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Protection of Transmission Lines by Detecting Line Faults using Time Frequency Transformation

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Abstract: This paper discusses protection of transmission lines by detecting line faults using time frequency transformation. Initially the electrical signal is processed with a new time frequency transformation known as s-transform. Here the instantaneous power is taken as input and transformation is applied on it. After getting frequency information, an energy profile is calculated, which is used as fault detection index.

Keywords: power systems, protection, stock well transform.

I. INTRODUCTION

Power system protection is important for the effective operation of the power system and for protecting equipments from abnormal conditions. There are many techniques involved to protect the system against various faulty conditions. The main objective is to detect the fault and process the signal to relay for tripping. Then the relay closes its contacts and in turns opens the corresponding circuit breakers. Protective relays are the devices that detect abnormal conditions in electrical circuits by constant measuring the electrical quantities which are different under normal and fault conditions. [1-3]

. In this paper study is done for protection of transmission lines using time frequency transformation [11-15]. The presented technique is better than wavelet transform applied for transmission line protection with different schemes [4-10]. The paper organizes as follows, chapter 1 consist introduction to power system protection, and chapter 2 includes description of time frequency transform and proposed method. Chapter 3 includes system studied for algorithm assessment. Chapter 4 includes simulation results and discussions on results for different families of wavelets and finally chapter 5 includes conclusion.

II. TIME FREQUENCY TRANSFORMATION

By applying Stock well(S)-transform to the power system signals several typical events can be determined. To shrink the length of paper, precise explanation of S-transform (ST) is given below. The continuous S-transform for input signals h (t) is defined as shown below. [11]- [14] The continuous S-transform for input signals h (t) is defined as shown below.

$$S(\tau,f) = \frac{|f|}{\sqrt{2\pi}}\int_{\infty}^{-\infty} h(t)e^{-\frac{(t-\tau)^2 f^2}{2}} e^{-i2\pi f t}\,dt \tag{1}$$

The width of the Gaussian window is:

$$\sigma(f) = T = {}^{1}/_{|f|} \tag{2}$$

The discrete S-transform is defined as follows. Let h [kT], k=0, 1... N-1 denotes a discrete time series corresponding to h (t) with a time sampling interval of T. The discrete Fourier transform (DFT) of h (kT) is obtained as shown below.

$$H\left[\frac{n}{NT}\right] = \frac{1}{N}\sum_{k=0}^{N-1} h[kT]\, e^{-\frac{i2\pi nk}{N}} \tag{3}$$

Where n=0, 1... N-1. In the discrete case, the S-transform is the projection of the vector defined by the time series h[kT] onto a spanning set of vectors. The spanning vectors are not orthogonal, and the elements of the S-transform are not independent. Each basis vector (of the Fourier transform) is divided into N localized vectors by an element-by-element product. With the N shifted Gaussian, the sum of these N localized vectors is the original basis vector. Using Eq. (1), S-transform of a discrete time series h[kT] is obtained by letting f tending to n/(NT) and tending to jT. Thus discrete S-transform is given by the equation given below.

$$S\left[jT, \frac{n}{NT}\right] = \sum_{m=0}^{N-1} H\left[\frac{m+n}{NT}\right] G(m,n) e^{\frac{i2\pi mj}{N}} \qquad (4)$$

$$G(m,n) = e^{-\frac{2\pi^2 m^2 \alpha^2}{n^2}} \qquad (5)$$

and $\alpha = {}^{1}/_{b}$; n≠0; n=1,2,3,….,N-1; j=m=0,1,2,3,….,N-1; N=total number of samples. A typical value of b varies from 0.33 to 5 giving different resolutions. For the low frequency analysis, a high value of b is chosen and for high frequency analysis, lower value of b is chosen to provide suitable frequency resolutions [1]. In this paper S-transform is applied to the current signal, energy (E) is calculated from the given formula and this E chosen as fault Index.

$$E = abs\{s(j,-)^2\} \qquad (6)$$

By selecting suitable threshold, faults can be detected.

III.SYSTEM STUDIED

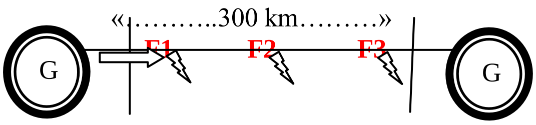

Fig 1(a): system studied

A 220kV, 50-Hz two terminal transmission systems as shown in Fig. 3 has been chosen to assess performance of fault detection method. The system has been simulated using simulink available in the MATLAB

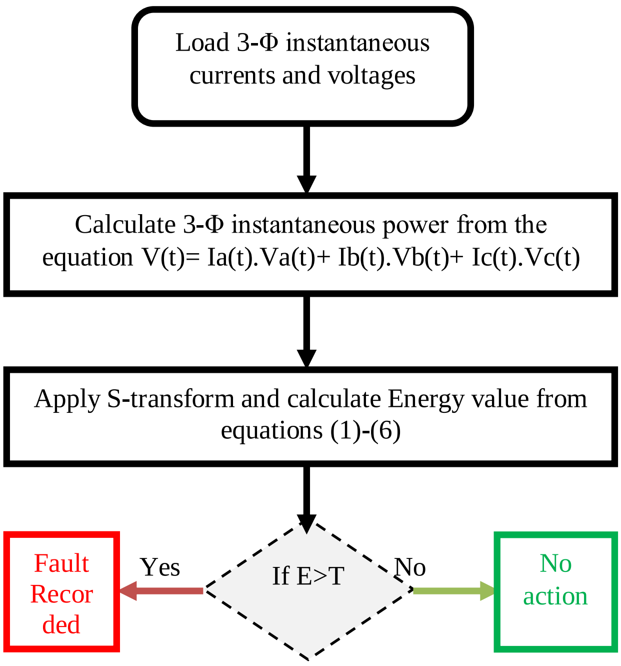

Fig 1 (b): Limited Flow chart of Detection Algorithm.

IV. SIMULATION RESULTS

In this paper, the s- transform algorithm is applied for faults of different types like A-G, B-G, C-G, A-B, B-C, C-A, A-B-G, B-C-G, A-C-G (unsymmetrical Faults) A-B-C and A-B-C-G (symmetrical faults), faults occurring at different locations of the transmission lines, faults incepted at different inception angles 0^0, 30^0, 60^0 etc.

Case 1: Initially algorithm is tested for faults occurring at near locations of sending end where the relay is placed. Here the time frequency transformation is applied to instantaneous power signal and after getting contour energy profile is calculated and which is used as fault detection index. Let us consider the fault occurs at 20 Km from sending end (F1 in the system studied i.e. fig 1). The number of samples per cycle is 400. In this case, the fault is incepted at 0.05 sec i.e. 1000th sample. Fault detection is done within 50 samples (less than 1/4 Th cycle length.

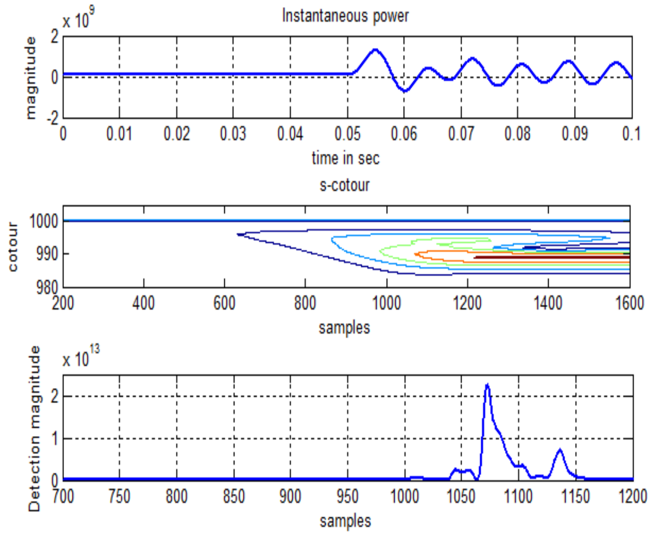

Fig 2: Fault located at 20 Km from sending end and L-G type fault with low fault resistance.

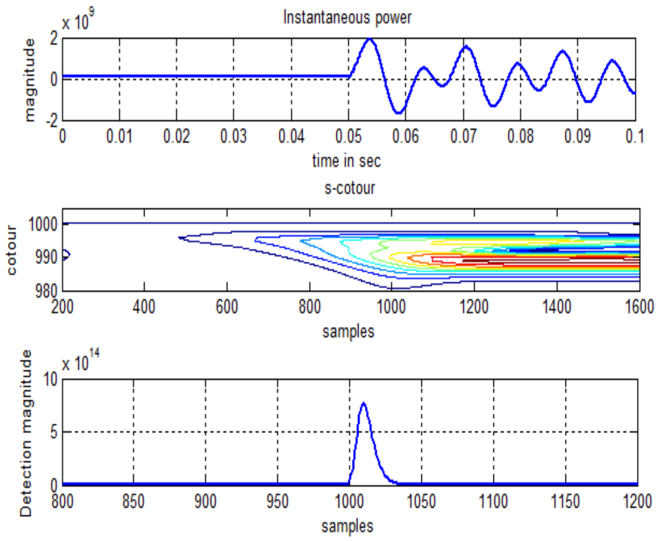

Fig 3: Fault located at 20 Km from sending end and L-L type fault with low fault resistance

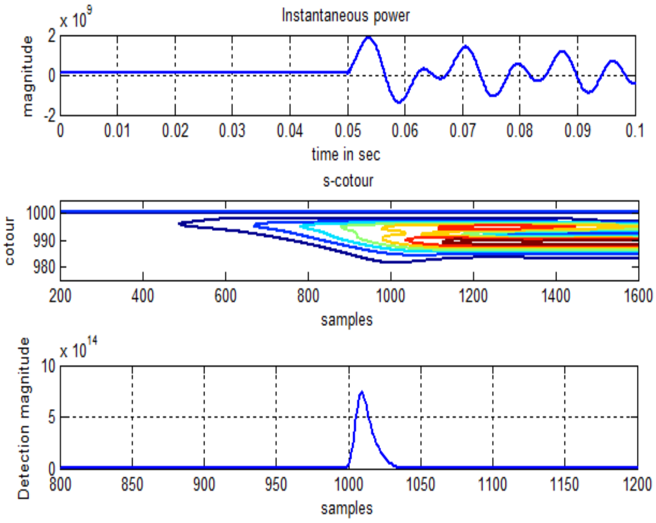

Fig 4: Fault located at 20 Km from sending end and L-L-G type fault with low fault resistance

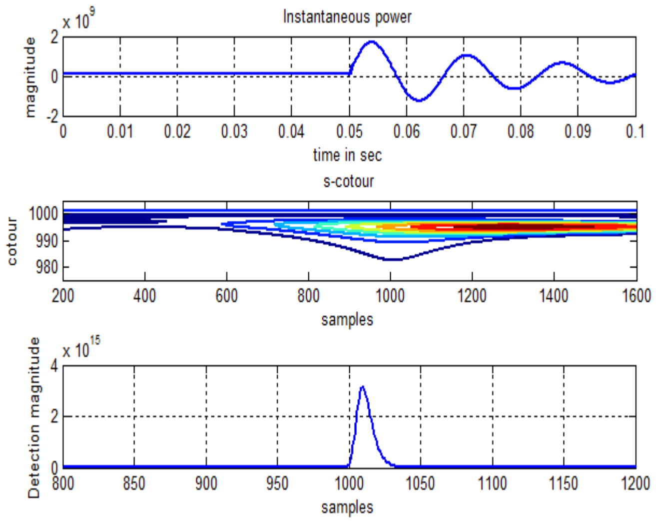

Fig 5: Fault located at 20 Km from sending end and L-L-L-G type fault with low fault resistance.

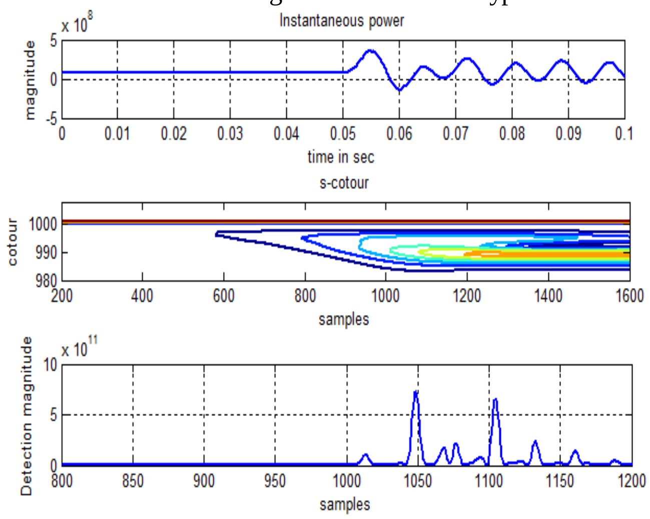

Fig 6: Fault located at 150 Km from sending end and L-G type fault with low fault resistance.

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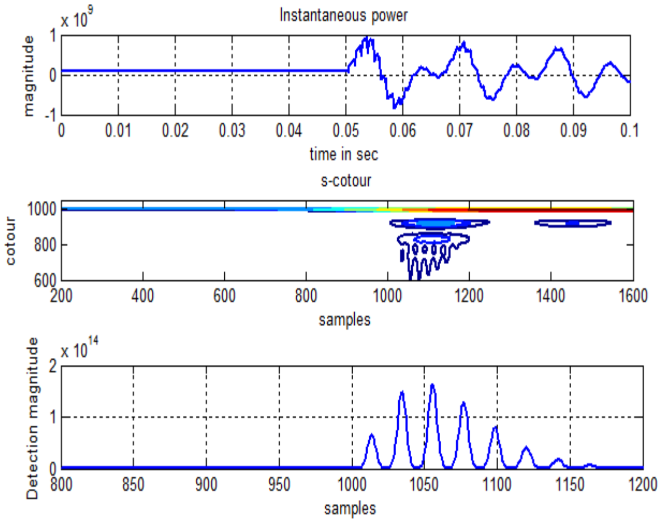

Fig 7: Fault located at 150 Km from sending end and L-L type fault with low fault resistance.

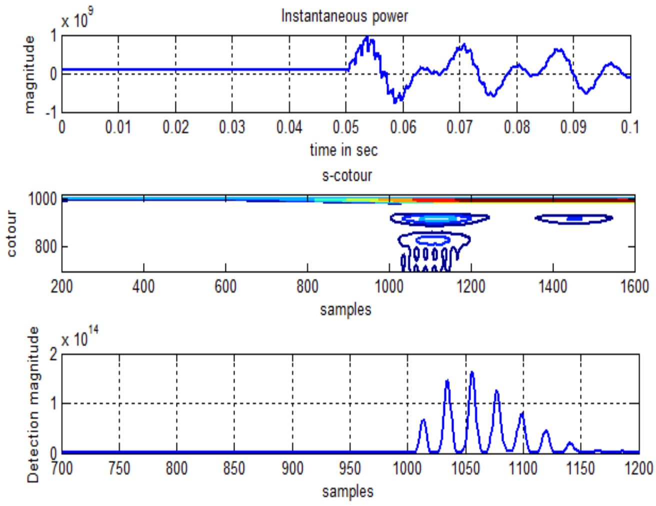

Fig 8: Fault located at 150 Km from sending end and L-L-G type fault with low fault resistance.

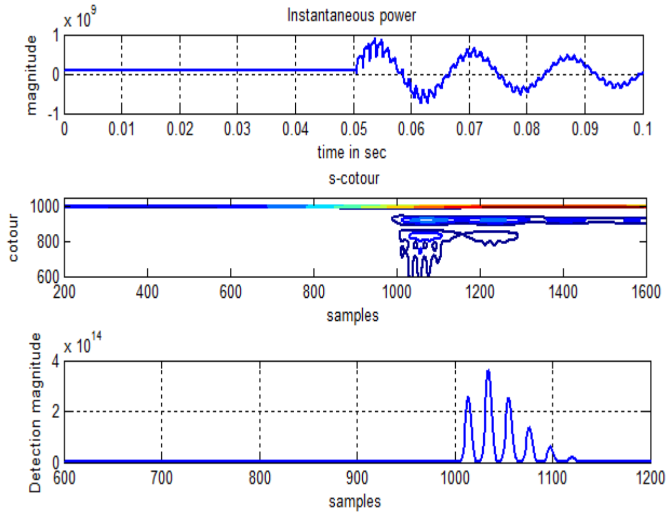

Fig 9: Fault located at 150 Km from sending end and L-L-L-G type fault with low fault resistance.

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Case 2: In this case, the algorithm is tested for faults occurring at middle of the transmission line. For the simulated system, faults occur at 150 km from either sending end or receiving end (F2 in the figure 1(a)). In this case also faults of all types (LG, LL, LLG and LLLG) are incepted at 0.05 sec. fig 2-fig 5 shows detection plots for faults occurring nearer to sending ends i.e. case 1, and from fig 6-fig 9 shows detection plots for faults occurring at middle of the transmission lines.
Case 3: In this case, the algorithm is tested for faults occurring at receiving end of the transmission line. For the simulated system, faults occur at 280 km from sending end or 20 Km from receiving end (F3 in the figure 1(a)). In this case also faults of all types (LG, LL, LLG and LLLG) are incepted at 0.05 sec. fig10 –fig 13 shows detection plots for faults occurring nearer to sending ends.

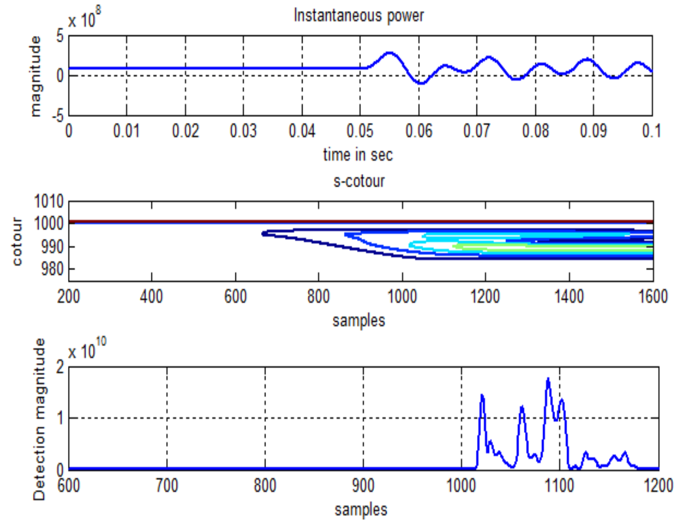

Fig 10: Fault located at 280 Km from sending end and L-G type fault with low fault resistance.

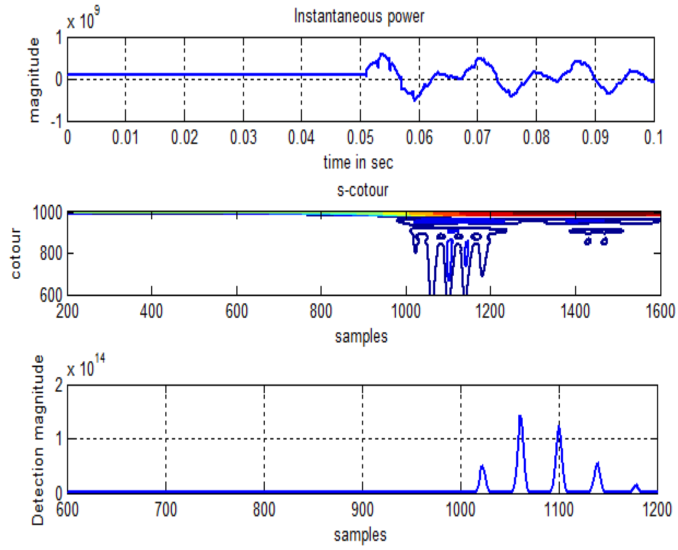

Fig 11: Fault located at 280 Km from sending end and L-L type fault with low fault resistance.

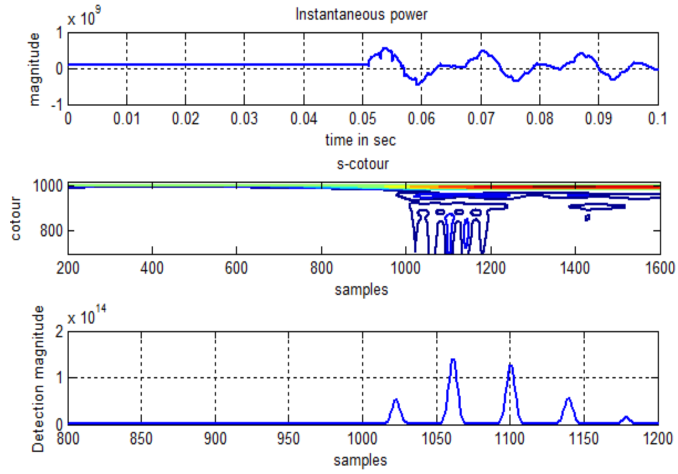

Fig 12: Fault located at 280 Km from sending end and L-L-G type fault with low fault resistance.

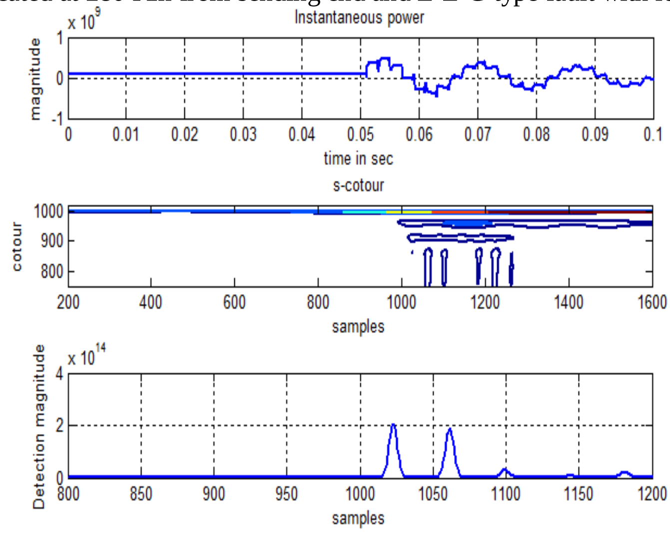

Fig 13: Fault located at 280 Km from sending end and L-L-L-G type fault with low fault resistance.

V. CONCLUSION

In this paper, time frequency transformation is applied for protection of two terminal transmission line network.The Algorithm was tested under different type of faults with different inception angles, by changing the location of faults etc. finally the method presented in this paper gave better results with small variations in detection magnitudes.

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