Measurement of Power Quality through Transformed Variables

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Abstract: It is the objective of this paper to present unique features that characterize power quality events & to extract them from generated voltage and current waveforms using Windowed Discrete Fast Fourier Transform. Examples of unique features include peak amplitudes, RMS, frequency & sensitivity. This paper characterize the quality parameters namely voltage sag/swell & harmonics .Index evaluation is done on generated data & a qualitative comparison of results shows the advantages of signal processing technique applied to power quality analysis.

Keywords: Power Quality, identifying features, WDFFT.

1. INTRODUCTION

Study of power quality phenomena have emerged as an important subject in recent years due to renewed interest in improving the quality of the electricity supply. As sensitive electronic equipment continues to proliferate, the studies of power quality will be further emphasized.

In recent years, power quality phenomena have been investigated directly from actual recorded disturbance waveforms. These disturbance recordings are stored as voltage and current time-series which bring a wealth of information about the characteristics of the associated power quality events. Since these characteristics are unique to each power quality event, they are useful to portray the process of power quality disturbances and to pinpoint their causes. In this paper, we present unique features that characterize power quality events and methodologies in order to extract them from generated waveforms.

The reminder of this paper is organized in eight major sections. A brief review of Power Quality is presented in section**1**.In section **2.** Characterization of quality parameters namely voltage sag/swell & harmonics are discussed. In section **3**, Signal processing Technique applied to power quality analysis is discussed. Introduction to Scalable Vector Graphics based power quality analysis is presented in section **4.**The results are presented and discussed in section **5.**Finally in section **6** conclusions are given.

II. CHARACTERIZATION OF POWER QUALITY PARAMETERS: VOLTAGE SAG/SWELL, HARMONICS

Characterization means extracting information from individual power quality events, captured by any one of the triggering or segmentation methods. Concerns with the extraction of features & information from measured digital signals. That is data are available in the form of sampled voltage/current waveforms & from these waveforms

information is extracted. Each step is refinement of the previous step. Here signal processing extracts & enhances the information that is hidden.
This is the first step in quantification of supply by means of site or system indices.
STEP1: After obtaining waveform is to calculate characteristics as function of time.
STEP2: From characteristics vs. time single event indices are obtained.
STEP3: Making use of single event characteristics is to quantify the Severity of the event.

III. SIGNAL PROCESSING TECHNIQUE APPLIED TO POWER QUALITY ANALYSIS.

Power quality analysis is a major source of concern in terms for distributors. The number of disturbances must be estimated to optimize the reliability of electrical systems and thus to reduce cost of system faults. This estimate should be accurate enough to be able to identify the cause of disturbances. To date, most of the signal analysis tools used for measuring electrical disturbances are based on disconnected time and frequency representations inducing limited interpretations.

3.1 The Discrete Fast Fourier Transform Algorithm

The discrete FFT is an algorithm that converts a sampled complex-valued function of time into a sampled complex-valued function of frequency.
Most of the time, we want to operate on real-valued functions, so we set all the imaginary parts of the input to zero.
Here is an equation which tells you the exact relationship between the inputs and outputs.

$$\mathbf{Yp = \sum_{K=0}^{n-1} Xk\{ \cos(2\Pi(kp/n)) + i \sin(2\Pi(kp/n))\}}$$

In this equation, *xk* is the *k*th complex-valued input (time-domain) sample, *yp* is the *p*th complex-valued output (frequency-domain) sample, and $n = 2^N$ is the total number of samples. Note that *k* and *p* are in the range 0.. *N-1*.
Discrete fast Fourier transform is extremely important in the area of frequency (spectrum) analysis because it takes a discrete signal in the time domain and transforms that signal into its discrete frequency domain representation .Without discrete time to discrete frequency transform we would not be able to compute the Fourier transform with a microprocessor or DSP based system.
Basically to characterize the power quality parameters like voltage swell, sag & harmonics. Apply WDFFT to monitor these indices, so we are doing "Quality Index Computation.
To generate data for

a) Voltage sag:
e(t) = A1* Sin(wt) - A2 *U1*(t-T1)*U2* (t-T2)*Sin (wt)
Assign values for A1, A2, T1, T2, ▲t=1msec
Given
U1=0 for t<T1
U1=1 for t>T1
Similarly U2=1 for t<T2
U2=0 for t>T2
Magnitude A2=0.5A1
T2-T1= 0.5 seconds
Where w=314

Moving the window by 0.5 seconds each time, apply WDFFT.As a Result we get sequences of transforms. Plot these sequences as function of time. Finally the affectivity of these transforms is seen in characterization of power quality events based on RMS values.

b) Voltage swell is generated by changing the negative sign in the expression .The amplitude values for A1, A2 are changed.
e(t) = A1* Sin(wt) + A2 *U1*(t-T1)*U2*(t-T2)*Sin (wt)
A2=2A1.

c) Harmonics are generated with the expression having multiple frequencies.
e(t) = A1* Sin(wt) – A3 *U1*(t-T1)*U2*
(t-T2)*Sin(3wt)+A5*Sin(5wt)+A7* Sin(7wt)

Where A3=0.2,A5=0.3,A7=0.3.
Characterization of quality parameters are obtained by peak amplitudes& at what frequency it is occurring.

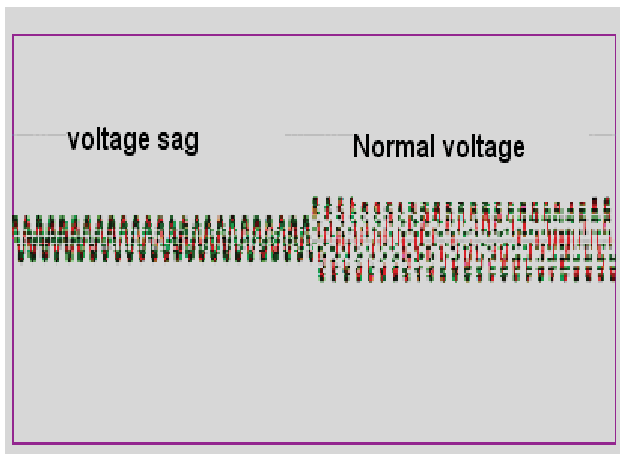
IV. INTRODUCTION TO SCALABLE VECTOR GRAPHICS BASED POWER QUALITY ANALYSIS

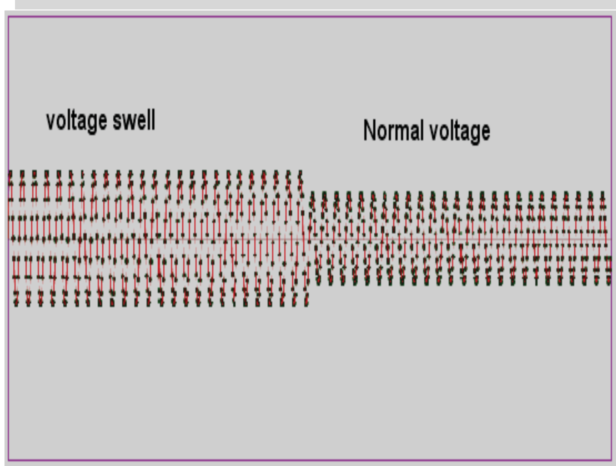
What is SVG?
SVG stands for **S**calable **V**ector **G**raphics.SVG is used to define vector-based graphics for the Web and the graphics in XML format .SVG graphics do NOT lose any quality if they are zoomed or resized .Every element and every attribute in SVG files can be animated

SVG is a World Wide Web Consortium (W3C) recommendation. SVG integrates with other W3C standards such as the DOM and XSL

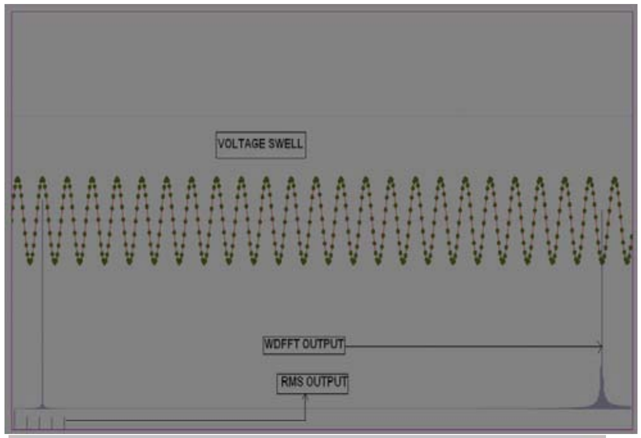
V. RESULTS

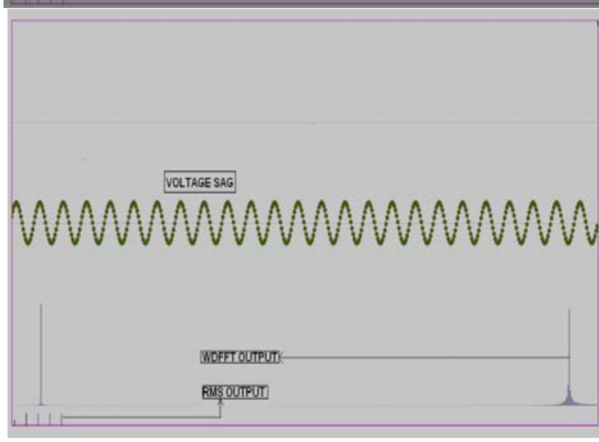
Voltage Sag Generation: Voltage Swell Generation:





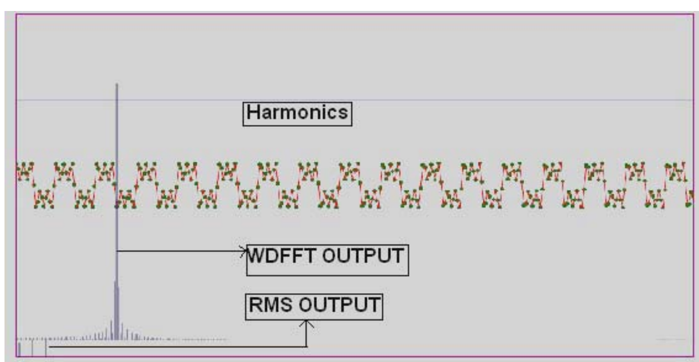
WDFFT, RMS OUTPUT FOR VOLTAGE SAG, SWELL, HARMONICS





a) e(t) = A1* Sin(wt) - A2 *U1*(t-T1)*U2* (t-T2)*Sin (wt) (Voltage sag)

b) e(t) = A1* Sin(wt) + A2 *U1*(t-T1)*U2* (t-T2)*Sin (wt) (Voltage swell)



c) e(t) = A1* Sin(wt) – A3 *U1*(t-T1)*U2* (t-T2)*Sin(3wt)+A5*Sin(5wt)+A7*Sin(7wt) (Harmonics)

VI. CONCLUSIONS

In this paper, since the characteristics are unique to each power quality events, they are useful to portray the process of power quality disturbances & pinpoint there causes. Complete Analysis of the event that took place in the network & appropriate mitigation options can be selected based on the outcome of the algorithm.

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