



PATTERN RECOGNITION OF ISLANDING DETECTION USING TT-TRANSFORM

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ABSTRACT

Islanding is a condition where a part of the distribution system becomes electrically isolated from the remainder of the power system. The islanding detection for distributed generation (DG) units becomes an important issue in power system where the DG installations must be managed and protected during the islanded mode of operation. This paper proposed a new signal processing technique by introducing TT-transform in detecting islanding condition. This proposed method can detect the islanding condition by extracting the features of the voltage signals from the targeted DG location. The proposed technique has been simulated and analyzed in SimPowerSystem/MATLAB[®] simulation software. The results of the three-phase fault and islanding event were represented using 2D TT transformed plots of the original signals. The finding shows that each event case has a unique pattern so that it is possible to detect islanding conditions with accurate and faster manner.

Key Words: Islanding detection, Distributed generation, Voltage signal, TT-transform

INTRODUCTION

The unintentional islanding occurred when the distributed generation (DG) is continued to power a part of the grid system even though powers from the utility do not exist, due to the fault at upstream or any other disturbance. Failure to trip unintentional islanded DG may lead to several problems such as power quality, safety and operational problems (Mahat 2008). Furthermore, according to IEEE STD 1547-2001 and IEC 61727, unintentional islanding had to be cleared within two second from DG and utility connection to the formation of the island (Mahat 2009). Therefore, various

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methods to detect the unintentional islanding conditions have been receiving great interest among many researchers.

The wavelet transform is one of the effective techniques that have been previously used for local islanding detection. Wavelet transform was applied to the negative sequence voltage and the current signals (Samantaray 2009). The change in energy and standard deviations of coefficients was used to detect the islanding events from non-islanding ones. Alternatively, Shariatinasab (2010) uses of wavelet in detecting islanding event by using only terminal current of DG as a parameter.

Due to the limitation of Wavelet techniques to process noisy signal, better techniques are required. The S-transform was used to extract the negative sequence voltage during islanding event (Ray 2010). The energy content and standard deviation of S-transform contour was clearly shown in detecting islanding events and also disturbance due to load rejection. Besides, the negative sequence voltage and current were processed through S-transform, and spectral energy content was calculated (Samantaray 2010). However, the detection using S-transform needed extra time in extracting the features. Therefore, it was advisable to use some techniques that can address the disturbances in short duration events and higher frequencies (Simon 2010). Thus, this paper proposed TT-transform in extracting the features of islanding and three-phase faults. In this work only the voltage signals of DG are used as a parameter in detecting the events. The finding of this study helps in the interpretation of the features besides using the S-transform.

THE S-TRANSFORM AND TT-TRANSFORM

This section describes the basic concept of S and TT transform. Since the TT-transform is derived from the S-transform, the basic equations of S-transform are presented first.

S-transform

The fundamental mathematical formula of S-transform is a relation with short-time Fourier transform (STFT) and wavelet transform (WT). The relation between STFT and S-transform can be defined as

$$S(\tau, f) = STFT(\tau, f) = \int_{-\infty}^{\infty} h(t) \frac{|f|}{\sqrt{2\pi}} e^{-j2\pi ft} dt \quad (1)$$

Where, f is the frequency; and t and τ are the time variables. Other than that, S-transform can be defined using continuous wavelet transform (CWT) multiply by the phase factor (Ray 2010)

$$S(\tau, f) = e^{-j2\pi ft} W(\tau, d) \quad (2)$$

Given that the CWT is defined by

$$W(\tau, d) = \int_{-\infty}^{\infty} h(t)\omega(t - \tau, d)dt \quad (3)$$

Where, t denotes time; $h(t)$ denotes a function of time; τ denotes the time of spectral localization; d denotes the "width" of the wavelet $w(t, d)$ and thus it controls the resolution, and $w(t, d)$ denotes a scaled copy of the fundamental mother wavelet. This mother wavelet can be defined as

$$\omega(t, f) = \frac{|f|}{\sqrt{2\pi}} e^{-\frac{t^2 f^2}{2}} e^{-j2\pi ft} \quad (4)$$

Note that the factor d is the inverse of the frequency f .

TT-transform

TT-transform is obtained from the S-transform as given by equation (5) (Suja 2010)

$$TT(t, \tau) = \int_{-\infty}^{\infty} S(t, f) \exp(2\pi i f \tau) df \quad (5)$$

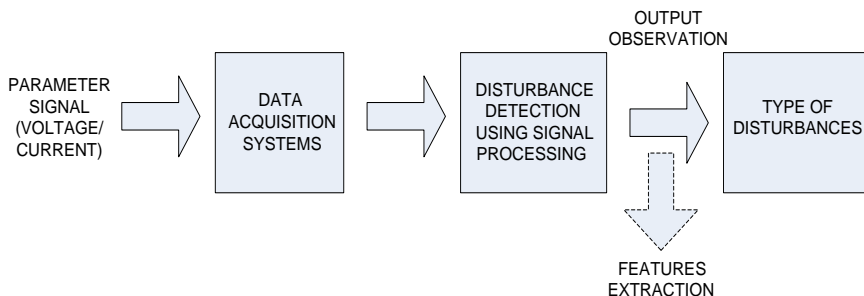
The time-local function is different from the windowed function of STFT. The scaling properties of S lead to higher amplitudes of high frequency around $\tau = t$. Therefore,

$$\int_{-\infty}^{\infty} TT(t, \tau) dt = h(\tau) \quad (6)$$

FEATURE EXTRACTION

The purpose of the feature extraction is to identify the specific signature of the voltage waveform that can help to differentiate between islanding and three-phase fault disturbance. For this purpose, signal processing tools could be used to extract most salient features that represent either islanding condition or three-phase fault disturbance. In many cases, signal pre-processing was needed at initial condition. In this work, TT-transform was employed to generate a set of parameter for both types of disturbance. The flow chart for analysis and classification of disturbance events is depicted in Figure 1.

Figure-1. Flow chart for analysis and classification of disturbance events.



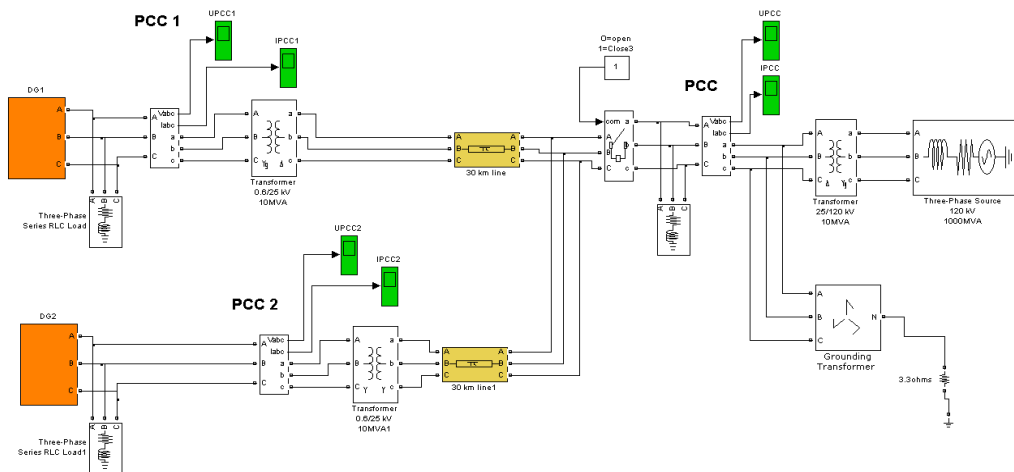
SIMULATION MODEL FOR DISTRIBUTION NETWORK WITH MULTIPLE DGS

The detailed study system is shown in Figure 2. The test system consists of a radial distribution system with two identical DG units, which is fed with 120kV, 1000MVA source at 50Hz frequency. The DG units are placed at a distance of 30-km with a distribution line of π -sections. This DG unit is designed using 1200Vdc and controlled by a decoupled power control. The voltage signals are retrieved at each of the target DG locations for the islanding and fault occurrences. For example, the measurement of voltage signals is placed at the PCC1 for DG-1 for both islanding and three-phase fault event. The possible situation of the event conditions studied is given as follows:-

- (a) Sudden of the three-phase fault applied at PCC and cleared after 150ms.
- (b) Tripping the main circuit breakers for islanding conditions.

The result and discussion are represented in the next section.

Figure-2. Power distribution systems with multiple DGs



RESULT AND DISCUSSION

Three-phase fault

Figure 3 shows the trend of contours for three-phase fault, subjected to TT-transform. From the observation, the system was in stable condition and a voltage dip occurred during the fault condition. The unique contour of the three-phase fault could be seen as the fault occurred at 600sec until 750sec. Furthermore, the disconnection line between two contours arises since a very low voltage magnitude was detected during the disturbances. This observation can be compared with original voltage signal illustrated in Figure 4.

Figure-3. Voltage signal at the target DG location with fault condition events subjected to TT-Transform

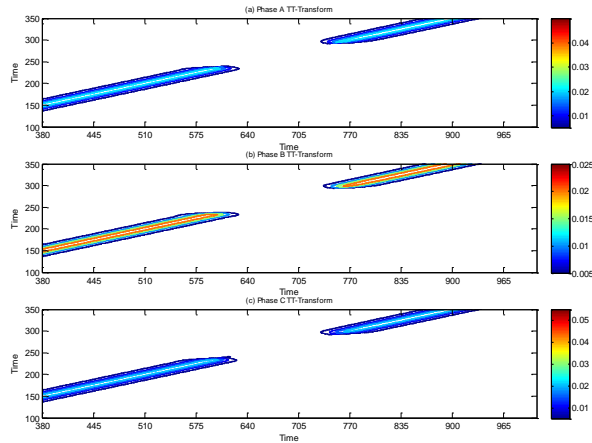
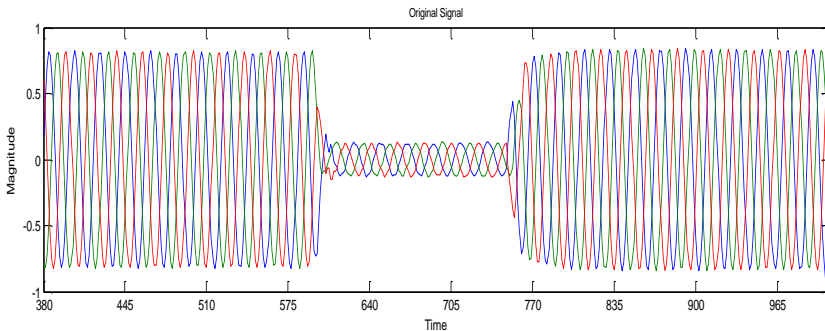


Figure-4. Original voltage signal at three phase fault disturbance



Islanding condition

The islanding conditions were tested with TT-transform. Figure 5 shows the voltage signal at the target DG location. From the figure, the pattern of transformation was changed respectively to the point of islanding detection. The disturbance was injected first into the system. After a few second, the main circuit breaker was opened, and the system was in islanding condition until the disturbances cleared, which is within 600sec until 750sec.

The variation in voltage signals gives the unique pattern contour as it was extracted using TT-transform. The low magnitudes are shown by the color variation before the disturbance happens. The disconnected line indicates the system was a three-phase fault as very low magnitudes presented at this point. However, the red color variations were occurred at higher magnitudes voltage points. This is because of the main circuit breaker was opened in order to clear the fault, and the system was islanding at 650sec until 750sec. The system still needs several times before it goes to stable condition. This observation can be compared with original voltage signal illustrated

in Figure 6. The color of variation and the pattern distribution of the transformation clearly indicate the presence of islanding.

Figure-5. Voltage signal at target DG location with islanding condition subjected to TT-Transform

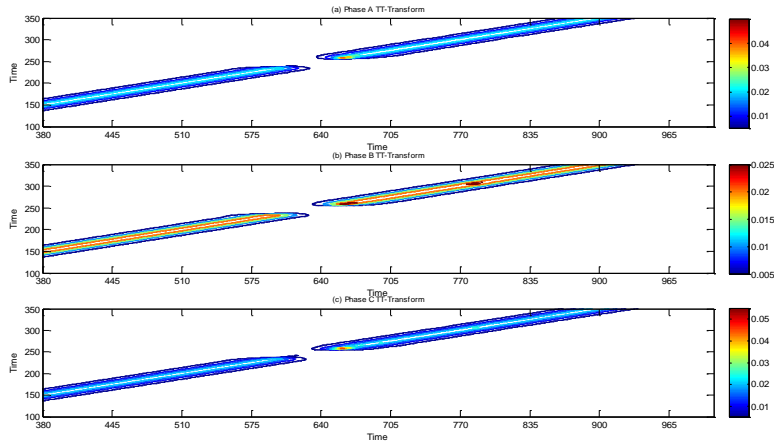
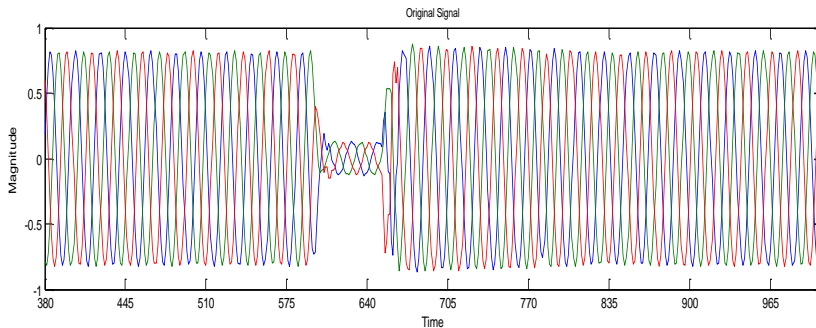


Figure-6. Original voltage signal at islanding condition



CONCLUSION

This paper has presented an alternative pattern recognition method known as TT-transform for islanding detection. The pattern obtained for three-phase disturbances and islanding signals clearly show unique signatures. One of the most significant findings is the unique contour pattern observed in difference disturbance cases. However, this paper only considers two disturbances voltage signals. Therefore, future work needs to be done to establish whether TT-transform can generate unique patterns similar to other establish techniques such as S-transform and Wavelet-transform.

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REFERENCES

- Fayyad, Y. (2010)** Neuro-Wavelet Based Islanding Detection Technique. IEEE Electrical Power & Energy Conference : pp.1-6.
- Mahat, P., & Bak-Jensen, B. (2008)** Review of islanding detection methods for distributed generation. 2008 Third International Conference on Electric Utility Deregulation and Restructuring and Power Technologies : pp.2743-2748.
- Mahat, P., Chen, Z., & Bak-jensen, B. (2009)** "A Hybrid Islanding Detection Technique Using Average Rate of Voltage Change and Real Power Shift" IEEE Transactions on Power Delivery, Vol.24, No.2, pp.764-771.
- Mahat, P., Chen, Z., & Bak-jensen, B. (2011)** Review on Islanding Operation of Distribution System with Distributed Generation. Power and Energy Society General Meeting : pp.1-8.
- Ray, P. K., Kishor, N., & Mohanty, S. R. (2010)** S-Transform based Islanding Detection in Grid-connected Distributed Generation Based Power System. IEEE International Energy Conference (pp. 612-617).
- Ray, P. K., Mohanty, S. R., Kishor, N., & Dubey, H. C. (2010)** Islanding and Coherency Detection in Distributed Generation Based Hybrid Power System. Annual IEEE India Conference (INDICON) : pp.1-4.
- Samantaray, S. R., Pujhari, T. M., & Subudhi, B. D. (2009)** A New Approach to Islanding Detection in Distributed Generations. Third International Conference on Power Systems : pp.25-30.
- Samantaray, S. R., Samui, A., & Babu, B. C. (2010)** S-Transform based Cumulative Sum Detector (CUSUM) for Islanding Detection in Distributed Generations. Power Electronics, Drives and Energy Systems (PEDES): pp.1-6.
- Shariatinasab, R. (2010)** New Islanding Detection Technique for DG Using Discrete Wavelet Transform. IEEE International Conference on Power and Energy (PECon2010) : pp.294-299.
- Simon, C., Schimmel, M., & Dañobeitia, J. J. (2010)** "On the TT-Transform and Its Diagonal Elements" IEEE Transactions On Signal Processing, Vol.56, No.11, pp.5709-5713.
- Suja, S., & Jerome, J. (2010)** "Pattern recognition of power signal disturbances using S Transform and TT Transform" International Journal of Electrical Power & Energy Systems, Vol.32, No.1, pp.37-53.