# Wavelet Entropy Based Transmission Line Protection

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**Abstract -** *Electrical transmission lines square measure at risk of faults and failures. Once a fault happens, it's not possible most of the days to repair it manually. A fault on a high voltage line affects the power system stability that generally results in permanent injury of the instrumentation. Relays square measure developed and put in to shield the lines. The conductor protection relays, within the trade, square measure supported the elemental frequency parts of the voltages and currents. These relays want a minimum of one first harmonic cycle for playacting the protection operation. Voltage and current traveling waves square measure generated once a fault happens on the conductor. The speed of propagation of traveling waves is finite and also the level of the waves decreases with increase within the distance traveled. Data concerning the fault may be obtained by analyzing the traveling waves.*

*This paper presents the transmission line protection system using wavelet multi-resolution analysis. The faulted current and voltage signal get transfer into multi-resolution analysis the after analysis this transfer to threshold based system. That threshold system operates the circuit breakers connected at the each end of transmission line by sending trip signal during abnormal faulted condition occurs.*

*An improved simulation software using MATLAB was developed to study the proposed fault diagnosis techniques. Comprehensive performance studies were implemented and the test results validated the enhanced performance of the proposed approach over the traditional fault diagnosis performed by the transmission line distance relay.*

**Keywords- Multi resolution analysis, Fault, Distance protection.**

## 1. INTRODUCTION

To unfold power from generating stations to remote load centers, transmission lines square measure used. As a result of lightening, miss-operation, overload, short circuits, human errors, faulty instrumentality and aging, faults might occur on these lines. Once fault happens, the faulted section voltage decreases and high magnitude currents can flow which might fail the elements if not interrupted quickly.

Either insulation failure or failures of conducting path area unit the main causes for the prevalence of faults. Additionally to the present, faults caused due to over voltages that are occurring due to switching surges and lightening. Falling of conducting objects on overhead lines, encounter of flying birds, tree branches, direct lightening strokes, ice loading, creepers, storms etc. area unit the opposite reasons which may cause faults in overhead lines. Wet within the soil, heat of earth, ageing of cables might result in the solid insulation failure in cables, transformers and generators [1].

| Types of Faults | Symbol | % occurrence | Severity |
|---|---|---|---|
| Line to Ground | L-G | 75-80% | Very less severe |
| Line to Line | L-L | 10-15% | Less severe |
| Double Line to Ground | L-L-G | 5-10% | less severe |
| Three phase | 3-Phase | 2-5% | Very severe |

## 2. PROPOSED METHODOLOGY

This work aims at to achieve wavelet transform based transmission line distance protection. The main objectives of this project are:

- To study the existing fault classification, detection and location scheme for transmission line.
- To appropriately design transmission line model with power system components with specification.
- Design Multiresolution analysis (MNA) for discrete wavelet transform techniques for faults signal decomposition.
- Design MATLAB simulation model for propose methodology using MATLAB 2013 b software environment.

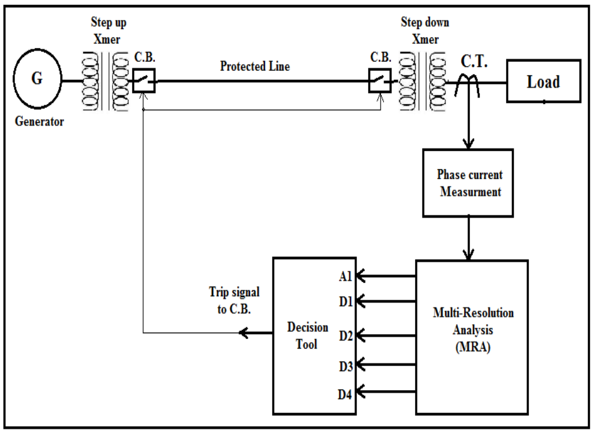


Fig.1. Block diagram of proposed methodology

Presently conventional distance protection are used for transmission line but these protection scheme are also operate during load switching. (e.g. motor, transformer..). This is undesirable condition for protection point of view. This condition is occurs due to high starting inrush current flowing in transmission line, that seen as fault condition for relay.

In these proposed work, new protection scheme design based on multi-resolution analyses which identify exact fault condition with the help of proper decision tool.

## 3. MATLAB SIMULATION MODEL

The project model implemented using MATLAB simulink atmosphere. Figure 2 shows the complete matlab simulation model of proposed approach.

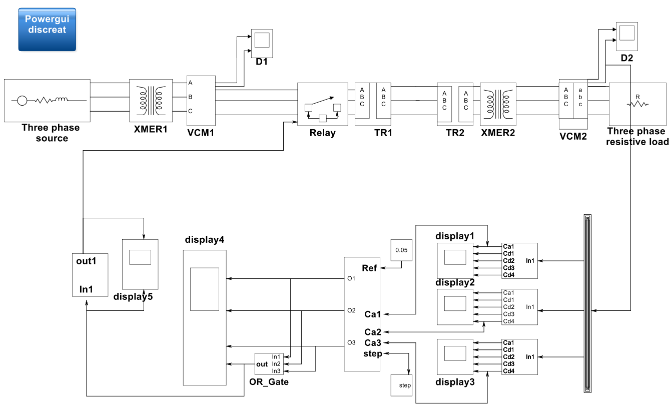


Fig.2. Matlab simulation model of main transmission system.

Table 1. Transmission line matlab Simulink model parameter specifications.

| LOAD TYPE | RESISTIVE | INDUCTIVE | TRANSFORMER |
|---|---|---|---|
| SAMPLING TIME | Ts = 55e-6 ; | Ts = 55e-6 ; | Ts = 55e-6 ; |
| GENERATOR INFORMATION | gen1<br>ppv = 153e3;<br>Frq = 50;<br>pva = 100e6;<br>bv =153e3; | gen1<br>ppv = 153e3;<br>Frq = 60;<br>pva = 100e6;<br>bv =153e3; | gen1<br>ppv = 153e3;<br>Frq = 50;<br>pva = 100e6;<br>bv =34.5e3; |
| TRANSFORMER (SOURCE SIDE) | xmer1<br>xmer1pva = 100e6 ;<br>xmer1pr = 153e3 ;<br>xmer1sr = 34.5e3 ; | xmer1<br>xmer1pva = 100e6 ;<br>xmer1pr = 153e3 ;<br>xmer1sr = 34.5e3 ; | xmer1<br>xmer1pva = 50e6 ;<br>xmer1pr = 34.5e3 ;<br>xmer1sr = 10e3 ; |
| TRANSFORMER (LOAD SIDE) | xmer2<br>xmer2pva = 80e6 ;<br>xmer2pr = 34.5e3 ;<br>xmer2sr = 440; | xmer2<br>xmer2pva = 80e6 ;<br>xmer2pr = 34.5e3 ;<br>xmer2sr = 400; | xmer2<br>xmer2pva = 50e6 ;<br>xmer2pr = 10e3 ;<br>xmer2sr = 440; |
| LOAD INFOMATION | load side<br>RL = 80e6;<br>CL = 0;<br>LL = 0; | load side<br>RL = 10e3;<br>CL = 0;<br>LL = 0; | load side<br>RL = 10e3;<br>CL = 0;<br>LL = 0; |

Fig.3. MATLAB simulation model specification

*A. Wavelet transform subsystem*

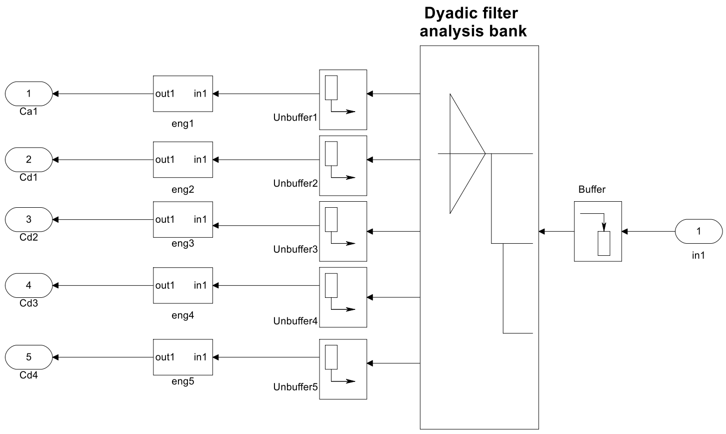


Fig.4. MATLAB simulation model of wavelet multi resolution filter bank

The specification of each blocks in Discrete Wavelet Transform subsystem are following way:

(1)DWT block: Mother wavelet = Daubechies; Wavelet order = 2; Number of levels = 5; tree structure = symmetric; output = multiple ports

(2)Buffer: output buffer size (per channel) = 128; buffer overlap = 0; initial condition = 0

(3)Unbuffer: Initial condition = 0

*B. Threshold subsystem*

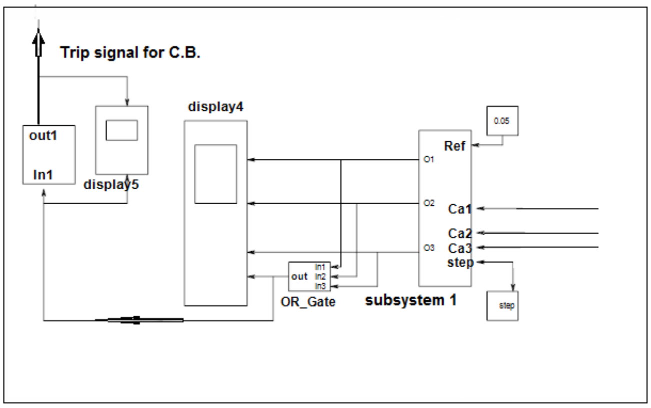


Fig.5. MATLAB simulation model of threshold subsystem trip signal

Generator generates the electricity, step up transformer step up the signal and share to transmission line. Now second transformer step down the signal and send it to required load ,Now current transformer is used for takeout transients during the fault condition and this transients signal send to multi-resolution analysis and also transferred to load side. C.T. send it to phase current measurement and also MRA block. MRA block decomposed the signal into different frequency bands. At lower scale. And thus the data is goes to decision tool. Now decision tool has its own standard threshold value pick up from its normal stage. Now this normal threshold is compare with appear threshold value. As soon as the appear value goes above the standard threshold value ,decision tool generates a trip signal and send it to circuit breaker for isolating the transmission line from transformer.

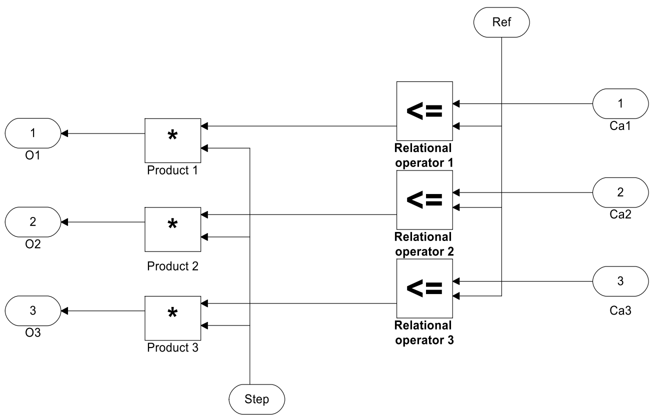


Fig.6.Internal structure of threshold subsystem (logical operation)

Next is subsystem, whose inputs are ca 1 – 3 of 3phases, reference value and step input , these approximated (ca) values compares against the reference value if it exceed the reference value output goes to high which indicate the value about the reference value , but due to some uncertain conditions at the start of system output may goes to cross the reference values to protect from going high , a multiplier is use along with step input which keep the output not going to high.

*C. OR Gate subsystem*

OR-gate is use to generate the high signal if there is any fault on any phase, which gives high output if there is any input is high, it is simple or gate logic .As soon as incoming value cross the normal threshold value, it taken as or consider as fault if it appears after a given time .and hence OR-Gate subsystem generate high signal.

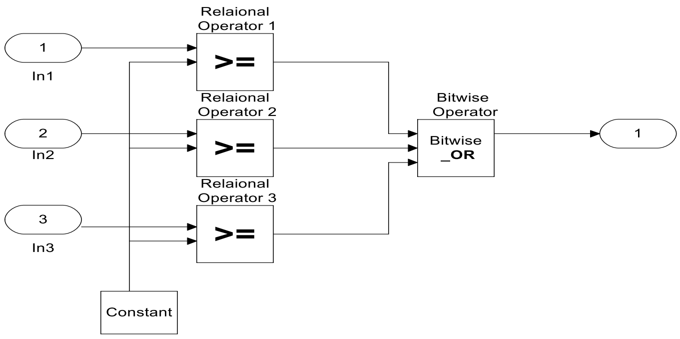


Fig.7.OR gate logic based simulation model

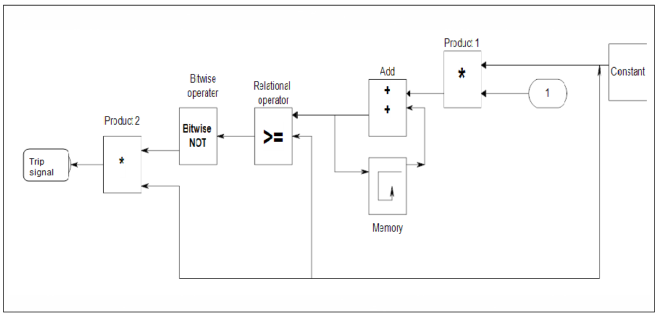


Fig.8. Trip signal with memory unit (subsystem 2)

Subsystem 2 is use to generate trip signal if there is any detection of fault and keep trip signal low even fault detection signal goes low, it has memory elements which will keep check on input signal, if at any instants it goes high it will make trip signal low and keep remains low .Now this trip goes to circuit breaker to isolate the transmission line. And hence transmission line is protected.

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## 4. MATLAB SIMULATION RESULTS

*A. Results from C.T.*

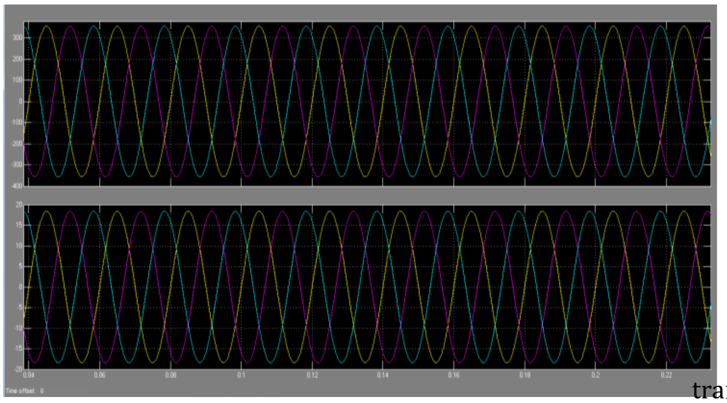

Fig.9.Voltage and current waveform from Current transformer (C.T.) for resistive load during normal condition.

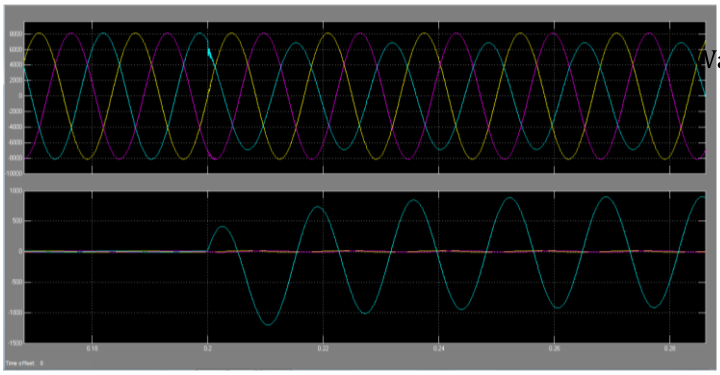

Fig.10.Voltage and current waveform from Current transformer (C.T.) for resistive load during LG fault.

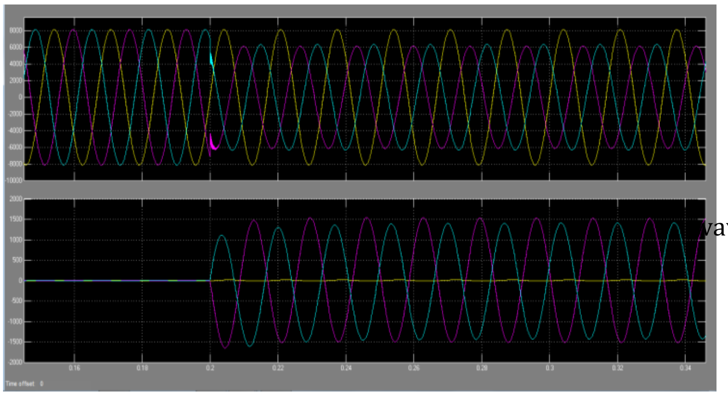

Fig.11.Voltage and current waveform from Current transformer (C.T.) for resistive load during LLG fault.

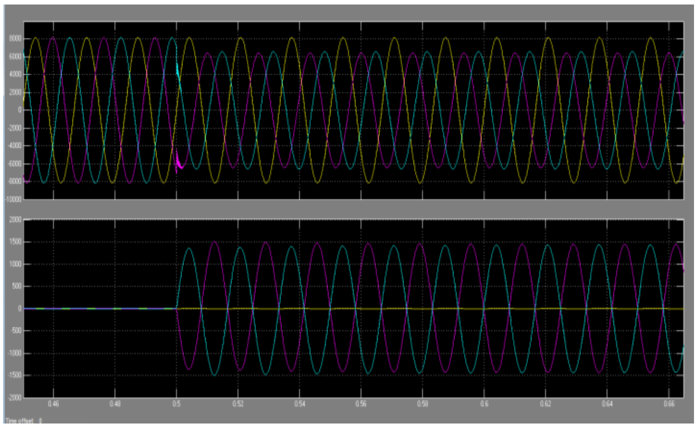

Fig.12.Voltage and current waveform from Current transformer (C.T.) for resistive load during LL fault.

*B. Wavelet decomposition level analysis for different mother wavelet*

Table 2. Wavelet decomposition level analysis for Haar Wavelet

| Haar(DB1) | | | |
|---|---|---|---|
| | d1 | d2 | d3 |
| R | 5.8*10^5 | 5.8*10^5 | 5.8*10^5 |
| RL | 5.8*10^5 | 6*10^5 | 5.8*10^5 |
| RLL | 5.8*10^5 | 5.8*10^5 | 5.9*10^5 |
| RLLG | 5.8*10^5 | 5.8*10^5 | 5.8*10^5 |
| M | 0.05 | 0.06 | 0.05 |
| ML | 0.062 | 0.07 | 0.05 |
| MLL | 0.2 | 0.1 | 0.15 |
| MLLG | 0.13 | 0.06 | 0.1 |
| T | 150 | 150 | 150 |
| TL | 4 | 5 | 1300 |
| TLL | 0.095 | 80 | 75 |
| TLLG | 35 | 220 | 450 |

Table 3. Wavelet decomposition level analysis for Db wavelet

| DB2 | | | |
|---|---|---|---|
| | d1 | d2 | d3 |
| R | 140 | 2*10^4 | 2*10^4 |
| RL | 700 | 1500 | 2000 |
| RLL | 145 | 5000 | 4500 |
| RLLG | 109 | 2500 | 3800 |
| M | 3*10^-5 | 4.5*10^-4 | 4*10^-4 |
| ML | 4.5*10^-5 | 4.5*10^-4 | 4*10^-4 |
| MLL | 4.5*10^-5 | 0.7*10^-3 | 0.7*10^-3 |
| MLLG | 3*10-3 | 0.7*10^-3 | 0.7*10^-3 |
| T | 1 | 17 | 15 |
| TL | 1.35 | 1 | 1200 |
| TLL | 3*10^-5 | 50 | 50 |
| TLLG | 0.015 | 140 | 400 |

Table 4. Wavelet decomposition level analysis for symlet wavelet

| Sym 1 | | | |
|---|---|---|---|
| | d1 | d2 | d3 |
| R | 6*10^5 | 6*10^5 | 6*10^5 |
| RL | 6*10^5 | 6*10^5 | 6*10^5 |
| RLL | 6*10^5 | 6*10^5 | 6*10^5 |
| RLLG | 6*10^5 | 6*10^5 | 6*10^5 |
| M | 0.05 | 0.06 | 0.05 |
| ML | 0.07 | 0.07 | 0.05 |
| MLL | 0.3 | 0.1 | 0.15 |
| MLLG | 0.13 | 0.06 | 0.1 |
| T | 150 | 150 | 150 |
| TL | 4 | 5 | 1300 |
| TLL | 0.1 | 80 | 80 |
| TLLG | 35 | 240 | 450 |

Table 4. Wavelet decomposition level analysis for conflits wavelet

| conflits | | | |
|---|---|---|---|
| | d1 | d2 | d3 |
| R | 125 | 12500 | 12000 |
| RL | 650 | 1200 | 1350 |
| RLL | 120 | 3000 | 3000 |
| RLLG | 175 | 2000 | 2500 |
| M | 1.5*-5 | 4.5*-4 | 4.5*-4 |
| ML | 5*-5 | 4.5*-4 | 4.5*-4 |
| MLL | 4*-5 | 1*-3 | 1*-3 |
| MLLG | 2.5*-5 | 1*-3 | 1*-3 |
| T | 0.035 | 3.2 | 3 |
| TL | 0.2 | 0.25 | 1150 |
| TLL | 3*-5 | 50 | 50 |
| TLLG | 0.017 | 140 | 410 |

From table it is clear that Db2 wavelet provide sufficient difference in decomposition coefficients. From reading, we can say that normal thresholds value is very different from fault condition value. This differentiate every fault from normal switching action.

*Results from discrete wavelet transform decomposition*

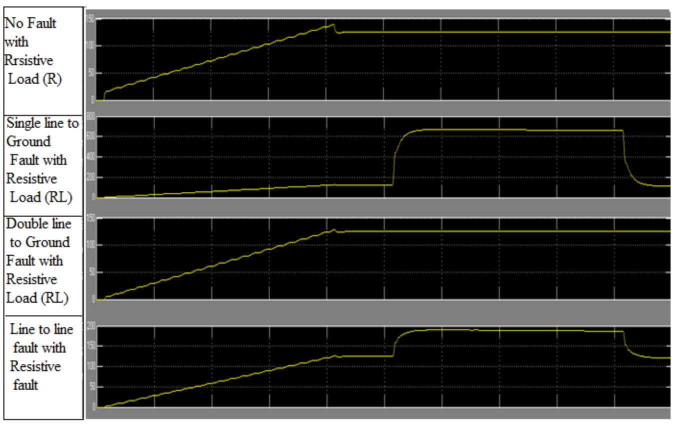


Fig.13. Signal energy calculation using multi resolution analysis for phase A at resistive load.

Figure shows the a four display in one window where first display shows no fault condition, second display shows single line to ground fault, third and fourth displays shows double line to ground, and line to line fault respectively for resistive type load for phase A.

After a sufficient time taken as 0.5 sec . displays shows variation with reference to normal or no fault condition .from this we cleared that, every phase get changes in fault condition.

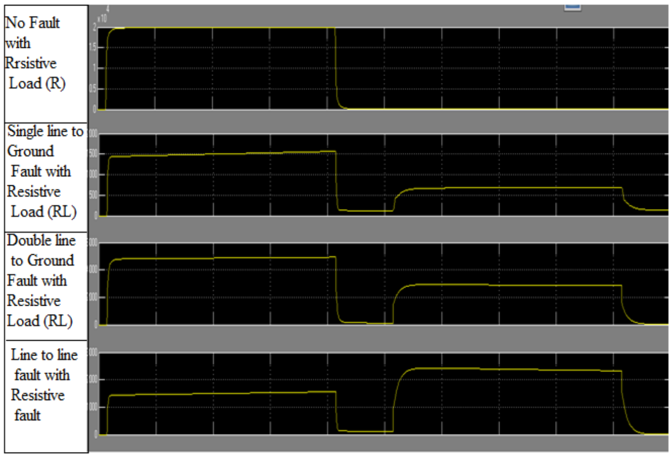


Fig.14. Signal energy calculation using multi resolution analysis for phase B at resistive load.

## 3. CONCLUSION

This dissertation presented a non-communication protection technique for transmission lines. . The Threshold subsystem technique was employed to classify the faults according to the fault currents components decomposed by the wavelet transform.

An application of wavelet transform to digital distance protection of transmission line was presented in this model. Use of wavelet transform gives the ability to detect faults including high impedance fault. Wavelet based distance protection scheme has been tested using MATLAB version 2010 computer simulation model.

Proposed worked capable to identify major faults in less than half cycle after fault inception. Present work studied some important factors which influence the operation relay. Efficiency of this threshold system is up to 92% calculated from different normal and abnormal 246 cases at different fault location.

Proposed approached extended for protection of double circuit transmission line and multi terminal transmission lines.

Proposed approached extended with combination of wavelet transform and neural network for power quality observation and fault identification.

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