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Power Quality Analysis of Grid-Connected Wind Turbine System

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***Abstract*—this paper develops time-frequency methods for complex investigation of transient states in wind power plants two algorithms were proposed: short-time Fourier transform (STFT) and Choi-williams (CWD). In order to explore advantages of the methods several experiments were performed using model of squirrel-cage induction machine connected directly to the grid. Investigated phenomena concerned power distortion caused by fault in accordance with the influence of wind speed on instantaneous character of appeared power distortions.**

Keywords—Transient states, Choi -Williams, Induction machine, power distribution, power plants.

I. INTRODUCTION .

In the era of technological development power quality issues have more and more crucial meaning. In spite of achieved experience in specifications of distribution, including IEC norms, some cases and accompany phenomena require individual approach. As examples can use wide researchers on influence of dispersed energy sources on power quality, especially occluding wind power plants.

Wind turbines become nowadays regular element of power systems with all its desirable as well as undesirable influence .Behind the undisputed significance of wind power plants for searching the renewable energy sources there are some aspects, which have impact on power quality. One of them is natural result of variable weather conditions. Another comes from mechanical construction of power plant and power electrical equipment. Recognizing sources and symptoms of mentioned impacts it can be detailed [2], [3], [10]. Influence of stochastic wind variation on output torque, power, voltage and current fluctuation, periodical drop of output torque when the mill blade passes the tower (shadow effect), complex, nonlinear oscillation of the tower and wind turbine which can be transferred to turbine shaft (the frequency of generated oscillation can attain value from tenth to few HZ), and finally wide spectrum of harmonica in current and voltage caused by present of power converters.

Selection of proper method for analysis of power distortion in wind turbine systems is still actual and crucial. In [10] we can find an idea. Which apply classical Fourier spectrum in order to investigate and classify power distortion? In this paper the propose to apply two-dimensional time-frequency analysis in order to obtain comprehensive analysis of power distortion. One of the contributions of this paper developing a new qualitative method for analysis of transient phenomena in wind turbine systems. Particularly, the investigation is aimed at revealing the instantaneous character of power distortion under transient conditions. In order to explore the effects, grid connected wind turbine system was modeled using Mata lab simpowersystem toolbox.

II. METHODS OF ANALYSIS

The standard method for study time-varying signals is the short-time Fourier transform (STFT), which utilizes short-time window h ( ). Then, the Fourier transform of this windowed signal is calculated to obtain energy distribution along the frequency direction at the time corresponding to the window [1], [5], and [7]:

$$STFT_x(t,w) = \int_{-\infty}^{+\infty} x(\tau)h(\tau - t)\, e^{-jw\tau} d\tau \qquad (1)$$

This method belongs to non-parametric liner transformation the crucial drawback of this method is that the length of the window is related to the frequency resolution. This inherent relationship between time and frequency resolution becomes more important when one is dealing with signals whose frequency content is changing rapidly. A time frequency characterization that would envelopment based on non-parametric, bilinear transformation. Performing the transformation brings two dimensional planes which represent the changes of frequency component, here called auto-terms (a-t).unfortunately, bilinear nature of discussed transformation manifests itself in existing of undesirable components, called cross-terms (c-t). Cross-terms are located between the auto-terms and have an oscillating nature. It makes interpretation of the distribution difficult. Development in discussed family was concentrated on selection of suitable kernel functions, which would deliver smoothing effect of the cross-terms with preservation of useful properties of designed distribution. One of the participants of mentionable approach is choi-williams. Distribution (CWD) with Gaussian kernel [3], [5]:

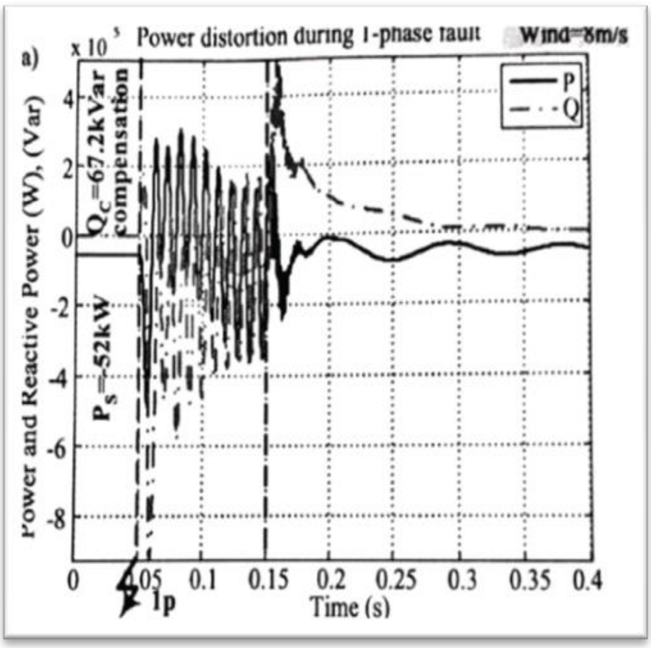
$$CWD_x(t,w)=\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\sqrt{\frac{\sigma}{4\pi}\frac{1}{|\tau|}e^{\left[\frac{\sigma}{4}\left(\frac{t-u}{\tau}\right)^2\right]}}\ldots\ldots$$

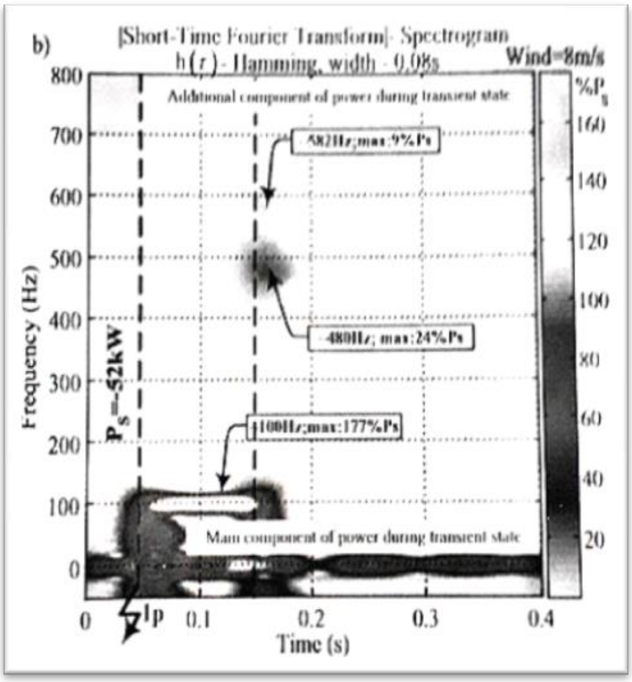
$$\ldots\ldots\ldots\ldots\left(u+\frac{\tau}{2}\right)x^2\left(u-\frac{\tau}{2}\right)e^{-jw\tau}\,dud\tau \qquad (2)$$

The mail fields of application consist speech processing seismic, economic and biomedical date analysis [1], [7]; recently some efforts were also made to introduce time-frequency analysis in electrical engineering area [3], [5].

III. MODEL OF WIND-TURBINE POWER SYSTEM

Simulated generator is a squirrel-cage induction machine rated at $160kw, 380V, 1500rpm$. it is connected to the grid through a Dyg $25/0.4$ distribution transformer which nominal power equals $1MVA$. Point of common coupling is connected with the system via typical $5Km$ overhead line, represented by positive, negative and zero-sequence of impedance. The system was simulated by equivalent sources with short circuit capacity of $100MVA$ and X/R ratio of 7. Capacitor banks realize compensation of absorbed reactive power and are directly connected. That type of wind turbine is cheap and robust and therefore popular, but from the system analysis point of view if has some drawbacks [4], [6], [7]. The simulation was done in mat lab using the simpowersystem toolbox.





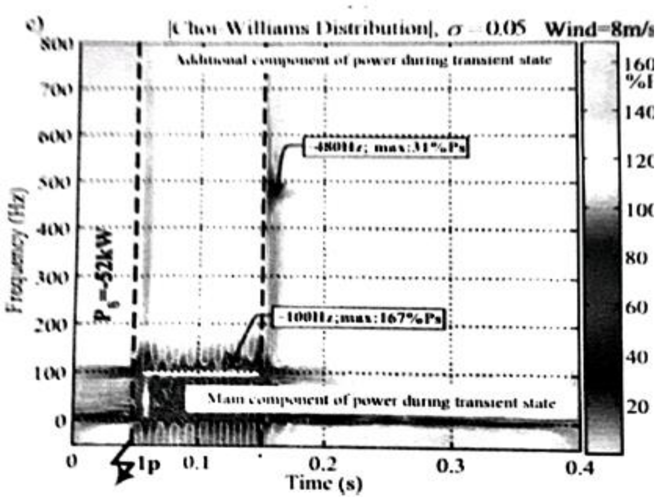


Fig1. One-phase fault in phase A for low speed wind 8m/s: power distortion (a) And its time-frequency analysis using STFT (b) and CWD (c)

TABLE I. *ADDITIONAL COMPONENT OF POWER DISTORTION AND ITS CONTRIBUTION IN 1- PHASE FAULT USING STFT (P_g - NOMINAL POWER FOR GIVEN WIND CONDITION)*

Wind (Power)	Frequency component (instantaneous max. power corresponding to P_S)		
8 m/s (P_S=-52kW)	f1=100Hz (177%P_S)	f2=480Hz (24%P_S)	f3=581Hz (5%P_S)
11 m/s (P_S=-155kW)	f1=100Hz (74%P_S)	f2=430Hz (10%P_S)	f3=540Hz (5%P_S)

IV. INVESTIGATION AND RESULTS

The aim of carried out investigation is to study the distortion of power generated by wind turbine under transient states caused by 1-phase fault with ground in point of common coupling (PCC), fig. 1. Depicts an example of 3-phase power behavior during the fault for low speed of the wind equals $8m/s$, that corresponds to the non-nominal, $P_S = 52KW$, value of generated power. Time –frequency analysis, using (STFT) and 9 CWD), allowed revealing main component as well as transient components: $100Hz$, which exist during the fault, and $480Hz$, $582Hz$ which accompany the operation of switching of the fault. Fig.1c confirms sharp decoction of transient states when (CWD) is applied but also indicates problem of separation for components localized in near time-frequency regions or modulated by peak value. Additionally, some comparisons of wind condition on transient was done, table 1 indicate that for nominal condition , wind equals $11m/s$, transient components are localized in lower frequency regions and its contribution in power distortion decreases.

V. CONCLUSION

Carried out investigation using time-frequency methods allow to uncover complex nature of power distortions in wind power system during transient states, simultaneous observation of the phenomenon time and frequency domain indicates relation between transient components and wind conditions. Here reveals complexity of the analysis, which should be treated as benefits of proposed method.

REFERENCES

[1] Boashash B. *time-frequency signal analysis method and application*, Longman Cheshire's Melbourne or wily attested press, network 1992

[2] Chin Z, sponger: grid power quality with variable speed wind turbine, IEEE transition on energy conversion, vol, 16, no, 2 app 148-145, 2001.

[3] A Hybrid Approach for Spam Filtering using Local Concentration and K- means Clustering", 2014, 5th International Conference, pg no: 194- 19

[4] Anwar M.N., Husain I.: Design of a Switched Reluctance Machine for Wide-speed Range Operation. Proceedings of International Conference on Electrical Machines. ICEM'2000, 28-30 August 2000, Espoo Finland, pp.1581-1585.

[5] Besbes M., Gabsi M., Hoang E., Lecrivain M., Grioni B., Plasse C.: SRM design for starteralternator system. Proceedings of International Conference on Electrical Machines. ICEM'2000, 28-30 August 2000, Espoo Finland, pp.1931-1935.

[6] Vipin N S, Abdul Nizar M "A Proposal for Efficient Online Spam Filtering" First International Conference on Computational Systems and Communications 2014.

[7]]Kolar, J.W.; Ertl, H.; Zach, F.C.: Design and Experimental Investigation of a Three-Phase High-Power Density High Efficiency Unity PowerFactor PWM (VIENNA) Rectifier Employing a Novel Integrated Power Semiconductor Module, in APEC 1996, pp. 514-523.

[8] Pinheiro, J.R.; Barbi, I.: Three-level Zero-Voltage-Switching PWM DC-DC Converters - A Comparison, in PESC 1995, pp. 914 –919.

[9] Alecks, F.; Ford, M. Tuffs, M.: Design of an Advanced High Power Density 1U Intelligent Rectifier, in INTELEC 2000, pp. 17-23.

[10] Nabae, A.; Takahashi, I.; Akagi, H.: A New Neutral Point Clamped PWM Inverter, in IEEE Transac. On IA, Vol. IA-17, No. 5, Sep. /Oct. 1981, pp. 518-523.