Proceedings of **"National Conference on Recent Trends in Science and Advances in Engineering"**
Organized by Fabtech Technical Campus, College of Engineering & Research, Sangola
International Journal of Innovations in Engineering Research and Technology [IJIERT]
ISSN: 2394-3696, Website: www.ijiert.org,, June, 2022

THE VOLTAGE STABILITY ANALYSIS OF SHIP ELECTRICAL POWER SYSTEM USING ARTIFICIAL NEURAL NETWORK(ANN)

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Abstract
An crucial, independent electric power system for ships is the ship's electric power system. Increased ship tonnage and a rise in the number of electric-powered ships result in an increase in the generator capacity at a marine power plant. Modern marines use electric propulsion technology, so the voltage stability control system needs to be more effective. The electricity generated by diesel generators drives a vessel's propulsion system in addition to being sent to each load. If the marine power system's voltage is not maintained within an acceptable range, the marine electrical system will be severely harmed. The idea of voltage stability and the current state of the research were first summarised in this work. A critical step in a voltage stability analysis is choosing the right load model because any factor that significantly raises tension losses also raises load losses. A critical step in a voltage stability analysis is choosing the right load model because any factor that significantly raises tension losses also raises load losses. The load model construction issue for the ship power system has been investigated. Then, a brand-new index that is simple to calculate and can be used for online usage was introduced to address the voltage stability index issue. The lack of complex matrix calculations or other time-consuming calculations should result in faster results with this strategy. In order to assess voltage stability and certify secure and unsecure power system modes, this study uses artificial neural networks (ANNs). supplying the neural network with data In the MATLAB simulation environment, the network is subject to transmission line settings, sensors, feedback, and point load flow analysis.

Introduction

Voltage Stability in Ship Electric Power Systems: A Concept Since the 1970s, much progress has been made in the investigation of voltage stability issues. The nature and mechanism of voltage stability were initially grasped, and the implications of the major component of voltage stability became increasingly clear. Voltage stability is the capacity of a system to maintain an equilibrium state following a disruption as a result of the combined influence of system characteristics and load. The methods for analysing voltage stability can be classified into two categories: those that make use of the power flow equation's static analysis and those that make use of the differential equation's dynamic analysis. Current State of Voltage Stability Problem Investigation Voltage stability research has recently been divided into two primary categories. The first looks at the voltage stability problem and how to define it, while the second looks at the aim for voltage stability and steps to prevent voltage collapse, among other things. The second respect issue may typically be remedied once the first respect issue has been resolved. Respect should, however, take precedence for the time being. There hasn't yet been a satisfactory solution to the issue. Thus, there are currently two respect-related issues being addressed. The system states (i.e., Vi, I reflecting the operational status of the system) must be known in order to create any index that provides information about the vicinity of voltage collapse. There is no way to put a number on the situation. In reality, the actual and reactive powers of a ship's electric power system can be calculated using measuring equipment in the line flows. A state estimator will be used to determine the operational states of the system after the measured values are relayed to a central computational hub via a telemetry system.

To maximise efficiency, the state estimator's task is to identify the system's optimum, realistic operating states. data from the measurement and telemetry system that contains errors. This calls for a sophisticated measuring and telemetry system, and putting one in place would be expensive. Both industrialised and developing countries' electricity systems often lack these qualities. This suggested method makes use of a reliable voltage stability index that illustrates the potential for voltage collapse at a load bus in order to determine the static voltage stability condition of a load bus.

Simulations are used to determine the voltage stability index for a load bus under various system loading scenarios. A second bus index known as "bus loading index" is generated for the load bus at the same time and under the same system loading conditions. These "bus loading indices" are supplied into an ANN during training together with the appropriate bus voltages, and the voltage stability indices produced are the output. The trained ANN is then used after that. Using "bus loading indices" and the associated bus voltages as the ANN's input, determining the static voltage stability of a load bus for a new operating state of the system.

Literature review

[1] Zhaomin et al. The ship's electric power system is a crucial, independent electric power system for ships. Increased ship tonnage and a rise in the number of electric-powered ships result in an increase in the generator capacity at a marine power plant. Modern marines use electric propulsion technology, so the voltage stability control system needs to be more effective. The electricity generated by diesel generators drives a vessel's propulsion system in addition to being sent to each load.

[2] Caroline Maina & Welma Nyabuto The shore-to-ship power connection is one method that has been advocated as a means of lowering emissions from maritime vessels, the number of which has expanded as a result of the quick expansion of global trade. System operators and regulators are worried about the stability of the system as a result of marine boats' connectivity to an existing shore power grid at berth because the on-and-off addition of loads to the network causes voltage variations.

Noel Schulz et.al [3]. In the past, there have been close linkages between electric utilities and power programmes. Power engineering graduates are now being sought after by colleges from a wider range of industries. Power equipment manufacturers, consulting firms, chemical manufacturers, automakers, and other businesses are among them. Naval shipbuilders and other shipbuilding support industries are among a new class of companies looking for power engineers. The new all-electric ship programme, which will improve the configurability and survivability of ships, lays the groundwork for better management and utilisation of electric power systems. To meet its future difficulties, the industry currently requires more electrical power engineers. Mahiraj Singh Rawat1 & Shelly Vadhera2 [4] This paper optimises the network reconfiguration issue in radial distribution networks while maximising voltage stability and minimising power loss without deviating from the system's requirements. Natural-inspired population-based standard particle swarms The global best and particle best locations are usedto determine the current particle's flight path when using the optimization (PSO) approach. But as the particle approaches any of these places, the guiding rule weakens and even disappears. Integrated particle swarm optimization (IPSO) is utilised to identify the optimal reconfiguration in the radial distribution network to address this problem and find the world's ideal location.

K. L. Butler-Purry et.al [5] In this paper work, During shipboard power system reconfiguration procedures, it is suggested that stability, a crucial aspect of dependability, should be retained (SPS). The impact of SPS features and dynamic phenomena on its stability during reconfiguration operations is covered in this article. The trials' outcomes were used to create an SPS modelling strategy and an SPS stability evaluation technique.

Haseltalabet, Ali et.al[6] In the shipping sector, which depends on consistent power production and the dependability of the power and propulsion systems, power availability to sustain propulsion is a significant concern. There have been extensive studies on stabilisation and power generation control to enable robust and reliable performance of DC-PPS during various ship operations since the introduction of on-board all-electric Direct Current Power and Propulsion Systems (DC-PPS) with hybrid power generation, which are more efficient than direct-diesel and Alternating Current (AC) all-electric configurations.

Arthit Sode-Yome et al [7] In this work, the maximum loading margin (MLM) technique is advised in order to maximise the static voltage stability margin. The MLM is evaluated across multiple viable generation directions in the generation direction space. The MLM point is computed using a simple and approximate model that shows the relationship between the generating direction and the LM.

Aleksandar Borii et al [8] . The evaluation and monitoring of the stability of the power system in real time is becoming more and more common. Compared to long-term voltage and frequency stability, short-term (voltage) instability is a subject that receives less attention in stability research. The most popular assessment methods are covered in this paper, with an emphasis on how they relate to modern power networks that incorporate a significant amount of renewable energy.

Single Line Diagram Of Ship Electrical Power System:

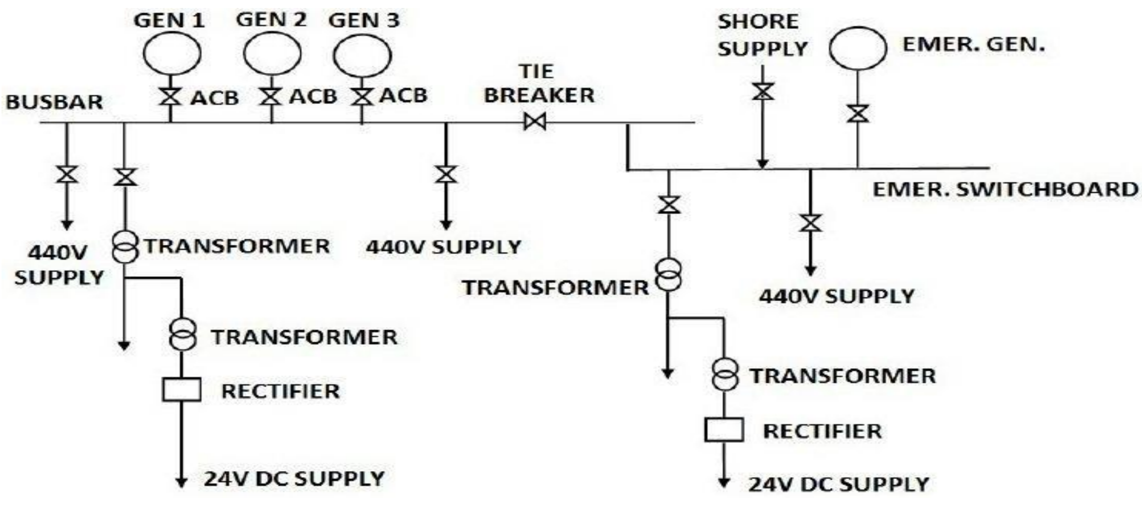


Fig 1. Single line diagram of ship electrical power system.

The first area of voltage stability research focuses on characterising the voltage stability issue, while the second examines voltage stability goals and techniques for preventing voltage collapse. The second respect issue may typically be remedied once the first respect issue has been resolved. But the initial respect problem has still not had a suitable resolution. As a result, two respect-related problems are now being addressed.

A.* Voltage Stability together with Load Developments Relationship*:

The loss of voltage stability can be attributed to the load, the dynamic character of the load-tap changing transformer, and the maximum current limit of the excitation system of the ship electric power system. The method of losing stability has been explained in several literatures based on the dynamic features of three categories of component. The load loss firmly and completely follows the loss of stability, regardless of its cause. The most crucial step in evaluating the stability of an electric power system on a ship is thus creating an accurate load model.

The following elements of the load dynamic characteristic should be taken into account while looking at voltage stability. Reactive power system area equilibrium will become worse when the load bus voltage declines because more reactive power will be absorbed by the load from the system. The voltage decreases as a result of a positive feedback process. Property for dynamic active power recovery: When the voltage drops, various active and reactive power loads can immediately or gradually increase to the appropriate level. Under extreme conditions, the voltage will first drop to its lowest point before rising again. The dynamic load has the ability to alter admittance in order to achieve input/output active power balance.

B.* The Analysis of Voltage Stability Load Model Building*:

When solving the voltage stability problem, it is useful to address the issue that the voltage stability was typically assessed using the load model for a certain portion of load property. In other words, it's crucial to consider the nature of the properties that relate to voltage stability while creating load models. One of the three categories of dynamic models listed below may be used for the voltage stability investigations of a ship's electric propulsion system: Model for reactive power equilibrium Reactive power's equilibrium state determines the static voltage level, hence the voltage collapse can be traced to reactive power disequilibrium.

The association between various burden node properties and reactive power disequilibrium was found during the construction of the voltage stability load model. the creation of the upcoming model

$$\frac{dy}{dt} = \frac{Qd - Qs(V)}{K(V)} \quad \ldots.(1)$$

This model argued that there is no dynamic physics method that employs reactive power equilibrium to calculate voltage fluctuations and those voltage variations are produced by reactive power disequilibrium. model for power recovery Power restoration after a load disruption has a substantial impact on voltage stability. That model is an input/output model since it is based on the properties of dynamic loads that have roughly single-order resumed power when step voltage is interrupted.

$$T_p \ P_d + P_d = P_s(\mathrm{V}) \quad + K_p \ (\mathrm{V})\ \mathrm{V} \ \ldots\ldots\ldots(2)$$

$$T_q + Q_d = \mathrm{Q(V)} + K_q\ (V)V \ldots\ldots (3)$$

The recovery attribute in that concept applies to both active and reactive power. It is impossible to evaluate voltage stability using the preceding model since the bus voltage V, load active power Pd, and reactive power Qd do not alternate after a disturbance. However, the model may be improved to the following state variable standard form.

$$T_p \; P_r + P_r = \; + N_p \; (V) \ldots(4)$$

$$T_q \, Q_r + Q_r \; = N_q \, (V) \ldots(5)$$

$$P_d \; = \; P_r \; + P_t \, (V) \ldots.(6)$$
$$Q_d = Q_r + Q_t \, (V) \; \ldots.(7)$$
$$N_P \, (V) = P_s \, (V) + P_t \, (V) \; \ldots.(8)$$
$$N_q \, (V) = Q_s \, (V) + Q_t \, (V) \ldots.(9)$$

Variable Pr, Qr undergoes mutation to become the following alternation state variable. The following form of a universal load model, which also applies to the state variable pattern, describes the load power recovery feature.

$$\text{TP} \frac{dy}{dx} = Ps \; (V) - P \ldots \ldots (10)$$
$$\text{Tq} \frac{dy}{dx} = Qs \; (V) - Q \ldots \ldots (11)$$

The input/output model can be converted into a state variable model by choosing various state variables, and a model of recovering power stress on the port property can then be created.

System Architecture

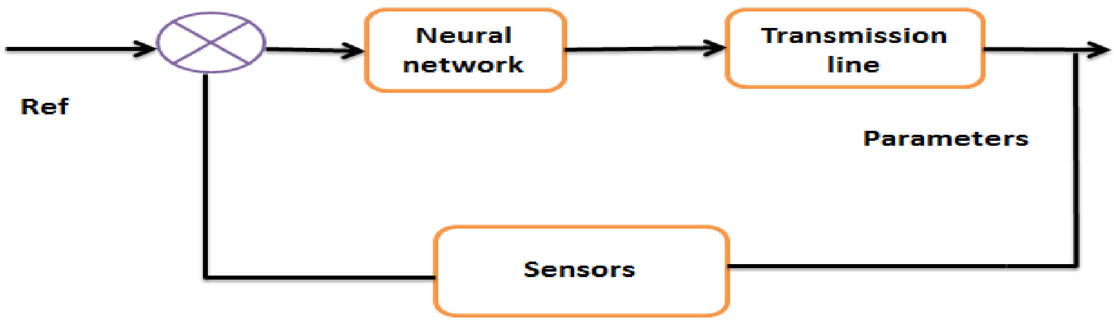


Fig 2. Power system block diagram.

The human brain is implanted in a computer in deep learning, a subfield of machine learning. Deep learning, a branch of computer learning that is inspired by how the human brain works, is like a human brain implanted in a machine. It is a collection of neural network algorithms made to look and learn like way the human brain does. It takes its cues from how the human brain works. In this session, we'll look at how a simple neural network works and how it self-optimizes.

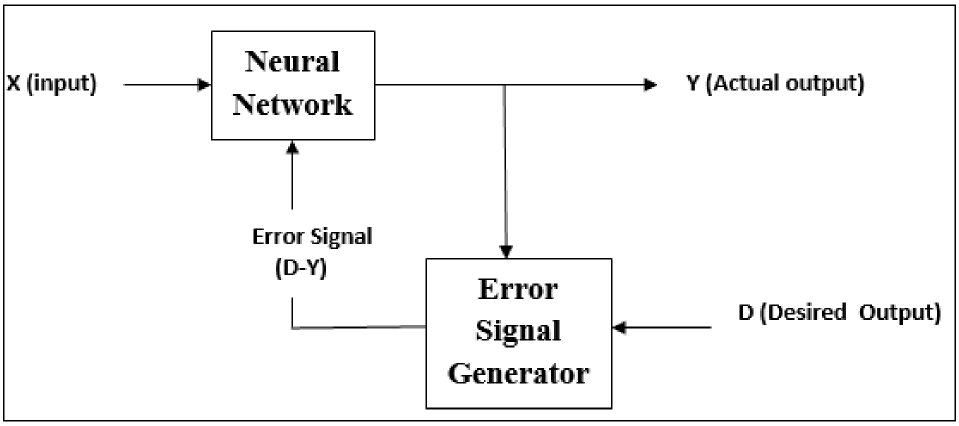
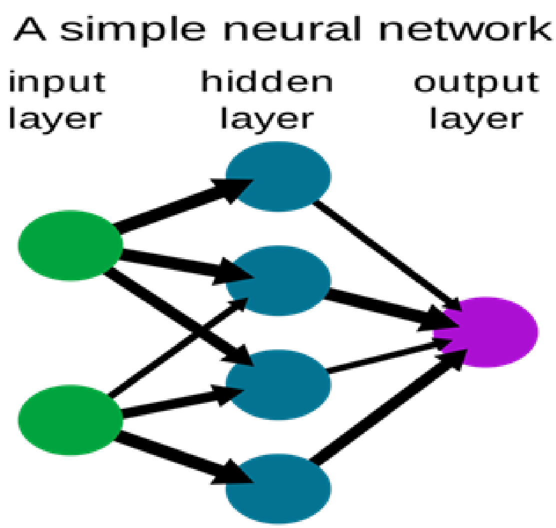


Fig 3. Block diagram of Artificial neural network.



1. **Input layer** - These neurons represent traits or variables in problem-solving in this layer.
2. **The output layer**- Is made up of neurons that represent the outcome of the computation in the cell body.
3. **Weight**- Refers to the strength of a neuron's connection.
4. **Activation function** – This is a function that determines the output based on the problem to be addressed.
5. **A learning function**-, Also known as an optimization function, is used to update Weights in order to get the lowest possible Error.
6. **Hidden layer** - This is an optional layer that is determined by the ANN design.

This model argued that there is no dynamic physics method that employs reactive power equilibrium to calculate voltage fluctuations and those voltage variations are produced by reactive power disequilibrium. a model for power recovery Power restoration after a load disruption has a substantial impact on voltage stability. That model is an input/output model since it is based on the properties of dynamic loads that have roughly single-order resumed power when step voltage is interrupted.

Perceptron and Multi-Layer Perceptron:
All of the mathematical computations are carried out in a single layer in the straightforward

neural network design known as a perceptron.

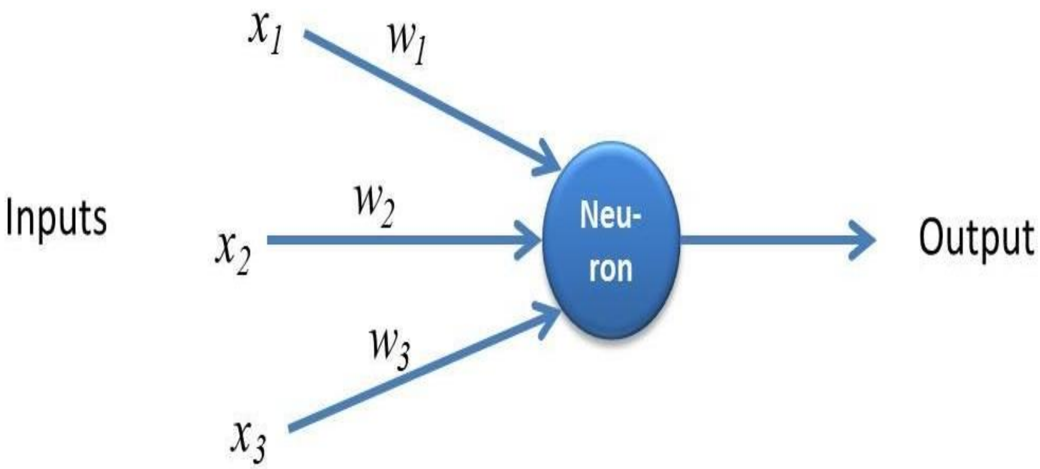


Fig 4.Multi –layer Perceptron

Contrarily, a multilayer perceptron, commonly referred to as an artificial neural network, is made up of various perceptions that are combined to form the network's multiple layers.

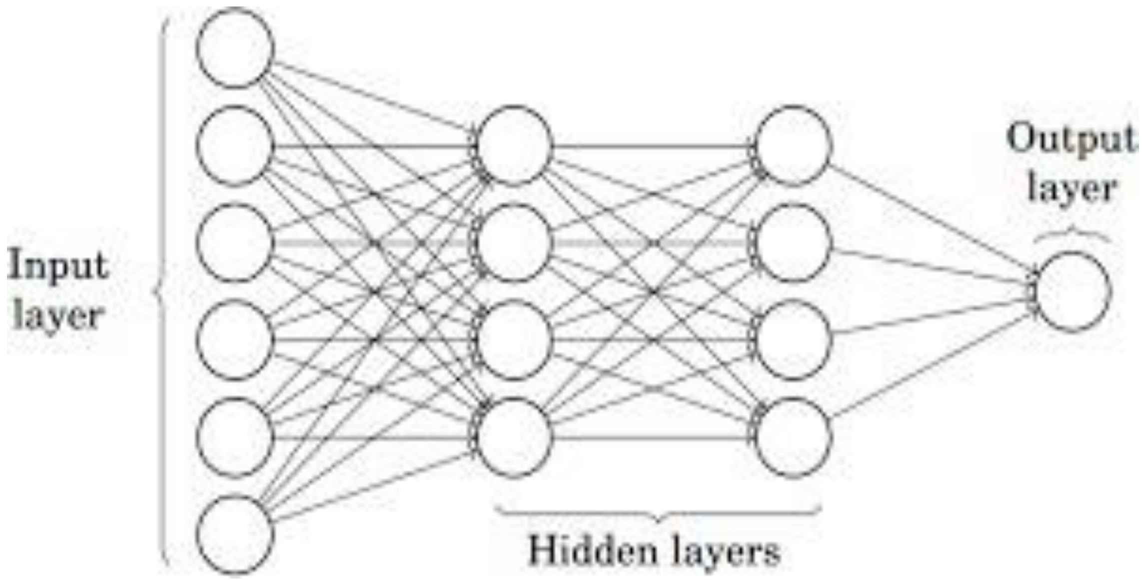


Fig 5.Neural Networks

In the above image, The Artificial Neural Network consists of four layers interconnected with each other:

- An input layer, with 6 input nodes
- Hidden Layer 1, with 4 hidden nodes/4 perceptrons
- Hidden layer 2, with 4 hidden nodes
- Output layer with 1 output node

Step by Step Working of the Artificial Neural Network:

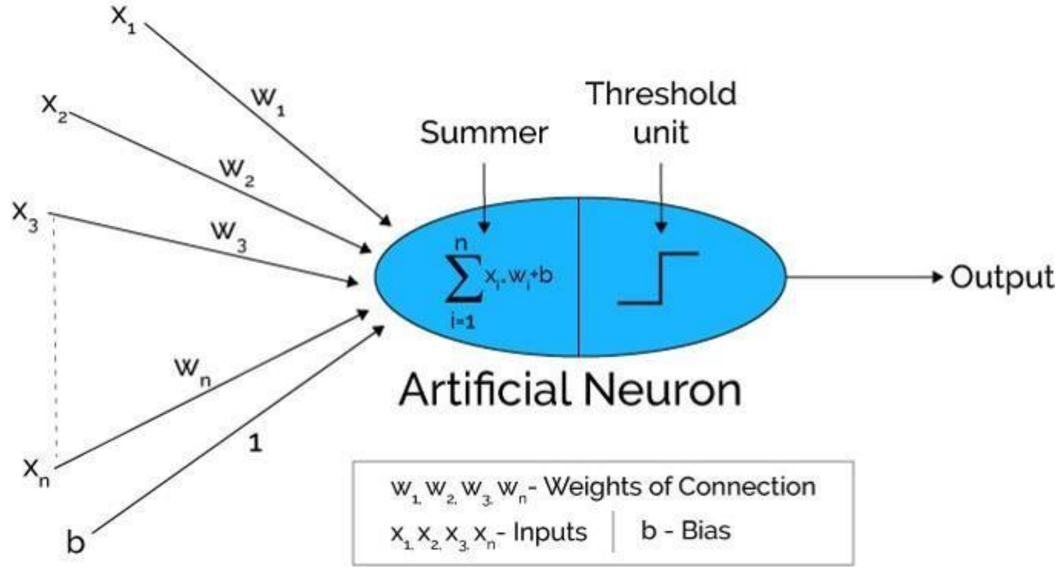


Fig 6.Matmatical model of artificial neural network

1. Input units are passed in the first stage. Data is given to the hidden layer with some weights applied, for example. There can be countless hidden layers. Inputs x1, x2, x3, ...xn are passed in the image above.
2. Neurons make up each concealed layer. Each neuron is wired to receive all inputs.
3. All calculation is done in the hidden layer after passing on the inputs (Blue oval in the picture)

Computation performed in hidden layers are done in two steps which are as follows :

• All of the inputs are first multiplied by their respective weights. The gradient or coefficient of each variable is called weight. It demonstrates the potency of the specific input. A bias variable is included after the weights have been assigned. The presence of bias ensures thatthe model fits the data as accurately as feasible.

Z1 = W1*In1 + W2*In2 + W3*In3 + W4*In4 + W5*In5 + b

W1, W2, W3, W4, W5 are the weights assigned to the inputs In1, In2, In3, In4, In5, and b is the bias.

• The linear equation Z1 is then subjected to the activation function in the subsequent phase. Before the input is passed on to the next layer of neurons, it undergoes a nonlinear alteration called the activation function. The activation function's role in the model is to introduce nonlinearity.

There are several activation functions that will be listed in the next section.

1. Each hidden layer goes through the entire procedure outlined in point 3. We proceed to the final layer, our output layer, which provides us with the ultimate output, after passing through each concealed layer.

The process explained above is known as forwarding Propagation.

The error, or the difference between the actual and expected output, is calculated after receiving the predictions from the output layer.

Transmission line parameters*:*

When the output and input voltages diverge, the system will experience sensor feedback and continue to be stable. While references offer details on the specific input line voltages, transmission line parameters provide anomalies of the transmission line parameters to train neural networks. This technology, which was created utilising machine learning techniques, is very useful because it increases the system's adaptability and efficiency without requiring human interaction. This system is built before hardware implementation to confirm the system's capabilities using a neural network, which shortens implementation time and provides extra advantages to enhance process performance.

Conclusion

By contrasting various methods, we design a system that leverages machine learning and gives improved performance and voltage stability while also resolving the issues stated in this research paper in our proposed system. Studying this with MATLAB simulation is one of the most efficient approaches and one that yields an efficient outcome. The main benefit of the system is that, before installing the hardware, you may build a mathematical model and obtain the output parameters.

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