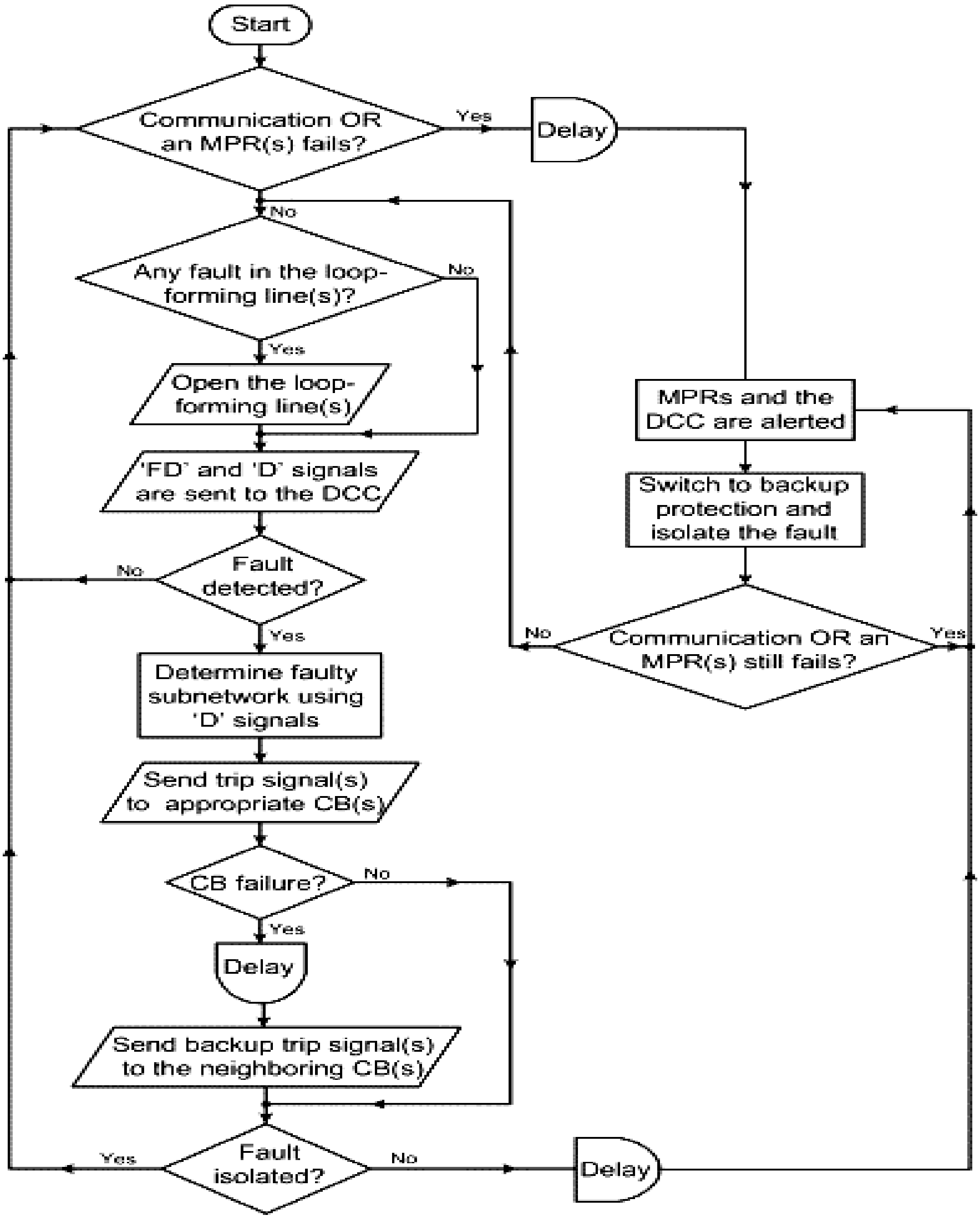

Fig 5.1 Flow chart of proposed protection strategy

CHAPTER 6

MICROGRID PROTECTION RELAY

To enable the proposed strategy and to address the micro grid protection issues, it is required to utilize different protection functions required for the protection of a micro grid in both the grid connected mode and the islanded mode are embedded in a microprocessor based relay. Microprocessors based relay has capable to communicate with other devices.

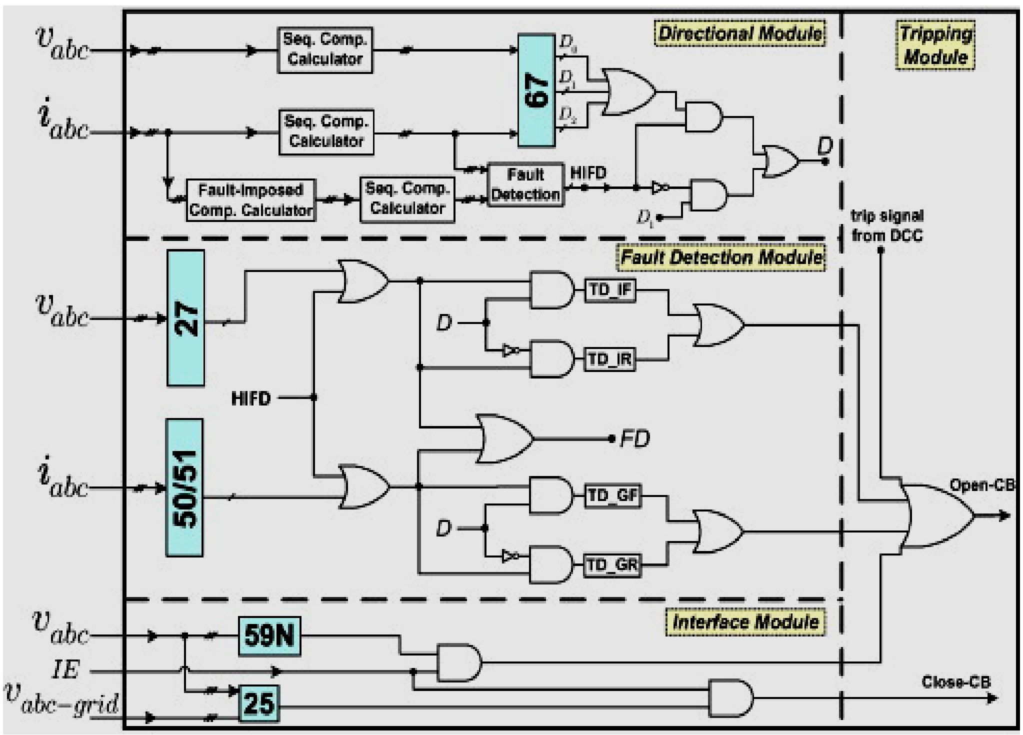

Fig 6.1 Micro grid protection relay

6.1 Directional module:

This module has been designed to deter-mine the correct direction of faults. The output of the directional module D is sent to the DCC in order to recognize the faulty sub-network. The directional signal is also used in the fault detection module (to be described next) to provide backup protection for both the islanded and grid-connected modes in a coordinated way. Since the directional module is intended to determine the direction of different types of faults, including high-impedance faults, it utilizes sequence components to do the task faithfully. When a high-impedance fault impacts the network, the conventional directional elements may fail to indicate the correct direction of the fault. To deal with the issue, this paper proposes the employment of zero-sequence directional elements; the strategy is similar to what is exercised in directional earth fault relays [18]. Moreover, a negative-sequence directional element is used to ensure protection against faults with small current magnitudes that do not include all three phases. Directional elements are simulated.

6.2 Fault detection module:

The main duty of this module is to generate fault detection signal (FD) to be sent to the DCC. Similarly, the fault detection module is assumed to detect all types of faults, including high-impedance faults. To do so, the module benefits from fault-imposed components. In addition, the fault detection module provides backup protection for the micro grid in the islanded and grid-connected modes if the communication network fails.

6.3 Interface module:

This module consists of neutral voltage dis-placement (NVD) and synchronism-check functions. The NVD function is employed to help an MPR detect faults at the high-voltage side of the substation transformer. The synchronism-check function, on the other hand, is used to ensure safe reconnection of the islanded micro gird to the main utility grid.

6.4 Tripping module:

The final stage of the decision-making process in an MPR is performed in the tripping module. It decides whether or not a trip signal should be issued to the corresponding circuit breaker(s).

6.5 BENEFITS OF MICROPROCESSOR BASED RELAY

1. Proposed strategy is independent of fault current level, type size and location of distributed energy sources, operation mode of micro grid, subject to the modified relay setting for grid connected mode.

CHAPTER 7

MODES OF OPERATION

7.1 ISLANDED MODE

7.1.1 Grading: In an islanded micro grid, the voltage drop caused by a fault appears more or less across the entire network, due to the limited geographical span. Therefore, it is almost impossible to coordinate protective devices based on voltage profile. To ensure coordination, this paper proposes the use of a directional element, in conjunction with fault detection modules. The combination of a fault detection module and a directional element, with proper definite time delays for forward and reverse faults, can offer acceptable protection coordination.

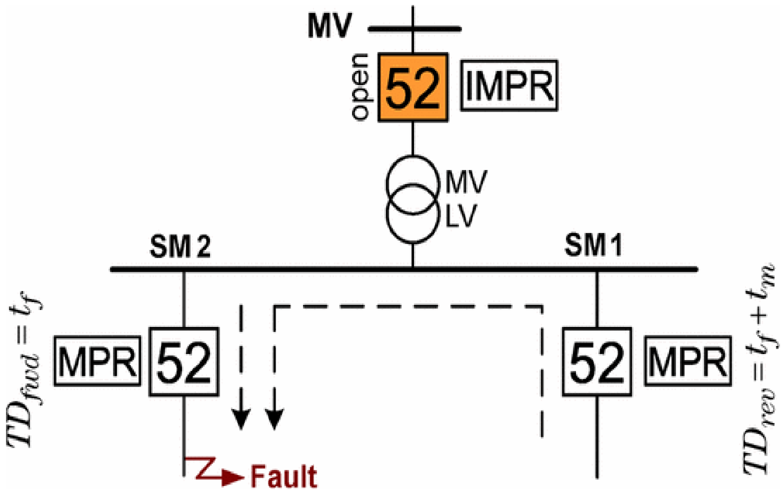

Fig 7.1 MPR s in the islanded mode

The proposed grading method requires incorporation of directional elements in each MPR, to preclude false tripping when a fault impacts a neighbouring SM. Thus, the directional elements of a sound SM rapidly block their respective circuit breaker(s), for a prespecified period of time, to allow the protective devices not continue for any longer than the duration of the relay reverse definite time; afterwards, the circuit breaker(s) of the sound SM is commanded to open, as a backup protection. This concept is illustrated by Fig. 8 in which tf and tf + tm and respectively denotes the relay forward and reverse definite time delays. It is noted that the reverse definite time delay is larger than its forward counterpart, by a suitable grading margin, tm. It is also remembered that the circuit breaker installed at the micro grid interface point is open in the islanded mode of operation.

7.1.2 Protection Scheme Extension

Each MPR in Fig. 7.1 has its own forward and reverse time delays and is intended to protect a protection zone; the time delays used for forward and reverse operations of the MPRs are also indicated in the figure. Shows that for a forward fault at location Flt1, MPR11 operates first with a delay of tf. This time delay is chosen in such a way that it allows the lateral protection to clear the fault if it is within the household or lateral installations. If MPR1 fails to operate, MPRs 2, 3, and 4, in sequence, are expected to clear the fault through their delayed operations. The same grading strategy is employed to coordinate the MPRs for the reverse path (e.g., for a fault at location Flt2). The same coordination grading scheme can also be employed for a micro grid with several SMs.

7.2 GRID CONNECTED MODE

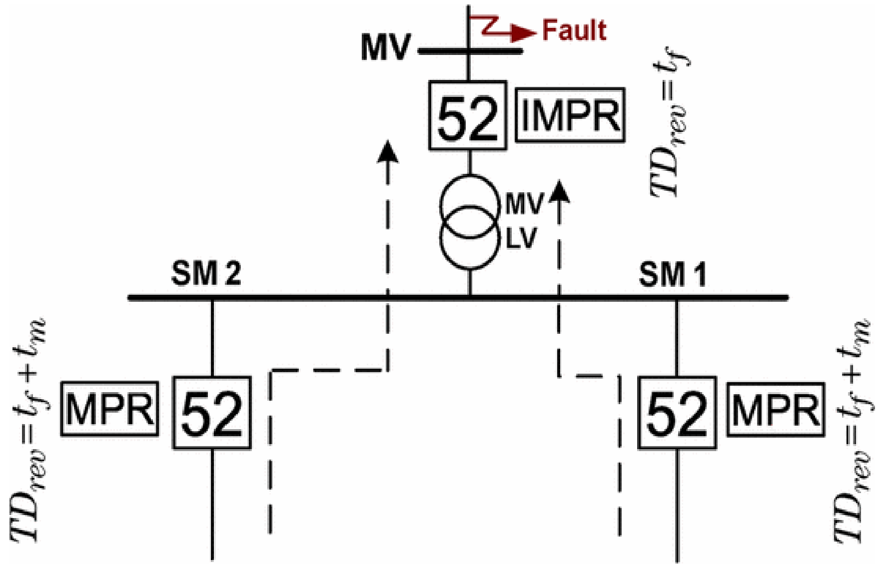

Fig 7.2 Grid connected mode

As mentioned earlier, the conventional overcurrent protection can still be employed for the protection of a micro grid in the grid-connected mode of operation. Fig. 7.2 illustrates an example of the conventional coordination practice for two fuses, one main relay, and one backup relay for a typical distribution network. The figure indicates that the devices are coordinated in such a way that for all fault currents between (minimum fault current of the feeder) and (maximum fault current of the feeder), the minimum melting time (MMT) curve and the total clearing time (TCT) curve of the fuses lie below the characteristic curves of the relays to ensure that the fuses will operate before the relays intervene. In addition, coordination must also be made between the fuses. If the fuses fail to operate for a fault, the main relay will back them up by operating according to its inverse-time characteristic. The backup relay will operate only if the main relay and the fuses fail to act. Hence, to maintain the coordination, one has to ensure that the fault current passing through the devices has a value between Ifmin and Ifmax .The addition of a DR to an SM, anywhere downstream of the relay, affects Ifmin and Ifmax and also causes the fuse current to exceed the current seen by the relay.

7.2.1 External Faults

For a fault taking place outside of the micro grid jurisdiction, a low fault current may be contributed by the (grid-connected) micro grid, which does not guarantee the operation of the overcurrent protection scheme of the relay that is located at the micro grid interface point (IMPR). To address this shortcoming, the IMPR must also employ the islanded-mode protection strategy of Section III, despite the fact that it always operates in the grid-connected mode. The only difference is that definite-time grading of the IMPR starts at the micro grid interface point and ends at the load side of the SMs. Fig. 7.2 illustrates the process for two adjacent SMs with their respective MPRs.

7.2.2 Neutral Voltage Displacement Protection

Another issue concerning the IMPR may arise when the micro grid operates in the islanded mode of operation. Although the neutral grounding of the LV micro grid is preserved due to the LV-side star winding configuration of the step-down transformer, the MV side of the step-down transformer, which is still energized, becomes ungrounded in the islanded mode of operation. Therefore, over voltages may be experienced if a ground fault impacts the ungrounded MV side of the step-down transformer (area “A ” in Fig. 7.2), in the islanded mode of operation. To address this issue and to detect such faults, this paper proposes the use of a neutral voltage displacement (NVD) protection function in the IMPR.

CHAPTER 8

DISCUSSION

Q.1. What you meant by micro grid?

Ans. A micro grid is a localized grouping of electricity generation, energy storage, and loads that normally operates connected to and synchronous with the traditional centralized grid but can disconnect and function autonomously.

Q.2. Why in islanded mode is not used by conventional relay?

Ans. Micro grids are expected to operate independently (islanded mode), as well as in conjunction with the rest of the grid (grid-connected mode). The protection scheme of a micro grid must be able to ensure safe operation of the micro grid in both modes of operation. In the grid-connected mode, fault currents are fairly large due to the contribution of the host grid and, thus, the employment of conventional overcurrent relays is possible. How-ever, due to the existence of DERs, the protection coordination may be compromised, or even entirely lost in some cases. In the islanded mode, on the other hand, fault currents are relatively small due to the limited current ratings of silicon switches that are employed in EC-DERs. Therefore, traditional overcurrent schemes are not effective for the protection of islanded micro grids.

CHAPTER 9

CONCLUSION

It is observed that if the main protection fails to operate, the backup protection scheme isolate the fault through the intervention of MPR.

Since fault currents are relating small in the islanded mode, the network fuses take a relatively longer time to isolate the fault. Therefore, the faults are first isolated by MPR’s.

MPR’s are effective in both modes of operation, can be implemented by strategy

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