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SIMULATION OF THE WIND GENERATOR. STUDY WIND SPEED CONTOUR

Summary. Today, there are several ways to find and maintain the maximum power value. This may be as already built-in controllers on the search engine power value (or MPPT controllers), as well as separate intelligent systems (with phase-logic or neural networks). An example of using a neural network for finding a point of maximum power in a power supply system with a renewable energy source (wind generator) is considered in this paper. Neuronal network is two-layer (the first layer is a sigmoid (in which four neurons), and the second is a linear function (two neurons). In order to find out the weights and coefficients of the function, the neural network was investigated. It was trained on models whose results were known in advance. A further trained neuron network is small in dealing with different tasks, during which time she constantly retrained. This happened as long as the results did not fall within the tolerable limits of error deviation. The construction of the neural network was performed in the Matlab program.

Keywords: wind generator, Matlab, maximum power point, neural network, recovery signal source, smart grid, voltage ampere characteristic.

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МОДЕЛЮВАННЯ ВІТРОГЕНЕРАТОРА. ВИВЧЕННЯ КОНТУРУ ШВИДКОСТІ

Анотація. В осатаній час на зміну центральному електроживленню приходить розподілена генерація. В її основі закладена невеликого, за потужністю, виробника енергії, як правило це відновлювальні джерела енергії (або ВДЕ). Такими джерелами є, як вже нам широко відомі вітрогенератори та сонячні панелі так й мало відомі пристрої, що працюють на водні. Проте системи в яких є такі джерела не є стабільними, бо залежать від зовнішніх факторів. Сьогодні існує декілька способів знайти та підтримувати максимальне значення потужності в електричних системах з ВДЕ. Це можуть бути вже вбудовані контролери на потужність пошукової системи (або MPPT контролери), а також окремі інтелектуальні системи (з фазовологічними або нейронними мережами). У даній статті було розглянуто приклад використання нейронної мережі для знаходження точки максимальної потужності в системі електропостачання з джерелом відновлюваної енергії (вітрогенератора). Нейронна мережа є двошаровою (перший шар – сигмоїдний (у якому знаходяться чотири нейрона), а другий – лінійна функція (там знаходяться два нейрона). Для виявлення ваг та коефіцієнтів функції досліджено нейронну мережу. Вона навчалася за моделям, результати яких були відомі заздалегідь. Ще одна навчена мережа нейронів мала при вирішенні різних завдань, протягом яких вона постійно перенавчалася. Це відбувалося до тих пір, поки результати не потрапляли в допустимі межі відхилення помилок. Побудова нейронної мережі виконувалася в програмі Matlab. Моделювання та перевірка працездатності, розробленої схеми, відбувалася також у цьому програмному пакеті. Отже повною метою даної статті є розробка моделі вітрогенератора, вибір структури та розробка системи управління, що має структуру управління потужністю в автономній системі електроживлення для забезпечення її максимальної ефективності.

Ключові слова: вітрогенератор, Matlab, максимальна точка потужності, нейронна мережа, джерело енергії, Smart Grid, характеристика напруг.

The aim of the work is to develop a model of a wind generator, select a structure and develop a control system that would have a power control structure in an autonomous power supply system in order to ensure its maximum efficiency.

Wind generator is a device for converting the kinetic energy of the wind flow into mechanical energy by rotating the rotor, followed by its conversion into electrical energy. Wind generators can be divided into three categories: industrial, commercial and domestic. As a rule, they are combined in a network, the result is a wind power plant. Its main difference from the traditional – the complete absence of both raw materials and waste.

Most modern wind turbines have a relatively low efficiency (up to 25-32%) and high production costs. Also, the use of wind turbines nature imposes certain restrictions. It all depends on the average wind speed in the region. It is known that the initial speed of rotation of wind turbines is 2 m/s. At maximum efficiency, the wind speed should be from 10 to 14 m /s. Already starting from a wind speed of 4,5-5 m/s the installation of a wind generator is considered appropriate.

At the moment, asynchronous and synchronous generators of various designs are used in wind turbines. Asynchronous generator: with short-circuited rotor or dual power supply; synchronous generator with winding or permanent magnets. Wave power plants are considered to be a potentially profitable source of electricity and are developing more rapidly every year.

The use of any of the above generators has its advantages and disadvantages.

To successfully create a simulation of the wind turbine operation, it is necessary to fulfill the conditions (or idealized conditions):

– the wind turbine has no mechanical or aerodynamic losses and has an infinite number of blades;

– air is incompressible and friction-free;

– the flow before and behind the wind wheel is laminar (or without vortices), the current lines are parallel to each other and perpendicular to the surface of the wind wheel. This involves the use of a wind wheel, which takes away the flow of energy without changing the ideal flow pattern.

If we **consider the study of the problem** state, then it can be noted that the world wind power industry is today a completely independent industry with the highest annual energy growth rates in the energy sector, which exceed 30% [1]. Wind power makes a significant contribution to solving the most important scientific and practical tasks: improving the human condition, preserving the environment and rationally integrating the industrial world into the environment.

By the end of 2017, the capacity of the global wind energy industry reached 540 GW, of which more than 57 GW were installed in 2017 alone [2]. From this we can say that the installed capacity of the wind energy industry is increasing annually [3]. The annual electricity production of all wind turbines installed in the world in the middle of 2013 amounted to 5% of the world's electricity consumption. Wind power has covered 100 countries and regions of the world.

In particular, according to the report of the Global Wind Energy Council, it is noted that the sharp decline in prices in both the mainland and offshore wind energy continues to be surprising. So in the markets of countries such as Morocco, India, Canada, prices fluctuate around 0.03$ per kWh, and recently at a Mexican tender, prices fell below 0.02$ per kWh. In offshore wind energy, the first facilities will be built without subsidies in Germany and the Netherlands – almost 2 GW.

By the end of 2022, according to the GWEC report, about 840 GW of the installed capacity of global wind power is predicted. That is, in five years, the indicator should grow by more than 1.5 times.

In recent years, the concept of intelligent unified energy system (Smart Grid) has been developing rapidly. The concepts of such a system represent the idea of future power systems, in which the transmission and distribution electrical network is used for two-way communications between power stations, consumers and the control center. This is done in order to optimize the processes of electrical supply and electricity consumption, to improve their efficiency.

One of the disadvantages of wind is its unpredictability – it can often change direction or calm even in the most windy areas. To compensate for the volatility of the wind, they construct huge "wind farms". Dozens and sometimes hundreds of such turbines are installed together in the most windy places. Such "farms" exist in the USA, in France, in England, but they occupy a lot of space.

The concept of "Smart" system is based on the principles of compatibility and implementation with the Internet Protocol. The smart grid concept has the following objectives:

– providing the consumer with the possibility of automated control and use, minimizing the cost of electricity;

– self-repair of systems in the event of an accident, the use of high-quality energy resources, including renewable;

– improving the quality of electricity, reliability of supply;

As noted in the beginning, the main thing in the work to use a neural network to find a point that is equal to the maximum power.

Figure 1 shows the speed contour implemented in the Matlab/Simulink package (General view).

It is worth Recalling once again how to solve any surrender for the help of artificial intelligence in stages:

1) formation of the problem and prediction of practical experiments;

2) description of the object;

3) analysis of the appropriateness of using NI for the set purposes;

4) development of a model that includes a neural network;

5) the choice of neural network architecture that would meet the goals;

Great role in robotic neural engineering. Functions of the asset in the way of normalization in the native danikh. This means that, first of all, the number of people who have gone through activation will be normal for warming. In this robotic activity, the following task will be undertaken:

$$y=\frac{1}{1+e^{-c\cdot S}}$$

During the training of the network, as in other networks (for example, with the reverse error propagation), a direct passage is applied to the network's input. For each step of the time, an error is calculated, as in the network with a back propagation error. The change in weight ratios is calculated for each neuron of the network and then formed. Sets of weights of all network links must be the same.

The basis of NM was laid multilayer perceptron. In order to build a BP, it is necessary to select its parameters. To study, you need to select the value of the weights and thresholds of training.

The complete neural network is as follows (Figure 3).

The formula that describes the neuron:

$$u_i(k) = \sum_{j=1}^{N} x_j(k) \cdot w_{ij}(k) + b$$

$$y_i(k) = f(\sum_{j=1}^{N} x_j(k) \cdot w_{ij}(k) + b_i)$$

The type of neural network in this work is a multi-layer neural network. In a recurrent network, neurons are involved repeatedly in the processing of each input information, which allows you to use some of the dynamic properties of the neural network. Through the use of feedback, the volume of the neural network is reduced.

This network is a fully connected neural network with a symmetric matrix of bonds. When receiving output, each node is an input, in the learning process it becomes hidden, and then becomes an output. The network learns as follows: the values of the neurons are set to the desired pattern, after which the scales are calculated that do not change in the future. Once the network has learned one or more templates, it will always be up to one of them. Each neuron has its own activation threshold, which depends on the temperature at which the neuron takes one of two values -1 or 1, sometimes 0 or 1.

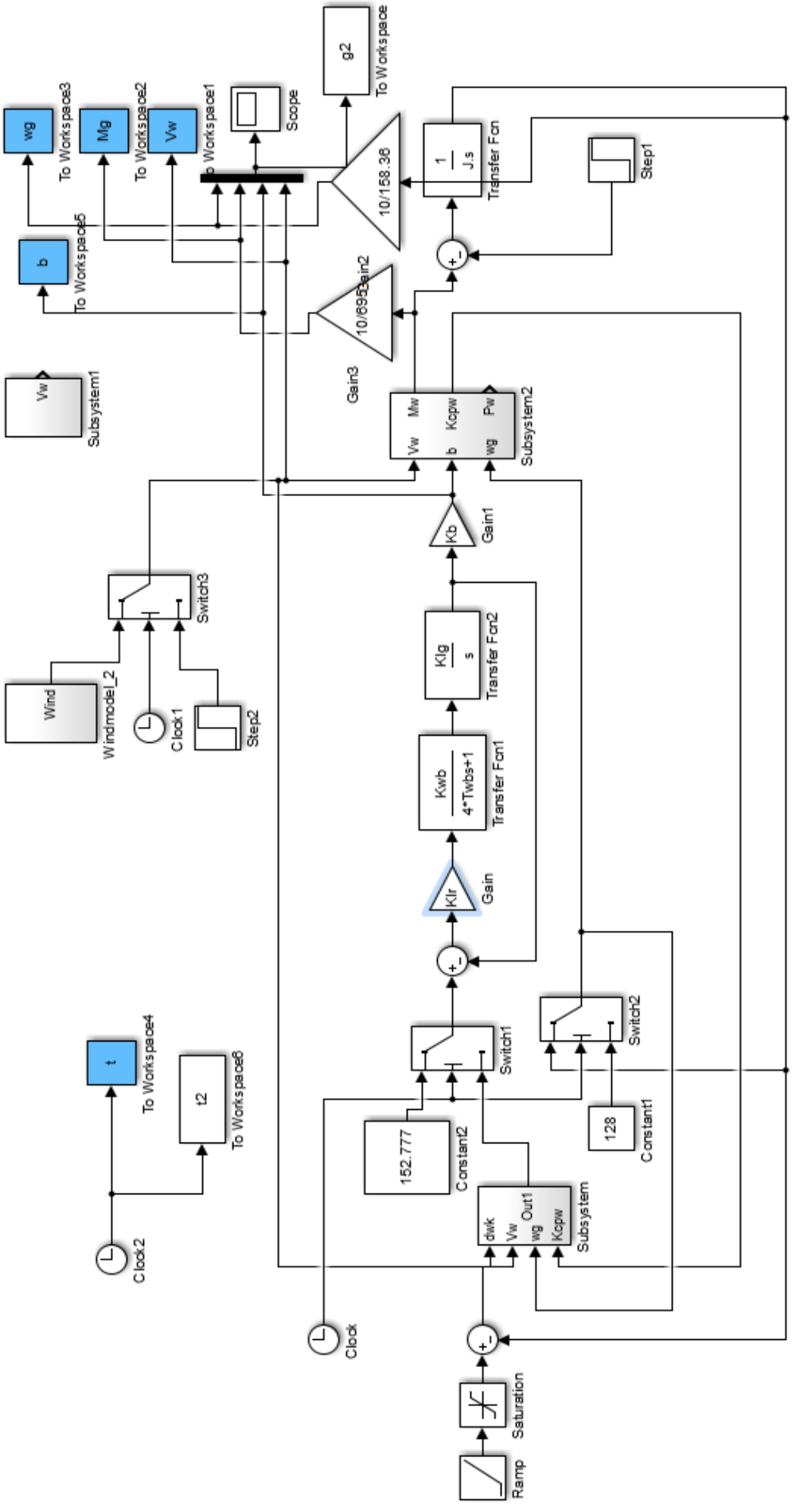

Figure 1. Speed loop implemented in Matlab/Simulink program

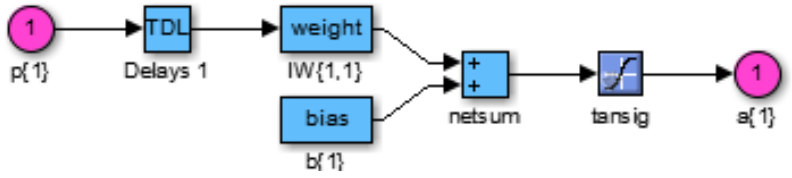

Figure 2. Image of a part of the neural network

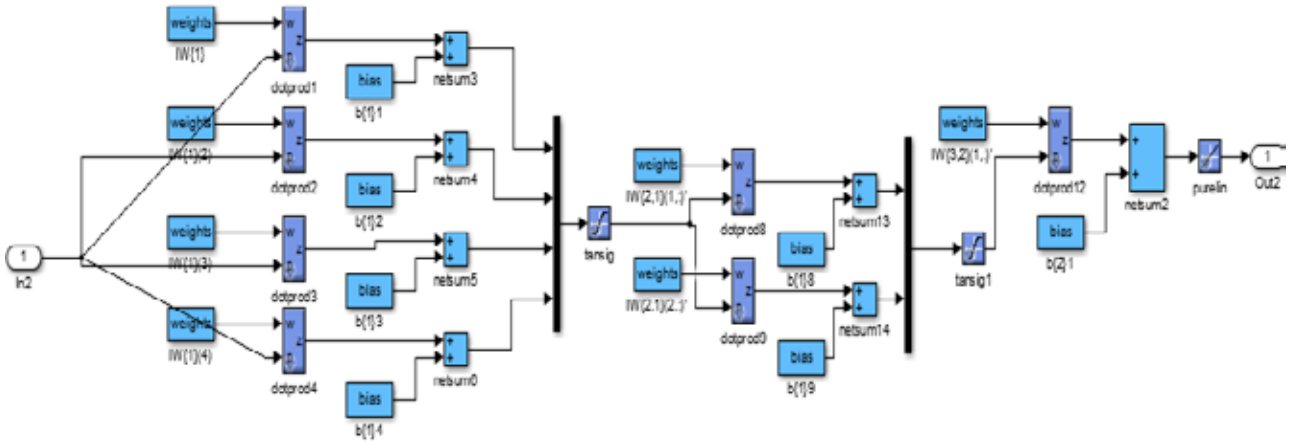

Figure 3. Neural Network

It's also worth telling about Elman's network. Firstly, it will still be in work, and secondly, it is very interesting because it is able to predict events that are important for systems with REE. This network is also referred to as recurrent, it is based on multilayer perceptron with the introduction of feedback, but they are not coming from the network, but from the inputs of internal neurons.

This allows you to take into account previous observations. Basically, these networks are used in systems that control moving objects, because there is a repetition of sequences, but they should also be used in RE systems, since the input values are also subject to certain laws that have the property to repeat.

During the training of the recurrent network with the reverse distribution of errors on the network input, a direct pass is performed. For each step of the time, an error is calculated, as in the network with a back propagation error. The change in weight ratios is calculated for each neuron of the network and then formed. Sets of weights of all network links must be the same.

Also, the work of the system was simulated, which searches for the maximum power. To do this, the input was given a different value of wind speed Figure 4.

Timing diagram of the robot model figure 5.

Consequence. In this work the circuit of management of consumers of energy of the wind generator on the basis of a neural network is collected. Experiments were conducted with a system with different wind speeds at the entrance. A neural network was developed and modeled in the work in order to find the maximum value of the mechanical power of the wind turbine wheel. Further, the wind generator drive worked with this value.

It is possible to draw a general conclusion that a system was created in the work that allows selection of the maximum power, with measured external parameters.

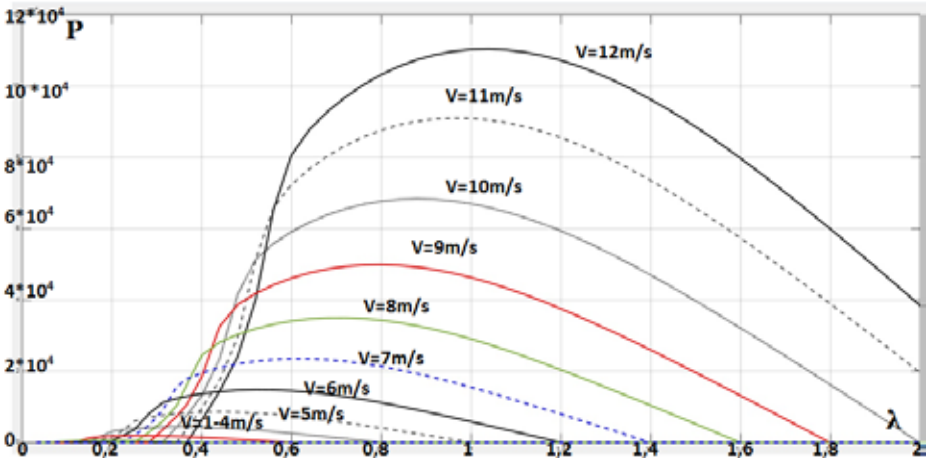

Figure 4. Characteristics of the maximum power of the wind turbine

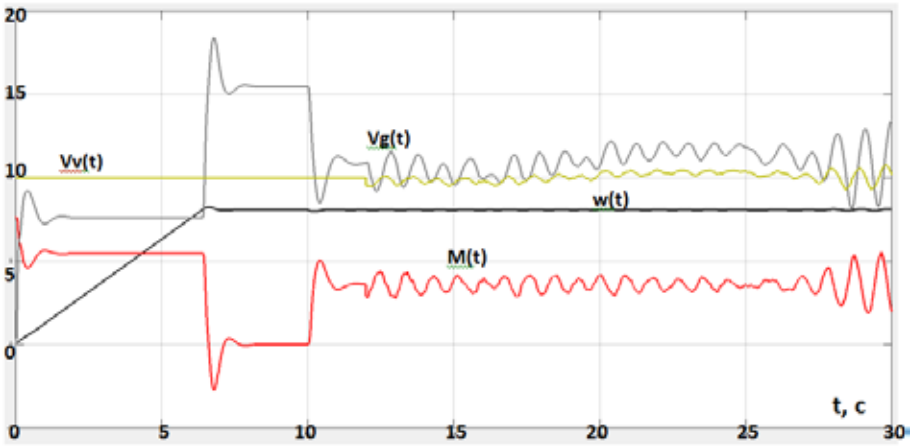

Figure 5. Timing diagram M(t),w(t),Vv(t),Vg(t)

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