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SAG/ SWELL AND FREQUENCY STABILITY DETECTION USING MODIFIED SYNTHESIS FILTERS OF QMF

Murugesan.C[1] and Gopinath. K[2]
[1]PG Student, [2]Assistant Professor
Department of Electrical and Electronics Engineering, P.S.V College of Engineering& Technology, Krishnagiri, India

Abstract— This Paper proposes a novel sag/swell detection algorithm based on wavelet transform (WT) operating even in the presence of flicker and harmonics in source voltage.The developed algorithm is the hybrid of Dauble chies wavelets of order (db2) and order (db8) to detect voltage sag/swell with and without positive/negative phase jumps.The good robustness and faster processing time to detect balanced and unbalanced voltage sag/swell are provided using proposed method. With the proposed hybrid detection algorithm consisting of db2 and db8 wavelet functions, a robust sag/swell detection is achieved which can give precise and quick response. The performance of proposed hybrid algorithm is validated and confirmed through simulation studies using the MATLAB analysis program.

Keywords- WT, FFT, PQ, IEEE, IEC,PWM, PEE

I. INTRODUCTION

Nowadays, the end users are affected and exposed to the unexpected malfunction and outage due the widespread application of power electronic loads that are more sensitive to voltage/current disturbances and high frequency transients Power quality (PQ) problems can be described as any variation in the electrical power supply such as voltage sags/swell, interruption, flicker, harmonic and notch. Also, The International Electro technical Commission (IEC) defines the PQ in IEC 61000-4-30 as: ‘‘Characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters’’. This definition is related to the possibility of measuring and quantifying the performance of the power system. Another standardized PQ definition is given by IEEE standard 1100 as: ‘‘The concept of powering and grounding sensitive equipment in a matter that suitable to the operation of that equipment’’ The voltage sag/swells are short duration variations of the root mean square (RMS) value of the voltage from the nominal value. The voltage sag/swells are characterized by their magnitude and duration. Depending on their duration they can be instantaneous, momentary or temporary. The different definitions and limits for magnitude and duration of voltage sag/swell are mentioned in European Standard EN50160 and in IEEE Std. 1159-2009.The voltage sag/swells are usually associated with system faults or with switching or heavy loads. They constitute one of the most important PQ disturbances because of their detrimental effect on equipment. Their fast detection and analysis are one of the most important problems in modern power systems. There is no standard method defined to detect and analyze the voltage sag/swell. There are several methods used in the literature that can be applied to this end, although none of them is dominant.Standard IEC 61000-4-7 and Refs. report some of the most commonly used methods. They can be divided into two categories: time-domain and frequency-domain methods. The time-domain methods are the comparative, the envelope, the sliding window, the dv/dt and the RMS methods. The time-domain methods are easy to implement than the frequency-domain methods but they can present worse detection performance than the frequency domain methods. The most common frequency-domain methods are FFT, Kalman filter, wavelets and S-transform. The use of wavelets allows the decomposition of a signal into components as a function of time and frequency, providing a more precise time location of a transient than other frequency-domain methods. The voltage sags/swell can be exactly detected using discrete wavelet transform (DWT), which is a powerful and useful tool to analyze non-stationary signals. The well-known application of the DWT is to detect, characterize and locate power system transients.. Much research efforts have focused on wavelet-based techniques applied on analyzing power system transients, detecting and classifying PQ disturbances and faults. The start and end times of voltage sags and faults were also detected by means of the wavelet transform analysis. In addition, the wavelet transform can be used for harmonic indices assessment, the detection of harmonic sources, fault location detection, computation of power quantities and islanding detection in PV systems . In the previous studies, to classify the PQ disturbances and to detect the voltage sags/swell, the effect of disturbances was analysed individually and the effectiveness of system under different combinations of PQ disturbances was not analyzed. But in real power systems the voltage waveform is non-stationery and distorted with flicker and harmonics. In this research paper, a novel algorithm to detect the voltage sag/swell in harmonics and flicker distorted non-stationary voltage signals is proposed. The hybrid discrete wavelet transform (DWT) is developed to detect fast changes in the voltage signals, which allows time localization of differences frequency components of a signal with different frequency wavelets.As the composition of power systems changes with the increased use of distributed generation (DG), the ability to maintain a secure supply with high power quality is becoming more challenging. The increased use of power electronic converters as part of loading systems could cause further power quality problems: converters act as strong harmonic current (or voltage) sources. The information on power system parameters(particularly the net power system impedance to source) at any instant in time is central to addressing these problems. For example, power system impedance monitoring is an important enhancement to active filter control. The impedance estimation can be embedded into the normal operation of grid connected power electronic equipment (PEE) such as sinusoidal rectifiers and active shunt filters (ASF). PWM harmonics associated with PEE, as measured in the active filter line current or voltage at the point of common connection (PCC) can provide non-invasive estimation of power system impedance changes, although it is not accurate enough to provide a suitable value for control. A small disturbance introduced by a short modification to the PEE's PWM strategy can be used to excite the power system impedance and the associated voltage and current transients can be used to determine more exactly the supply impedance back to source, Zs. This invasive method is only triggered when the non-invasive method determines a significant change in Zs.

The previous estimation strategy required that the PEE line current and PCC line voltage be measured for 160 ms before the transient injection, and 160 ms post-transient in order to get a suitable frequency resolution for the impedance measurement(6.25 Hz). The analysis proposed in this paper would substantially reduce the period for data capturing to 5 ms post transient, and reduce pre-transient data requirement. This is because the Continuous Wavelet Transform (CWT) is used to process voltage and current transients for calculating the supply impedance. The proposed method therefore has the potential to determine the change in the supply impedance within half a supply cycle.This project introduces the concept of real-time impedance estimation, and then describes how CWT is used to significantly speed up impedance estimation, demonstrating this capability with experimental results. The paper then goes on to describe how this estimation technique may be used to locate faults inside and outside a defined power "zone." Fault identification and location is an important application of real-time impedance estimation, and may find use in renewable/distributed energy systems, and power grids for more-electric aircraft and more-electric ships.

II. PROPOSED SYSTEM

- This project proposes a novel sag/swell detection algorithm based on QMF with modified synthesis filters with reduced number of operations while operating even in the presence of flicker and harmonics in source voltage.
- The good robustness and faster processing time to detect balanced and unbalanced voltage sag/swell are provided using proposed method.

- The performance of proposed hybrid algorithm is validated and confirmed through simulation studies using the MATLAB analysis program.

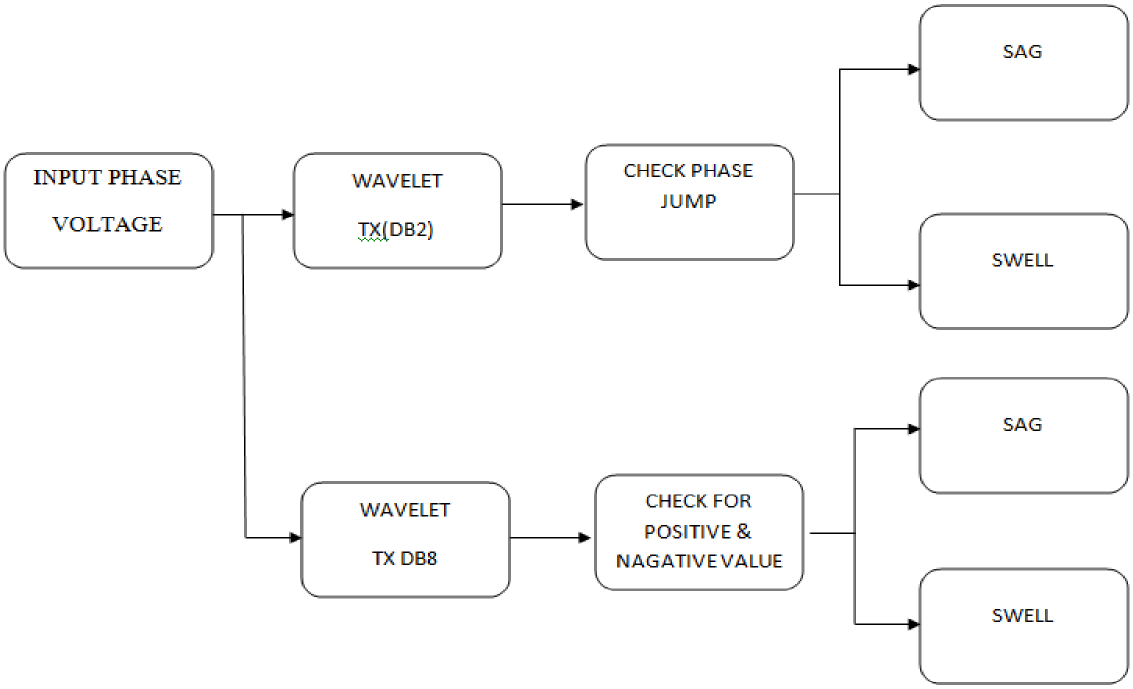

Fig 1. Block diagram

Dmey Both and ψ defined in the frequency domain ,starting with an auxiliary function v by typing wave info('meyr') at the MATLAB command prompt,you can domain obtain a survey of the main properties of this wavelet. General Characteristics infinitely regular orthogonal wavelet. The Demy wavelet and scalling function are defined in the frequency domain wavelet function.

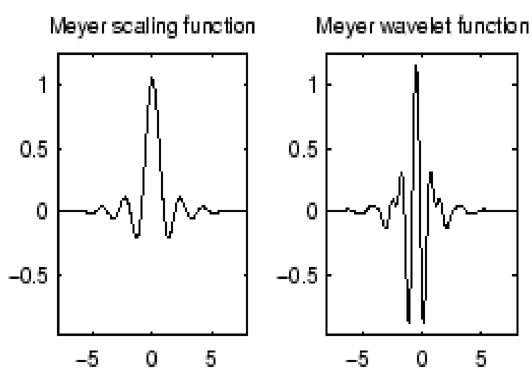

Fig 2. Dmey wavelet waveform

QMF SCHEMES

The performance of the proposed voltage sag/swell detection method is compared with the results of dq-transformation, Fast Fourier Transform (FFT) and Enhanced Phase Locked Loop (EPLL) based voltage sag/swell detection methods.

In digital signal processing, a **quadrature mirror filter** is a filter whose magnitude response is the mirror image around $\pi/2$ of that of another filter.

Together these filters are known as the Quadrature Mirror Filter pair.A filter $H_1(z)$ will be quadrature mirror filter of

$H_0(z)$ if $H_1(z) = H_0(-z)$. The filter responses are symmetric about

$$\Omega = \pi/2 |H_1(e^{j\Omega})| = |H_0(e^{j(\pi-\Omega)})|$$

In audio/voice codes, a quadrature mirror filter pair is often used to implement a filter bank that splits an input signal into two bands. The resulting high-pass and low-pass signals are often reduced by a factor of 2, giving a critically sampled two-channel representation of the original signal. The analysis filters are often related by the following formulae in addition to quadrate mirror property:

$$|H_0(e^{j\Omega})|^2 + |H_1(e^{j\Omega})|^2 = 1$$

where Ω is the frequency, and the sampling rate is normalized to 2π.

This is known as power complementary property. In other words, the power sum of the high-pass and low-pass filters is equal to 1.Orthogonal wavelets the Hear wavelets and related Daubechies wavelets, Coif lets, and some developed by Mall at, are generated by scaling functions which, with the wavelet, satisfy a quadrature mirror filter relationship.

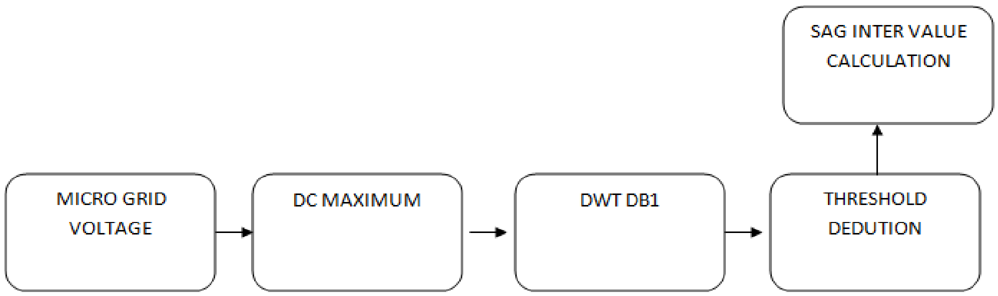

Fig 3. Sag /Swell Harmonic detection

ANALYSIS BANK

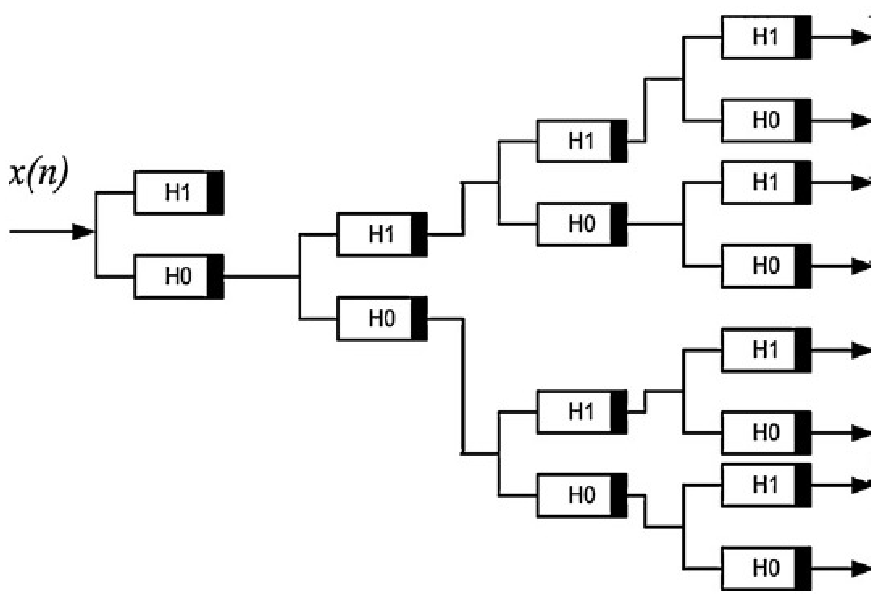

Fig 4. Analysis Bank

SYNTHESIS BANK

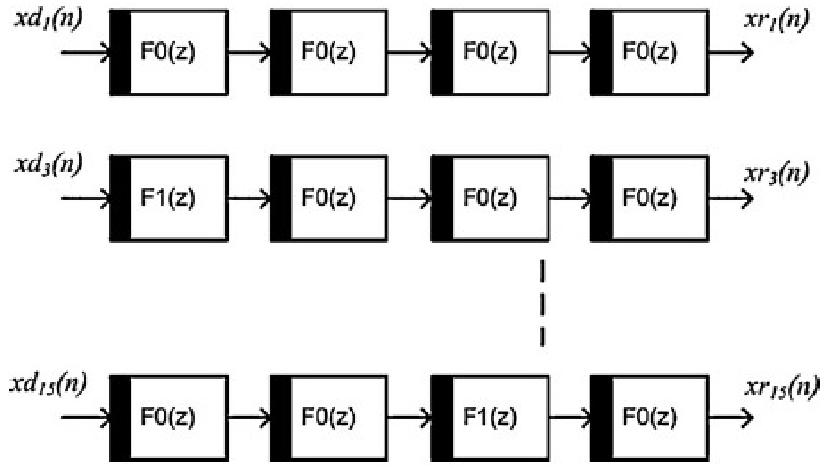

Fig 5. Synthesis Bank

In this situation the best way to construct an equivalent filter bank is to use the multi rate technique. Fig. 5.2 shows how an equivalent structure to Fig. 5.1 can be obtained by using the multirate approach. The filters H0(z) and H1(z) are quadrature mirror filters (QMF), designed using the power-symmetric approach,with the first one as a low-pass filter and the second a high-pass filter. At this point is useful to comment the difference between the QMF filters and typical wavelets filters, such Daubechies filters.

The first difference is in the form that the high-pass filter is related with the low-pass filter. In QMF approach the relationship is given by H1(z) =H0(−z) what implies that the impulse response of the H1(z) has alternating signs, meaning, {h0(0), −h0(1), h0(2),−h0(3)., where h0(n) is the impulse response of H0(z). In this case the magnitude of the high-pass filter is a mirror image of the magnitude of the low-pass filter with respect to the middle frequency. In the Daubechies filters the relationship is giving by H1(z) =−zN ·H0(−z) resulting in an alternating flip in the impulse response, {h0(N), −h0(N−1), h0(N−2), −h0(N−3).

The second point is related with the way that the filters are generated. The QMF filter can be designed by using different techniques in frequency domain, being the power-symmetric approach used in this work.

The wavelet filters are generated by using time domain especial function, proposed by the wavelet family creator. The simulations presented at this paper reveals that QMF filters are better choice for harmonic decomposition application than wavelet filters.

Note that the central frequency of each filter corresponds to the odd harmonic. Also the band-pass filters have poor rejection for even harmonics, so if they are present in the input signal they will mix up with even harmonics.

The main difference between the structure shown in Fig., and the other one obtained by using the multi rate technique, is the fact that the equivalent band pass filter is obtained by using only two QMF filter (low-pass and high-pass) and decimating operator. It can be represented by the equivalent filter bank . The decimated signal at the output of each filter has a sampling rate 16 times lower then the input signal.

Note that the central frequency of each filter corresponds to the odd harmonic. Also the band-pass filters have poor rejection for even harmonics, so if they are present in the input signal they will mix up with even harmonics. Section 2.3 will focus on the way to eliminate even harmonics adding an extra IIR band pass filter at each output on the analysis filter banks structure.

The equivalent filters Hi(z), with i=1, 2. k, are obtained by using the noble identities for multi rate systems. These identities are shown in Fig. 6(a) and (b). The first identity shows that H(z) must be changed to H (zM) when the down-sampling operator is moved from left to right. The second identity shows the reverse case.

Moving the down-sampling operators corresponding to the levels1–3, in Fig. 3 to the right side of the level 4, and by using the noble identity 1, one can write, for example,

$$H1(z) = H0(z) \cdot H0(z2) \cdot H0(z4) \cdot H0(z8) \quad (1)$$

and,

$$H7(z) = H0(z) \cdot H0(z2) \cdot H1(z4) \cdot H0(z8) \quad (2)$$

MultiMate systems employ a bank of filters with either common input or summed output. The first structure is known as analysis filter bank as it divides the input signal into different sub bands in order to facilitate the analysis or the processing of the signal. The second structure is known as synthesis filter bank and is used if the signal needs to be reconstructed. Together with the filters, the MultiMate ystemsmust include the sampling rate alteration operator (up- and down-sampling). Figure shows two basic structures used in a MultiMate system. Figure shows a decimator structure composed by a filter followed by the down-sampler device with a down sampling factor of M, and next figure shows the inter-politer structure composed by a up-sampler (with an up-sampling factor of L) followed by a filter. The decimator structure is responsible to reduce the sampling rate by M, while the interpolator

Structure to increase it by L. The decimator and interpolator, used in this work is, when M= L = 2, is presented. The direct way to build an analysis filter bank, in order to divide the input signal in its odd harmonic component, is represented in

Figure In this structure Hk(z) is the transfer function in the z domain of the kith band-pass filter centered at the kith harmonic and must be designed to have 3 dB bandwidth lower than 2f0, where f0 is the fundamental frequency. If only odd harmonics are supposed to be present in the input signal, the 3 dB bandwidth can be relaxed to be lower than 4f0. Note that Fig. 2 is not amultirate system, because the structure does not include sampling rate alternation, which means that there is only one sampling rate in the whole system. The practical problem concerning the structure shown in Figure is the difficulty to design each individual band-pass filter. This problem becomes more challenging when a high sampling rate must be used to handle the signal and the consequent abrupt transition band. In this situation the best way to construct an equivalent filter bank is to use the multirate technique. The filters H0(z) and H1(z) are quadrature mirror filters (QMF), designed using the power-symmetric approach, with the first one as a low-pass filter and the second a high-pass filter. At this point is useful to comment the difference between the QMF filters and typical wavelets filters, such Daubechies filters. The first difference is in the form that the high-pass filter is related with the low-pass filter. In QMF approach the relationship is given by H1(z) =H0(-z) what implies that the impulse response of the H1(z) has alternating signs, meaning, {h0(0), -h0(1), h0(2), -h0(3). . .}, where h0(n) is the impulse response of H0(z) [2]. In this case the magnitude of the high-pass filter is a mirror image of the magnitude of the low-pass filter with respect to the middle frequency. In the Daubechies filters the relationship is giving by H1(z) =-zN ·H0(-z) resulting in an alternating flip in the impulse response, {h0(N), -h0(N-1), h0(N-2), -h0(N-3). . .}. The second point is related with the way that the filters are generated. The QMF filter can be designed by using different techniques in frequency domain, being the power-symmetric approach used in this work. The wavelet filters are generated by using time domain especial

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III. SIMULATION RESULTS

To verify the feasibility of the proposed strategy, simulations are carried out.

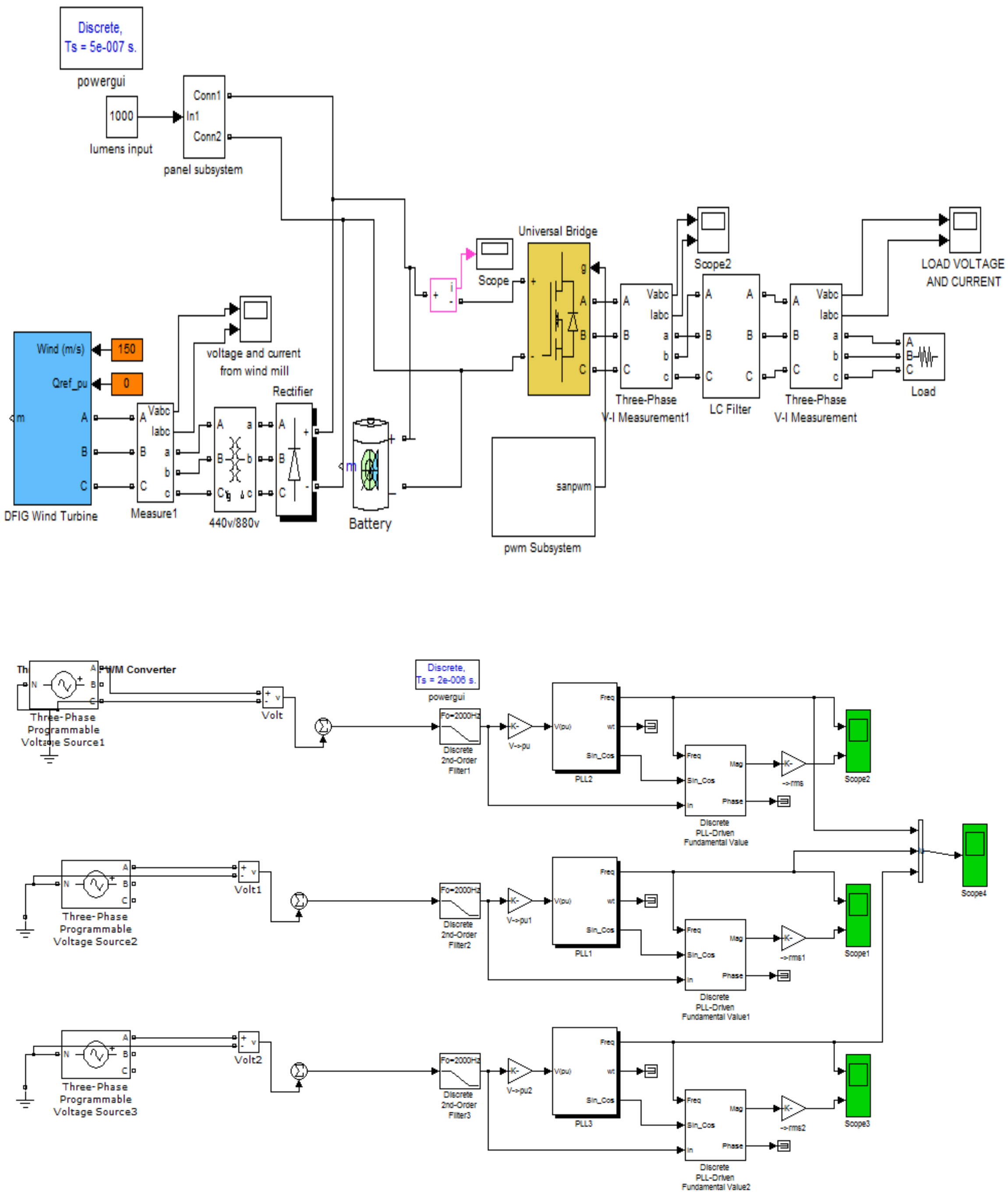

Fig.6. Proposed system Simulink diagram

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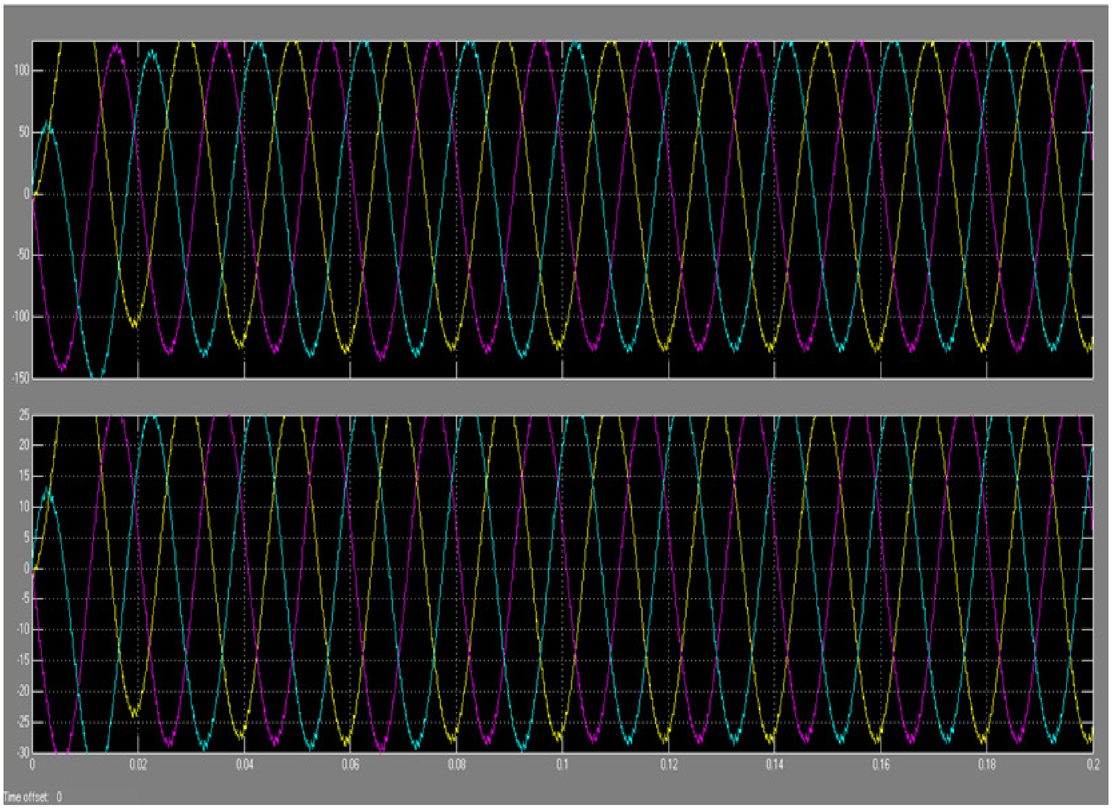

Fig.7. Three phase AC voltage and current

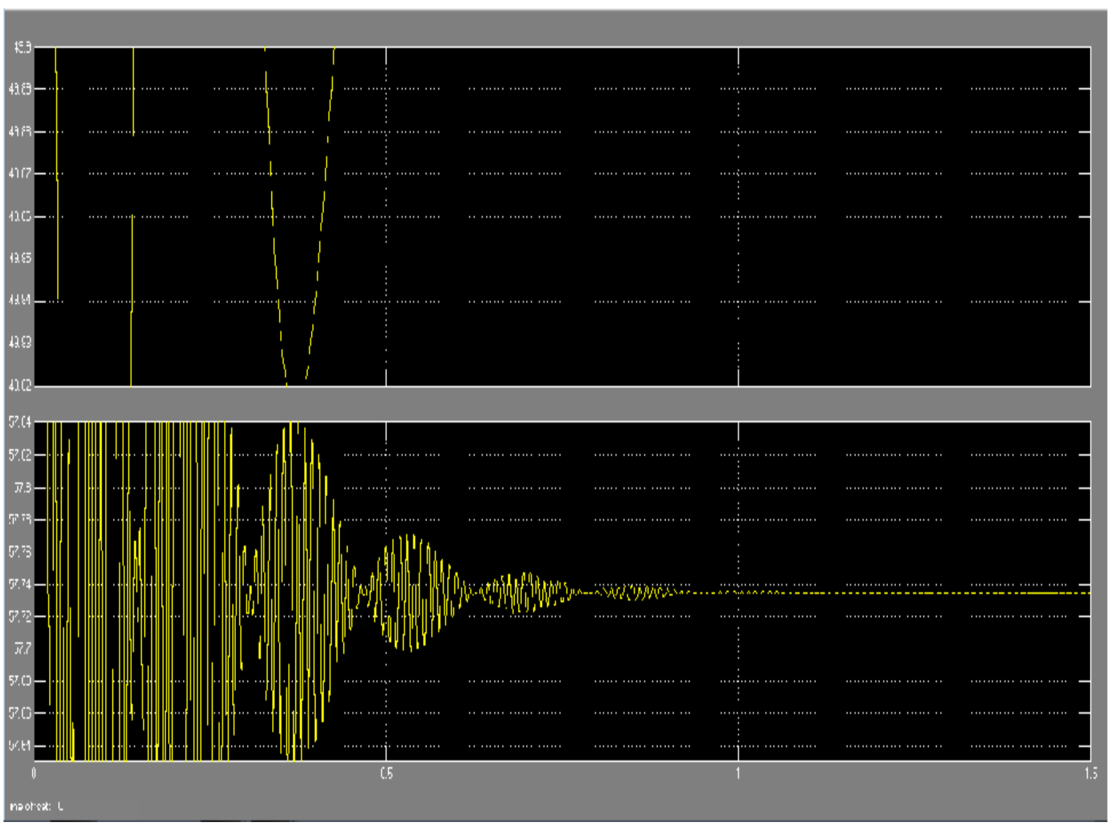

Fig.8. Three phase AC voltage sag swell

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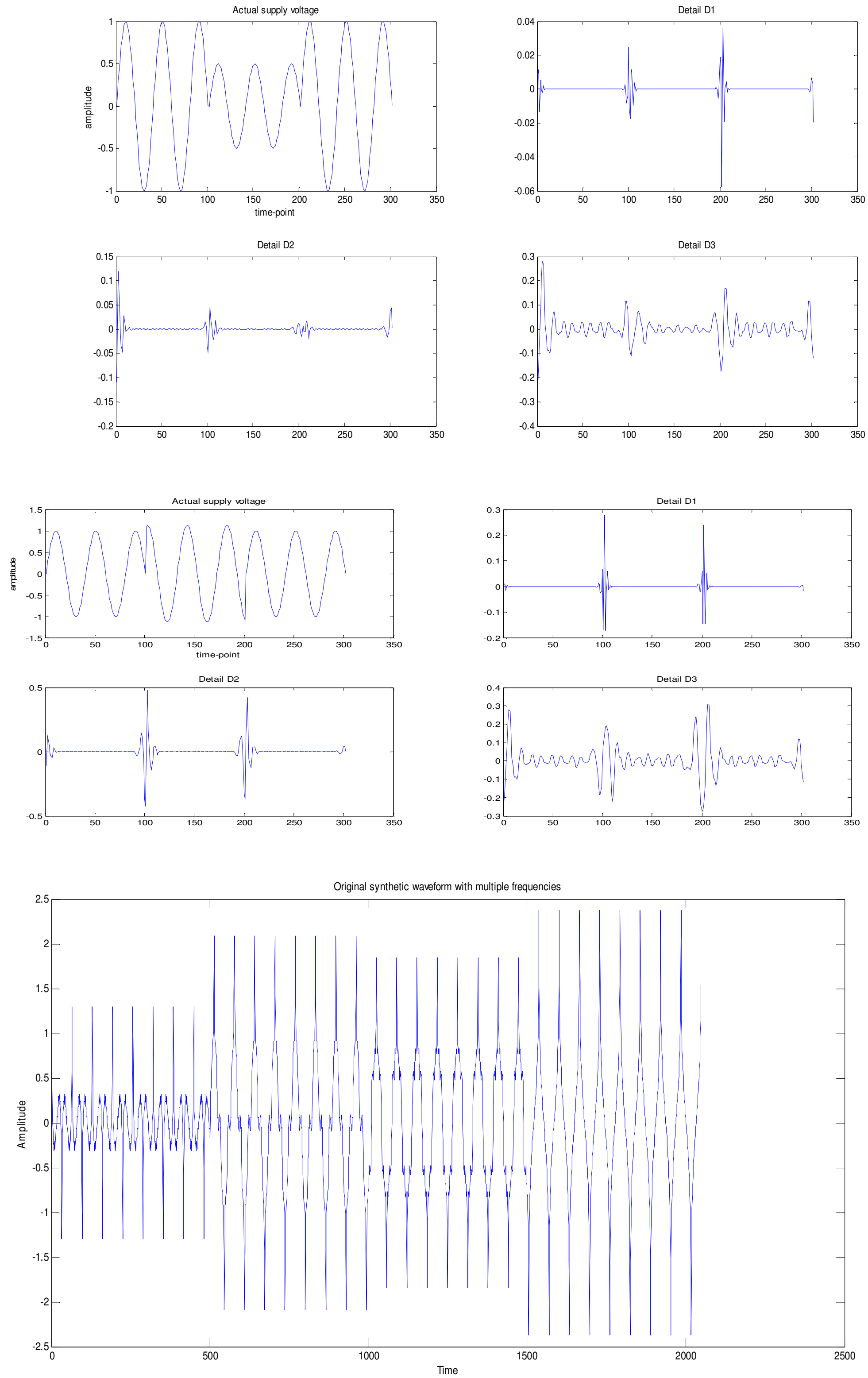

Fig.9. Sag, Swell, frequency variation detection

IV. CONCLUSIONS

This project proposed a novel method of QMF based abnormality detection to decide the decision of islanding is needed or not. Using wavelet transforms always results in time localization and hence the instant of islanding also can be detected with our proposed method. The problem of micro grid is its discontinuity in the power delivery based on the available power. This is a serious problem in power delivery. A Simulink model consisting of a distributed generator and the main power grid based generator is designed and faults are created at random times. In such conditions, islanding is needed to protect the loads, grids and even to maintain the continuity in the power delivery. QMF transform are the peculiar category of frequency domain approaches, where, the time localization property is well utilized to find the time instant of such faults. The implementing algorithm of the presented method is derived and its performance is analyzed in detail. Theoretical analysis and experiment results proved that the proposed method is practically feasible.

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