International Journal of Sciences & Applied Research

www.ijsar.in

A Simplified Approach for Using PLC and SCADA System in 330 kV distribution Substations in Nigeria.

Ngang Bassey Ngang[1], Anthony Lordson Amana[2], UkoOfe[3]

[1]Department of Electrical Engineering, Veritas University, Abuja.
[2]Department of Electrical Engineering, Veritas University, Abuja.
[3]Department of Pure and Applied Physics, Veritas University, Abuja.
Corresponding Author[1]: *Ngang Bassey Ngang, Email: nbngang@gmail.com

ABSTRACT

Introduction of SCADA system in Generation, Transmission and Distribution sectors of our electricity industry has changed the traditional way of doing our routine work in the industries. SCADA monitors the status of various equipment in the substations and sends control signals to the remote control equipment on a continuous basis. It gets the historical data of the substation and generates the alarms in the event of electrical accidents or faults. Most substations now utilize the SCAD system to monitor measurements, of relevant parameters for correction and regulation of end devices. Certain measurements, supervision, control, operation and protection functions are performed using the technology.. The problem of not controlling power substation properly by the conventional approach has made some areas not to have power supply as at the time they are meant to have it. That is the reason SCADA control of power substation applying programmable Logic Controllers is now adopted by power systems Engineers. It has improved the overall efficiency of operating power system components. The design is done by taking cognizance of the fact that a membership function for SCADA control is required. You can now proceed by designing a SCADA rule for controlling of power substation, training these rules in ANN, designing a visual basic model for SCADA control of power substation using PLC and designing a Simulink model for SCADA control of power substation using PLC. The result obtained when compared to the conventional one was 10% better.

Key Words: SCAD, PLC, Distribution Substation, ANN, Rule.

I. INTRODUCTION

Substations are the connecting points of all lines with incoming and departing feeders. Traditionally these functions were performed manually by system operators from control rooms. As progress in digital technology is made, data processing, data communication and microprocessors, a host of new devices and systems are being introduced for power system automation.

In fact, a supervisory system must take into account the physiological and cognitive features of the supervisory operator [1]. Power Distribution Automation function is to deliver electricity in a stable and efficient manner to consumers; Automation is very vital in maintaining power system stability, due to increase in power demand, modern power system networks are being operated under

highly stressed conditions [2]. Power utilities are using computer aided monitoring, control and management of electric power distribution system to give better services to consumers. Distribution automation systems provide utilities the ability to optimize the operations of distribution systems and directly improve reliability A hydropower automatic speed governor is used to control the turbine output when a sudden load change occurs; this kind of close loop control requires accurate monitoring and supervisory control to avoid losing out of synchronism, hence the need for SCADA System[3].The attention of electric R&D activities these days is to automate electric power distribution system, with the help of recent advancement in the area of Information Technology and data communication system. SCADA is a based programmable and distributed supervisory control and data acquisition system. It is the latest trend in power system protection, control and metering [4].The use of conventional electromechanical relays and earlier generation of hard-wired static relays, were only limited to performing the following functions of protection systems: Sensing faults, abnormal conditions, giving alarm, tripping circuit breakers, auto enclosing of circuit breakers etc. Data logging and some control and supervision functions were manually done electrical operators, from control rooms. In traditional substation controls, the four functions such as protection, control, monitoring and metering were not integrated fully. With the advent of modern automatic SCADA systems, the functions are interlinked by means of digital processing devices and power line carrier/radio communication links [5]. A typical power substation has a control room, with relay panels, protection panels, distribution panels and Human Machine Interface (HMI) installed in the control room. The introduction of programmable digital systems like the microprocessor based SCADA systems, the entire supervisory, control and protective functions are combined into one module [6].

1.1 AIM OF THE STUDY

The paper is aimed at achieving Substation automation using PLC and SCADA to improve performance and overall efficiency of the system.

1.2 OBJECTIVES

As the complexity of distribution networks grew, it became safe and economically necessary to automate supervision and control of substations from a control room to allow overall coordination in case of emergencies, and to save and minimize injury to personnel and damage to equipment due to human error. The objectives of the research work are stated sequentially to achieve the aim of this work; which is to

- Design a membership function for SCADA control
- Design a SCADA rule for controlling of power substation
- Train these rules in Artificial Neutral Network (ANN).
- Design a visual basic model for SCADA control of power substation using PLC
- Design a Simulink model for without SCADA control of power substation using PLC
- Design a Simulink model for SCADA control of power substation using PLC
- Compare the loss reduction in power substation using PLC without and with SCADA

2. EXTENT OF PAST RELATED WORKS

The conventional power substations in Nigeria which are mostly operated manually has resulted in lots of human

problems .With the implementation of SCADA system in the power substation, these problems have been minimized or totally solved[7]. These are earth due to electrocution caused by improper manual operation of the equipment, Visibility and accessibility for the network operation [8], Outage of telephone network for proper communication, Non-compliance of instructions, huge time required to collect data and pass instructions. The causes of not using SCADA have resulted to load shading because the power loss in the substation lines is high. A lot of renowned authors have researched on this issue but could only achieve 46% reduction of power losses in the substation lines. Some of these prominent authors are [9] control of power substation using PLC,[10]control of power substation using PID,[11]control of power substation using SVC and [12]control of power substation using proportional integral PI. The Digital control systems for 330 kV substations have been installed in different areas of Nigeria in the recent years. The techniques used a Supervisory Control and Data Acquisition (SCADA) with Remote Terminal Unit (RTU) for monitoring the metering devices for incoming and outgoing feeders, while the other system used a Programmable Logic Control (PLC) technique for controlling and monitoring the system inside substations by professional engineers [13]. This method is what this paper is focusing on. The power system components monitoring system uses two monitoring hosts (one main host, and one standby host) to call and monitor the load status, load distribution curve, important alarm, accident statistics, working status, and other electricity monitoring data of various substations. The monitoring system has one database server to store historical data and allows other devices to access the data base. The server exchanges data with the monitoring system via the switch. The monitoring system uses PLC to collect field data and analyze & process data information [14]. On this basis, it makes various electricity utilization programs for the utility company. Industrial automation is an integral part of modern lives that help to monitor and control the Industrial electrical devices as well as other aspects of our daily lives.

3. MATERIALS AND METHODS

The methodology has to start by the collection of data from substation central control room monitoring the parameters of 330kV substation by personal interview. The control room System Electrical Operators were interviewed; the reason for the study was discussed and Permission granted to have access to what they referred as classified information /Data. The next step was to characterize the substation in order to have a proper knowledge of the station; design a membership function for SCADA control. The next step was the designing of a SCADA rule for controlling the power substation. The fifth is to train the rules in Artificial Neutral Network (ANN), designing a visual basic model for SCADA control of power substation using PLC. For the purpose of validation, a Simulink model is designed without SCADA control for the power substation using PLC; and the design of Simulink model for SCADA control of power substation using Programmable Logic Controller. Finally, a comparison between the Loss reduction in power substation using PLC without and with SCADA technology was juxtaposed

3.1 Design of a membership function for SCADA control

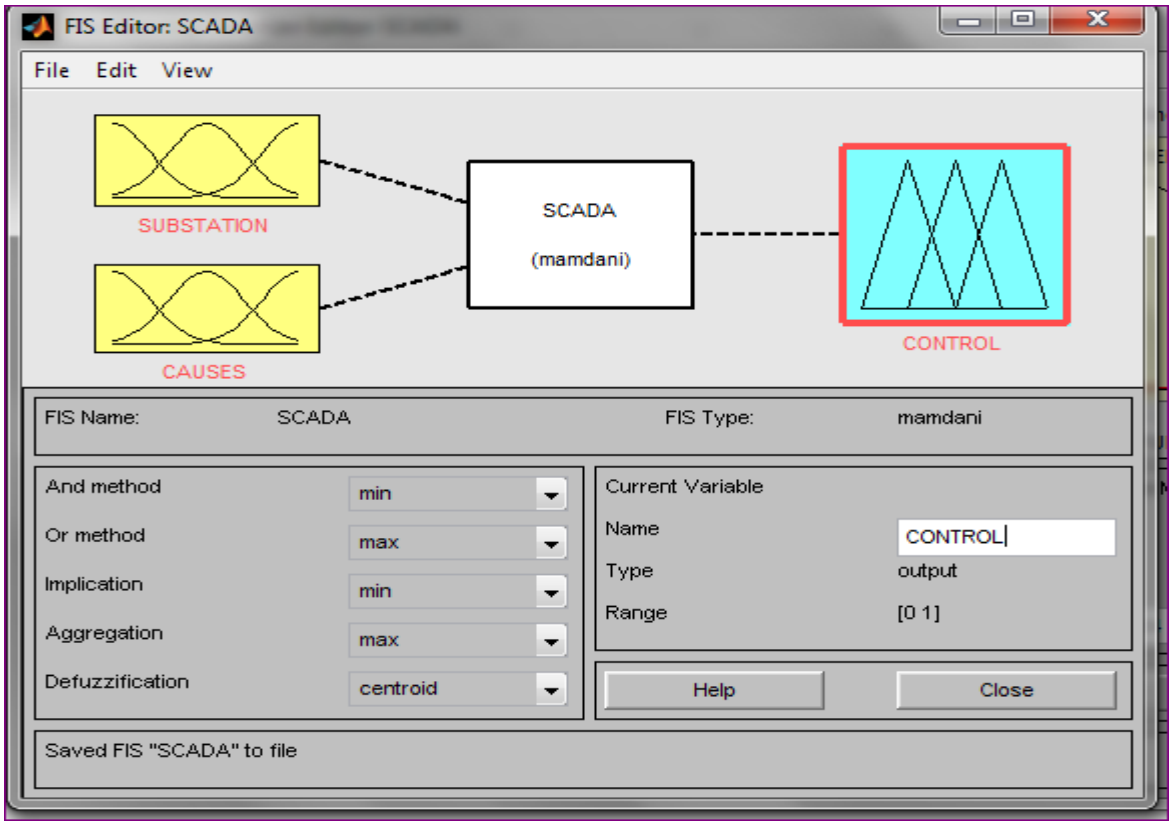

Figure- 1 Designed fuzzy inference system for SCADA control

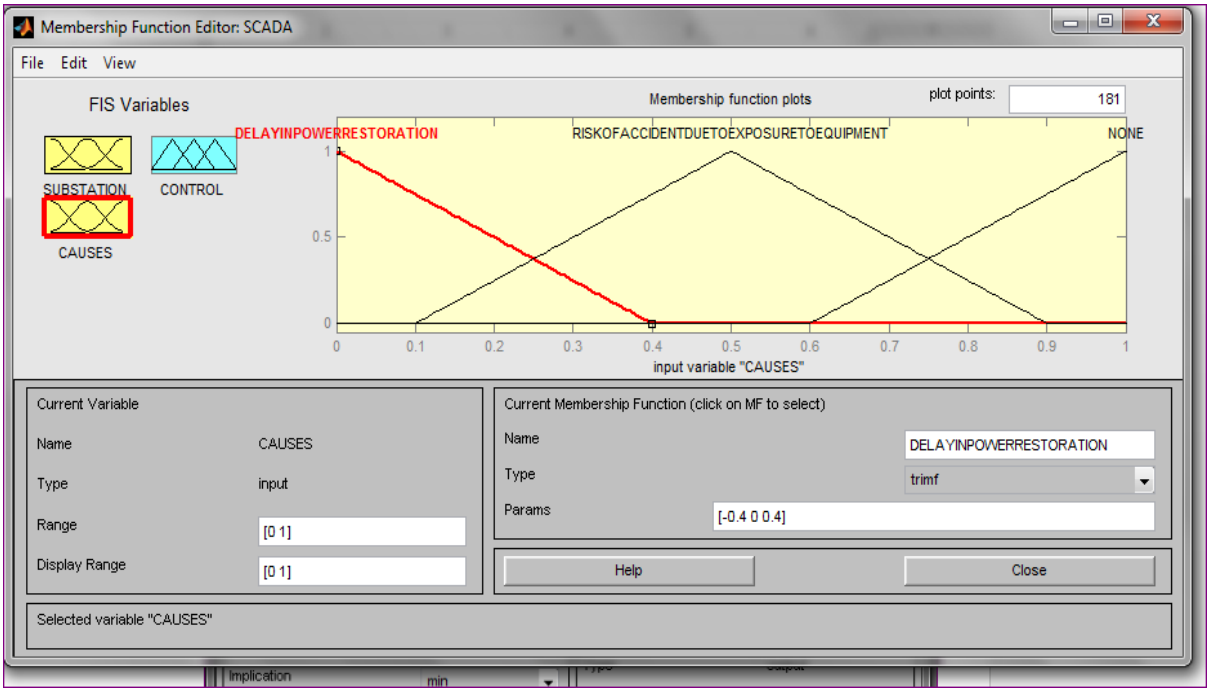

Figure- 2 Designed membership function for SCADA control

3.2 Design of a SCADA rule for controlling of power substation

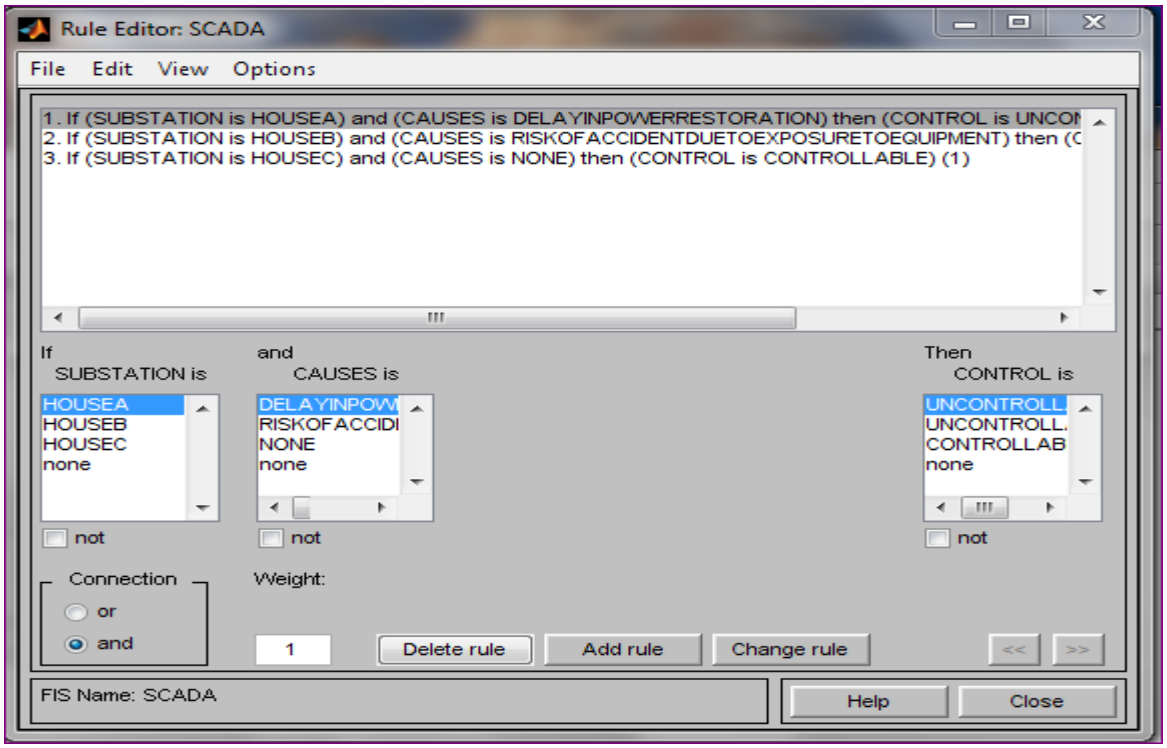

Figure- 3 Design a SCADA rule for controlling of power substation

3.3 To train these rules in ANN.

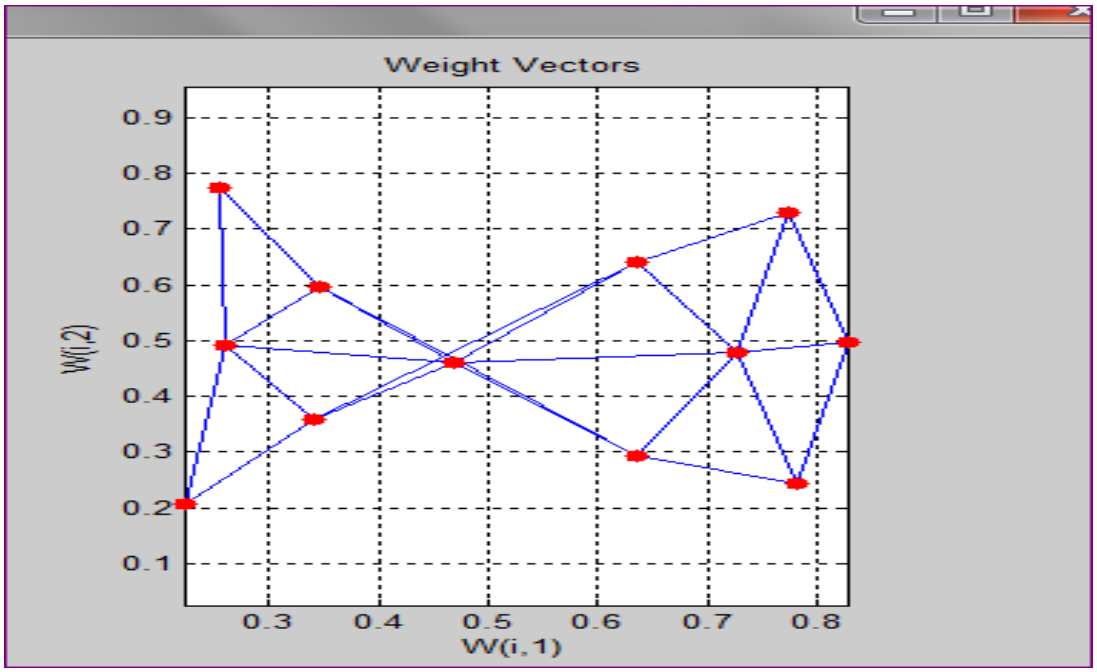

Figure- 4 Trained rules in Artificial Neural Network.

3.4 To design a visual basic model for SCADA control of power substation using PLC

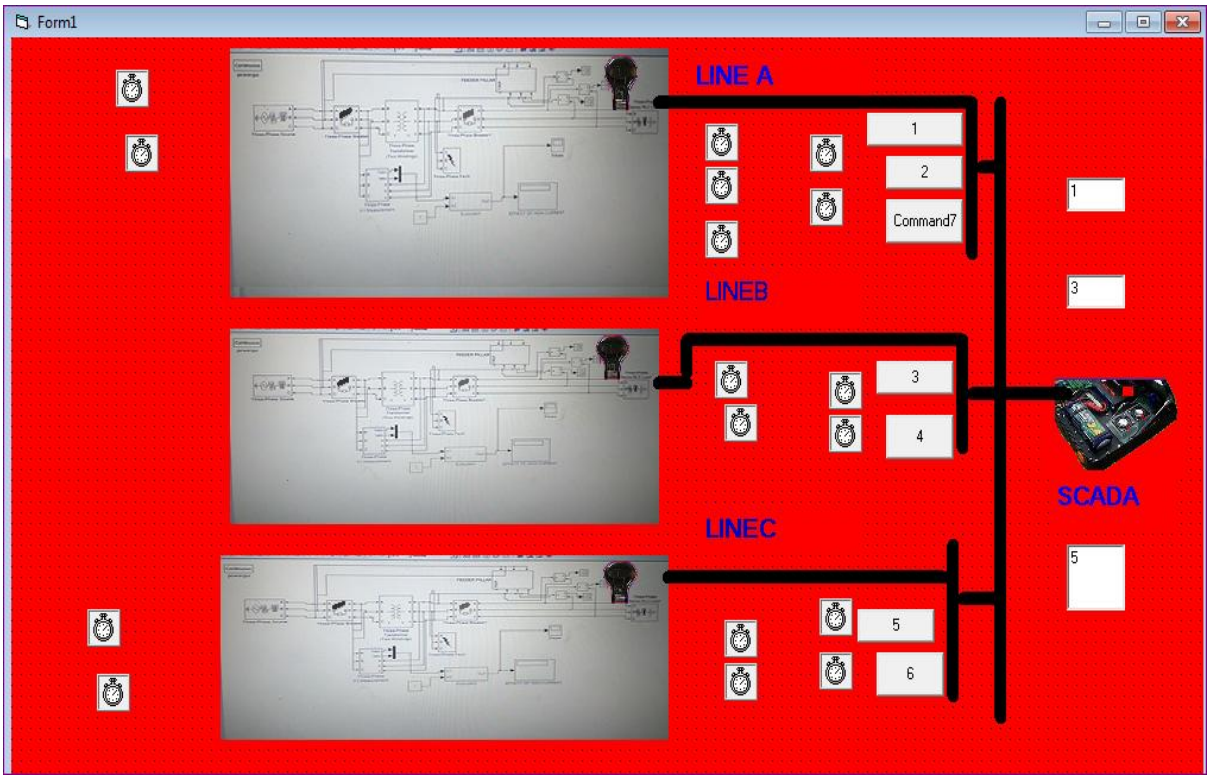

Figure: 5 Designed visual basic model for SCADA control of power substation using PLC

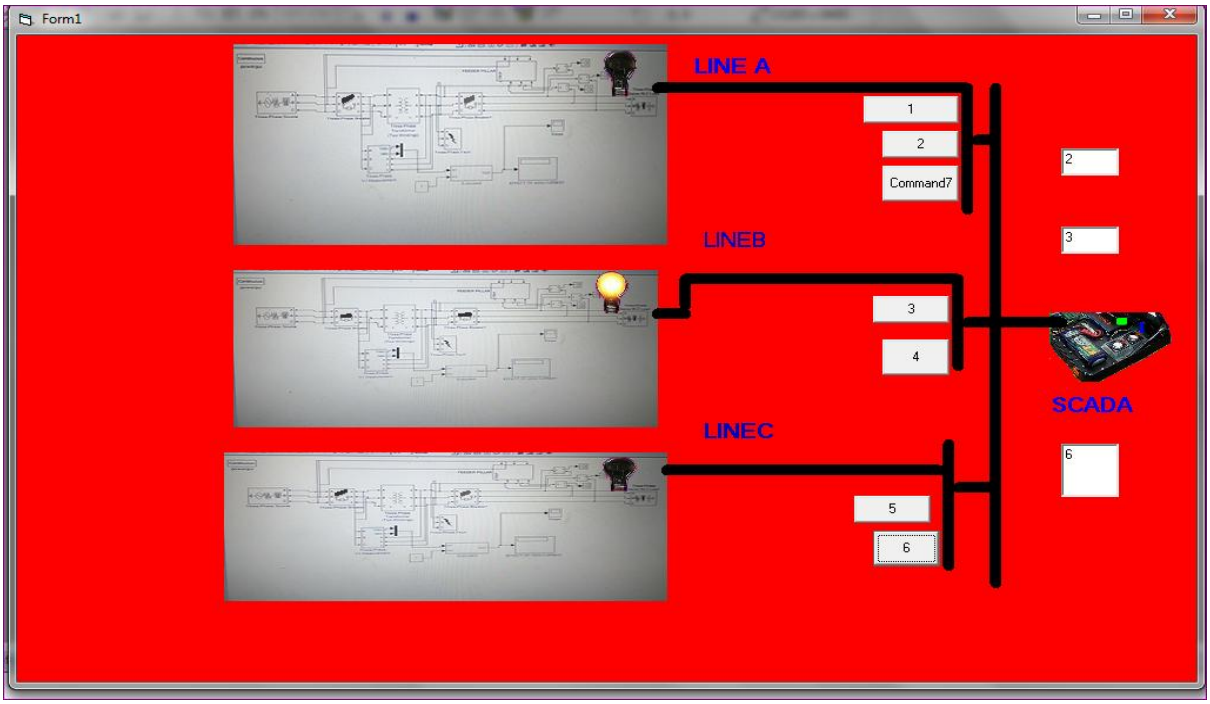

Figure- 6 Designed visual basic model for SCADA control of power substation using PLC (When line B only is close)

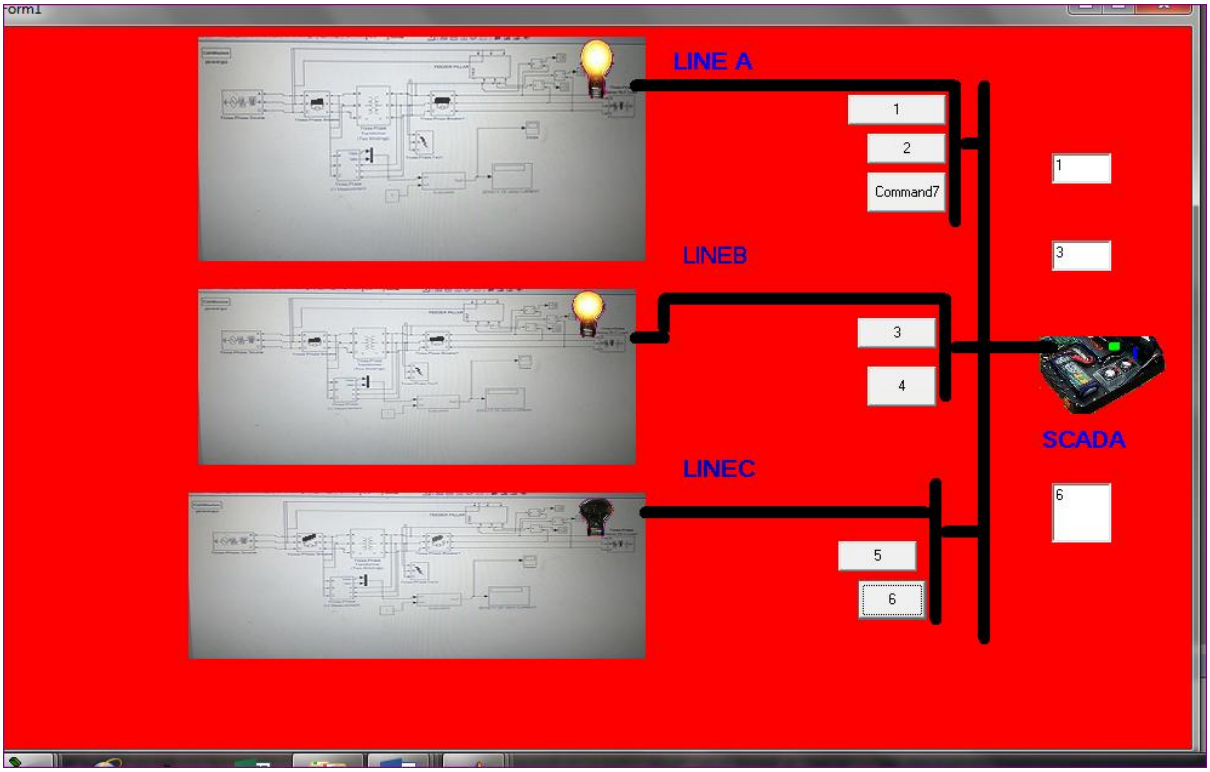

Figure- 7 Designed visual basic model for SCADA control of power substation using PLC (When lines A and B are closed)

3.5 Design of a Simulink model for SCADA control of power substation using PLC

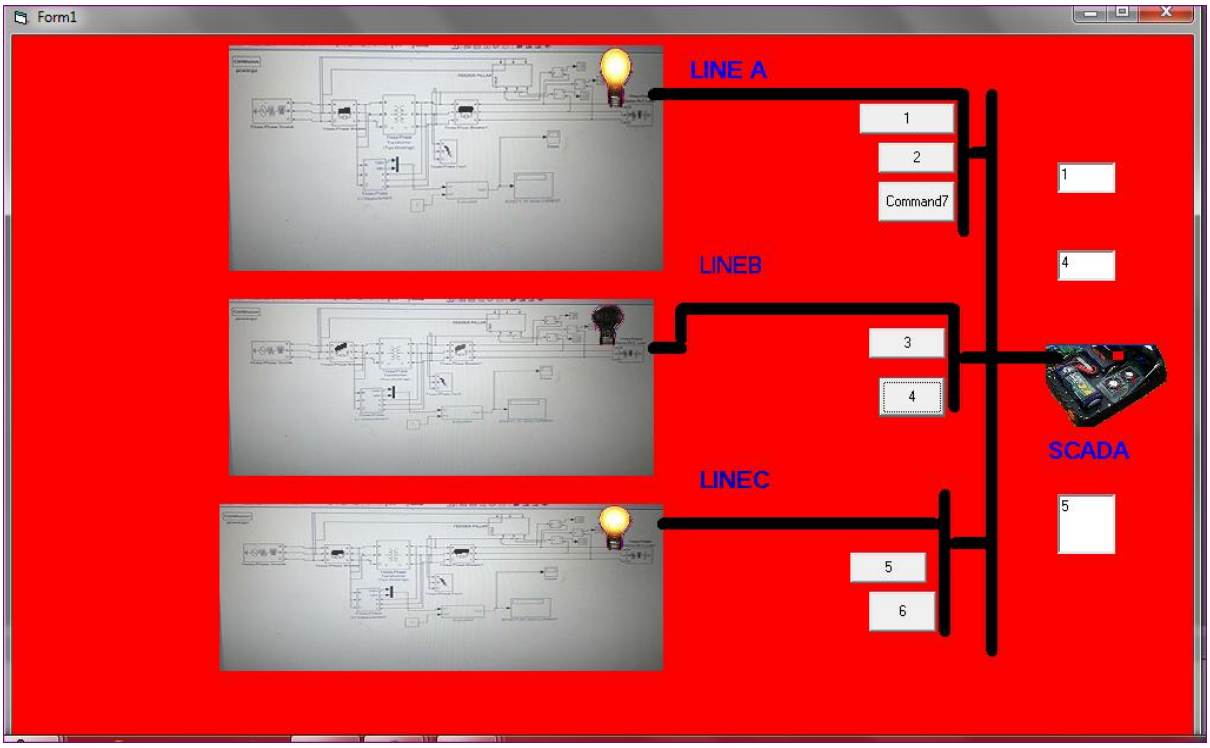

Figure- 8 Designed visual basic model for SCADA control of power substation using PLC (When lines A and C are closed)

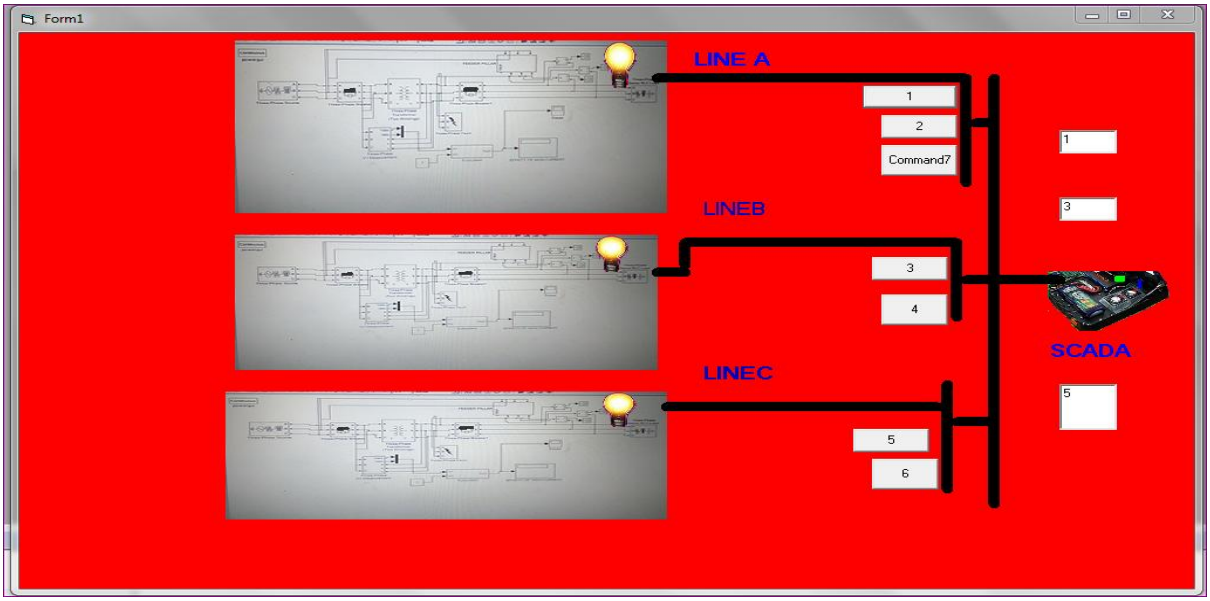

Figure- 9 Designed visual basic model for SCADA control of power substation using PLC when all the lines are closed.

3.6 Design of a Simulink model for without SCADA control of power substation using PLC

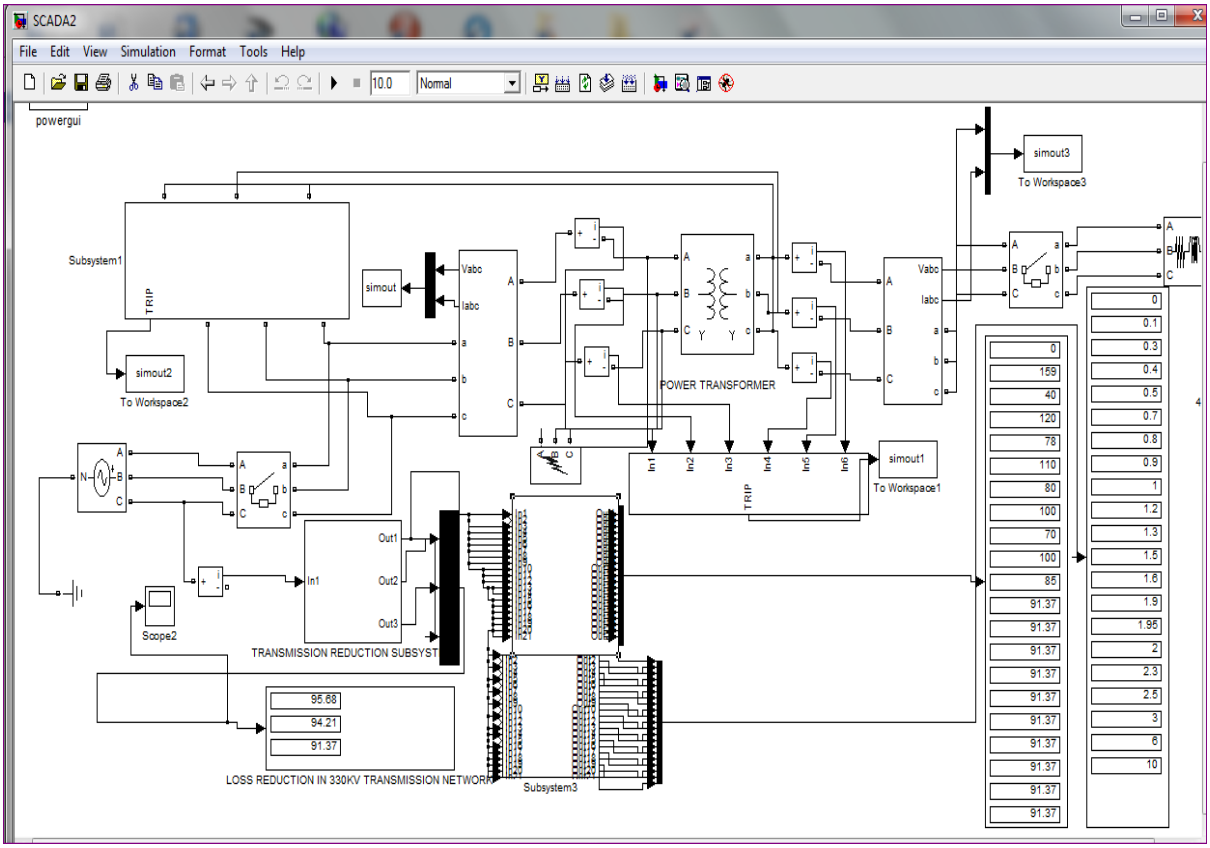

Figure: 10 Designed Simulink model for none SCADA control of power substation using PLC

3.7 Design of a Simulink model for SCADA control of power substation using PLC

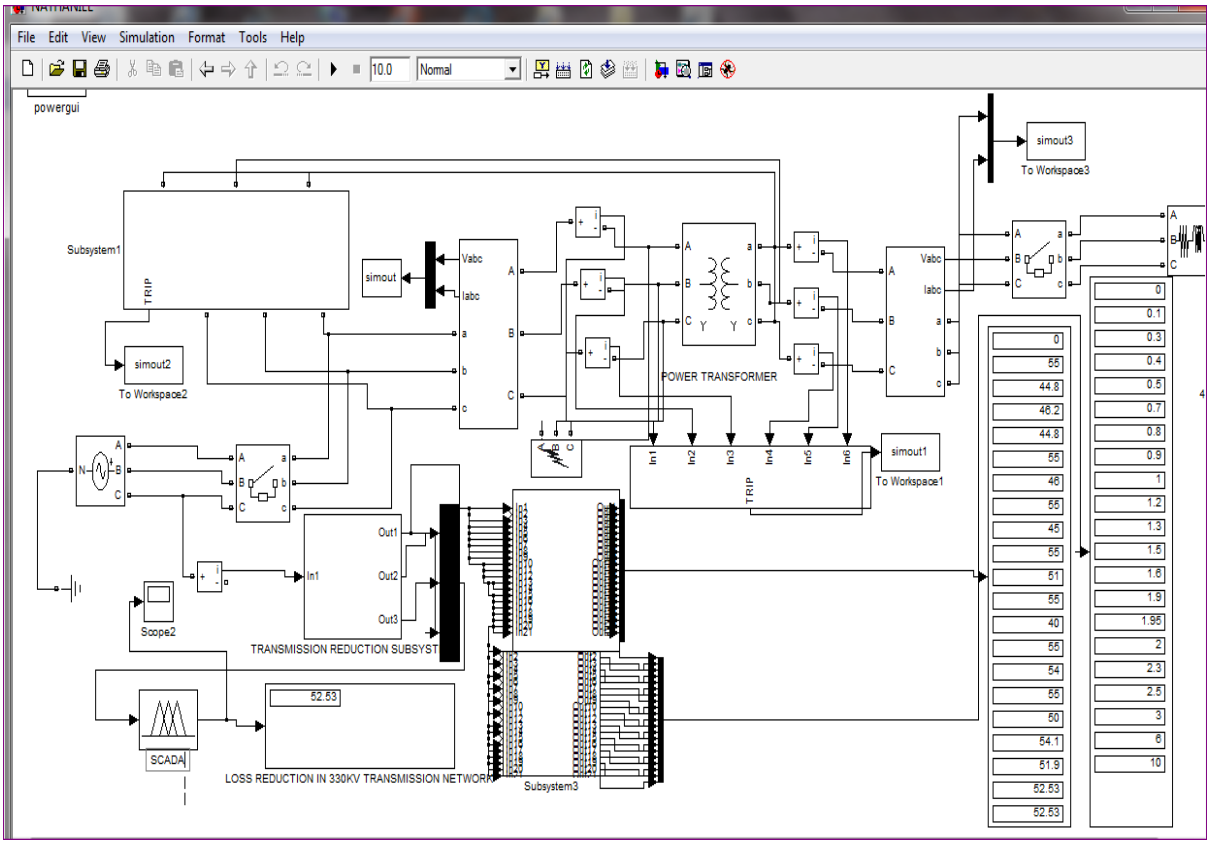

Figure: 11 Designed Simulink model for SCADA control of power substation using PLC

4. RESULTS AND DISCUSSION

Figure 1shows the design of a membership function for SCADA control that gives the analysis of the causes of not controlling power in the substation properly. Figure 2 is the design of a SCADA Rule for controlling the power substation, Figure 3 shows a SCADA Rule for controlling of power substation. These rules enhanced the efficiency of controlling substation lines. The number of Rules that guides the substation lines are three in number; Figure 4 trained Rules in Artificial Neural Network (ANN).Recall that Figure 4 is a neuron-like human brain that does what it is commanded to do. The three rules were trained four times that is the reason we are having twelve neurons. The essence of training these rules is to stick strictly to control the substation lines to have stable power supply. Figure 5 is the designed visual basic model for SCADA control of power substation using PLC. Fig 5 shows that there is no power supply in all the lines of the substation which might arise as a result of fault in the transformer. Figure 6 the designed visual basic model for SCADA control of power substation using PLC (When line B only is closed). The closing of line B might could be as a result of load shedding.

Figure7 is the designed visual basic model for SCADA control of power substation using PLC (When lines A and B are closed).The only opened line is line C. Figure 8 is the designed visual basic model for SCADA control of power substation using PLC (When lines A and C are closed). Figure 9 is the design of a visual

basic model for SCADA control of power substation using PLC when all the lines are closed. Figure 10 shows also a design of Simulink model without SCADA control of power substation using PLC. Figure 11 shows the complete design of a Simulink model for SCADA control of power substation using PLC. The detailed result was obtained in Figure 12 and tabulated in Table 1.Figure 12 compared the loss reduction in power substation using PLC without and with SCADA system. I could be inferred from Figure 12 that when SCADA was used there was higher percentage of loss reduction than when SCADA was not introduced.

Table1. Comparison between the loss reduction in power substation using PLC without and with SCADA

Loss reduction for none SCADA control of power substation using PLC	Loss reduction for SCADA control of power substation using PLC	Time (s)
0	**0**	**0**
159	**55**	**0.1**
40	**48.8**	**0.3**
120	**46.2**	**0.4**
78	**44.8**	**0.5**
110	**55**	**0.7**
80	**46**	**0.8**
100	**55**	**0.9**
82	**45**	**1**
100	**55**	**1.2**
70	**45**	**1.3**
100	**55**	**1.5**
85	**45**	**1.6**
91.37	**52.53**	**1.96**
91.37	**52.53**	**2**
91.37	**52.53**	**2.3**
91.37	**52.53**	**2.5**
91.37	**52.53**	**3**
91.37	**52.53**	**6**
91.37	**52.53**	**10**

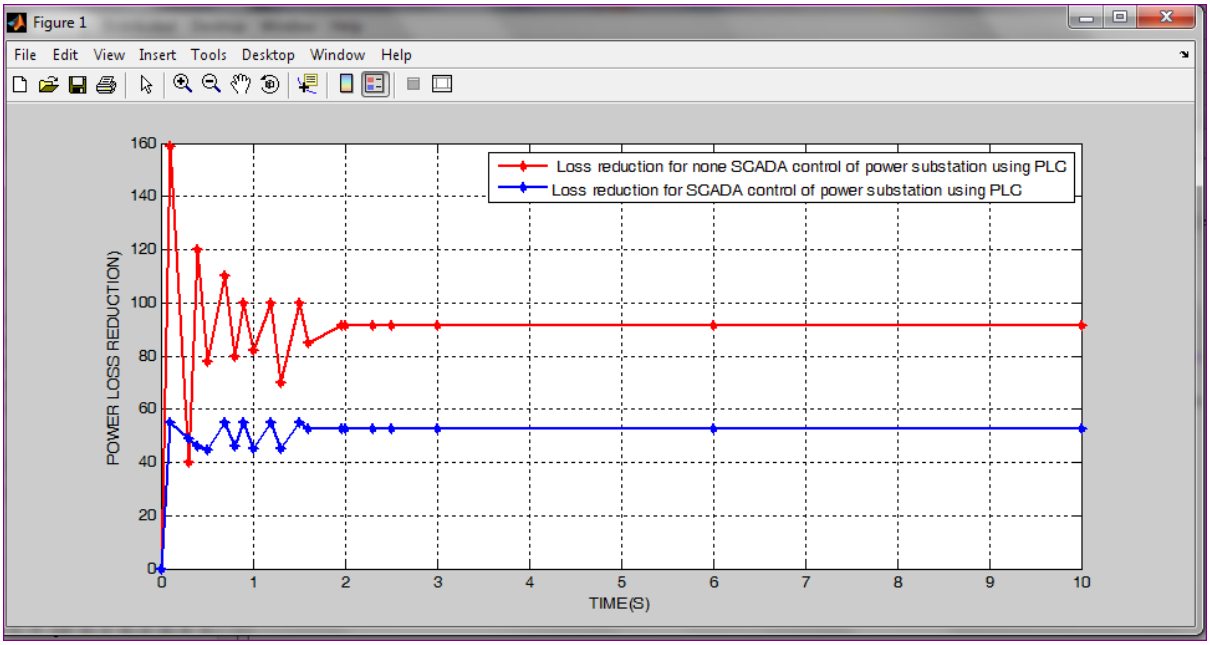

Figure 12.Comparison between the loss reduction in power substation using PLC without and with SCADA

5. CONCLUSION

There is a lot of power losses in substation lines which has led to load shading, over current thereby constituting instability of power supply. this can be overcome by designing a membership function for SCADA control , designing a SCADA rule for controlling of power substation, training these rules in ANN, designing a visual basic model for SCADA control of power substation using PLC and designing a Simulink model for SCADA control of power substation using PLC.

ACKNOWLDGEMENT

I wish to acknowledge the contributions of my co-Authors and that of the Company Ngatek Global Services Limited for providing funds during this period of research work.

CONFLICTING OF INTEREST

There is no conflict of interest.

REFERENCES

[1] Mohamed, N. L. (2010). SCADA applications in thermal power plants. International Journal of Physical Sciences, VOL. 5, Issue

[2]Aneke,N.E.,Ngang,N.B.(2021) Improving the Efficacy of the Nigerian Electric Power Transmission Network Using Static Synchronous Compensator(STACOM).Journal of Information Engineering and Applications,(JIEA),Vol.11,No. 2.

[3] Ngang, N.B. (2020). Hydropower Generator speed control using Fuzzy software Tool. International Journal of Emerging Trends in Engineering and Development (IJETED) Vol.3, N o.10,DOI :https://dx.doi.org/10.26808/rs.ed.i10v3.02

[4] Duo Li., "Concept Design for Web-based SCADA System", (2002).

[5] Guangzhi Li et. al., "IP over Optical Cross-Connect Architectures", White paper, IEEE Communications Magazine, February 2007.

[6] Data sheet of AREVA Company, "Fallujah 132/33/11KV AIS Substation", Metering

[7] Mike Clayton, "A SCADA-Web Interconnection with TCP in Java", (2002). URL:

http://ess.web.cern.ch/ESS/GIFProject/PVSSJava/pvssweb.0.8.pdf
[8]Philip, (2017) Migration of a Sscada system to laas clouds-a case study,Journl of clouds computing.
[9] Jose, M. (2017).Substation Automation System for Energy monitoring (IJRTE)
[10] Qiu,B. And Gooi, H. B. "Web-Based SCADA Display Systems (WSDS) for Access via Internet", IEEE transactions on power systems, vol. 15, no. 2, may 2000.
[11]Bhatt,.M.(2017).Interconnected Substation Monitoring and controlling using PLC, SCADA. International Research Journal of Engineering and Technology (IRJET)
[12]David. B. and Edwin.W.(2003).Practical SCADA for industry", Newnes.
[13]Salih,A.(2009).Practical Implementation of SCADA System for Falluja
[14] Zhang.K. (2012). Design of SCADA Power Distribution Monitoring System based on PLC and configuration software. Proceedings on international conference on Mechanical Engineering and Materials Science (MEMS) Substation. Anbar Journal of Engineering Sciences (AJES), Vol.2 Issue 2.