TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol. 14, No. 1, April 2015, pp. 9 ~ 15
DOI: 10.11591/telkomnika.v14i1.7232

Detection of Power Quality Disturbances in Micro Grid Connected Power System

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Abstract

Micro Grid is a contracted distributed AC or DC network. Micro Grid resources are connected to the distributed linear as well as nonlinear loads through power electronics converter to provide an efficient, more reliable and quality power to the distributed loads with reduced co_2 emission. Consequently makes full use of low cost generation resources and reduce waste. Interconnected Mode in the MG is connected to main grid either being absorbed by it or injecting some amount of power into the main system. Islanding Mode in the MG operates separately when upstream volt occurs in main grid network. Usage of power electronic interface converters, Integration of the renewable-resources based MG system to the main power system and nonlinear loads results in harmonics generation clutter the system reliability and other associated quality issues. Most of demanding users of electricity are suffering to a certain poor quality of electrical power. 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 WT plays important role in analysis, design and classification of discrete signal processing. The accuracy and reliability of classification techniques have assessed on signals contaminated with noise.

Keywords*: carbon dioxide, power quality, wavelet transform, micro grid, distributed generation.*

1. Introduction

A title of article recent technological developments committee works towards the Micro generation domain focus need of reducing emissions in the electricity generation field with the help of Micro Grid which is a local AC/DC grid used to increase the system efficiency along with renewable energy resources [1]. Losses in entire power system network is due to distribution so, Micro Grid as used to improve the quality of power because Power Quality (PQ) is a big problem, which plays an important role in our modern dynamic power systems network. However, this integration has introduced Power Quality issues [2] that should be considering when designing Micro Grid. The quality of the power supplying to the utilities, become a red-hot issue recently. The users' demand for pure electricity is rising constantly due to the wide spread use of sensitive electrical and electronic devices [3]. The interconnection of Micro Grid (MG) systems to existing power systems persuade power quality, degrade system reliability, and cause over-voltage and safety issues, this paper mainly focusing on these issues. The extensively fashionable generation resources are wind, photovoltaic (PV), fuel cell, etc., which can be operated in isolated or grid-connected mode depending upon the requirements [4]. Due to some operational issues and uncertainties in characteristics of power generation from wind and PV systems, these resources need to be integrated along with main energy system to enhance the quality and reliability of the power supply [5] and [6]. Thus, concentration of solar and wind varies over the period potentially lead to unpredictable PQ disturbances like voltage sag, swell, harmonics along with power flow those caused by load adjustments, capacitor switching, etc. In conventional power systems, PQ disturbance related problems caused by sudden addition or rejection of large linear and nonlinear load, induction motors, transformers, etc in the voltage signal. PQ disturbances arising either from the source side or the load side may lead to various operational issues such as malfunctions, failure of electrical equipment, instabilities, and so on [7]. PQ disturbances need to be detecting effectively and classified for effective operation, control, and protection of the MG system from any unwanted operation. On islanding detection in Micro Grid-connected systems had considered based on frequency

Received December 24, 2014; Revised February 27, 2015; Accepted March 13, 2015

variation at the PCC [8] and [9]. In addition to various researches, work available for detection and classification of PQ disturbances FFT, WT, etc were included. Different from FFT, WT have based on the Multi Resolution Analysis (MRA), which decomposes the original signal into various estimated descriptions and detailed versions by time -scaling and wavelet function [8]. The wavelet transform has been introduced as an adaptable technique for non-stationary signal analysis; the signals may be having faulted sinusoidal or non-sinusoidal waves [10]. The recognition and classification of faults is important for safe and optimal operation of power systems used for secure maintenance and operation of Micro Grid system a feasible approach is to monitor fault signals so that accurate and rapid classification of fault is possible only through Wavelet Transform [11]. Wavelet Transform's effective windowing technique is used to extract the fault information [12]. The presence of the MG system opens a new challenging task to researchers in the study of the detection and classification of PQ related problems. [2] and [3] based on artificial intelligence techniques such as Artificial Neural Network (ANN), fuzzy logic, etc. Again, Kalman filters and Fast Fourier transform are used for the feature extraction, but these techniques require the ability to decompose the signal in both time and frequency domains [13]. AC signal is injected into DC power system to detect the AC harmonics associated with signal using both combination of WT and ANN [14]. WT has implemented to detect and identify the various kinds of PQ disturbances, this technique require the ability to decompose the signal in both time – scaling domains [15] and [8]. The detection and localization of PQ disturbances by wavelet approaches entirely depend on which mother wavelet. To overcome the disadvantage of the original WT, Kalman filter have developed for detecting the PQ events [4]. Parallel Active Power filter have been used to improve the power quality in grid connected system [16].

2. Modelling of Hybrid MG System

Fashionable energy resources, such as solar PV and wind energy have attracted energy sectors to generate power that interconnected at PCC to the main power grid with an aim to improve reliability in power supply against the load demand. Both wind and solar, is unsystematic in nature and dependence on climatic changes. Fortunately, the problems can moderately overcome by integrating the resources to form a hybrid MG system, strength of one source overcome the limitation of the other source. The energy resources connected to the MG to allocate the shortage power as per conditional demands. However, the interfacing of MG with these energy resources lead to several PQ and islanding problems which must be detected, analyzed and mitigated effectively.

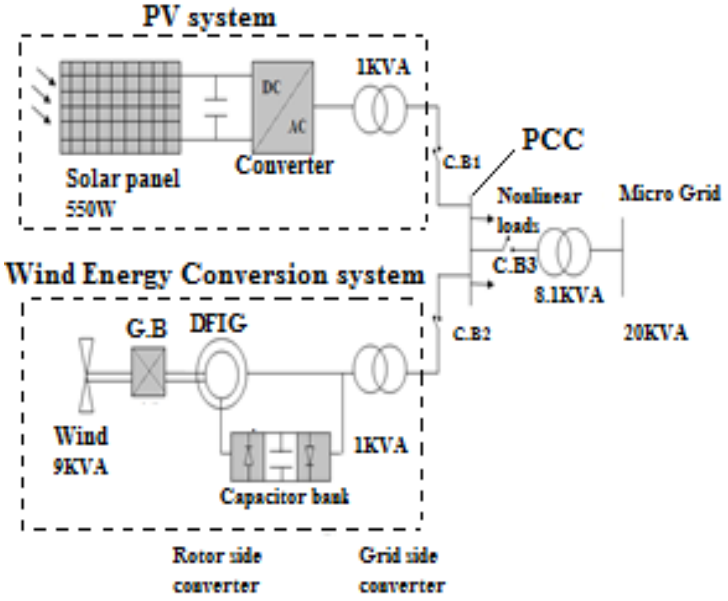


Figure 1. Micro Grid Connected Energy Resources

Maximum power obtaining from solar has directly related to solar irradiance intensity and temperature. Several photovoltaic cells connected in series, which is a PV module. The output current is equal to difference of light generated current to diode current [17].

$$I = I_{ph} - I_D \quad (1)$$

I_D = Current of the diode
I = Cell output current and voltage.
I_{ph} = Light generated current.

Wind turbine extracts maximum kinetic energy from the wind, which strikes rotor blade. The power coefficient C_p is a measure of how much the energy extracted by the turbine. C_P may be expressed as a function of the Tip Speed Ratio (TSR) given by equation [17].

$$\lambda = {}^{\omega_m R}/_{V} \quad (2)$$

$$P = {}^{1}/_{2}\, C_p \rho V_\omega{}^3 A\, W \quad (3)$$

P = Power (W).
C_p = Power coefficient.
$V\omega$ = Wind velocity (m/s).
A = Swept area of rotor disc (m^2).
ρ = Density of Air (kg/m^3).

3. Classification Method for Disturbance Detection

In this section, it is explained the proposed method for detection of power quality disturbances and this give the brief discussion about wavelet transform.

3.1. Discrete Wavelet Transform (DWT)

The voltage signal taken at PCC is used as input signal to the wavelet algorithm and Daubechies4 (dB4) as mother wavelet is employed as it has been confirmed to perform well [3] and [18] in detecting the PQ as well as islanding disturbances. The signal passed through a series of high pass filters to analyze the high frequencies, and it passed through a successive of low pass filters to evaluate the low frequencies. Therefore, the signal (S) decomposed into two types of components; approximation (A) and detail (D). The approximation is high scale as well as low-frequency component of the signal. The detail is low scale as well as high-frequency component. The decomposition process might be progressed, with successive approximations decomposed in turn, accordingly that one signal has divided into many lower resolution components, which called the wavelet decomposition tree and shown in Figure 2. As decompositions have done on higher levels, lower frequency components have filtered out progressively. The WT uses short windows for high frequencies and long windows for low frequency components.

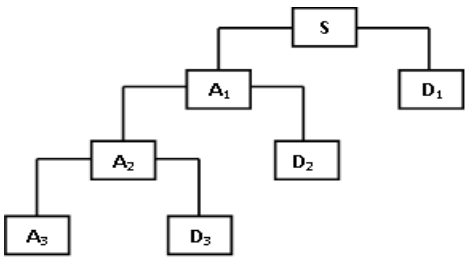


Figure 2. Decomposition of Wavelet Tree

4. Simulation Results and Discussion

In this section, it is explained the results of research based on PQ disturbances in Micro Grid connected power system and at the same time is given the comprehensive discussion. Results can be presented in figures, and tables. The discussion have made in several sub-chapters. The various operating scenarios of the generation resources like Wind and PV connected to the MG and their combinations have created and simulated in MATLAB / Simulink. The voltage signal at PCC is extracted for simulation of each operating scenario and fed to detection algorithms. Simulations are carried out using WT and the time-frequency localization property of the WT and the disturbance instants are detected. Disturbance detection instants have observed using MAT LAB / Simulink.

4.1. Inter Connected Detection for Energy Resources Connected to Micro Grid:

This subsection explains the grid-connected hybrid MG system under various operating scenarios. The three-phase voltage signal is captured at PCC. Voltage and current waveform of grid connected MG system have voltage unbalance at initial state. Voltage deviation in terms of Total Harmonic distortion of grid connected MG shown in Figure 3(a). There is THD present in grid connected system, frequency of grid connected MG is shown in Figure 3(b). Frequency deviation present in the power system with the allowable limit because of loads and power electronic interfaces. The computed values for all the considered scenarios are given in Table 1.

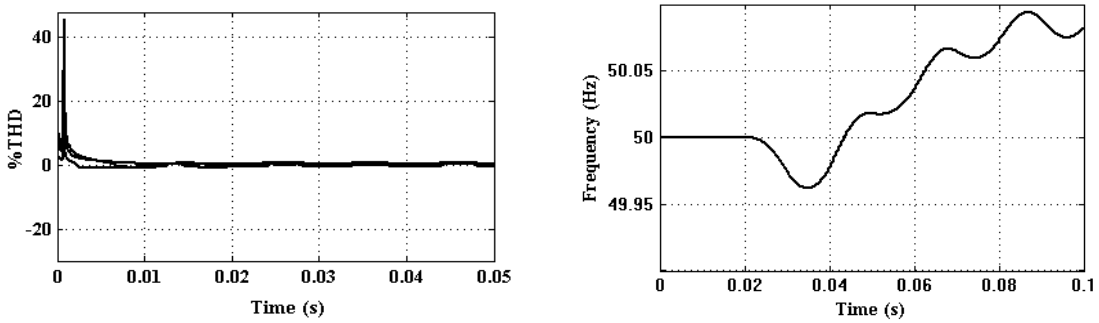
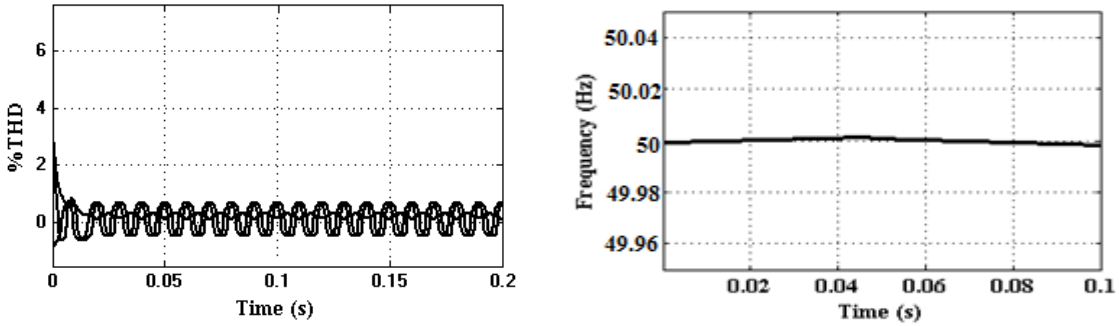


Figure 3. Grid Connected, (a) THD, (b) Frequency

4.2. Islanding Detection for Energy Resources Connected to Micro Grid

This subsection explains the islanded detection using WT in the grid connected hybrid DG system under various operating scenarios. Islanding is a phenomenon occurs when DG resources integrated to the local load and the utility grid and is disconnected [19]. The three-phase voltage signal have captured at PCC. Voltage deviation in terms of Total Harmonic distortion of grid connected MG shown in Figure 4(a). There is some minimum amount of THD present in grid connected system, with the allowable limit of frequency in grid connected MG shown in Figure 4(b). No frequency deviation present in the islanded power system.

If any fault occurs in the main power grid want to secure the distributrd generation resource, in that case islanding is necessory for Micro Grid system.in addition to the fault islanding two cases have considered addition of sudden load, rejection of sudden load.with the help of Wavelet Transform here the power quality disturbance events have detected, shown through graphical representation as weel as tabulated.



(a) (b)

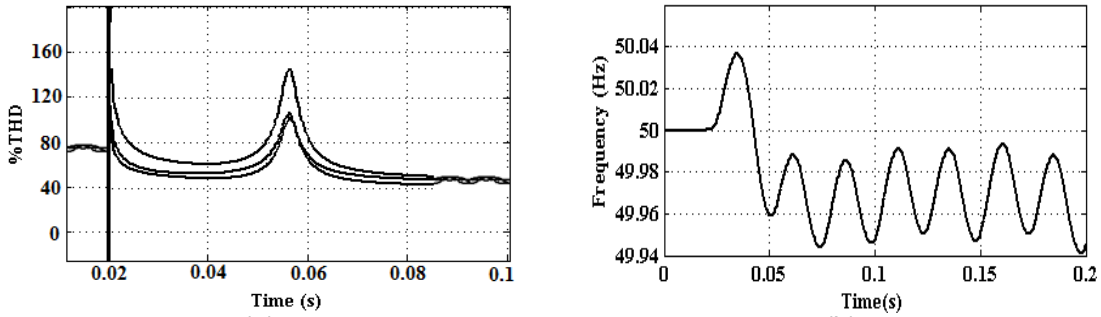
Figure 4. Islanded, (a) THD, (b) Frequency

4.3. PQ Disturbance Detection for Energy Resources Connected to Micro Grid

Detection of the different PQ disturbances plays an important role for their possible mitigations using some effective algorithms so that the stability gets improved there by increasing the reliability of system. This subsection further demonstrates performance of WT in detection of PQ disturbances such as Voltage Unbalance (VU) and load switching. The PQ disturbances have created in grid-connected hybrid power system in MATLAB / Simulink.

4.3.1. Detection of THD at Sudden Addition Load Switching

Signal switching are considered the method proposed in two scenarios; islanding and load scenarios are extracted and the corresponding change in THD is calculated in percentage and tabulated in Table 1.



(a) (b)

Figure 5. Addition of Load Switching; (a) THD, (b) Frequency

The abrupt change in THD values is observed to be more than the threshold value and thus both the disturbances are detected as islanding event. It was observed that the drawback of VU/THD technique is that a load switching can cause an abrupt change in performance indices even if the MG is connected to the utility grid (no islanding case). Voltage and current waveform of grid connected MG with current value has increased with increase in load, voltage deviation in terms of Total Harmonic distortion of grid connected MG shown in Figure (a) there is an increase in percentage of THD present in micro grid connected system. Frequency of grid connected MG shown in Figure (b) severe frequency deviation within the allowable limit present in the micro grid connected system. The three-phase voltage signal have captured at PCC.

4.3.2, Detection of THD at Sudden Rejection Load Switching:

Voltage and current waveform of grid connected MG with current value decreases at the decrease in load.

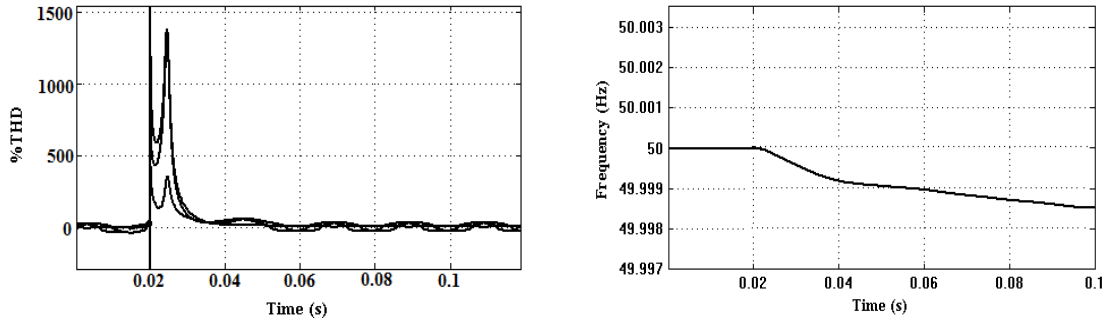


Figure 6. Rejection of Load Switching; (a) THD, (b) Frequency

Voltage deviation in terms of Total Harmonic distortion of grid connected MG shown in Figure 6(a). There should be severe increase in percentage of THD present in grid connected system. Frequency of grid connected MG shown in Figure 6(b). Dip in frequency deviation within the allowable limit present in the power system.

Table 1. The Performance of various scenarios with their comparison

Scenarios	Events	Power Quality Disturbance Events			
		WT		FFT	
		THD	Frequency	THD	Frequency
Modes of operation	Grid-connected mode	45.34	50.08	09.34	48.53
	Islanded mode	03.07	50.00	07.07	49.97
PQ disturbances	Rejection of load	180.24	49.94	150.24	50.01
	Addition of load	1500	49.99	1500	49.33

5. Conclusion

The work in this paper has introduced a simulation on detection of islanding event and PQ disturbances in Micro Grid connected distributed power system using WT techniques under various operating scenarios. Various cases such as detection of islanding event and PQ disturbances simultaneous occurrence of islanding event with three-phase fault at PCC have considered. Three-phase fault with islanding and PQ events were investigated for different operating scenarios. The qualitative and quantitative results clearly showed the merits of WT in detection, localization of islanding event and PQ disturbances in the Micro Grid power system.

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