Protection of Microgrid Through Coordinated Over-Current Relays

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***Abstract*- Microgids are distributed energy source to provide environment friendly reliable and economic power to large rural area and small urban area. In microgrid uses wind energy, solar energy, battery, distribution generator etc. It operate in two mode of generation, i.e island mode and grid connected mode. Distribution system protection is important aspects in the microgrid. When it operate in island connected mode fault current is very less. To increase the fault current Distribution generator (DG) are connected to all bus bar. It create over voltage, under voltage problem, reverse power flow problem and also not economical. For eliminate this problem, the proposed system coordinated overcurrent relay near bus bar and remove DG from bus bar. This result will be verified by using MATLAB simulation.**

Keywords—Microgrid; Protection; curve of overcurrent (CO); distribution generation (DG); over current relay;

I. INTRODUCTION

A microgrid is a same form of smart grid, which are operate in modern time for local area power distribution. It is especially important that because of flexible operation in island mode and grid connected mode to enhance security and reliability of electricity grids. In islanded mode, integration of distribution generator is most important part of supplying electricity to the loads [1]. Distribution generator provide high system efficiency and high power quality with some environmental impacts, but integrated distribution generator uses on bus bar increase fault current in island mode just because of detect the fault current by relay. Integrated DG is not healthy for system, its increase complex of system.

The microgrid approach to create plan and design for local area energy (both thermal and electrical) delivery that meet the needs of the constituents being served. In local area, microgrid's generation and distribution of electricity is most economically and efficiently to integrate consumers and buildings. Coordination of various micro sources is complex as it is affected by resource availability, weather condition and demand [10]. The protection scheme of microgrid must be work for island mode and grid connected mode of operation. The fault current level are different for both mode of operation. Fault also create problem like unintentional islanding, overcurrent and in reach of impedance relay. Fault current depend on location of fault, bidirectional power flow and fluctuation in voltage profile. In island mode inverter is contribute low magnitude of fault current, Its undetected by protection scheme [1].

The main objective of paper is to understand different issue about the protection of microgrid and consider a suitable protection scheme by using MATLAB [5]. The main objective are given following:

- Create a model of microgrid with containing different type of distribution generation in MATLAB.
- For protection of microgrid to use overcurrent relay.
- For Proper coordination of relay to provide relevant relay settings.
- Remove integrated DG from bus bar location and add overcurrent relay near the bus bar.

The main problem occurs that when microgrid work on island mode inverter based operation, inverter fault current are nearly 2 p.u. of rated current. Fault current by inverter is not sufficient to detect by relay. This problem can be solve by adding DG at bus bar of microgrid but this cause over voltage, under voltage and reverse power flow problem occur. This problem short-out by removing DG from bus bar and use overcurrent relay near to bus bar.

II. PROTECTION ISSUES

The modern microgrid is capable to automatically connected and disconnected from main grid. It can operate independently for main grid. When power in main grid available, it is automatically reconnect and recharge battery. When it operate in island mode many of power electronics devices are working. For example, DC power generated in microgrid by photovoltaic cell, fuel cell, convert DC power to AC power etc. this converter don't supply sufficient current to operate relay in island mode of operation because low magnitude of fault current. Therefor use of converters in microgrid are challenging issue [11]. All DG (wind energy, photovoltaic cell) are not operate in same time. Therefore different fault current are different active DG connection. The result of fault current level detected by protection scheme will be difficult [4, 7].

All DG should be protected from abnormal condition in microgrid, therefore each DG should be protected by own protection scheme; over voltage, reverse power flow, under voltage and synchronism problem. For protection of DG due to abnormal condition, relay of DG should connected through trip command in circuit breaker [5].

Under voltage, reverse power flow and over voltage protection are not healthy for microgrid. Remove some DG, which are use to maintaining the fault current of microgrid for sensing relay in island mode. For maintaining fault current during island mode uses overcurrent relay.as fig.2

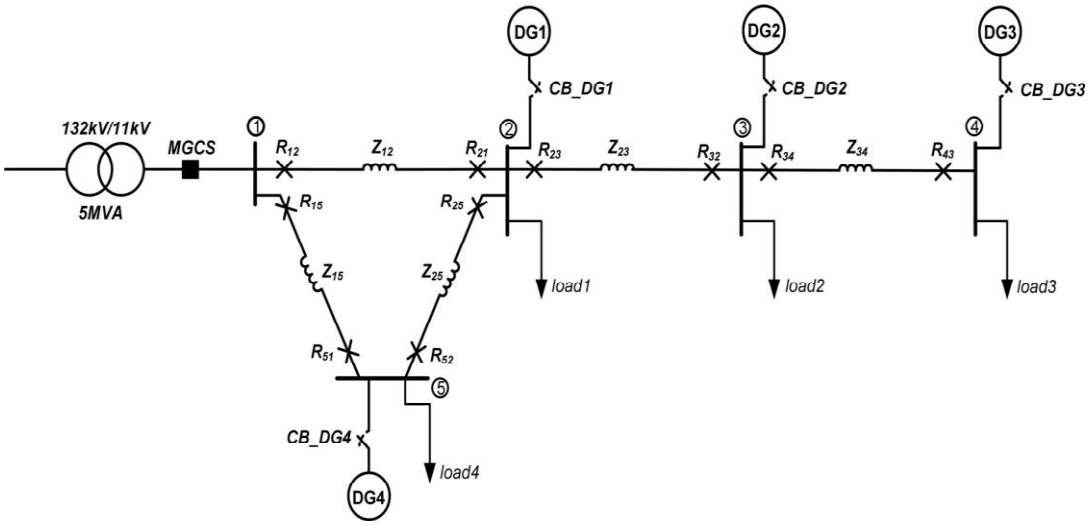

Fig.1. Schematic diagram of the microgrid,with DG.

III. RELAY COORDINATION

Relay are coordinated in power system circuit to based according to current and other parameters. Which relay closest to fault current those relay operate first. The usual function of main protection to detect the permanent or temporary fault, if main protection fail to detect the fault backup protection operates and this protection is restrict to loss of supply due to permanent fault. The fault detect by protection scheme as possible as much less time required. Overcurrent protection relay detect the fault current, when current in relay is greater then pre-set value.

Protection of distribution system is most important problem in power system. The best relay of power system is overcurrent, which is commonly use in protective relay. A proper setting in relay play a important role in reducing unwanted effect of fault in the power system. There are two type of setting in overcurrent relay: current setting and time setting.

A. Current Setting

When relay operate a current is known as pickup current. This current is depend on maximum load current flow through relay and minimum fault through it. Pickup value depend on the number of turns of current coil, its value can be change by changing number of turn of current coil. The plug setting can be denoted in percentage of rated current or in term of current setting. For phase to phase fault protection, the overcurrent relay is set at 50% to 200% of the rated current in steps of 25%. The usual current rating of the relay is 1 or 5 Amps. In time current curves current is taken along the X-axis and Time is taken along the Y-axis. But this results in multiple curves for each relays. To avoid this Plug Setting Multiplier is taken along the X-axis. Plug Setting Multiplier is expressed as a multiple of the pickup current and the actual RMS current flowing through the relay.

$$Plug\ Setting\ Multiplier\ (P.S.M) = \frac{Secondary\ fault\ current}{Relay\ current\ setting}$$

$$Seconday\ Fault\ Current = \frac{Primary\ fault\ current}{CT\ Ratio}$$

B. Time Setting

The operating time of the relay can be set to alter the time at which the relay picks up. TMS of an IDMT relay is given by the ratio of Operating time to the time obtained from the relay characteristic curve at TMS=1 and the PSM at which maximum fault occurs. The TMS can be varied from 0.1 to 1 in steps of 0.1. Time multiplier setting is also called Time Dial setting (TDS).

$$TMS = \frac{rating\ Time}{\begin{matrix}Relay\ operati\ \ g\ time\ at\ TMS = 1\ for \\ PSM\ at\ ma\ \ imum\ fault\ \ current\end{matrix}}$$

We determine the value of the TMS by plotting a current *vs* time curve. This project implements time as well as current grading for setting the relay characteristics.

WORKING PRINCIPLE OF OVER CURRENT RELAY

In an over current relay, current coil is a essential part of relay. When current flow less then pickup current through this coil, then no magnetic effect upto generate to move the element of relay, as in this condition the restraining force is greater than deflecting force. But when the current increase through the coil its also increase magnetic effect, and after a certain level of current, after certain level of current, deflecting force increase due to magnetic effect of coil, crosses the restraining force. Its cause, moving part starts moving to change the position of contact in relay. Although

there are different types of overcurrent relays but basic working principle of relay is approximately same for all overcurrent.

Depending upon time of operation, there are various types of Over Current relays, such as,

1. Instantaneous over current relay.
2. Definite time over current relay.
3. Inverse time over current relay.

IV. RESULTS AND ANALYSIS

Overcurrent relay is consider as a higher selective relay. Suitable sensitivity and protection operate at the actual time. Coordination of overcurrent protection ensures that the microgrid system can be protected securely during operation in both modes of operation [8]. Instantaneous overcurrent relay scheme is based on two type of routines that are able to perform instant protection local line and remote bus bar despite the location of distribution generation [10]. Overcurrent protection schemes may benefit from utilizing a communication assisted protection selectivity strategy that has different levels that are applied with voltage-restrained directional overcurrent protection [6]. We can also protect low voltage in microgrid using microprocessor based relay, which can also operate in both mode of operation and no any communication required and not depend on fault current magnitude. The last type of overcurrent protection takes into consideration the usage of symmetrical components for most types of faults, both symmetrical and asymmetrical, in microgrids that have a communication channel that's purpose is limited to exchanging status information only and not electrical measurements [11]. The main problems in these types of protection schemes are usually related to the need of deploying wide-reaching communication systems. In the case of a failure in the communication system the entire protection scheme may be endangered [6]. In new energy sources current limiting device equipped to fault current occurs only for short time. Overcurrent protection scheme is not capable for detect the short time fault current.

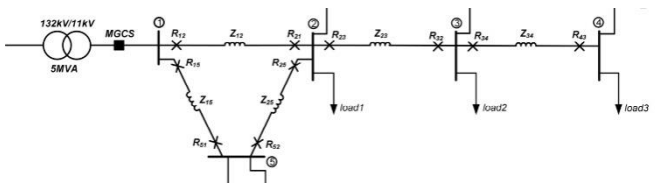

Fig.2 schematic diagram of microgrid without DG.

IMPACT OF DG ON COORDINATION OF OVERCURRENT RELAYS

In microgrid several DG source connected with distribution system; its causes the increase in short circuit current capacity. Moreover, due to the limited current rating of silicon devices, the fault current of electronically interfaced DGs must be limited to a maximum of about two times their nominal current. Therefore, the traditional overcurrent relay protection is not applicable for longer duration in island converter based microgrids. The major protection issues associated with the introduction of distributed generation (DG) to a distribution network includes blinding of protection and false/sympathetic tripping.

Blinding of Protection is known as when fault current in distribution system recognize by overcurrent protection is lower by an amount negatively supply by DG connected to the system. The reduction of current effect the result of overcurrent relay. This situation may arise when DERs are connected anywhere between the feeding substation and fault location. With the help of DERs, feeder relay measure the fault current, DER is generally located at start of feeder, decreases as compared to the situation when no DER is connected to the network. This may result in malfunction operation of the relay in order to detect the faults.

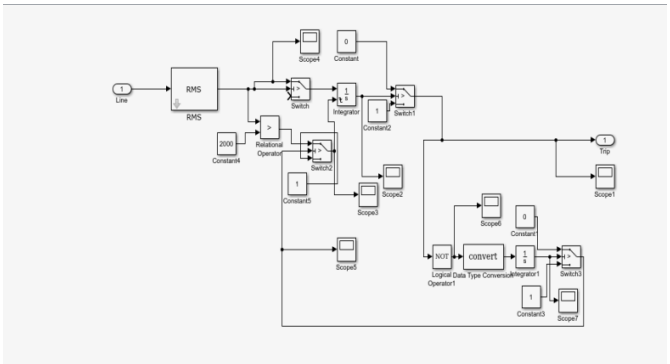

Fig.3 schematic diagram of relay tripping

TABLE 1: SYSTEM PARAMETERS

System parameter	value
Voltage	11kv L-L rms
frequency	50 HZ
Transformer power rating	5MVA
Transformer impedance	(0.05+j2.1677)Ω
Each feeder impedance	(0.94+j2.5447)Ω
Each load impedance	(100+j75)Ω

In American standard there are five different types of time overcurrent relay. Their time-current characteristic curves are:

- Definite minimum,CO-6
- Moderately inverse,CO-7
- Inverse,CO-8
- Very inverse,CO-9
- Extremely inverse,CO-11

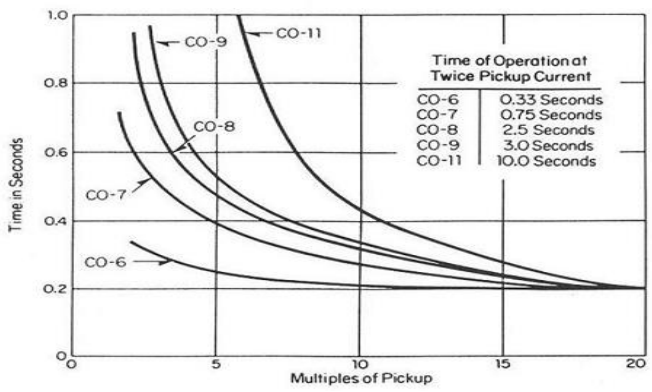

Fig.4 Characteristic of various overcurrent relay

In fig.2 many overcurrent relay use, which time delay are approximated by following equation:

$T_{relay} = TD\ [5.95/(M^2-1)+0.18]$

TD = Time delay
$M=I_{relay}/I_{pickup}$
T_{relay}=operating time of the relay
Relay operating time design at different fault current of microgrid in grid connected mode and islanded mode:

TABLE 2: TIME DELAY OF RELAY

Fault current	Pickup current	CT ratio	Relay current	M	T_{relay}
480A	3A	400:5	6A	2	2.1sec
500A	2A	400:5	6.25A	3.125	0.858sec
520A	2.25A	400:5	6.5A	2.889	0.989sec
600A	2.25A	400:5	7.5A	3.333	0.768sec
650A	2.50A	400:5	8.125	3.25	0.802sec

For counting operating time of relay (table 2) time delay (TD) taken 1 sec.

From table 2 following characteristic find that:

1. As pickup current reduce relay operating time also reduce, when relay current is constant.
2. As relay current increase relay operating time reduce, when pickup current constant.
3. If time delay of relay increase operating time of relay increase according characteristic of fig.5.

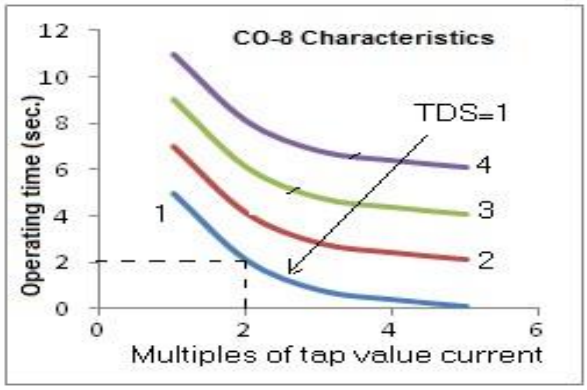

Fig.5 Characteristic of Inverse overcurrent relay

CONCLUSION

A practical test system was model by using MATLAB with suitable setting for the relays. A study of overcurrent relay specified for different fault location in presence and absence of distribution generation (DG). There are two effect of DG on protection coordination problem i.e. false tripping and blinding of protection. I observe that when microgrid working with all DG connected on bus bar, at this condition if fault occur fault current is more to detect the fault, DG connection is not healthy for fault due to over voltage and under voltage problem. Therefore microgrid should not use all bus bar connected to DG. Overcurrent relay should use to island mode to detect low fault current from converter. This is solution of low fault current in island mode operation of microgrid.

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