NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 6, ISSUE 10, Oct. -2020

ANALYSIS OF ELECTRICAL SYSTEM USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT:

Electricity is undergoing unprecedented change. Recently, the use of artificial intelligence has become more and more important in all fields. In this paper, the determination of the voltage and voltage deviation angles in each bus when the active and reactive power loads on five busbars are given is solved using the Newton – Raphson and Artificial Neural Network methods. Also, the results obtained by the Artificial Neural Network method were compared with the Newton – Raphson method.

KEYWORDS: Artificial Neural Network, neuron, input, intermediate and output neurons, dendrites, synapses, computing network, voltage, voltage deflection angle.

INTRODUCTION:

It is known that the human brain and nervous system are made up of many nerve cells - neurons, which are interconnected by nerve fibers. Nerve fibers are used to exchange information, receive signals from receptors, and transmit control impulses to effectors. The nervous system and brain are made up of more than 100 billion nerve cells.

Every action, thought, and emotion is carried out in a living organism as a neuronal transition of a special electrochemical substance called a neurotransmitter. Neurons have an unusual structure that is different from other cells in our body. The body of the neuron makes up the largest mass of the entire neuron. It contains a cell nucleus that contains genetic information. From the body of the neuron there are dendrites, the longest of which is called the axon (Fig. 1).

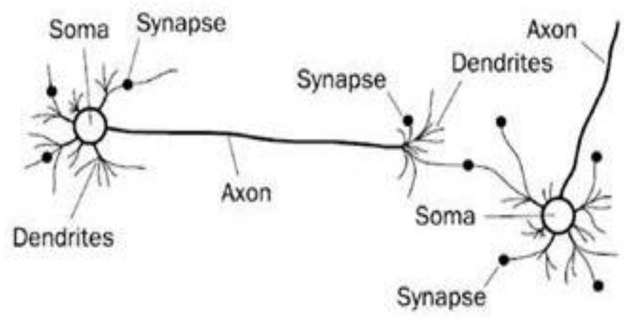

Figure1. Biological Neural Network

Nerve cells and their tumors are covered by a protective membrane that electrifies neurons called myelin sheaths. The axon communicates with the dendrites of other neurons through specific compounds that amplify and correct nerve signals called synapses.

Thus, our brain is a kind of "computing network" that constantly (even when we are asleep) processes information.[1]

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Neural networks are a computerized form of neurons in the human brain, each of which is made up of neurons that are connected to each other and process information. The layer of neurons that receive external information is called input neurons, and the neurons that produce ready-made results are called output neurons. Interstitial neurons are called internal or latent neurons. Each neuron has multiple inputs and only one output. The advantage of ANNs is that they can be trained, which means that the error of the output signals can be deliberately reduced to a minimum value. [2]
An artificial ANN model will be developed, trained and tested. (Figure 2).

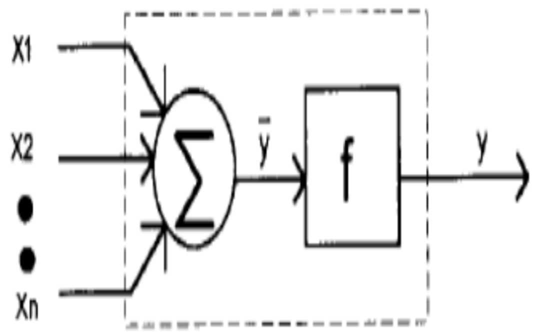


Figure 2. Artificial Neural Network.

ANALYSIS OF THE ELECTRICAL SYSTEM USING THE NEWTON-RAPHSON METHOD:

To analyze the electrical system, we select the following system. The system should be equipped with five busbars, a power plant and an unlimited power supply. (Fig. 3)

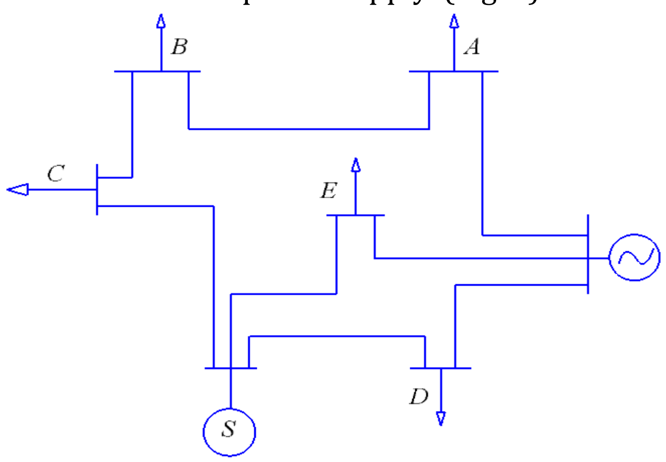


Figure 3. Selected electrical system.

Table 1. Busbar Loading Values

	Busbar A	Busbar B	Busbar C	Busbar D	Busbar E
P_1(MVt)	52	70	79	76	68
P_2(MVt)	50	68	67	74	66
P_3(MVt)	48	66	65	72	64
P_4(MVt)	66	62	59	68	60
P_5(MVt)	63	79	87	85	76
Q_1(MVAr)	25,18472	33,90255	35,99335	41,02045	28,96789
Q_2(MVAr)	24,21608	32,93391	30,52601	39,94096	28,1159
Q_3(MVAr)	23,24744	31,96527	29,61479	38,86147	27,2639
Q_4(MVAr)	31,96523	30,02798	26,88113	36,7025	25,55991
Q_5(MVAr)	30,51228	38,26143	39,63831	45,87814	32,37587

Table 2. Power line brand parameters.

Power line	U_n (kV)	Power line brand	The length of the power line (km)	R_0	X_0	B_0*10^{-4}
G – B	220	AC-400	30	0.075	0.42	0.027
B – A	220	AC-240	42	0.121	0.435	0.026
A – C	220	AC-240	31	0.121	0.435	0.026
C – System	220	AC-240	35	0.121	0.435	0.026
G – E	220	AC-300	45	0.096	0.429	0.0264
E – System	220	AC-240	46	0.121	0.435	0.026
G – D	220	AC-300	55	0.096	0.429	0.0264
D – System	220	AC-240	43	0.121	0.435	0.026

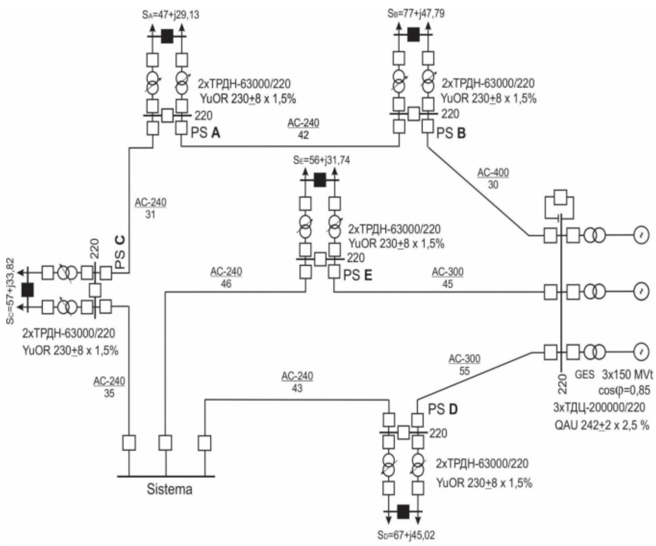


Figure 4. Schematic diagram of the selected electrical system.

Given several values of the load on five tires, we find the absolute value of the voltage in each bus and the values of the voltage deviation angle (Table 3) using the Newton – Raphson method in the DIgSILENT PowerFactory program used in electrical system analysis and compare with the results obtained using the ANN method. (Figure 4)

In the DigSILENT PowerFactory program, using the Newton – Raphson method, we can find the stresses and strain angles in the tires when the load values on the tires (Table 1). (Table 3)

(Table 3)

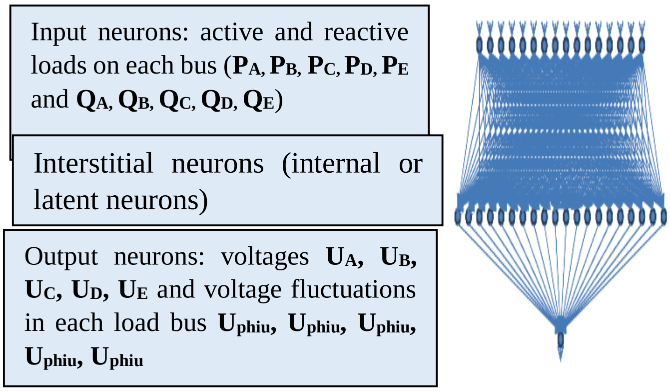
	Busbar A	Busbar B	Busbar C	Busbar D	Busbar E
U_1(kV)	6,133828	5,930085	5,881859	6,018489	6,084519
U_2(kV)	6,151551	5,951327	5,909349	6,027073	6,092985
U_3(kV)	6,173292	5,972878	5,92486	6,040765	6,105939
U_4(kV)	6,129817	5,961082	5,92337	6,038003	6,10136
U_5(kV)	6,079519	5,879147	5,846624	5,986465	6,055647
U_{1phiu}(grad)	1,484291	-0,8926295	-1,657673	0,1138167	0,621181
U_{2phiu}(grad)	1,667045	-0,6632786	-1,286867	0,2119523	0,7245269
U_{3phiu} (grad)	1,908016	-0,4125734	-1,094695	0,3736177	0,8920599
U_{4phiu}(grad)	1,337883	-0,5388077	-1,091214	0,3423419	0,8485606
U_{5phiu}(grad)	0,8800856	-1,478829	-2,082702	-0,258953	0,2580654

ANALYSIS OF ELECTRICAL SYSTEMS USING THE ARTIFICIAL NEURAL NETWORK METHOD:

ANN is currently used to solve many problems in the power system of a power plant. Power can be used to accurately forecast loads, determine electrical system parameters, monitor power plants, and analyze short circuits and system stability [3].

In the analysis of voltages and voltage deviations in each load bus in the electrical system selected using the ANN method (Figure 3), the MATLAB program provides external data, ie the previous 50 active reagents and loads on each bus in the circuit given to us (**P_A, P_B, P_C, P_D, P_E** and **Q_A, Q_B, Q_C, Q_D, Q_E**). These layer of receptor neurons are called input neurons. Intermediate neurons are then trained and examined in internal or latent neurons. Hidden neurons have multiple inputs and only one output. [4] Eventually the voltages on each loading bus **U_A, U_B, U_C, U_D, U_E** and the voltage deviation **U_{phiu}, U_{phiu}, U_{phiu}, U_{phiu}, U_{phiu}** i.e. ready results are formed. These neurons are called outgoing neurons.

The following figure illustrates the process of working in ANN in MATLAB.



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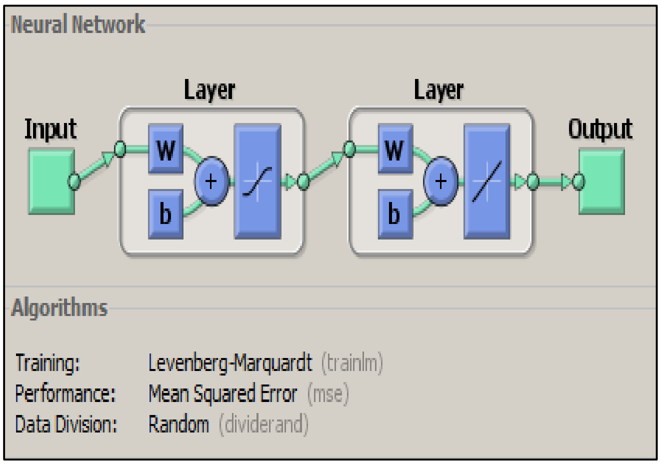

Figure 5. a) Artificial Neural Network Scheme; b) Artificial Neural Network Scheme in MATLAB

Incoming data in the ANN, that is, the load on the bus, is variable. Not all parameters of the EULs in the circuit remain the same. ANN has 10 incoming neurons (**P_A, P_B, P_C, P_D, P_E** and **Q_A, Q_B, Q_C, Q_D, Q_E**), 17 latent neurons and 10 outputs (**U_A, U_B, U_C, U_D, U_E** and **U_{phiu}, U_{phiu}, U_{phiu}, U_{phiu}, U_{phiu}**).

50 active and reactive powers were used in the formation of ANN. 70% of the data included in the ANN in the formation of the output values were used in the training process, and 30% were used for the verification process. The training was completed in 94 iterations. (Figure 6)

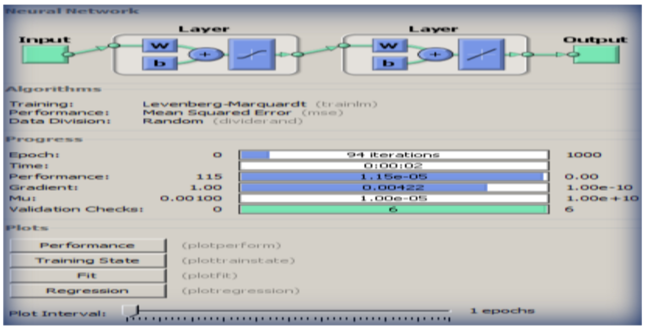

Figure 6. The teaching process at ANN

We compare the results of the ANN with the Newton – Raphson method. Table 4 shows the difference between the two methods.

Table 4. When there are 17 latent neurons, the results are in percent.

Busbar 1	Newton - Raphson		Artificial Neural Network		Difference	
	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)
P_1,Q_1	6,133828	1,484291	6,134	1,484	0,002804043	0,01960532
P_1,Q_1	6,151551	1,667045	6,152	1,667	0,00729844	0,002699387
P_1,Q_1	6,173292	1,908016	6,162	1,908	0,183252191	0.000838574
P_1,Q_1	6,129817	1,337883	6,13	1,338	0,002985318	0,008745159
P_1,Q_1	6,079519	0,8800856	6,08	0,8802	0,007911184	0,012998736
Busbar 2	Newton - Raphson		Artificial Neural Network		Difference	
	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)
P_2,Q_2	5,930085	-0,8926295	5,93	-0,8927	0,00143339	0,007898014
P_2,Q_2	5,951327	-0,6632786	5,951	-0,6631	0,005494875	0,026926845
P_2,Q_2	5,972878	-0,4125734	5,962	-0,4175	0,182455552	1,491602339
P_2,Q_2	5,961082	-0,5388077	5,961	-0,539	0,001375608	0,035689913
P_2,Q_2	5,879147	-1,478829	5,879	-1,479	0,002500425	0,011563203
Busbar 3	Newton - Raphson		Artificial Neural Network		Difference	
	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)
P_3,Q_3	5,881859	-1,657673	5,882	-1,658	0,002397144	0,019726448
P_3,Q_3	5,909349	-1,286867	5,909	-1,287	0,005906245	0,010335178
P_3,Q_3	5,92486	-1,094695	5,917	-1,091	0,132837587	0.338680110
P_3,Q_3	5,92337	-1,091214	5,923	-1,091	0,006246834	0,019611185
P_3,Q_3	5,846624	-2,082702	5,847	-2,083	0,006430648	0,014308336
Busbar 4	Newton - Raphson		Artificial Neural Network		Difference	
	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)
P_4,Q_4	6,018489	0,1138167	6,018	0,1139	0,008125623	0,073187854
P_4,Q_4	6,027073	0,2119523	6,027	0,2123	0,001211216	0,164046344
P_4,Q_4	6,040765	0,3736177	6,034	0,3733	0,112114683	0.085105813
P_4,Q_4	6,038003	0,3423419	6,038	0,3423	4,96853E-05	0,012239226
P_4,Q_4	5,986465	-0,2589536	5,986	-0,259	0,007768126	0,017918268
Busbar 5	Newton - Raphson		Artificial Neural Network		Difference	
	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)	Voltage (kV)	Angle (grad)
P_5,Q_5	6,084519	0,621181	6,084	0,6208	0,008530572	0,06133478
P_5,Q_5	6,092985	0,7245269	6,093	0,7243	0,000246184	0,031316988
P_5,Q_5	6,105939	0,8920599	6,099	0,898	0,11377275	0.661481069
P_5,Q_5	6,10136	0,8485606	6,101	0,8481	0,005900672	0,054280154
P_5,Q_5	6,055647	0,2580654	6,056	0,2583	0,00582893	0,090907189

CONCLUSION:

The main problem in analyzing the power flow in an electrical system is that many parameters need to be analyzed in a short period of time. To overcome this problem, one of the methods of power flow analysis in many modern electrical systems is ANN.

The paper provides a comprehensive analysis of power flow in a five-bus system. Performed by the first classical method, the Newton-Raphson method. The artificial neuron was then performed in a network. The solutions for comparison can be seen in Table 4. The statistics of the proposed method solutions satisfy the error limits of the approach to classical method solutions. Comparisons show that the artificial neural network method can be used to analyze power flow problems in electrical systems.

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