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IMPROVING VOLTAGE STABILITY OF A 132KV TRANSMISSION LINE IN SOUTHERN NIGERIA, USING AN INTELLIGENT LINE REACTOR

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ABSTRACT

Low transmission network power supply performance is caused by voltage instability; this has been a concern to customers in Nigeria due to epileptic power supply. This is avoided by using an Intelligent Line Reactor to increase voltage stability in the transmission network. This procedure includes running the load flow from the characterized data, locating the faulty buses whose per unit volts do not fall within the acceptable ranges of 0.95 through 1.05, designing a conventional model for voltage stability in the Nigerian 132kV transmission network, designing a SIMULINK model for a line reactor, and designing a rule base to improve the faulty buses to achieve voltage stability. When an intelligent Reactor is introduced as a VAr compensator, combined with the planned SIMULINK model for the Reactor with the designed rule base,the performance was enhanced. The recorded results are: Per unit voltages in bus1 are 0.92P.U.volts, this falls below the voltage stability range of 0.95 to 1.05 P.U. volts. The per-unit volts climb to 0.9779P.U.volts when an intelligent line reactor was introduced to the system, resulting in improved voltage stability. In bus 9, the normal per unit volts is 0.922P.U.volts, after improvement we have 0.9801P.U.volts due to the reactor.

Keywords- Minimising, instability, intelligent line Reactor, Transmission Line

INTRODUCTION

The transmission power system blackout in Nigeria has hampered certain firms that rely completely on electricity to maintain their operations. One of the main causes of the country's intermittent power supply

is when the per-unit voltages of some malfunctioning buses do not fall within the range of 0.95 to 1.05, which is intended for stability. Because of the country's electricity unreliability, innovative solutions for enhancing voltage stability in Nigeria's 132kv transmission network are needed. As demonstrated in this work, an intelligent Line Reactor would be used to alleviate this situation. The ability of a power system's network to withstand disturbances and return to its normal stable state without breaking down is referred to as its security [1]. The transient stability of a power system, which is one of the key performance indices, can be used to assess the system's security. [2] Stated that, it has to do with a power system's ability to maintain stability or revert to the desired state of equilibrium in the event of a voltage surge or other system disturbances. [3], Numerical integration, direct method, a probabilistic technique [2], and artificial intelligence methods such as Artificial Neural networks are some of the techniques for assessing the unstable state of the power system. in the
study [4]., the system is really important; Clearing Time is used to assess transient stability in response to various types of disturbances, such as external faults, synchronous generator excitation loss resulting in generation loss, and transmission line loss due to voltage surge. [5]. CCT indicates how long a power system can remain stable in the face of a system surge or disruption [6]. The consistent response of a power system to system surge is a measure of power system stability.This work is aimed at achieving improvement in Voltage Stability in a short Transmission line using
Intelligent Line Reactor.The specific objectives are to:
utilize an Intelligent Line Reactor to improve voltage stability in Nigeria's 132kv transmission network, Run the load flow from the characterized data, locate the faulty buses whose per unit volts do not fall within the ranges of 0.95 through 1.05, design a conventional model for voltage stability in the Nigerian 132kV transmission network, design a SIMULINK model for a line reactor, and design a rule base that will enhance the faulty buses to achieve voltage stability. The tasks are achieved in this procedure by integrating an intelligent Reactor as a VAr load, imbibing the designed SIMULINK model for the Reactor to the designed rule base, and constructing a SIMULINK model for increasing voltage stability in the transmission network.

EXTENT OF PAST RELATED WORKS

The magnitude of a network's security level is a factor in defining the level of integrity of a power system (this involves transmission capability limit and how flexible the power system becomes.) [8]. The synchronization power coefficient of the Power system elements attached to the infinite bus bar can be enhanced by effectively regulating the Voltage Ampere reactive ((VAr) components power triangle. As a result, Grid integrity can be enhanced by applying a strategy for strengthening transient stability in order to prevent system collapse.The transmission substation's power system components have become overwhelmed over time. The bulk of national grid system failures can be attributed to a lack of effective maintenance planning [9]. Proper maintenance planning can give efficient techniques of improving transient stability without the need to install new transmission lines [10]. For improving the power system, the Static Var Compensator (SVC), Controllable Series Compensator (CSC), Phase Shifter (PS), Series Capacitors (SC), Thyristor Controlled Series Capacitors (TCSC), Unified Power Flow Controller

(UPFC), Convertible Series Compensator (CSC), Inter-phase Power Flow Controller (IPFC), Static Synchronous Series Controller (SSSC), STATCOM, and other FACTS devices have Intelligent reactors appeared when the parameters were correctly supplied.It is currently widely employed as an important part of electrical power components and has proven to be the most effective FACTS device for increasing transient stability [12]. This work will employ an intelligent Solid State Voltage Ampere reactive (VAr) Compensator (SSVC) to achieve a superior result, as shown at the end of the study. It is one of the modern vital devices that will respond rapidly to system changes [13]. It is built of solid semiconductor devices. Shunt-connected SSVCs are commonly positioned in the middle of the transmission line, where they are coupled to a coupling or matching transformer [14]. It can improve voltage stability at the receiving end with improved voltage regulation, and it will eventually attain the function of controlling its reactive power output [15], unlike traditional methods of boosting transient stability. The Nigerian National Grid is experiencing technical challenges as a result of government protocols and foreign exchange for ordering spare parts, a poor maintenance culture, and a long, radial, weak, and aging transmission network [16]. Numerous scholars have undertaken various studies on the Nigerian 330kV transmission network in order to improve the network: [17 The author used the sequence technique in his study [18], creating a Simulink model to comprehend the network after characterizing it; similarly, this work produces a model for the transmission line under examination and uses it to improve power system stability. Most power supply companies have devised several processes, procedures, and criteria that must be followed when wind generators are linked to the system in order to avoid instabilities in our power system, according to the study [19, 20].

MATERIAS AND METHOD

To complete this job, follow the given objectives in order; the first step must be completed before moving on to the next level, and so on until the validation stage. The company's database is a useful source of information; it begins with characterizing the 132kV transmission line from Afam power station to Port Harcourt city Substation, running the load flow from the characterized data, locating the faulty buses whose per unit volts do not fall within the ranges of 0.95 through 1.05, designing a traditional model for voltage stability in the Nigerian 132kV transmission network, and designing a SIMULINK model for intelligent voltage control. Using an intelligent VAr Load, combining the designed SIMULINK model for the Reactor with the designed rule base, and building a SIMULINK model to improve voltage stability in the Nigerian 132kV transmission network.

Characterizing the 132kV transmission network

Table-1
132kVParameters for evaluating Southern Nigerian transmission line

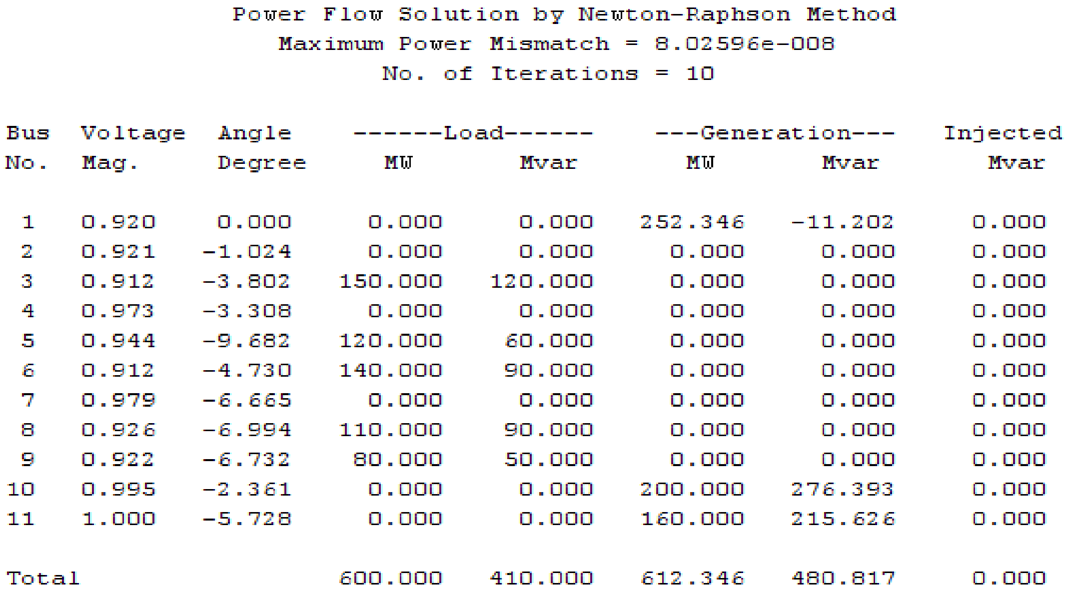
Bus No	Bus code	P.U	Ang Deg	Load MW	Load Mvar	Gen MW	Gen Mvar	Inject Min	Inject Max	Inject Mvar
1	1	0.92	0	00.0	0.0	0.0	0.0	0	0	0
2	0	0.92	0	00.0	0.0	0.0	0.0	0	0	0
3	0	1.0	0	150.0	120	0.0	0.0	0	0	0
4	0	1.0	0	0.0	0.0	0.0	0.0	0	0	0
5	0	1.0	0	120.0	60	0.0	0.0	0	0	0
6	0	0.94	0	140.0	90	0.0	0.0	0	0	0
7	0	1.0	0	0.0	0.0	0.0	0.0	0	0	0
8	0	1.0	0	110.0	90.0	0.0	0.0	0	0	0
9	0	1.0	0	80.0	50.0	0.0	0.0	0	0	0
10	2	1.025	0	0.0	0.0	200	0.0	0	180	0
11	2	1.05	0	0.0	0.0	160	0.0	0	120	0

To run the load flow from the characterized data thereby locating the faulty buses that their per unit voltsdo not fall within the acceptable ranges of 0.95 through 1.05

```
disp(')

basemva = 1000;  accuracy = 0.0001;  maxiter = 10;

% The impedances are expressed on a 1000 MVA base.

% characterized load flow.

%     Bus  Bus  |V|  Ang  ---Load---     ---Gen---   Gen Mvar Injected

%     No.  code p.u.  Deg   MW     Mvar   MW    Mvar   Min   Max    Mvar

busdata=[1    1   0.92   0    00.0    0.0     0.0   0.0    0     0     0

         2    0   0.92    0    00.0    0.0     0.0   0.0    0     0     0
```

```
        3   0   1.0    0   150.0  120.0     0.0   0.0    0     0    0
        4   0   1.0    0     0.0    0.0     0.0   0.0    0     0    0
        5   0   1.0    0   120.0   60.0     0.0   0.0    0     0    0
        6   0   0.94    0   140.0   90.0     0.0   0.0    0     0    0
        7   0   1.0    0     0.0    0.0     0.0   0.0    0     0    0
        8   0   1.0    0   110.0   90.0     0.0   0.0    0     0    0
        9   0   1.0    0    80.0   50.0     0.0   0.0    0     0    0
        10   2   1.025 0     0.0    0.0   200.0   0.0    0    180   0
        11   2   1.05   0     0.0    0.0   160.0   0.0    0    120   0];
%       Bus   Bus     R       X       1/2B
%       No.   No.    p.u.     p.u.     p.u.
linedata=[1     2    0.00     0.06     0.0000     1
          2     3    0.08     0.30     0.0004     1
          2     6    0.12     0.45     0.0005     1
          3     4    0.10     0.40     0.0005     1
          3     6    0.04     0.40     0.0005     1
          4     6    0.15     0.60     0.0008     1
          4     9    0.18     0.70     0.0009     1
          4    10     0.00     0.08     0.0000     1
          5     7    0.05     0.43     0.0003     1
```

```
          6    8    0.06    0.48    0.0000   1
          7    8    0.06    0.35    0.0004   1
          7   11     0.00    0.10    0.0000   1
          8    9    0.052   0.48    0.0000   1];
%        Gen.  Ra     Xd'
gendata=[ 1     0     0.20
          10    0     0.15
          11    0     0.25];
    lfybus                      % Forms the bus admittance matrix
    lfnewton            % Power flow solution by Newton-Raphson method
    busout              % Prints the power flow solution on the screen
    Zbus=zbuildpi(linedata, gendata, yload)%Forms Zbus including the load
    symfault(linedata, Zbus, V)    % 3-phase fault including load current
```



```
                   Power Flow Solution by Newton-Raphson Method
                      Maximum Power Mismatch = 8.02596e-008
                             No. of Iterations = 10

 Bus  Voltage  Angle    ------Load------    ---Generation---   Injected
 No.  Mag.     Degree     MW       Mvar       MW       Mvar       Mvar

  1   0.920    0.000     0.000     0.000   252.346   -11.202     0.000
  2   0.921   -1.024     0.000     0.000     0.000     0.000     0.000
  3   0.912   -3.802   150.000   120.000     0.000     0.000     0.000
  4   0.973   -3.308     0.000     0.000     0.000     0.000     0.000
  5   0.944   -9.682   120.000    60.000     0.000     0.000     0.000
  6   0.912   -4.730   140.000    90.000     0.000     0.000     0.000
  7   0.979   -6.665     0.000     0.000     0.000     0.000     0.000
  8   0.926   -6.994   110.000    90.000     0.000     0.000     0.000
  9   0.922   -6.732    80.000    50.000     0.000     0.000     0.000
 10   0.995   -2.361     0.000     0.000   200.000   276.393     0.000
 11   1.000   -5.728     0.000     0.000   160.000   215.626     0.000

 Total                 600.000   410.000   612.346   480.817     0.000
```

Fig. 1 showing load flow of 132kV transmission network.

In fig 1 the seven faulty buses are buses,1, 2, 3, 5, 6,8 and 9 with per unit volts of 0.920, 0.921, 0.912, 0.944, 0.912, 0.926 and 0.922

Designing a Conventional Model for Voltage Stability in Nigerian 132kV Transmission Network

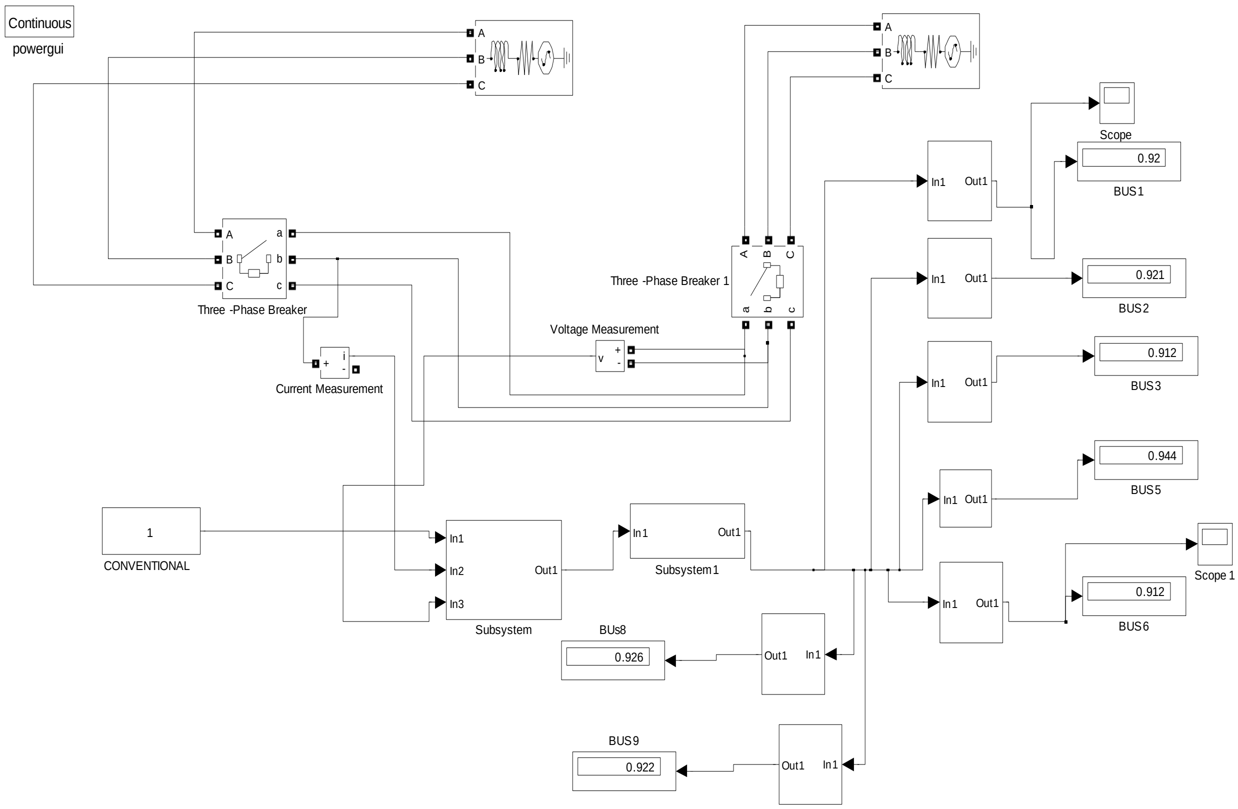


Fig. 2. Designed conventional model for voltage stability in Nigerian 132kV transmission network.

Designing a SIMULINK Model for the electrical Line Reactor

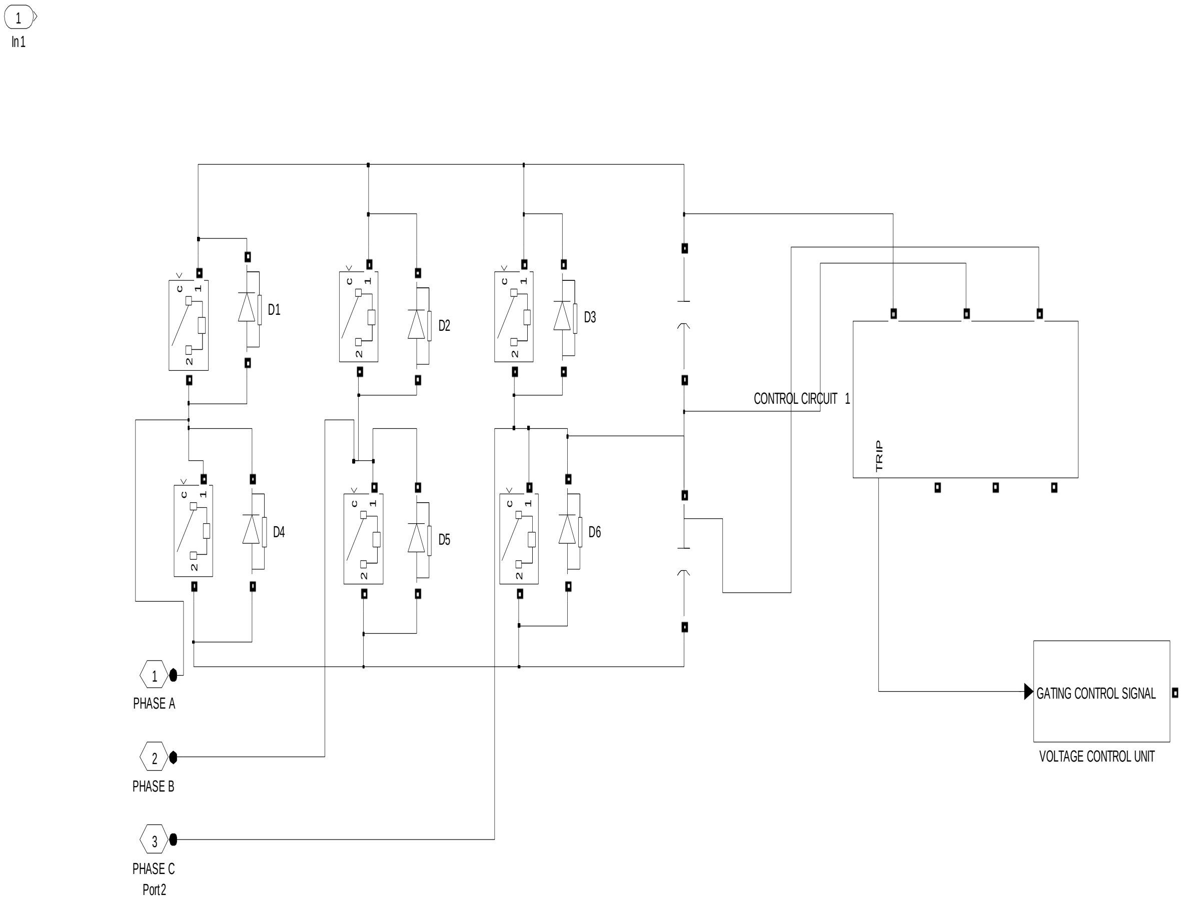
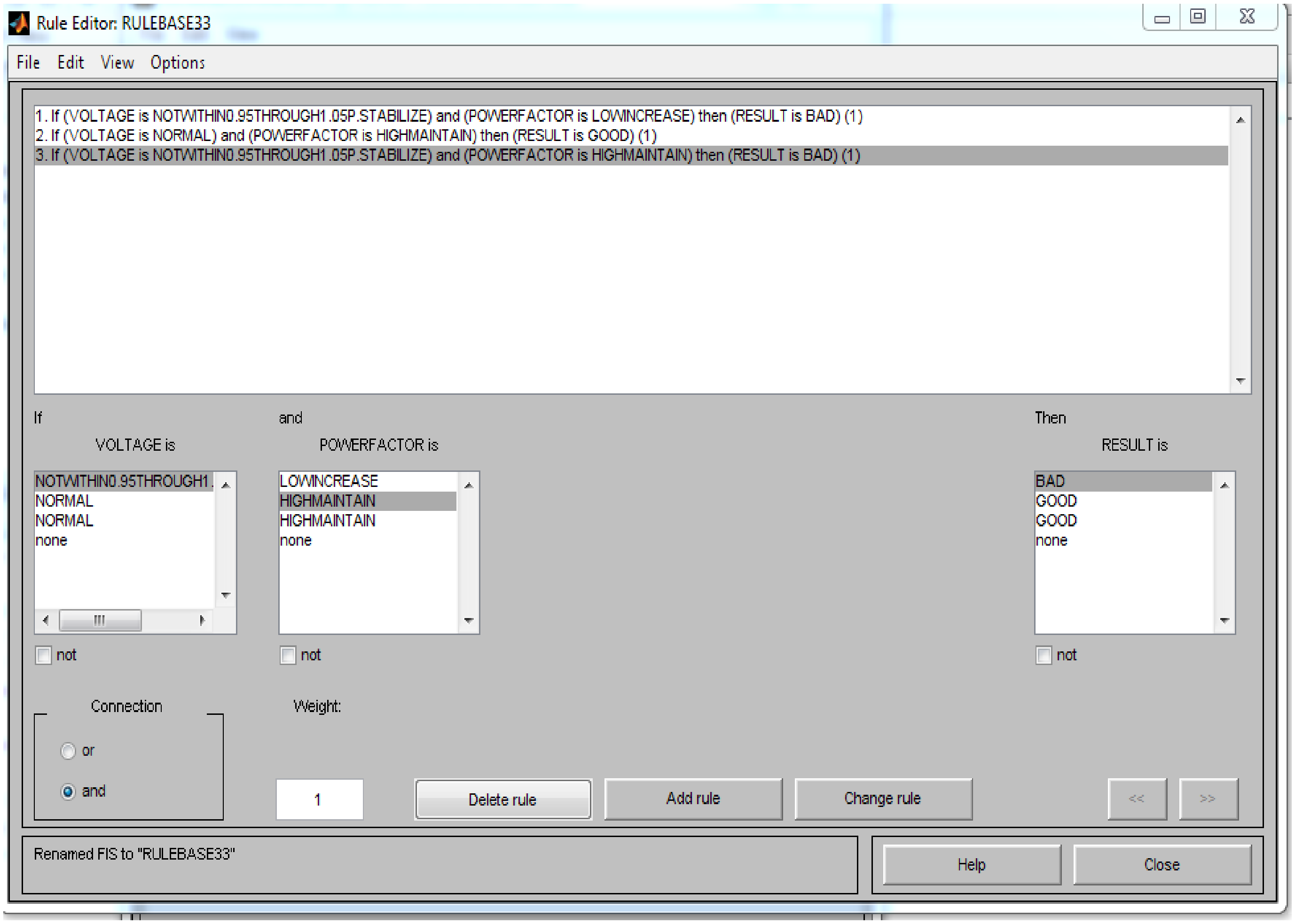


Fig. 3. Designed SIMULINK model for intelligent line Reactor Fig 3. Shows designed

Designing a rule base that will enhance the faulty buses to attain voltage stability



1. If (VOLTAGE is NOTWITHIN0.95THROUGH1.05P.STABILIZE) and (POWERFACTOR is LOWINCREASE) then (RESULT is BAD) (1)
2. If (VOLTAGE is NORMAL) and (POWERFACTOR is HIGHMAINTAIN) then (RESULT is GOOD) (1)
3. If (VOLTAGE is NOTWITHIN0.95THROUGH1.05P.STABILIZE) and (POWERFACTOR is HIGHMAINTAIN) then (RESULT is BAD) (1)

VOLTAGE is: NOTWITHIN0.95THROUGH1. / NORMAL / NORMAL / none
POWERFACTOR is: LOWINCREASE / HIGHMAINTAIN / HIGHMAINTAIN / none
RESULT is: BAD / GOOD / GOOD / none
☐ not ☐ not ☐ not
Connection: ○ or ● and
Weight: 1

Renamed FIS to "RULEBASE33"

Fig. 4. Designed rule base that will enhance the faulty buses to attain voltage stability

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Incorporating the Designed SIMULINK Model for a line Reactor to Designed Rule Base

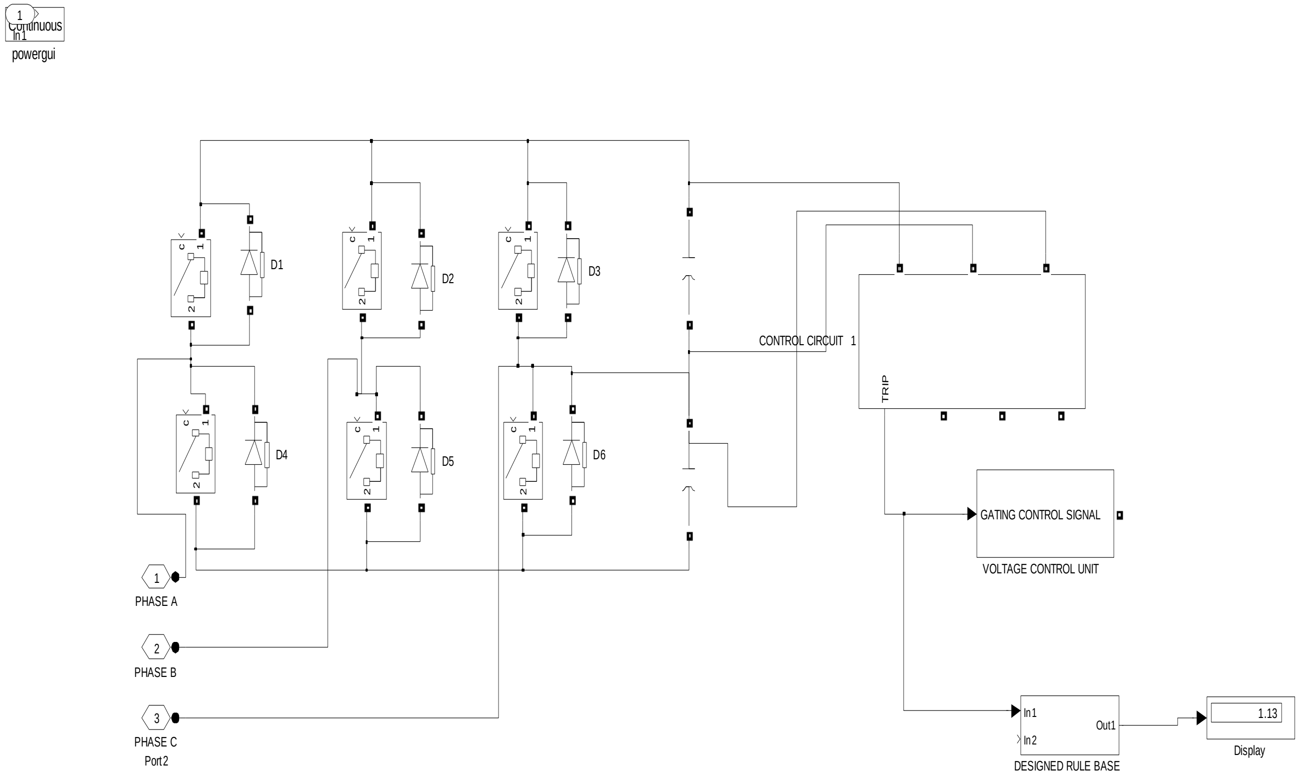

Fig. 5. Integrated designed SIMULINK model for a line reactor to designed rule base

Designing a SIMULINK Model for Improving Voltage Stability of the network Using Intelligent Reactor

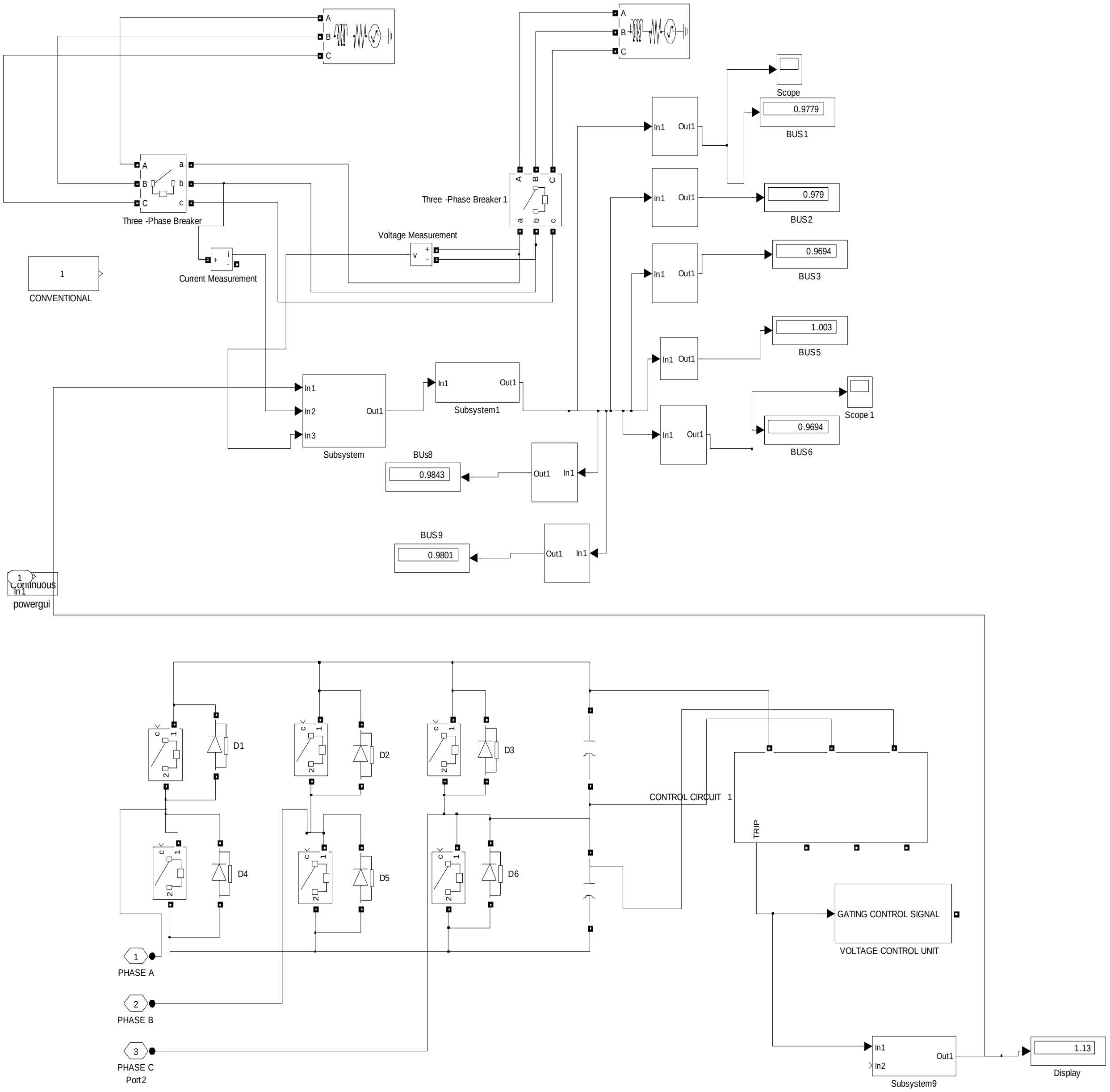

Fig. 6. Designed SIMULINK model for improving voltage stability in Nigerian 132KV transmission network using intelligent line Reactor

RESULTS AND DISCUSSION

The simulated results are shown graphically in figures 7 and 8 respectively. A closer look at Table 1 displays a comparison between a conventional and intelligent Var load(VL) in bus1 of the Nigerian 132kV transmission network to improve voltage stability. Buses 1, 2, 3, 5, 6, 8, and 9 with per unit volts of 0.920, 0.921, 0.912, 0.944, 0.912, 0.926, and 0.922 are shown in fig 1. Figure 2 depicts a standard model for voltage stability in a 132kV transmission network in Nigeria. The designed SIMULINK model for the Reactor shown in Figure 3.

Figure 4 depicts a developed rule basis that will improve the voltage stability of problematic buses. There are three rules in all. Figure 5 depicts the incorporated designed SIMULINK model for the Reactor to the designed rule base. Figure 6 displays a SIMULINK model that uses an intelligent line Reactor to improve voltage stability in a Nigerian 132KV transmission network; the results obtained after simulation are as shown in figures 7 and 8.

Figure 7 compares conventional and intelligent Reactor in bus1. Figure 8 compares traditional intelligent line Reactor in bus9 for enhancing voltage stability in Nigeria's 132kv transmission network.

Figure 7 contrasts conventional and intelligent Reactor in bus1 to improve voltage stability of the tansmission network.The conventional per unit volts on bus1 is 0.92P.U.volts, which did not exceed the voltage stability range of 0.95 to 1.05 P.U.volts. When an intelligent Var Load is added to the system, the per unit volts rise to 0.9779P.U.volts, resulting in improved power supply voltage stability.

Table-2

Comparison between Conventional mode and Intelligent Reactor Load

Time (s)	Conventional voltage in **bus1 of** improving voltage stability in Nigerian 132/330kv transmission network(P.U.VOLTS)	intelligent Reactor in **bus1 of** improving voltage stability in Nigerian 132/330kv transmission network(P.U.VOLTS)
0	0	0
1	0.58	0.6
2	0.8	0.85
3	0.87	0.92
4	0.92	0.9779
10	0.92	0.9779

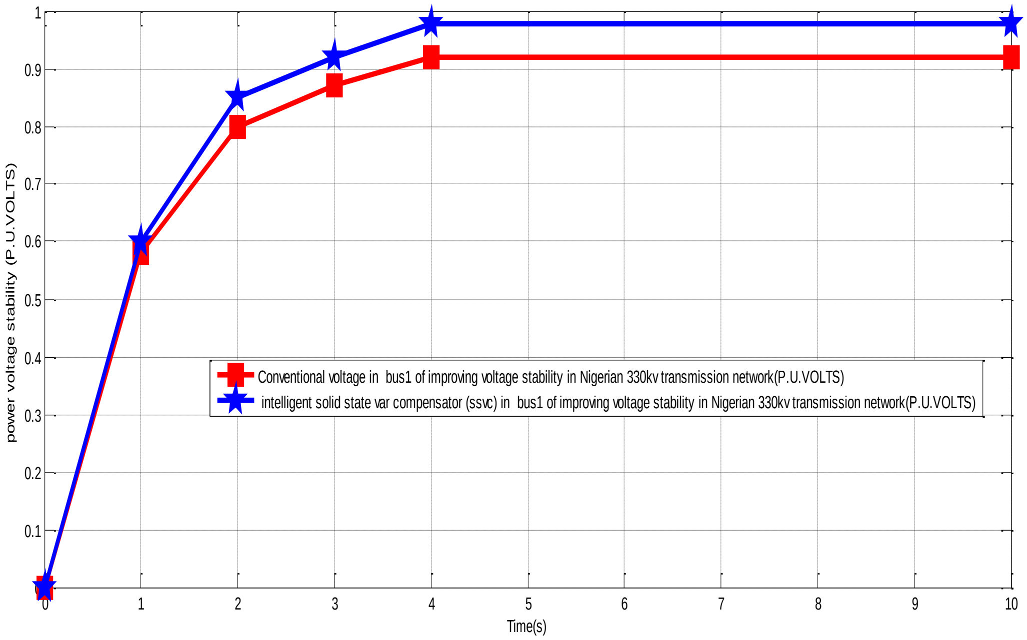

Fig 7 comparing conventional and intelligent line Reactor in bus1 of improving voltage stability in Nigerian 132 kV transmission network.

Table 2 comparison between a conventional and intelligent line Reactor in bus 9 of improving voltage stability of the Transmission Network.

Time (s)	Conventional voltage in **bus9 of** improving voltage stability in Nigerian 132/330kv transmission network(P.U.VOLTS)	intelligent solid state var compensator (ssvc) in **bus9 of** improving voltage stability in Nigerian 132/330kv transmission network(P.U.VOLTS)
0	0	0
1	0.58	0.6
2	0.8	0.85
3	0.88	0.93
4	0.922	0.9801
10	0.922	0.9801

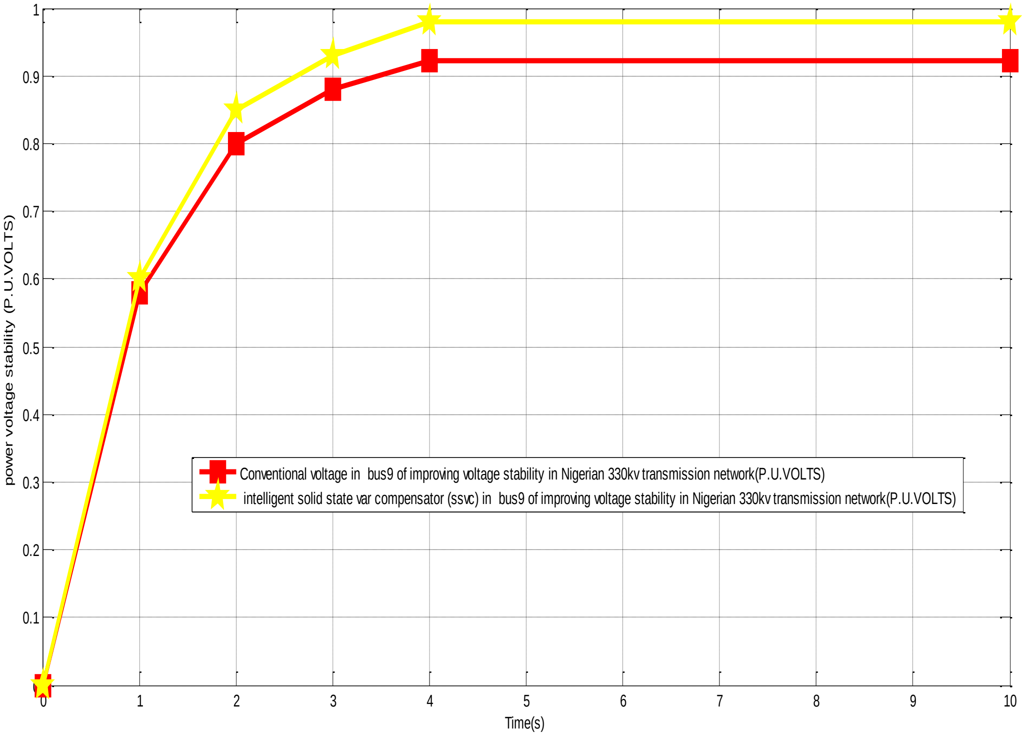

Fig.8 comparison between a conventional and intelligent Line Reactor in bus 9 of improving voltage stability of the Transmission Network

CONCLUSION

This paper outlines a method for reducing voltage instability in southern Nigeria's transmission network, with a focus on the Afam–PortHarcout short transmission line (60km). Power system instability in Nigeria's transmission network has become a big concern; as a result of the voltage instability, companies no longer rely on public utilities for power. The deployment of an intelligent Line Reactor to improve voltage stability in Nigeria's 132 and 330kv transmission network mitigates this endermic problem. To complete this assignment, the following steps were taken: executing the load flow from the described data, detecting the problematic buses whose per unit volts do not fall within the ranges of 0.95 through 1.05, and constructing a typical voltage stability model.

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