# Probalistics on Voltage Characteristics using Facts Devices

Mrs. S. Sooriyaprabha[1],
Assistant Professor,
department of Electrical and Electronics Engg
Parisutham instate of technology and science
Thanjavur-613006

M. Anbarasi[2]
M.E Power Systems Engineering
Department of Electrical and Electronics Engg
Parisutham instate of technology and science
Thanjavur-613006

***Abstract:-*** **This paper presents the probabilistic density function is examined over the various samples of observed wind speed and enable to find the probability of defined wind speed. This method is implemented to extract the quantity of wind power that could flow into the grid. Besides the FACTS device named Unified Power Quality Conditioner (UPQC) is utilized to provide optimized regulation of active and reactive powers that empower the load compensation. In addition to that it aids the enhancement of voltage characteristics of bus system. The electrical system element such as real power, reactive power and voltage profile for each bus in the distribution system has been examined. The study has been carried out us being MATLAB or SIMULINK. The proposed FACTS device (UPQC) has been evidenced to be effective in enhancement of voltage profile.**

## I INTRODUCTION

With the increased consumption of electricity, present fossil fuel based power stations are unable to supply the increased demand, which leads to increased electricity interruptions and possible blackouts. Therefore, the expected solution is to build new power stations to cover the deficit in the demand; however, due to lack of fossil fuel needed to run these stations, other alternative sources should be used based on renewable energy sources such as wind energy. Renewable energy based wind power generation systems are not fully controllable due to the stochastic nature of their prime source. This will introduce additional uncertainties into the daily operation and long-term planning of the electric system with increased penetration level of wind power generation systems [1]. Power and voltage generated by a wind turbine are more variable than that produced by conventional generators. Therefore, with the increased penetration level of wind energy systems in the electric grid, it is very important to determine the effect of voltage fluctuations caused by the connection of wind energy systems to the electric grid and other power quality aspects, using proper Power Quality (PQ) indices.

In recent years, the technological development of high power electronics devices has led to implementation of electronic equipment suited for electric power systems, with fast response compared to the line frequency. These active compensators allow great flexibility in: a) controlling the power flow in transmission systems using Flexible AC Transmission System (FACTS) devices, and b) enhancing the power quality in distribution systems employing Custom Power System (CUPS) devices [6] [9]. The use of these active compensators to improve integration of wind energy in weak grids is the approach adopted in this work.

The paper is organized as fallows. The Section II states the art of the UPQC. The Section III Introduces the problem formulation and power quality limits. The Section IV describes the topology for power quality improvement. The Sections V, VI, VII describes the control scheme, system performance and conclusion respectively.

## II UPQC – STATE OF THE ART

There are two important types of APF, namely, shunt APF and series APF [8]–[10]. The shunt APF is the most promising to tackle the current-related problems, whereas, the series APF is the most suitable to overcome the voltage-related problems. Since the modern distribution system demands a better quality of voltage being supplied and current drawn, installation of these APFs has great scope in actual practical implementation. However, installing two separate devices to compensate voltage- and current-related power quality problems, independently, may not be a cost effective solution. Moran [11] described a system configuration in which both series and shunt APFs were connected back to back with a common dc reactor.

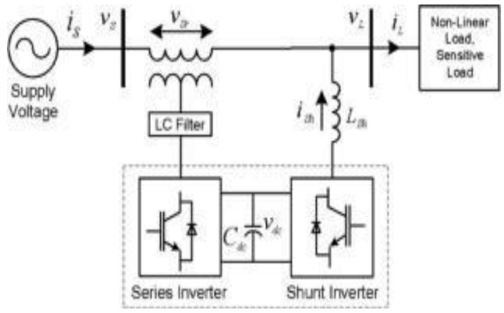



**Fig. 1. UPQC General Block Diagram Representation.**

In construction, a UPQC is similar to a unified power flow controller (UPFC) [5]. Both UPQC and UPFC employ two voltage source inverters (VSIs) that are connected to a common dc energy storage element. A UPFC is employed in power transmission system whereas UPQC is employed in a power distribution system, to perform the shunt and series compensation simultaneously. However, a UPFC only needs to provide balance shunt and/or series compensation, since a power transmission system generally operates under a balanced and distortion free environment. On the other hand, a power distribution system may contain dc components, distortion, and unbalance both in voltages and currents. Therefore, a UPQC should operate under this environment while performing shunt and/or series compensation. The main purpose of a UPQC is to compensate for supply voltage power quality issues, such as, sags, swells, unbalance, flicker, harmonics, and for load current power quality problems, such as, harmonics, unbalance, reactive current, and neutral current. Fig. 1 shows a single-line representation of the UPQC system configuration.

The basic operation of a series inverter of UPQC can be represented by the following equation:

$$v_{Sr}(\omega t) = v_L^*(\omega t) - v_S(\omega t) \qquad (1)$$

where $v_{Sr}(\omega t)$, $v^*_L(\omega t)$, and $v_S(\omega t)$ represent the series inverter injected voltage, reference load voltage, and actual source voltage, respectively.

## III PROBLEM FORMULATION

This section has two subsections, first section represents the power quality analysis, and second section represents the mathematical formulation of Markov analysis.

A. Power quality

However, the current total harmonic distortion is calculated according to Eq. (4), has to be less or equal 6%:

$$THD_i = \left[\sum_{h=2}^{40} (I_h)^2\right]^{1/2} \qquad (4)$$

Perfect power quality means that the voltage is continuous and sinusoidal having a constant amplitude and frequency. Power quality can be expressed in terms of physical characteristics and properties of electricity. It is most often described in terms of voltage, frequency and interruption. The quality of the voltage must fulfill requirements stipulated in national and international standards.

In these standards, voltage disturbances are subdivided into voltage variations, flicker, transients and harmonics' disturbances [14].

B. Harmonics

Harmonics have always been presented in power systems. Recently, the wide spread use of power electronic components resulting in an increase in harmonic magnitude, it becomes a key issue in installations. The fluctuating nature of the wind energy conversion system (WECS) is expected to inject both voltage and current harmonics into power systems. This harmonic injection is obvious to increase by increasing the wind penetration in the system. However, the grid has to make sure that the injected harmonics doesn't exceed the permitted level [6,15].

The distorted waveform may be expressed as a sum of sinusoids with various frequencies and amplitudes, by application of the Fourier transform. The sinusoids with frequencies equal to an integer multiple of the fundamental frequency are denoted harmonics, whereas the others are denoted inter harmonics [16,17].

Harmonic voltages, $U_h$, where h denotes the harmonic order (i.e.an integer multiple of 50 Hz)
can be evaluated individually by their relative amplitude as shown:

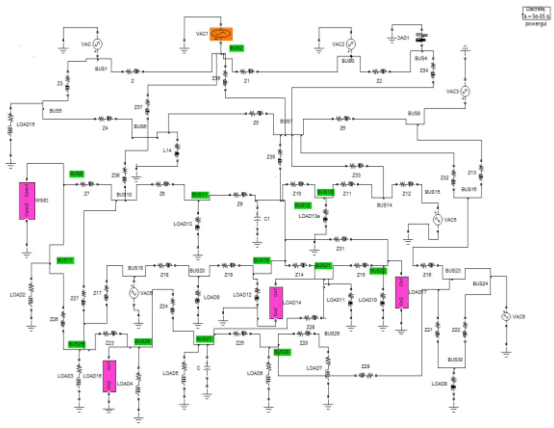
$$U_h = \frac{V_h}{V_n}$$

While harmonic current, $I_h$ can be evaluated individually by their relative amplitude as shown:

$$I_h = \frac{I_h}{I_n}$$

Further, the total harmonic distortion (THD) of the voltage, is calculated according to Eq. (3), has to be less or equal 8%:

The connection of electric equipment does change the harmonic impedance of the network; for example, capacitor banks, which are often installed as part of wind farms consisting of fixed speed wind turbines, may shift the resonance frequency of the harmonic impedance. Hence, possible harmonic sources already present in the network may, then, given unfortunate conditions, cause unacceptable harmonic voltages. Consequently, for networks with significant harmonic sources, the connection of new appliances such as wind farms with capacitor banks



should be carefully designed in order to avoid an ill conditioned modification of the harmonic impedance.

**C. Voltage sag**

The monitoring of sags is critical to ensuring optimal performance of power systems. Monitoring can be used as a vital diagnostic tool, identifying problem conditions on a power system before they can cause disturbances or interruptions. A successful power quality monitoring program requires flexibility, powerful data processing, value adding reports, and easy access to information[18].

For sags, indices of interest include:
_ Sag Score
_ Sag Energy

Typically, once sag is detected, the RMS method is used to determine the sag magnitude and duration. For advanced monitoring, instantaneous data is stored for later analysis. Algorithms that can track the amplitude, phase and frequency of anon-stationery sinusoid offer the possibility to store indices are not possible to determine with the RMS. The objective of this research is the application of a real-time algorithm to determine single event sag indices [19] monitoring, instantaneous data is stored for later analysis. Algorithms that can track the amplitude, phase and frequency of a non-stationery sinusoid offer the possibility to store indices are not possible to determine with the RMS. The objective of this research is the application of a real-time algorithm to determine single event sag indices [19]. Sag score

The Detroit Edison sag score is probably the first used in a contract by an electric utility. The score is [20]:

$$\text{Sag Score} = 1 - \frac{V_A + V_B + V_C}{3} \qquad (5)$$

Sag energy

Sags cause a reduction in energy transfer to load equipment. The ability of equipment to function as specified can be compromised depending on the amount of energy lost. The computation of sag energy has received a lot of attention by the IEEE P1564 working group on voltage sag indices. Voltage sag energy is defined as [20]:

$$\text{EVS} = \int_0^{\tau} \left[ 1 - \left\{ \frac{v_{sag(t)}}{v_{nom}} \right\}^2 \right] dt \qquad (6)$$

## IV CIRCUIT MODELLING OF UPQC

The configuration of proposed UPQC, which additionally has a DC-DC converter and super capacitors for compensating the voltage interruptions. The energy in the DC link charges the super capacitors through the bi-directional DC – Dc converter when the system is in normal operation. Lessening voltage and current wave form bends to worthy levels has been an issue in the control framework plan from the beginning of substituting current.

The control system consists of three major elements, which are shunt inverter control, series inverter control, and DC-DC converter control. When the level of the source voltage is maintained at 1.0 per unit (p.u.), the system works in normal mode. When the level falls between 0.5 and 1.0 p.u. or higher than 1.0 p.u., the system works in voltage sag or swell mode. When the level is lower than 0.5 p.u., the system works in interruption mode. In normal mode, the series inverter injects the zero voltage and the shunt inverter absorbs the current harmonics generated by the load. The DC-DC converter works in charge mode or stand-by mode depending on the voltage level of super capacitors.

In voltage hang or swell mode, the arrangement inverter infuses the repaying voltage to keep up the heap voltage steady. The shunt inverter retains the present sounds produced by heap and the DC-DC converter works in standby mode. In voltage interruption mode, the series inverter is disconnected from the line and the circuit breaker is opened to isolate the source side. The shunt inverter starts to work as an AC voltage source. The DC-DC converter works in discharge mode to supply the energy stored in the super–capacitors to the load.

## 30-BUS SYSTEM FOR WIND POWER DISTRIBUTION WITHOUT FACTS

In this paper the 30-bus system has been taken as a module they are interconnected by transmission lines encapsulating resistance and inductance of specific value. In this system it contains five generators and two wind turbines for the purpose of supplying the load demand.

In this system the real power, reactive power and the voltage as been taken without FACTS. 30 –bus system for wind power distribution without FACTS is shown in fig4.1. The voltage of the bus-4 system is shown in fig4.2 and its peak value is 0.9*104V.

**Fig.4.1 30- bus system with Wind Power Distribution for without Facts**

The Real power at bus-4 is shown in Fig.4.3and its value is 1.5*105watts. The Reactive power at bus-4 is shown in Fig.4.4and its value is 4.5*104 watts. The voltage of the 12-bus system is shown in fig.4.5 and its peak value is 0.85*104V.

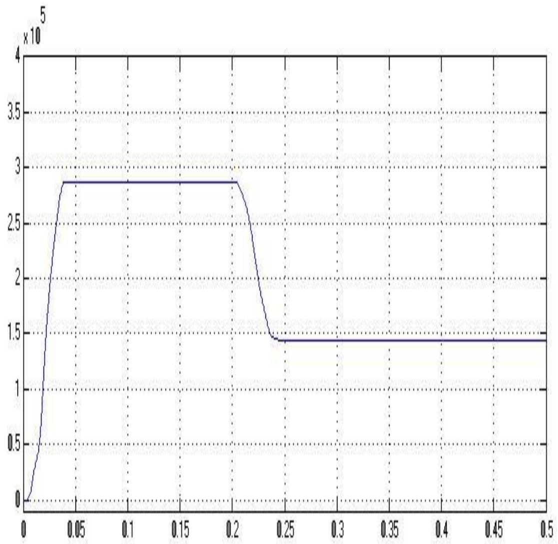


**Fig.4.2 BUS-4VOLTAGE**

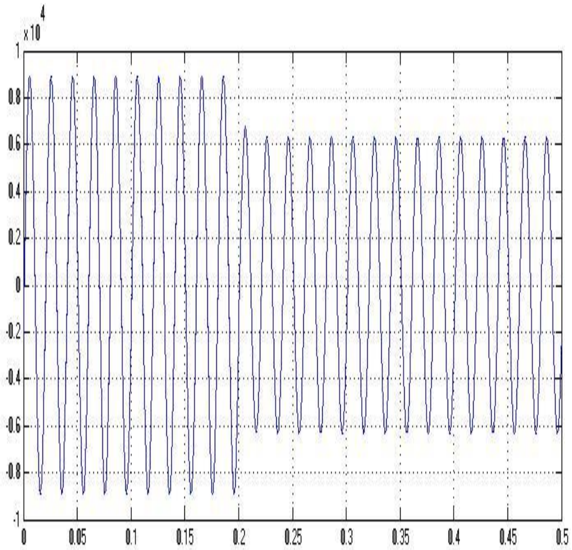


**Fig4.3 REAL POWER AT BUS 4**

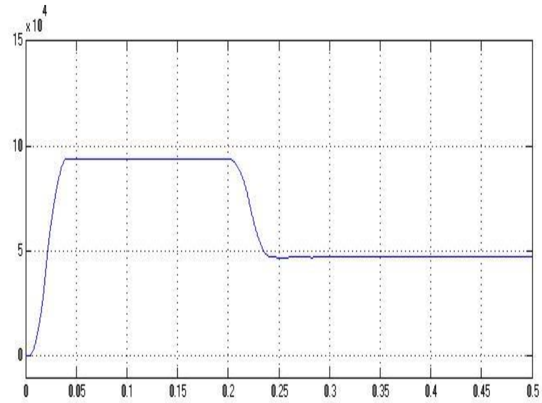


**Fig4.4 REACTIVE POWER AT BUS 4**

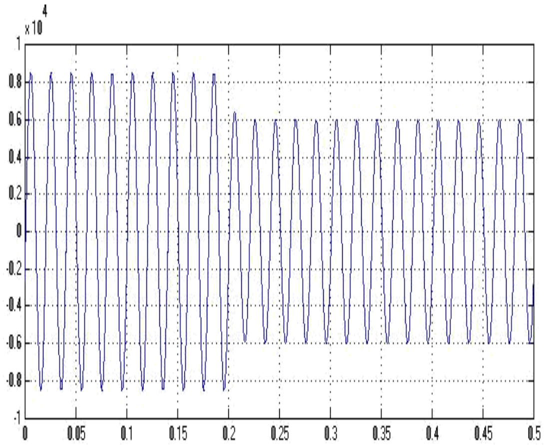


**Fig4.5 BUS-12 VOLTAGE**

The Real Power at bus-12 is shown in Fig.4.6 and its value is 6.4 *105 watts. The reactive power at bus-12 is shown in Fig.4.7. and its value is 2.4*105watts. The voltage of the 26-bus system is Shown in Fig.4.8 and its peak value is 8000V.

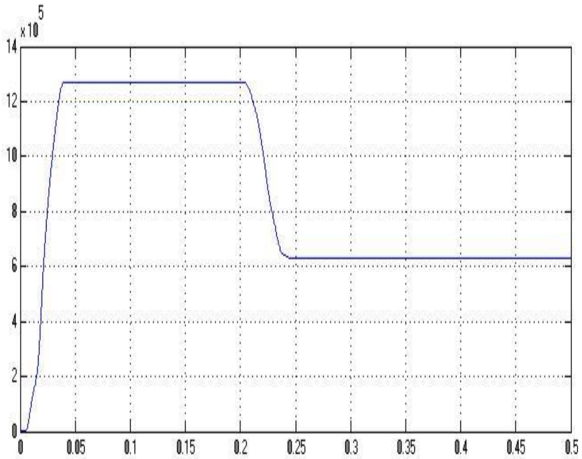
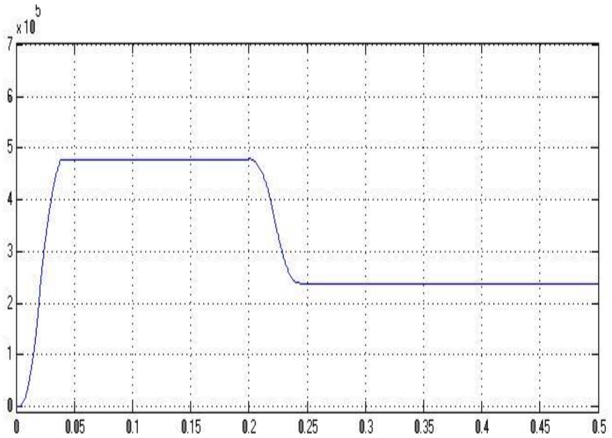


**Fig 4.6 REACTIVE POWER AT BUS 12**

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The real power at bus-26 is shown in Fig.4.9 and its value is 2.25*105watts. The reactive power at bus-26 is shown in Fig.4.10 and its value is 6.9*105watts.

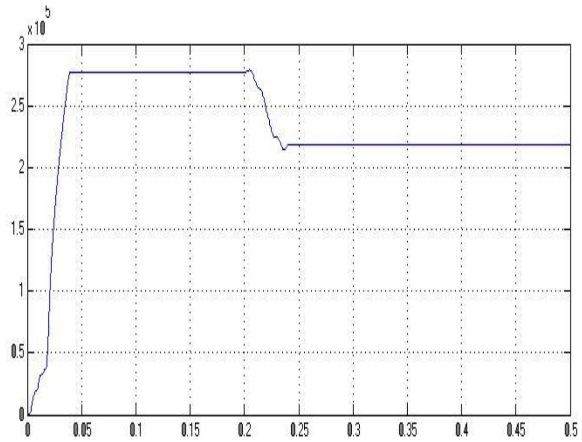


Fig 4.8 REAL POWER AT BUS 26

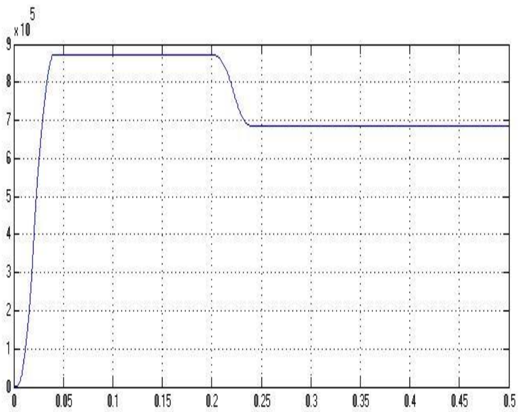


Fig 4.9 REACTIVE POWER AT BUS 26

| Bus no | P (MW) without Facts | P (MW) with Facts | Q (MVAR) without Facts | Q (MVAR) With Facts |
|---|---|---|---|---|
| 4 | 0.149 | 0.163 | 0.049 | 0.051 |
| 5 | 0.138 | 0.152 | 0.091 | 0.113 |
| 6 | 0.126 | 0.149 | 0.106 | 0.118 |
| 7 | 0.123 | 0.145 | 0.103 | 0.114 |
| 8 | 0.146 | 0.161 | 0.098 | 0.104 |
| 10 | 0.153 | 0.190 | 0.099 | 0.101 |
| 11 | 0.367 | 0.360 | 0.115 | 0.113 |
| 13 | 0.294 | 0.287 | 0.922 | 0.150 |
| 19 | 0..277 | 0.267 | 0.108 | 0.105 |
| 21 | 0.144 | 0.169 | 0.047 | 0.055 |
| 22 | 0.63 | 0.917 | 0.237 | 0.346 |
| 25 | 0.364 | 0.377 | 1.14 | 1.185 |
| 26 | 0.218 | 0.257 | 0.685 | 0.807 |

Table 4.1 COMPARISON OF REAL AND REACTIVE POWER

## CONCLUSION

Power quality is one of the major problems arising with increased penetration level of wind power in electric grids. The probability Density Function has been examined over the observed wind speed sampled and that enable to find the wind power for observed hours. The UPQC implemented in Thirty-bus system has been successfully executed, modeled and simulated using MATLAB. The comparison of results of the thirty-bus system with and without UPQC is presented. The resemblance revealed that the real power losses are reduced by 6% by introducing the UPQC in the multi-bus system. The developed indices are suitable for power systems that include high penetration level of wind based power sources. The method used is general and can be applied to other power quality indices or power system performance indices. An effort is made to categorize

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