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Spectrograms to Distribute Power in Harmonic Signals

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***Abstract**: The paper proposes an improved approach to locating and categorizing harmonic signals in the power distribution by means of using spectrograms and time-frequency distribution (TFD) analysis. Spectrogram (occasionally referred to as temporal frequency representation (TFR)) is an appropriate means of presenting signals in the joint time-frequency domain. Since the property of signals is recorded as the result of TFR, it can simply locate the detection and approximated information about the signals in the spectrum. The application of a rule based classifier and a set of thresholds referred to in the IEEE Standard is used to identify and categorize 200 individual signals with a range of harmonic features. The recommended approach is examined with the help of MAPE, and the outcomes suggest that the method is accurate. Moreover, the spectrogram is able to give hundred percent classification of harmonic signals. The proposed method to detect and classified harmonic signals in the distribution system has been proved to be accurate, fast, and cost effective.*

***Keywords**: Spectrogram, Time-frequency distributions, Classification technique, Detection, Harmonic signal, Power distribution*

I. Introduction

Spectrograms provide very important information in signal processing because they reveal how a signal varies in the frequency content with time. They are particularly useful when looking at harmonic signals, that is, signals constituted of a number of frequency components that are integer multiples of a fundamental frequency. Under these conditions [1], thanks to the spectrogram, the distribution of the power over different harmonics can be analysed in detail, which contributes to estimating the prevailing frequencies and temporal variations of these frequencies. A spectrogram simultaneously measures data at both frequency and time: a signal is split into overlapping time slices and the power spectrum calculated within each slice with short-time Fourier transform (STFT). On this basis, it can be highly beneficial in several cases, including communications, vibration checks, and sound analysis. Analysis of spectrogram in power distributions is useful in detection of defects, enhanced clarity in signals and diagnosis of system behaviours. Ultimately, spectrograms provide a dependable method to examine the arrangement and modulation of power in harmonic dense sounds at some point over time.

II. Harmonics and Non-Harmonics

Components of signal frequencies which are whole multiples of a fundamental frequency are termed as harmonics. They appear as isolated bands or peaks which are regularly spaced along the frequency axis in analysis of spectrogram and one can easily identify how power density at specific harmonics evolves with time. On the other hand, inter harmonics are frequency elements which are not the multiples of the fundamental frequency. They often are observed in the spectrograms between the harmonic bands and are produced by non-linear loads, frequency conversions or disruptions of the signal. A good understanding of power distribution of complex signals may be achieved through applying both harmonic and inter harmonic using spectrograms. Inter harmonics are often indicators of system instability, or noise, however harmonics have regular periodic behaviours. The spectrogram has been useful in isolating, tracking and quantifying such elements in applications such as power quality performance, analysis of audio signals as well as detection of equipment failures. Spectrophotograms thus are good tools used in analysing the time-frequency power distribution.

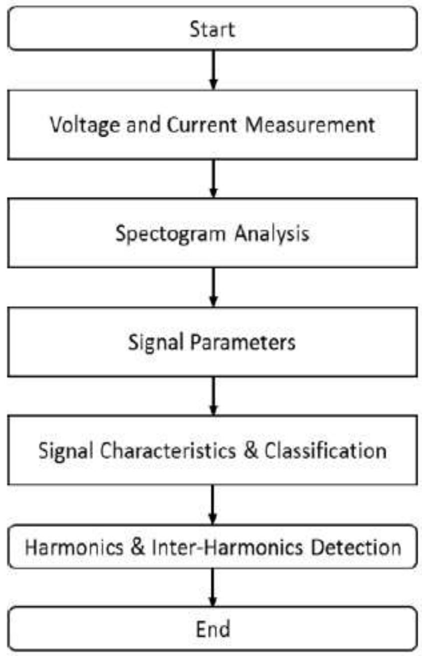


Fig 1: Flow Chart for Harmonics and Inter-Harmonics Detection

III. Detection of Harmonic Signals

Spectrograms are one good approach of analyzing a signal in time frequency that can be used to identify a harmonic signal. Detection of harmonic signals (also composed of a fundamental frequency and its rational multiples) is an important issue in several fields, such as structural health monitoring, audio engineering, and power systems. Spectrograms display the signal energy in graphical form as a function of time and frequency and they are generated with Short-Time Fourier Transform (STFT). Harmonics indicate the presence of consistent power at the specific frequencies and they appear in clear horizontal lines at specific intervals on top of the fundamental frequency [4]. Examination of the patterns allows determining the presence, amplitude, and temporal behavior of harmonic components. This helps in diagnosis of faults, identification of resonance effects and the system performance. Also, it should be noted that spectrograms augment the detection of transient harmonics not detected by the steady-state frequency analysis. Consequently the spectrogram-based frequency analysis approach offers a foolproof and convenient method of detecting and monitoring of harmonic content in the non-stationary signal condition.

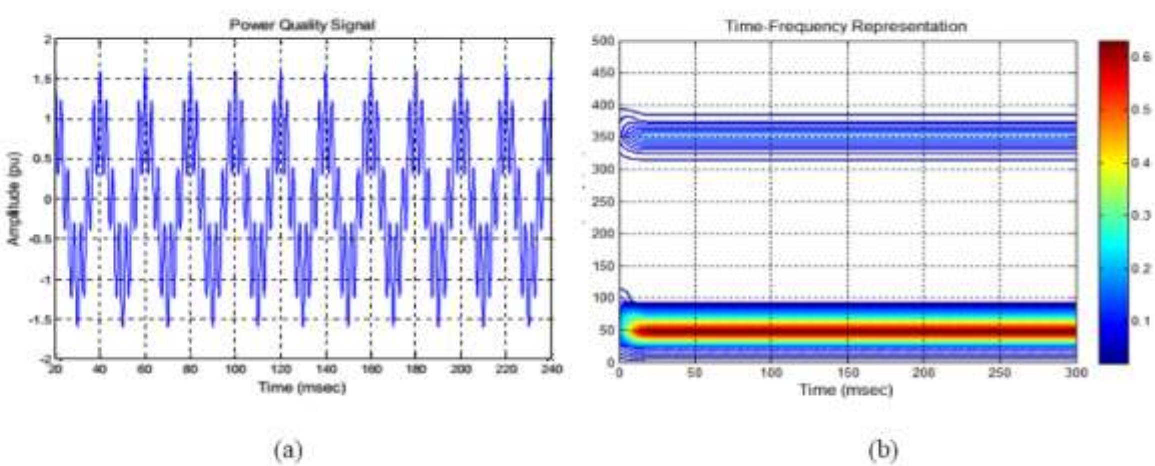
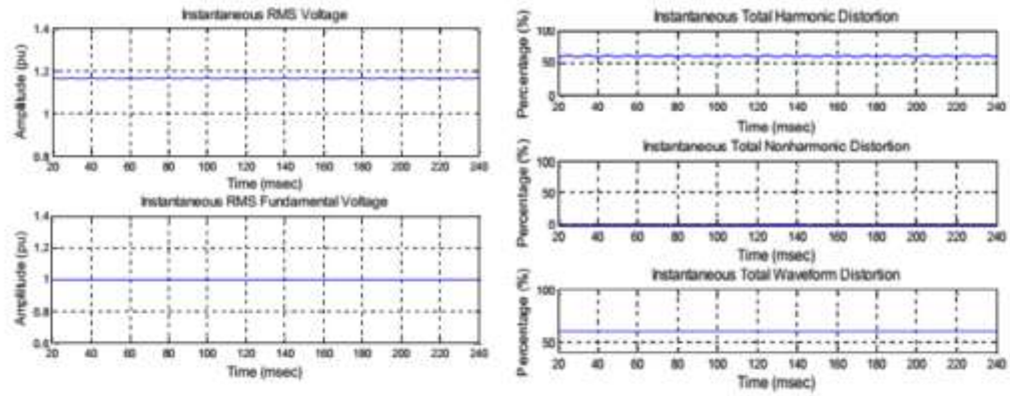


Fig 2: (a) Harmonic Signal (b) TFR Spectrogram

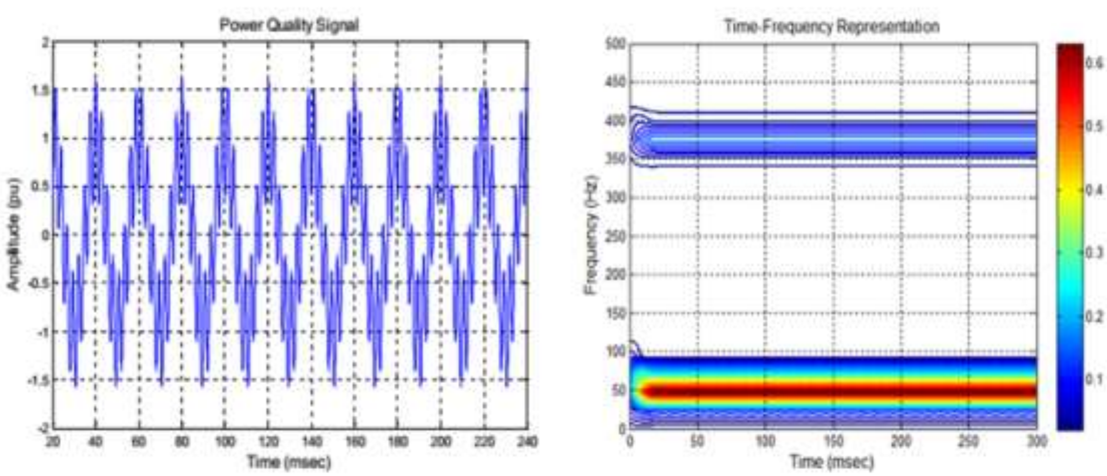


(c) (d)

Fig 3: (c) Instantaneous of RMS (d) Total Harmonic Distortion

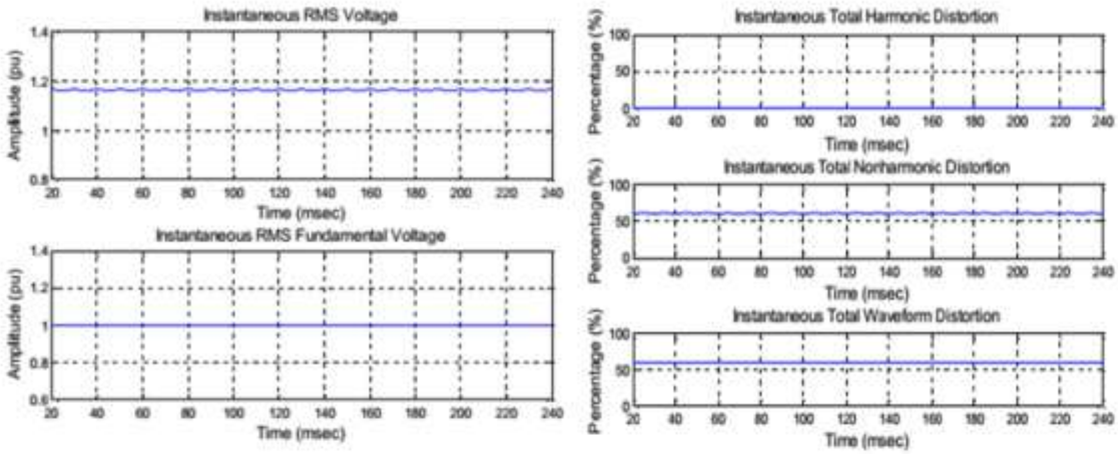
IV. Detection of Non Harmonic Signals

Components that are not harmonically related to some fundamental frequencies are called non-harmonic signals. They are frequently caused by non-regular or not periodical sources like switching devices, mechanical failures or signal interferences, and can take the form of inter types of harmonics, noise or disturbances. Non harmonic signals are displayed in spectrogram as irregular or scattered energy patterns that distort the harmonic pattern. Through time-frequency representation these elements are detectable and easily observable especially when they occur suddenly or vary with time using the spectrogram. It particularly aids in investigation of environmental sounds, interpreting vibration on machineries as well as identifying flaws within electric circuits. The continuous observance of the power distribution through spectrograms makes it possible to come up with correct diagnostic and mitigation techniques that help to distinguish between harmonic and non-harmonic content. In all perspectives, spectrograms are practical tools in the identification and understanding of the behavior of non-harmonic signals in complex and dynamic systems [2-3].



(a) (b)

Fig 4: (a) Simulation (b) TFR using Gabor Transform



(c) (d)

Fig 5: (c) RMS and RMS Voltage, (d) Instantaneous of THD

V. Conclusion

Using the MAPE, the analysis of the signals performed with the help of spectograms is checked in a time and frequency domain. The identification and categorization of harmonic signals are also checked with the help of 200 signals having various features of each type of the voltage signal. The conclusions reveal that the spectrogram is 100 accurate, and has good signal classification. Spectograms hence can be an appropriate technique that is applicable in power distribution systems during detection and classification of harmonic signals.

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