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Power Transmission Line Fault: S-Transform based Feature Extraction and ANN-based Classification

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Abstract: *In this paper a new technique for the identification and discrimination of faults on the transmission line of the power system has been presented. The power system network considered in this study is the two-generator system simulated in a Matrix laboratory i.e., MATLAB milieu. Firstly, captured voltage and current are transformed using S-transform techniques then the various energy of faults has been calculated using Parseval's theorem. Then these energies are given as an input to ANN. The classification results obtained show the effectiveness of this technique.100 percent classification is achieved by using this method.*

Keywords*:* ST(S-transform), Parseval's theorem, ANN, MATLAB.

I. INTRODUCTION

This paper corresponds to the S-transform and ANN for transmission line fault cataloguing. The S-transform is having good characteristics determination of changes in frequency and period. The fault classification can be done using other various feature extraction techniques such as wavelet transform having a problem of selection of appropriate mother wavelet, FFT cannot be used for non-stationary signal, and Hilbert transforms having high computational complexity. so, ST has a better performance than above mentioned transform.

II. POWER SYSTEM MODEL

The MATLAB-based Simulink of 300KM is used for capturing the raw voltage and current results. Table 1 consists of the actual parameter used during the development of the model). The following system has developed; symmetrical and unsymmetrical faults have been created at different locations such as at 300km,600km, and 900km. The developed system is shown in the following Figure 1 it consists of faults at a 300 KM distance.

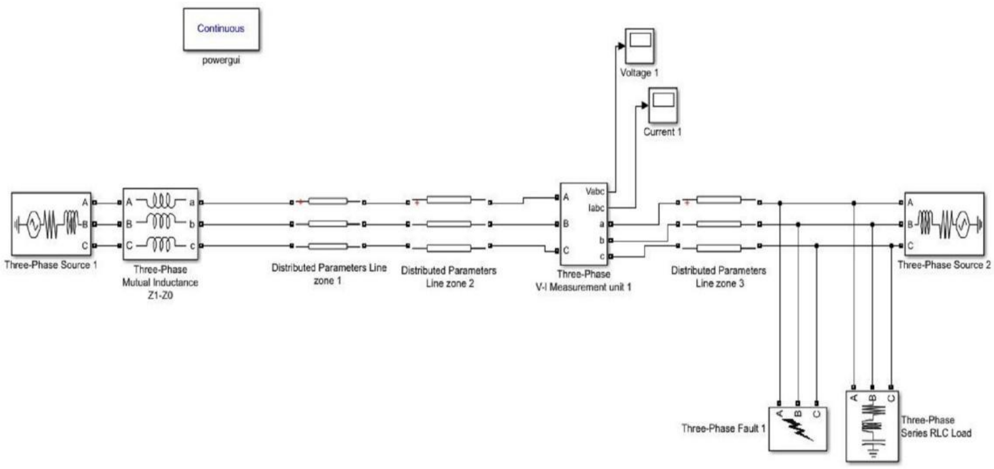

Fig. 1. Transmission line faults at 300km distance.

The following parameters are used to create the simulation model of transmission line faults.

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The various fault created are LL, LG, and LLL in MATLAB Simulink and voltage and current signals were captured. Similarly, faults are created at 600km and 900 km. the raw signals of voltage and current are recorded.

Table 1: Parameters used for a simulation model of transmission line

Parameter	Specifications
source	
(Vrms)	25e3
F (Hz):	50Hz
R (Ohms)	0.8929
L (H):	16.58e-3
distributed line (Transmission line model)	
Several phases [N]:	3
Line length	300km, 600km, 900km
R per unit	[0.01274 0.3865]
L per unit	[0.9339e-3 4.1267e-4]
C per unit	[12.84e-9 7.751e-6]

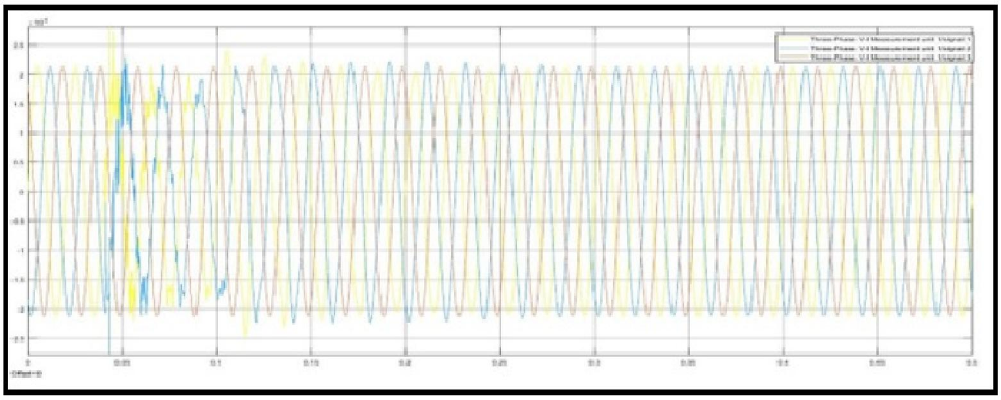

Fig. 2. Current waveform 300 KM LL Fault (Phase AB)

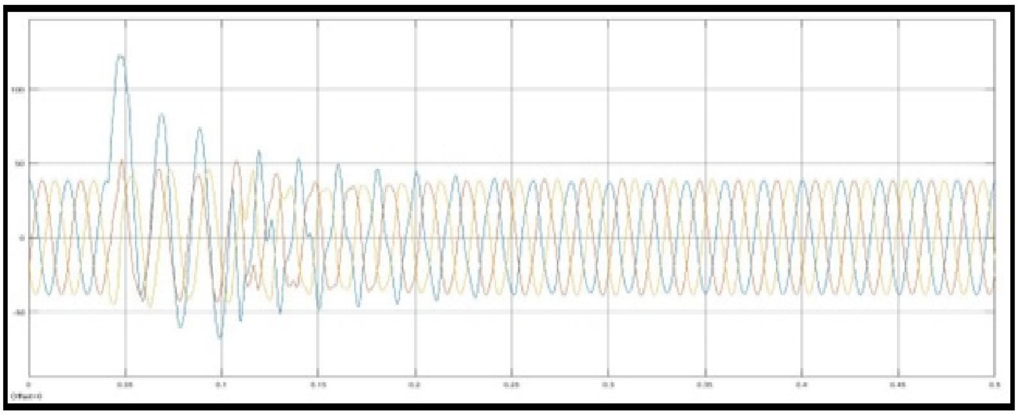

Fig. 3. Current waveform 300 KM LG Fault (Phase AG)

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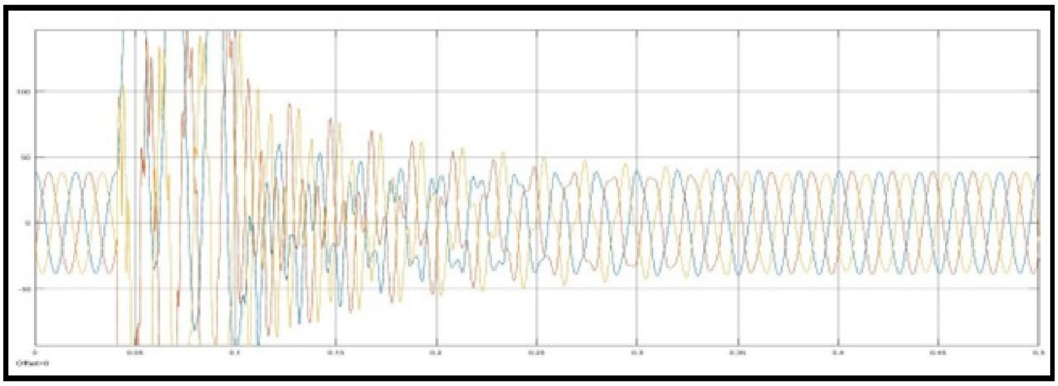

Fig.4. Current waveform 300KM LLL Fault (Phase ABC)

Similarly, various waveforms for faults between BC, CA, BG, CG, and ABC at 600km and 900km are recorded.

III. S-TRANSFORM-BASED FEATURE EXTRACTION

The time-frequency contour is obtained in the following Figs 5,6 and 7. These contour observations indicate the changes in frequency and period amplitude. Therefore, the calculated energy after this stage can be given as an input for transmission line faults classification. this type of plot is a specialty of S-transform and no other feature extraction technique such as an FFT, or DWT has this advantage.

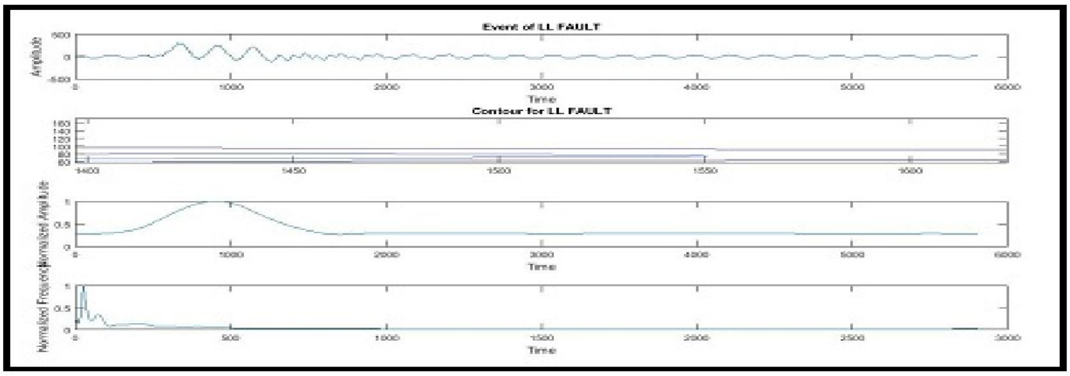

Fig.5. Contour representation for 300KM LL Fault

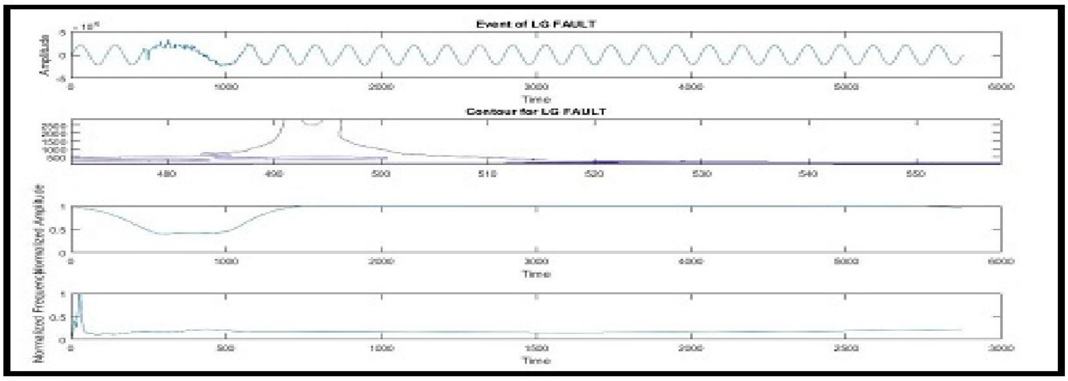

Fig.6 Contour representation for 300KM LG Fault

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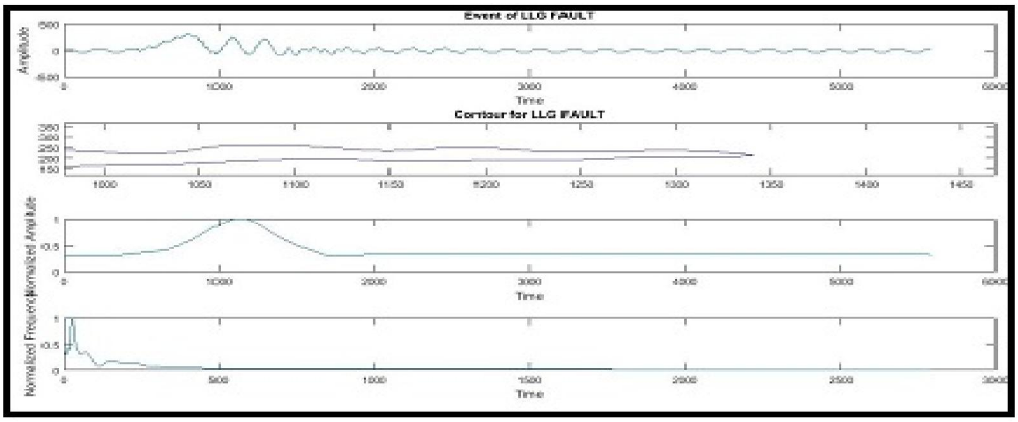

Fig. 7 Contour representation for 300KM LLL Fault.

The following figures show the 3D view of Amplitude, Frequency, and Time relation for the various fault situation.

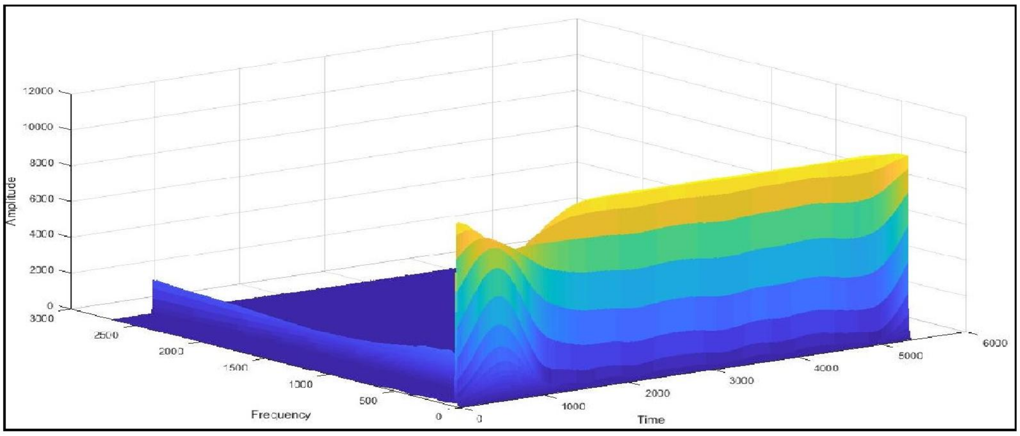

Fig. 8 3D plot for 300KM LL Fault

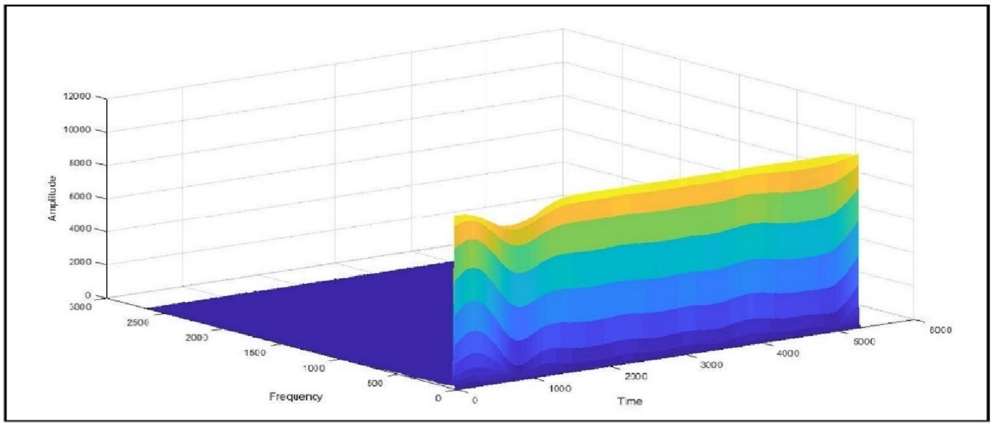

Fig. 9 3D plot for 300KM LL Fault 3D plot for 300KM LG Fault

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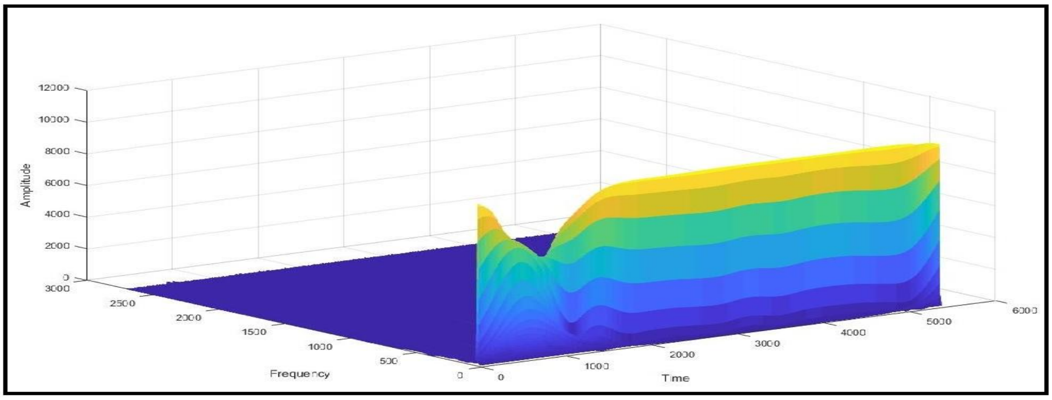

Fig. 10 3D plot for 300KM LL Fault.3D plot for 300KM LLL Fault

IV. ENERGY LEVELS FOR DIFFERENT FAULTS

Parseval`s energy determination is a key step in this work the voltage and current signals are given as an input to S-Transform for the feature extraction of various contours at the various fault location with different types of faults now Parseval`s energy has been calculated using the following formula:

$$E=\frac{1}{T}\int_0^T(t)^2dt = \sum_{n=0}^{N} |\,V\,[N]^2\,| \text{ ---(1)}$$

Where T = Periods

N= length of the entire signal

and V[n] =FT of the signal.

The calculated energy is tabulated in the following table.

Table 2: Calculated Energy values for different faults such as LL, LG, and LLL at different locations Line A-B.

KM and Fault	EAIA	EAIB	EAIC	EAVA	EAVB	EAVC
300KM LG	19.62324	19.47912	26.03786	90.76439	90.4864	92.66529
300KM LL	91.06198	11.25217	91.14425	19.40605	19.40605	19.54298
300KM LLL	14.74992	27.33527	28.68186	11.61259	2.68E+02	2.88E+02
600KM LG	1.27E+02	1.41E+02	73.60312	27.56991	27.12089	30.24258
600KM LL	36.08655	11.48016	33.8067	35.35378	11.86862	35.1309
600KM LLL	12.96985	59.48306	63.54803	14.39028	70.16776	80.25311
900KM LG	6.57E+01	4.91E+01	5.27E+01	19.69894	19.85441	32.70953
900KM LL	41.1927	11.12013	37.99804	31.87283	11.72898	31.61142
900KM LLL	22.53765	67.17354	73.7722	19.61247	54.11459	66.01558

Similarly, energy calculated for phase B-C and phase C-A line

V. CLASSIFICATION NETWORK USED

In this research work, Artificial Neural [13] Network is used and trained with supervised learning. The neural network is provided with 3 input layers, 3 hidden layers, and 3 output layers during the fault classification process. The energy of the current signal in the feature extracted data-sheet is fed to the neural network in MATLAB and several iterations are varied and decided by the trial-and-error method. In the ANN transfer function ‘tension’, the learning rule, ‘learngdm’, momentum 0.7, and maximum epochs1500 iterations are used to train that network.the ANN architecture which is shown in Fig. 11 is chosen as the final NN for the given input and output.

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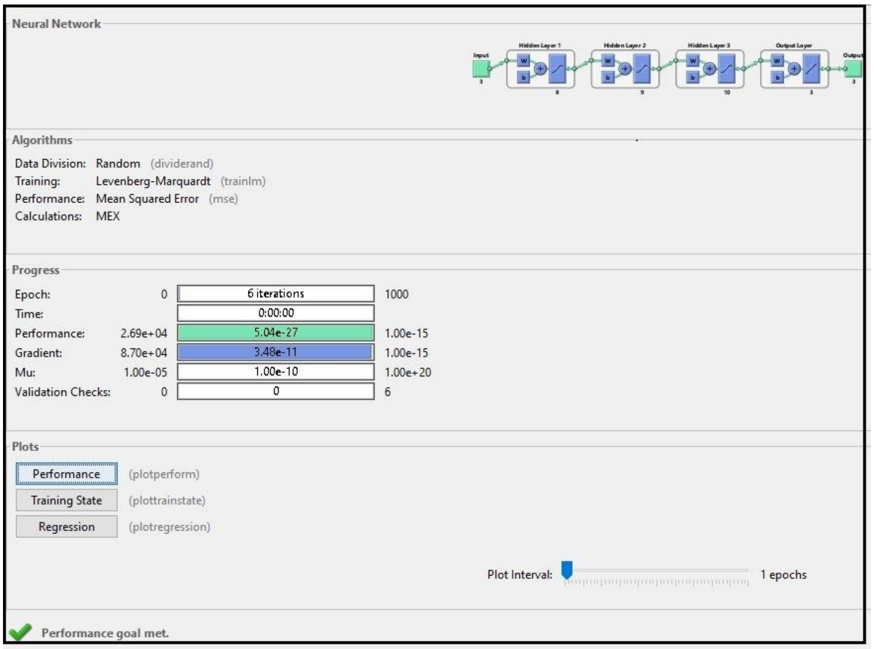

Fig. 11 ANN architecture used for fault classification

It can be seen in Fig. 12 the chosen neural network has 100 percent accuracy in fault classification.

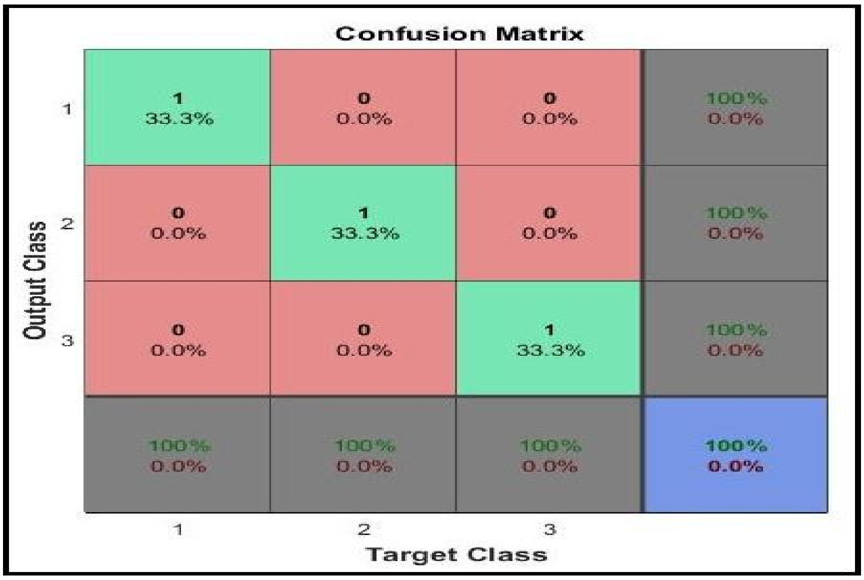

Fig. 12 ANN classification matrix

VI. CONCLUSION

The proposed algorithm is a fast, reliable algorithm for transmission line fault identification and discrimination This technique uses ST for the feature extraction then the extracted features are fetched to ANN. The ST-based ANN classifier gives 100 percent classification. the results show the effectiveness of this technique, which is more suitable than Wavelet and FFT.

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