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Design Analysis and Classification of Digital Transmission Based Composite Relay and Artificial Neural Network Approach

Dr. Nookala Venu

Professor, Department of Electronics and Communication Engineering, Balaji Institute of Technology and Science, Warangal - 506 331, Telangana, India

Corresponding Author Mail id: venunookala@gmail.com

Abstract

This paper examines the evolution of digital relays for transmission line safety. A selective high-speed clearance of faults on high-voltage transmission lines is crucial for a modern power grid, and this report outlines effective and promising fault identification, classification, and fault position implementations in power transmission line safety. Computerized relays, digital communication technologies, and other technological advances are being developed in this region to eliminate cascading failures and enable safer, more stable, and more efficient power systems. Efforts have been made to incorporate almost all transmission line safety strategies and philosophies. This study focuses on the most recent techniques in transmission line security, such as artificial neural networks, fuzzy logic, fuzzy neuro, fuzzy logic-wavelet based, and phasor measurement unit-based principles, as well as other traditional approaches.

Keywords: *Artificial intelligence, digital relay, distance security, neural network, and wavelet transform are some of the main words.*

1. Introduction

Recent regulatory changes, the energy demand, and constraints on the construction of new transmission lines have resulted in power line overloading, necessitating efficient transmission network service. The use of a capacitor in long transmission cables is becoming more common to meet these needs. A capacitor in a line series, on the other hand, provides a level of protection. In a stable operation, the energy system maintains a balance between output and load. Automatic switching lines, connecting links, and turning large loads on and off create cuts in rotor angles between sources, which may lead to large power changes [1-3]. As a result, the related impedance observed by span transmission could be under its operational range. That might be misread as unhealthy condition, jumping that line excessively [4-6]. During a power swing, there are several ways to locate a fault in transmission cables. Since then, supervised learning methods for the PSB have been used, including the adaptive neuro fuzzy inference scheme (ANFIS), AI-based ANN, and vector support devices (SVM). The PSB model relies on ANFIS and achieves its objectives by varying approximate impedance, current, negative sequence and P.S.C capacity. Despite the fact that the system uses a variety of signals, the system's inputs, such as the application, impose a natural limit due to the thought process involved in deciding PSC values [7-9] .We used an AI-based ANN technique to distinguish between healthy and unhealthy conditions in this paper.

2. Protection of Transmission line

2.1 Over current Relay

The over current relay is one that works when the valuation of current exceeds the time it takes to set the relay. It protects appliances in the power system from fault current [10-12].

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2.2 Pilot Relay

Many of the valves and solenoids controlled by a speed switch draw a lot of current, so it might be important to "buffer" the power in front of the dangerous currents. The signal is actually "relayed" to the high current load by the Pilot relay. The Pilot relay's input can be very low, but it can regulate currents of hundreds of amps. When the device is in an environment where electrical interference can be reduced, positioning pilot relays close to loads provides additional electrical benefits [13-15].It is the fastest power relay of all Switchgear relays. It trips the relay at a high rate, sends a signal to the circuit breaker, and shuts down the circuit device to prevent any damage or malfunction.

2.3 Distance Relay

There is one form of relay that operates based on the distance of a fault in a line. Relays work by measuring the impedance between the point of failure and the location where the relay is located. Distance relays and impedance relays are two types of relays. Distance relays work based on the impedance they calculate. When a fault occurs, impedance enters relay protective areas, causing the relay to trip after a predetermined amount of time [16-19]. By computing the impedance at the relay location, which would be dependent on the distance to a problem and irrespective of the fault current magnitude, the distance relay protects transmission system linked to a grid. Because of its versatility, this safety, which is adapted to local calculations, is the most often used by services for transmission system safety.

2.3.1 Problems associated with distance relay

By splitting the power grid into harbor area and eliminating a small portion of the network, power grid protective relays are added, allowing the problem to be typically extracted. Three safety zones are typically used to produce coverage for the distant adjacent line segment for transmission system spacing security. When local main protection or sector two remote coverage crashes due to a native issue, the sector three distance relay provides remote backup protection. To achieve synchronization, the Zone three time delay is usually one to two seconds. Distance relays can often work incorrectly (owing to the power swing phenomenons) and voltage uncertainty conditions during transient stability conditions [20-23]. Remote protective relays (Zone three operation) must operate correctly in order for a wide portion of the power system to not come to a halt unnecessarily. The proper operation of a distance relay depends on finding stable power swings and blocking. The standard power swing detection scheme of blinder finds the variation in the degree of variation of the positive-sequence impedance vector. The blinder structure is better, even though discovery of the situations for stalling throughout steady power swings and to trip uneven power swings of that relay is challenging. It necessitates thorough system stability studies for various contingency scenarios [24-27]. The quickest degree of a potential power swing, for example, must exist determined using a large number of stability studies. On a large power grid, finding all of the power swing circumstances and functioning situations is extremely difficult. Benm-ouyal developed the swing center voltage (S C V) process that senses the degree of modification of a power structure's swing center voltage to govern if that is steady or uneven state. The thump center voltage process is unaffected by device source and line impedances, has the same magnitude as the position alteration between causes, and is restricted between zero to one per unit [28-30].

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3. Artificial Intelligence

3.1 Materials and Methods

The method of statistics guided reading and evaluation is computerized using AI. AI, on the other hand, is not the same as programmed computerization, which is driven by ironware. Instead of powering physical missions, AI powerfully plus devoid of exhaustion works regular, large-amount of automated duties. Anthropological data is however needed to establish the structure and look for the proper problems in this sort of automated situation [31-34]. AI incorporates intelligence into existing goods. Generally, AI won't be marketed to a standalone use. Instead, present creations will be improved with AI capacities, similar to how Siri is a feature that has been introduced to new Apple devices. Computerization, colloquial stages, bots, and intelligent technologies could be merged by massive quantities of statistics to boost multiple innovations by the side of different places, since defense acumen to financing study [35-39]. Continuous understanding processes are used in AI to enable statistics to programme itself. In order to teach algorithm dexterity, AI looks for patterns and neural correlates in information. The process is currently a forecaster and an allocator. As a result, at the same time as the procedure could instruct the situation in what way to perform any game that could as well educate in self those results to imply available then. While fresh statistics is given to the prototypes, they take action [40-43]. When the first response isn't quite correct, back going is an AI system which lets the prototype to acclimate all through reading and additional statistics. To evaluate higher and internal data, AI practices neural networks accompanied by many concealed layers. A couple of ages ago, creating a fake recognition scheme of seven invisible coats was practically unfeasible. All of this has changed as a result of massive computer processing capacity and big data. Deep learning models take plenty of statistics to teach because that understands right away of the statistics. If we give them more data, it becomes more reliable [44-47].

Deep neural networks enable AI to achieve extremely high accuracy that was earlier unachievable. Deep learning is used in many smart applications and when we utilize these apps further, these become more specific. Deep learning, image processing, and object recognition are currently being applied in the therapeutic industry to uncover melanoma on MRIs with the identical meticulousness as extremely skilled radiologists [48-51].

AI benefits the generally from results. While procedures are understandable, statistics could grow to be intelligent acreage in and of itself. That replies are in the statistics the whole thing you need to act currently is to employ A.I to obtain results. While the condition of statistics is currently highly valuable than all the time, it can deliver a cutthroat improvement. Even though everyone is implementing traditional mechanisms, the latest research will win in a global marketplace while you possess outstanding data [52-56].

3.2 Single Layer Perception

The first proposed neural model was the single layer perception. A vector of weights makes up the data of a neuron's local memory [57-58]. A single layer perception is computed by solving the sum of the input vectors, each with the value multiplied by the corresponding element of the weights vector. The value shown in the output will be the activation function's input.

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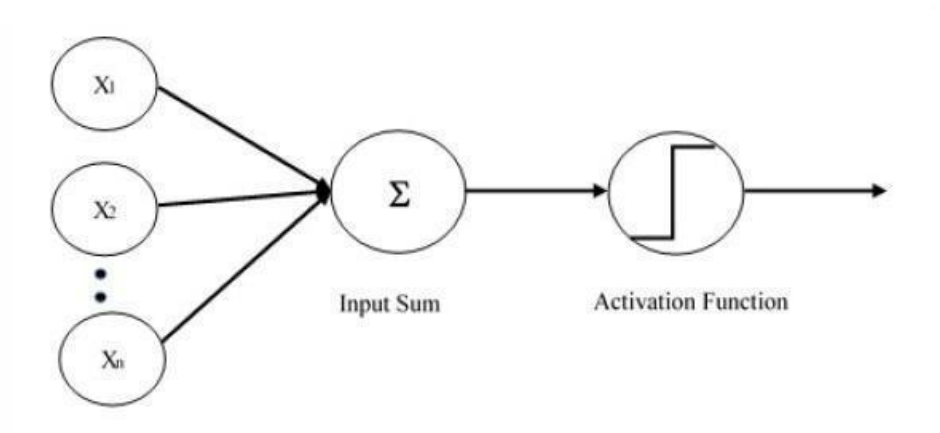

Fig.1: Single Layer Perception

Now let's look at how to use Tensor Flow to solve an image classification problem with a single layer perception. The representation of "Logistic Regression" is a great way to demonstrate the single layer perception.

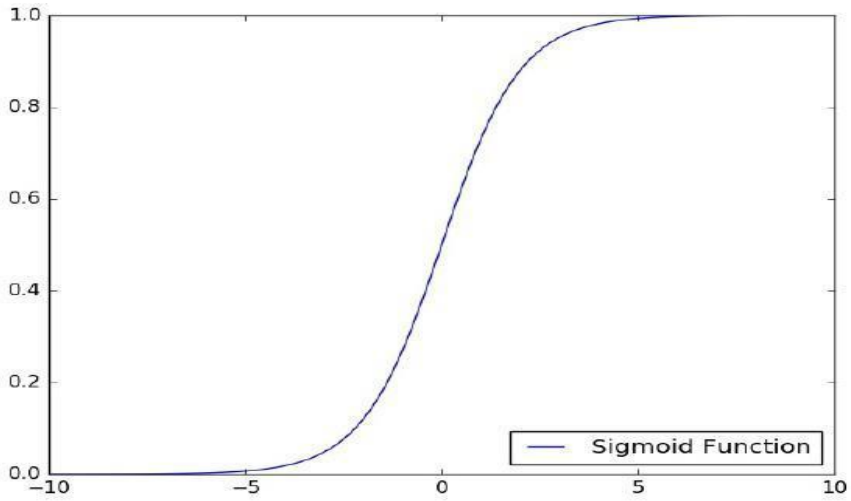

Fig.2: Waveform of Single Layer Perception with sigmoid

Let us now look at the basic steps of training logistic regression. At the start of the training, the weights are set to some value. The error is determined for each aspect of the training set using the diversification between the desired and actual performance. The weights are controlled using the measured error. The procedure is repeated until the total number of iterations reached is greater than the specified threshold and the total number of errors made on the entire training set is less than the specified threshold.

3.3 Training a Neural Network

After building a network to specific purpose, network is complete to be taught. Starting loads is decided at random to begin this procedure [59-60]. The teaching, or learning, then begins. Unsupervised and supervised training are the two types of training available. The supervised approach includes device for giving necessary output to the network, either by "rating" its efficiency or by providing the required answers to the questions inserted. In the unendorsed process, the network left to its own devices to make sense of the inputs. Supervised instruction is used by the vast

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majority of networks. Unsupervised instruction is utilized for performing little preliminary feedback description. Though, if genuinely own-taught, that's only highlighted assurance which isn't entirely agreed, doesn't function perfectly, and is thus relegated to the lab.

3.3.1 Supervised Training.

Two inputs and outputs are given in supervised training. Following that, it procedures inserted values & matches the outside values with desired outside values. Mistakes is transmitted posterior into scheme, affecting scheme lose control of network's bulks [61]. As weights are constantly tweaked, this mechanism repeats itself. The "training collection" is the set of data that is used to perform the training. Similar collection information are treated several periods during network training due to link bulks is purified. Present marketable system enlargement sets offer gears for determining in what way AI setup are meeting about skill of correctly guess response. Such gears let drill procedure continue several hours, with the system discontinuing if extents some chosen data. Few systems, on the other hand, do not learn at all. This is due to the lack of unique details in the input data using necessary production resulting. Systems do not join with insufficient information for allowing whole education. Data can be remembered by several layered networks of many nodes. Supervised testing necessitates holding some collection information utilizing for checking scheme afterward which had finished his preparation in order of keep an eye on the network to see whether the system is just remembering its data in a non-significant way. If a network alone is unable of solving problematic, creator should examine inside variables & outside variables, how many coats are there, how many material on each coat, interconnections among layers, summary, transition, teaching tasks, also primary bulks. Those adjustments must be made. Creating a successful network is a work that involves the "art" of neural networking.

The rules of training are governed by the next part of the designer's imaginative thinking. Numerous rules (procedures) are utilized for starting response required for regulating masses at preparation. Regressive mistake transmission, also called back propagation, is the most common technique.

However, preparation is more than a technique. To ensure that the network is not overstrained, it needs a "feel" and conscious analysis. An AI system first organizes him to data's universal arithmetical designs. After that, remains for "study" of other elements to information that might suspect after broad perspective. After network is skilled, masses may be "frozen" when wanted. This final network is then translated into hardware in certain systems to make it faster. Other devices do not bolt to them, instead carry on absorbing when operating.

3.4 Feed forward Neural Network

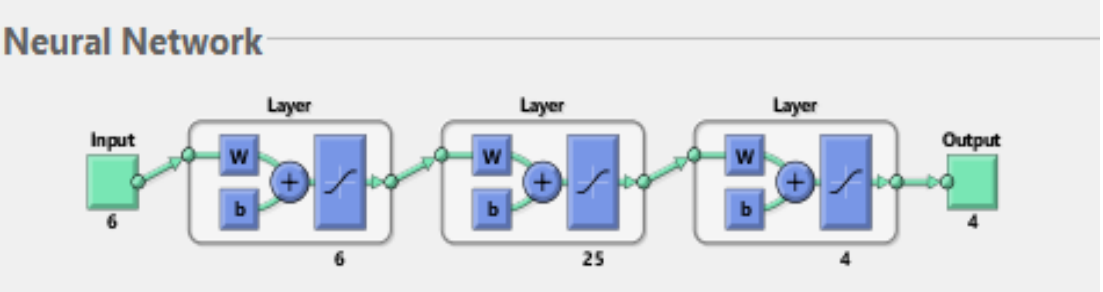

Fig.3: Feed forward Neural Network

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A feed forward neural network is a biological based segregation algorithm. It is organized in layers and contains a (possibly big) figure about humble neurons liked process unit. Each unit inside coat is related to entire unit inside preceding coat. This links aren't whole the same: one can have a different weight or power. The knowledge of a network is studied by the weights on these connections. Nodes are the basic building blocks of a neural network. Information flows from the inputs to the outputs, layer by layer, as it travels through the network [62]. There is no feedback between layers in normal operation, i.e. when it functions as a classifier. That is why they are referred to as feed forward neural networks. In the next diagram, we see an example of a two-layered network with, from top to bottom, a five-unit output layer and a four-unit hidden layer. Three input units make up the network.

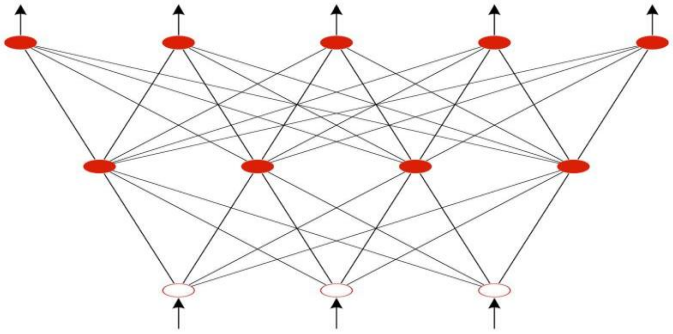

Fig.4: Two-layered network

The three inputs are depicted as triangles, and they do not correspond to any network layer (although the inputs many times are counted as an imaginary layer with layer number zero). The layer that isn't an output layer is called a secret layer. So there is only one hidden layer and one output layer in this network. All of the relations between the units in different layers are also shown in the diagram. A layer may only communicate with the layer before it.

3.5 Recurrent Neural Network

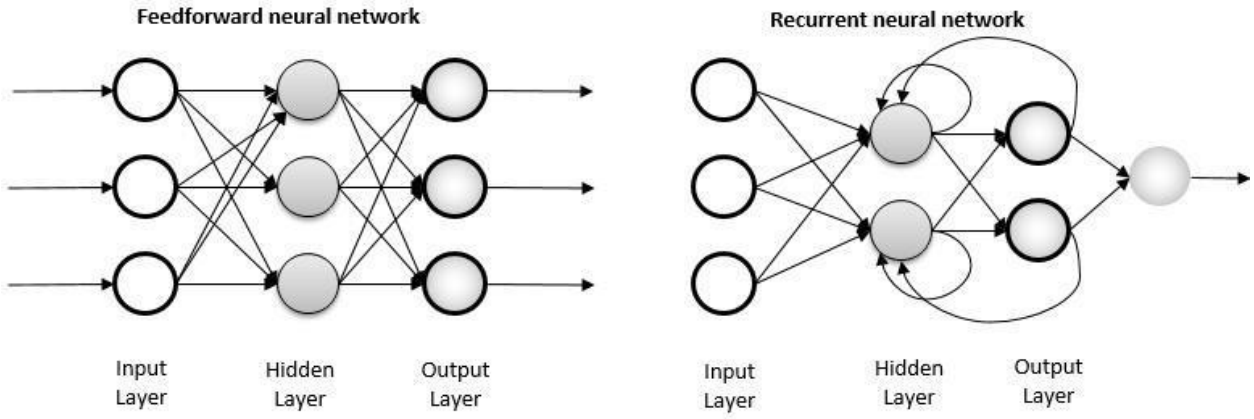

Fig.5: Recurrent Neural Network

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Since it is the only one with an internal memory, recurrent neural networks are a powerful and stable neural network that is a part of the most promising algorithms in use. RNNs, like many other deep learning algorithms, are fairly new. They were first established in the 1980s, but it has only been in the last few years that we have realized their full potential. RNNs have risen to prominence as a result of increased computing capacity & development about extended short-range memory at 1990. Recurrent neural networks may recall significant details of feedback it receives thanking their internal memory, allowing them to predict the future with great accuracy [63]. That is the reason of most effective algorithm of consecutive information like period sequence, speech, writing, monetary information, acoustic, film, and climate. In comparison to other algorithms, RNNs may provide bottomless knowledge about arrangement & meaning of it.

4. WSCC 9-Bus System

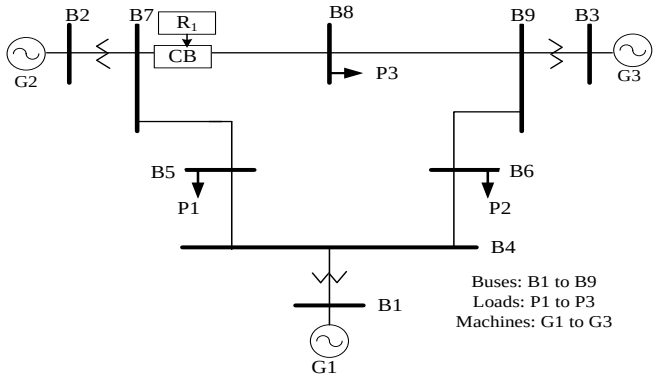

Fig.6: WSCC 9 Bus Scheme.

The behavior of the considered AI-based scheme has been evaluated for a transmission system of nine buses, which reflects WSCC's approximation about analogous scheme of 9 bus, 6 line, & 3 producers. To secure transmission link between buses 7 and 8, a fault breaker has been installed at bus 7. We may test whether the proposed scheme is applicable by modifying fault parameters such as fault position, fault resistance, and fault types. The input feature vector is developed in the same way as in a two-bus system by extracting the standard deviation third level approximate of voltage and current signals from post fault signals while changing fault parameters such as fault form, fault resistance, fault position, and inception angle [64].

4.1 Wavelet Transform

Over the years of progress, new procedures in the arena of culpability diagnostics have arisen. The fact that the evidence in fault signals is commonly a assortment of properties that are in period and occurrence in the procedure of transients is an essential aspect. A non steady wave is the technical word for such a wave. This eliminates the need for adequate analytic procedures. It is vigorous and adaptable to knob waves in relations of their time frequency domain. Wavelet is a little ripple in conjunction with a zero-typical value. The Wavelet Transform (WT) is beneficial aimed at perusing non sporadic waves since it can locate the different modules of sign's frequency scale across time. That is exceptionally crucial for getting transient wave elements that could be employed as a organization for expanding extreme-velocity shield procedures [65].

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Wavelet transform (WT) tactic have been magnificently practiced for multi level depiction and examination of waves in modern times. Transients are perished by the wavelet transform obsessed by a string of wavelet elements, for each of that resembles to a time sphere wave encompassing a precise frequency group and holding additional exact data. Wavelets focus info in the time–frequency plane, and they are predominantly upright at bartering a category of steadfastness for alternative, that styles it idyllic for non steady wave administering. In transient wave study, wavelet analysis is idyllic for swift variations. The capability of wavelet study to expose the homegrown feature of a definite zone of a gigantic wave is its key asset. WT disconnects statistics into frequency mechanisms, then inspects individually element beside a steadfastness that resembles to their measure [66].

Wavelets are arithmetic actions which split information in regularity segments & read each portion with the same resolution as its size. In physical environments where the signal involves a stop and sharp resistance, they are more useful than conventional Fourier approaches. In the fields of mathematics, quantum physics, electrical engineering, and geology, wavelets have been developed independently. Over the last decade, the transition between these developments has resulted in the use of many new waves, including image compression, confusion, human vision, radar, and global forecasting. Without the method of processing digital signals, this paper presents the rise of an interested technician. I start with the Fourier transform, compare the versatile wavelet to the Fourier converter, state buildings, and other wavelet special features, and then heat it up with some exciting features like image compression, music tones, and sound data. The wavelet transform has two steps. In the first step, suitable features are extracted from voltage and current signals. To distinguish between a stable and a defective state, features from the voltage and current signals must be extracted properly. The gotten power indicators are tested on 1.20 kilo hertz at simulation. Features are then extracted using the wavelet transform, which has several benefits over the traditional Fourier transform method. Wavelet transform extracts features together the frequency & time extents, requiring fewer processing period & allowing sign demising short of important loss of unique sign. This scheme necessitates careful choice about mom wave let, that's then mounted for obtaining sign features. Daubchies is a wave let that was chosen alike the mother wavelet because of its suitability for detecting transient phenomena inside control scheme due to its small duration & big amount disappearing instants. To obtain the estimated coefficients, the 6 phase current & voltage wave forms is decayed unequal to near 3. The standard deviation is calculated using the following formula based on the approximate coefficients of voltage and current signals:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Where

x_i denotes the input feature's individual value (approximate coefficient)

x = mean inside coming features value

n is the total no. of features in the inside coming value.

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To train an ANN to achieve the desired results. As input, the estimated coefficients of current & voltage signal are given according to standard deviations.

5. Results and Discussions

Time-dependent prefault waveforms of voltage and current signals. In the first image below, the first waveform is for voltage and the second is for current. All signals are sinusoidal. The variations in both the waveforms after 0.166 times can be seen in the second picture below. The value in current increases of a given phase depending on the type of faults.

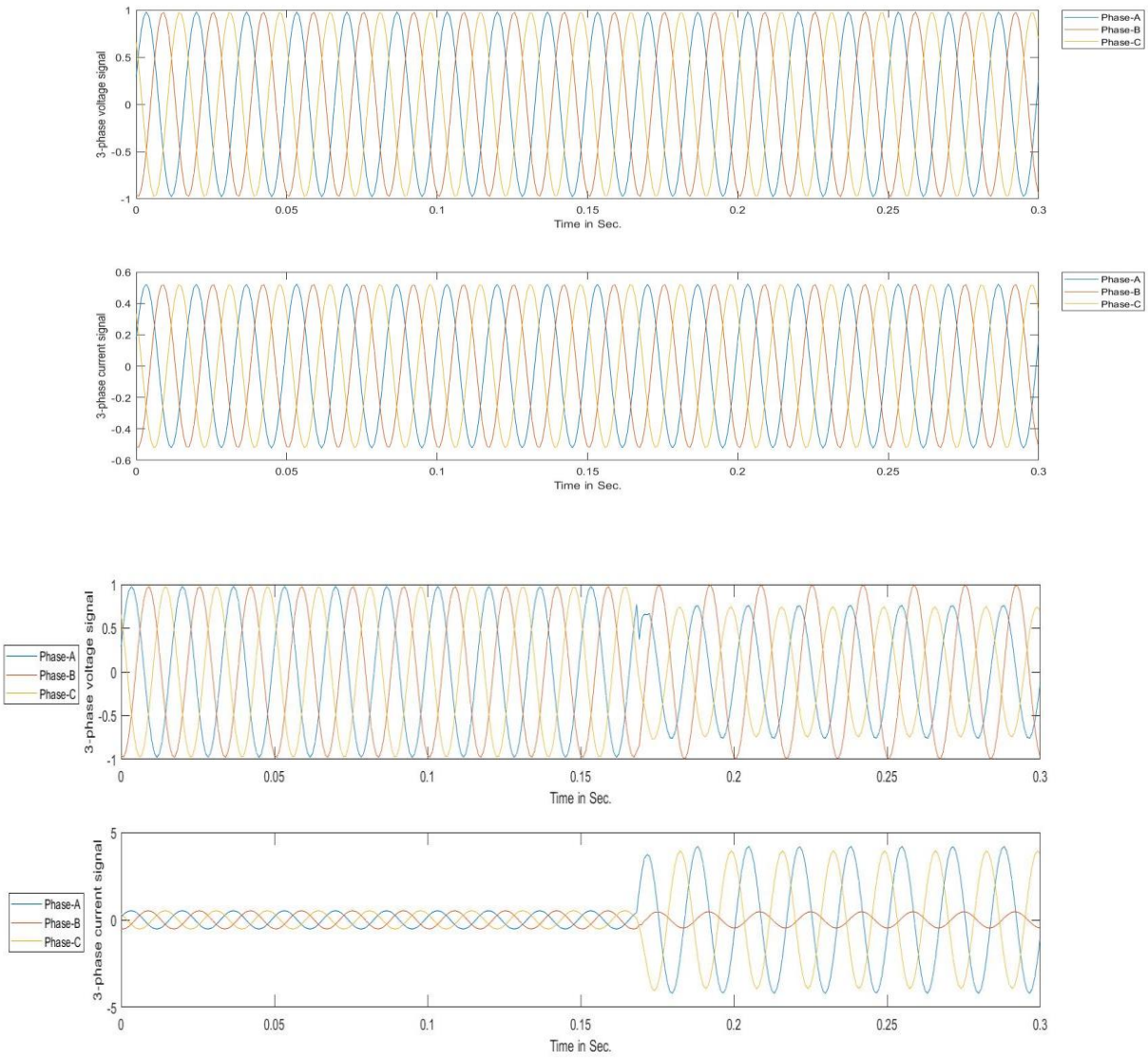

Fig.7: Voltage and Current waveforms

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Table 1: Variation in angle of inception

Fault Type	Fault Inception Angle	Fault Resistance	Fault Location	Input Feature	Output of ANN based Fault detection / Classification			
					A	B	C	G
AG	0.169	36	42	1.44831825687447 1.84122918761904 1.68923313370531 5.63458791925312 1.03282421293598 0.821317615331768	1	0	0	1
BCG	0.176	36	42	1.73029004868371 1.56344058700203 1.41878819552998 0.903643568353750 5.30732444663916 6.04351233274791	0	1	1	1
ABCG	0.180	36	42	1.72874518865428 1.57814467484889 1.41690354698389 0.903488579485835 5.38121126689078 5.91678311047392	1	1	1	1
AB	0.188	36	42	1.72874518865428 1.57814467484889 1.41690354698389 0.903488579485835 5.38121126689078 5.91678311047392	1	1	0	0
ABC	0.192	36	42	1.72874518865428 1.57814467484889 1.41690354698389 0.903488579485835 5.38121126689078 5.91678311047392	1	1	1	0
No fault	_	_	_	1.47038073529204 1.56400409572161 1.43844401287765 4.90057039641858 4.77435749987435 5.13873944132355	0	0	0	0

In above tables table shows the variation in angle of inception. Here there is a column named input feature is mentioned in each table which shows the different final input data values for these variations. Input feature has six values whereas output of ANN based classification has four values. These six vales correspondence to 3rd level coefficient of each phase voltage and each phase current in sequence i.e. A, B, C. four values are showing 4 bits which shows fault detected by ANN.

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6. Conclusion

Recent regulatory changes, the energy demand, and constraints on the construction of new transmission lines have resulted in power line overloading, necessitating efficient transmission network service. The use of a capacitor in long transmission cables is becoming more common to meet these needs. A capacitor in a line series, on the other hand, provides a level of protection. In a stable operation, the energy system maintains a balance between output and load. Automatic switching lines, connecting links, and turning large loads on and off create cuts in rotor angles between sources, which may lead to large power changes. To remove issues associated with conversation relay here proposed model uses a digital relay trained using ANN and an AND GATE to detect faulty or healthy conditions.

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