International Journal of Research and Review
www.ijrrjournal.com E-ISSN: 2349-9788; P-ISSN: 2454-2237

Research Paper

Assessment of Power Quality Disturbance Signals Using Fractional Fourier Transform

Mithilesh Kumar Thakur[1], Neeraj Kumar Kumawat[2]

[1]P.G Scholar, Deptt. of Electrical Engg., YIT, Jaipur, Rajasthan, India
[2]Assistant Professor, Deptt. of Electrical Engg., YIT, Jaipur, Rajasthan, India

Corresponding Author: Neeraj Kumar Kumawat

ABSTRACT

In this paper disturbances like voltage sag, voltage swell and harmonics in power signal using fractional Fourier transform methods are analyzed for different values of transform 0.1 to 1. We have analyzed this algorithm in MATLAB simulation tool. This analysis is performed to find out the performance of this method on different types of disturbances. We have analyzed this to find out maximum deviation in each disturbance.

Keywords – *Fractional Fourier Transform, Sag, Swell, Harmonic, power quality.*

INTRODUCTION

Power quality (PQ) has turned into a big concern in the current years with the growing utilization of non-linear loads, power electronics based instruments etc. Power quality concerns utility and consumers similarly. Poor power quality provides results such as; breakdowns, instability, shortened life of the instrument etc. Power quality disturbances such as; voltage sag, voltage swell, momentary interruption, notches, glitches, harmonic distortions, transients etc. have become normal in present power system. The sources and reasons of such disturbances must be known in order to enhance the quality of the electric power. These power quality disturbances are non-stationary in nature and happen for short duration. IEEE 1159-2009 describes these disturbances in terms of their magnitude, frequency content, and duration. Quality of electric power is generally degraded due to the occurrence of disturbances like voltage sag, swell, transients, interruption, harmonics and flicker. These disturbances cause malfunctioning of circuit breaker, failure of end-user instrument and decay the performance of transmission system devices. Detection of the disturbances and its source is important to install a mitigation device for enhancing the power quality. Most of the typical power analyzers do not provide enough temporal information of the disturbances. Therefore, the monitoring device should be capable to identify and classify the power quality disturbances. [1-2] The signal processing methods frequently implemented for parameter extraction include fast Fourier transform (FFT), S-transform (ST), Wavelet transform (WT), empirical mode decomposition (EMD) and Kalman filter. [3–6] Good power quality (PQ) is necessary for robust functioning of power systems. Major reasons of power quality degradation involve faults, capacitor switching, load switching, solid state switching instruments, arc furnaces, power converters, and energised transformers. These features increase the chances of power quality disturbances (PQDs) like sag, swell, transient, harmonics, notch, interruption, flicker and spikes. Literature [7] provides the initial introduction to all the power quality disturbances may occur in power distribution scenario. Literature [8] gives a survey of several distribution sites and as a result provides various interesting observations about the various types of disturbance occurrence statistics which involves computations that the majority of the voltage sags in power signal have a magnitude of around 80% and a time span of around 4 to 10 cycles and that the total harmonic distortion on harmonic disturbances has value around 1.5 times the normal value. Literatures [9–10] propose the features of wavelet transforms and their use to situations equivalent to power quality disturbance categorization. Poisson, P. Rioual and M.Meunier [11] proposed the possibility of utilizing continuous wavelet transform, Quadratic Transform and Multi-resolution analysis for identification of the disturbances. Olivier Poisson, Pascal Rioual, and M.Meunier [12] presented a technique of using continuous wavelet transforms to recognize and examine voltage sags and transients. One more interesting transform known as S-transform which is an advancement of wavelet transform is presented by P. K. Dash, B. K. Panigrahi, and G. Panda. [13] The S-transform process had many promisingly impressive time-frequency resolution features.

Fractional Fourier Transform

Fractional Fourier transform (FRFT) is a simple form of Fourier transform (FT). It has been demonstrated to be one of the most important equipment in non-stationary signal processing methods. [14] There has been a vast research on the significant topics connected with Fractional Fourier Transform. [15-16] One of the benefits for the FRFT differentiated with the FT is that the signal which is non-band limited in the fourier transform domain may be band limited in the fractional Fourier domain (FRFD). Sampling theorem is an important problem in signal processing. In the sampling mechanism, the sampling rate must fulfill the Nyquist sampling rate, otherwise the spectrum aliasing will happen and influence the performance of the signal recovery and estimation. [15] However, non-uniform sampling usually occurs in practical applications. The signal recovery and spectral analysis from non-uniform sampling sequence in the fractional fourier transform have been researched in recent years. [17-18]

Fourier Transform (FT) joins the time domain and frequency domain, which represents the signal frequency components from the overall and is feasible to examine the certainty and stability signal. To the non-stability signal's time-frequency investigation, FT can map one dimensional signal in time domain to two dimensional signals in time-frequency domain, which totally reflect the signal frequency distribution feature as time varying. Fourier transform is a linear operator, if which is view as from time axis to frequency axis through anticlockwise rotating the π/2, then fractional fourier tranform operator can rotate any angle. So fractional fourier tranform can be considered as a generalized FT. [19] FRFT of p order is expressed as:

$$X_p(u) = \int_{-\infty}^{\infty} x(t) K_p(t,u)\,dt$$

Where, $K_p(t, u)$ is kernel function, which is defined as:

$$K_p(t,u) = \begin{cases} \sqrt{(1 - j\cot\alpha)}\, e^{j\pi\,(t^2 \cot\alpha) - 2ut\cos\alpha + u^2\cot\alpha)} & \alpha \neq n\pi \\ \delta(t-u) & \alpha = 2n\pi \\ \delta(t+u) & \alpha = (2n+1)\pi \end{cases}$$

PROPOSED METHOD

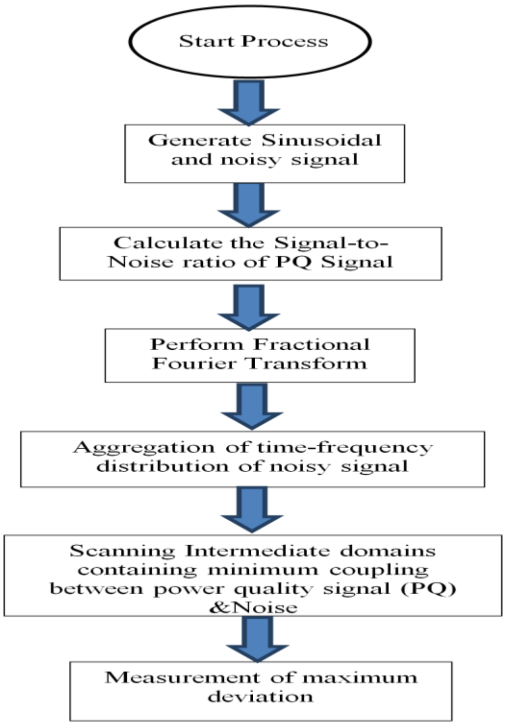


Fig. 1 Proposed algorithm

EXPERIMENTAL RESULT

We have taken the signal of duration 0.5 second and sampled with sampling frequency of 6.4 KHz and signal frequency of 50 Hz. Therefore the time period of signal is 0.02 second, number of cycle is 25, total number of samples per cycle is 128 and total sampling points is 3200. Our main objective is to analyze the various disturbed signals based on fractional Fourier transform and simulate its results performed in MATLAB with the results of fourier transform.

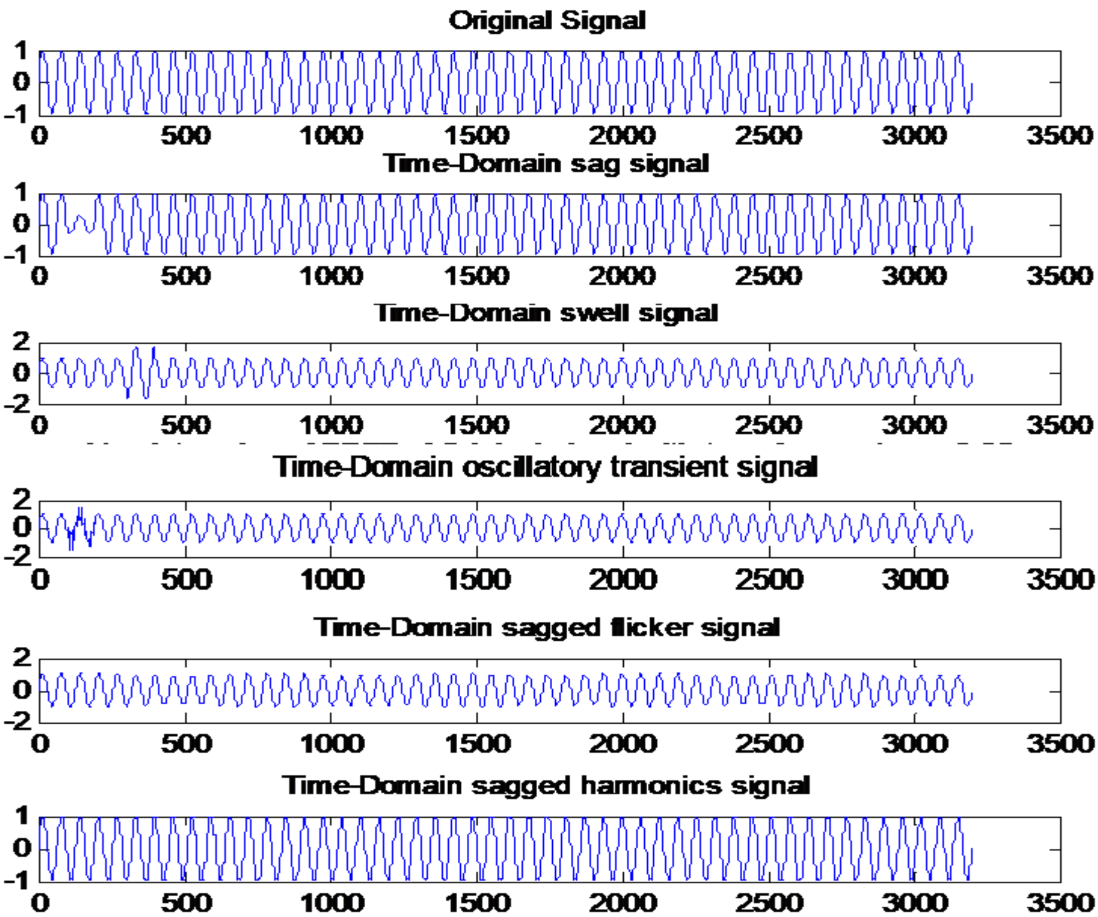
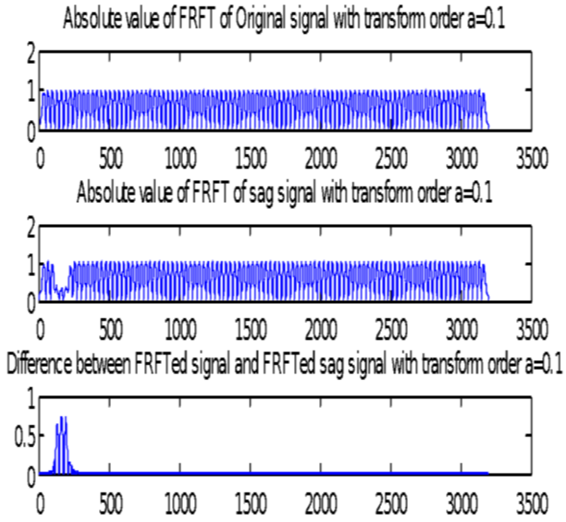
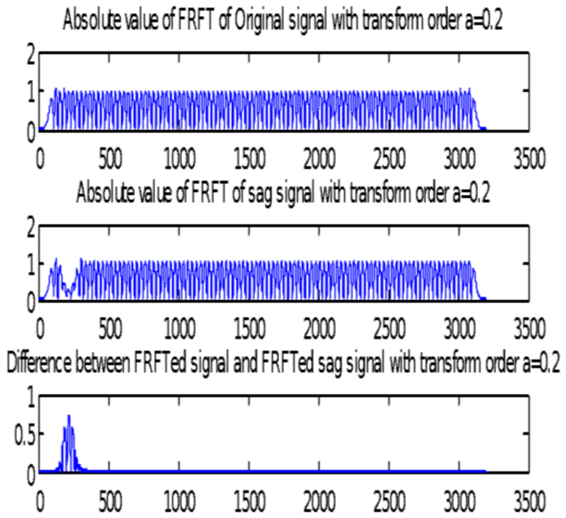
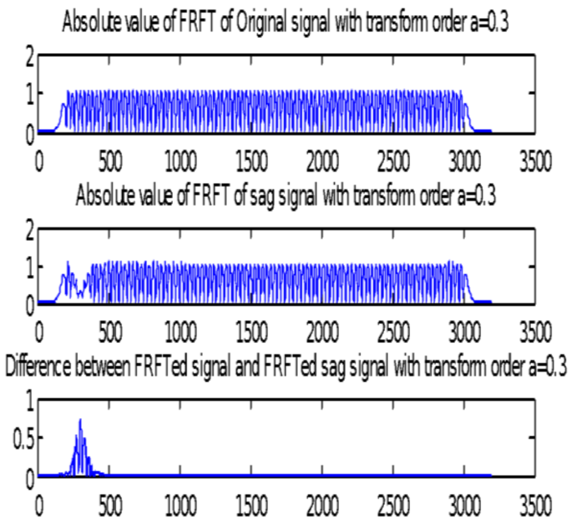


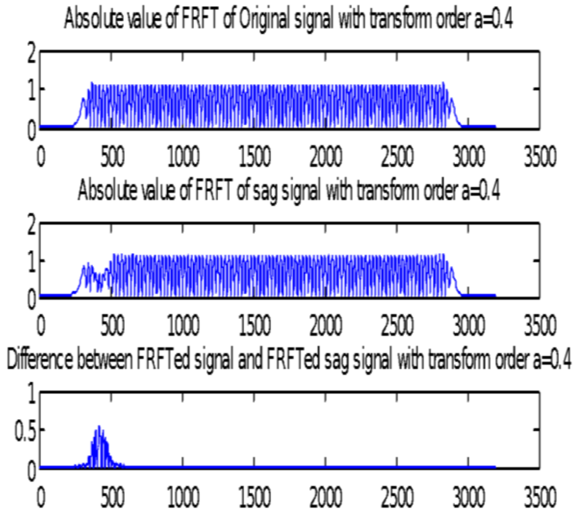
Fig. 2 Original signal and time domain signals with disturbance

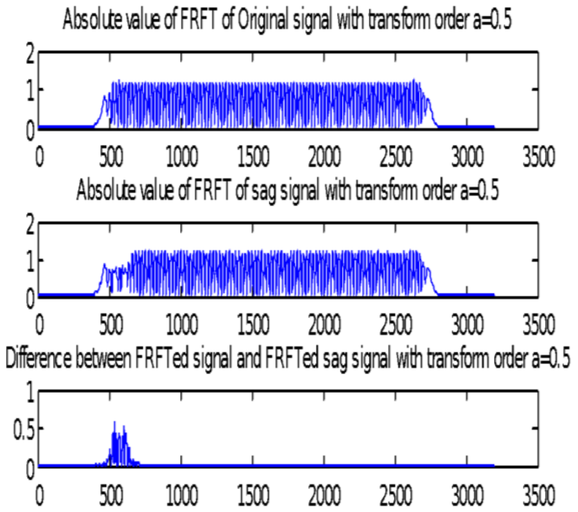
FRFT Analysis of Sag Signal

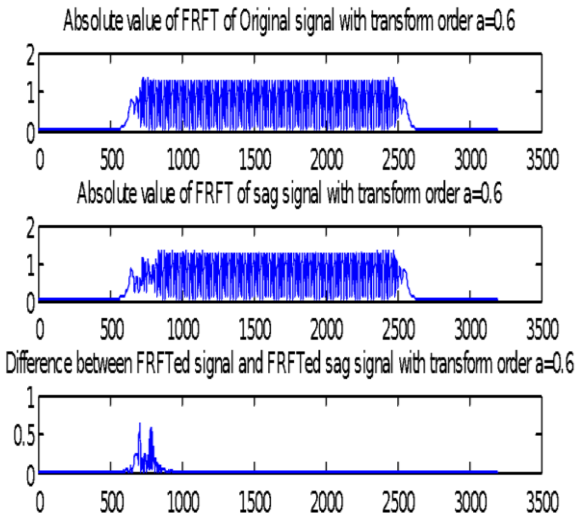


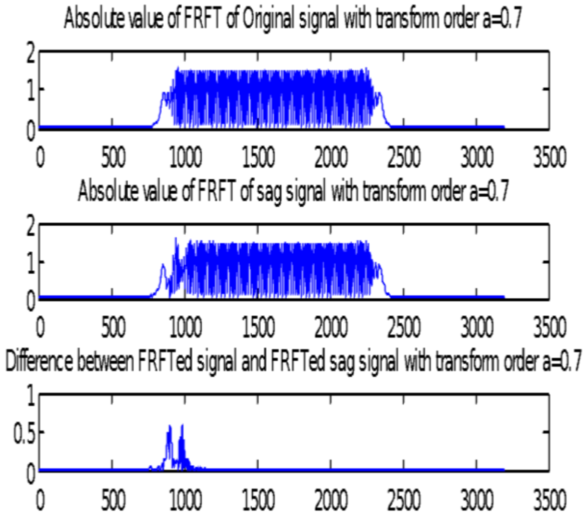


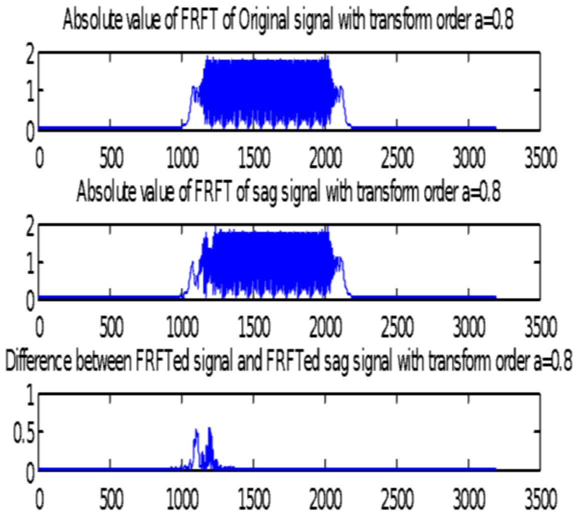


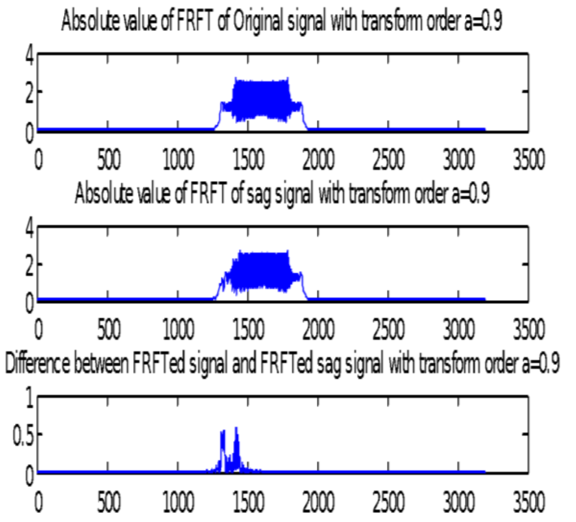












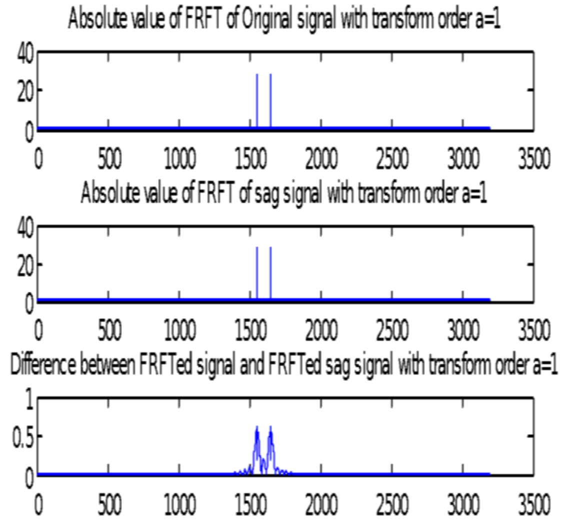
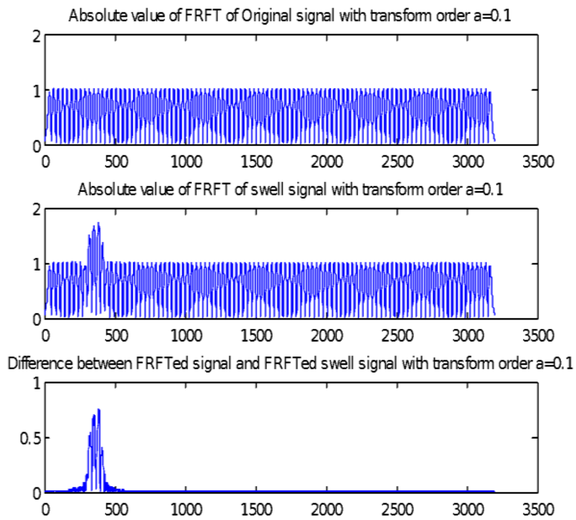
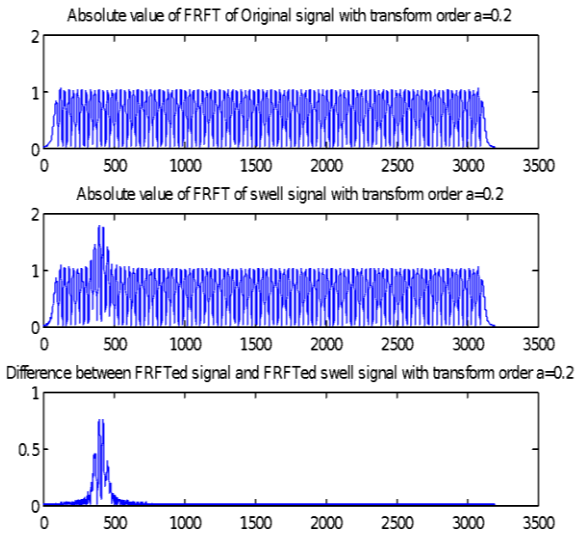
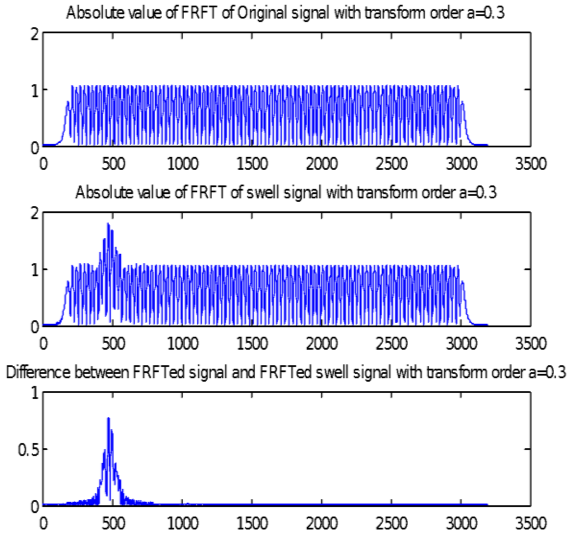


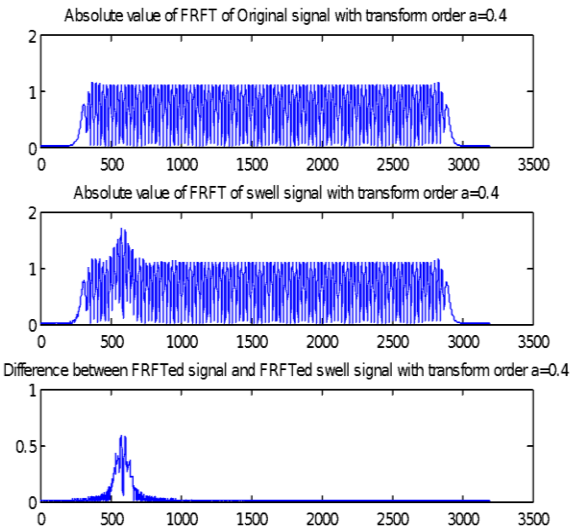
Fig. 3 FRFT analysis of Sag signal according to different transform order

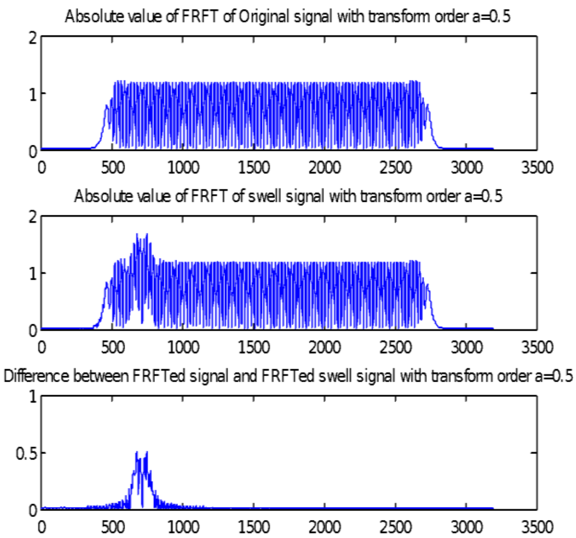
FRFT Analysis of Swell Signal

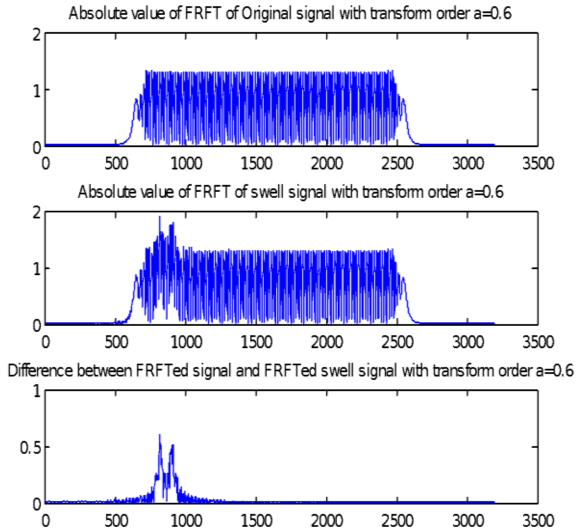


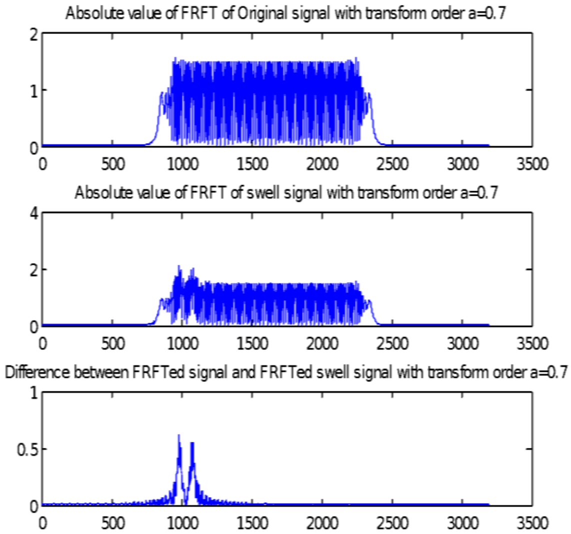


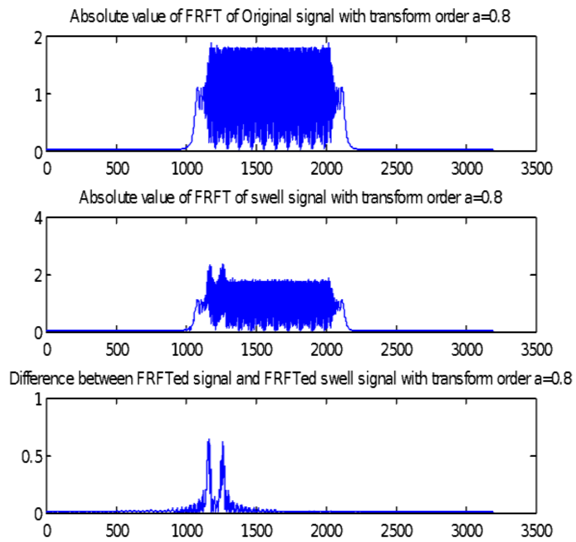

Absolute value of FRFT of Original signal with transform order a=0.3
Absolute value of FRFT of swell signal with transform order a=0.3
Difference between FRFTed signal and FRFTed swell signal with transform order a=0.3

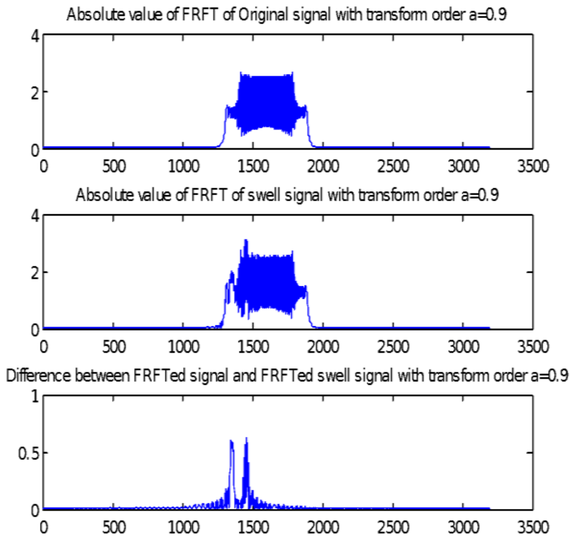

Absolute value of FRFT of Original signal with transform order a=0.4
Absolute value of FRFT of swell signal with transform order a=0.4
Difference between FRFTed signal and FRFTed swell signal with transform order a=0.4


Absolute value of FRFT of Original signal with transform order a=0.5
Absolute value of FRFT of swell signal with transform order a=0.5
Difference between FRFTed signal and FRFTed swell signal with transform order a=0.5


Absolute value of FRFT of Original signal with transform order a=0.6
Absolute value of FRFT of swell signal with transform order a=0.6
Difference between FRFTed signal and FRFTed swell signal with transform order a=0.6


Absolute value of FRFT of Original signal with transform order a=0.7
Absolute value of FRFT of swell signal with transform order a=0.7
Difference between FRFTed signal and FRFTed swell signal with transform order a=0.7


Absolute value of FRFT of Original signal with transform order a=0.8
Absolute value of FRFT of swell signal with transform order a=0.8
Difference between FRFTed signal and FRFTed swell signal with transform order a=0.8



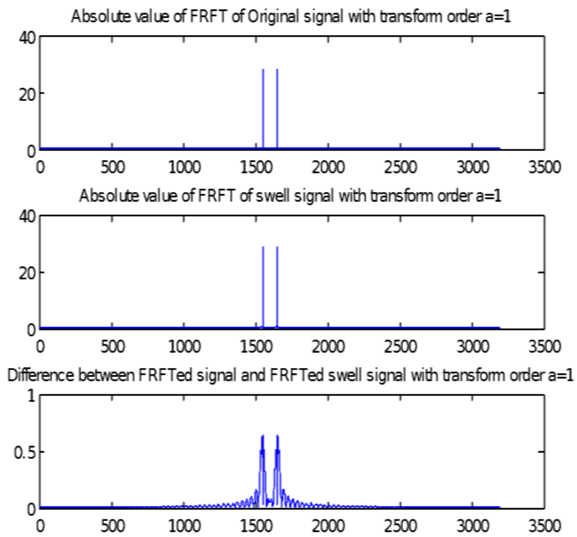
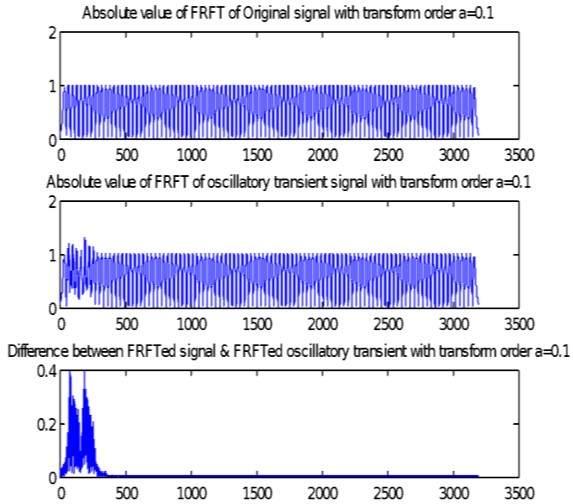
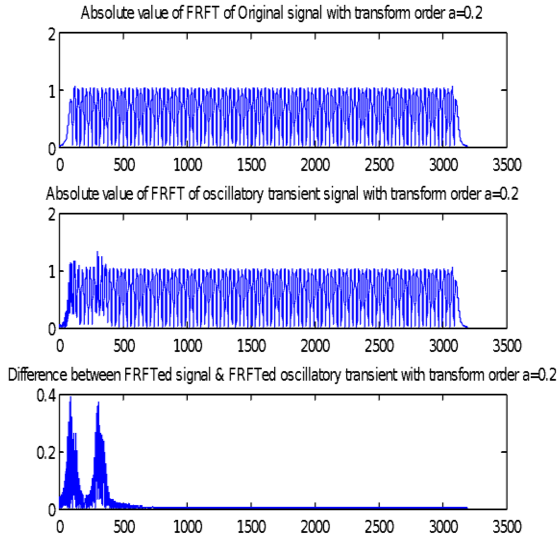
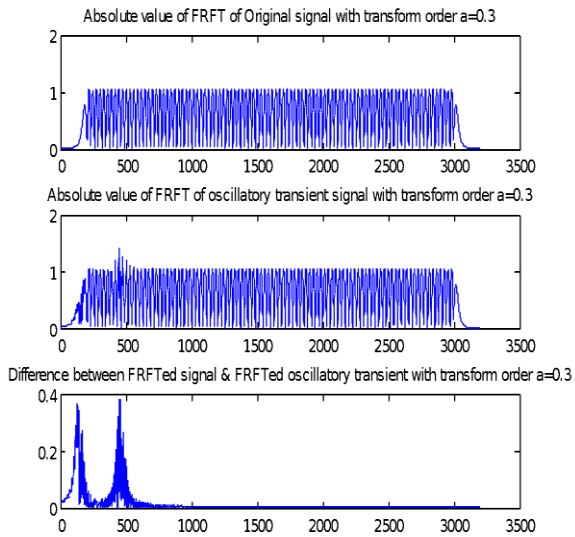


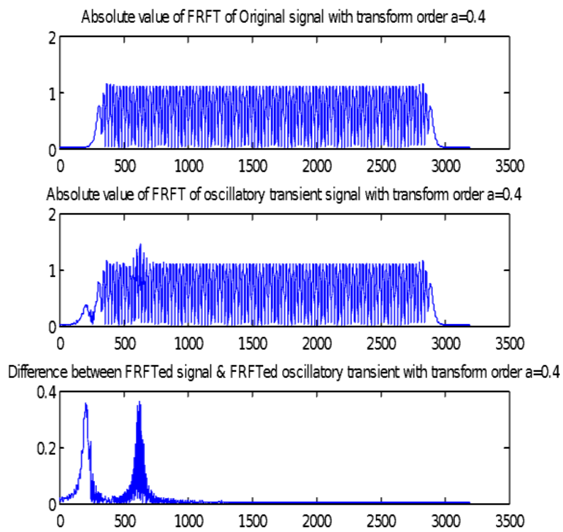
Fig. 4 FRFT analysis of Swell signal according to different transform order

FRFT Analysis of Transient Signal









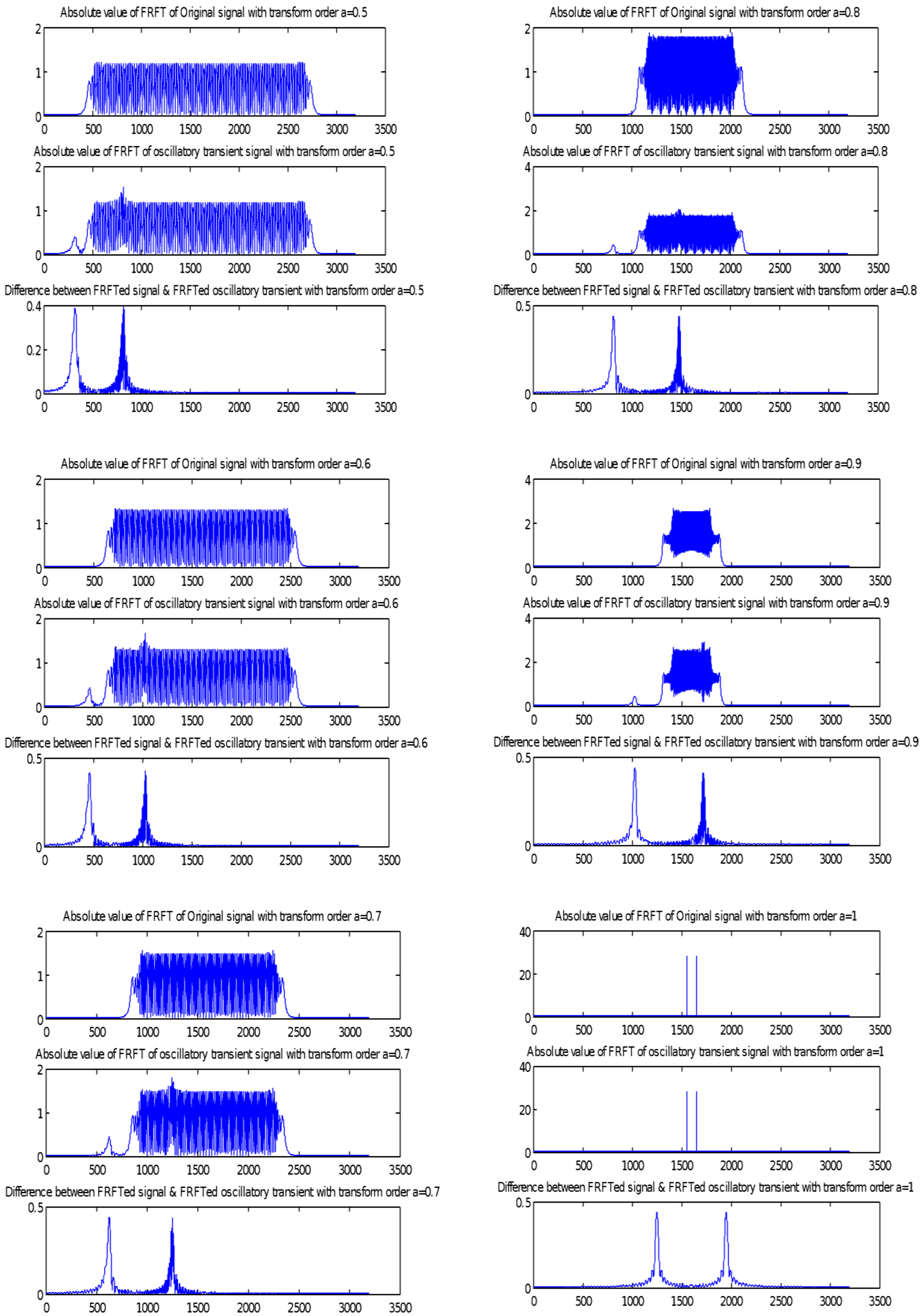


Fig. 5 FRFT analysis of Transient signal according to different transform order

Maximum Deviation for Different Transform Order

Table 1: Maximum deviation for different transform order

S. No.	Transform order	Sag	Swell	Transient
1.	0.1	0.7428	0.3943	0.0991
2.	0.2	0.7449	0.3909	0.1000
3.	0.3	0.7294	0.3826	0.1014
4.	0.4	0.5611	0.3609	0.1029
5.	0.5	0.5781	0.3974	0.1036
6.	0.6	0.6366	0.4290	0.1009
7.	0.7	0.5867	0.4415	0.1129
8.	0.8	0.5703	0.4386	0.1701
9.	0.9	0.5941	0.4412	0.2469
10.	1.0	0.6078	0.4400	1.3303

CONCLUSION

In this Dissertation research work, a new method based on Fractional Fourier transform (FRFT) is proposed to detect the power quality disturbances from the power quality signal. I have considered some of the disturbances like voltage sag, swell, transient, flicker and harmonics. All the simulations are carried out in MATLAB simulation tool and performed by taking different transform order. FRFT order control provides flexibility to features under noisy environment. Signal to noise ratio for each power quality disturbance signal is calculated.

Table 2 : Signal to noise ratio

Disturbance Signal	Signal to noise ratio (dB)
Sag	1.5540
Swell	1.2136
Transient	2.1053

REFERENCES

1. IEEE Recommended Practice for Monitoring Electric Power Quality, IEEE Std. 1159-2009, 2009.
2. J. Milanovic, J. Meyer, R. Ball, and et al, “International Industry Practice on Power-Quality monitoring,” IEEE Trans. Power Del., vol. 29, no. 2, pp. 934–941, 2014.
3. M. Kezunovic and Y. Liao, “A Novel Software Implementation Concept for Power Quality Study,” IEEE Trans. Power Del., vol. 17, no. 2, pp. 544–549, 2002.
4. M. Uyar, S. Yildirim, and M. T. Gencoglu, “An effective wavelet-based feature extraction method for classification of power quality disturbance signals,” Elect. Power Syst. Res., vol. 78, no. 10, pp. 1747–1755, 2008.
5. S. Shukla, S. Mishra, and B. Singh, “Empirical-Mode Decomposition With Hilbert Transform for Power-Quality Assessment,” IEEE Trans. Power Del., vol. 24, no. 4, pp. 2159–2165, 2009.
6. C.-Y. Lee and Y.-X. Shen, “Optimal Feature Selection for Power-Quality Disturbances Classification,” IEEE Trans. Power Del., vol. 26, no. 4, pp. 2342–2351, 2011.
7. IEEE Recommended Practice for Monitoring Electric Power Quality, IEEE Inc., New York, USA, 1995.
8. E. W. Gunther and H. Mehta, “A survey of distribution system power quality-preliminary results,” IEEE Transactions on Power Delivery, vol. 10, no. 1, Jan. 1995, pp. 322-329.
9. G. Beylkin, R. Coifman, I. Daubechies, S. G. Mallat, Y. Meyer, L. Raphael and M. B. Ruskai, “Introduction to Wavelets”, Jones and Bartlett, Boston, 1991.
10. A. Daubechies, “Ten Lectures on Wavelets”, CBMS-NSF Regional Conference Series in Applied Mathematics for the Society for Industrial and Applied Mathematics, Philadelphia, 1992.
11. Oliver Poisson, Pascal Rioual and Michel Meunier, “New Signal processing tools applied to power quality analysis”, IEEE transactions on Power Delivery, vol. 14, no. 2, July 1999, pp. 324-327.
12. Oliver Poisson, Pascal Rioual and Michel Meunier, “Detection and Measurement of Power quality disturbances using Wavelet transform”, IEEE transactions on Power Delivery, vol. 15, no. 3, July 2000, pp. 214-219.
13. P K Dash, B K Panigrahi and G Panda, “Power quality analysis using S transform”, IEEE transactions on power delivery, vol. 18, no. 2, April 2003, pp. 23-29.
14. H. M. Ozaktas, Z. Zalevsky, and M. A. Kutay, “The fractional Fourier transform with applications in optics and signal processing”, New York: Wiley, 2001.
15. T. Erseghe, P. Kraniauskas, and G. Cariolaro, ”Unified fractional Fourier transform and sampling theorem,” IEEE Trans. Signal Process., vol. 47, no. 12, pp. 3419-3423, 1999.
16. R. Torres, P. Pellat-Finet, and Y. Torres, “Fractional convolution, fractional correlation and their translation invariance

properties," Signal Process, vol. 90, no. 6, pp. 1976-1984, 2010.
17. K. K. Sharma, "Approximate signal reconstruction using non-uniform samples in fractional Fourier and linear canonical transform domains," IEEE Trans. Signal Process., vol. 57, no. 11, pp. 4573-4578, Nov. 2009.
18. X. G. Xia, "On bandlimited signals with fractional Fourier transform," IEEE Signal Process. Lett., vol. 3, no. 3, pp. 72-74, Mar. 1996.
19. U. Borup, F. Blaabjerg, and P. N. Enjeti, "Sharing of nonlinear load in parallel-connected three-phase converters", IEEE Trans. Ind. Appl., vol. 37, no. 6 (2001), pp. 1817–1823.

How to cite this article: Thakur MK, Kumawat NK. Assessment of power quality disturbance signals using fractional fourier transform. International Journal of Research and Review. 2019; 6(1):57-66.

******