ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
(An ISO 3297: 2007 Certified Organization)
Vol. 5, Issue 3, March 2016

Islanding Detection in Micro Grid Using Wavelet Transform

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ABSTRACT: Distributed energy is generated or stored by a variety of small, grid-connected devices referred to as Distributed Generations (DG).The Micro grid consists of DG resources like photovoltaic, fuel cell, micro turbine generation system and wind energy systems connected to grid/utility supply. When a section of distribution system gets isolated electrically from remainder of the power system, yet DG(s) connected to it continues to energize it, this condition is termed as Islanding. In this paper negative sequence components are used for islanding detection in distributed generation (DG) based system and utilizing the wavelet transform methodology to characterize the DG islanding contingency. The negative sequence component of the voltage signal is used in islanding detection of these resources from the grid. Voltage signal extracted directly at the point of common coupling (PCC) is passed through the above-mentioned techniques and is considered for detection of PQ disturbances due to Islanding. The excellent time-scaling resolution characteristic of WT used for detection of various power quality disturbances of integrating and islanding Micro Grid connected Distributed Generation systems. The proposed methods were verified using a simple distribution system consists of a utility supply/grid with 2 DGs connected (Micro turbine generation system, Wind turbine generation system) and 2 loads connected to it normally. The generated data were used to test the performance of the detection technique. The proposed technique has been simulated and analyzed in SimPowerSystem/MATLAB® simulation software.

KEYWORDS: Micro Grid, Distributed Generations (DG), Islanding, Negative sequence components, WaveletTransform, Distribution System.

I.INTRODUCTION

Power utilities invest huge money for expanding transmission and distribution of power supply because of the fast growing demand of electric energy. Electric power generating plants follow the load demand by increasing the generated power output. In order to meet the expanded load demand, the normal methods include addition of new transmission lines/feeder and generation resources to maintain reliability in power system[1]. In entire power system network more losses occur basically in transmission and distribution lines only. The already stressed transmission system may suffer severe congestion in the next few years as because of increasing power demand. The quality of the power supplying to the utilities, become a red-hot issue recently[2]. Increasing demand of power, affects the power quality. Distributed generation (DG) is one of the most promising alternatives for generation of electric power in today’s time. The advancement in new technology like fuel cell (FC), wind turbine, photovoltaic (PV), and new innovation in power electronics, customer demands for better power quality (PQ) and reliability are forcing the power industry to shift to DGs. Generally, a DG system consists of small-scale power generation resources like wind, photovoltaic, fuel cell, etc., that are located close to loads. The Hybrid grid is defined as a cluster of Distributed Generations (DGs), loads and energy storage systems connected to utility grid to serve the demand.[3-5].

According to the IEEE standards 1547-2003, Islanding concept is "a condition in which a portion of the utility system that contains both loads and Distributed Energy Resources (DER) remains energized while isolated from the remainder

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of the utility system"[6]. Islanding is a phenomenon that occurs when DG resources feed to the local load and the utility grid is disconnected. Accurate and early detection of these disturbances is very important to improve the operation of DG systems. Moreover, islanding operation may present a threat to the safety of the working personnel. These issues call for immediate disconnection of the DG as per IEEE Standard 1547-2003 [6].

According to the IEEE 929-1988 standard **[7]**, in islanding condition the DG has to be disconnected as soon as possible. The shutdown of the utility grid might lead to Islanding of engenderers, throughout the maintenance accommodation on the utility grid.

II. DISTRIBUTED GENERATION

Distributed energy, also on-site generation (OSG)[8] or district/decentralized energy is generated or stored by a variety of small, grid-connected devices referred to as distributed energy resources (DER) or distributed energy resource systems[9].Distributed energy resources are mass-produced, small, and less site-specific.Hence, DG can fulfill customer's demand in stand-alone as well as grid-connected mode as per situation requirements and the surplus power generation can be fed to the grid thereby increasing the reliability of power supply. But there are many issues to be seriously and critically considered with the DG connected to utility grid such as islanding of resources and PQ disturbances such as voltage sag, swell, notch, momentary interruptions, etc[10].The primary advantages of DG systems are that consumers can generate electric power with or without grid backup and the surplus power generation (PG) can be sold back to the grid under low load-demand conditions.Distributed generation reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used. A microgrid is a localized grouping of electricity generation, energy storage, and loads that normally operate connected to a traditional centralized grid (macrogrid). This single point of common coupling with the macrogrid can be disconnected. The microgrid can then function autonomously.[11]

III.ANTI-ISLANDING CONDITIONS

If DG feeds power to the local loads and utility grid supply gets isolated due to some emergency conditions, then it is called islanded operation which leads to several negative impacts on utility power system and the DG itself, such as the safety hazards to utility personnel and the public, the quality problems of electric service to the utility customers, and serious damages to the DG if utility power is wrongly restored[12]-[13].There are also safety and health issues.

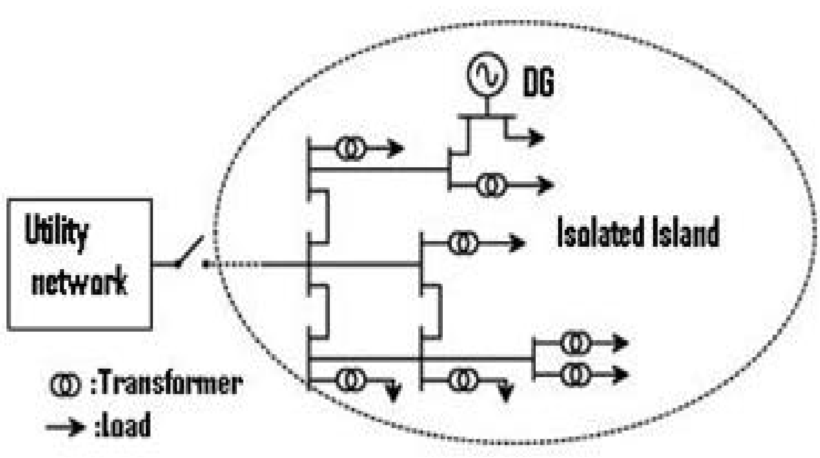

Fig.1: Scenario of Islanding Operation

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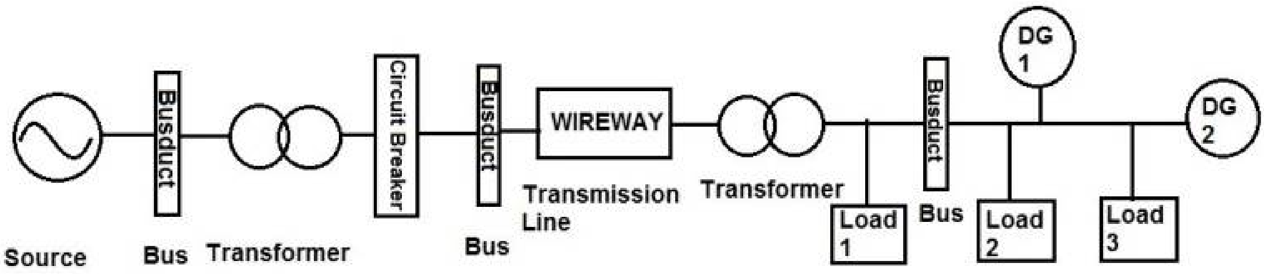

Fig.2: Single Line diagram

IV.WAVELET THEORY

Wavelets can be formulated to describe signal in a localized time and frequency format by decomposing it into its constituents at different frequency bands. Wavelet Transform (WT) is a fast and efficient means of analysing transient voltage and current signals. Wavelet technique has been used in several power system applications e.g. detection, feature extraction, de-noising and data compression of power quality waveforms, power system protection etc. [14-16].One important aspect of the signals under islanding and PQ condition is that the information is often a combination of features that are localized in time and frequency and called non-stationary signal. Due to non-stationary property of transient signals, a wavelet based signal processing technique is considered as an effective tool. Using the wavelet transform, it is possible to decompose a signal into several signals in different frequency bands, which are known as wavelet coefficients. WT divides up data, functions into different frequency components, and then studies each component with a resolution matched to its scale.

Wavelet transformation can be either continuous or discrete. However, the Discrete Wavelet Transformation(DWT) is more widely used, mainly due to its computational efficiency, data compression capability and simplicity as well as non-redundancy. DWT is a signal-processing tool which can be applied when time-varying harmonics must be evaluated and, as in the case of the detection of the islanding condition, time localization is required [17]-[18].

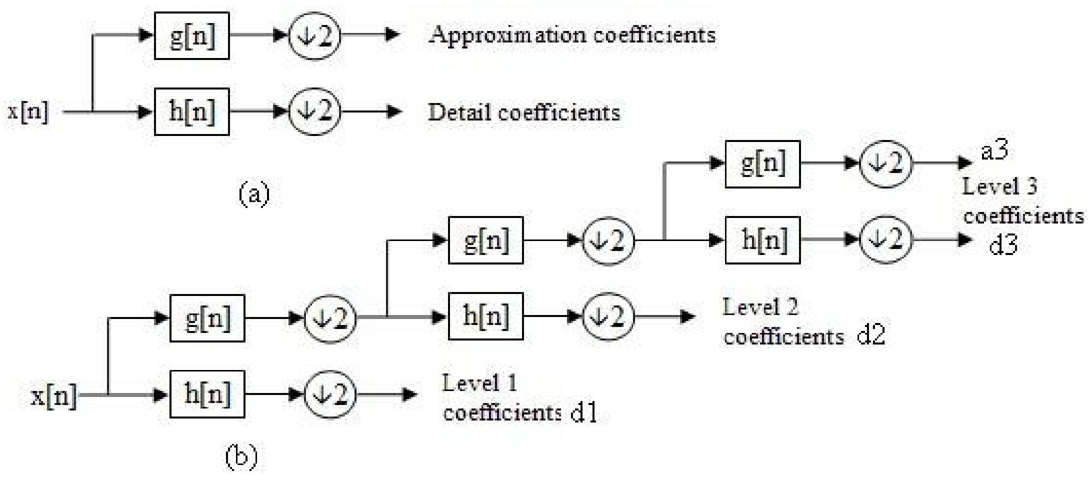

Fig. 3: (a) Analysis wavelet filter banks (b) 3-stage DWT decomposition

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DWT of a discrete signal $f(k)$ is mathematically defined as shown in eqn.(1)

$$DWT_{\psi}.f(m.n)=\sum_{k}f(k).\psi^{*}_{m,n}(k) \quad \text{................ (1)}$$

Where the discrete mother wavelet is as follows

$$\psi_{m,n}(t)=\frac{1}{\sqrt{a_0^m}}.\psi\left(\frac{t-n.b_0.a_0^m}{a_0^m}\right) \quad \text{................. (2)}$$

Where a_0 (>1) and b_0 (>0) are fixed real values and m andn are positive integers.

V. NEGATIVE SEQUENCE COMPONENT AT DG LOCATION

In this proposed technique, the negative sequence component of the voltage retrieved at the target DG location is considered for analysis towards effective detection of islanding and non-islanding events. The negative sequence component of voltage and current signals at the target DG location can be expressed by symmetrical component analysis as:

$$V_n=\frac{1}{3}(V_a+\lambda^2 V_b+\lambda V_c) \quad \text{..................... (3)}$$

$$I_n=\frac{1}{3}(I_a+\lambda^2 I_b+\lambda I_c) \quad \text{............... (4)}$$

Where V_a, V_b, V_c are three phase voltages, and I_a, I_b, I_c are three phase currents. The negative sequence component of the extracted voltage and current signals at the target DG location i.e. at PCC (Point of Common Coupling) is obtained by passing it through the three-phase sequence analyser block in MATLAB/Simulink. Out of the three sequential components, it is only negative sequence component of the voltage signal, considered in this study because it reflects the information under disturbance condition. Quantification of the negative-sequence voltage at the target DG location is carried out which provides high degree of immunity to noise, for detection of islanding event and other disturbances due to sudden load change, DG line cut-off etc, thus enable better performance.

VI.PROPOSED MODEL

The islanding conditions occur when the utility circuit breaker is opened. The fault happening in the upstream network is the main reason for the circuit breaker opening. The local methods detect the islanding conditions by change in the monitored values (measured at PCC) caused by utility circuit breaker opening. The proposed method measures the negative sequence component of voltage signal. This measured parameter is processed by the discrete wavelet transform (DWT). The DWT extract the feature from the measuredparameter to distinguish between the islanding conditions from non-islanding ones.

VII.SIMULATION RESULTS

In the proposed model, two individual DGs are connected to the utility supply having bus voltage of 120KV. One of the DG connected is Wind system and the other is Micro turbine system. Utility supply of 120KV is stepped down to 25KV & by using transmission line of 20Km it is brought to distribution side & the voltage is stepped down to 574V. Here we have considered three different bus voltages for our analyse as shown in fig.2.

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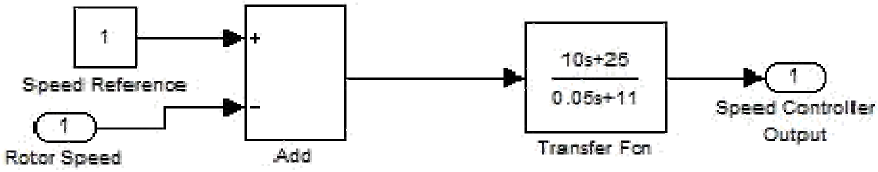

Fig. 4: Simulink Representation of Micro Turbine system

The above figure (Fig.4) shows the Simulink representation of the micro turbine system that is used in main Simulink model of micro grid for the analysis of Islanding i.e. it is connected as one of the DG to distribution system.

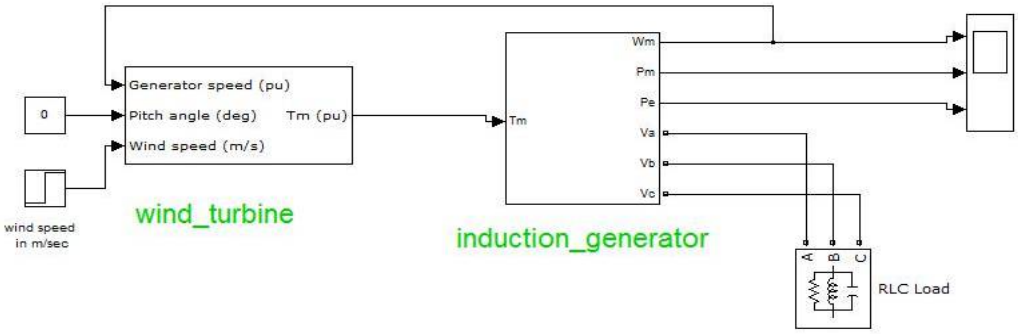

Fig.5: Wind Turbine Simulink Model

The above figure (Fig.5) shows the Simulink representation of the Wind turbine system that is used in main Simulink model of micro grid for the analysis of Islanding i.e. it is connected as another DG to distributed system.

In Fig.6, Fig.7 and Fig.8, we can visualise the voltage waveforms when a symmetrical fault (L-L-L-G)occurs in distribution system and how an Islanding occurs.The output voltage suddenly decreases for the time range of 0.025 to 0.075 seconds of 25KV bus and 575V bus as the circuit breaker which was initially closed is opened with transition time of 0.05 to 0.08 seconds.

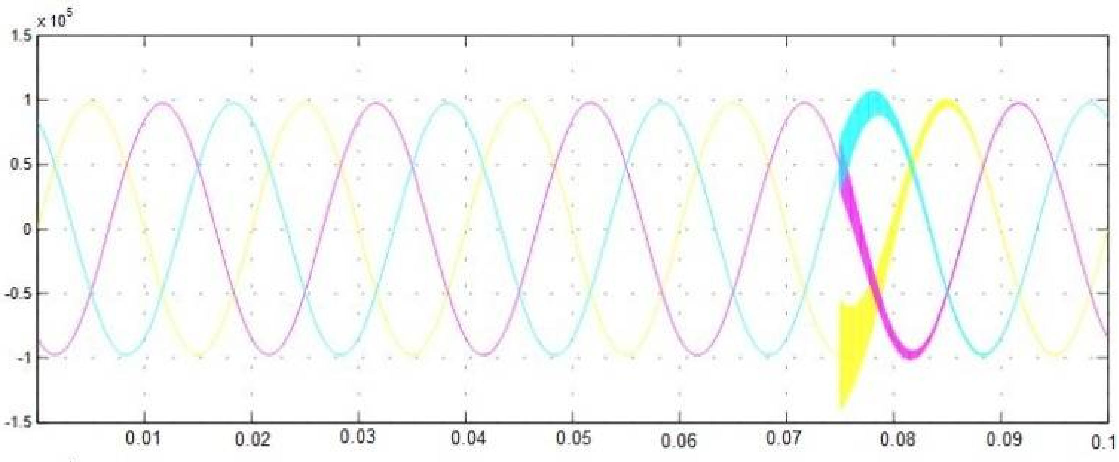

Fig.6: Phase voltage waveform of 120KV bus during Islanding

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In the above figure (Fig.6), the three phase output voltage waveform for the bus of voltages 120 KV is shown. The voltage is merely affected due to a fault in distribution system, almost there is no change in the three phase output voltage from 120 KV bus as it does not lie in the fault region.

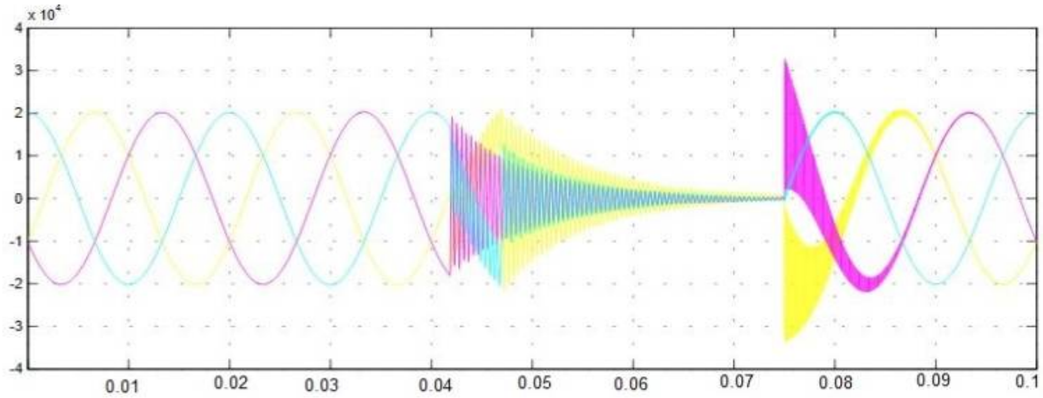

Fig.7: Phase voltage waveform of 25KV bus during Islanding

In the above figure (Fig.7), the three phase output voltage waveform of bus of voltage 25KV is shown.It is observed that slowly voltage decreases as due to the fault occurrence.

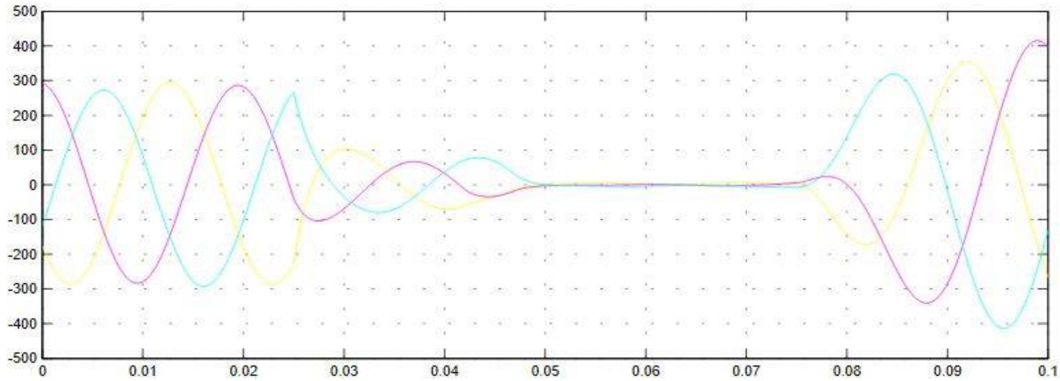

Fig.8: Phase voltage waveform of 575V bus during Islanding

In the above figure (Fig.8), the three phase output voltage waveform of bus of voltage 575V is shown. It is observed that suddenly or drastically the voltage decreases as due to Islanding, because here the fault is closer to the bus.

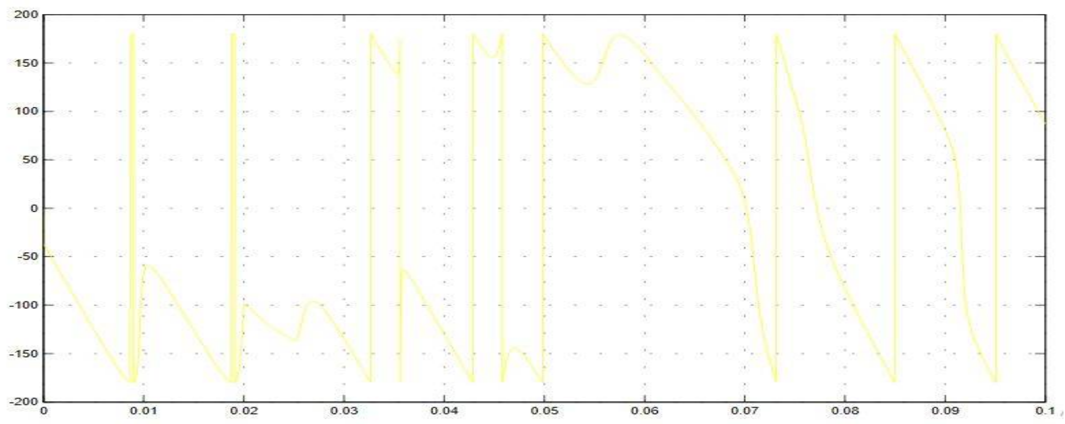

Fig.9: Negative Sequence Component of Voltage at PCC

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In the above figure (Fig.9), the negative sequence component waveform of voltage derived from distribution system i.e. at PCC (Point of Common Coupling) during Islanding condition is shown. This negative sequence voltage gives the clear idea of Islanding occurrence.

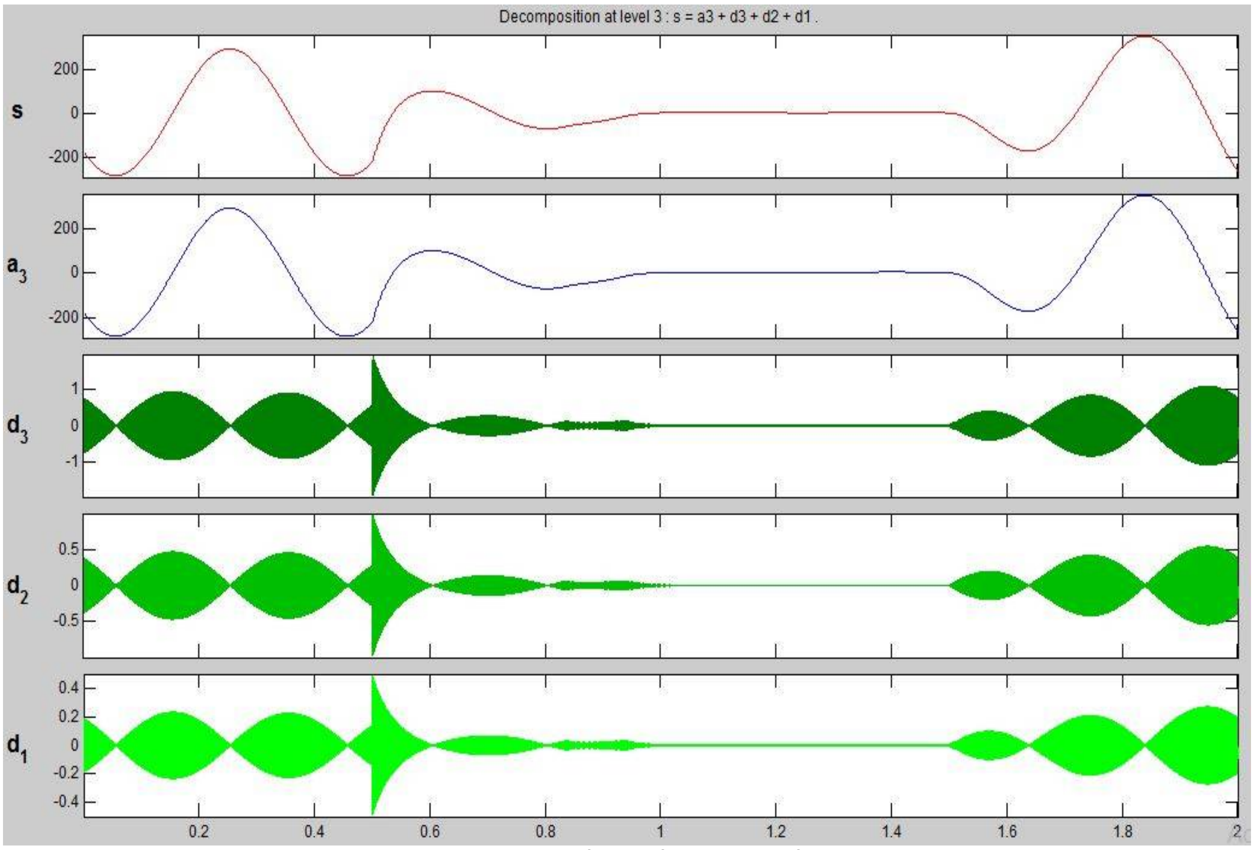

Fig.10: 3-stage wavelet decomposition of one of the phase of 575V bus during Islanding

VIII. CONCLUSION

The proposed technique investigates the negative sequence component of voltage for islanding detection in Microgrid distributed generations. Wavelet transform is used to process the negative sequence voltage signal & bus voltage at PCC. Data obtained from the simulations were analysed using DWTs. The characteristics of the cases and difference between cases signatures were presented. The results of the DWT analysis have 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.

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