Micro grid Fault Monitoring and Relay Coordination with ANN based Approach

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ABSTRACT
For Microgrid system, a protection scheme is essential, even though having coverage of small area, to minimize the fault in Grid connected system as well as islanded system. Microgrid experiences difficulty in occurrence of fault, if system is in grid connected mode or in islanded mode, as the fault current level have different for both mode. In such condition the relay coordination is much essential part to monitor and control during occurrence of fault. In this paper the monitoring and control approach has been tested in MATLAB/Simulink. The proposed method has been tested in different mode as well as at different fault location. Further work will include the relay coordination to operate the circuit breaker.

Keywords – Mircrogrid, Utility Grid, Relay, Fault, Circuit Breaker **.**

I. INTRODUCTION

Distribution generation (DG) in medium and low voltage power networks based power system commissioning grow at a rapid pace because of use of small-scale distributed energy resources. It avoids losses that should be occurring in transmission line over long distance [1]. This can be operated in parallel to or islanded from the utility grid. Such topology is called Microgrid. In term of power continuity, it has advantages as continuous power supply guaranties if grid failure. Microgrid has other technical advantages: higher operating efficiency, improved load profile and network capacity enhancement [2]. But on the other hand, Microgrid has significant impact on protection and control. The structure of microgrid is dynamic. Protection system play very important role in such system for reliable power system network. The ultimate object behind the microgrid is to provide reliable supply to load. Hence, for the fault in the system, it should get isolated [3] Due to connection and disconnection of grid and distributed generator (grid connected mode and islanded mode) and dynamic load profile causes challenge in conventional protection strategies. Hence, new protection strategies required for such dynamic condition. Such system is usually protected with overcurrent relay, which are expected to operate at fixed fault current level.

Whenever the magnitude of short circuit current changes, the degree of failure of such relays to respond to new operating conditions may be increased leading to a miscoordination between the protective devices. For proper operation, the parameter of microgrid should follow the changing conditions of the network [4], [5].

These strategies require centralized monitoring and control system for controlling operation of microgrid. In most instances, communication schemes might be required to either alter protection setting based on system configuration and/or provide communication between devices to adequately detect faults [6].

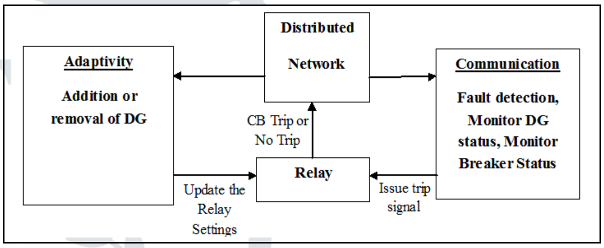

Fig 1. Microgrid Protection overview

In proposed paper, a modernized protection scheme is suggested to accommodate with span changes in behavior of short circuit current levels. Strategies and Problem formulation were discussed in section II. Calculation for Relay coordination is discussed in section III. The proposed method is tested for different operating condition in section IV. Further, test result is discussed in section V.

II. PROTECTION STRATEGY AND PROBLEM FORMULATION

As discussed above, due to the dynamic behavior, it is imperative to update power rating and fault current of protection equipment. Let us take microgrid as shown in Fig.1, The system shown in Fig 1 is consist of two Distributive generator set (DG1, DG2) connected with utility grid. Overall system supplies to load connected with microgrid. If three phase fault occurs at different location, then relay adjacent to fault location senses the fault current then sends tripping signal to circuit breaker to isolate the faulty section from main grid. If microgrid is in islanded mode the relay has to sense the fault to isolate the faulty section, but the level of fault current can be different in both cases. In later case, main grid does not contribute the fault current. Hence, level of fault current could be lower.

At islanded mode protection devices (relay) will not able to detect the fault in islanded mode because the fault detection threshold in grid connected mode is higher. Thus making it difficult to isolate the faulty section. So, the communication can be used to provide to each relay of microgrid by central monitoring and control unit. In other terms, unit assigns the current value above which the relay should operate. For any given relay 'r', the operating current calculated by using equation (1).

III. CALCULATION FOR RELAY COORDINATION

The fault current is calculated with the following equation

$$I_r = I_{grid\,Fault}\ X\ operating\ condition + I_{all\,DG\,fault} \qquad (1)$$

$$I_{all\,DG\,fault} = \sum_{i=1}^{n} k_i\ \ X\ \ I_{faultDGi}\ \ X\ \ DG_i\ Status$$

Where n is total number of DGs in microgrid

k_i is the impact factor of DG

$I_{faultDGi}$ is maximum fault current contribution of DG

If the microgrid is operating in islanded mode, then the grid's fault contribution will be multiplied by operating condition bit. In order to be practical the fault current is considered in between 1.5 to 2 times of its rated current.

IV. SIMULATION AND RESULT

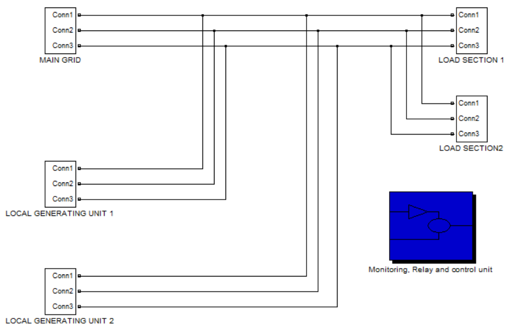

Fig. 2 Microgrid with monitoring and relay control unit simulation diagram

Simulink diagram in MATLAB of microgrid is shown in fig. (2), consisting of Main grid connected with Local Generator Unit 1 and Unit 2 feeding the load. The current contribution of each source at steady state is shown in Fig 3.

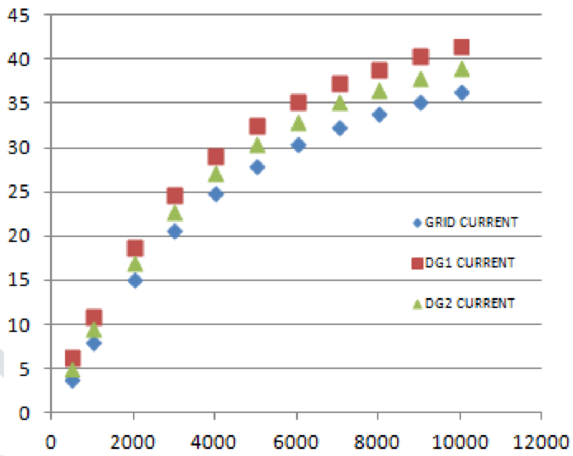

Fig 3 Steady stage current contribution on Various loads

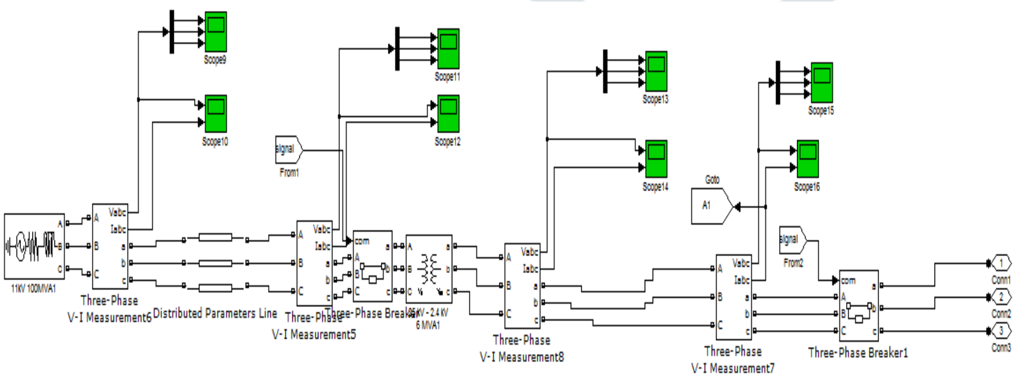

Fig.4 Simulation diagram of main grid

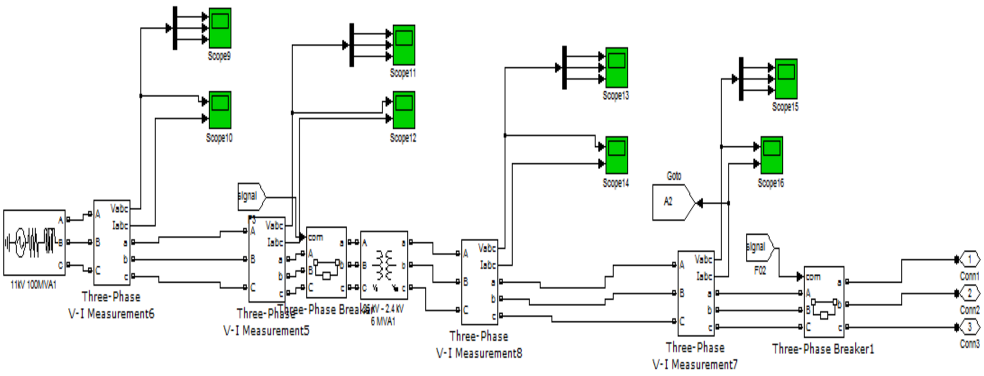

Fig.5 Simulation diagram of Local Generation Unit (1)

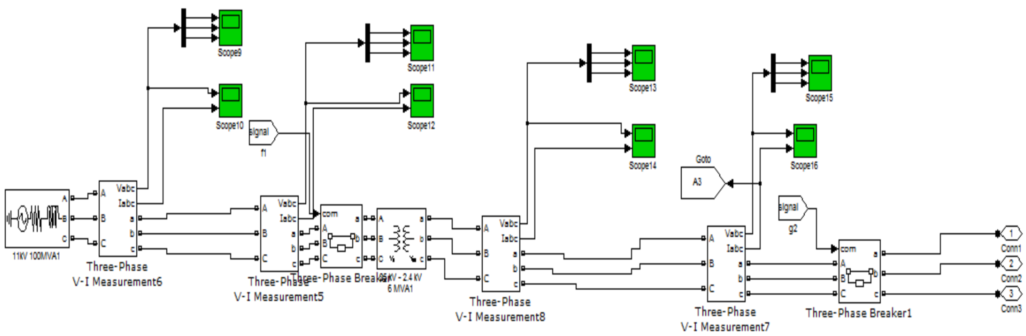

Fig. 6 Simulation diagram of Local Generation Unit (2)

To test the SIMULINK model, test were performed with three phase fault occuring at load section of microgrid. The monitoring and control unit uses intruppt-based-algorithm to send signal tor relay. According to fault current occuring at load, the data updated with cheaking connectivity of different generating unit and signal sends to relay by control unit causing circuit breaker to trip it. Fig (6)shows the waveform for different operating condition. Table 1(a), (b), (c) enlisted the various status of Grid and DGs and their corresponding status value.

Table -1(a)

Operating Mode	Grid- Connected	Islanded
Status	1	0

Table -1(b)

DGs	Irated	Ifault DG	Status (On-1, Off-2)
DG1	I_{DG1}	$I_{faultDG1}$	1
DG1	I_{DG1}	$I_{faultDG1}$	0

Table -1(c)

DGs	Irated	Ifault DG	Status (On-1, Off-2)
DG2	I_{DG2}	$I_{faultDG2}$	1
DG2	I_{DG2}	$I_{faultDG2}$	0

V. Result & Discussion

The calculation based on above formula is done and trained the artificial neural network (ANN) offline based on set of data patterns on fault current at different load. ANN has been widely used in many literatures to get target values. This makes system intelligent and gives accurate results. The ANN gives the values to update the relay based on DGs and Grid status and load values. fig 7 graph shows test result for sample data. fig. 8(a), (b), (c) shows the waveform at different status without updation of relay values whereas fig 8(d), (e) shows the waveform with relay updation with ANN.

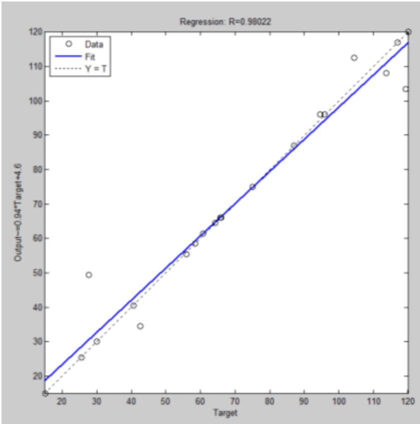

Fig. 7 Regression plot after test

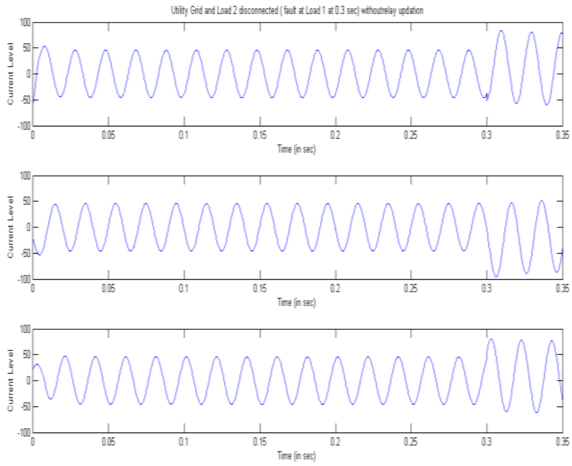

Fig 7(a):waveform (utility grid disconnected Fault at 0.3 sec at load with relay updation)

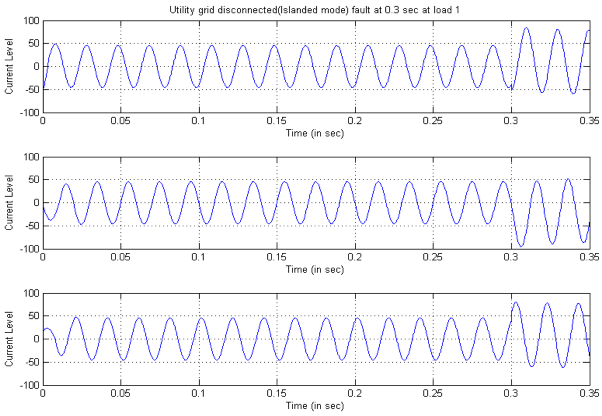

Fig 7(b):waveform (utility grid & load 2 disconnected Fault at 0.3 sec at load without relay updation)

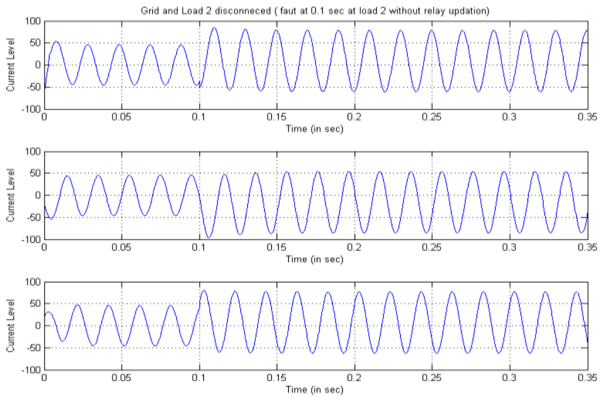

Fig 7(c):waveform (utility grid & load 2 disconnected Fault at 0.1 sec at load without relay updation)

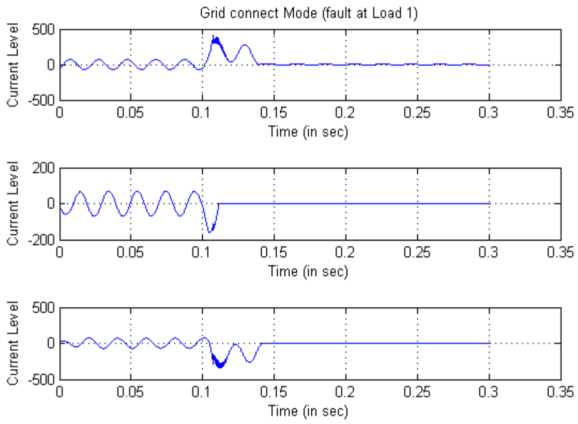

Fig 7(d):waveform (grid connected mode Fault at 0.1 sec at load with relay updation)

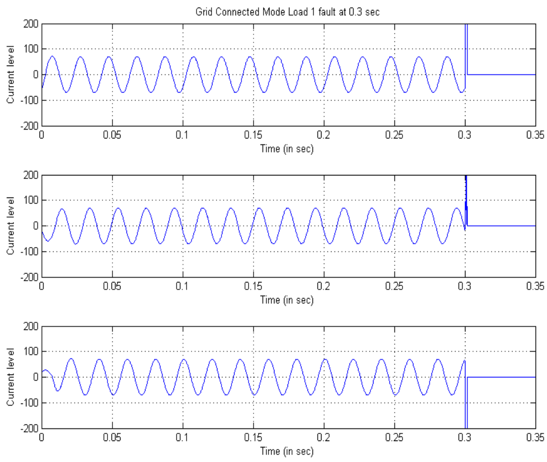

Fig 7(e)waveform (grid connected Fault at 0.3 sec at load with relay updation)

VI. CONCLUSION

This paper has presented a novel protection scheme for microgrid with high DG penetration. In this protection scheme, MCU is used to communicate with microgrid and thus send the signals to relay. Three different situations were considered in this paper to test the model. In order to further research work, the different fault condition at different location can be tested to analyze real life situation in microgrid.

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