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The Innovative Method of Islanding Detection Based on the Unbalance Voltage Parameters with Frequency Control Loop

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ABSTRACT

Repeatedly events and blackouts are of the most important accidents and threats to the security of power systems. A division of the network structure and intentional islanding are of the most important characteristics of a power system in the process of blackouts. One of the suitable ways for improving the security of the power system in this context is the division of power network into suitable controlled intentional islands; if the system is going to be destroyed, it is possible to divide the network to controllable islands that decreases the risk level and black-out time. On these days' power networks that their application of distributed generation units is increasing, the units can have significant influence in independent islanding while repeating events occur. Islanding or disconnecting main network happens when supplying power from a main network because of some reasons is stopped while distributed generation units are still serving the system. islanding has negative effects on protection and usage of the distribution system, islanding should be effectively detected and the distributed system unit will be separated. One of the advantages of distributed generations in the grid is using the capacity of these units as the back-up for providing local load while losing main source. In these circumstances it is possible to divide a distribution network into islands that stability is maintained because of existing distributed generation sources and using power in each island. Synchronous generator is used in this case as a distributed generation and unbalanced voltage parameter with controlling frequency loop is adapted for islanding process detection. Finally, the suggested method is tested on both systems and the result is reported.

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INTRODUCTION

The contribution of distributed generation is so important because of its effect on the power system. Recently, researchers have paid attention to use the distributed generation for supplying the local load. For this purpose, using the wind turbines, batteries, Synchronous generators, and the induction generators have become the focus of concern (Tegui, O, 2007). Electric power production that lets the extra electric power to be fed to the network. The power production from distributed generation and renewable energies is growing because of many and varied advantages. Islanding detection of distributed generation causes this source in a system, to continue supplying part of the plant which is subtracted from it due to the fault in the grid. This operation occurs when the distributed generation for some reasons interrupted, but the distributed generation has consistently kept producing power (Naderi, p, 2011) (Ghadani, N, 2011).

The intentional islanding can improve the quality of generation resource indicators and reliability; in this way more income for DG systems is produced. The generation sources are divided in two sections: renewable and non- renewable sources(Naderi, p, 2011)(Balaguer, 2011). In this method of production, a local generator like wind, gas, water powerhouse, micro turbines, Photovoltaic, batteries, synchronous generator is used. Synchronous generator is a better suggestion for providing more power. The reason of using this kind of generators is their high capability in control of voltage level and frequency in the network. Obviously, in this situation the control of frequency-load loop and exciter system of the generator is used.

Islanding happens in two ways:

- Intentional
- Unintentional

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The recognition techniques of islanding are divided into two main groups:

- The local methods
- Remote technique

The local methods are divided in two sets that are active and passive approaches. Communication methods are based on sending and receiving signals. The communication signals are defined between the network and the DG. Therefore, this method in the set is better than the local method, but the implement and the usage of this method is so expensive and is totally uneconomical. The local method based on the data received is defined as the DG.

In recent years different control strategies have been studied to define its location and time islanding, and make the island. Each of these active and passive methods has its own subset. The passive methods are used when the indicators of voltage and the frequency are available. This method depends on system measurement parameters and the difference in the level and threshold settings of these parameters can result in the identification of islanding conditions. In this method tries to effect on voltage and frequency in the network connection point and the protection operation had done by manipulating the voltage and frequency in connection point (pcc).

1.Purpose:

The purpose is showing the islanding detection method in the time of definitive disconnection in the network. Most mistakes are a momentary type after the short time period they were solved, also the load switch led to send the wrong trip signal. In this consideration, the synchronous generator is applied as distributed generation with its control system and a distributed output units are connected in parallel with the network. In permanent condition, one part of the load power provided by the network and other parts set by the synchronous generator. If this balance distributed change, the system frequency will be transient according to equation (1):

- $P_{SYS} - P_{SG} - P_{L} = \frac{2H}{F}\frac{df}{dt}$ (1)

By disconnecting the network the equation (1) becomes equation (2):

- $P_{SG} - P_{L} = \frac{2H}{F}\frac{df}{dt}$ (2)

In recent years because of restructuring in the power industry and technological advances, the usage of distributed production units based on the synchronous generators has increased. The distributed Generation made by synchronous generators, exciter system and governor. The exciter system with its appropriate change maintained the generator terminal voltage and reactive power in the appropriate rank. The schematic of the exciter system display in Fig. 1.

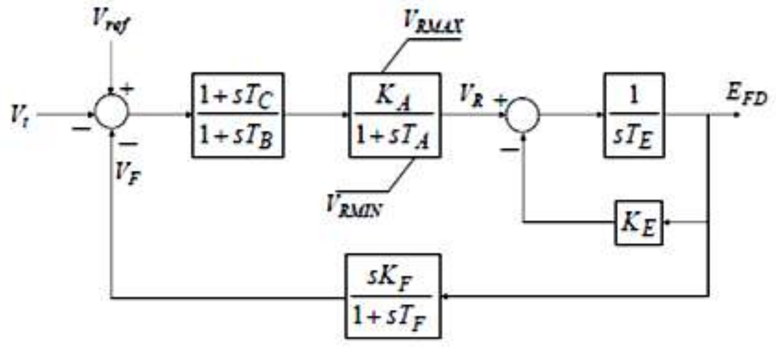

Fig. 1: Schematic of the exciter system.

The speed control system is made by the governor and a primary exciter. It provided the mechanical power from the generator. Fig. 2 shows the schematic of governor.

2.The proposed structure:

The proposed technique for islanding detection is a combination of the positive feedback and the UV technique. So, this method is a combination of active and passive approach. In this method the voltage magnitude measured in terminal point of distributed generation source in the PCC point and calculated the

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unbalanced voltage parameters. Any distortion entered to the distributed generation system like transient fault,randomize switch load led to make a distortion in the amount of unbalanced voltage parameters.

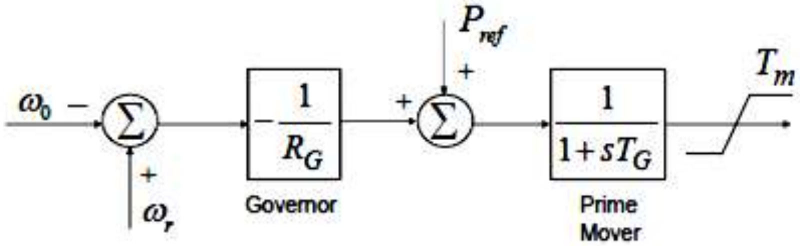

Fig. 2: Schematic of the governor.

To distinguish the distortion made by transient fault and load switch and interruption in the UV features, the other features should be added to this method. The features have been added work as a backup to prevent false tripping. Any variation in UV led to reduced DG frequency from 50Hz to 49 Hz and After the frequency decreased from 50 Hz to 49 Hz, The DG output voltage and frequencies are observed since 1.5s . At this period time If the frequency developed to 50 Hz, it will show that the equipment follows the main network frequency; therefore, the interruption doesn't occur But if the frequency trend to 49 Hz, it will show that it doesn't feed by main network and the interruption occurs which indicated that the islanding is happening in the network. In this condition the DG should be separated from the network. At this time the tripe signal should be sent to the existing breaker in the PPC point and the related frequency restores to 50 Hz. In this way, the highest and the best reaction will occur. This proposed method is also used for non-synchronous DGs as a solar system.Fig . 3 shows the flowchart of purposed method.

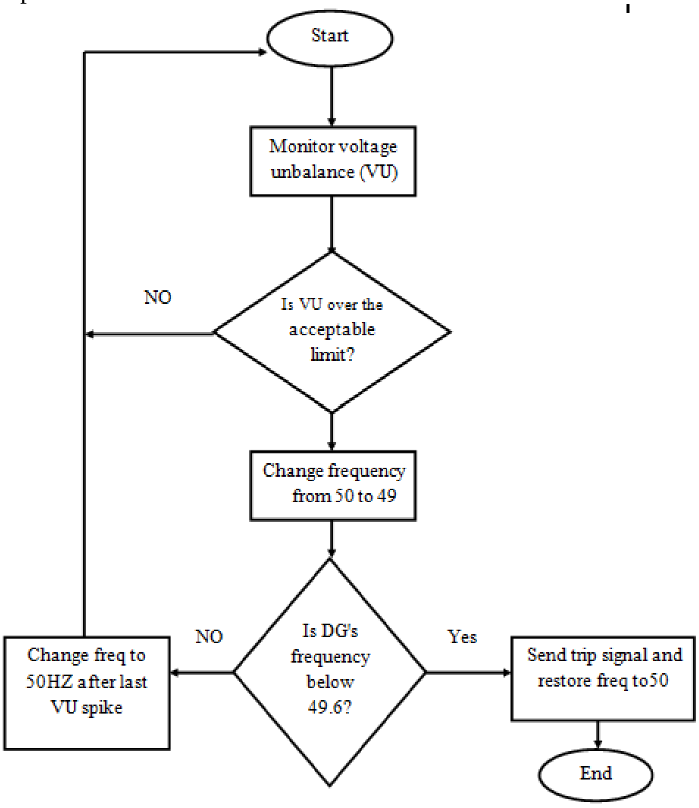

Fig. 3: Simplified algorithm for islanding detection.

3.Case study:

In this part to test the proposed method, Khodabandelo Tehran network (Iran) with some changes in feeders is used. Single line diagram of the network in fig. 4 and the parameters in table 1 and 2 are seen. Two units DG with synchronous generations are used that the related features are shown in Table 3. The system will be implemented in MATLAB/ SIMULINK environment. And the results are presented below.

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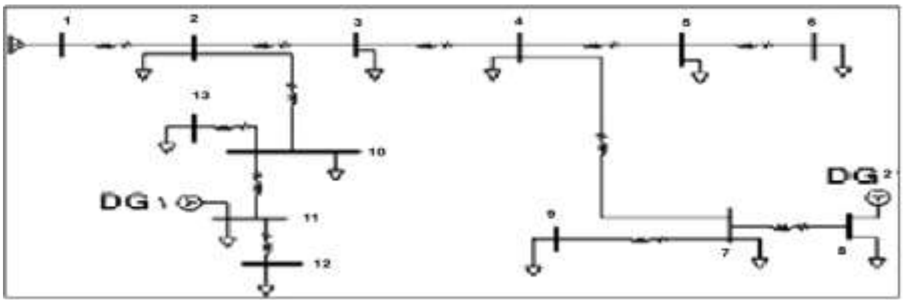

Fig. 4: Single line diagram of the network.

Table 1: Line parameters.

From	To	R(ohm)	X(ohm)
1	2	0.176	0.138
2	3	0.176	0.138
3	4	0.045	0.035
4	5	0.089	0.069
5	6	0.045	0.035
4	7	0.073	0.073
7	8	0.074	0.058
7	9	0.093	0.093
2	10	0.116	0.091
10	11	0.063	0.05
11	12	0.068	0.053
10	13	0.062	0.053

Table 2: Load parameters.

Bus Number	P(KW)	Q(Kvar)
1	0	0
2	1.483	0.78
3	1.047	0.783
4	1.853	1.273
5	1.06	0.63
6	0.79	0.573
7	1.533	0.487
8	1.277	0.83
9	1.103	0.8
10	2.237	1.797
11	1.15	0.31
12	2.153	0.923
13	1.873	0.8

Table 3: DG parameters.

DG Number	S(KVA)
1	700
2	300

In the system under study, the two synchronous generators are used as a source of distributed generation. These generators power are 300 KVA, 700 KVA that located for supplying two loads 300 KW and 500KW on the bus 8 and 11. Synchronous Generators with governor system and exciter are located on the buses that the schematic software environment, in the Fig. 5 and Fig. 6 are seen.

RESULT AND DISCUSSION

The goal is to identify the moment of the islanding under the different conditions which are presented in the table 4.

One three phase fault occurred in 0.7 s to 0.9 s and other at the time of 2.3 to 2.6 (s) in the related network. In addition, in 3.4s switch off load occur and at 4 second the connection between the DG and main network are interrupted by opening the breaker. Under the circumstances of this control system is expected to identify the time of islanding correctly and for transient errors and load switch won't send the wrong signal. By use the proposed method, UV (unbalanced voltage parameters) is measured from generator terminal and for the occurrence of the first spike in this parameter, the frequency control system is activated. By Reducing the DG system frequency and considering the procedure of increasing and decreasing in frequency in the interval of 1.5s lead to the identification and detection of islanding process. As shown in Fig. 7, the occurrence of any changes

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will effect on unbalanced voltage parameters that calculated from the generator bus and will cause distortions and spike in this parameter. As seen in the interval of 0.7-0.9 and also 2.3- 2.6s, the existence of transient fault led to appearance of distortion in UV. In addition switch load in 3.4s and opening the breaker at 4s made spike. For each of this fluctuation, the frequency control loop started to work, and identified the time of the Islanding. It is clear from the results, the distance of the transition fault to distributed generation influenced on the intensity of distortion in parameters of unbalance voltage which is calculated from the terminal bus of related generator.

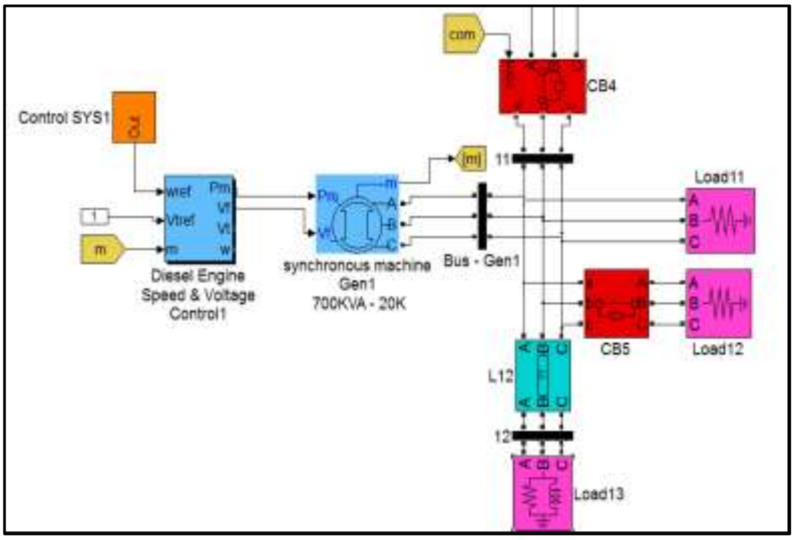

Fig. 5: Part of case study with distributed generation (Gen1) and control system.

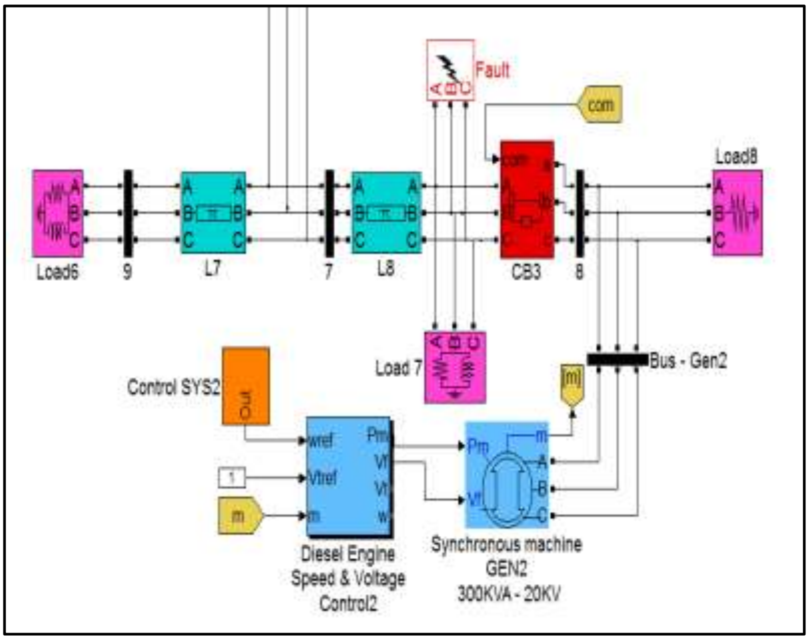

Fig. 6: Part of case study with distributed generation (Gen2) and control system.

Table 4: Events List During Simulation.

Event Number	Time Of Event	Type Of Event
1	0.7(s)	Three phase fault
2	0.9(s)	Clear fault
3	2.3(s)	Three phase fault
4	2.6(s)	Clear fault
5	3.4(s)	Switch load
6	4(s)	Black Out

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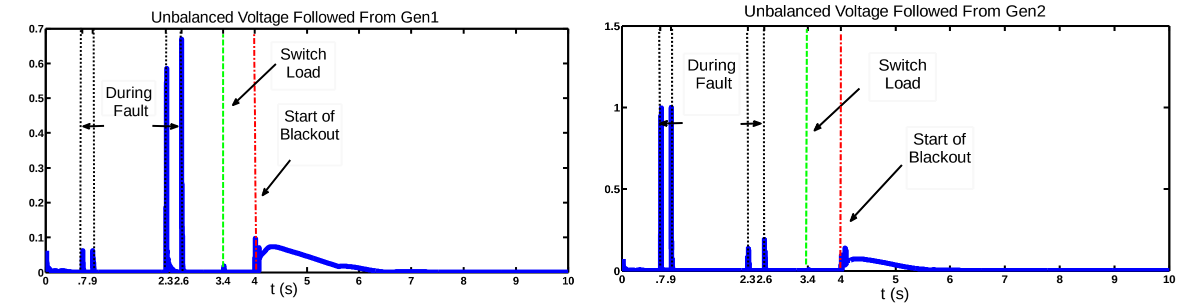

Fig. 7: UV measured from Gen1, Gen2 terminal.

At the base of the proposed plan for distortion in UV parameter, the frequency control system is activated. As seen in Fig. 8 and Fig. 9, the frequency of generators reduced and the system studied under 1.5 s. The frequency reduction and tend to 49Hz indicate the islanding performance occurred and starting permanent blackout in the network.

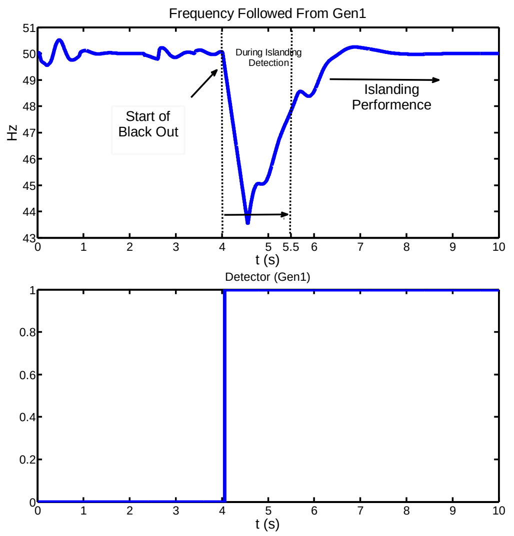

Fig. 8: Frequency and detecting the time of islanding

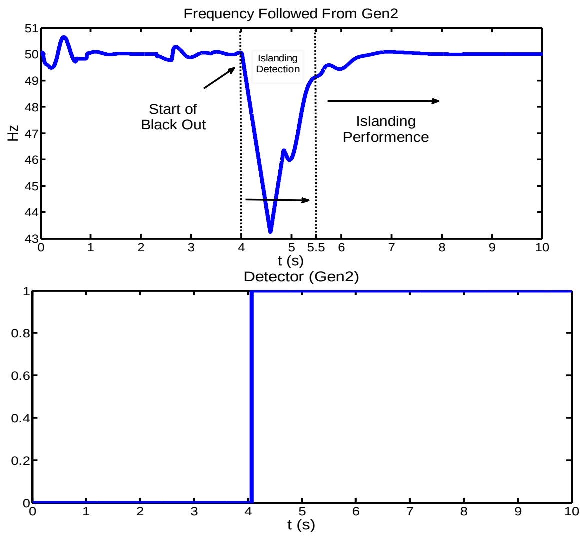

Fig. 9: Frequency and detecting the time of islanding

In addition to, the rotor speed shows that in the fourth second of simulation the connection of system with main network is interrupted and islanding happen. The speed of synchronous generator rotors is shown in Fig. 10.

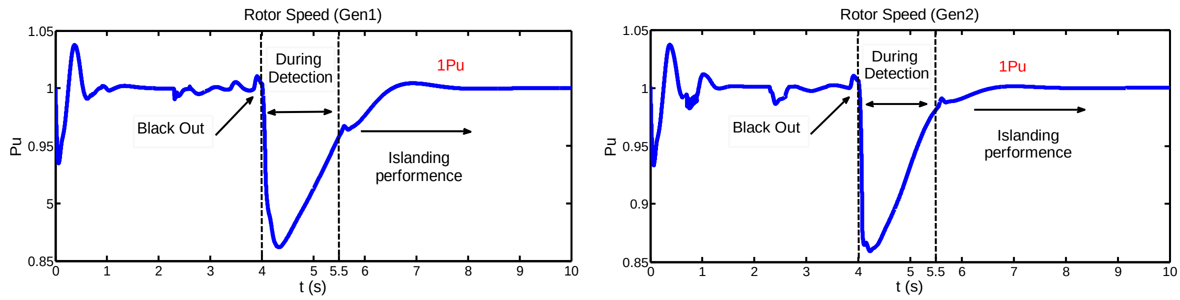

Fig. 10: Rotor speed of distributed generation Gen1, Gen2 under conditions apply.

In addition , observed the value of active and reactive power transfer between distributed generation and the grid confirmed the accuracy of islanding detection time. Observing all active and reactive output powers from synchronous generators indicated this fact that at the moment of 4s because of the blackout of the system from the network, the related load supplied through existing generators. Because of the quality of the load , (induction- resistive) The value of injection reactive power after the fourth second is Mvar 0 and the value of active power for first generator is KW700 and the second generator is KW 300. The results for Gen1, Gen2 are shown in the fig. 11 and Fig. 12. The occurrence of transient fault made fluctuations, but the islanding cannot be created due to these faults will be ended after a moment. By starting the blackout and integrated supply of local load with synchronous generator, the power which is delivered to the load will be equal to the transfer power from synchronous generator.

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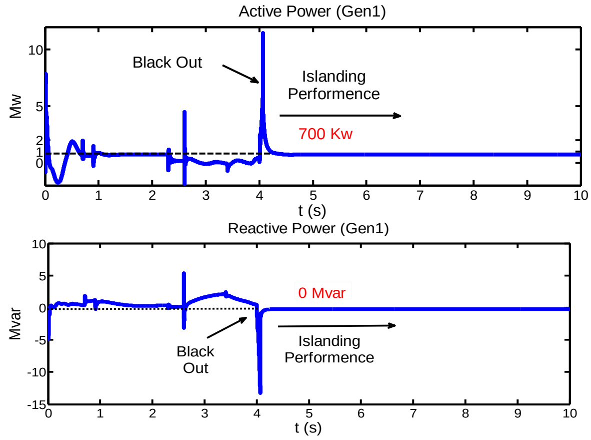

Fig. 11: Active and reactive power Gen1

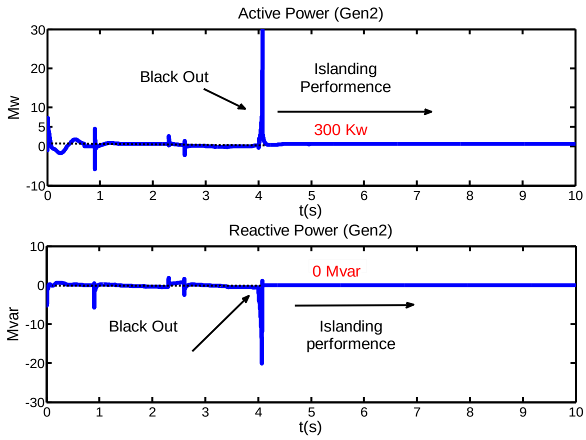

Fig. 12: Active and reactive power Gen1

Also THD (total harmonic distortion) is one of the parameters when events occurred, it will be influenced and it can be used to detect the time of island creation. It should be mentioned that the only use of this parameter due to existence of distortion for each fault is not suitable for detection of islanding ; therefore, the other control loops must be added. The results and changes of THD are shown in fig. 13. As can be seen, the occurrence of transient fault in time of 0.7s to 0,9s and time of 2,3s to 2.6s also the load switch in 3.4s caused distortion in this parameter that in some cases, this parameter can be used to identify the islanding process by using the deviation value and added control loop.

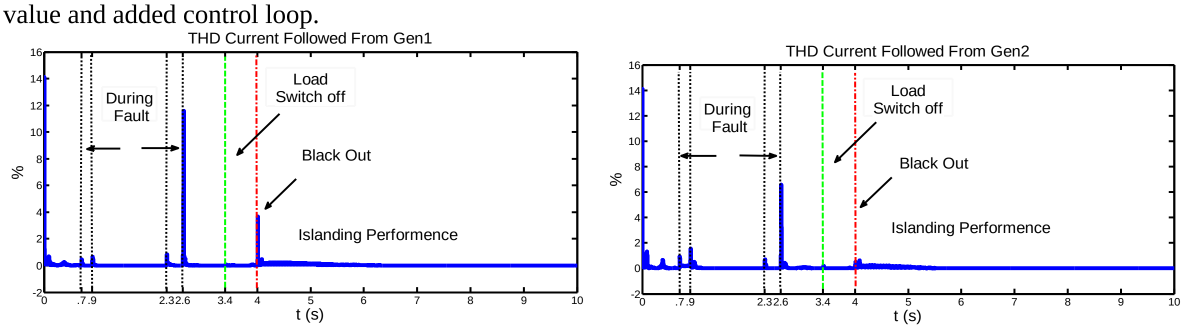

Fig. 13: THD current Gen(1),Gen(2).

5.Conclusion:

In the last two decades, so much progress has made in the field of distributed generation, but one of the problems in this field is an islanding phenomenon due to failure in detection this field lead to technical problems in the network. In this research, the new techniques are presented for islanding detection. In this method, two indices, unbalanced voltage and frequency, are combined and used. At any moment the value of unbalanced voltage is calculated from the terminal bus connected to distributed generation. Since the existence of different events like transient fault, load switch and permanent blackout caused fluctuation in this parameter. The islanding process must be tried to announce for existing blackout in the network, for this purpose, a frequency control system is used in this detection loop. Its performance is in the way that the frequency loop is activated for each fluctuation peak of unbalanced voltage and events in the network and reduced DG frequency and studied for the period of 1.5s. If the frequency in this interval approached to the reduced frequency of distributed generation can be concluded that the blackout happened in the main network. The islanding process is announced and the islanding detection time is determined. Otherwise, it can be reached to this conclusion that the events were transient typed and after a while is solved. And the network continued to work. Another important point is that the distributed generation returned to its initial value after islanding detection. In this model the synchronous generator is used as a source of distributed generation.

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