DETECTING ISLANDING CONDITION IN DISTRIBUTED GENERATION

[1]Sourav Bhattacharjee, [2]S Lakshmi Prasanna, [3]Kumaresh Pal, [4]Chandan Kumar and [5]Soni Kumari

1 Sourav Bhattacharjee, B.Tech,, Electrical & Electronics Engineering, ARKA JAIN UNIVERSITY, Jharkhand, India, souravbhattacharjee.nttf@gmail.com

2 S Lakshmi Prasanna, B.Tech,, Electrical & Electronics Engineering, ARKA JAIN UNIVERSITY, Jharkhand, India, shivratrilakshmiprasanna@gmail.com

3 Kumaresh Pal, Assistant Professor, Electrical & Electronics Engineering Department, ARKA JAIN UNIVERSITY, Jharkhand, India, kumaresh.pal@rediffmail.com

4 Chandan Kumar, Electrical & Electronics Engineering Department, ARKA JAIN UNIVERSITY, Jharkhand, India, chandandaviet@gmail.com

5 Soni Kumari, Electrical & Electronics Engineering Department, ARKA JAIN UNIVERSITY, Jharkhand, India, sonikumariksk@gmail.com

ABSTRACT

In the present decade, distributed generation has gained lots of importance in the power system. The consequences on the power system develop further significance with the increase in the contribution of distribution energy resources to the electric power production. Nowadays islanding condition has become a major problem as the use of distributed generators (DG) in power system has increased. Islanding condition is defined as a condition where a DG(s) continues to deliver power to load connected in that portion of power system even though that part of distributed system becomes electrically separated from rest of the system. In this paper, for detecting islanding condition in distributed generation, we have used the wavelet transform, a powerful signal processing tool, which uses the negative sequence component of current and voltage derived from point of common coupling (PCC). The islanding condition is further detected when the detailed coefficient at the level-1 (d1) evidently isolates the event.

Keywords: Distributed Generation (DG), Point of Common Coupling (PCC), Islanding, Wavelet transform

1 INTRODUCTION

In past few years, distributed generation has become an emerging trend in power engineering. Minute isolated decentralised power sources, often called as ―Distributed Generation‖ (DG), have begun to be in demand a substitute to greater amount of electric power generation **[1]**. Numerous occasions have led to the emerging demand of DG; but nevertheless, DG can be a cost efficacious substitute to vital system enhancements for peak load demands or increasing load demand limits in order to be more non-conventional. Nevertheless, if required generation resources could be made to match the growing demand, the entire distribution and transmission functional zones will be in need of improving to maintain generation demand balance. Therefore, installing extra centralised power sources and customizing the transmission system will require huge amount of cost and time, while in both cases it may not be achieved **[2]**. This paper basically investigates about a uncertainty that appears at the coupling point between a distributed generation and the rest of the electrical system. The quandary could be explained as detecting the islanding condition in DG connected power systems. Islanding condition is a condition where a distribution system becomes electrically isolated from the system to which earlier power was delivered, but still continues to get power from

the DG attached to it. As we know, there is no active power source in a distribution system and also power is not supplied during fault detection in transmission line upstream, but if in case a DG is connected, this perception is not any more correct. Present applications show that DG is required by all utilities in order to get isolated from the grid effectively at the earliest for islanding detection.
According to the IEEE 929-1988 standard **[3]**, in islanding condition the DG has to be disconnected as soon as possible. Islanding can be classified as Intentional or Non Intentional. The disconnection of the utility grid might lead to Islanding in system, throughout the maintenance work done on the utility grid. The islanding is kenned, since the loss of the grid is voluntary. However, Non intentional islanding, due to accidental shut down of the grid is more interesting due to the several problems with unintentional islanding. According to the IEEE 1547-2003 standard **[4]**, 2 seconds of maximum delay is set forth for an unintentional islanding detection and all DGs starts to discontinue energizing the distribution system. The uncertainty has been investigated and discussed further.

2 DISTRIBUTION GENERATION (DG) & ISLANDING

Distributed generation is an approach that employs small-scale technologies to produce electricity close to the end users of power. DG technologies often consist of modular (and sometimes renewable-energy) generators, and they offer a number of potential benefits. In many cases, distributed generators can provide lower-cost electricity and higher power reliability and security with fewer environmental consequences than can traditional power generators.
In contrast to the use of a few large-scale generating stations located far from load centres--the approach used in the traditional electric power paradigm--DG systems employ numerous, but small plants and can provide power onsite with little reliance on the distribution and transmission grid. Consumer advocates who favour DG point out that distributed resources can improve the efficiency of providing electric power. They often highlight that transmission of electricity from a power plant to a typical user wastes roughly 4.2 to 8.9 percent of the electricity as a consequence of aging transmission equipment, inconsistent enforcement of reliability guidelines, and growing congestion. At the same time, customers often suffer from poor power quality—variations in voltage or electrical flow—that results from a variety of factors, including poor switching operations in the network, voltage dips, interruptions, transients, and network disturbances from loads.
In addition, residents and businesses that generate power locally have the potential to sell surplus power to the grid, which can yield significant income during times of peak demand. Beyond efficiency, DG technologies may provide benefits in the form of more reliable power for industries that require uninterrupted service. DG facilities offer potential advantages for improving the transmission of power. Because they produce power locally for users, they aid the entire grid by reducing demand during peak times and by minimizing congestion of power on the network. DG technologies can provide ancillary benefits to society. Recent studies have confirmed that widespread use of DG technologies substantially reduces emissions.
The puissance systems are intricate and seldom facile to immediately interpret. These systems are immensely automated and expand over almost all nations and continents. Contingencies and faults keep occurring conventionally and numerous such cases are removed naturally without any human interference **[9]**. The utilities are accountable for the protection of the puissance system.
Electricity can result to be hazardous to both humans and animals and it can nevertheless be harmful to equipment connected to the grid. If a component of the puissance system creates an uncontrolled island there is a serious & immediate danger to those personnel discharged for maintenance work in the islanded system to get in contact with the live components of the equipment. This might lead to severe injuries and even death.
Therefore, it becomes essential for identification and shut down of accidental electric islands. Many distribution feeders have bulwark systems with automatic reclosing equipment. This is worldly practice when the feeders are constructed with overhead lines where the fault is liable to vanish

after a short interruption. Reclosing by Automatic method increases the availability of the puissance system as the interruption time is reduced. Additional disadvantage with automatic reclosing in opposition to an energized feeder is that a capacitive switching transient can lead to rigorous overvoltage **[10]**. The capacitances involved in the transients in the islanded system are found in cables and shunt capacitances.

3 ISLANDING DETECTION TECHNIQUES

Islanding is the condition in which a distributed generator (DG) continues to power a location even though electrical grid power is no longer present. Islanding can be dangerous to utility workers, who may not realize that a circuit is still powered, and it may prevent automatic re-connection of devices. Additionally, without strict frequency control the balance between load and generation in the islanded circuit is going to be violated, leading to abnormal frequencies and voltages. For those reasons, distributed generators must detect islanding and immediately disconnect from the circuit; this is referred to as anti-islanding. Even when the load and production are exactly matched, the so-called "balanced condition", the failure of the grid will result in several additional transient signals being generated.

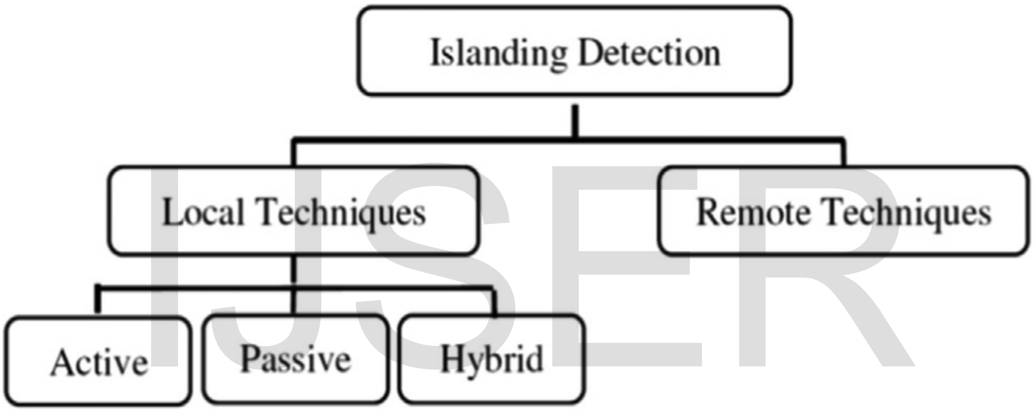


Fig.3.1 Islanding Detection Methods

Each method has some threshold that needs to be crossed before a condition is considered to be a signal of grid interruption, which leads to a Non-Detection Zone (NDZ), the range of conditions where a real grid failure will be filtered out **[5]**. Passive methods include any system that attempts to detect transient changes on the grid, and use that information as the basis as a probabilistic determination of whether or not the grid has failed, or some other condition has resulted in a temporary change. The passive methods includes under/over voltage, under/over frequency, rate of change of frequency, voltage phase jump detection & Harmonics detection. The active methods include negative-sequence current injection, impedance measurement, slip mode frequency & frequency bias.

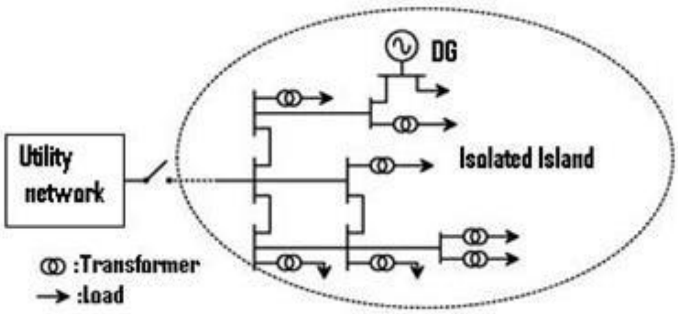


Fig.3.2 Single line diagram for Islanding Condition

4 PROPOSED ISLANDING DETECTION TECHNIQUES

In this paper a powerful tool is used for islanding detection which is ―Wavelet Transformation. The Wavelet Transform is a power time frequency method to analyze a signal within different frequency ranges by means of dilating and transiting of a single function named mother wavelet **[14]**. The main advantage of wavelet over the short time Fourier transform (STFT) is that it uses a variable-sized regions windowing technique. This feature allows wavelet to use long time intervals where we want more precise low-frequency information, and short regions where we want high-frequency information. Wavelet transformation is one of the most popular of the time-frequency-transformations.

The integral wavelet transform is the integral transform defined as

$$[W_\Psi f](a,b) = \frac{1}{\sqrt{|a|}} \int_{-\infty}^{\infty} \Psi\left(\frac{x-b}{a}\right) f(x)dx \text{……... } \mathbf{(4.1)}$$

The wavelet coefficients *Cjk* are then given by

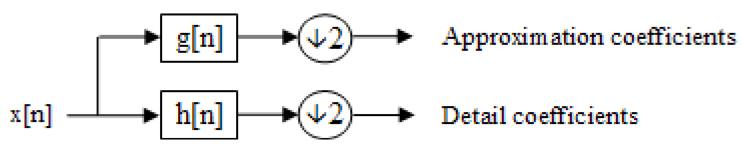
$$C_{jk} = [W_\Psi f](2^{-j}, k2^{-j}) \text{ ………………… } \mathbf{(4.2)}$$

Here, $a = 2^{-j}$ is called the binary dilation or dyadic dilation, and $b = k2^{-j}$is the binary or dyadic position. The wavelet transform can provide us with the frequency of the signals and the time associated to those frequencies, making it very convenient for Islanding detection application.

The DWT of a signal 'x' is calculated by passing it through a series of filters. First the samples are passed through a low pass filter with impulse response 'g' resulting in a convolution of the two:

$$y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k] \text{………….. } \mathbf{(4.3)}$$

The signal is also decomposed simultaneously using a high-pass filter. The outputs giving the detail coefficients (from the high-pass filter) and approximation coefficients (from the low-pass). It is important that the two filters are related to each other and they are known as a quadrature mirror



filter. Daubechies mother wavelet based DWT is used in.

Fig. 4.1 Wavelet Transform Decomposition

Out of many detection methods, negative sequence component method is the main condition in which the existence of any disturbances in the voltage signal found at point of common coupling (PCC) **[11]**. Therefore, voltage signals of the negative sequence component found at PCC has been considered in this paper for analysis towards efficacious detection of islanding and notch perturbance due to load repudiation events. In this paper negative sequence component method is adopted as it emulate the information under perturbance condition. Assessment of voltage of the negative-sequence at point of common coupling is done which gives tremendous protection to noise for the islanding detection, thus it gives good performance **[12].**

The information in the time–frequency plane is localized by Wavelets which is congruous for the non-stationary signals to be analysed. The data, functions are divided into different frequency components by WT, after which each component is studied with a resolution matched to its scale. In this paper, the negative sequence component of voltage signals are being used as the input signals for the wavelet analysis. The decomposition process can be iterated, with successive approximations being decomposed in turn. Therefore one signal is broken down into many lower-resolution components. This is called the wavelet decomposition tree.

5 PROPOSED MODEL

With regard to carry out the research on the operation and behaviour of the number of various cases during sundry contingencies, a simulation design has been carried out. It is paramount that the simulated system demonstrates to display an authentic system in all vital components. The demeanour of the model has to be homogeneous to what transpires into an authentic situation.
It is further described how this has been established. In this paper the accentuation has been put on wind power turbines and induction engenderers. This has been done for the perpetual extension of wind puissance. In the primary research, we have considered a system as shown in the Fig.5.1.

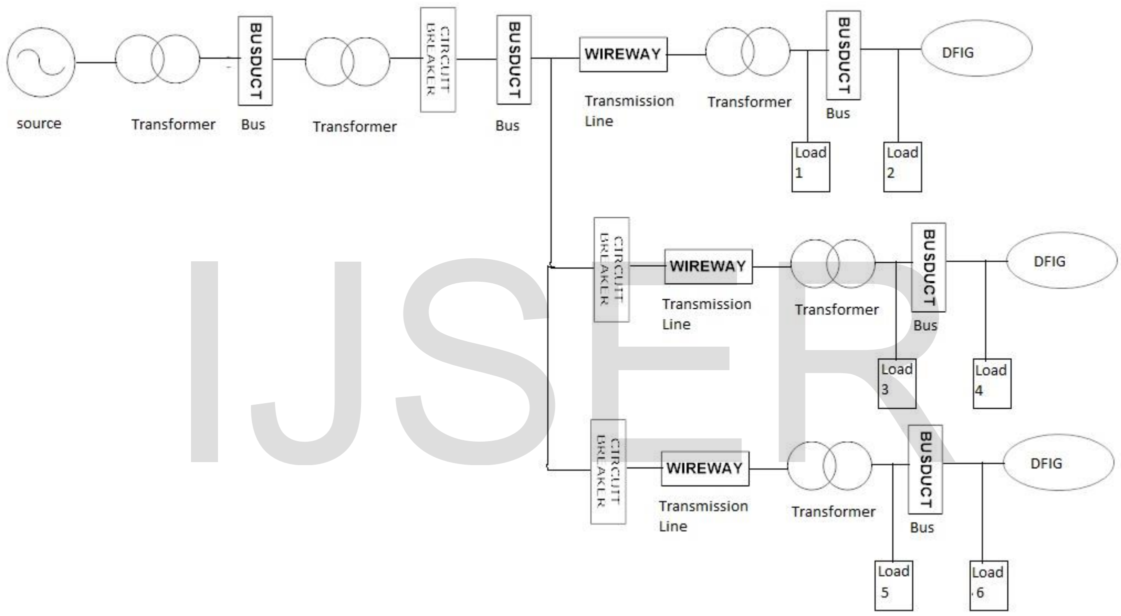


Fig.5.1 Single line diagram of proposed model

In this model three DGs are used. And one of the DG is SOFC fuel system which is a stand-alone system and is operating with a constant rated voltage 1.0 p.u. and power demand 0.7 p.u. The other parameters are the same as in **[15]**. Fuel cells generate power through the electrochemical reaction between hydrogen and oxygen. From the simulation result, we can conclude that the step increase of the demand power is related to the fast electrical response of the fuel cell. After that, the output power started to increase slowly until it reached the demand power. This is due to the slow chemical response time of the fuel processor.

6 RESULT ANALYSIS

In the Fig.6.1, the voltage waveforms at the DG location for the bus voltages 125 KV (topmost waveform), 25 KV (second most waveform from top) and 575 V (Third waveform from top) respectively during islanding are shown. The last (bottom) waveform is form current. It is observed that suddenly voltage decreases. There is no change in the three phase output voltage Vabc_B120 as it does not lie in the fault region. So we obtain three phase sinusoidal output voltage. But the output voltage suddenly decreases for the time range of 0.3 to 0.4 seconds of Vabc_B25 and Vabc_B575 as the circuit breaker which was initially closed was opened with transition time 0.3 to 0.4 seconds.

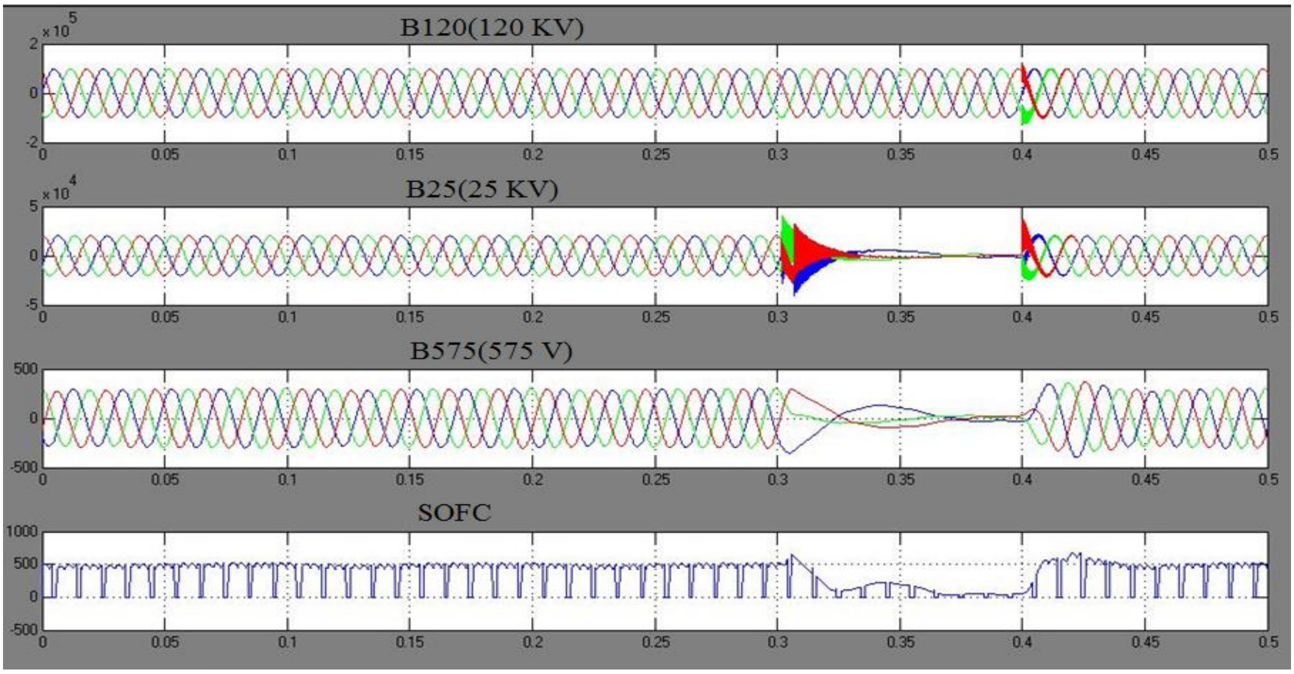


Fig.6.1 The voltage along the source bus (Vabc_B120), across the Vabc_B25 and Vabc_B575 and the rated voltage are shown below respectively for a L-L-L-G fault [transition time: 0.3-0.4], with C.B. transition time [0.3-0.4]

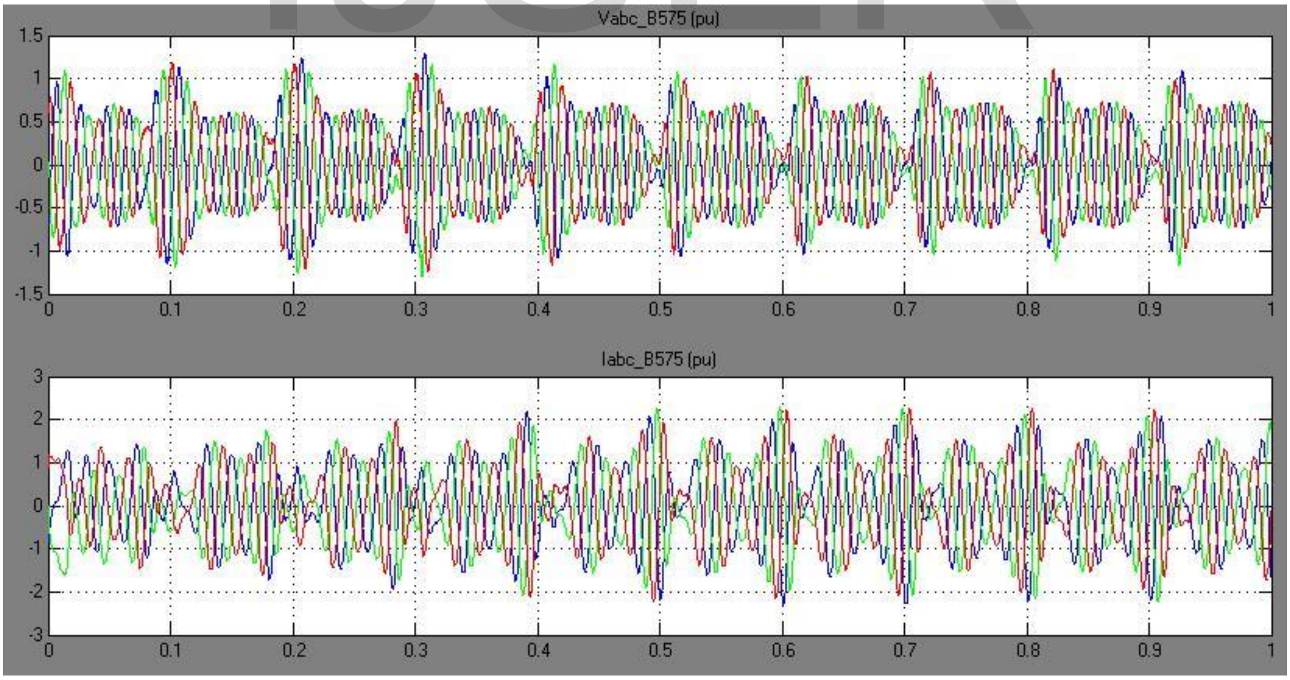


Fig.6.2 Negative Sequence Component of Voltage and Current at normal condition

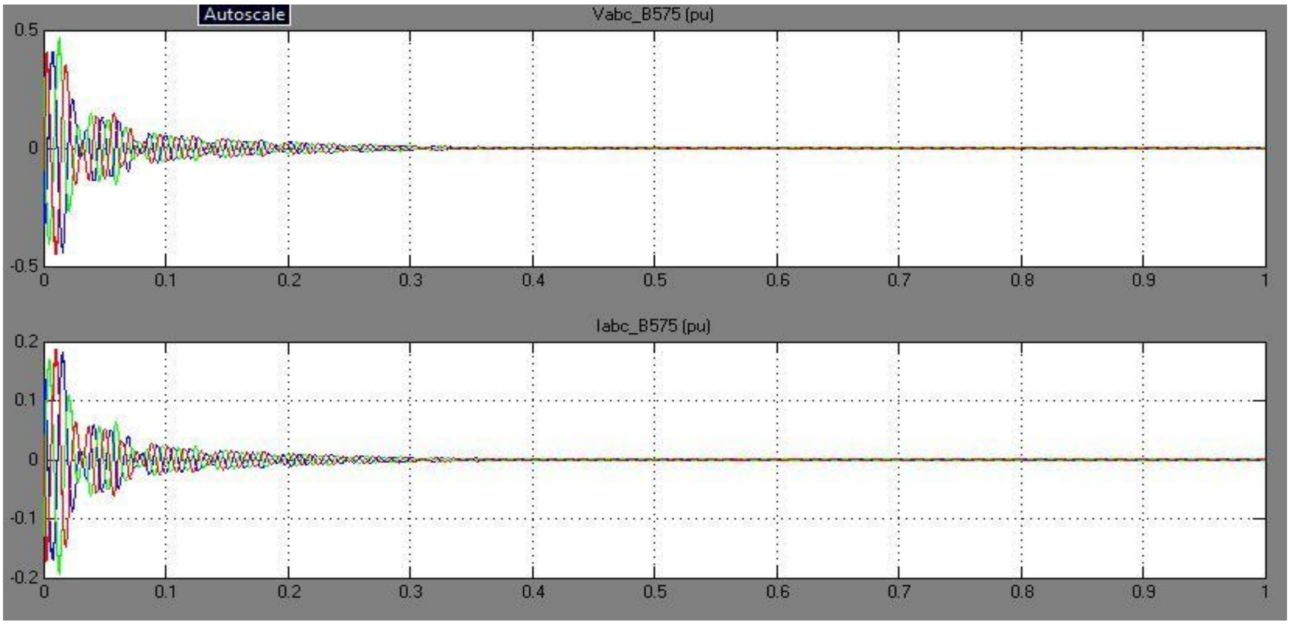


Fig.6.3 Negative Sequence Component of Voltage and Current at Islanding condition

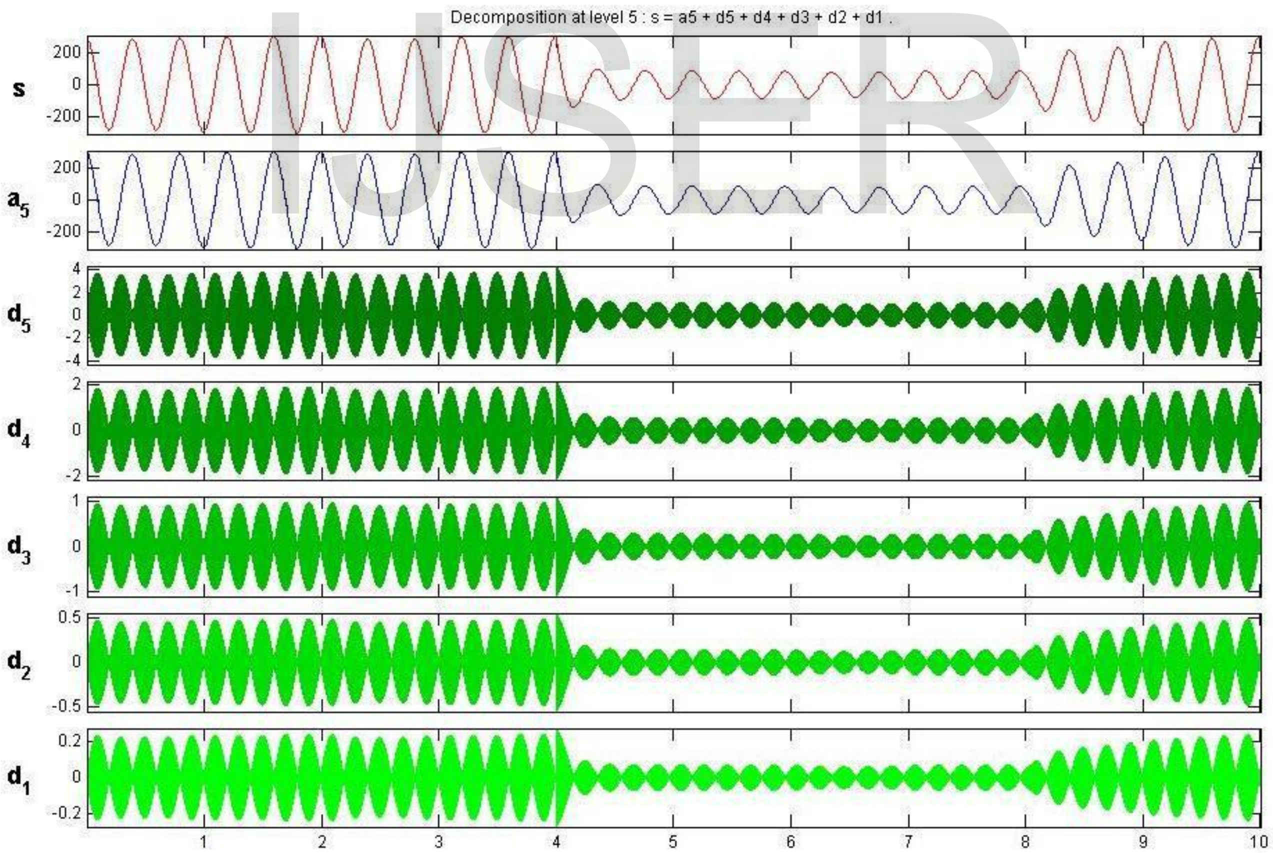


Fig.6.4 Wavelet transform for Islanding Condition detected for the phase B

Condition-1: Both the three phase circuit breaker& three phase fault are in closed conditions. That is the normal condition .So the voltage waveforms found at any DG end is purely sinusoidal.
Condition-2: Three phase circuit breaker is initially closed and is opened with transition time 0.3 to 0.4. Three phase fault is permanently closed. As after switching off the three phase breaker whole part of the distribution system is isolated from the remainder part of the power system. So this is the islanding condition.
Condition-3: Three phase circuit breaker is permanently closed. Three phase fault is initially closed and is opened with transition time 0.2 to 0.4. As another DG is there in the line where three phase fault is connected. This is the DG line trip condition.

7 CONCLUSION

The paper discussed efforts to classify DG islanding operational condition, resulting from main supply interruption. To prevent the possible problems caused by DG islanding, fast and reliable anti-islanding classifier is needed. DWT used in analyzing power system transients provide valuable information for use in feature detection systems. Data obtained from the simulations were analyzed using DWTs. The characteristics of the cases and difference between cases signatures were presented. The results of the DWT analysis shown an ability to quantify different types of disturbances. It also shows high ability of wavelets to extract the different harmonic components disregarding the length of their occurrence in time.

ACKNOWLEDGEMENTS

Sourav Bhattacharjee: *I take this opportunity to thank my entire family for their love and support. I would take this opportunity to thank specially my mentor Dr. Binod Kr. Choudhary for his immense moral support and encouragement.*

S Lakshmi Prasanna: *I express my gratitude towards my friends & few faculties for their guidance & encouragement.*

Kumaresh Pal: *I would like to thank my family & friends for their love, support & encouragement.*

Chandan Kumar: *I take this opportunity to thank my family, friends & colleagues for their love, support & encouragement.*

Soni Kumari: *I express my gratitude towards my friends, family & colleagues for their support & encouragement.*

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