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IMPROVING ENERGY EFFICIENCY THROUGH REDUCTION OF POWER CONSUMPTION IN BASE STATION OR A CELL SITE USING NEURO-FUZZY CONTROLLER

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ABSTRACT

The high power consumption in modules of a cell site has led to high bit error rate, congestion and high cost of power consumed. This has equally led to low network performance in base station. This is overcome by improving energy efficiency through reduction of power consumption in base station or a cell site using neuro-fuzzy controller. This is overcome in this manner, characterizing and determine the power consumption of the modules of the cell site under study, developing a simulink model for the cell site under study, designing a rule base that would monitor the power consumed by the cell site and reduced it if raised, training ANN in this rule base for effective monitoring of the power consumed by the cell site and reduced it if raised. Finally, design a SIMULINK model for improving energy efficiency through reduction of power consumption in base station or a cell site using neuro-fuzzy controller and validating and justifying the percentage of power consumption reduction of the modules of the cell site with and without incorporation of neuro-fuzzy. The results obtained are 532KW power consumed in the base station when neuro –fuzzy is not incorporated in the system and 514.9KW when neuro-fuzzy is incorporated in the system. With these results obtained, it shows that the percentage reduction of power consumed at the base station when neuro-fuzzy is imbibed in the system is 3.21%.

Keywords: *energy efficiency, reduction of power consumption, neuro- fuzzy controller*

Introduction

The issue of energy efficiency is one of the major challenges facing wireless cellular network providers around the world today. In Nigeria, some cellular network providers have been greatly affected, resulting in the closing down of sites due to the problem of energy efficiency. To handle this situation, which deals with Power consumption reduction in a base station, various approaches have been adopted that led to the introduction of green communication techniques.

Green Communication technique focuses on the Global warming due to increase in Carbon Dioxide (CO2) emission and escalating problem of energy efficiency that has resulted in a worldwide movement to research on the methods that can be used to reduce energy consumption and also fight against the effect of the steady increase of CO2 emission in the environments. Green communication is also the practice of selecting energy-efficient communications, networking technologies, products, and minimizing resource use whenever possible in all branches of communications. Notable projects on-going internationally for Long term evolution of 3Gs and 4Gs on green communication includes; European Union's FP7 projects Energy Aware Radio and Network Technologies (EARTH), Cognitive Radio and Cooperative Strategies for Power Saving (C2POWER), Mobile VCE Green Radio (M-VCE-GN), Green Touch (GT) and Green IT (G-IT) (Karmokar & Anpalagan, 2013).

Over the years, effective telecommunication is one of the vital tools used to measure the progress of a country in technological advancement. In our country Nigeria, it is a well-known fact that efficient and robust mobile communication has not been fully achieved since the advent of wireless communication in August 2001 (Communicator 2019, NCC). This is due to several factors militating against the set goal of efficient wireless mobile network in the country, like high energy consumption by numerous cellular networks and base stations deployed around the country, resulting in high energy cost to operators in telecommunication industry, which is worsen by poor power supply situation in Nigeria, hence the need to save cost through efficient energy management scheme.

Research Methodology

To characterize and determine the power consumption of the modules of the cell site under study.

A period of Twenty-Seven (27) days was used to monitor and carry out the measurements. The days include morning period (peak), afternoon (off peak) and evening/night (main Peak).

The readings are shown in tables C1to C27 of appendix C. The method used for data collection was repetitive method of measurement for twenty- seven (27) days at the cell site under study.

In each day, measurements were taken at a period of two (2) hours, with an interval of every fifteen (15) minutes for eight (8) times. At the end, an average for the eight (8) intervals was taken for each day for all equipment.

For instance, in day 1, the 2G BTS MTN with current of 25Amps as the average of eight (8) intervals for every fifteen minutes in the two hours period, has the following current readings of 25.4A; 24.6A; 25.8A; 24.3A; 25.6A; 24.4A; 24.7A; and 25.4A for the intervals. The average is;

$$Average = \frac{25.4 + 24.6 + 25.8 + 24.3 + 25.6 + 24.4 + 24.7 + 25.4}{8}$$

= 25.03Amps ≅ 25Amps

Sample of the measurement process for the 2G BTS MTN is in table C1 of Appendix C.

The measurements were first carried out in the BTS equipment cabin, it is the backbone of the cell site housing the transmitter and receiver modules. The BTS also is interconnected with equipment on the tower for transmission and hopping activities with other cell sites linked to the tower through the RF and microwave antennas.

At the end of the measurement taken, summary of Twenty-Seven (27) days were calculated using;

3.3 To determine the module to go on sleep mode and its power requirement

Power consumed = PCon = VAver x IT (Watt) (3.2)

Where **PCon** is the power consumed in (Watt)

VAver is the average voltage calculated from each day measurement (Volt).

IT is the average total current consumed by the equipment in the cell site (Amps).

Day 1 at 13:30HRS – 15:30HRS on 3rd October 2018.

Total current = IT = 109.8 Amps
Average Voltage = VAver = 52.5 Volts
Power consumed = PCon = IT x VAver = 109.8 x 52.5
= 5764.50 Watts

Day 2 at 11:00HRS – 13:00HRS on 4th October 2018.

Total current = IT = 102.4 Amps
Average Voltage = VAver = 50.7 Volts
Power consumed = PCon = IT x VAver = 102.4 x 50.7
= 5191.68 Watts

Day 3 at 15:00HRS – 17:00HRS on 5th October 2018.

Total current = IT = 110.8 Amps
Average Voltage = VAver = 52 Volts
Power consumed = PCon = IT x VAver = 110.8 x 52
= 5761.60 Watts

Day 4 at 10:00HRS – 12:00HRS on 6th October 2018.

Total current = IT = 94.9 Amps
Average Voltage = VAver = 52.8 Volts
Power consumed = PCon = IT x VAver = 94.9 x 52.8
= 5010.72 Watts

Day 5 at 14:00HRS – 16:00HRS on 9th October 2018.

Total current = IT = 105.6 Amps
Average Voltage = VAver = 51.3 Volts
Power consumed = PCon = IT x VAver = 105.6 x 51.3
= 5417.28 Watts

Day 6 at 10:30HRS – 12:30HRS on 11th October 2018.

Total current = IT = 98.5 Amps
Average Voltage = VAver = 52.3 Volts
Power consumed = PCon = IT x VAver = 98.5 x 52.3
= 5151.55 Watts

Day 7 at 16:00HRS – 18:00HRS on 12th October 2018.

Total current = IT = 107.9 Amps
Average Voltage = VAver = 52.9 Volts
Power consumed = PCon = IT x VAver = 107.9 x 52.9
= 5707.91 Watts

Total = 170098.78watts =170.09878kw = 170.1kw(approximation)
Number of hours for 27days = 27 x 2 = 54hours
KWH = 170.1 x 54 =9185.4KWH
#60 = 1KWH
9185.4KWH = # 9185.4 x 60 = #551124

The summary of these days are given in table C29 of appendix C. It can be seen that day12 power consumption was the highest at a period of 19:00hrs to 21:00hrs with 8634.96 Watts, while day4 was the lowest at a period of 10:00hrs to 12:00hrs with 5010.72 Watts.

This means that more users are usually in the network at peak period of 19:00hrs downward. The average of the two days (i.e. day 12 and day 4) is taken to show the expected power consumption of the cell site, which is;

$$\text{PAver (Two days)} = \frac{PCon\ (Day3) + PCon(Day\ 2)}{2} = \frac{8634.96+5010.72}{2} = \mathbf{6822.84Watts}$$

To calculate the power consumed;

Since #60 = kwh

1000watt = 1KW

5010.72Watts = 5010.72/1000 = 5.01072KW

KWH = 5.01072 x 2 = 10.02144KWH

The cost becomes = 10.02144 x 60 = #601.29

To develop a Simulink model for the cell site under study.

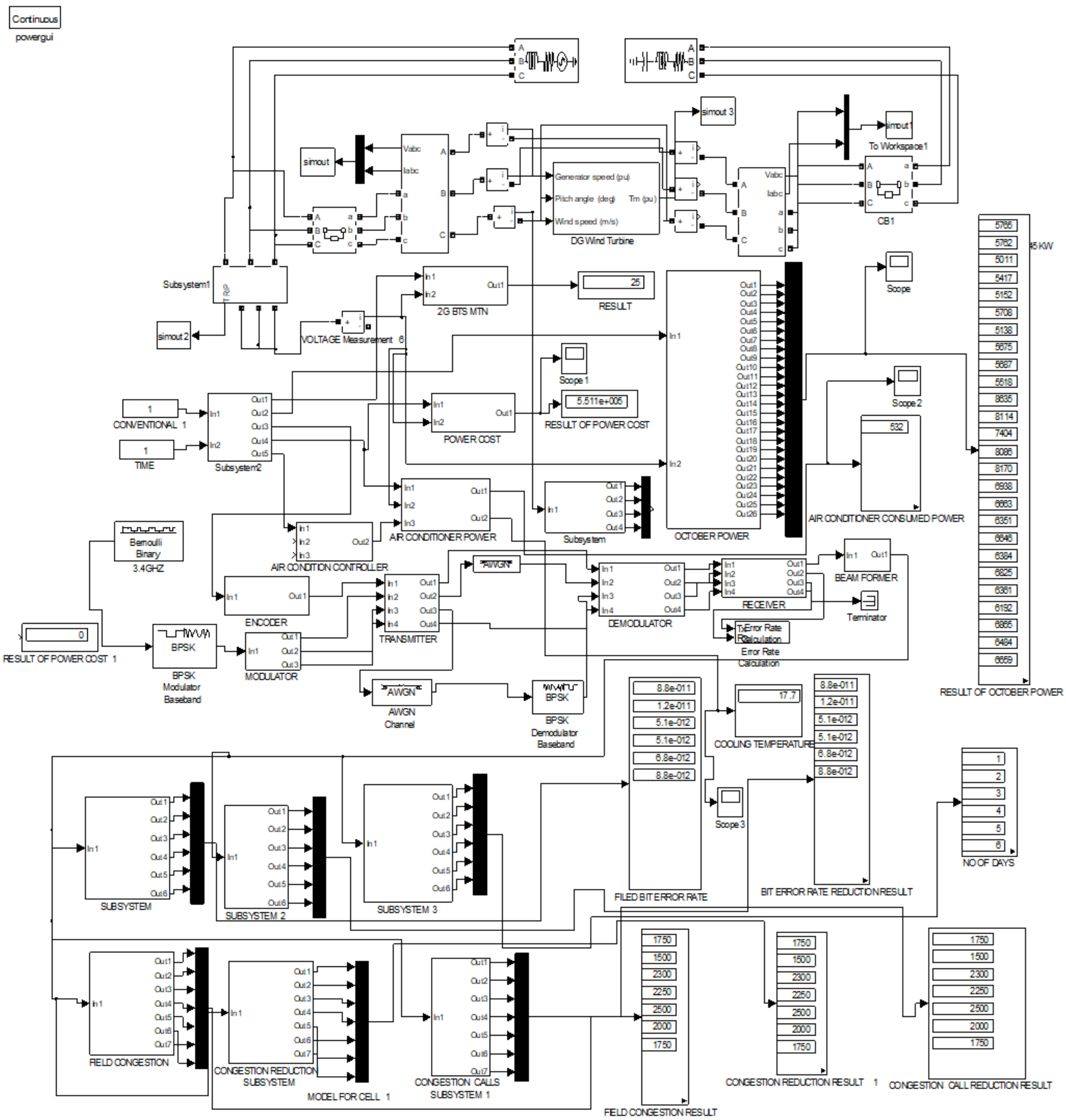

Fig 1 developed simulink model for the cell site under study

Fig 1 shows developed SIMULINK model for the cell site under study. The results obtained after simulation are shown in figures 6 and 7.

To design a rule base that would monitor the power consumed by the cell site and reduced it if raised.

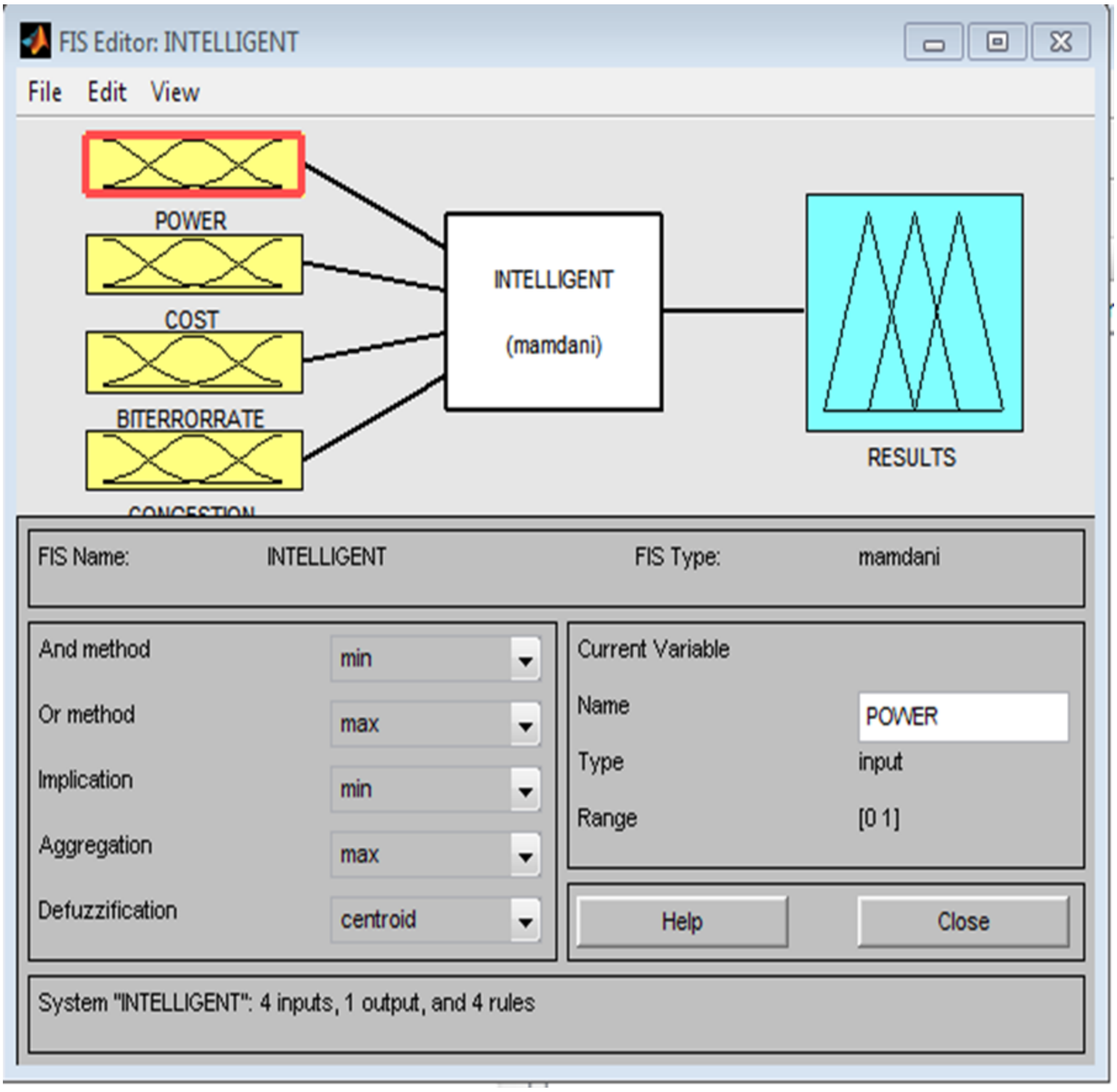

Fig 2 designed fuzzy inference system (FIS) that would monitor the power consumed by the cell site and reduced it if raised.

This has four inputs of power, cost, bit error rate and congestion. It also has an output of results.

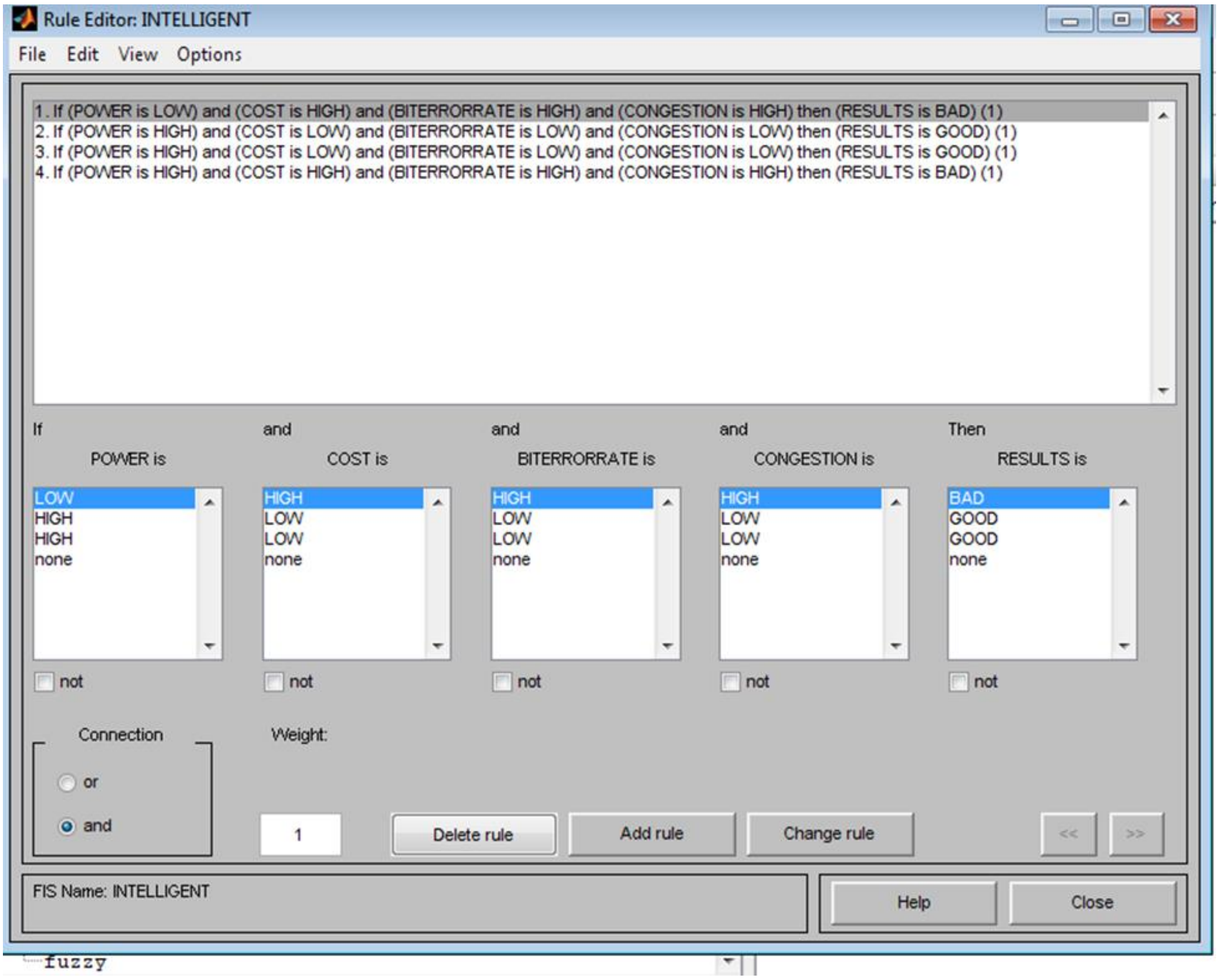

Fig 3 designed rule base that would monitor the power consumed by the cell site and reduced it if raised.

Fig 3 shows designed rule base that would monitor the power consumed by the cell site and reduced it if raised. This rules are four in number.

To train ANN in this rule base for effective monitoring of the power consumed by the cell site and reduced it if raised.

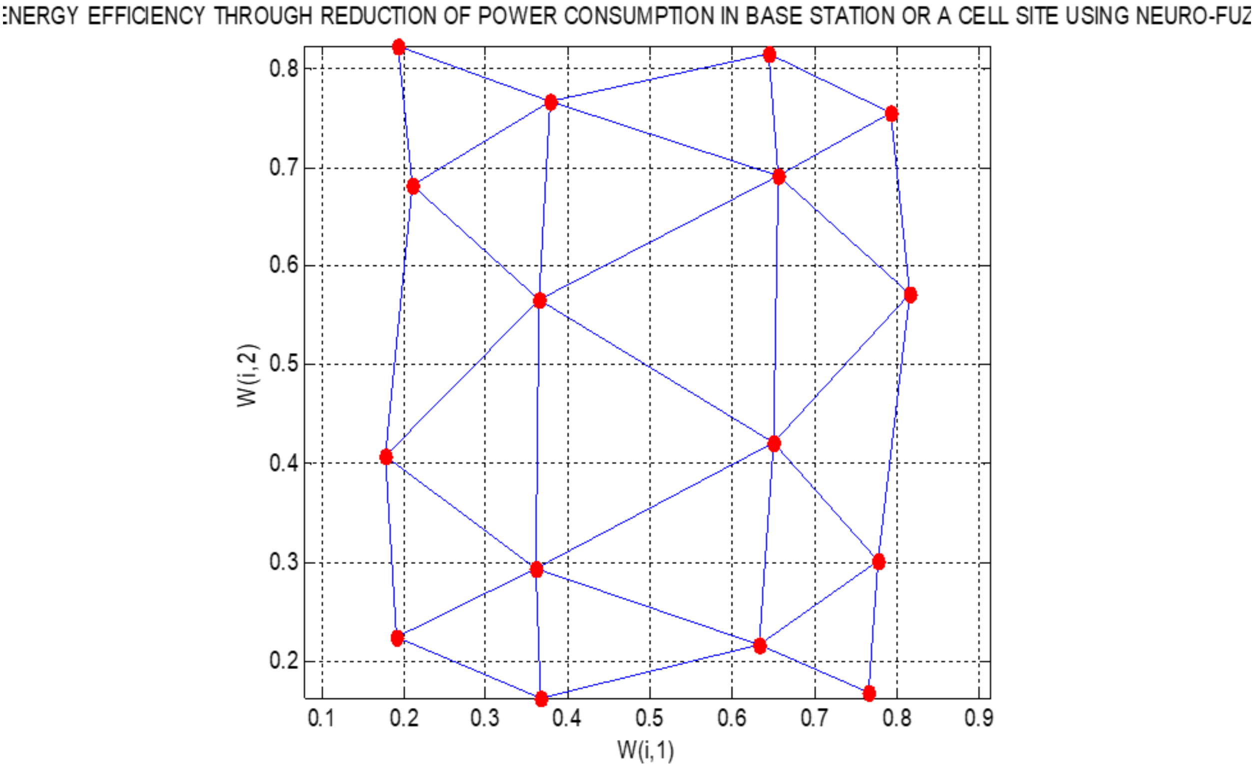

Fig 4 trained ANN in this rule base for effective monitoring of the power consumed by the cell site and reduced it if raised.

Fig 4 shows ANN trained four times in the four rules that is the reason it has sixteen neurons. This makes it to adapt to what it is instructed to do because it mimics human brain.

To design a SIMULINK model for improving energy efficiency through reduction of power consumption in base station or a cell site using neuro-fuzzy controller.

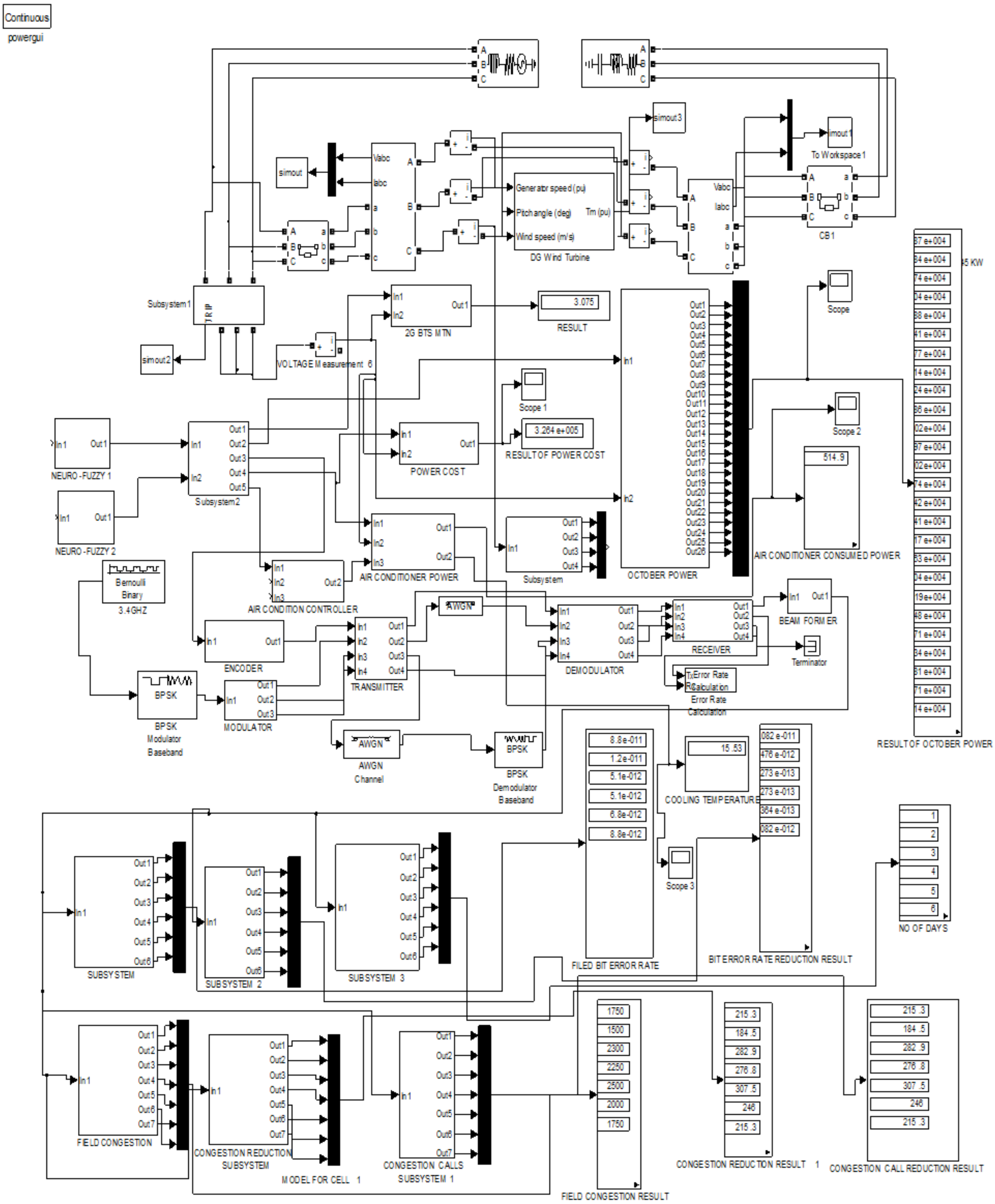

Fig 5 designed SIMULINK model for improving energy efficiency through reduction of power consumption in base station or a cell site using neuro-fuzzy controller.

The results obtained when fig 5 is simulated are shown in figures 6 and 7.

To validate and justify the percentage of power consumption reduction of the modules of the cell site with and without incorporation of neuro-fuzzy.

Conventional power consumed = 532Kw
Neuro – Fuzzy power consumed in the cell site = 514.9KW
% improvement in power reduction in the cell site =

$$\frac{\text{Conventional power} - \text{Neuro-fuzzy power}}{\text{Conventional power}} \times \frac{100\%}{1}$$

% improvement in power reduction in the cell site =

$$\frac{532Kw - 514.9KW}{532Kw} \times \frac{100\%}{1}$$

% improvement in power reduction in the cell site = 3.21%

Results

Table1 Comparing power consumed in the cell site without and with neuro-fuzzy controller

Time (s)	Conventional cell site power consumption (KW)	Neuro-fuzzy cell site power consumption (KW)
0	0	0
1	720	700
2	480	450
3	560	550
4	532	514.9
10	532	514.9

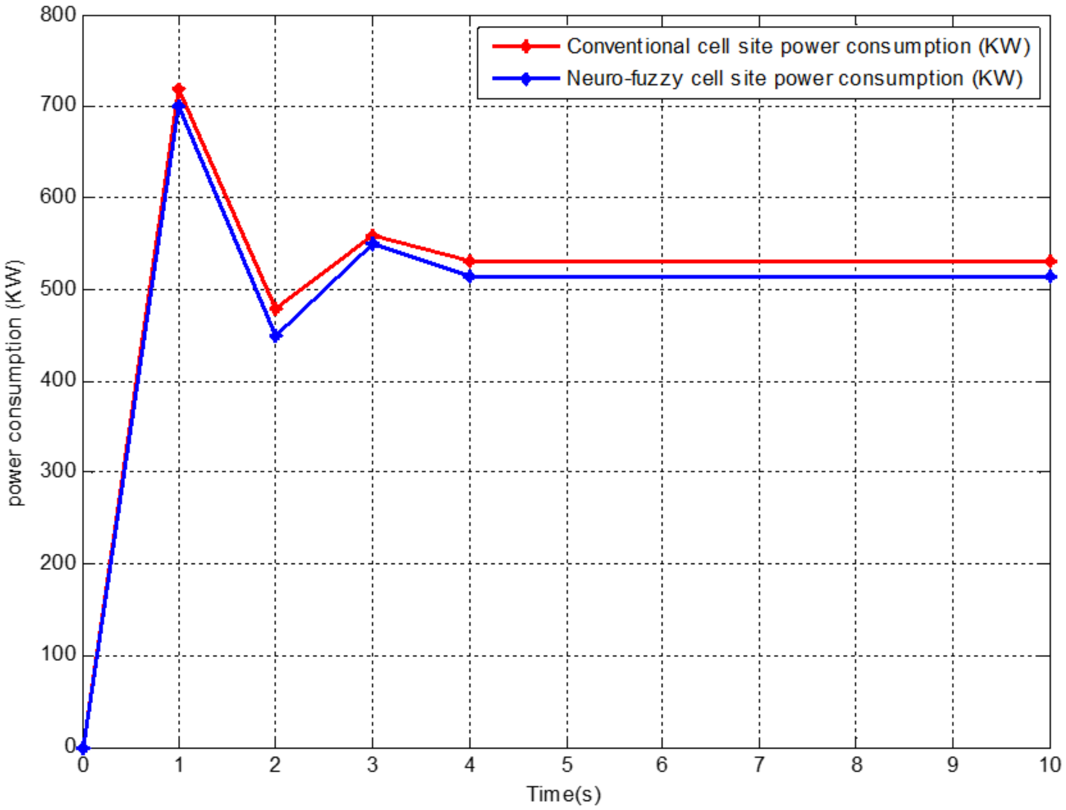

Fig 6 Comparing power consumed in the cell site without and with neuro-fuzzy controller

In fig 6 the power consumed in the cell site without introduction of neuro-fuzzy is 532Kw while that when neuro-fuzzy is introduced is 514.9KW. With these results, it shows that using neuro-fuzzy gives lower power consumption in the cell site than its conventional approach.

Table2 Comparing price of power consumed in the cell site without and with neuro-fuzzy controller

Time (s)	Conventional price of power consumption in a cell site (₦)	Neuro-fuzzy price of power consumption in a cell site (₦)
0	0	0
1	720000	440000
2	480000	280000
3	560000	380000
4	551100	326400
10	551100	326400

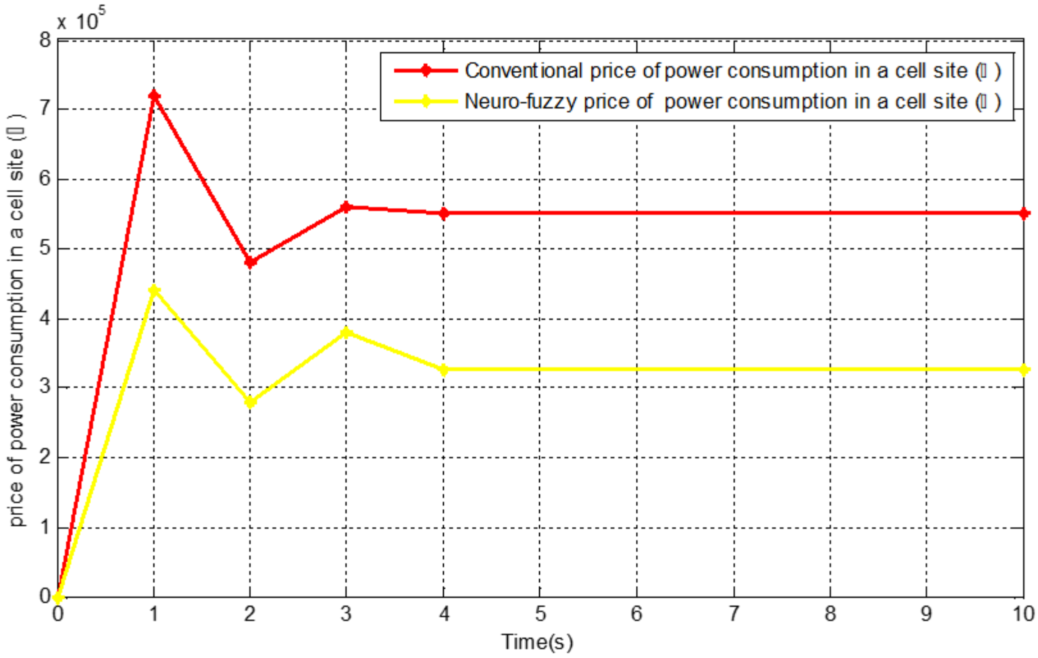

Fig 7 Comparing price of power consumed in the cell site without and with neuro-fuzzy controller

Fig 7 shows Comparing price of power consumed in the cell site without and with neuro-fuzzy controller. In fig 7 the cost of power consumed in the site without using neuro-fuzzy is stable at 4s through 10 s which is ₦551100 while that when neuro-fuzzy is introduced is ₦326400. With these results obtained, it shows that when neuro-fuzzy is incorporated gives lesser cost than its conventional approach.

To find percentage improvement when SSVC is incorporated in the system in Onuiyi
Conventional Onuiyi power loss = 6.24%
SSVC Onuiyi power loss = 5.226%
% improvement when SSVC is incorporated in the system in Onuiyi
6.24% - 5.22% = 1.02%
Results

Table 2 comparing the percentage improvement in power loss reduction at Township in NSUKKA 33kv distribution network without and with SSVC

Time (s)	Power loss at Township in NSUKKA without SSVC %	Power loss at Township in NSUKKA SSVC%
0.5	4.28	3.585
1	4.28	3.585
1.5	4.28	3.585
2	4.28	3.585
2.5	4.28	3.585
3	4.28	3.585
3.5	4.28	3.585
4	4.28	3.585
4.5	4.28	3.585
5.0	4.28	3.585

Conclusion

The high power consumption in the base station has led to decrease in the communication network performance. This is surmounted by improving energy efficiency through reduction of power consumption in base station or a cell site using neuro-fuzzy controller. This is done in this manner, characterizing and determine the power consumption of the modules of the cell site under study, developing a simulink model for the cell site under study, designing a rule base that would monitor the power consumed by the cell site and reduced it if raised, training ANN in this rule base for effective monitoring of the power consumed by the cell site and reduced it if raised. Finally, design a SIMULINK model for improving energy efficiency through reduction of power consumption in base station or a cell site using neuro-fuzzy controller and validating and justifying the percentage of power consumption reduction of the modules of the cell site with and without incorporation of neuro-fuzzy.

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