Analysis of Different Types of Faults in Power System Using S-Transform

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Abstract— This paper proposes a new Signal Processing approach for analysis of different types of faults on transmission line in power system. The power system circuit under consideration is "IEEE 14 BUS SYSTEM" which is simulated in PSCAD and the S-Transform technique is used here for analysis of different faults. The multiresolution S-transform is based on a variable width window, which changes with frequency. Current signals are captured at receiving end and Meshgrid plots from S-Matrix are used for analysis of faults. The objective is to make analysis of faults to detect and classify it.

Keywords- *IEEE 14 BUS SYSTEM, S-Transform, fault Analysis.*

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I. INTRODUCTION

Different transient phenomenon's occur on the transmission line. From these transient phenomena, faults on transmission lines need to be classified accurately, and cleared as fast as possible. In power transmission line protection, fault detection and classification is very important items which need to be addressed in a reliable and accurate manner. A fault occurs when two or more conductors shorts or come in contact with ground in three Phase systems, faults are classified as Single line-to-ground faults, Line-to-line faults, Double line-to-ground faults and three phase faults. Detection and classification of fault is an area of continuous research in power system. The objective is to make analysis of faults to detect and classify it.

Signal Processing techniques involving Fourier Transform, Wavelet Transform and S-Transform have become very popular tools in detection of transients of power system network, diagnosis of Transmission line faults, classification of faults and identification of the affected phase. A technique of fault categorization for distribution systems is given in [1] by using a different sequence networks. Different signal-processing techniques have been applied for classifying different types of Transmission line faults in power systems. Among, the most widely used are the Fast Fourier transforms (FFT) and the Short Time Fourier Transforms (STFT) [2]. Fourier transform have restriction of constant bandwidth of window size so using Fourier Transform study of non-stationery signal is not possible. So Gabor develop new method i.e. STFT which consists of variable window. Wavelet theory, which deals with edifice a model for non-stationary signals, using a set of components that look like small waves, called wavelets [3]. Discrete Wavelet Transform (DWT) is a dominant signal analysis tool which is broadly used for fault classification in transmission lines. Many vital features are mainly extracted from the line current or voltage signals [4 -5] using DWT method.

The S-transform is an expansion of the concept wavelet transforms, it is a combination of STFT and CWT and it provide excellent time localization of current signals throughout fault conditions. It has suitably and accurately identified power system disturbances in [6-9].
S–Transform gives S- Matrix in output which is complex in nature. Different features are extracted from this S-Matrix. This simple feature extraction is done by programming in MATLAB.

II. S -TRANSFORM

S-transform (ST) is the Combination of Wavelet transform and short time Fourier transforms overcomes the limitation of Wavelet transform and short time Fourier transforms. S-transform has an important property is that it combine a frequency dependent resolution of the time-frequency space and absolutely referenced local phase information [10]. S-Transform (ST) has the capability to detect the fault in the influence of noise due to which it is very popular in detecting power system faults and power quality disturbances. S-Transform is based on moving and scalable modulating Gaussian window function. The S-transform maintains entirely referenced phase information, a property that the wavelet transform is not present. In addition, the S-transform has a frequency invariant amplitude response in distinction to the continuous wavelet transform which attenuates high frequency signals relative to the low frequency signals. Integration of the S transform with regard to time results in the Fourier transform. This direct relation of the Fourier transform makes the inversion to time domain an important feature.

The generalized S transform is given by:
The S-transform of a basic continuous signal h (t) is defined by equation (1)

$$S(f,\tau)=\int_{-\infty}^{\infty} h(t)g(f,\tau-t)e^{-j2\pi ft}dt \qquad (1)$$

Where the Gaussian modulating function is given by equation (2)

$$g(f,\tau)=\frac{|f|}{\sqrt{2\pi}}e^{-\left(t^2/2\rho^2\right)} \quad (2)$$

Where

$$\rho = 1/(|f|)$$

The final expression is obtained from equation (1) and (2)

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

Where f denoted frequency and t, ɽ both represent time. Thus discrete S-transform is given by

$$S[jT,\frac{n}{NT}]=\sum_{m=0}^{N-1}H[\frac{m+n}{NT}]G(m,n)e^{\frac{2\pi mij}{N}}$$

Where

$$G(m,n)=e^{\frac{-2\pi^2 m^2\alpha^2}{n^2}}$$

n=0, 1, 2…., N-1. j=m=0, 1, 2…., N-1.

Where N= number of samples

S-Transform of a signal generates S-matrix in output in which the row relates the value of frequency and the column relates the value of time. Size of S-Matrix depends on number of samples of the signal.

III. SYSTEM UNDER CONSIDERATION

The IEEE 14 BUS TEST SYSTEM [13] is shown in figure has been simulated using PSCAD (power system computer aided design) software. The Circuit contains 14 buses which are unified through 20 transmission lines. Base MVA is 285.81 MVA. Two Generators are connected on bus 1 and bus 2 respectively and voltage regulators are connected on bus 3, 6 and 8 respectively and system frequency is 60Hz. Different Faults are created on middle of the line connected between bus 2 and bus 4. Duration of run for simulation is 2 cycles.

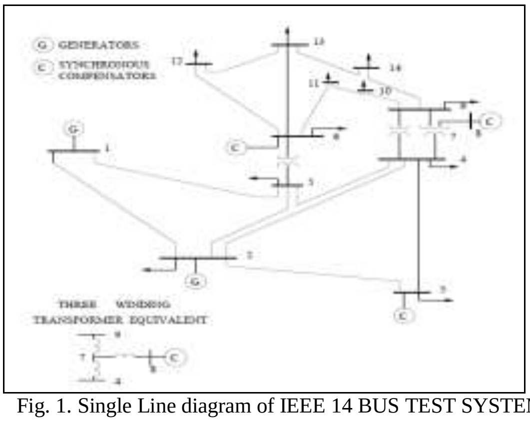

Fig. 1. Single Line diagram of IEEE 14 BUS TEST SYSTEM.

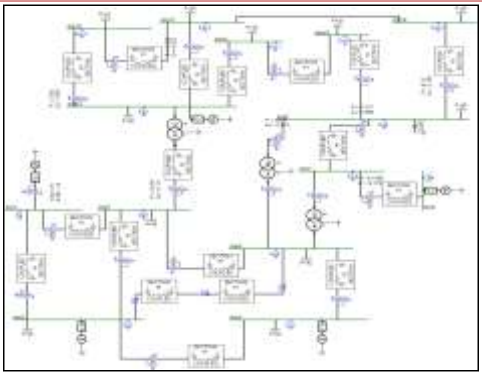

Fig. 2. Simulated Circuit Of IEEE 14 BUS TEST SYSTEM In PSCAD.

IV. FAULT ANALYSIS

Meshgrid plots of current signal captured at receiving end during different types of Transmission line faults are used here for analysis .S-Matrix is obtained in output of S-Transform in which rows pertains value of frequency and column pertains the value of time . Following are the Time-Frequency meshrid plots for each type of fault.

CASE I) Normal system

Fig. 3 shows meshgrid plot for normal system. In normal plot there is only blue band is present which is of amplitude up to 0.1 units.

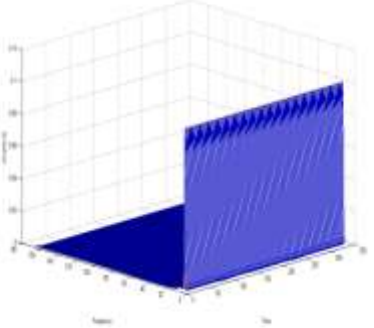

Fig. 3 Meshgrid plot for normal system

Case II) L-G fault on System

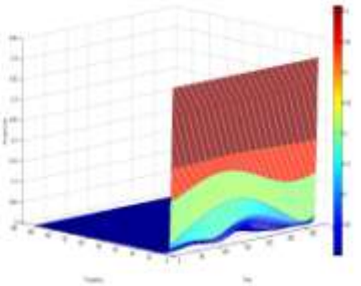

Fig. 4 Meshgrid plot for L-G fault on system

Fig. 4 shows the meshgrid plot for L-G fault on the system in which different color bands are observed. Color band shows the different magnitude of signals. In L-G and L-L fault plots the pure green band is observed which is of magnitude about 0.2 unit. In fault conditions blue band is present in rare proportion.

Fig. 5 shows the meshgrid plot for L-L fault on the system, which shows that there is no green band, is present in the plot. Brown band of maximum amplitude is present in large scale.

Case III) L-L fault on System

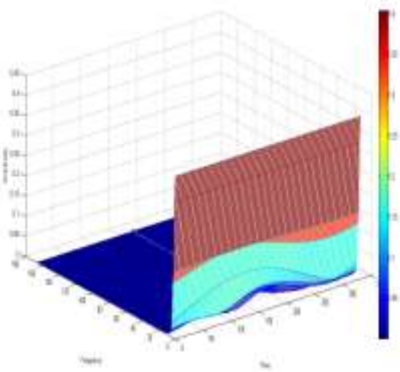

Fig. 5 Meshgrid plot for L-L fault on system

Case IV) L-L-G fault on System

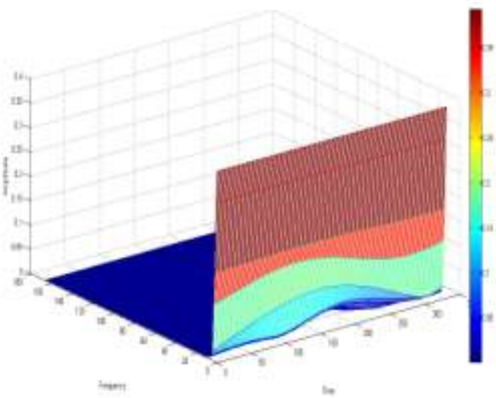

Fig. 6 Meshgrid plot for L-L-G fault on system

Fig. 6 shows the meshgrid plot for L-L-G fault on the system and Fig. 7 shows meshgrid plot for L-L-L fault on the system. By simply visualization of this different meshgrid plots we can detect the fault and classify this faults.

Case V) L-L-L fault on System

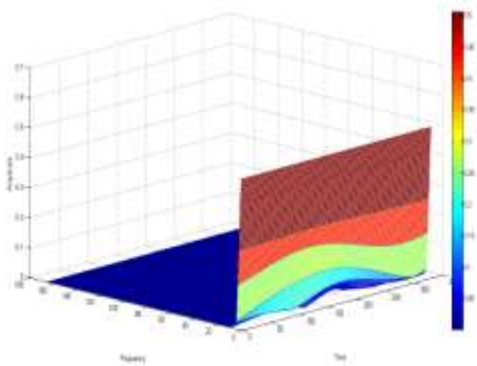

Fig. 7 Meshgrid plot for L-L-L fault on system

V. CONCLUSION

This paper proposed method of analysis for a detection and classification of the transmission line fault. Receiving end current signals are captured for fault analysis gives effective results from meshgrid plots. S-Transform is recent method which is advanced as compared to wavelet and Fourier. The obtained result shows effectiveness of this technique.

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