Islanding Detection in Distribution Generation using Active Method

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ABSTRACT- There are two techniques to ensure that renewable energy systems run continuously: on-grid and off-grid. In the first case the system can be managed in a network, in the second case it can be managed in a micro grid or island mode. Islanding means when a distributed generator (DG) keeps running even after there is no longer any external electricity. This situation can be dangerous for utility systems because it prevents equipment from connecting properly. Therefore, this paper proposes an active method for detecting island patterns at a given time. The use of DG installations such as photovoltaics can cause islanding detection issues. In addition, the number of DG sets in the power distribution system will affect the accuracy of island detection (ISD). On a test example DC power supply linked to a 415 V, 50 Hz network, the suggested solution was put into practice. In the MATLAB Simulink environment, the proposed method's efficacy was assessed. The proposed method is compared with existing active methods and shortens the detection time.

Keywords: Active Method, Distribution Generation, Detection Time, Islanding Detection.

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1. INTRODUCTION

All Step converters are the name for the category of electrical equipment that converts DC to AC. These components must deliver a current that is equal to the network's output current. A grid responsive converter must regulate the power line's phase, amplitude, and frequency in addition to the voltage and frequency of the power line to which it is attached. A networked interactive converter might be available for homes with rooftop solar panels. [1]. These components change the various direct currents produced by the solar panels into alternating current that is compatible with the grid's current capacity[2]. The voltage on the line could become zero if the power supply is cut off.

During a power outage, the unit can keep supplying power if the building load matches the panel's power output. This makes it quite evident that the power supply has not been disrupted. even when the load and output are exactly matched, network faults can still cause some transient signals to be transmitted[3]. For example, a short-term voltage drop in a power supply could indicate a system failure. These events can also be triggered by starting a motor[4].There have been many studies of islet detection methods that do not give false positive results. Each of these methods has its own threshold that must be passed to determine whether the condition is considered a sign of a network outage[5]. A Non Detection Zone (NDZ) is an area of the grid that can be filtered[6]. Before field deployment, interactive transmitters are typically tested by reproducing network conditions at their output terminals[7]. This approach can help evaluate the performance of various methods used to detect islets[8].

The process of detecting if a distributed generation system is operating in "islanded mode" or connected to the grid is referred to as islanding detection [9]. This occurs when a system that generates power continuously supplies it to the local load even after the main grid has been disconnected. Islanding can pose a threat to the safety of workers who are on the electric grid [10]. It can also affect the quality of power. Islanding detection in distributed generation systems is of significant importance [11]-[12] for several reasons as shown below

Safety: One of the main reasons why islanding detection is important is to ensure the safety of workers. When a system that is continuously supplying power to a local load continues to operate in island mode, it can create dangerous conditions that can affect the workers' safety. This issue can also lead to accidents. Having the proper equipment and procedures in place can help prevent these types of incidents [13].

Grid Stability: The stability of the electric grid can be negatively affected by islanding. When a generation system operates in this mode, it becomes disconnected from the main grid, which can result in issues with the quality of power, such as frequency deviations and voltage variations. Grid stability can be maintained by detecting and preventing islanding [14].
Equipment Protection: The equipment connected to the generation system can be damaged if the system continues to

operate in island mode even after the main grid has been disconnected. This issue could cause overvoltage or frequency variations, which could lead to various issues. Having the proper equipment and procedures in place can help prevent these types of incidents [15]. One of the most important factors that can be considered when it comes to protecting the equipment is by detecting islanding [16].

Power Quality: The quality of power distributed within a microgrid can be affected by islanded operation [17]. The lack of control mechanisms and grid support can result in frequency and voltage variations, which can affect certain loads and lead to disruptions or malfunctions. Islanding can be detected and taken into account to address the issue and mitigate its effects [18]-[20].

Regulatory Compliance: Region-Specific Regulations and Standards for Distributed Generation Systems: Every region has its own regulations and standards for the operation of generation systems, such as islanding detection [21]-[22]. System operators must abide by these regulations to guarantee the safety and reliability of their distributed power. Islanding Detection Techniques Ensure Compliance with Industry Standards and Regulations [23].

Efficient System Operation: When transitioning from islanded to grid-connected mode following detection of islanding, efficient system operation can be achieved [24]. This process ensures that the generation system operates seamlessly with the main grid, allowing it to utilize available resources more efficiently and improve the overall performance of the system. Efficient operation can also help support the integration of renewable resources into the electric grid [25].

In *section 2* explained the proposed methodology and results are discussed in *section 3* finally concluded with conclusion in *section 4.*

2. ACTIVE ISD METHOD

The proposed active technique is based on applying a weak interfering signal to the output of the DG. Application of external signals leads to significant changes in system parameters in isolation and activates joint actions. Active methods can cause power quality and harmonic issues due to external signal inputs, degrading system performance. Therefore, this paper proposes an active islanding detection method implemented in a test case where a DC power supply is connected to a 415 V, 50 Hz network, as shown in *figure 1*. The proposed method improves(fast detection) the detection time. The test case parameters are tabulated in *table 1*.

Table 1: Suggested Test Case Parameters

Parameter	Value
Grid Voltage	415 V
Load	8 kW
DC Link Voltage	600 V
Inverter output Voltage	415 V

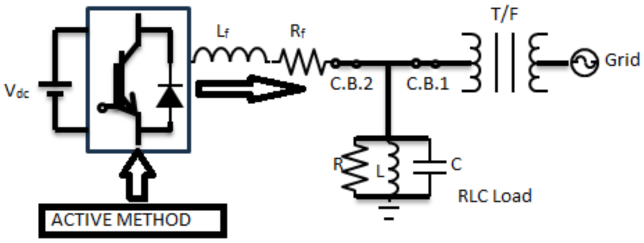


Figure 1: Suggested Test Case

The concept of fuzzy membership is based on the constraints of the cull tree (CT) fuzzy rule. This allows the development of a variety of multi-functional applications that can be used to improve the efficiency of the system.

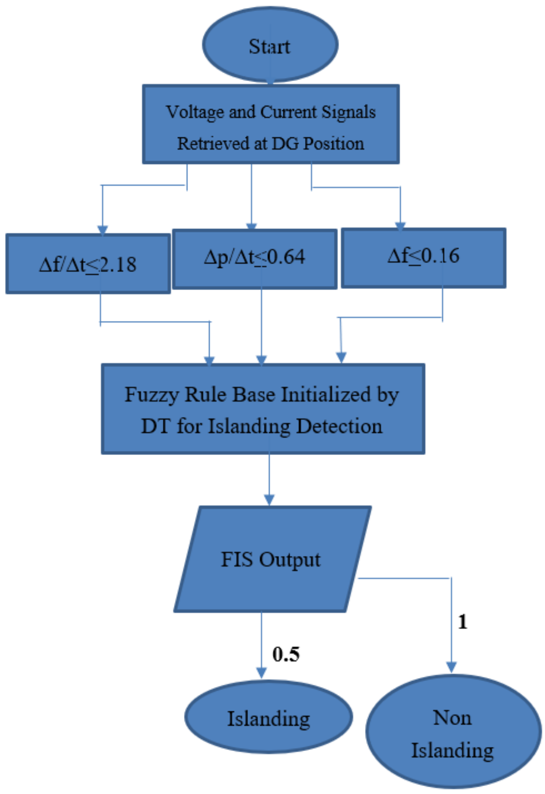


Figure 2: Proposed Active ISD Method Flowchart

The proposed method comparing three parameters i.e rate of change of frequency , rate of change of power and frequency deviation as shown in *figure 2.*

The Phase Locked Loop (PLL) is a common mathematical function in PCC to find frequency and angle. Currently, there are concerns about two types of transitions, the Clark transition and the Parks transition. If a transformation is performed from dq0 to xyz, it is called a Clarke transformation, otherwise a transformation from xyz to dq0 is performed, it is called a Park transformation. Both cases perform the function of two-stage transformation to 3D and vice versa. Three-phase balanced waveforms are generated by the DQ-PLL method and a 120°

phase shift is applied to the voltage source converter input. The following is the Parks & Clarks conversion equation.

Parks transformation:

$$V_x = V_d sin(\omega t) + V_q Cos(\omega t) + V_o \quad (1)$$

$$V_y = V_d sin(\omega t - 2\pi/3) + V_q Cos(\omega t - 2\pi/3) + V_o \quad (2)$$

$$V_z = V_d sin(\omega t + 2\pi/3) + V_q Cos(\omega t + 2\pi/3) + V_o \quad (3)$$

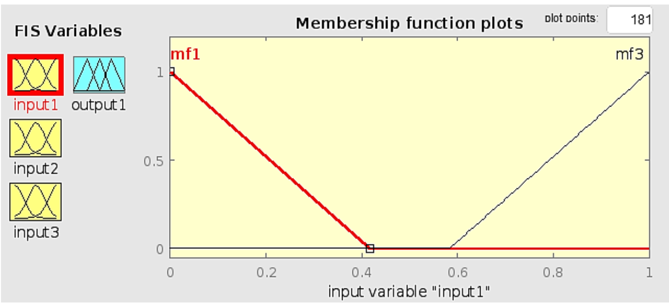
Clark's transformation:

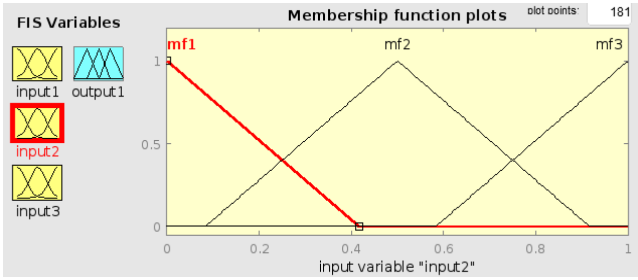
$$V_d = 2/3 V_x sin(\omega t) + V_y sin(\omega t - 2\pi/3) + V_z sin(\omega t + 2\pi/3) \quad (4)$$

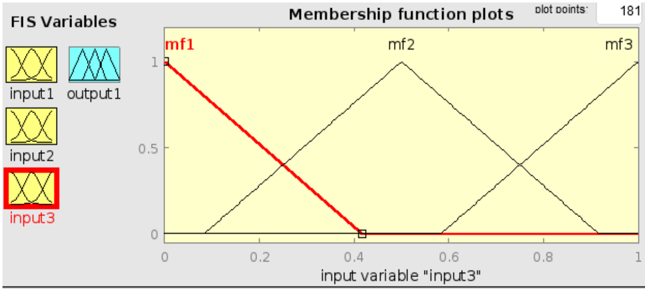
$$V_q = 2/3 V_x cos(\omega t) + V_y cos(\omega t - 2\pi/3) + V_z cos(\omega t + 2\pi/3) \quad (5)$$

$$V_o = 1/3(V_x + V_y + V_z) \quad (6)$$

A typical fuzzy rule-based model is generated from a combination of numerical data and homogeneous sets. This type of model leads to a low-key phonetic description of the system and a super fluent brainwashing. A standard reorganization method is proposed to reduce the number of sets in the model. The dominant set of the model is the comparative sets, which suppress the other sets in the standard base. The strengthening of this set can lead to the establishment of well defined guidelines, which can reduce the number of regulations. *Figure 3* presented Input and Output Membership Functions. Fuzzy rule base is presented in *table 2*.







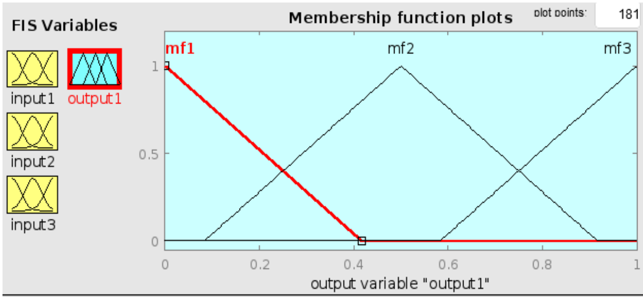


Figure 3: Membership Functions for Fuzzy Input and Output

Table 2: Fuzzy Rule Base

Input-1	Input-2	Input-3	Output
Low	Low	Low	Low
High	Medium	None	Low
Low	Low	Medium	Medium
Low	Medium	High	High

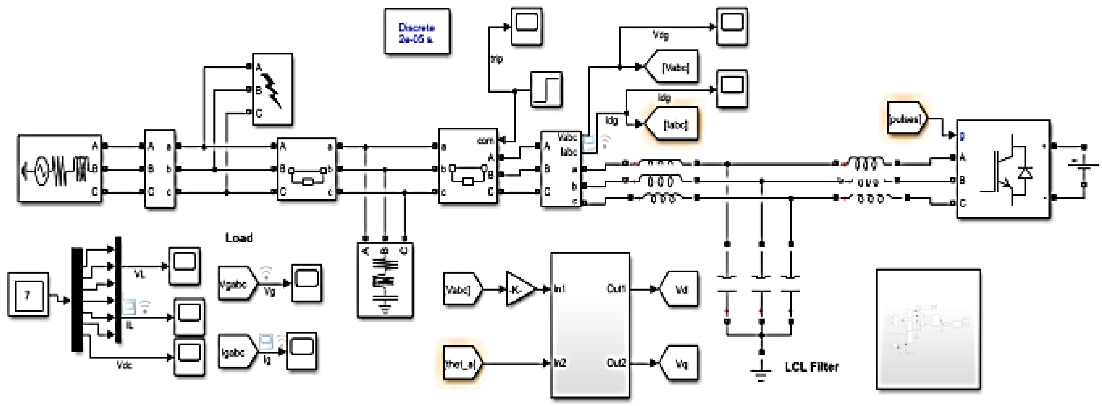


Figure 4: MATLAB Simulink model of proposed method

The above Simulation model shows the proposed method in test case which was developed in MATLAB Simulink software.

3. RESULTS AND DISCUSSION

In The Active ISD method is implemented on a test case as presented in *figure 1*. The Grid Voltage (V_g), Grid Current (I_g), DG Inverter output voltage (V_{dg}), DG Inverter output current (I_{dg}), Load voltage (V_L) and Load current (I_L) before islanding are shown in *figure 5 to figure 10* respectively.

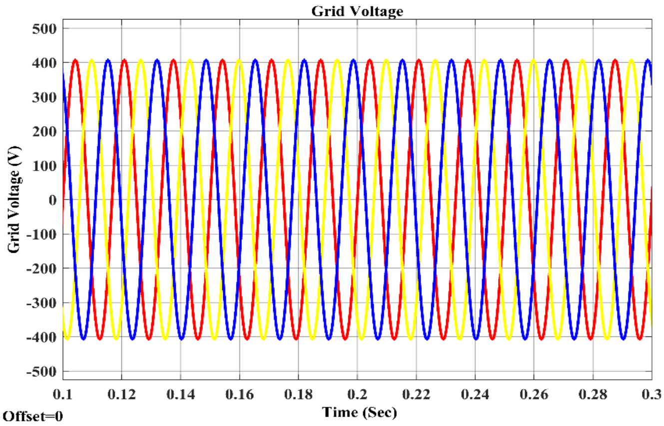


Figure 5: The Grid Voltage (V_g) before islanding

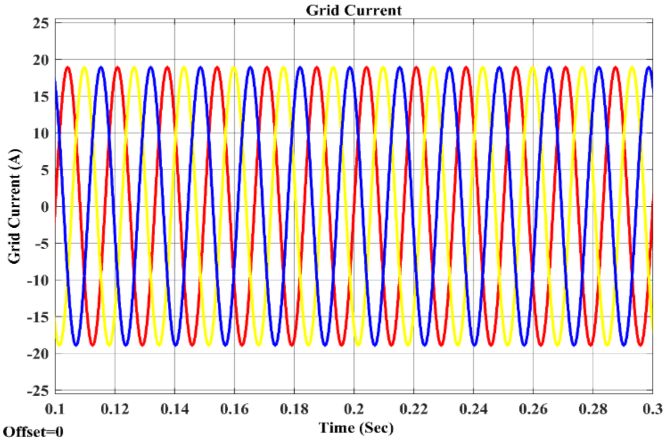


Figure 6: The Grid Current (I_g) before islanding

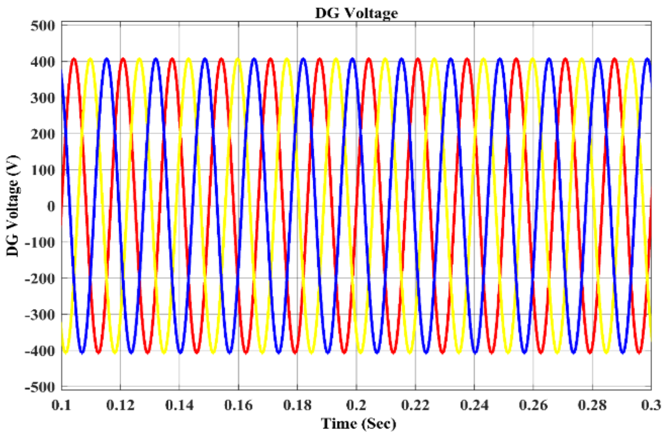


Figure 7: The DG Inverter output voltage (V_{dg}) before islanding

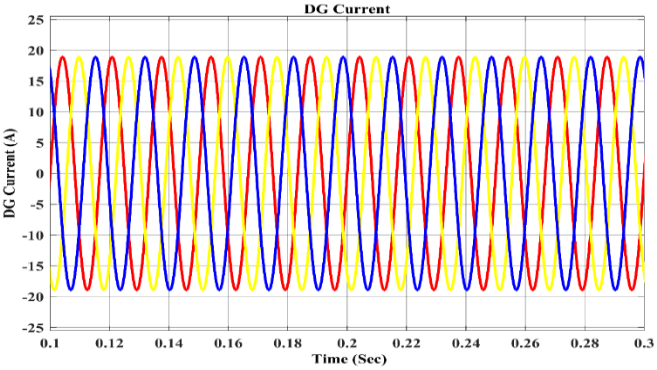


Figure 8: The DG Inverter output current (I_{dg}) before islanding

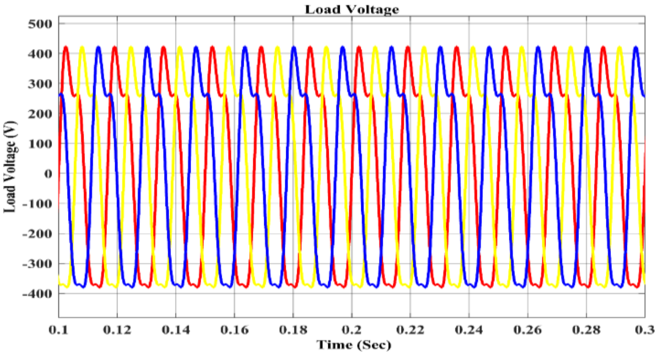


Figure 9: The Load Voltage (V_L) before islanding

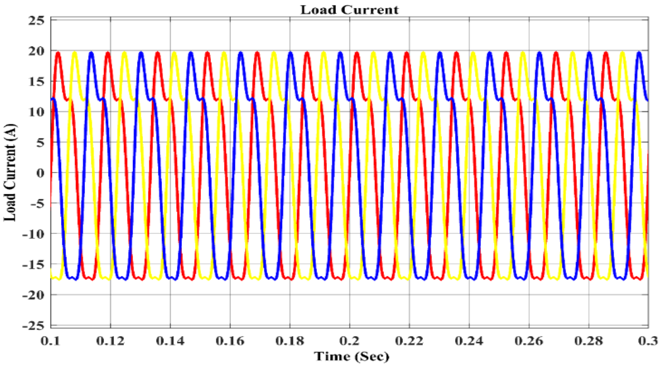


Figure 10: The Load Current (I_L) before islanding

In all the above wave forms the constant magnitude is maintained. Islanding is created by opening the circuit breaker at 0.15 Sec. *Figure 11* shows the Grid Voltage (V_g) after islanding, after islanding occurs at 0.15 sec voltage swell is observed.

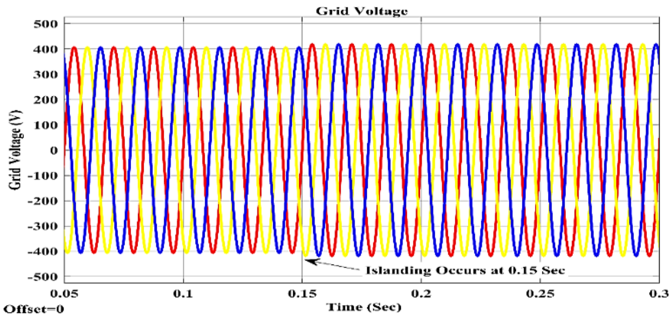


Figure 11: The Grid Voltage (V_g) after islanding

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The Grid Current (I_g) after islanding is presented in *figure 12* after islanding occurs at 0.15 sec immediately the grid current becomes zero, *i.e.*, supply from the utility grid is interrupted.

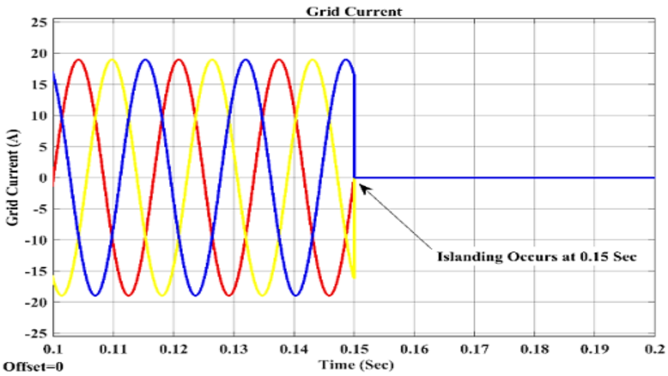

Figure 12: The Grid Current (I_g) after islanding

The DG Inverter output voltage (V_{dg}) after islanding is presented in *figure 13*, after islanding occurs at 0.15 sec slight voltage sag is observed and Islanding detects at 0.34 sec and the islanding detection time is 190 milli seconds.

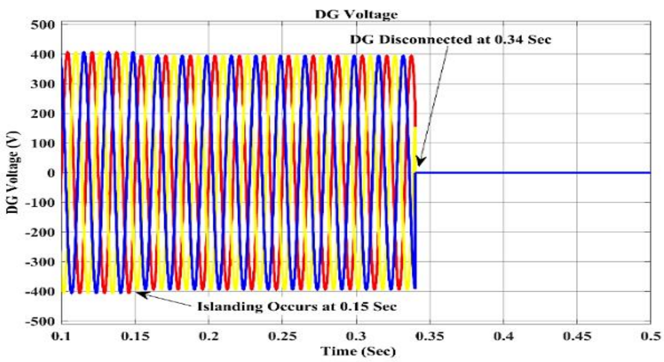

Figure 13: The DG Inverter output voltage (V_{dg}) after islanding

The DG Inverter output current (I_{dg}) after islanding is presented in *figure 14*, after islanding occurs at 0.15 sec slight sag is observed and Islanding detects at 0.34 sec and the islanding detection time is 190 milli seconds.

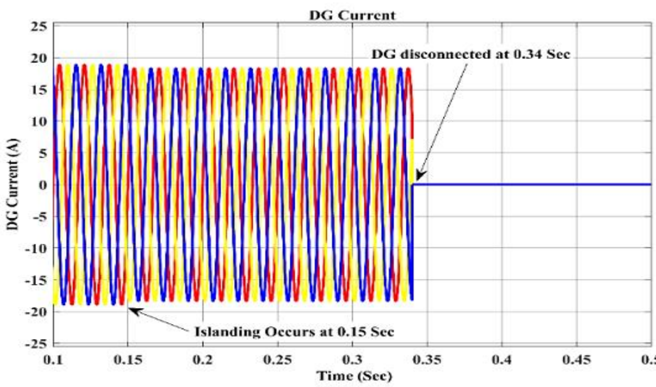

Figure 14: The DG Inverter output current (I_{dg}) after islanding

The Load voltage (V_L) after islanding is presented in *figure 15*, after islanding occurs at 0.15 sec slight voltage sag is observed and supply to the load is interrupted at 0.34 sec.

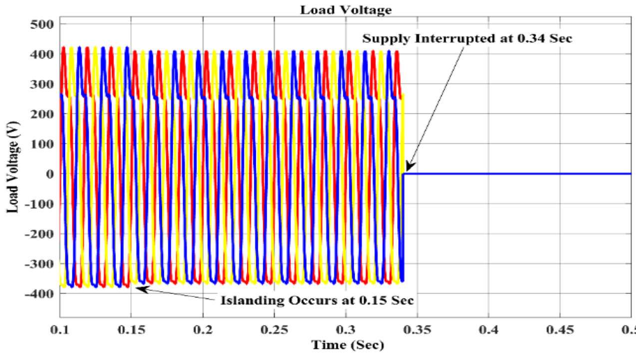

Figure 15: The Load voltage (V_L) after islanding

The Load current (I_L) after islanding is presented in *figure 16*, after islanding occurs at 0.15 sec slight voltage sag is observed and supply to the load is interrupted at 0.34 sec.

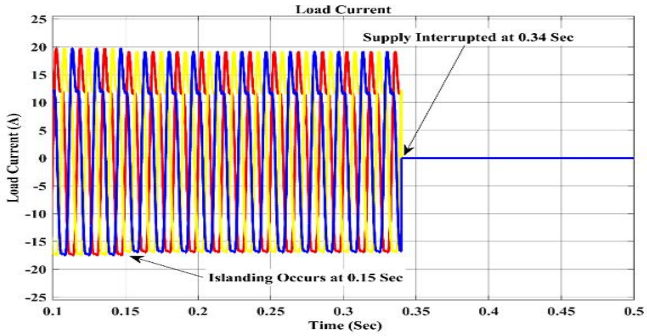

Figure 16: The Load current (I_l) after islanding

The grid current THD is presented in *figure 17* and Load current THD is presented in *figure 18*. The Total Harmonic Distortion of Grid current is 0.74 % and the Load Current is 7.44 %. In this Active ISD method Islanding is detected in 190 milliseconds.

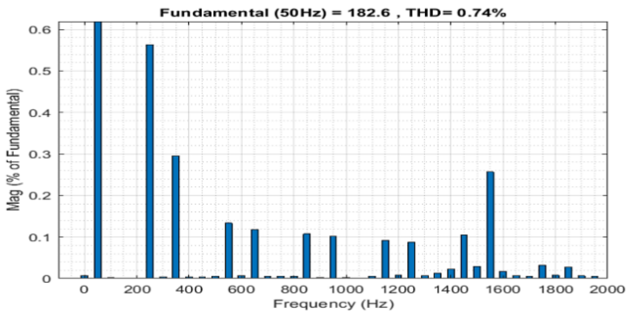

Figure 17: Grid Current THD

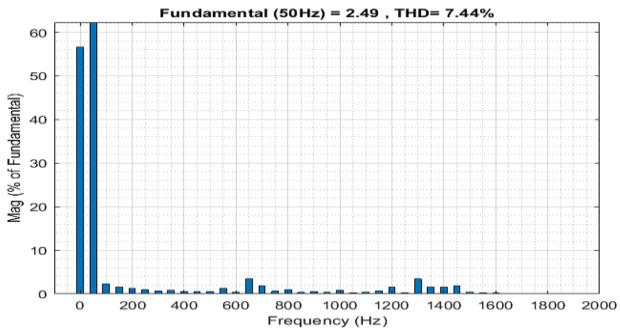

Figure 18: Load Current THD

Table 3: Computational Results

S.no	Performance Metrics	Timings /THD
1	Islanding Occurs	0.15 sec
2	DG Disconnected Time	0.34 Seconds
3	Load Disconnected Time	0.34 Seconds
3	Islanding Detection Time	0.19Seconds
4	Grid Current THD	0.74 %
5	Load Current THD	7.44 %

Table 4: Comparison Results

Reference Paper No.	Change in Parameters	Islanding Detection Time (ms)	Grid Current THD	Load Current THD
04	Reactive Power	350	5.08%	11.41%
06	Forced Helmholtz Oscillator	250	4.27%	10.24%
Proposed Method	1. Rate of Change of Frequency 2. Rate of Change of Power 3. Frequency Deviation	190	0.74%	7.44%

The above table shows the comparison with existing active methods in terms of detection time and THD's.

4. CONCLUSION

The Proposed Active ISD Method is implemented on test case consists of DC source connected to a utility grid of 415 V 50 Hz supply. Islanding is created using the circuit breaker at 0.15 Seconds. The Active method detects the islanding in 190 milliseconds and DG disconnected at 0.34 Seconds and hence the supply is interrupted to the load. TheTotal Harmonic Distortion of Grid current is 0.74 % and the Load Current is 7.44 % and compared with existing active methods.

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