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AC Micro Grid Fault Analysis

Abstract: - Implementation of micro grid concept creates several issues to the existing protection scheme in the radial distribution network. Depending on the location and capacity of the distributed generators, the short-circuit current from the main grid and distributed generations causes variations in the fault current levels inside the micro grid. The changes cause effect of sympathetic tripping, blinding of protection, relay over-reaching, relay under-reaching and loss of selectivity of the overcurrent protection scheme. Such issues must be managed carefully to ensure full benefit from micro grid adaptation.

Conventional protection schemes are unable to detect fault current levels common in micro grid. Several methods have been proposed in various research paper. Micro grid protection is substantial to provide reliable and continuous power supply to the customers. The main aim of proposed work is to detect the fault for fast restoration of the system back to the normal operation. The proposed protection scheme for micro grid uses intelligent electronics device for detecting the fault

Keywords: Micro grid, Renewable Energy, Diesel Generator, Grid protection, Fault analysis

I. Introduction

Because of the limitation in quantity of conventional fossil fuels and the environmental pollution problem, the development and utilization of renewable energy is increases and get more and more attention all over the world. The cleaner and free source of power generation is known as the Renewable energy, and it get confessedly attention. These renewable energy resources include solar, wind, mini hydro, Biofuels etc. Two main reasons associated with conventional power generation are the environmental problems and increasing fossil fuel consumption. To supply clean energy to users, Renewable Energy Sources like Solar Photovoltaic, Wind, and Micro hydel power plants are effectively penetrating in the existing power infrastructure. Load growth, aging of electrical power infrastructure are the challenges for modern power systems, these challenges can be answered by upgrading the infrastructure, but extension of transmission network is not possible. [1-2]

Distributed Generation (DG) is the generation of Electrical power near load. Distribution system consist of Renewable energy source for power generation. This renewable energy sources includes solar energy, wind energy etc. Renewable Energy sources with storage such as super capacitors and battery banks forms micro grid. [3] To utilize the distributed renewable energy resources more efficiently, Micro grids are used as building blocks of the future power generation systems. Micro grids (MGs) as

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the main building blocks of power generation systems are able to locally control the grid using power electronic interfaces shown in Fig.1.

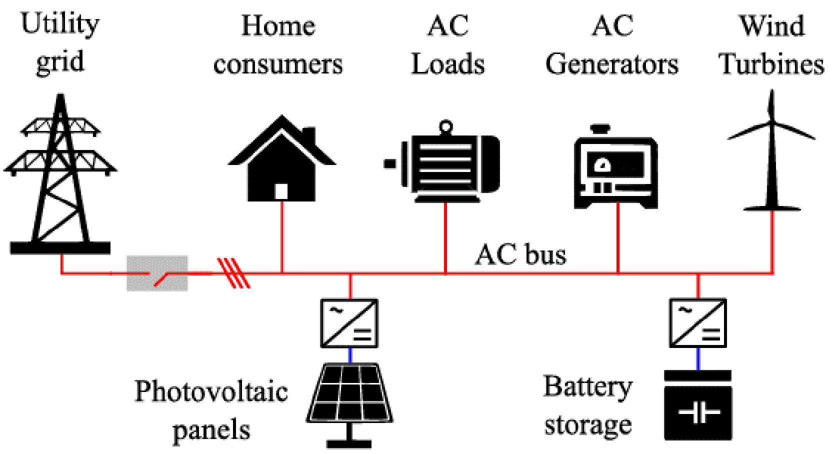

Fig. 1. AC Micro Grid

AC micro grids, distributed generators and energy storage systems are connected to an AC bus through power electronics devices. Through on/off control at the point of common connection (PCC), the micro grid can be switched into either grid-connected mode or islanded mode. The MG control system plays an important role in the successful implementation of MG. The control system must be provided reliable operation in the grid-connected and islanded operating modes. Microgrid operates as an integral part of the main grid while operating in grid connected mode and react as an isolated system while operating as Islanded mode to locally supply the power needs. The major components of Micro grid in Islanded or grid connected mode are inverters. The inverters are the key components to control Active and reactive power flow to create a stable power sharing among renewable energy generators. The Micro grid (MG) consists of Energy storage elements, controlling units and protective switchgears to be operated for reliable power distribution at local level for On and Off grid modes. [4-5]

When micro grid is employed with the renewable distributed energy sources, it can change the behavior of the protection system such as variation in the magnitude of fault current, the flow of direction of fault current and the fault duration. In accordance with that, the short-circuit current levels need to be recalculate and power ratings of different protection equipment need to be change accordingly. The fault point location in the Micro Grid can results into protection coordination problems. [6] Therefore, the conventional methods based on overcurrent principle are thus inappropriate to provide protection for micro grid. Hence, the right choice of fault detection method is required, which can resolve the issues such as short-circuit power, false tripping, bi-directional power flow, device discrimination, fault current level etc. and need to use new techniques with advance protection scheme.

II. AC Micro Grid

A typical Micro grid has 3 main elements renewable energy sources such as solar, wind, diesel generator and fuel cell, storage element and ac local load depending on the type of supply. Micro grid can be a grid connected mode or islanded mode, can be single-phase or three-phase, low voltage or medium voltage as per the requirements. Here, sources, storage element, loads are connected with the ac bus. It operates with PCC (point of common coupling) for reliable power supply to the load. Power electronics converter controls the power conversions. Micro grid has several benefits such as improved energy efficiency, reduced transmission losses, environment friendly, increase reliability etc. At the same time, it also has challenges of operation, protection, control. [7]

III. Fault Protection Issues

Some protection difficulties due to the integration of various sources like diesel generator sets, renewable sources etc. are discussed here briefly.

A. Dynamics in Fault Currents Level

The fault current level during different modes of operation changes base on the type of Micro grid integration mode, types and switching patterns of the load. Based on the different type of mode of operation and the network configuration the level of fault current changes. Apart from that based on the type of DG integration like inverter-based DG the fault current is going to be clamped to 2 P.U. of the rated current, for the case of synchronous base DG the fault current is going to be 5 times the rated current. So, the penetration of the Distributed Energy Resources (DER), different modes of operation of the micro grid are the major reasons due to which this fault current changes. [8-12]

B. Bidirectional Fault Current

The direction of the fault current contributed by DG differs based on the location of the fault with respect to the DG location. In recent time, as the renewable energy sources (RES) are integrated in the distribution network the fault direction is changing accordingly. So, providing protection through the over current relay only is not sufficient. It is necessary to add the directional unit along with the over current unit. [12]

C. False tripping

Considering a microgrid system with 2 feeders, feeder 1 and feeder 2 with one Diesel Generator (DG) set connected in the system as shown in Fig. 2. In the scenario where in a fault occurs in feeder 1, the DG set will be contributing to the fault current. In addition, the main grid will be contributing to the same. In such case the fault current becomes $I_f = I_{Mf} + I_{DGf}$. R1 and R2 are over current protection relay for feeder 1 and feeder 2 respectively. Feeder 1 is basically the faulty section and feeder 2 is healthy section So, only feeder 1 needs to be disconnected and feeder 2 must remain in normal operation. Due to the fault at feeder 1, the fault current I_{DGf} will be fed and if the R1 is directional in nature it will disconnect feeder 2 which is healthy. Thereby leading to a false trip. [9-12]

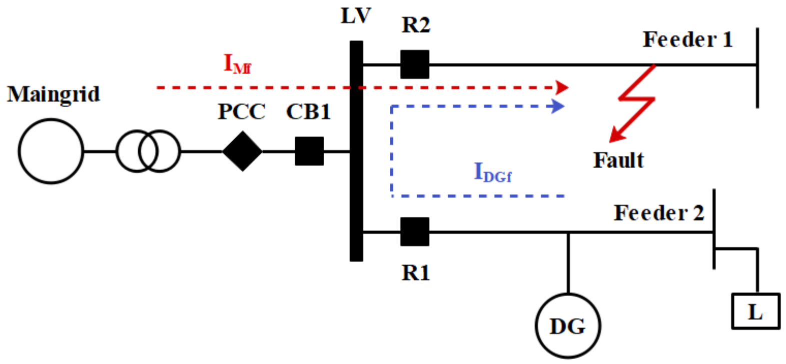

Fig. 2 False tripping issues at grid side fault

D. Blinding protection

When multiple DGs are connected in the grid, and a fault occurs it is possible that the fault is being fed by one of the DGs, as shown in Fig. 3. let the fault be fed by DG1 and the fault current be I_{DG1}. The main relay located at the substation is unable to detect the fault as the fault current magnitude may be lower than that of the set value, as most fault current is supplied from the DG1. In this case the relay is not blind, however it cannot see the fault which is incepted in front of it. Such property is known as blinding of protection. [8-9]

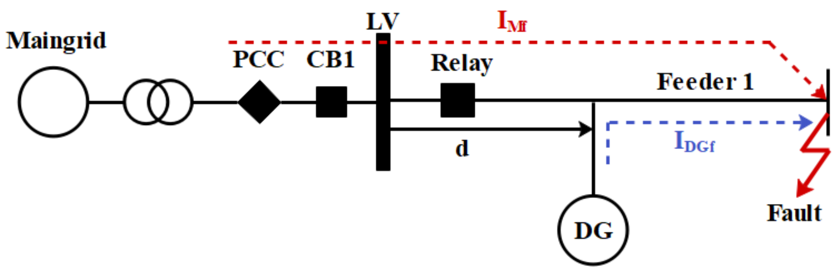

Fig. 3 Blinding protection issues at grid side fault

Fig. 4 shows the blinding of protection concept with multiple sources like grid, DG, PV etc. It is same as the change in the fault current level issue. If the grid is present, then fault current is summation of the grid fault current and PV system fault current. In case the grid is not present, then only PV system gives fault current. So, the CB settings are changed, and they are not operated. In CB result we can see that fault current are changed. So, the relay becomes blind, and it does not operate the breaker.

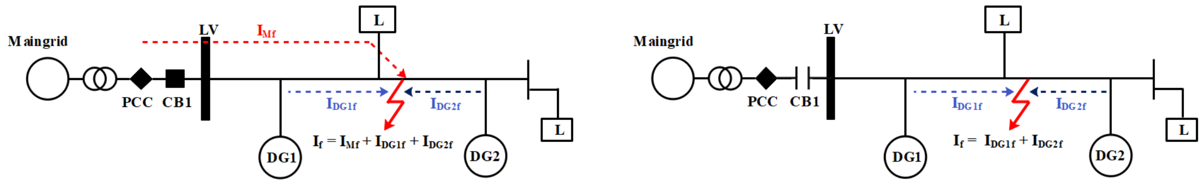

Fig. 4 Blinding of protection with PV system

Overcurrent relay without sensing direction will not be able to discriminate the fault, an unpredictable tripping of overcurrent relay occurs due to undefined source feeding the fault. For safe operation and the reliability of the electric system, the coordination of protection devices is maintaining the selectivity in severe fault possibilities. The setting of directional overcurrent is divided into two sections: overcurrent and directional element. Directional overcurrent relay refers to an event that can use the phasor relationship of voltage and current to determine direction to a fault. [10-11]

IV. FAULT ANALYSIS OF AC MICROGRID USING MATLAB

The DC output of PV is fed to the DC to DC (boost/buck-boost type) converter for boosting the voltage level. DC to AC converter (inverter) converts DC supply into AC supply, where the inverter is grid following and takes grid voltage as reference. MPPT extracts the maximum power from PV module. Operate at close to maximum point of voltage for maximum power. Battery works as a bidirectional buck boost converter as required. In grid connecting mode, micro grid works with the main grid, load supplies with the main grid and micro grid both. In islanding mode, micro grid is disconnected from the main grid through PCC, load is supplied only from the micro grid.

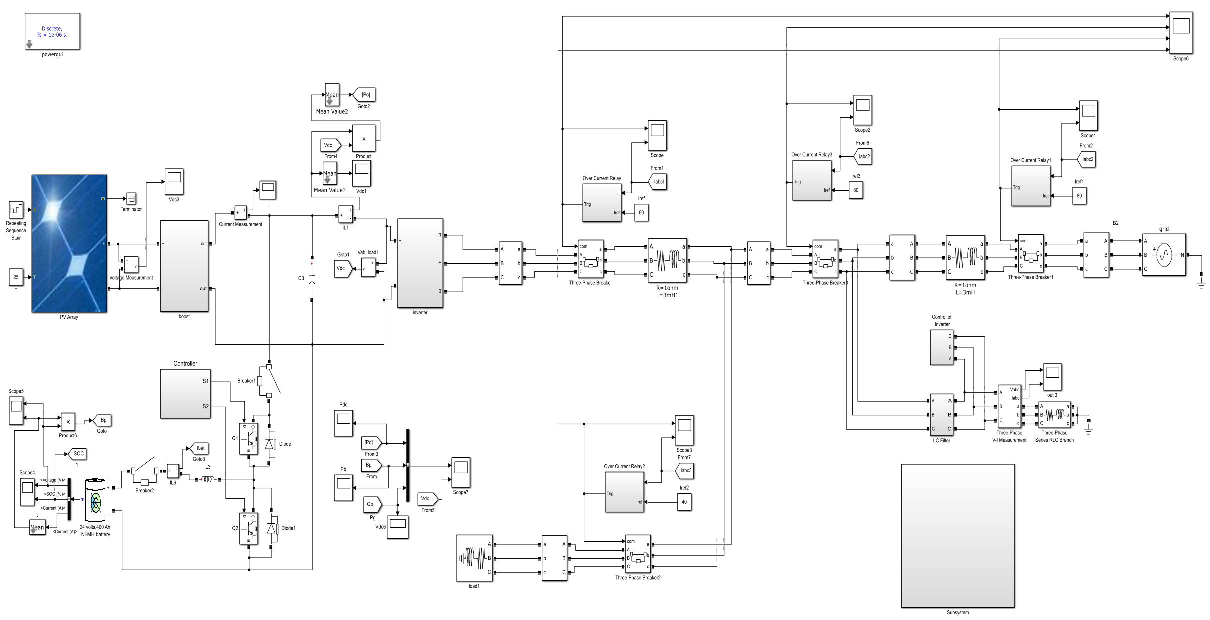

Fig. 5 AC Simulation of microgrid with protection system

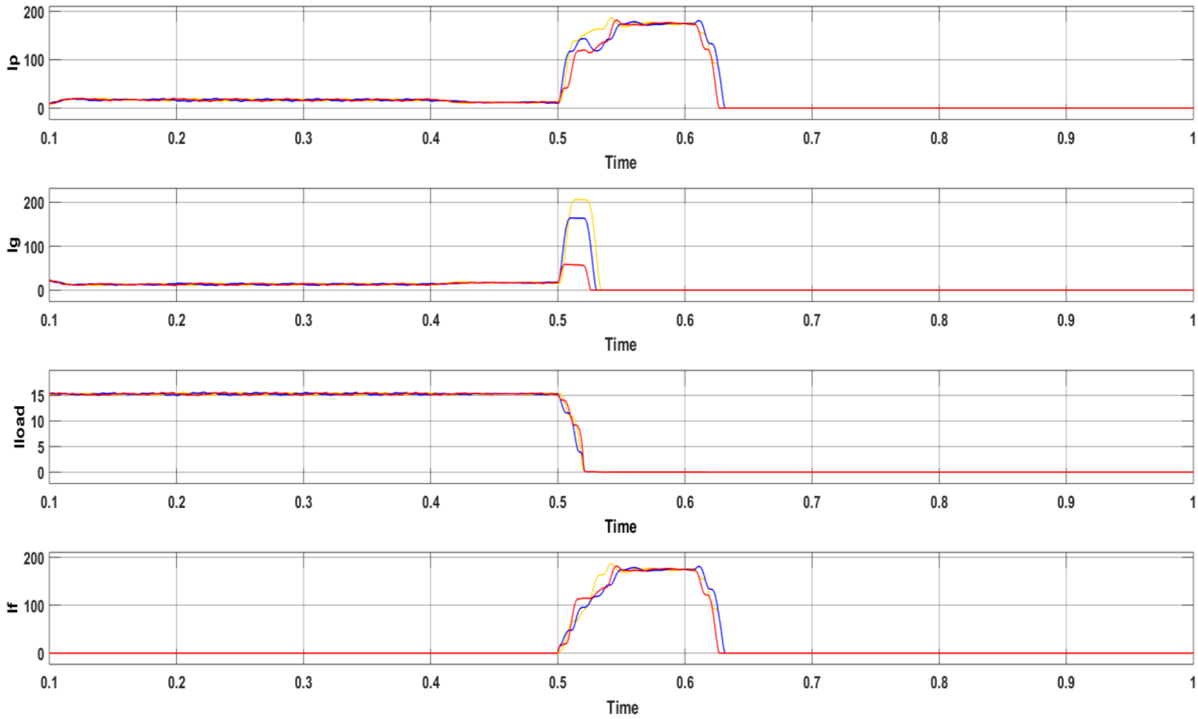

Fig. 6 Fault current contributions (If = Ip + Ig)

When Grid is connecting with PV and Load. At Fault point, Main grid and PV system current is contributing as a fault current.

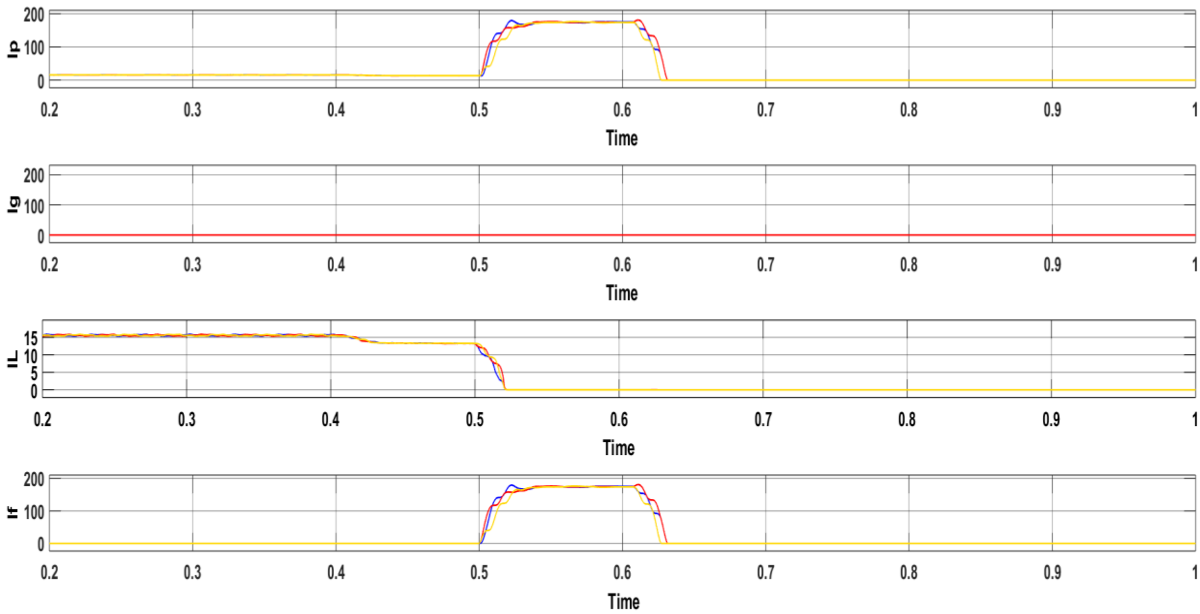

Fig. 7 Fault current contributions (If = Ip)

When Grid is disconnecting in the system. At Fault point, only PV system current is contributing as a fault current.

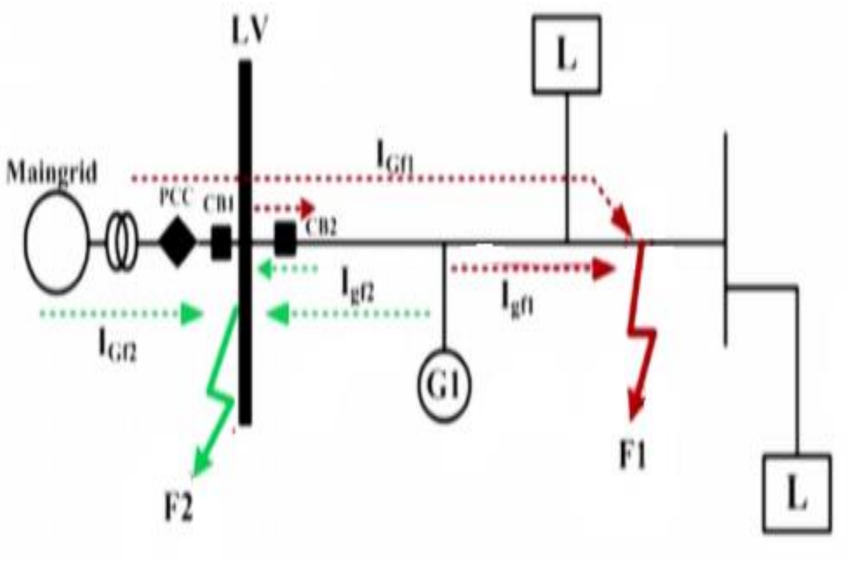

Fig. 8 Bidirectional Fault Current issue at PV side

Fig. 8 shows Bidirectional Fault Current issues at PV side fault. If Fault occurs at point F1, then Fault current is contributed by main grid and G1. For CB2 direction of current is forward so it is operated. If Fault occurs at point F2, then Fault current is contributed by both main grid and PV but for CB2 direction is reverse. Due to overcurrent relay, it is not operated. If we take place directional over current relay it solves this issue.

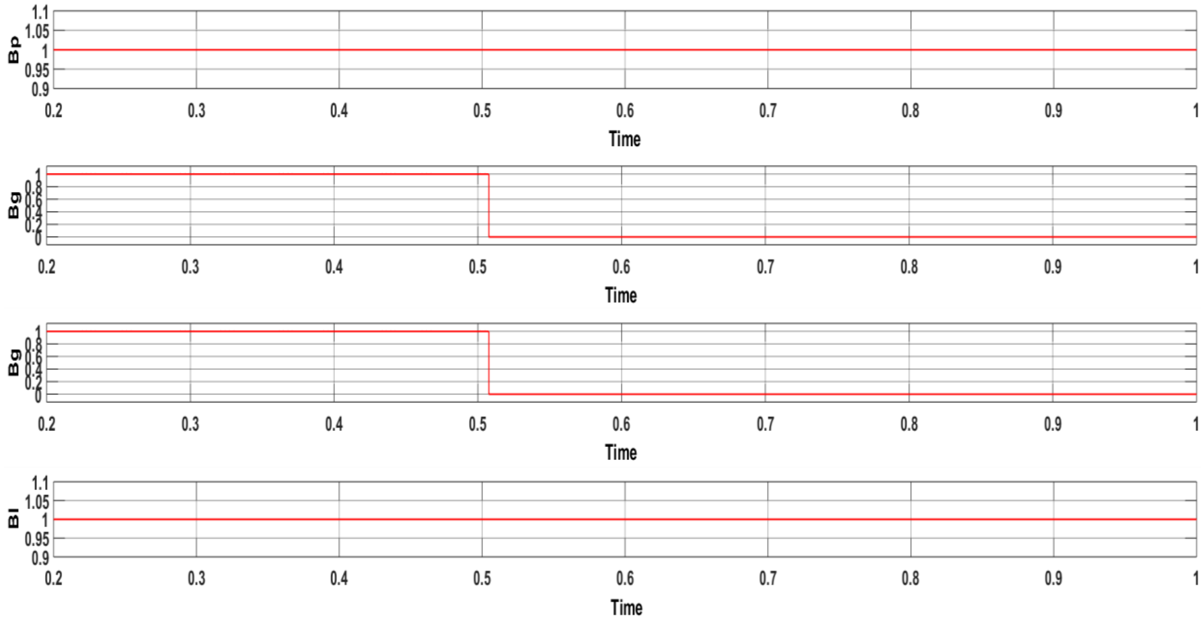

Fig. 9 Output Trip signal of Overcurrent relay

Fig. 9 shows Bidirectional Fault Current issues at PV side. Due to overcurrent relay, it is not operated at PV side. (Bp)

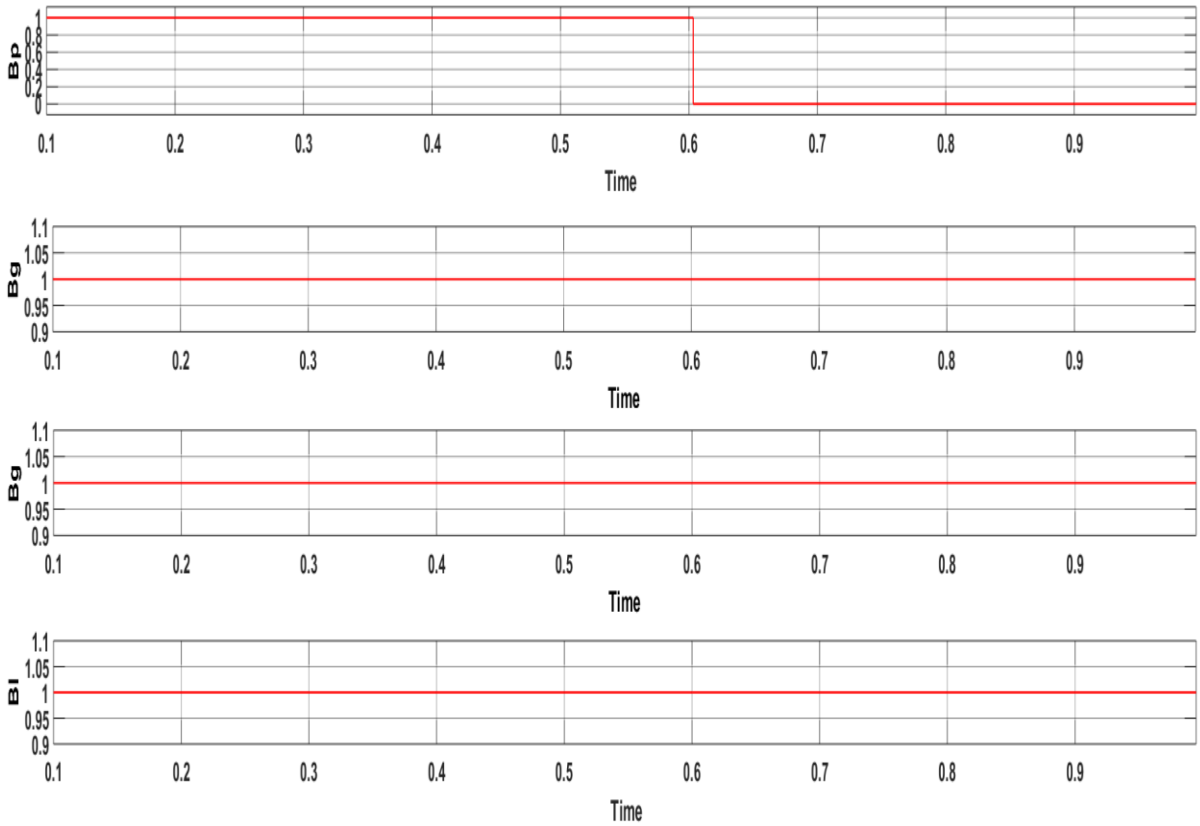

Fig. 10 Output Trip signal of directional Overcurrent relay

Fig. 10 shows Bidirectional Fault Current issues solution. If we take place directional over current relay at PV side, then it is operated. (Bp)

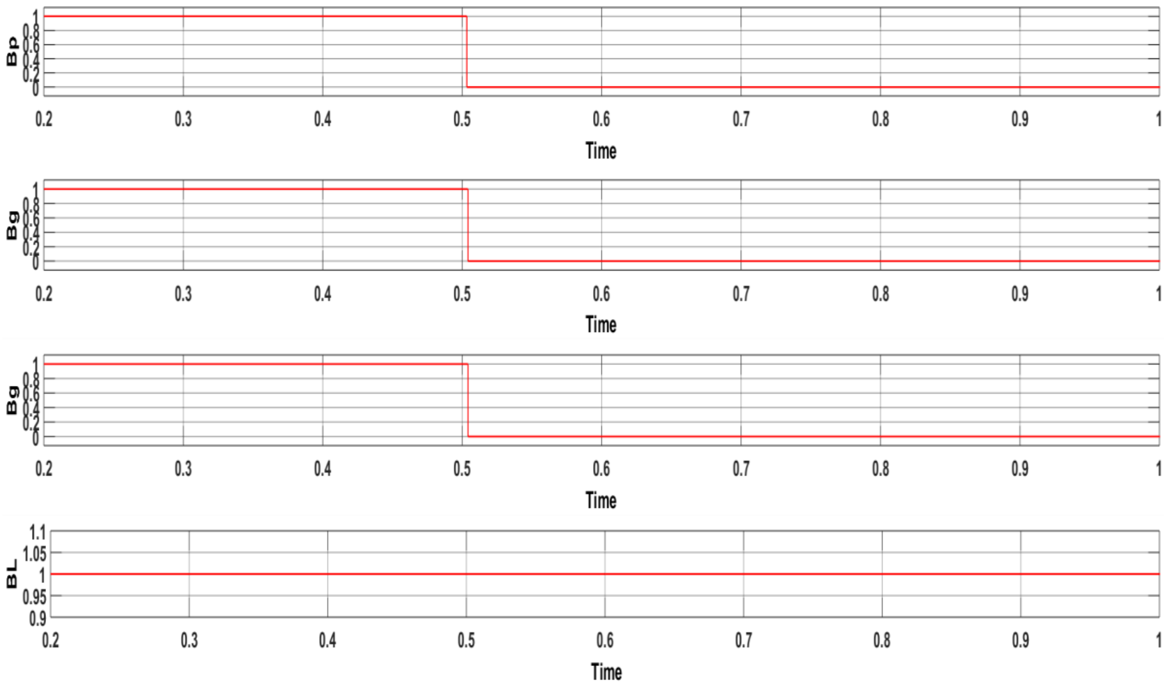

Fig. 11 Output Trip signal of Overcurrent relay

As shown fig. 2 Suppose If we create fault at feeder 1, then G1 and Main grid is contributing fault current at that point. When G1 is contribute, their CB is showing a fault current and as shown in fig. 11 CB of feeder 2 is operated (Bp). That is false tripping of relay.

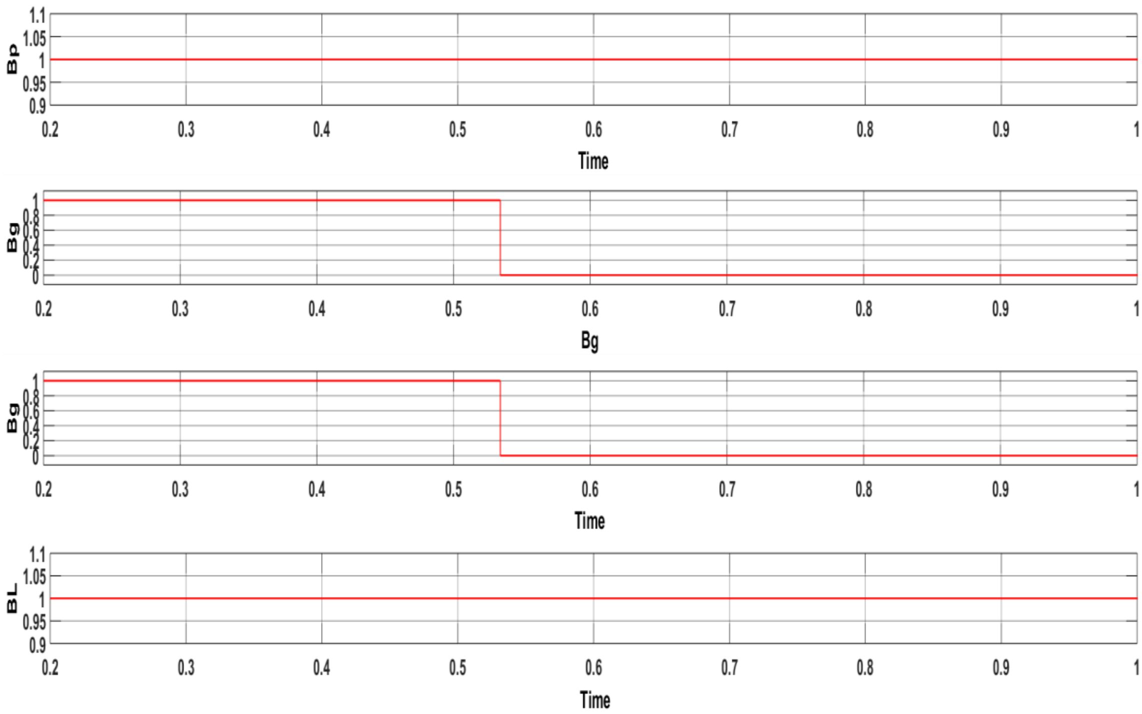

Fig. 12 Output Trip signal of directional Overcurrent relay

Fig.12 shows false tripping issues solution. CB of feeder 2 is not operated due to direction Overcurrent relay. (Bp)

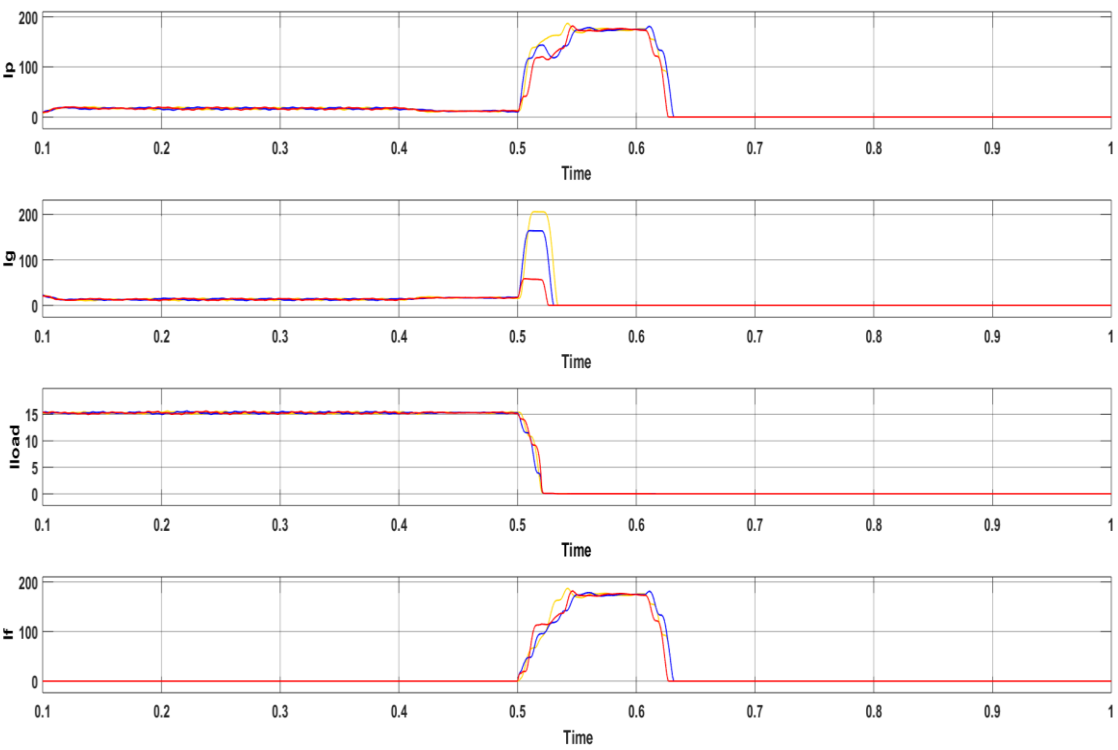

Fig.13 Fault current with Grid

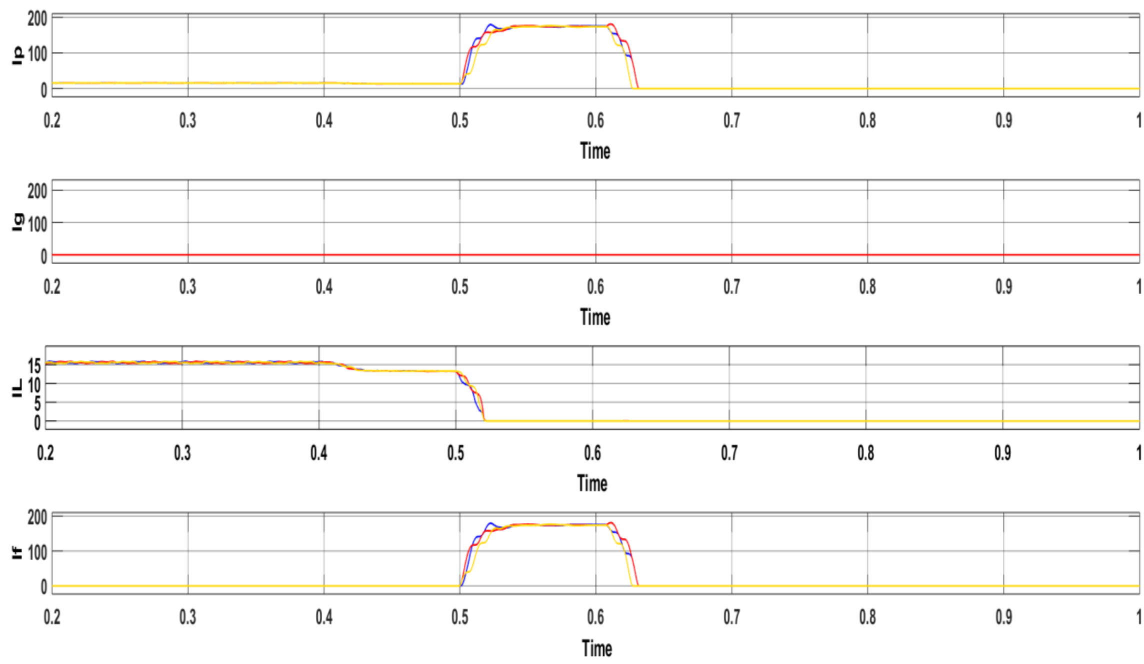

Fig.14 Fault current without Grid

V. CONCLUSION

In this paper protection for microgrid has been discussed in-depth and the proposed techniques have been proven by the supporting simulation result of MATLAB. The overall objective of this work is to carry out the investigation of the protection-related problems occurring due to the presence of distributed energy sources. Development of a new topology and scheme for protection of AC micro grids has been carried out. A microgrid has been created and connected to the utility grid. After integrating a renewable source with grid, some issues are introduced into the system which affects the traditional conventional protection system, and it does not work efficiently. Due to the impact of DGs in the existing system, protection devices and their settings need to be changed accordingly. Presence of DGs and its fault current contribution to the main grid depends on its location. By using overcurrent protection scheme, detection of fault in the micro grid is difficult and protection schemes are failed in their operation due to the DGs penetrations. Use of directional over current relay in the system can efficiently detect the fault. In advance for the fault location in micro grid due to penetration of PV is also one of the challenges. To determine the fault location of some advance infrastructure systems, communication methods are investigated in newly proposed methods.

VI. REFERENCES

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