International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE)
ISSN: 0976-1353 Volume 20 Issue 3 – MARCH 2016.

HARMONIC CURRENT INJECTION BASED ISLAND DETECTION USING LIFTED WAVELETS SCHEME BASED ESTIMATION

D.GOKULNATH[#1]and Prof.N.KARTHICK[*2]

[#]*Final year, M.E, Power systems Engineering, P.S.V College of Engineering and Technology, Krishnagiri (D.T) -635108*

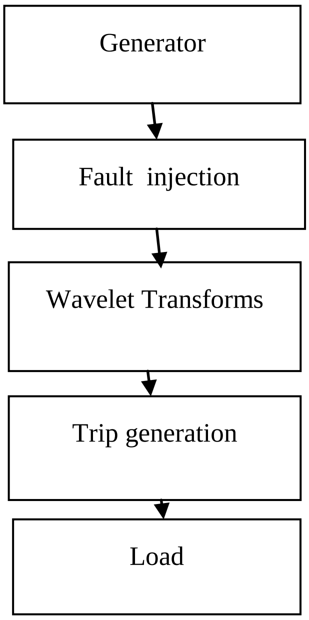
[*]*Assistant Professor, Electrical and Electronics Engineering, P.S.V College of Engineering and Technology, Krishnagiri (D.T) -635108*

Abstract— **This project introduces an optimum method by "Harmonic current injection based island detection using lifted wavelets scheme based estimation" by wavelet transforms and hence the instant of islanding also can be detected with our proposed method. In unbalanced condition, the harmonic voltage caused by the injected symmetric harmonic current is asymmetric, which affects the calculation of grid impedances and even leads to failed detection. Wavelet lifting differs from the conventional wavelet transform by the way of changing the wavelet shapes as per the target decomposition. The estimation of harmonic content and based on the amount of harmonics islanding is decided. Using wavelet transforms always results in time localization and hence the instant of islanding also can be detected with our proposed method. Hence in this method harmonic current injection is injecting two non-characteristic symmetric harmonic currents, and then according to the different harmonic voltages caused by different frequency harmonic currents, all three-phase impedances can be calculated accurately.**

Index Terms— **wavelet transforms, instant of islanding, harmonic content, time localization.**

INTRODUCTION

Nowadays modern industrial devices are mostly based on electronic devices such as programmable logic controllers and electronic drives. The electronic devices are very sensitive to disturbance and become less tolerant to power quality problems such as voltage sags, harmonics in power systems changes with the increased use of distributed generation, the ability to maintain a secure supply with high power quality is becoming more challenging. when 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 impedance estimation can be embedded into the normal operation of grid connected power electronic equipment such as sinusoidal rectifiers and active shunt filters. Pulse Width Modulation harmonics associated with PEE, as measured in the active filter line current or voltage at the point of common connection 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 impedance. This invasive method is only triggered when the non-invasive method determines a significant change in Source impedance. 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 is used to process voltage and current transients for calculating the supply impedance. 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. In this the concept it describes how Continuous wavelet Transforms used to significantly speed up impedance estimation, demonstrating this capability with experimental results. The topic 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.



I. STRATEGIC MODELING

A. Islanding Phenomenon

Islanding refers to the condition in which a distributed generator continues to power a location even though electrical grid power from the electric utility 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. For that reason, distributed generators must detect islanding and immediately stop producing power; this is referred to as anti-islanding. The common example of islanding is a grid supply line that has solar panels attached to it. In the case of a blackout, the solar panels will continue to deliver power as long as irradiance is sufficient. In this case, the supply line becomes an "island" with power surrounded by a "sea" of unpowered lines. For this reason, solar inverters that are designed to supply power to the grid are generally required to have some sort of automatic anti-islanding circuitry in them. In intentional islanding, the generator disconnects from the grid, and forces the distributed generator to power the local circuit. This is often used as a power backup system for buildings that normally sell their excess power to the grid.

B. Distributed Generation

Distributed generation is the practice of decentralizing electrical supply services in favor of small, consumer specific sources of power. Also known as distributed energy resources, these facilities may serve consumer units as large as a city or as small as a single household. The DER facility typically generates power with alternative methods than those used by centralized electrical utilities. These alternate energy sources include micro turbines, wind turbines, and solar cells and are generally located in the immediate vicinity of or within the consumer unit boundaries. Distributed generation facilities require careful consideration regarding installation specifics to reach their full potential but can be highly beneficial and even becoming income producers through excess power resale initiatives. Most consumers of electricity receive their power supply from an established power grid. These grid networks are fed by large power generation facilities which typically generate the electricity using fossil fuel fired or water driven turbines. These large steam and hydroelectric power stations are generally located far from the majority of the consumer points they supply due to air pollution and fuel availability issues. This requires extensive overhead cable and secondary distribution networks to maintain the supply of power. Although these large facilities feature excellent economies of scale values and can supply affordable power to their consumers, the overall cost in terms of related financial, environmental, efficiency, and reliability factors is usually very high.

C. Wavelet Transform

The wavelet transform is similar to the Fourier transform (or much more to the windowed Fourier transform) with a completely different merit function. The main difference is this: Fourier transform decomposes the signal into sines and cosines, i.e. the functions localized in Fourier space; in contrary the wavelet transform uses functions that are localized in both the real and Fourier space. Generally, the wavelet transform can be expressed by the following equation:

$$F(a,b) = \int_{-\infty}^{\infty} f(x)\, \psi^{*}_{(a,b)}(x)\, \mathrm{d}x$$

where the * is the complex conjugate symbol and function ψ is some function. This function can be chosen arbitrarily provided that obeys certain rules. As it is seen, the Wavelet transform is in fact an infinite set of various transforms, depending on the merit function used for its computation. This is the main reason, why we can hear the term "wavelet transform" in very different situations and applications. There are also many ways how to sort the types of the wavelet transforms. Here we show only the division based on the wavelet orthogonality. We can use orthogonal wavelets for discrete wavelet transform development and non-orthogonal wavelets for continuous wavelet transform development. These two transforms have the following properties:

- The discrete wavelet transform returns a data vector of the same length as the input is usually, even in this vector many data are almost zero. This corresponds to the fact that it decomposes into a set of wavelets (functions) that are orthogonal to its translations and scaling. Therefore we decompose such a signal to a same or lower number of the wavelet coefficient spectrum as is the number of signal data points. Such a wavelet spectrum is very good for signal processing and compression, for example, as we get no redundant information here.

- The continuous wavelet transform in contrary returns an array one dimension larger than the input data. For a 1D data we obtain an image of the time-frequency plane. We can easily see the signal frequencies evolution during the duration of the signal and compare the spectrum with other signals spectra. As here is used the non-orthogonal set of wavelets, data are correlated highly, so big redundancy is seen here. This helps to see the results in a more humane form.

i. Discrete Wavelet Transform

The discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of the wavelet scales and translations obeying some defined rules. In other words, this transform decomposes the signal into mutually orthogonal set of wavelets, which is the main difference from the continuous wavelet transform (CWT), or its implementation for the discrete time series sometimes called discrete-time continuous wavelet transform (DT-CWT). The wavelet can be constructed from a scaling function which describes its scaling properties. The restriction that the scaling functions must be orthogonal to its discrete translations implies some mathematical conditions on them which are mentioned everywhere. Moreover, the area between the function must be normalized and scaling function must be orthogonal to its integer translations. After introducing some more conditions (as the restrictions above does not produce unique solution) we can obtain results of all these equations, i.e. the finite set of coefficients a_k that define the scaling function and also the wavelet. The wavelet is obtained from the scaling function as N where N is an even integer. The set of wavelets then forms an orthonormal basis which we use to decompose the signal. Note that usually only few of the coefficients a_k are nonzero, which simplifies the calculations.

ii. Continous Wavelet Transform

Continuous wavelet transform (CWT) is an implementation of the wavelet transform using arbitrary scales and almost arbitrary wavelets. The wavelets used are not orthogonal and the data obtained by this transform are highly correlated. For the discrete time series we can use this transform as well, with the limitation that the smallest wavelet translations must be equal to the data sampling. This is sometimes called Discrete Time Continuous Wavelet Transform (DT-CWT) and it is the most used way of computing CWT in real application. In principle the continuous wavelet transform works by using directly the definition of the wavelet transform, i.e. we are computing a convolution of the signal with the scaled wavelet. For each scale we obtain by this way an array of the same length N as the signal has. By using M arbitrarily chosen scales we obtain a field $N \times M$ that represents the time-frequency plane directly. The algorithm used for this computation can be based on a direct convolution or on a convolution by means of multiplication in Fourier space (this is sometimes called Fast Wavelet Transform). The choice of the wavelet that is used for time-frequency decomposition is the most important thing. By this choice we can influence the time and frequency resolution of the result. We cannot change the main features of WT by this way (low frequencies have good frequency and bad time resolution; high frequencies have good time and bad frequency resolution), but we can somehow increase the total frequency of total time resolution. This is directly proportional to the width of the used wavelet in real and Fourier space. If we use the Morlet wavelet for example (real part – damped cosine function) we can expect high frequency resolution as such a wavelet is very well localized in frequencies.

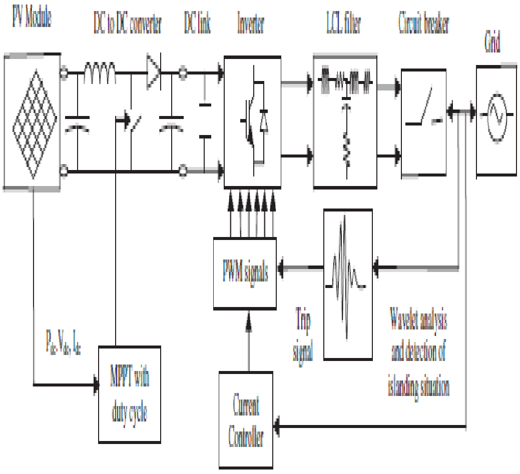
II. INFERENCE ANALYSIS

Islanding detection of Distributed Generation (DG) is considered as one of the most important aspects when interconnecting DGs to the distribution system. With the increasing penetration and reliance of the distribution systems on DGs, new interface control strategies are being proposed. Aside from its main task of supplying active power, the DG could provide voltage support, improve the power factor, or mitigate other power quality problems. The impact of the interface control strategy of inverter based DGs on islanding detection is examined. The Non-detective Zone (NDZ) for over/under voltage and over/under frequency is derived analytically for each interface control and validated by simulation. Islanding detection and prevention is a mandatory requirement for grid-connected distributed-generation systems. An anti islanding technique based on the proportional power spectral density of the voltage period at the point of common coupling (PCC) is also revised. The concept of proportional power spectral density (PPSD) is introduced as a normalized measure that can be used for islanding detection. We show that if the voltage period measured at the PCC is filtered and used to set the command period of the inverter, then an islanding condition results in a distinct PPSD.

The technique is implemented and demonstrated using a 4-kW inverter and verified in simulation. The performances of a new method for detecting ice accumulation on wind turbines is revised next. The presented method is based on constructing a multi resolution analysis (MRA) to extract frequency components present in the electric currents flowing out of an electric generator driven by a wind turbine. The foundations of the proposed ice detection method are established based on the fact that ice accumulation leads to a slow increase in the wind turbine inertia, which triggers pulsations in the electromagnetic torque of the electric generator. Such torque pulsations create certain frequency components that can be extracted from the direct and quadrature components of the electric generator output currents. The method of analyzing voltage variation sensitivity due to PV power fluctuations in an unbalanced network (unbalanced line configuration and phase loading levels). Based on this method, a network reconfiguration solution is developed to solve the voltage problems. This solution utilizes unbalanced line characteristics and realizes the potential of the network, so no extra compensation devices are needed for network support.

The validity of harmonic voltage monitoring method was demonstrated. As for prevention method applied to utility grid, the validity of the method of unbalancing reactive power by connecting capacitor load to the grid on islanding was confirmed. Detailed results of demonstration tests for preventing methods of islanding phenomenon are described. The power system impedance to source is measured by injecting a disturbance onto the system at PCC and analyzing the transient response using measured voltages and currents. The disturbance in this case is manufactured by manipulating two successive PWM cycles in the operation of PEE such that they appear to inject a very short disturbance. For this work, PEE is an active shunt filter as illustrated in Fig.3.1. The presence of the ASF filter inductance (Fig.3.1.1) results in a short current spike, of approximately 1 ms long and 20 A peak, injected into PCC as shown. Previous methods for analyzing data have included the use of a simple Digital Fourier Transform (DFT) on the measured data and the use of Welch's Averaged Period gram Algorithm.

In both techniques, 8 cycles of pre-transient measurement data are subtracted from 8 cycles of transient data to compensate for the system fundamental and other harmonics frequencies normally present in the system voltage. The impedance estimates at harmonic frequencies are discarded and an interpolation routine is used to determine the impedance to source at such frequencies describe how the estimated impedance at 5th, 7th, and 11th harmonic frequencies are used to generate reference signals for ASF. The excellent control of the filter demonstrates how an active shunt filter can operate in standalone or sensor less mode (where senseless means that ASF does not require an explicit measurement of supply or load currents).



In order to calculate power system quantities, one needs to analyze amplitudes and phase differences between the related voltages and currents. Complex wavelet bases are capable of delivering instantaneous amplitudes of voltages and currents as well as instantaneous phase angles. Using this information, alternative system impedance definitions can be found with time and frequency localization properties. In a single-phase system, the complex wavelets transform will yield two series of complex wavelet coefficients for voltage and current. Using these coefficients, instantaneous values of amplitude and phase are derived for different sub-bands.

$$v_w\ (\tau,s) = v_w\ (\tau,s) \angle \varphi_{vw}\ (\tau,s)$$
$$i_w\ (\tau,s) = i_w(\tau,s) \angle\ \varphi_{iw}(\tau,s)$$

Using the instantaneous voltage and current amplitude and the instantaneous phase difference between voltage and current, complex wavelet based system impedance is identified as

$$Z_w(\tau,s) = \frac{v_w\ \ (\tau,s)}{i_w(\tau,s)}$$

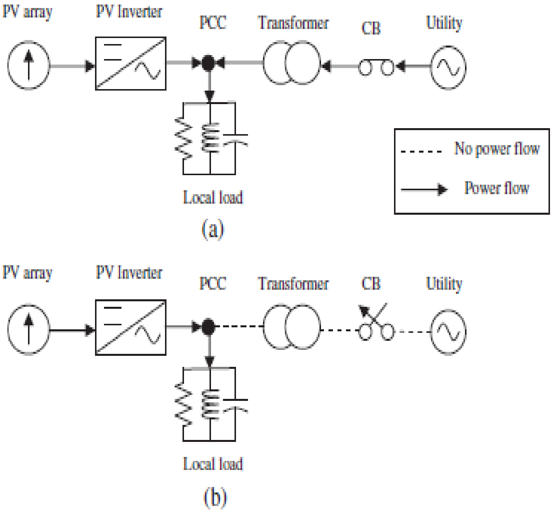
In this case, the system impedance is defined in the wavelet domain. For calculation, a series of impedances are considered at different scales and time, and an average value is estimated over the first half cycle (0.01 second) of the system impedance in the frequency ranges of interest. This can be done by mapping each level of scale to the pseudo-frequency f_s as:

$$f_s = \frac{f_c}{S.\Delta t}$$

Where f_c is the centre frequency of the wavelet in Hz, is the scale level, and delta t is the sampling period. The averaging of the estimated impedance will smooth the signal without using any particular threshold. Alternatively, taking the local maxima of CWT coefficients at each scale would provide similar results.

III. OPERATIONAL ANALYSIS

The system depicted includes the parameters like voltage and current are measured at some particular point and hence these measured parameters are used to calculate the impedance which in turn is evaluated by means of wavelet lifting technique.



(a)

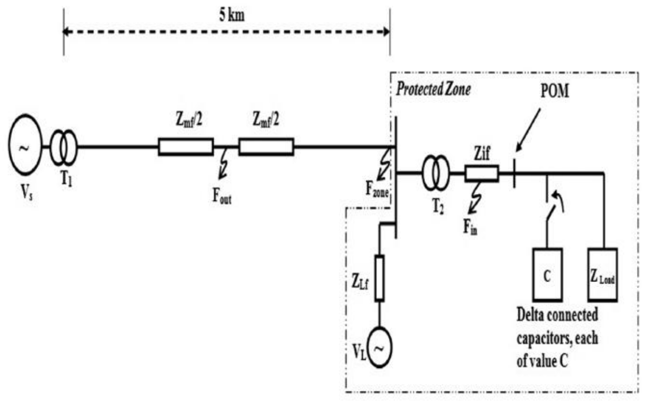
(b)

An optimum method by “Harmonic current injection based island detection using lifted wavelets scheme based estimation” by wavelet transforms and hence the instant of islanding also can be detected with our proposed method. In unbalanced condition, the harmonic voltage caused by the injected symmetric harmonic current is asymmetric, which affects the calculation of grid impedances and even leads to failed detection. Wavelet lifting differs from the conventional wavelet transform by the way of changing the wavelet shapes as per the target decomposition. The estimation of harmonic content and based on the amount of harmonics islanding is decided. Using wavelet transforms always results in time localization and hence the instant of islanding also can be detected with our proposed method. Hence in this method harmonic current injection is injecting two non-characteristic symmetric harmonic currents, and then according to the different harmonic voltages caused by different frequency harmonic currents, all three-phase impedances can be calculated accurately.

A. *Protection of Distributed Generation*

The impedance measurement is used to identify the proximity of a grid fault to PEE. This measurement is used to decide whether PEE should ride through certain remote faults to avoid nuisance trips. Islanding may also be detected. Consider the system in Fig. in which a small power system is defined to be a “protected zone” in a larger power system. Details of the system parameters, which are based on a medium voltage distribution system, are given in the Appendix. Within the zone there are distributed generation and power electronic equipment for example an active filter, a grid interface for a wind turbine, or photovoltaic system—which are connected at the point of measurement(POM). The grid connection codes state that if a fault is detected usually through the Rate of Change of

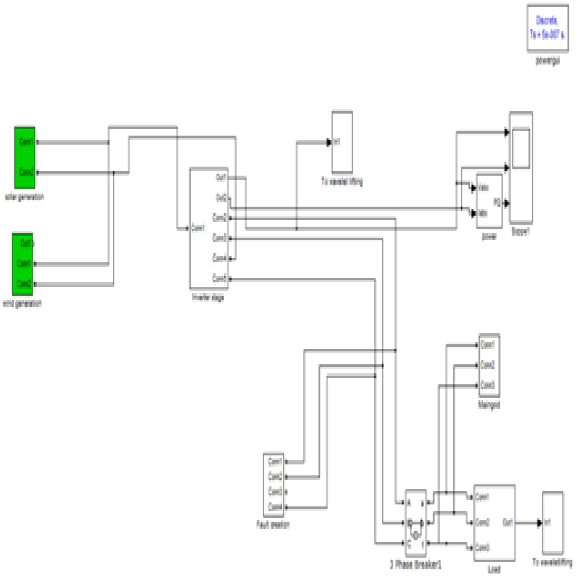
Frequency (ROCOF) measurement—the distributed generator must be disabled.



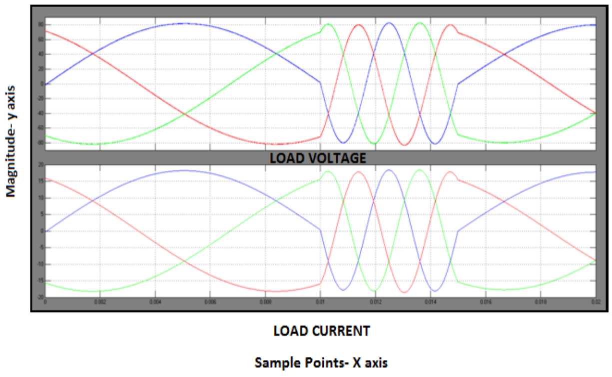
However, with the increasing interest in micro grids and other sustainable energy systems, it may be preferable to operate at the presence of certain faults (i.e., those outside the zone) and only shut down the zone if the fault occurs within the zone. It is possible to locate and specify a type of fault using the proposed impedance estimation. Referring to Fig. this work corresponds to the operating conditions.

IV. SIMULATION RESULTS

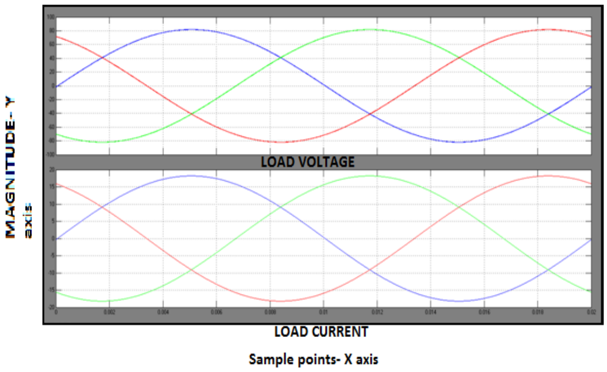
The detailed simulation studies are carried out on MATLAB/SIMULINK platform. The general overall system as shown in Fig.



The above simulation consists of wind, solar and an interconnection with macro grid. A fault is created at time 0.03 and the voltage waveforms are exported to workspace to apply for wavelet transforms. Also the simulation is done to obtain the output with load voltage, load current and magnitude along with the x-axis and y-axis with the sample points with fault at time 0.01 sec and without fault.



Simulink Output Waveform At Fault



Simulink Output Waveform At No Fault.

V. CONCLUSION & FUTURE WORK

A new method for estimating power system impedance is proposed. The earlier method employs the CWT to derive the impedance from measured transient data. The main advantage with this technique is that the data capture time is significantly reduced compared to previous techniques, and offers the possibility of true on-line real-time impedance estimation for both power quality equipment, and embedded generation interfaces, thus improving their reliability and dynamic response, and also enhancing the quality and operation of distributed generation equipment. But impedance calculation takes an additional time. Hence we proposed the direct method of finding the detail coefficients and classifying it with neural networks. One aspect of this intelligent grid operation is also to be shown in our further works, by using wavelet lifting schemes. The testing conditions are simulated using harmonic current injections at the test places. The proposed system, detects the time instant such fault, and hence any analysis in future can be done well with wavelet transforms. The system is able to maintain the power delivery to the load, without any interruptions even in the case of power discretion or shortage of power. The best application is to use this algorithm in power systems integrated with micro grid and macro grid, operated as hybrid grid. The placement of DG is also a matter, and hence the wavelet transforms helps us, to know the time instant. The application of solar cells are heaters, cars, dryers, lights, satellites, calculators, water pumps, green houses, etc.

REFERENCES

[1] Bella F, Lamberti A, Sacco A, Bianco S, Chiodoni A, Bongiovanni R. Novel electrode and electrolyte membranes: towards flexible dy-sensitised solar cell combining vertically aligned Tio2 nano bube array and light-cured polymer network. J Membr Sci 2014;470:125–31.

[2] Jiang Y, Qahouq JAA. Study and evaluation of load current based MPPT control for PV solar system. Arizona: IEEE Trans of Energy Conversion Congress and Exposition; 2011. p. 205–10.

[3] P. Brogan and R. Yacamini, “An active filter based on voltage feedback,” in Power Electron. Variable Speed Drives Conf. Proc., 1998,pp. 1–4.

[4] L. S. Czarnecki and Z. Staroszczyk, “On line measurement of equivalent parameters for harmonic frequencies of a power distribution system and load,” IEEE Trans. Instrum. Meas., vol. 45, no. 2, pp.467–472, 1996.

[5] Carrasco JM, Franquelo LG, Bialasiewicz JT, Galvan E, Portillo Guiesado RC, Prats MAM, et al. Moreno-Alfonso, power electronic systems for the grid integration of renewable energy sources: a survey. IEEE Trans Ind Electron 2006; 53(4):1002–16.

[6] L. Asiminoaei, R. Teodorescu, F. Blaabjerg, and U. Borup, “A digital controlled PV-inverter with grid impedance estimation for ENS detection,”IEEE Trans. Power Electron., vol. 20, no. 6, pp. 1480–1490, Nov. 2005.

[7] Xiao Y, Wu J, Lin J, Yue G, Lin J, Huang M, et al. A dual function of high performance counter-electrode for stable quasi-solid-state dye-sensitised solar cells. J Power Sources 2013;241:373–8.

[8] Thambidurai M, Kim JY, Song H, Ko Y, Samy NMK, Velauthapillai D, et al. Enhanced power conversion efficiency of inverted organic solar cells by using solution processed Sn-doped TiO2 as an electron transport layers. J Mater Chem A 2014;2:11426.

[9] M. Sumner, B. Palethorpe, and D. W. P. Thomas, “Impedance measurement for improved power quality Part 2: A new technique forstand alone active shunt filter control,” IEEE Trans. Power Del., vol.19, no. 3, pp. 1457–1463, Jul. 2004.

[10] V. Diana, M. Sumner, P. Zanchetta, and M. Marinelli, “Non-invasivepower system impedance monitoring for improved power quality,” in Proc. IEE Conf. PEMD 2004 (Conf. Publ. No. 498), 31 Mar.–2 Apr.2004, vol. 1, pp. 265–268.

[11] P. Kang and G. Ledwich, “Estimating power system modal parameters using wavelets,” in Proc. 5th Int. Symp. Signal Process. Appl., Brisbane, Australia, Aug. 22–25, 1999, pp. 563–566.

[12] G. Strang and T. Nguyen, Wavelets and Filter Banks. Wellesley, MA, USA: Wellesley-Cambridge, 1996.

[13] M. Tsukamoto, S. Ogawa, Y. Natsuda, Y. Minowa, and S. Nishimura,“Advanced technology to identify harmonics characteristics and results of measuring,” in Proc. 9th IEEE Int. Conf. Harmonics Quality Power.

[14] Phang JCH, Chan DSH, Philips JR. Accurate analytical method for the extraction of solar cell model parameters. Electron Lett 1984;20(10):406–8.

[15] xiao Y, Han G, Chang Y, Zhou H, Li M, Li L. An all-solid-state perovskitesensitized solar cell based on the dual function polyaniline as the sensitizer and p-type and hole-transporting material. J Power Sources 2014;267:1

[16] Peng X, He C, Fan Xi, Liu Q, Zhang J, Wang H. Photovoltaic devices in hydrogen production. Int J Hydrogen Energy 2014;39:14166–71.

[17] M. Sumner, B. Palethorpe, and D. W. P. Thomas, “Impedance measurement for improved power quality-part 1: The measurement technique,”IEEE Trans. Power Del., vol. 19, no. 3, pp. 1442–1448, Jul. 2004.

[18] S.Mallat, A Wavelet Tour of Signal Processing, 2nd ed. New York: Academic, 1999.

[19] F. Fernandes, R. Spaendonck, and C. Burrus, “A new framework for complex wavelet transforms,” IEEE Trans. Signal Process., vol. 51,no. 7, pp. 1825–1837, Jul. 2003.

[20] J. RenandM.Kezunovic, “Real-time power system frequency and phasorsestimation using recursive wavelet transform,” IEEE Trans. PowerDel., vol. 26, no. 3, pp. 1392–1402, Jul. 2011.