**DECLARATION**

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name: Mohammed S. Bahaaelden

Signature:

Date:

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# A special thanks to my brother Mohammed Kmail. Without forgetting my best friend Mohammed Jamal and Ahmed Faiz.

**ABSTRACT**

Preserving the power system at a secure position is considered the foundation stone in the power system operating to ensure the arrival of electricity to the customers with high quality and without interruptions. Due to the associated obstacles with conventional methods in the static security assessment, the Artificial Neural Networks (ANNs) will be utilized to overcome these problems and to prevent the status of the power system from sliding into more dangerous situations which is leading to the collapse of parts or the whole system. In addition, the usage of this technique will help the system’s operator for detecting the vulnerable areas at that system. The essential objective of this research is to examine the reliability by utilizing artificial neural network in the Static Security Assessment (SSA) to identify the power system's operating states (Normal, Alarm, Emergency and Extreme Emergency states). Therefore, Back propagation neural network is carried out on the IEEE-9 bus test system. The utilized data will be gathered by Newton-Raphson power flow simulation using Power World Simulator’s program for various system topologies over a domain of load grades to form the utilized data in the artificial neural network. The error between the actual outcomes of Newton-Raphson technique (actual line flows and bus voltages) and estimated results of feed forward back propagation neural network (estimated line flows and bus voltages) is obtained to be utilized in terms of accuracy. The percentage of classification accuracy to determine the status of IEEE 9 bus system and the vulnerable areas by feed forward back propagation neural network is 90.51852 %. The average time required by artificial neural network to predict the power system's operating states is 0.013 seconds while the average time required by Newton-Raphson technique is 0.0627 seconds. As a result of that, Artificial Neural Network proves the ability to determine the vulnerable areas and to assess the static security by supplying the current power system's operating status with high speed in IEEE 9 bus system.

Keywords: Artificial Neural Networks, Static Security Assessment, Newton-Raphson power flow, Back propagation neural network, Feed Forward Back Propagation Neural Network, Percentage Classification Accuracy.

**ÖZET**

Güç sistemlerinin güvenli çalıştırılması elektrik arz güvenliğinin sağlanması, kesintisiz elektrik enerjisi iletimi ve dağıtımı için önem arzetmektedir. Bu çalışmada, Statik güç güvenliği değerlendirilmesinde geleneksel yöntemlerin yanında Yapay Sinir Ağları (ANN) kullanılarak arz güvenliği açısından karşılaşılabilecek sorunlar ve elektrik güç sisteminin kararsız bir noktaya uaşarak çökme noktasına gelmesini engelleyecek sonuçlara ulaşılmıştır. Bu sistem güç sistemi control operatörünün sistem açısından tehlike arzedebilecek yüklenmeleri önceden farkederek müdahale edebilmesine yardım etmektedir. Tezin ana teması yapay sinir ağları kullanarak Statik Güvenlik Değerlendirilmesi (Static Security Assessment(SSA)) güvenilirliğini incelemektir, bu noktada sistem çalışma durumları olarak Normal, Alarm, Açil ve Çok Acil kullanılacaktır. Bu amaçla Power World Simulator programı aracılığı ile IEEE-9 bus sistemi tasarlanarak Newton-Raphson güç akış methoduyla veriler elde edildikten sonra Yapay Sinir Ağları yöntemiyle analiz edilmiştir. Bu yönemle güç güvenliği açısından tehlike arzeden bölgelerin tespit edilmesi açısından elde edilen doğruluk 90.51852 % ve çalışma durumlarının tespiti için gereken zaman 0.013 saniyedir. Newton-Raphson yöntemi ile ise 0.0627 saniyedir. Bu sistemle daha hızlı bir tespit yapılmıştır.

Anahter kelimeler: Yapay Sinir Ağları,Statik Güvenlik Belirlemesi, Newton-Raphson güç akışı, Back propagationYapay Sinir Ağları, Feed Forward Back Propagation Yapay Sinir Ağları, Yüzdelik Sınıflandırma Doğruluğu.

**DEDICTION**

*My parents: Thank you for your unconditional support with my studies I am honoured to have you as my parents. Thank you for given me a chance to prove and improve myself through all my walks of life. Please do not ever change. I love you*

*My family: thank you for believing in me: for allowing me to further my studies. Please do not ever doubt my dedication and love for you*

*My spirit: who has always encouraged me and give me hope and strength to continue forward and increasing my patience and pregnant in all difficulties*

*My brothers and sisters: hoping that with this research I have proven to you that these is no mountain higher as long as God is on our side. Hoping that you will walk again and be able to fulfill your dreams.*

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**LIST OF SYMBOLS**

|  |  |
| --- | --- |
| X1, X2… Xm: | Inputs of the neuron. |
| W1, W2…Wm: | Weights of the neurons. |
| b: | Bias |
| V: | Summation of these inputs, weights and bias |
| F: | The Activation Function |
| Y(x): | Sigmoid transfer function |
| i: | The input layer. |
| h: | The hidden layer. |
| j: | The output layer |
| Ii: | Input of the Input – Layer. |
| Oi: | Output of the Input – Layer. |
| Ih: | Input of the Hidden – Layer. |
| Oh: | Output of Hidden – Layer. |
| Ij: | Input of the Output – Layer. |
| Oj: | Output of Output – Layer. |
| F’(Ij): | Function for Input of the Output – Layer. |
| Tj: | Target at the out layer |
| ∆j: | The error signal at the output layer. |
| η: | The learning step size. |
| α: | Momentum factor. |
| ∆h: | The error signal at the hidden layer. |
| | VK |: | Voltage magnitude at bus k. |
| SK: | Apparent power at bus k. |
| PGK: | Real power of generator at bus k. |
| Ybus: | Bus-Admittance matrix. |
| θ: | Phase angle of Ybus. |
| J: | Jacobian matrix |
| QGK: | Reactive power of generator at bus k. |
| P Losses: | Real losses in the transmission lines. |
| Q Losses: | Reactive losses in the transmission lines. |
| PD: | Real power of load demand. |
| QD: | Reactive power of load demand |
| N: | Total number of buses. |
| δ: | Phase angle of the voltage. |
| R: | Series resistance of transmission line. |
| X: | Series reactance of transmission line. |
| I: | Current in the transmission line. |

**LIST OF ABBREVIATIONS**

|  |  |
| --- | --- |
| ANN: | Artificial Neural Network. |
| ADALINE: | Adaptive Linear Neuron. |
| AC: | Alternating Current. |
| AS: | Alert State. |
| AVR: | Automatic Voltage Regulator |
| B: | Shunt charging susceptance |
| BPNN: | Back Propagation Neural Network |
| C: | Shunt capacitance. |
| DC: | Direct Current. |
| ES: | Emergency State. |
| EES: | Extreme Emergency State. |
| G: | Shunt conductance |
| G-S: | Gauss-Seidel method. |
| IEEE: | Institute of Electrical and Electronics Engineers |
| KCL: | Kirchhoff’s current low. |
| LMS: | Least Mean Square error. |
| MW: | Megawatt |
| MVAR: | Mega volt ampere reactive. |
| MADALINE: | Multilayer ADALINE |
| MLP: | Multi-Layer Perceptron |
| MSE: | Mean Square Error. |
| N-R: | Newton-Raphson method |
| NS: | Normal State. |
| P: | Real power. |
| P.U. : | Per-unit |
| PR: | Pattern Recognition. |
| Q: | Reactive power. |
| R: | Resistance. |
| S: | Apparent power |
| SLP: | Single Layer Perceptron. |
| SVM: | The Multi-class Support Vector Machine |
| SSA: | Static Security Assessment. |
| X: | Reactance |
| Z: | The series impedance. |