New Approach for Protection of Distributed Generation using Islanding Technique

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Abstract:- Power system's traditional view is characterized by the unidirectional flow of power from a centralized generation to consumers. But for modern view by introducing DGs (Distributed Generations) into distribution system, it results to bidirectional flow of power. Rapid progress in modern technology like wind turbine, fuel cell, photovoltaic and power electronics new innovation, also the demand of customers for better reliability and quality of power are forcing power industry to shift for DGs. Hence DG (distributed generation)has gained momentum in power industry because of de-regulation of market and environmental concerns. When DG continues its power supply even when portion of distributed system becomes isolated electrically from power system remainder, Islanding occurs. DG should have capacity to detect islanding detection for interconnecting DG to power distributed system. Recently industry practices to disconnect all DGs after islands occurrence. In order to achieve this goal, all DGs must equip with detection device for islanding. This is also called as anti-islanding device such as ROCOF relay and vector-surge relay.

Keyword :- *DG(Distributed Generation),HV(High Voltage),EHV(extra high voltage),UHV(Ultra High Voltage).*

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1. Introduction

As demand of power is growing and concern regarding utilization of the fossil fuels in conventional power-plants is increasing, new good example of DG (distributed generation) is gaining greater as well as commercial importance across the world. DG (Distributed generation) involves interconnection of small scale, on-site resources of distributed energy with the utility of main power at a distribution voltage level [1]. These types of resources primarily represent sources of renewable energy and non-conventional type sources like wind turbines, solar PV, small scale hydro, fuel cells, micro turbines, wave generators and tidal etc. These type of generation technologies are being most popular for his or her high energy potency (fuel cell or micro turbine based CHP-systems), a low environmental impact (Hydro, Wind, Photovoltaic etc.) and their applicability as un-interruptible power provides to quality power sensitive loads. Conventional over-current protection is meant for radial distribution systems with unidirectional (one-way) fault-current flow. Connection of DG into a distribution networks converts singly fed radial networks to difficult ones with the multiple sources. And this changes flow of the fault-currents from unidirectional (one-way) to bi-directional (two-way) [2].

1.1 Power Systems Traditional Concept

Development of power electric system has been, for over half century, supported centralized large generating stations, with large generating units at a comparatively little number of the locations. Particular stations, voltage is stepped-up to the high voltage (HV), extra high voltage (EHV), and ultra high-voltage (UHV) levels will be transmitted over a long distances through the systems of inter-connected transmission. Voltage from systems of HV transmission is stepped right down to distribution systems of radial MV (medium voltage) then to the radial LV (low voltage) distribution systems, wherever the electrical power is distributed to the loads.

Generation of Electricity is created in large power plants, typically placed near the primary energy source (coil-mines) and much away from the consumer centres.

Electricity is then delivered to the customers employing a large passive distribution infrastructure, that involves HV (high-voltage), MV (medium-voltage) and LV (low-voltage) networks.

Distribution networks are designed to control radially. Power flows solely in the one direction: from a higher voltage levels down to the customers located on radial-feeders.

Particular method, there're 3- stages has to pass through before power reaching ultimate user, that is transmission, distribution and generation.

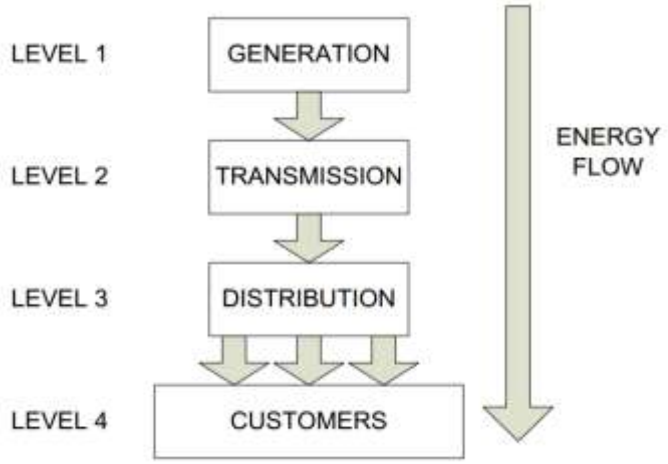

Fig.1.1: Conception of traditional Industry for supply of Electrical Energy

Within the initial stage, electricity is generated in large generation plants, placed in unpopulated areas/places far from the loads to get a round with economics of size and the environmental problems. Second stage is to be accomplished with a support of varied equipments such as underground cables, transformers and overhead transmission lines. Last stage is that the distribution, link between utility-system and also the end customers. Particular stage is that the most vital part of power system, because the final power quality is depending on its reliability [4]. Electricity demand is continuously increasing. However, electricity generation should increase so as to satisfy necessities or demand. Traditional type power systems face the growth, putting in a new support-systems in level1 (verify Figure 1.1). At the same time that, the addition within the distribution and transmission levels are less frequent.

1.2 Power Systems New Concept

Over a previous couple of years, variety of influences are combined to lead to increased interest within the use of small scale generation and connected to the local distribution systems, that is usually known as DG (Distributed Generation). Connection of a DG is meant to extend reliability of the power supply provided to consumer; using local sources, and if possible, reduced losses of distribution and transmission systems. Connection of DG to power system may improve support voltage stability, voltage profile and power quality. Hence, a system will withstand higher loading things. atmosphere friendly electricity provide, liberalization of electricity market , recent transmission lines development, increasing demand on extremely reliable electricity provide, and reduction of usage of fuel resources are some of advantages which DG offers. DG will return from non-renewable or renewable energy resources, using each modern and conventional technologies. DG technologies include combustion engines, wind turbines, small gas turbines, micro-turbines, small combined cycle gas turbines, fuel cells, solar photovoltaic, biomass and small geothermic generating plants.

Structures of a conventional power system and electric power system with the distributed generation are shown in the figure1.1. Presence of local generation in an exceedingly distribution system can have an effect on distribution system. As an example, DG can alter the power flow within the distribution system, and also the distribution system will not be considered as system with one-way (unidirectional) power flow. On the opposite hand, distribution-systems have, for several years, has been designed supported the assumption which the power flow is unidirectional. Therefore, presence of DG, particularly once dg share is vital, can clearly impact a operation of power distribution system and control. it's so deemed necessary to judge impact of increased DG on the design requirements for distribution systems.

Currently, environmental policies, technological evolution and additionally a growth of electrical markets finance, are promoting the new conditions within the sector of electricity generation [4]. The new technologies allow in small sized plants electricity generation. Furthermore, increasing use of the renewable sources so as to cut back an environmental impact of power-generation ends up in the event and application of latest electrical energy supply schemes. During this new conception, generation isn't exclusive to level 1. Thus a number of energy demands are provided by centralized generation and another part is made by distributed generation. Electricity goes to be made nearer to the customers.

2. Islanding Problem

Islanding is that the scenario during which distribution system has become electrically isolated from the rest of the power system, nonetheless it continues energizing by a DG connected to that. Traditionally, distribution system doesn't have any active power generating-source in it. As well, it does not get power just in case of fault in transmission line upstream however with dg, this presumption is not any longer valid. Current practice is that nearly all utilities need DG to be disconnected from grid as soon as possible just in case of islanding. The Islanding may be Non intentional or intentional. Throughout maintenance service on utility grid, a closing of utility grid might cause generators islanding. Because the loss of grid is voluntary, islanding is understood. Non intentional islanding is caused by an accidental shut down of grid is of additional interest.

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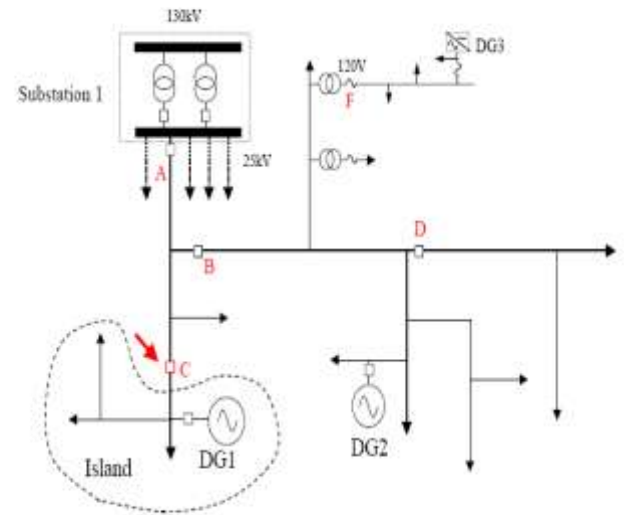

Fig.1.2: Distributed Generation Islanding Problem

3. Proposed Methodology

In order to check a performance of the different Techniques throughout various contingencies simulation model was implemented. Behaviour of simulated system should be the same as what happens in an exceedingly real state of affairs. It's necessary that a model reflects a real system altogether necessary element. However this has been achieved is described within the following. During this work the emphasis has been placed on induction generators and wind power turbines. the rationale for this is often the continuing extension of wind power. Within the preliminary study we've thought of system.

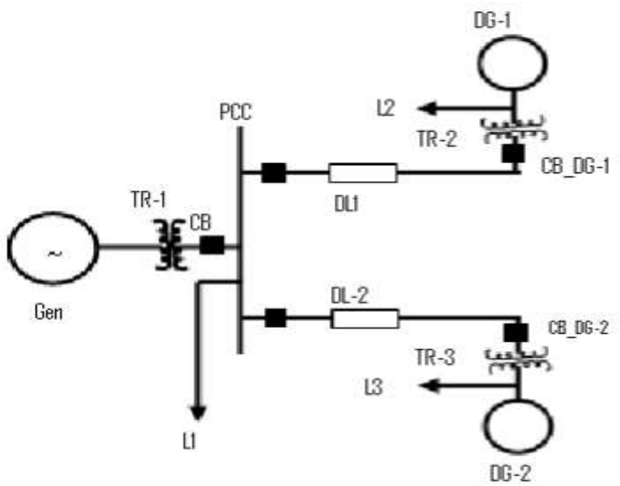

Fig.1.3: Multiple DGs Power Distribution Network

4.1 Model Description

Particular model is ready to have two 9MW wind-farms using detailed model of DFIG (Doubly Fed Induction Generators) driven by wind turbine. Every 9MW wind farm is consisting of six- 1.5MW wind-turbines connected to 120kV grid through 30 km, 25kV feeder. Model is compatible for observing harmonics and dynamic performance of system over comparatively short-periods of your time. 500kW resistive load & 0.9 MVAR filter connected at 575 generation bus. The wind turbines utilizing DFIG (Double Fed Induction Generator) and AC-DC-AC IGBT based mostly PWM convertor. DFIG technology permits extracting most energy from wind for low-wind speeds by optimizing turbine speed, whereas minimizing mechanical stress on turbine throughout gusts of wind. Fascinating turbine speed manufacturing maximum mechanical energy for given wind speed is a proportional to wind speed. Wind speed is maintained constant at the 10 m/s. For wind speed of 10 m/s, the utmost turbine out-put is 0.55pu of their rated-power 0.55* 9MW=4.95MW at the speed of 1.09 pu of synchronous generator.

Switching frequency is 1620 Hertz. A stator winding is connected on to 50 Hz grid whereas, rotor fed at frequency variable through AC-DC-AC convertor. System uses torque controller so as to take care of speed at 1.09 pu. Reactive power which is created by wind-turbine is regulated at 0 MVAR. Sample-time wont to discretise model is 5 µ sec and also the sample time employed by system is 10 µ sec.

Details of distribution lines, transformers, DGs, generator and the loads are:

Generator: short-circuit rated f= 50 Hz, MVA=1000, Vbase=120 kV & rated kV= 120.DGs (Distributed Generations): wind farm (9 MW) consisting of a six 1.5MW wind turbines DFIG is connected to 25kV system distribution exports power to 120_kV grid through 30 km 25kV feeder.T1(Transformer): rated-MVA=25, rated-kV=120/25, f=50Hz, R1=0.00375 pu, Vbase=25kV, X1= 0.1 pu, Rm=500 p u, Xm=500 p u.Transformer T5.T4,T3,T2: rated MVA=10, Vbase=25 kV, rated kV= 575 V/25 kV, R1=0.00375 p u, f= 50Hz, X1=0.1 p u, Rm=500 p u, Xm=500 p u.

DL (Distribution lines): DL1,DL2,DL3,DL4: PI Section, X1=5.01e-009 F/km, C0=11.33e-009F/km, L1=3.32e-3H/km, L0=1.05e-3 H/km, R1=0.413 ohms/km, R0=0.1153ohms/km, Vbase=25kV, rated-MVA=20, Rated-kV=25, 30km each,Loading data(Normal): L1=3MVAR, L2,L3,L4,L5=8.0MW, 5MVAR, 15MW.

Current and voltage signals are retrieved at target dg location for the islanding conditions and the non islanding conditions (other disturbances). Relays for every dg units are placed at dg end. As an example, CB_DG 1 relay is placed at the DG 1 to gather current and voltage info for each islanding and non islanding conditions. Potential things of islanding and non islanding conditions which studied are given:

Tripping of main CB (circuit breaker) for an islanding-conditions. In between dg and power system it is opening of the any breakers The Loss of a power on PCC bus. Sudden

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load of modification at target DG location. Tripping of a different DGs excluding target one.

Higher than the conditions are simulated below potential variations in operative loading, at normal, maximum and minimum loading conditions. They're varied at dg end also as at PCC. Model is simulated at 1.6 kHz (32 samples on 50 Hertz base frequency). Current and voltage signals are retrieved at target dg location (DG1, DG4).

Islanding starts at 0.3sec as shown within the Fig.No.4.2. The whole simulation is administered utilizing MATLAB/SIMULINK software package.

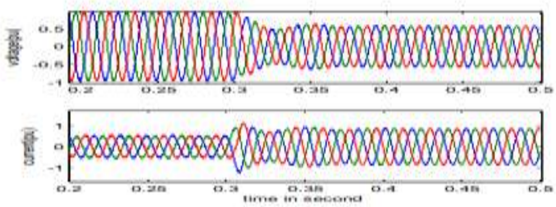

Fig.1.4: 3-Phase Current and Voltage Signals under the Islanding Condition retrieved at targeted location of DG (starting at 0.3sec)

4.2 Islanding Detection Suggested Method

There is brand new technique we've developed for islanding detection.

• The negative sequence element and d1-coefficients for an islanding detection

Single phase current and Voltage wave forms discovered at the DG 1 location throughout islanding:

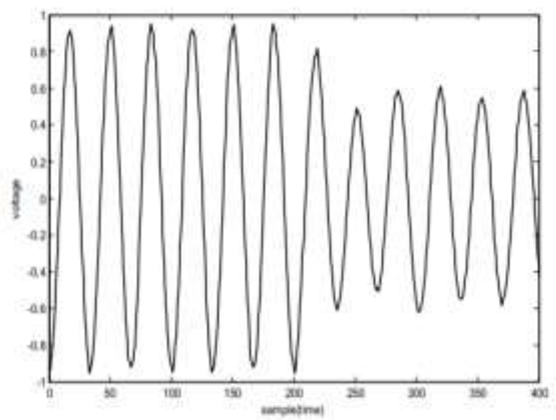

Fig.1.5: Voltage Waveform 1-Phase At Dg 1 During the Islanding

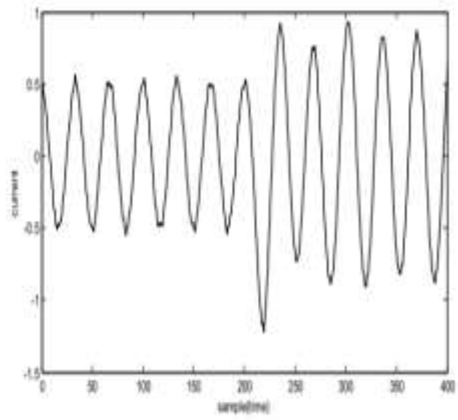

Fig.1.6: Current Waveform 1-Phase At Dg 1 During the Islanding

Voltage wave form at dg location once switching off 3-phase breaker is shown. It's discovered which suddenly voltage decreases. Similarly Figure 4.5 the present wave form at dg location once switch off 3-phase breaker is shown. It's discovered which suddenly current will increase.

4.3 Wavelet Transform Islanding-Detection

Wavelet transform based approach is suggested to notice prevalence of islanding events in DG (distributed generation) systems. Due to a frequency & time localization capabilities which is exhibited by wavelet-transform, certain approach embedded with particular transform-technique which has grasped appearance of islanding event during a highly effective manner. Furthermore, for those regions that are in need of a much better visual image, suggested approach would serve as an economical aid such that mains power disconnection will be higher distinguished. To validate feasibility of this approach, the tactic has been valid through many situations. Check results supported effectiveness of method for application considered.

In this Thesis, wavelet transform based approach is suggested to observe parameter variations of interests, wherever Daubechies wavelet is basis. Enhanced by such an approach, it's anticipated which any abrupt modification occurred within the non-inheritable signal would be effectively caught, thus increasing responsibility of islanding detection. Some helpful options of particular new methodology are listed below: [55]

• It helps to improve islanding detection capability of protecting relays. the security of utility engineers is highly ensured.

• Because time & frequency data may be simultaneously determined, strength of the method will be higher accomplished for the applying thought of.

• With increased number of installed DGs (distributed generators), suggested methodology would function as a

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potential alternative additionally to existent approaches. The method is simple to program, facilitating firmware realization of integrated circuit design for portable detector applications.

Wavelet analysis Basic functions are generally localized in the frequency creating mathematical tools like power spectra (power in a very frequency interval) helpful at choosing out frequencies and calculating PDs (power distributions). The foremost necessary feature of particular transforms is which individual type wavelet-functions are generally localized in the space. Particular localization of feature, together with wavelets localization of frequency, makes several operators and functions using wavelets “sparse”, once transformed into wavelet domain. Particular sparseness, successively leads to variety of helpful applications together with islanding detection.

4.4 Wavelet Transform

Real-time transient classification of power transients is incredibly difficult since high-frequency content superimposed on the power frequency signals are typically periodic, short-term and non-stationary waveforms. Wavelet transform is proposed so as to extract discriminative options which can facilitate in differentiating between transients related to islanding event and people created from the other event like switching of capacitor bank and temporary fault.

WT (Wavelet transform) is an efficient mathematical tool that has been widely utilized in several engineering applications like speech and image processing. WT has found several varied applications within the power systems field a number of applications are partial discharge, power quality and protection of power system.

Unlike FT (Fourier Transform) that transforms signal from time-domain to frequency-domain. WT extract frequency elements of signal whereas conserving time-domain properties [56]. The ideas of WT are going to be explained within following section.

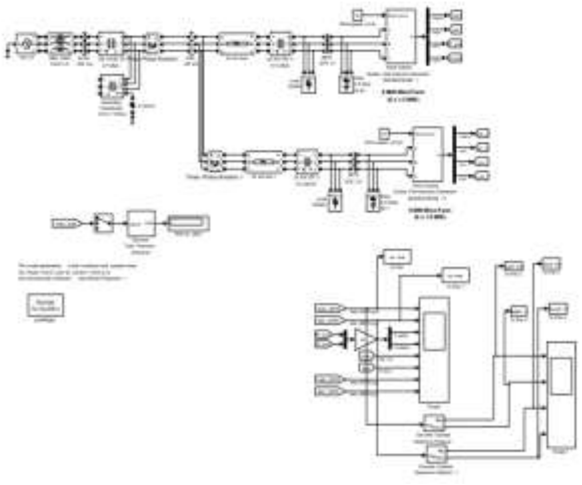

Fig.1.7: Model Of Simulink/Matlab

4. Simulation Discussion & Results

A test system is simulated with rate 1.6kHz. Sampling period is 5e-006 and Samples/ cycle is 32. Four events represented on top of are simulated. Here, steady state operation of a DFIG. Further that the dynamic-response for remote-fault on system of 120-kV is noticed. Current and voltage wave forms are noticed at DG terminals by opening and closing of the two circuit breakers.

5.1 Islanding Detections D-1 Coefficients & Negative Sequence Element.

Negative sequence is one among three quantities employed in symmetrical element analysis of 3-phase power systems. Symmetrical elements are accustomed to calculate un-balanced conditions on 3-phase system utilizing 1-phase calculation. And this simplifies the process of scheming fault quantities for the phase_to_phase_to_ground, phase_to_ground and phase_to_phase faults on the PDs (power systems). The Symmetrical elements contain zero sequence, negative and positive sequence quantities. Basically, the positive sequence quantities are those present throughout balanced, 3-phase conditions.

Positive-sequence quantities make up normal currents and voltages observed on the power systems throughout typical, conditions of steady-state. Quantities of negative sequence are measure of quantity of un-balance existing on power system. Zero sequence quantities are most typically related to ground being concerned in an un-balanced condition. Zero and Negative sequence quantities are sometimes solely present in substantial levels throughout faulted, unbalanced conditions on power system. Since the zero and negative sequence quantities are solely present in relatively large values for the faulted conditions, they're usually wont to confirm which faulted condition existed on power-system. Negative-sequence will be wont to observe phase_to_phase, phase_to_ground, and phase_to_phase_to_ground faults. A Zero-sequence will be used to observe phase_to_ground and phase_to_phase_to_ground faults.

Equations to calculate the negative sequence are given as:

$$V_n = \frac{1}{3}(V_a + a^2 V_b + aV_c)$$

$$I_n = \frac{1}{3}(I_a + a^2 I_b + aI_c)$$

Where, Va,Vb and Vc are 3-phase voltages and Ia,Ib,Ic are 3-phase currents retrieved at target DG location, and a= 1 at angle 120 Degree , is that the complicated operator.

Negative sequence elements are acknowledged using sequence analyzer block of Simulink.

Negative sequence currents and voltages are processed through wavelet transform (db4) for the time localization of islanding event. Negative sequence corresponding d1-coefficients and voltage for various non-islanding and islanding conditions are shown in Fig.5.1,5.2,5.3,5.4. Negative sequence corresponding d1-coefficients and current for completely different non-islanding and islanding conditions are shown in the Figure-5.5,5.6,5.7 & 5.8. d1-coefficients are clearly localizing islanding event and so facilitate in the detection of same.

5.1.1 Negative Sequence Component of Wavelet Transform and Voltage For Islanding Detection

Condition 1 :

(At Normal Condition)

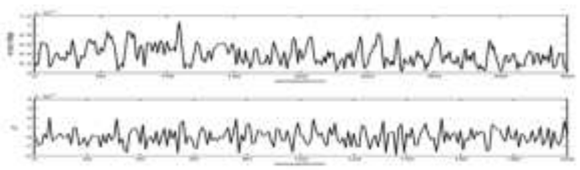

Fig. 1.8: Negative-sequence component of d1-coefficient and voltage for the Normal condition

Condition 2:

(At Islanding Condition)

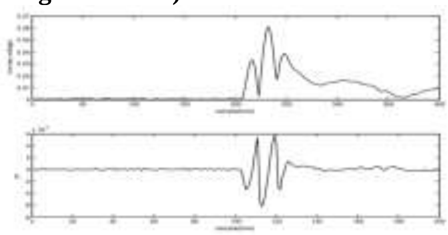

Fig. 1.9: Negative-sequence component of d1-coefficient and voltage for an Islanding condition

Condition 3:
(DG-line trip Condition)

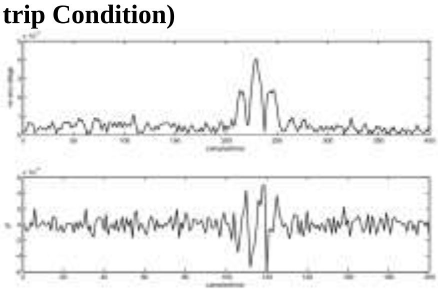

Fig. 1.10: Negative-sequence component of d1-coefficient and voltage for DG-line trip condition

Condition 4:
(at Sudden load-change)

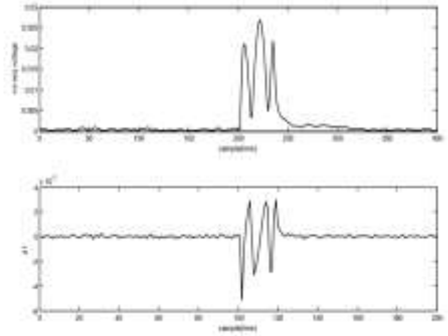

Fig. 1.11: Negative-sequence component of d1-coefficient and voltage for the sudden load-change condition

5.1.2 Detection of Islanding Based Upon Negative-Sequence-Component Current & Its Transform Wavelet (At the Normal Condition)

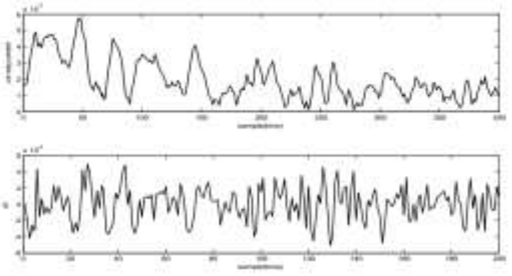

Fig. 1.12: Negative-sequence component of d1-coefficient and current for the normal condition

5.1.3 Condition of Islanding

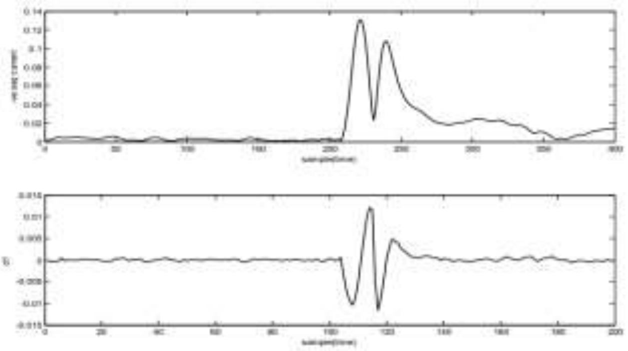

Fig. 1.13: Negative-Sequence Component of D1-Coefficient and Current for an Islanding Condition

5.1.4 Dg-Line Trip Condition

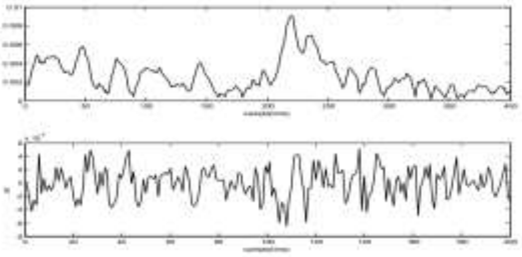

Fig.1.14: Negative-sequence component of d1-coefficient and current for DG-line (trip-condition)

5.1.5 Load-Change (Sudden) Condition

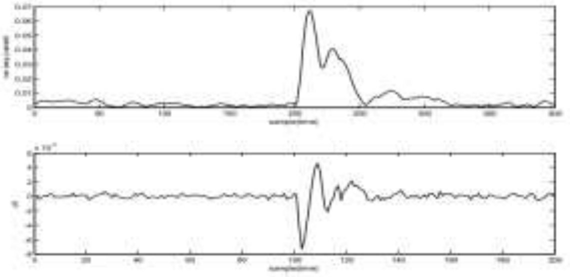

Fig.1.15: Negative-sequence component of d1-coefficient and current for the sudden-load change condition

6. Conclusion and Summary

The paper compares and describes techniques of different islanding detection. Modern power system has major challenges for detection of islanding accurately and quickly. A power system with different distribution system is having substantial DG's penetration as few issues regarding islanding which yet to be resolved. In future for to improve quality and reliability of supply, distributed system's islanding operation is seen to be workable, hence islanding is important. Suggested technique in paper inquires about negative sequence component of current and voltage for distributed generations islanding detection. Wavelet transform is used to process negative sequence current and voltage signals and d1-coefficients detect islanding events from non islanding.

When there is change observed in the parameters like current, voltage, reactive power and active power then the islanding is detected. The parameters change in case of load switching and faults. Simulation results accuracy is mostly depends on input data. And wrong data selection affects the results. An incorrect data feeding cause system overloading which leads to excessive power loss and voltage drop in distribution system.

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