Design of Automatic Switch System of Residential Load From Solar Cell and Power Plant Resources using Neural Network

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Abstract. Residential loads are electronic equipment that is often used at home. Residential loads are supplied from two sources, they are solar panel and the State Power plant. Selecting the supply load source, so an automatic switch system is needed from the load. Optimizing residential load resources and avoiding overloading, load balancing techniques are needed. The switch system uses a relay, determined by the solar panel power output. This research discusses the design of automatic load switch systems for residential loads from solar panels and State Power plant using Artificial Neural Networks (ANN). ANN control system that is arranged using ANN Backpropagation consists of 4 inputs, four hidden layers, each consisting of 4 neurons and one neuron in the output layer. In this research, to determine the network that has been formed to provide changes of load. The results of testing that the parameters used to get the smallest error rate in the process of setting an automatic power load switch is best to use a number of repetitions of 2000 times with an error percentage 5.3%. Artificial Neural Networks can experience convergent failure or not close to output because the initial guess is not good. Initial experiments with actual solar panel data with as many as 98 data produced non-convergent output values. The solution to improving the initial experiment is to simplify learning data 40 data produces convergent output.

1. Introduction
The requirement for electrical energy is a major need for all people in the world. Fossil energy fuels are getting thinner so that continuous electricity is needed. Therefore, many efforts were made to create alternative power plants to support the increasing need for electricity supply. Indonesia is a tropical country that has high solar energy strength with radiation per day with an average of 4.8 kWh/m2/day [1]. This power can be used as an environmentally friendly renewable energy source, one of which is by utilizing solar panel energy [2]. Solar panels are semiconductor materials that convert solar energy into electricity[3].

Solar panels used as an alternative energy source can be applied to household loads. Household expenses are electronic equipment that is often used at home [4]. Reduce dependence on electricity sources from the power plant of electricity supply continuous. One way to burden residential load can choose between two sources of electricity namely from solar panels and power plant. The selection of these two sources required a system of automatic residential load switches [5]. This system as a regulator of the electrical load power supply, so that the switch of electrical energy supply to the load can work automatically by prioritizing solar panel energy. Increasing the use of household loads and optimizing resources and avoiding overloading, the solution to these load problems is to load balancing techniques. With a switch system using a relay [6], determined by the solar panel power output.

Research that has been done there is a load power switch with a relay using a PLC [7]. The design of this research is based on the implementation of household load switches from the solar panel and
power plant sources that will produce alternative energy optimally. Based on this research, this study designed a load power automatic switch equipped with a relay as a household load automatic switch from a solar panel source and power plant using an Artificial Neural Network.

Automatic switches function to control the two-source electricity system between solar panel electricity and power plant [8]. The load is supplied from one source at a time. The automatic switch works automatically by detecting the availability of solar panel sources, if the electrical energy of the solar panel can supply the load, the power plant switch will be off and the load is only supplied by the solar panel electrical energy. The opposite condition, if the solar panel electricity cannot supply the household load, the power plant switch will be on and the load will only be supplied by power plant electricity.

Artificial Neural Networks are simulations of the human brain that have the ability to learn [9]. In the learning process consists of an input layer and the output layer is inserted into the artificial neural network, then the network will be studied to provide acceptable answers. Artificial Neural Networks have the main characteristic that is the ability to learn. Learning in artificial neural networks can be interpreted as an adjustment process according to the interconnect weighting parameters possessed by the cell [10]. The learning process will stop if the error value is considered to be small enough for all pairs of learning data. The network that is doing the learning process is called in the training phase[11].

2. Experimental Design

The design of this system is divided into three parts, namely the system block diagram design, hardware design and software design. Block diagrams are used to design systems in general, hardware design includes the design of electronic systems, while software design uses Python programming as a programming language for Arduino Uno microcontrollers for reading switches to displaying data. The input current and load voltage to do an automatic switch process with the output of an electric energy source changing AC current. The working principle of this system is a residential load with different power capacities connected to an automatic switch to regulate the electrical load to determine the source of electricity used by first determining the source of electricity for solar panels and power plant in accordance with the required characteristics and specifications.

In this hardware design explains the automatic switch system using technology with Artificial Neural Network Algorithm needed hardware to perform system tasks easily such as solar panels, batteries, inverters, microcontrollers, relays, current and voltage sensors and panel boxes. The device used to store electricity from solar panels is a battery. The device for charging batteries is to use the solar charge controller. The device to convert DC current to AC is an inverter [12]. The voltage sensor is used to detect voltage while the current sensor is used to detect current. The microcontroller used is Arduino Uno. The load used is a household load or AC [13].

In general, the duration of solar radiation for 6 hours is 70%. Then the solar panel power received is 469 Wh. Total power consumption a day needs to be added by 20% to be used for three-load devices namely fans, rice cookers and lamps. Other than solar panels, namely inverters as converters of DC to AC currents because in general household appliances use AC currents, and charge controllers to cover current to the battery if the voltage is over the battery and stop taking current from the battery if the battery is empty.

This software architecture and interface describe the software to be realized. The software used is python software for learning the Artificial Neural Network algorithm before it is converted into Language C. Arduino Uno Programming is used to be realized into automatic switches. First, the system will read the voltage and current on the solar panel, then calculate the total power available on the solar panel. Also carried out measurements of the current at the load to calculate the load power where the power is the current times the voltage 220V. Based on the results of the calculation of the power on the solar panels and the load then read the relay to turn on or not on each load and determine which load should be turned off. The load will adjust the power supply of the solar panel. When the voltage of the solar panel drops, the source switches to the power plant. If the panel has increased current and voltage is sufficient, the load will be returned to the solar panel supply. Figure 1 is the design of the system block diagram.
3. Result and Discussion

Current sensor calibration, the purpose of calibration of the current sensor is to see the accuracy of the output of the sensor so that when using an error does not occur. At the calibration of the current sensor is done comparing the output current of the power supply with the current sensor reading. This research uses three voltage sensors ACS712 current sensor separately. The current sensor calibration step has 3 main pins namely Vcc, GND and Vout. Vcc and GND pins are connected to Vcc and GND pins on Arduino Uno. While the Vout pin from the sensor is connected to pin A0 on Arduino Uno. The results of calibration of current sensor 1 have an average error of 1.38% while current sensor 2 has an average error of 1.25% and for current sensor 3 has an average error of 1.32%. The calibration results can be concluded that the current sensor has a high accuracy so that it can be used in testing.

Voltage sensor calibration, the purpose of the voltage sensor calibration is to see the accuracy of the output of the sensor so that when using an error does not occur. The voltage sensor has an average error of 2.0%. The data contained a large coma difference in the value of the reading of the voltage sensor with the calculated value. This happens because the ZMPT101B voltage sensor has a sensitivity of 100mV / A so the sensor cannot detect voltages below 1V properly. The results of the calibration, the voltage sensor has an average error of 01.00%. because the sensor has an error rate below 5%, it is suitable for use in testing.

Testing Phase, artificial neural network algorithm have a problem that can experience convergent failure or not close to the output. As a result, the number of iterations will produce less than expected or far-reaching output. Other things, the amount of data is too much, not more detailed. So, if there is too much data but the details lack artificial neural networks confuse because each calculation per line produces a difference that is always large. weight correction does not produce output close to the expected output. A large amount of data makes the experiment more complex, while a large amount of details helps the accuracy process.

At this stage, the data input matrix is sized 10 x 4, where the row is the amount of data while the column consists of solar panel power, load 1, load 2, load 3. So the total learning data is 10 x 4 = 40 pieces of data as training data and the output is the switch closure for each load. This data is then read by the python program to do the training process where at this stage a test is made which is the number of repetitions of training 2000 times. The results of this training are compared with test data. In solar panel power, the voltage ranges from 10-14V with a current of 35A so the solar panel power ranges from 350-460 watts.

Table 1. Simplification of the Amount of Data

| Solar Panel Power (Watt) | Load 1 | Load 2 | Load 3 | Load Index |
|-------------------------|--------|--------|--------|------------|
| 350                     | 350    | 40     | 25     | 1          |
| 385                     | 350    | 40     | 25     | 1          |
| 420                     | 350    | 40     | 25     | 0          |
So, be closer to the convergent results. First, the load and power of the solar panels are made into an index group, the panel power has an index of 1 or 2, meaning that 1 solar panel power is weak and 2 strong solar panel power. Load power has an index of 1.2 or 3 meaning 1 small load power, 2 medium load power and 3 high load power. Output index ranges from 0, 1, 2 and 3, when the learning index is normalized to 0, 0.333, 0.6667, 1. It means that if 0, then nothing is turned off, if 0.33 means load 1 dies, if 0.6667 means load 2 is dead, and if 1 means load 3 is dead.

To anticipate the range that experiences differences, if the output of the neural network algorithm is below 0.1 then the load index = 0, meaning that all load relays are on. If the index is between 0.1 and 0.3 then load 1 is dead, if the index is between 0.3 and 0.7 then load 2 is dead and if the index is above 0.7 then load 3 is dead. The results of this training show that the final synaptic range at 1000 repetitions is at an average of 0.406 while at 2000 iterations at an average of 0.404 and at a repetition of 3000 times at an average of 0.405. by multiplying the normalization value the accuracy results are as follows:

Table 2. Results of Error and Accuracy Percentage

| Iteration            | Error (%) | Accuracy (%) |
|----------------------|-----------|--------------|
| Iteration 1000 times | 7         | 93           |
| Iteration 2000 times | 5.3       | 94.7         |
| Iteration 3000 times | 6.5       | 93.5         |

In Table 2. Accuracy results obtained with 2000 repetitions of data are good accuracy. At iteration 2000 times get accuracy is 94.7%. This can be caused by the nature of the artificial neural network process which if more and more repetitions will lead to many error values while on repetitions that are too small will result in more errors. So, artificial neural networks algorithm at iteration 2000 times is the best regulation automatic power load switches.

4. Conclusion

The parameter used to get the smallest error rate in the process of regulating automatic power load switches is best to use 2000 repetitions with an accuracy of 5.3%. Artificial Neural Networks can experience convergent failure or not close to the output because the initial guess is not good. Initial trial results with many but complex data artificial neural networks with solar panel power data and the actual load with a total of 98 data result in non-convergent output values. Results of experiments with solutions: Artificial neural network with solar panel power data which is simplified into an index with a total of 40 data learning data, producing convergent output.

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