POWER SYSTEM TRANSIENT USING WAVELET TRANSFORM: A CASE STUDY

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Abstract: There are numerous causes of power system transients, such as short-circuits, capacitor bank switching, switching of large inductive loads (e.g., motors and transformers), and lightning. Power system transients can pose a serious threat to the reliability of power system apparatus (e.g., switchgear, transformers, feeder cables, etc.) and sensitive loads (e.g., computers and other sophisticated electronic equipment). The main objective of this paper is to detect system transients and to analyze the power system transient waves, for predicting the hazards and making the precaution scheme for against those travelling and transient waves using wavelet transform depend on a case study.

***Key words* –** Power system transient, Wavelets, Alternative Transient Program

1. Introduction

In the mainstream literature, wavelets were first applied to power system in 1994 by Robertson and Ribeiro. From this year the number of publications in this area has increased exponentially. The most popular wavelet applications in power systems are [1]

- **Power System Protection (36 %)**
- **Power quality (32%)**
- **Power System Transients (11%)**
- **Partial discharge (4%)**
- **Load forecasting (3%)**
- **Power System measurement (2%)**
-

There are various approaches for analysis of power system faults such as expert system [2], fuzzy logic based approach [3], optimization based [4], artificial neural network (ANN) based [5], wavelet based techniques [6] etc. Each of them has some difficulties in achieving speed, selectivity and accuracy. Discrete wavelet transform in combination with ANN has also been implemented for this purpose. However there is no report of using Continuous Wavelet Transform (CWT) in classification of power system transients. CWT has great potential in analyzing system transients.

The wavelet transform is introduced as a method for analyzing electromagnetic transients associated with power system faults and switching. This method, like the Fourier transform, provides information related to the frequency composition of a waveform, but it is more appropriate than the familiar Fourier methods for the non-periodic, wide-band signals associated with electromagnetic transients. It appears that the frequency domain data produced by the wavelet transform may be useful for analyzing the sources of transients through manual or automated feature detection schemes. The basic principles of wavelet analysis are set forth, and examples showing the application of the wavelet transform to actual power system transients are presented [7].Since transients are non-stationary both in time and space, their analysis and characterization are difficult, and the traditional method of Fourier Transform and short-time Fourier Transform have their limitations in transient analysis. We propose the use of a new time-frequency multi-resolution wavelet analysis of transients in power systems. The final objective is to build an intelligent transient recorder, which is capable of detecting and classifying power system transients by type from the transient waveform signature based on an effective and efficient wavelet modeling and characterization [8]**.**The quality of electric power has been a constant topic of study, mainly because inherent problems to it can lead to great economic losses, especially in industrial processes. Among the various factors that affect power quality, those related to transients originating from capacitor bank switching in the primary distribution systems must be highlighted. In this work, the characteristics of transients resulting from the switching of utility capacitor banks are analyzed, as well as factors that influence their intensities. The conditions under which these effects are mitigated can then be investigated. A circuit that represents a real distribution system, 13.8 kV, from CPFL (Cia Paulista de Força e Luz – a Brazilian utility) was simulated through the software ATP (Alternative Transients Program) for purposes of this study. Finally, a comparison with real-life data recorded at the distribution system was performed in order to validate the present simulation. Several experts around the world have been contributing to EMTP starting in 1975 and later to ATP in close cooperation with Drs. W. Scott Meyer and Tsu-huei Liu. [9]

2. Power System Transient

Electromagnetic transients in power systems result from a variety of disturbances on transmission lines, such as switching, lightning strikes, faults, as well as from other intended or unintended events. Such transients are extremely important, for it is at such times that the power system components are subjected to the greatest stresses from excessive currents or overvoltage [10][11]. According to their causes, EM transients in power systems can be classified as follows:

- Fault-induced transients,
- Switching transients,
- Lightning strike transients,
- Ferro resonance,
- Harmonic transients, and
- VFT (very fast transients) in GIs.

A typical fault-induced transient waveform is shown in Fig. 1. [12]

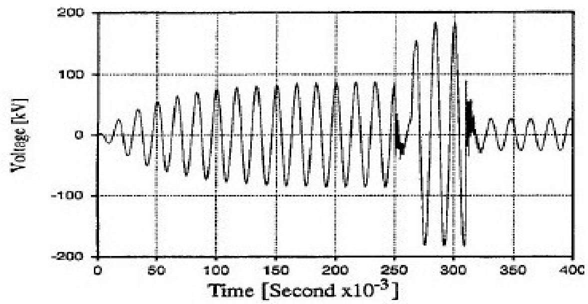


Fig-1

3. Wavelets

Wavelet analysis represents the next logical step: a windowing technique with variable-sized regions. Wavelet analysis allows the use of long time intervals where we want more precise low frequency information, and shorter regions where we want high frequency information. Here's what this looks like in contrast with the time-based, frequency-based, and STFT views of a signal [13].

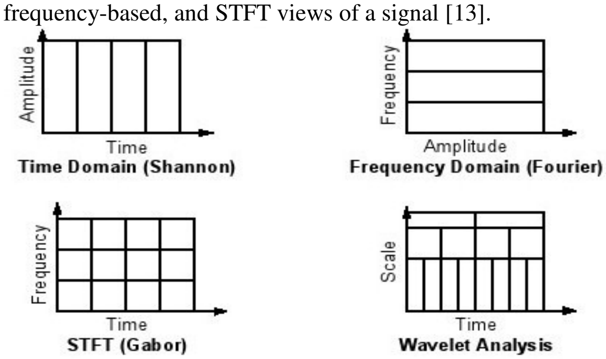


Fig-2

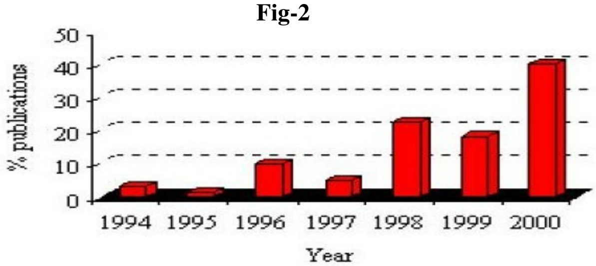


Fig-3 Evolution of Wavelet distribution publication in power system [14]

4. Alternative Transient Program

ATP is a universal program system for digital simulation of transient phenomena of electromagnetic as well as electromechanical nature. With this digital program, complex networks and control systems of arbitrary structure can be simulated. ATP has extensive modeling capabilities and additional important features besides the computation of transients.ATP has been continuously developed through international contributions by Drs. W. Scott Meyer and Tsu-huei Liu, the co-Chairmen of the Canadian/American EMTP User Group. The birth of ATP dates to early in 1984, when Drs. Meyer and Liu did not approve of proposed commercialization of BPA (Bonneville Power Administration) EMTP by DCG (the EMTP Development Coordination Group) and EPRI (the Electric Power Research Institute). Dr. Liu resigned as DCG Chairman, and Dr. Meyer, using his own personal time, started a new program from a copy of BPA's public-domain EMTP. Requirements of ATP development include honesty in all dealings and non-participation in EMTP commerce. ATP is not in the public domain, and licensing is required before ATP materials are received. [15]

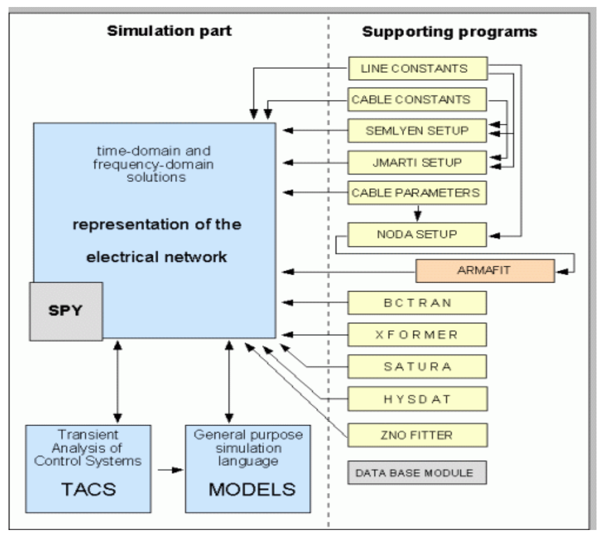


Fig-4

5. Proposed Scheme of work

5.1 Simulation of transmission line model:

In this study a power system network consisting of two single phase voltage sources are used. The length of the transmission line is 32 km. The power transmission system was modeled with ATP/ EMTP to test the performance of the proposed scheme. The line model is presented in fig.4 Extensive simulations were carried out, with different fault locations, for single line to ground fault (LG), with fault resistance of 5Ω . The transient voltage signals from both sending and receiving ends were captured using ATP/ EMTP simulation environment. The pictorial representation of the voltage signals are shown in the below Figs. The voltage waveforms were generated at a sampling frequency of 2.2 KH_Z.

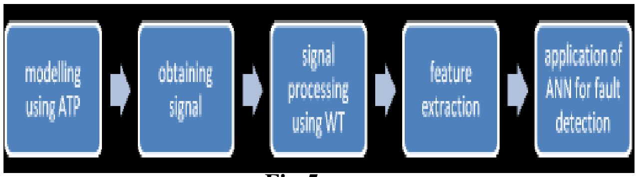
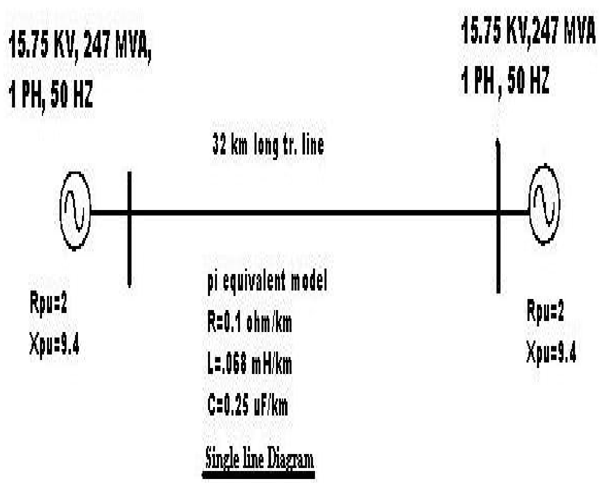


Fig-5

Fig-6 Basic circuit diagram of a single ph transmission system



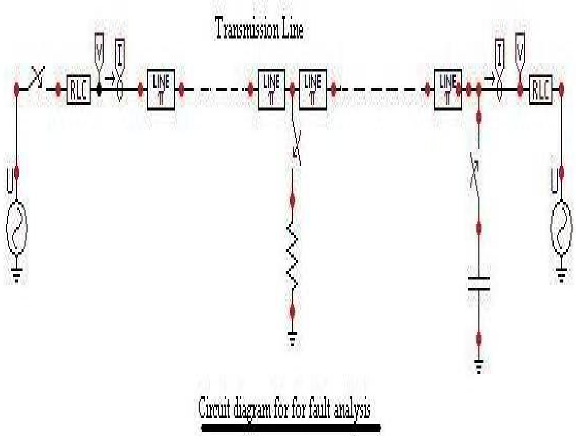
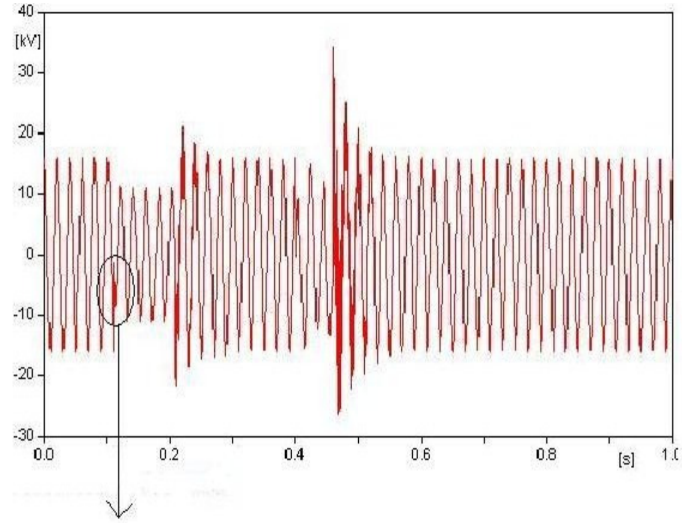
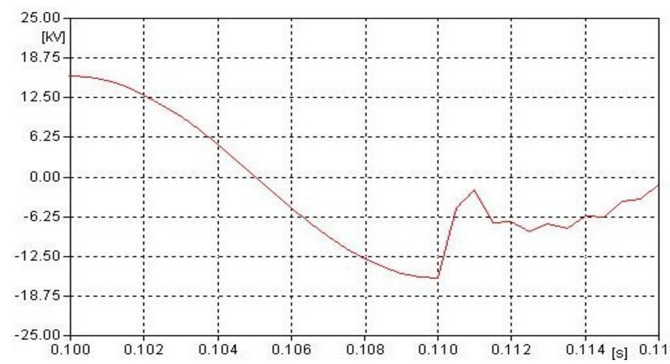


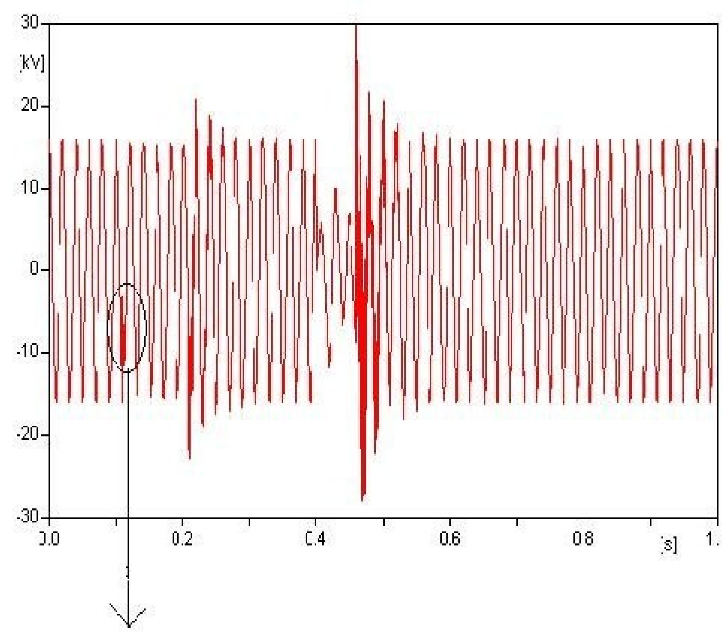
Fig-6 Basic circuit diagram of a single ph transmission system

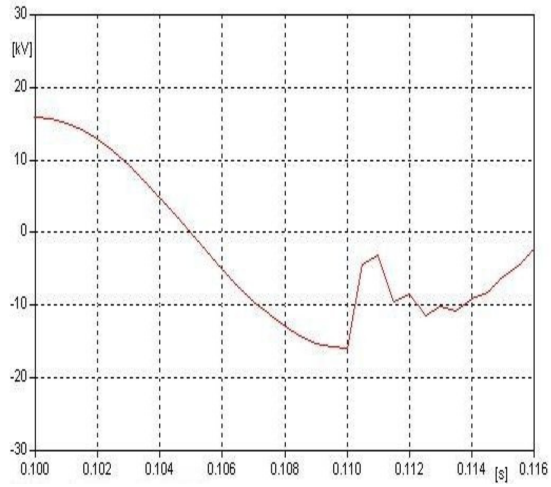
5.2. Transient signals (current & voltages)



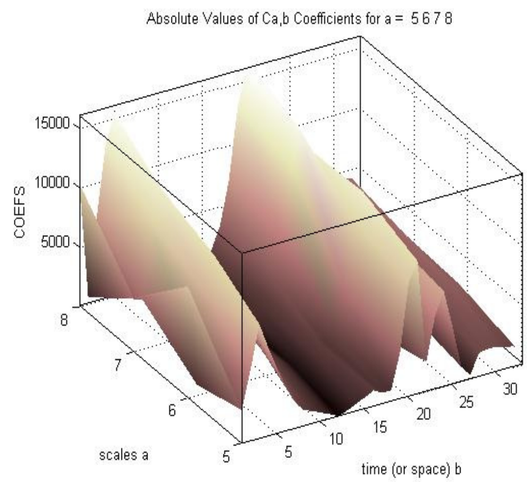


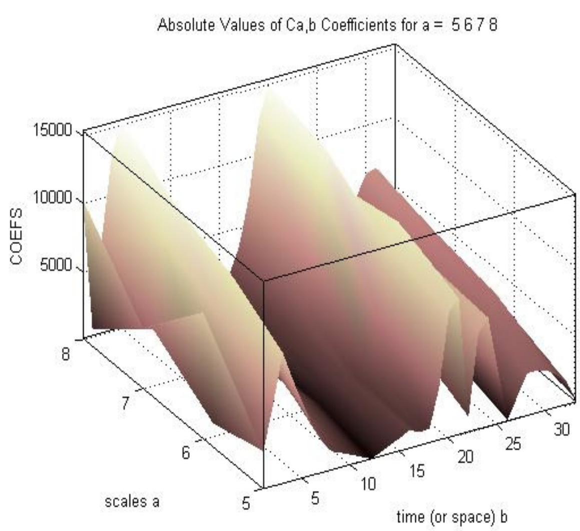
Receiving end voltage



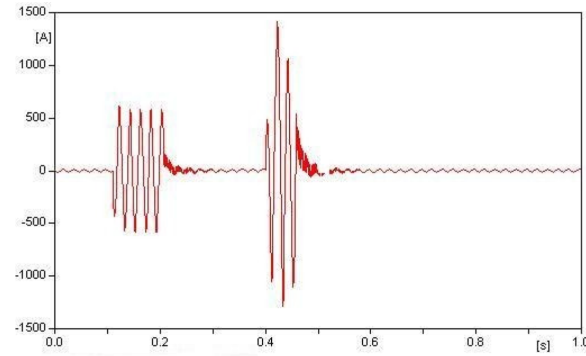


5.3. Wavelets for voltage for ground fault

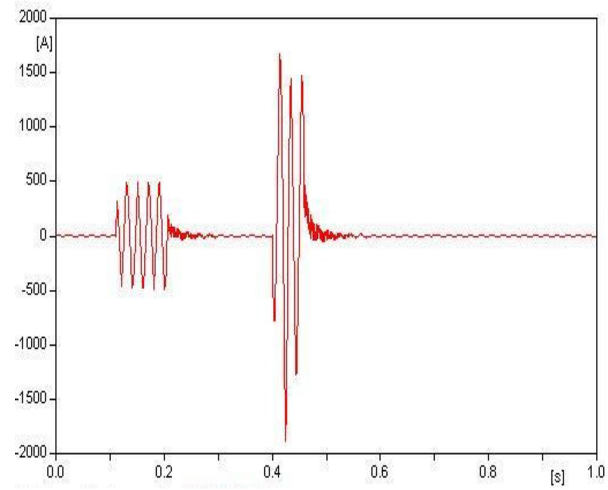




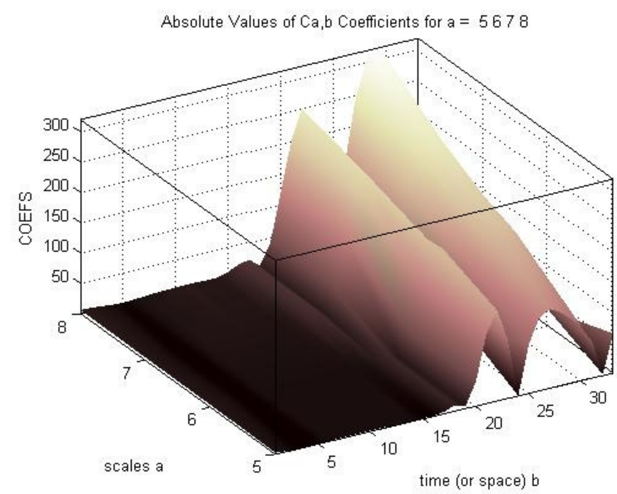
5.4. Transient current waveforms



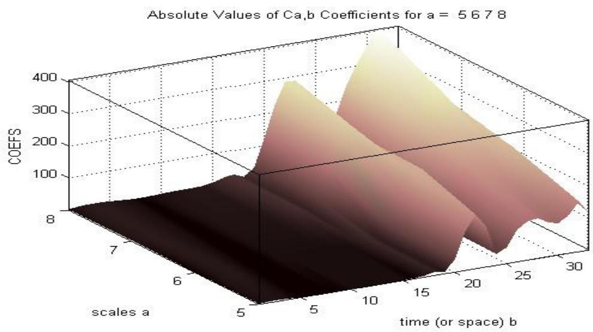
Sending end current



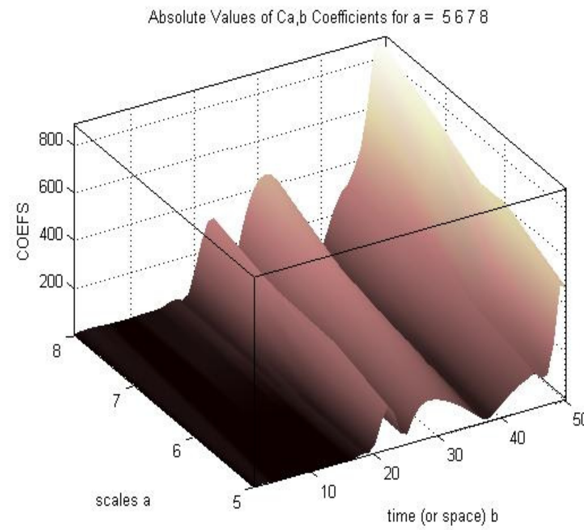
5.5. Wavelets for current



5.5.1. Voltage

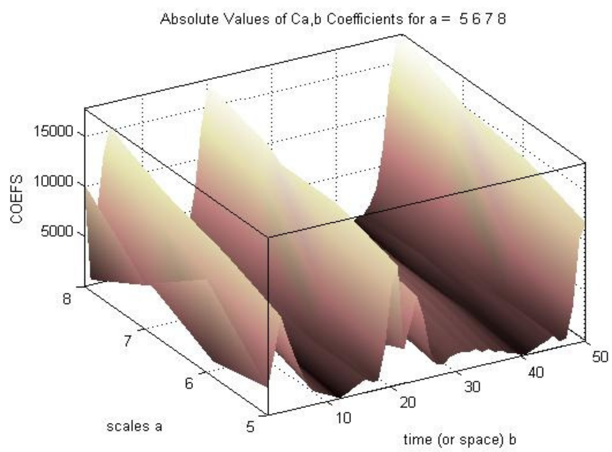


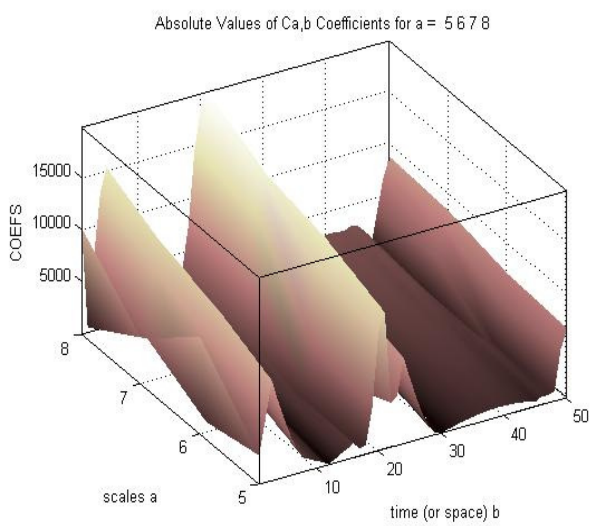
Current:

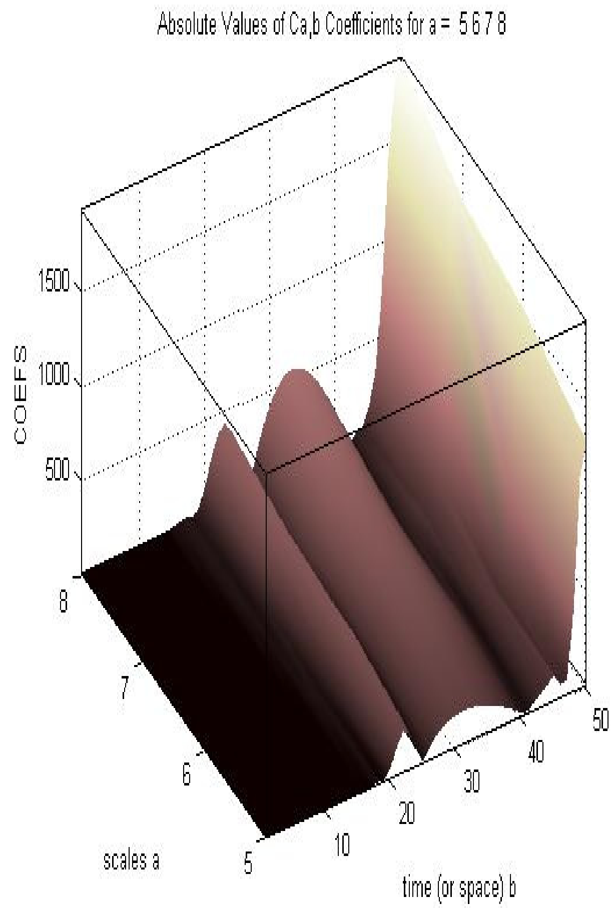


5.6. Capacitor bank switching wavelets

5.6.1. Voltage







6. Conclusion

In the present era of open access and deregulated electricity market, it is very important to restore the system after fault clearance. Accurate identification of fault and its location is thus of prime concern, where the transient signals can play a very vital role. In this paper, study demonstrates the effectiveness of transient voltage signals to identify the fault locations of single phase system. The properties of the proposed scheme are:

The wavelet transform (CWT) provides an efficient way to extract signal component

Neural network provides an intelligent method and a soft criterion for feature comparison

7. Reference

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