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A Novel Method for Islanding Detection of Microgrid Using Negative Sequence Components

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Abstract-—**In recent years, incorporation of micro grids in electrical networks has been increasing rapidly due to low cost green energy, reduce peak loads and protect the grid under disturbance. It can be operated either in autonomous mode or grid connected mode to provide reliable power to consumers. A micro grid integrates with Distributed Generators (DG) by small scale generation units and loads.**
The penetration of DG units has more prominent in micro grid. Even though, the presence of DGs has several advantages but they are encountered with safety issues. Islanding is an important issue out of them. It is the condition where DG units continue to power to loads even when grid power is no longer present. This is serious issue to utility grid personnel if the unintentional islanding occurred. This has to be detected for safe and reliable operation of micro grid. In this paper, evaluating the analysis of proposed passive islanding detection technique using MATLAB/ SIMULINK.

Keywords - Distributed Generator, Islanding, Micro grid, Point of common coupling (PCC)

I. INTRODUCTION

Energy demand has been growing up in the last two decades due to rapid urbanization and industrialization. However, generation of energy outstripped by demand. Renewable Generation is viable alternative to supplement this problem and also to reduce the dependency of fossil fuels
leading to preserve fossil fuel reserves for future generations. The adaptation renewable energy by incorporating Distributed Energy Resources (DERs) in micro grids to meet local demand, improve reliability and security of grid.
The micro grids operate in the grid-connected mode most of the time. However, they should operate as a standalone grid when they are disconnected from the utility grid whether it is intentional or unintentional. Under islanded mode, the micro grid should be stable and work autonomously like the way physical islands operate when there is a disconnection from the upstream medium voltage grid.
Islanding detection is vital tool for distributed generation protection islanding detection is ability to detect island state at point of common coupling (PCC). Detection methods are classified as active and passive methods. The passive methods are cost effective and have a challenge by setting an appropriate sensor threshold that can identify the difference between islands and natural power system variations [10].
The effectiveness of different AI detection algorithms is tested and the impact on network fault conditions and relays behavior during islanding is presented [1]. Islanding detection has been proposed for the operation of the islanding mode of operation and grid conned mode of operation [2]. It is also important as islanding operation of distributed system is seen a viable option in the future to improve the reliability and quality of the supply [3]. Remote and local techniques are presented for islanding detection [4]. The survey of several possible islanding detection methods for utility grid connected system has been analyzed [5]. In this paper, Islanding detection for the micro grid operated as on grid mode using passive detection methods.

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II. MODELLING OF MICROGRID

Micro grids are operated in grid connected mode of operation in order to draw power during high demand period and inject surplus power to main grid during excess generation. The main function of Micro grid is to ensure stable operation during faults and various network disturbances.

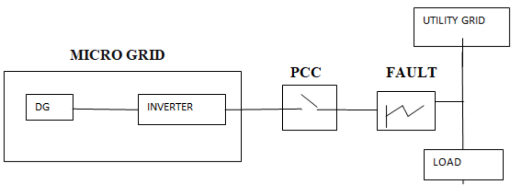


Fig. 1 Block diagram of micro grid on grid mode

The fig. 1 shows the grid connected mode of Micro grid. A Micro grid consists of a distributed generation source (DG) and an inverter to convert the DC supply to AC supply .The Micro gird is connected at PCC [8,9]. Whenever utility grid is disconnected or whenever a fault occurs, the system will move into islanded mode of operation. During islanding, disconnect the Micro grid from main utility grid. In the process of islanding, observes the negative sequence component at PCC. Whenever the measured components at PCC are more than the threshold values that are been set disconnection of micro grid from main utility grid resulting in successful anti islanding detection [6, 7].

Control circuit to trip the Circuit Breaker:

The comparator is used to compare the output of the RMS block. It is compared with the standard value of the current. Whenever the current value is greater than the given value, then The S-R flip-flop operates. When S is 1 and R is 0, the flip-flop goes to the set state (Qn is 1). When R is 1 and S is 0, the flip-flop goes to the reset state (Qn is 0). When both S and R tends to 0, the flip-flop stays in the previous state (Qn is Qn-1). The output taken from the Q, while the Q is terminated using a terminator[11]. Gate is enabled when all the inputs are high. Thus, if the inputs are high then the output is also high. The data conversion type block is to convert the Boolean to double value.

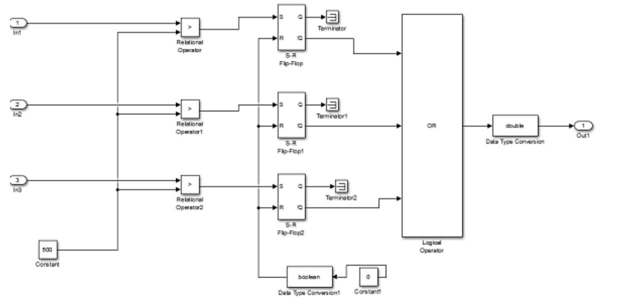


Fig. 2 Control circuit to trip circuit breaker

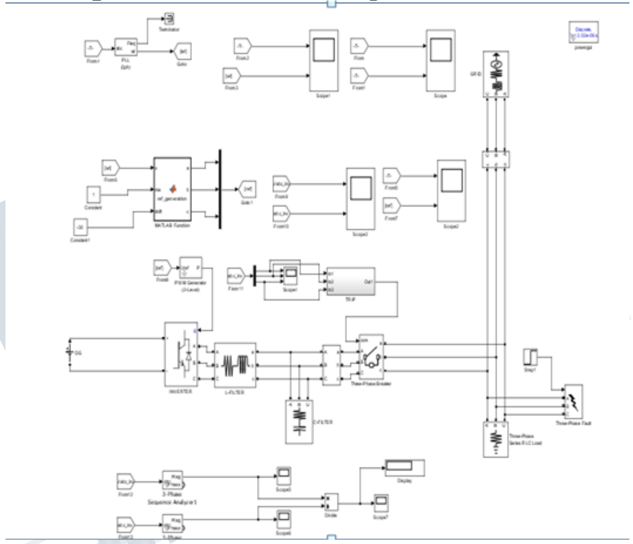


Fig. 3 Proposed model for simulation

III. PROPOSED METHODOLOGY

The proposed algorithm envisages that the number of islanding occurs in a grid connected mode of operation of the Micro grid. From this method reliability of the micro grid can be identified by continuous analysis. In this analysis the reasons might be identified and mitigating the abnormalities to improve the efficiency of the micro grid.

Proposed algorithm for islanding detection by using passive detection method:

Step 1: Consider a Micro grid connected with main grid.

Step 2: Ensure that whenever there is an abnormality, the circuit breaker at Point of Common Coupling (PCC) is opened.

Step 3: As the project deals with the passive island detection, we have to extract negative sequence components, current and voltage at PCC.

Step 4: An abnormality is created at an interval of 0.5 sec and the variations in negative sequence component is observed.

Step 5: Islanding is detected with the opening of circuit breaker at the Point of Common coupling (PCC).
Step 6: Repeat the step 4 for different intervals so that we can calculate how many times the circuit breaker is tripping per day/week/month/year.

IV. SIMULATION AND ANALYSIS

a. Proposed network without fault:
Fig 4 and 5 are the voltages of grid and inverter at PCC. The parameters are same as per system without fault

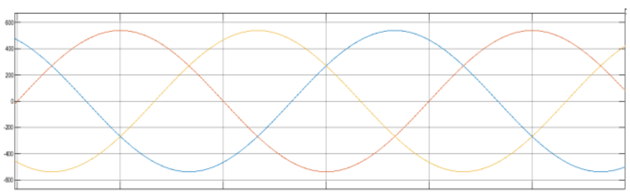


Fig. 4 Voltage of grid (Before fault)

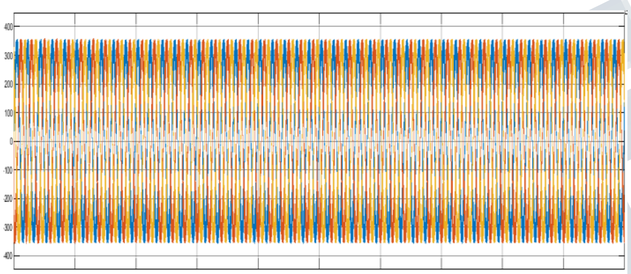


Fig. 5 Voltage of inverter at PCC (Without fault)

Fig. 5 is the saw tooth reference wave which is developed by phase locked loop (PLL) used as carrier wave for developing pulses to inverter. Similarly, Fig. 6 shows the output reference sinusoidal developed from MATLAB function block for switching operation of inverter.

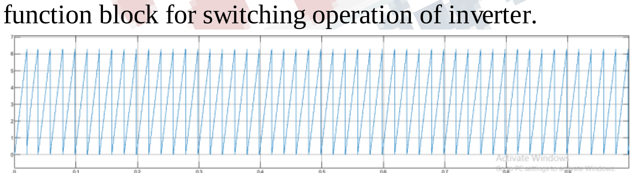


Fig. 5 Saw tooth reference wave

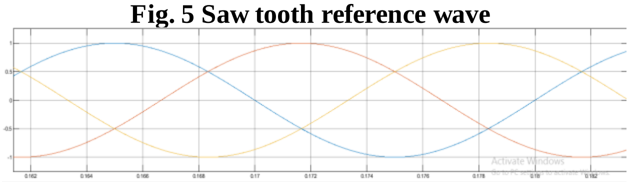


Fig. 6 Reference sinusoidal wave

Fig. 7, 8 and 9 are the Negative sequence voltage, current and impedances.

Fig. 10 is the inverter current. As there is no fault occurrence the output of system is not affected.

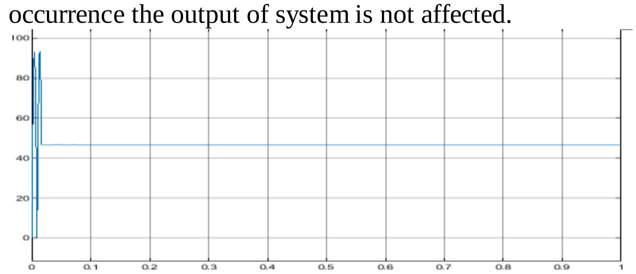


Fig. 7 Negative sequence voltage at PCC(Before fault)

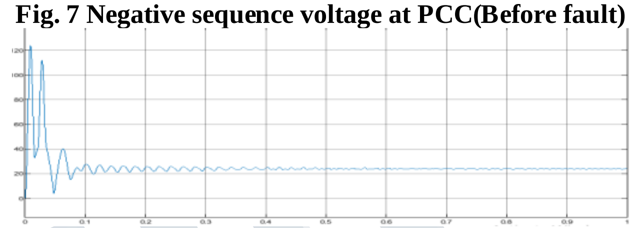


Fig. 8 Negative sequence current at PCC(Before fault)

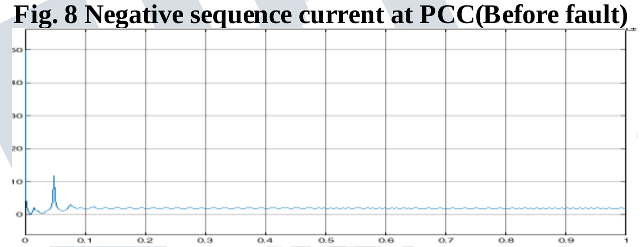


Fig. 9 Negative sequence impedance at PCC(Before fault)

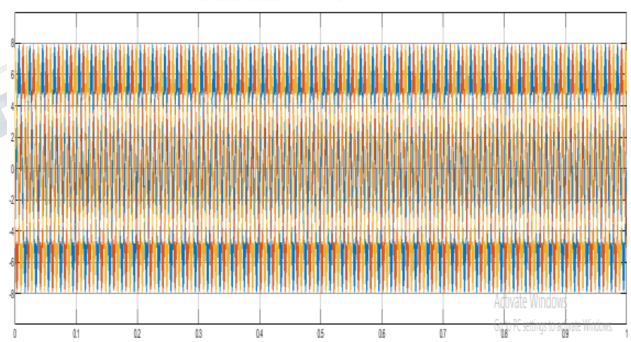
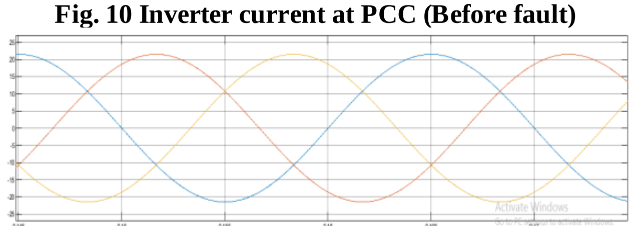


Fig. 10 Inverter current at PCC (Before fault)



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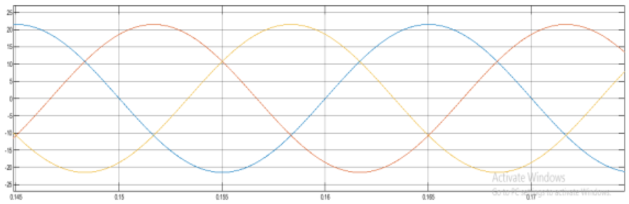

Fig. 11 Three phase grid current at PCC (Before fault)

Proposed network with fault::

The fault is occurring at 0.5 sec in the network, the fig. 12 shows the negative sequence voltage at PCC. This indicates the breaker opening time when negative sequence component is presented in Fig. 13 to 17.

Fig. 12, 13 and 14 shows breaker opening at 0.8 seconds, here it is observed that the negative sequence component is presented.

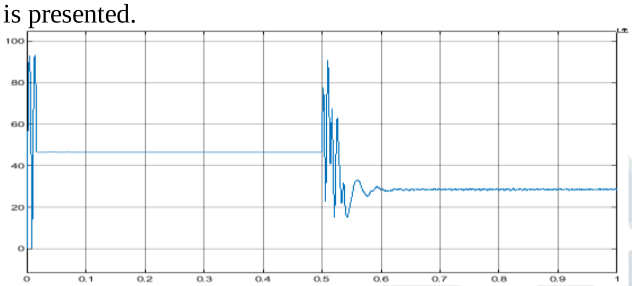

Fig. 12 Negative sequence voltage at PCC (fault condition at 0.5 sec)

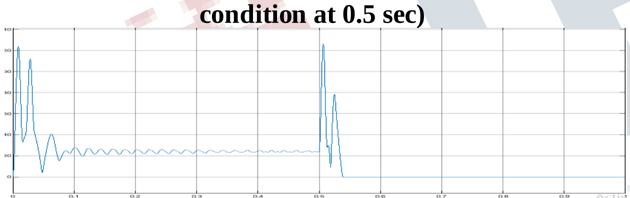

Fig. 13 Negative sequence current at PCC (Fault condition at 0.5)

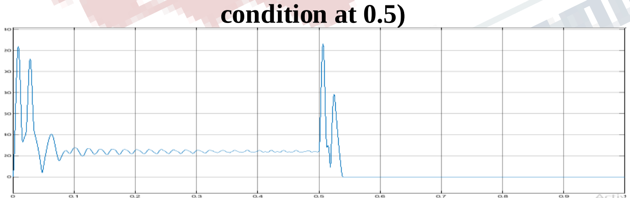

Fig. 14 Negative sequence impedance at PCC (Fault condition at 0.5)

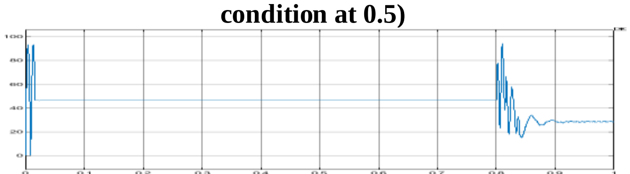

Fig. 15 Negative sequence voltage at PCC (fault condition at 0.8)

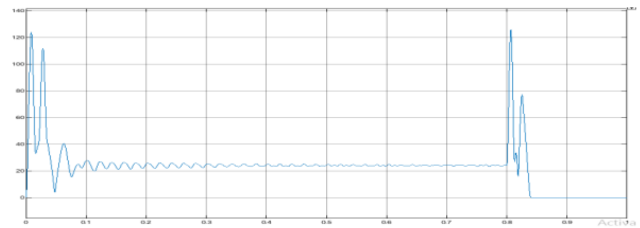

Fig. 16 Negative sequence current at PCC (fault condition at 0.8)

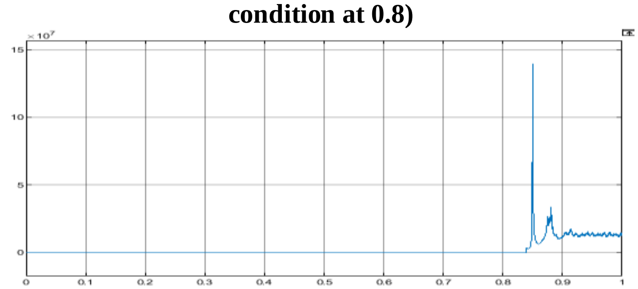

Fig. 17 Negative sequence impedance at PCC (fault condition at 0.8 sec)

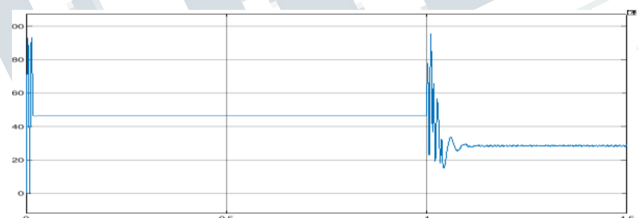

Fig. 18 Negative sequence voltage at PCC (fault condition at 1 sec)

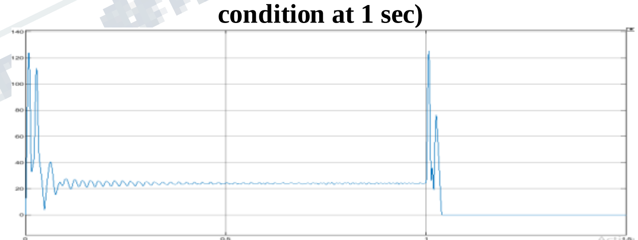

Fig. 19 Negative sequence current at PCC (fault condition at 1 sec)

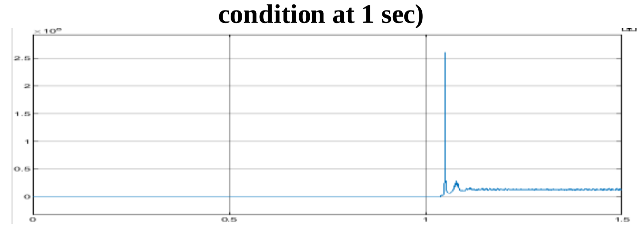

Fig. 20 Negative sequence impedance at PCC (fault condition at 1 sec)

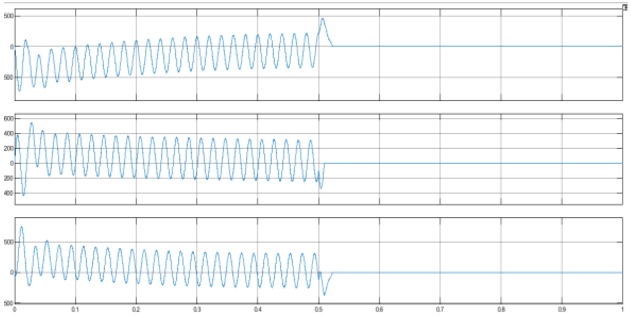

Fig. 21 Individual currents of inverter at PCC (fault condition at 0.5 sec)

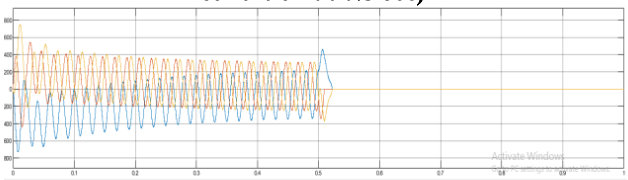

Fig. 22 Inverter current at PCC (fault condition at 0.5 sec)

Fig. 15, 16 and 17 shows the breaker opening at 1 sec and hence, it is observed
that the negative sequence component is presented. Here, quantifying negative voltage and current using phase sequence analyzer, then compute the impedance which is shown in fig. 20. Thus islanding detected by negative sequence component method for several abnormal conditions and to quantify the islanding occurred. From this data continuous analysis can be carried out and restore the repeated abnormalities. Fig. 21 and 22 shows the individual currents of inverter and three phase current of inverter at PCC.

The detection of islanding has been carried out by adopting relays with prescribed threshold parameters. For instance in case of over current flow detected by relay it trips the Circuit breaker. The response is shown on the graph. Observing the breaker opening in graphical representation thus quantifying the islanding of micro grid. This approach has been tested for over current condition.

V. CONCLUSION

The proposed method directs operators to run the micro grid in stable and reliable operation. The analysis concludes that the proposed method detects an islanding event within 200 milliseconds i.e. 10 cycles under SIMULINK test conditions. It identifies 2 to 3% of negative sequence component for islanding detection. It is observed that network becomes insensitive to variations of load parameters under test conditions. The islanding detection and quantification by negative sequence component method will be more promising by adopting unified three phase signal processor (UTSP) in PSCAD environment. The signal detected in UTSP is highly immune to noise which perform task accurately.

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