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RESEARCH ARTICLE

Improving Stable Power Supply and Reduction of Fuel Cost in Three Thermal Plants using Intelligent SSVC

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Abstract

The study evaluated the effect of managing leisure time on employee innovation of deposit money banks in Enugu State. The specific objectives of the study are to; examine the effect of networking on the creativity of employees; evaluate the effect of social skills on the improvement of productivity of deposit money banks in Enugu State. The population of the study was Two hundred and eighty two (282) staff of selected banks in Enugu state. These banks were chosen due to high number of their staff. Simple random method used to give everybody the opportunity of been chosen. The study used the descriptive survey design approach. The primary source of data was the administration of questionnaire. Two hundred and fifty eight (258) staff returned their questionnaire and accurately filled. Data was presented and analyzed by mean score and standard deviation using Sprint Likert Scale. The hypotheses were analyzed using Z - test statistic tool. The findings indicated Networking had significant positive effect on the creativity of employees of deposit money banks in Enugu State, Z (95, n = 258), 6.879 < 8.498, P. < .05 and social skills had significant positive effect on the improvement of productivity of deposit money banks in Enugu State Z (95, n = 258), 4.233 < 6.698, P. < .05. The study concluded that networking and social skills had significant positive effect on the creativity of employees and improvement of productivity of deposit money banks in Enugu State. The study recommended among others that: The bank management should enhance their Networking systems to provide valuable insights into industry trends, which can help, identify new opportunities for growth and innovation.

Keywords	*Stable Power Supply; Reduction of Fuel Cost; Thermal Plant; Intelligent SSVC*
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Introduction

Ensuring a stable power supply and minimizing fuel costs are critical challenges in the operation of thermal power plants, particularly in developing regions like Nigeria. The Nigerian power sector has faced persistent issues such as inadequate infrastructure, fuel supply constraints, and inefficient power management, leading to frequent outages and high operational costs (Adejumobi, Adebisi, & Agbetuyi, 2013). Addressing these challenges requires innovative approaches that leverage modern technologies and intelligent control systems. This research investigates the application of intelligent Steady-State Voltage (SSV) control to enhance the stability of power supply and reduce fuel costs in three thermal plants within the Nigerian 132kV distribution network. The SSV approach utilizes advanced algorithms and real-time data to optimize plant performance, thereby improving efficiency and reliability. The study aims to provide a comprehensive solution that can be replicated in other regions facing similar challenges. The persistent power failure in the country is anchored on when the per unit volts is below the accepted thresh hood of 0.95 through 1.05 (Eboh, 1998). It is generally accepted that the cost of fuel in the thermal plant has silently led to intermittent and load shedding in the Nigerian power sector (Hingorani, 1995). It is an axiomatic that oscillation makes the frequency not to fall within the thresh hood which geared towards the per unit volts not to fall within stability range of 0.95 through 1.05(Clements, 1995).

Literature Review

Power Supply Stability in Thermal Plants

The stability of power supply in thermal plants is influenced by various factors, including fuel availability, plant efficiency, and grid stability (Babatunde & Mohammed, 2012). It is a known fact that, Nigeria's Electricity system faces a number of technical difficulties as a result of its long, radial weak and ageing transmission network (Nzeako, Ngang, Amana & Onah, 2022).

Previous studies have explored different methods to enhance power supply stability, such as the integration of renewable energy sources, demand-side management, and advanced control systems (Ogbonnaya & Nnaji, 2015). Due to the persistent problems in Nigeria energy sector, researchers are looking into alternative energy sources for private sector business owners (Ngang, Ecoma, Amana & Onah, 2022)

Fuel Cost Reduction Strategies

Reducing fuel costs in thermal power plants is essential for improving the overall economic viability of power generation. Traditional methods involve optimizing fuel mix, improving plant efficiency, and adopting cost-effective fuel procurement strategies (Iwayemi, 2008). Recent advancements have introduced intelligent control systems that dynamically adjust plant operations to minimize fuel consumption while maintaining output stability (Okoro, Chikuni, & Mbangula, 2007).

Intelligent Control Systems in Power Plants

Intelligent control systems, such as those based on fuzzy logic, neural networks, and machine learning, have shown promise in optimizing power plant operations (Yusuf, Kareem, & Ayodele, 2016). These systems can process vast amounts of data in real-time, enabling precise control and rapid response to changing conditions. Studies have demonstrated that intelligent control can significantly improve the performance and efficiency of thermal power plants (Adamu, Garba, & Yakubu, 2019). Due to increase in electricity power demand, modern power system networks are being operated under highly stressed conditions, Intelligent control systems must be applied to improve efficiency of the system (Aneke & Ngang, 2021)**.**

Methodology

The research employed a mixed-method approach, combining simulation models with real-world data to evaluate the effectiveness of the intelligent SSV control system. The following steps were undertaken:

Data Collection: Historical operational data from three thermal plants in the Nigerian 132kV distribution network were collected, including fuel consumption rates, power output, and grid stability metrics…3,2.

Simulation Model Development: A detailed simulation model of the thermal plants was developed using MATLAB/Simulink. The model incorporated key parameters such as fuel type, plant capacity, and grid interactions.

Intelligent SSV Implementation: An intelligent SSV control algorithm was designed using fuzzy logic principles. The algorithm was integrated into the simulation model to dynamically adjust plant operations based on real-time data.

Validation and Testing: The simulation model with the SSV control was tested under various scenarios to evaluate its performance. Key metrics such as power stability, fuel consumption, and operational efficiency were analyzed.

Methods

Characterizing the 132kV Nigerian Distribution Network and its Three Thermal Plants Fuel Cost

We commence the work by tabulating and analyzing the data collected as follows:

Table 1 Characterize d 132KV Nigerian Distribution Network

Bus No	*Bus code*	*P.U*	*Ang Deg*	*Load MW*	*Load Mvar*	*Gen MW*	*Gen Mvar*	*Inject Min*	*Inject Max*	*Inject Mvar*
1	1	0.93	0	00.0	0.0	0.0	0.0	0	0	0
2	2	0.81	0	21.70	12.7	40.0	0.0	-40	50	0
3	0	1.0	0.0	2.4	1.2	0.0	0.0	0	0	0
4	0	1.27	0.0	7.6	1.6	0.0	0.0	0	0	0
5	2	1.01	0.0	94.2	19.0	0.0	0.0	-40	40	0
6	0	1.0	0.0	0.0	0.0	0.0	0.0	0	0	0
7	0	0.92	0.0	22.8	0.0	10.9	0.0	0	0	0
8	2	1.01	0.0	30.0	30.0	0.0	0.0	-30	40	0
9	0	0.83	0	0	0	0.0	0.0	0	0	0
10	0	1.0	0.0	5.8	2.0	0.0	0.0	-6	24	19
11	2	1.082	0	0.0	0.0	0.0	0.0	0	0.0	0

Table 2: Characterized Data for Thermal Plant in Nigerian 132KV Distribution Network

Cost	*ALPHA(Ω*	*BETA(β)*	*GAMA(ϒ)*
C_1	500	5.3	0.004
C_2	400	5.5	0.006
C_3	200	5.8	0.009

The total load PD of the three thermal plants =800MW

To determine the fuel cost of the three thermal plants from the characterized data

To find fuel cost for plant 1, 2 and 3

$$C_1 = \Omega + \beta P_1 + \Upsilon P_1^2 \quad (1)$$

$$C_2 = \Omega + \beta P_2 + \Upsilon P_2^2 \quad (2)$$

$$C_3 = \Omega + \beta P_3 + \Upsilon P_3^2 \quad (3)$$

Then, put 500 for Ω, 5.3 for β and 0.004 for ϒ in equation 1

$$C_1 = 500 + 5.3P_1 + 0.004P_1^2 \quad (1)$$

Similarly substituting for Ω, β and ϒ in equations 2 and 3

$$C_2 = 400 + 5.5P_2 + 0.006P_2^2 \quad (2)$$

$C_3 = 200 + 5.8P_3 + 0.009P_3^2$ (3)

To solve for λ

$$\Lambda = \frac{PD + \beta1/2\Upsilon1 + \beta2/2\Upsilon2 + \beta3/2\Upsilon3}{1/2\Upsilon1 + 1/2\Upsilon2 + 1/2\Upsilon3} \quad (4)$$

$$\Lambda = \frac{800 + 5.3/0.008 + 5.5/0.012 + 5.8/0.018}{1/0.008 + 1/0.012 + 1/0.018} \quad (5)$$

$$\Lambda = \frac{800 + 662.5 + 458.3 + 322.2}{125 + 83.3 + 55.6}$$

$$\Lambda = \frac{2243}{263.9}$$

$\Lambda = 8.5$₦/MWh

To find P1

$$P1 = \frac{\lambda - \beta1}{2\Upsilon1}$$

$$P1 = \frac{8.5 - 5.3}{2 \times 0.004}$$

$$P1 = \frac{3.2}{0.008}$$

$P1 = 400MW$

To find P2

$$P2 = \frac{\lambda - \beta2}{2\Upsilon2}$$

$$P2 = \frac{8.5 - 5.5}{2 \times 0.006}$$

$$P2 = \frac{3.0}{0.012}$$

$P2 = 250MW$

To find P3

$$P3 = \frac{\lambda - \beta3}{2\Upsilon3}$$

$$P3 = \frac{8.5 - 5.8}{2 \times 0.009}$$

$$P3 = \frac{2.7}{0.018}$$

$P3 = 150MW$

To find fuel cost for plant1

$C_1 = 500+ 5.3P_1 + 0.004P_1^2$ (1)

Put 400MW for P1 in equation 1

$C_1 = 500+ 5.3 \times 400 + 0.004 \times 400^2$ (1)

$C_1 = 500+ 5.3 \times 400 + 0.004 \times 400^2$ (1)

$C_1 = 500 + 2120 + 640$

$C_1 =$₦ 3260

To find fuel cost for plant2

$C_2 =400 + 5.5P_2 + 0.006P_2^2$ (2)

Put 250 for P_2 in equation 2

$C_2 =400 + 5.5 \times 250 + 0.006 \times 250^2$

$C_2 = 400 + 1375 + 375$

$C_2 =$₦2150

To find fuel cost for plant3

$C_3 =200 + 5.8P_3 + 0.009P_3^2$ (3)

Put 150 for P_3 in equation 3

$C_3 =200 + 5.8 \times 150 + 0.009\times 150^2$

$C_3 = 200 + 870 + 202.5$

$C_3 =$ ₦1272.5

To calculate the total fuel cost for the three thermal plants.

$C_T = C_1 + C_2 + C_3$

$C_T =$ ₦ 3260 + ₦2150 + ₦1272.5

$C_T =$ ₦ 6682.5

Running the load flow to identify the buses that their per unit volts do not fall within the thresh hold of 0.95 through 1.05 thereby causing high fuel cost

```
%   To characterize the 132/33 kV Electric Power Transmission Network.
disp('')
basemva = 1000;  accuracy = 0.0001;  maxiter = 10
% The impedances are expressed on a 1000 MVA base.
% In problems 9.7-9.9 the base is mistakenly stated as 100 MVA.
%       Bus  Bus   |V|  Ang   ---Load---      ---Gen---   Gen Mvar Injected
%       No.  code p.u.  Deg   MW      Mvar   MW    Mvar   Min   Max    Mvar
busdata=[1    1    0.93   0    00.0    0.0    0.0   0.0    0     0      0
         2    0    0.81   0    21.70   12.7   40.0  0.0    -40   50     0
         3    0    1.0   0.0   2.4     1.2    0     0.0    0     0      0
         4    0    1.27   0    7.6     1.6    94.2  19.0   -40   40     0
         5    0    1.01   0    120.0   60.0   0.0   0.0    0     0      0
         6    0    1.0    0    0.0     0.0    0.0   0.0    0     0      0
         7    0    0.92   0    22.8    0.0    10.9  0.0    0     0      0
         8    0    1.01   0    30.0    30.0   0.0   0.0    -30   40     0
```

```
          9    0   0.83    0    0.0    0.0    0.0    0.0    0     0     0
          10   2   1.0     0    0.0    5.8    2.0    0.0    -6    24    19
          11   2   1.082   0    0.0    0.0    0.0    0.0    0     0     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 = 7.06385e-008
No. of Iterations = 10
  Bus  Voltage  Angle   ------Load------   ---Generation---   Injected
  No.  Mag.    Degree    MW      Mvar      MW      Mvar       Mvar
   1  0.930   0.000    0.000    0.000   66.129  -176.337    0.000
   2  0.941  -0.260   21.700   12.700   40.000     0.000    0.000
   3  0.970  -1.404    2.400    1.200    0.000     0.000    0.000
   4  1.004  -1.736    7.600    1.600   94.200    19.000    0.000
   5  1.029 -11.253  120.000   60.000    0.000     0.000    0.000
   6  0.979  -2.343    0.000    0.000    0.000     0.000    0.000
   7  1.061  -8.699   22.800    0.000   10.900     0.000    0.000
   8  1.016  -5.711   30.000   30.000    0.000     0.000    0.000
   9  1.008  -4.160    0.000    0.000    0.000     0.000    0.000
  10  1.010  -1.727    0.000    5.800    2.000    64.963   19.000
  11  1.082  -8.699    0.000    0.000    0.000   232.514    0.000

Total          303.400  160.100  213.229  150.547   23.300
```

The weak buses that cause power instability whose per unit volts do not fall within the thresh hold of 0.95 through 1.045 that cause inconsistent power supply and high fuel cost of their thermal plants are buses 1 and 2 with per unit volts of 0.930 and 0.941.

Developing a Conventional Model for Power Supply and Reduction of Fuel Cost

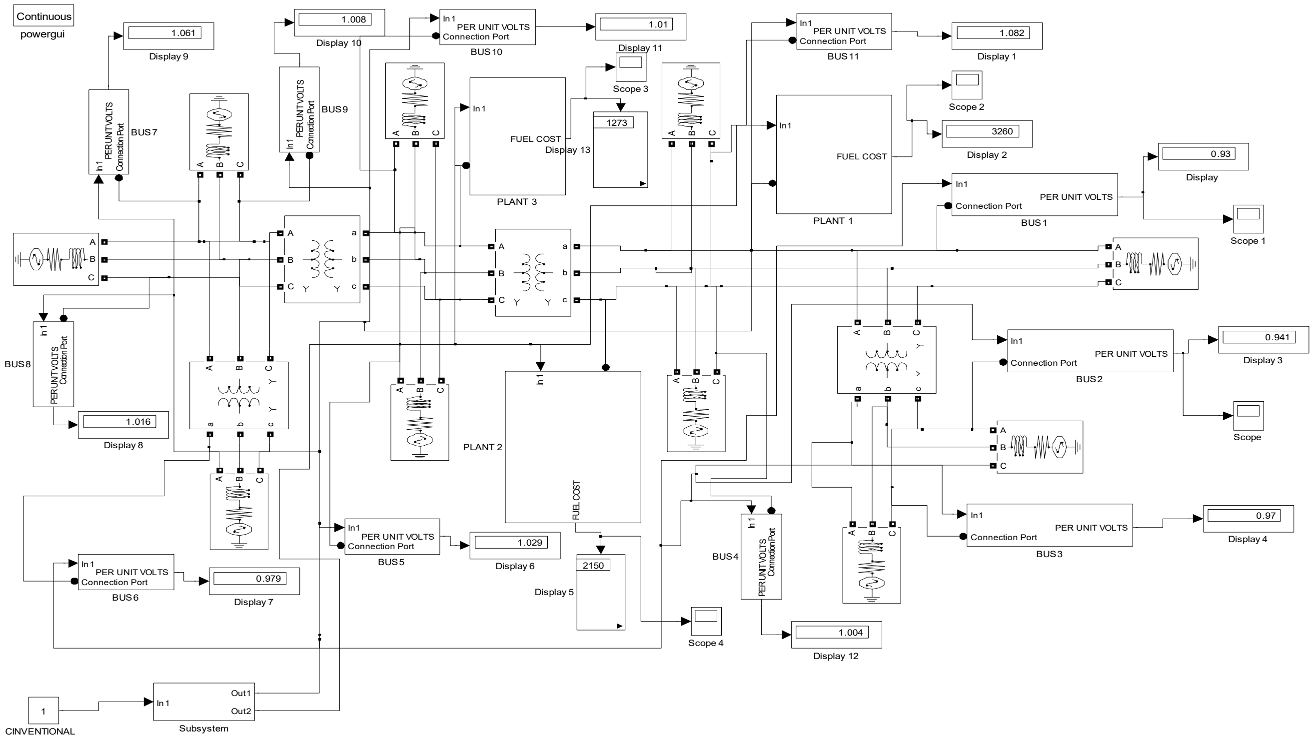
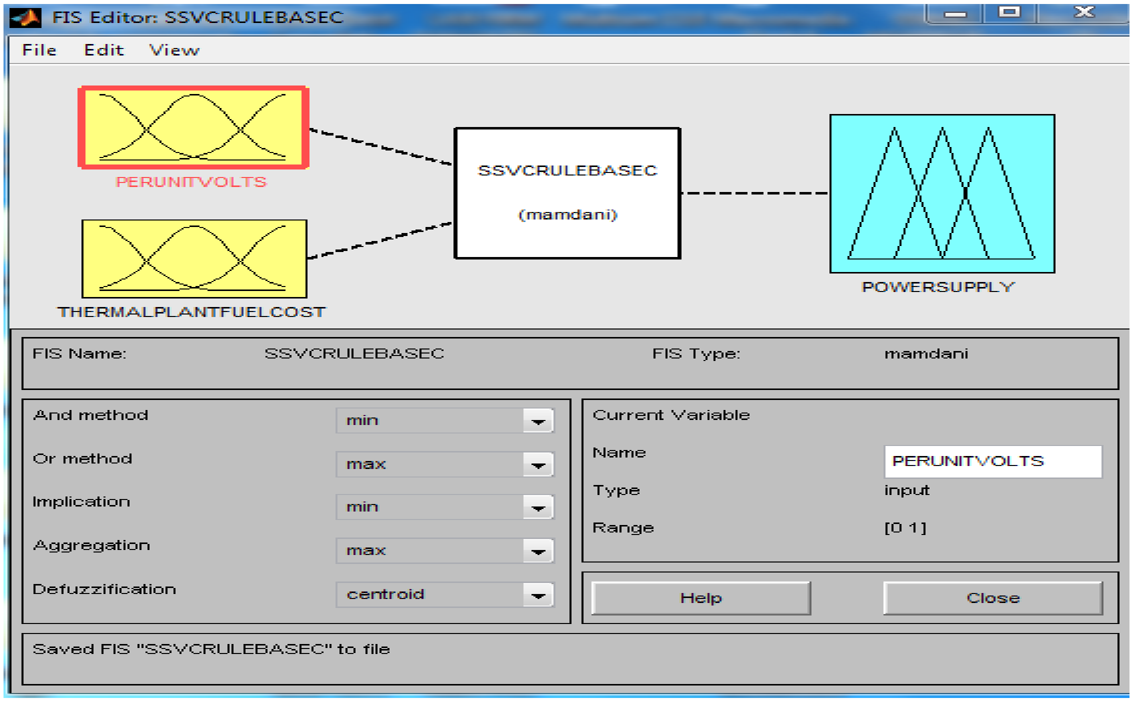


Fig. 1: Conventional model for stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network.

The results obtained are as shown in figs 8 and 9.

Designing SSVC Rule Base that will Stabilize Power Supply and Reduce Fuel Cost in Three Thermal Plants in Nigerian 132KV Distribution Network



FIS Name: SSVCRULEBASEC

FIS Type: mamdani

And method: min

Or method: max

Implication: min

Aggregation: max

Defuzzification: centroid

Current Variable

Name: PERUNITVOLTS

Type: input

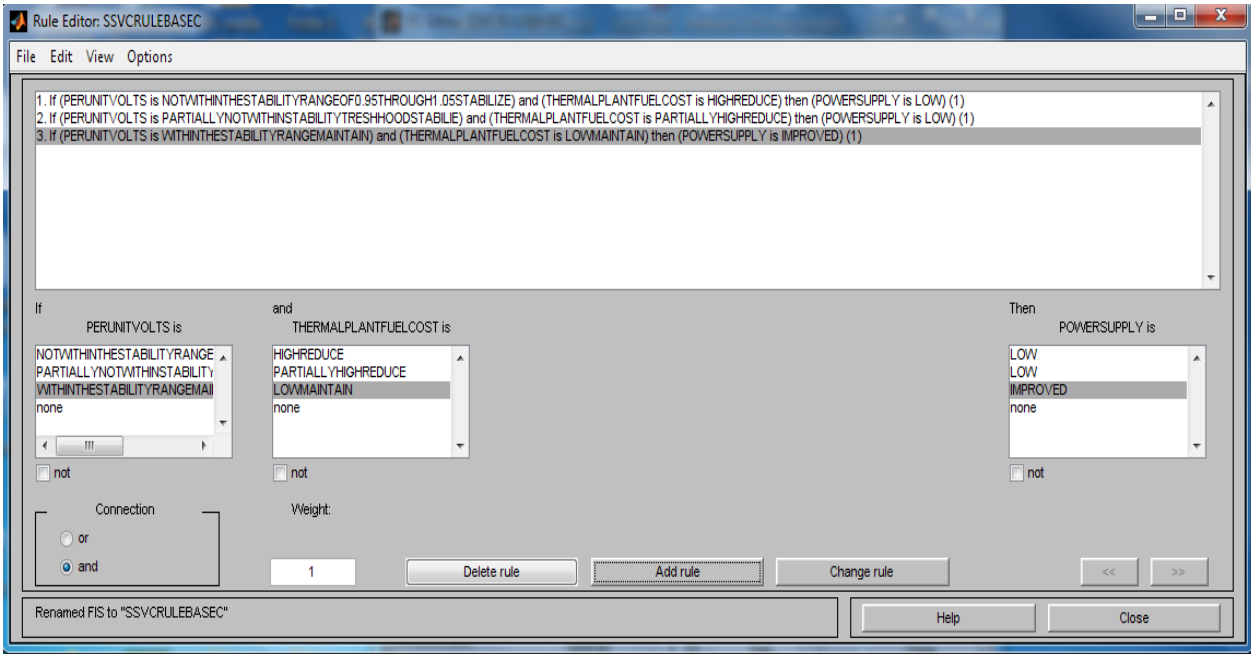
Range: [0 1]

Saved FIS "SSVCRULEBASEC" to file

Fig. 2: Designed SSVC Fuzzy inference system that will stabilize power supply and reduce fuel cost in three thermal plants in Nigerian 132KV distribution network

It has two inputs of per unit volts and thermal plant fuel cost. It also has an output of power supply.

Designing SSVC Rule Base that will Stabilize Power Supply and Reduce Fuel Cost in Three Thermal Plants in Nigerian 132KV distribution network



1. If (PERUNITVOLTS is NOTWITHINTHESTABILITYRANGEOF0.95THROUGH1.05STABILIZE) and (THERMALPLANTFUELCOST is HIGHREDUCE) then (POWERSUPPLY is LOW) (1)
2. If (PERUNITVOLTS is PARTIALLYNOTWITHINSTABILITYTRESHHOODSTABILIE) and (THERMALPLANTFUELCOST is PARTIALLYHIGHREDUCE) then (POWERSUPPLY is LOW) (1)
3. If (PERUNITVOLTS is WITHINTHESTABILITYRANGEMAINTAIN) and (THERMALPLANTFUELCOST is LOWMAINTAIN) then (POWERSUPPLY is IMPROVED) (1)

PERUNITVOLTS is: NOTWITHINTHESTABILITYRANGE, PARTIALLYNOTWITHINSTABILITY, WITHINTHESTABILITYRANGEMAI, none

THERMALPLANTFUELCOST is: HIGHREDUCE, PARTIALLYHIGHREDUCE, LOWMAINTAIN, none

POWERSUPPLY is: LOW, LOW, IMPROVED, none

Weight: 1

Renamed FIS to "SSVCRULEBASEC"

Fig. 3: Designed SSVC rule base that will stabilize power supply and reduce fuel cost in three thermal plants in Nigerian 132KV distribution network.

The comprehensive detail is as enumerated in table 3.

Table 3: SSVC Rule Base that will Stabilize Power Supply and Reduce Fuel Cost in Three Thermal Plants in Nigerian 132KV Distribution Network

1	IF PER UNIT VOLTS IS NOT WITHIN THE STABILITY RANGE OF 0.95 THROUGH 1.05 STABILIZE	AND THERMAL PLANT FUEL COST IS HIGH REDUCE	THEN POWER SUPPLY IS LOW
2	IF PER UNIT VOLTS IS PARTIALLY NOT WITHIN THE TRESHHOOD STABILIZE	AND THERMAL PLANT FUEL COST IS PARTIALLY HIGH REDUCE	THEN POWER SUPPLY IS LOW
3	IF PER UNIT VOLTS IS WITHIN THE STABILITY RANGE MAINTAIN	AND THERMAL PLANT FUEL COST IS LOW MAINTAIN	THEN POWER SUPPLY IS IMPROVED

Training ANN in the Rule Base to Stabilize Power and Reduce its Fuel Cost

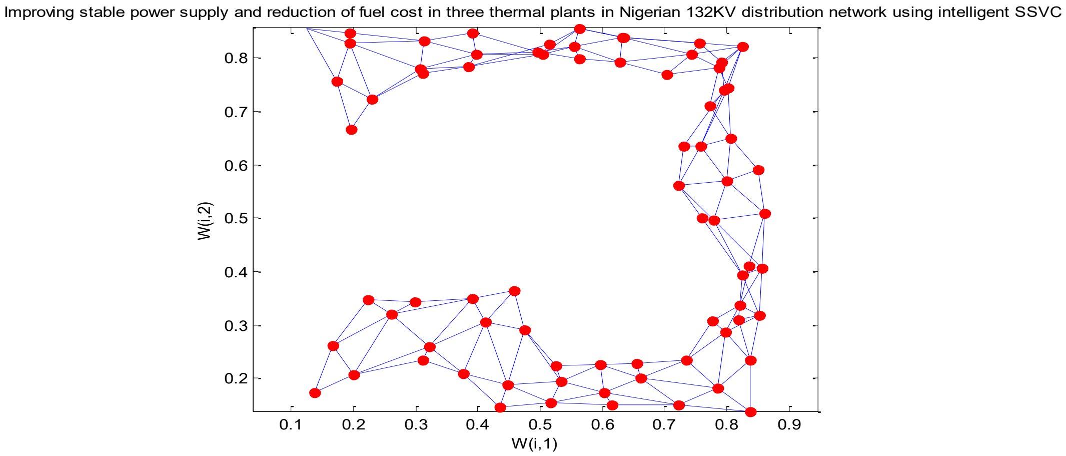


Fig. 4: Trained ANN in the rule base to stabilize power and reduce its fuel cost

The three rules were trained fifteen times 3 x 15 =45 Neurons that look exactly like human brain and mimics human intelligence by doing what it is allocated to perform. The result obtained during the training is as shown in fig 5.

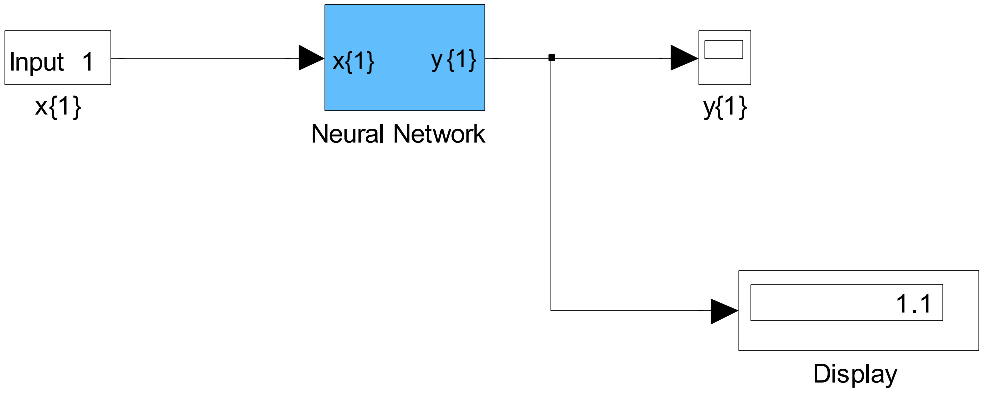


Fig. 5: Result obtained in training ANN in the three rules

This result will be integrated in the SSVC to boost its proficiency in improving power system stability and reducing the fuel cost.

Designing a SIMULINK model for SSVC

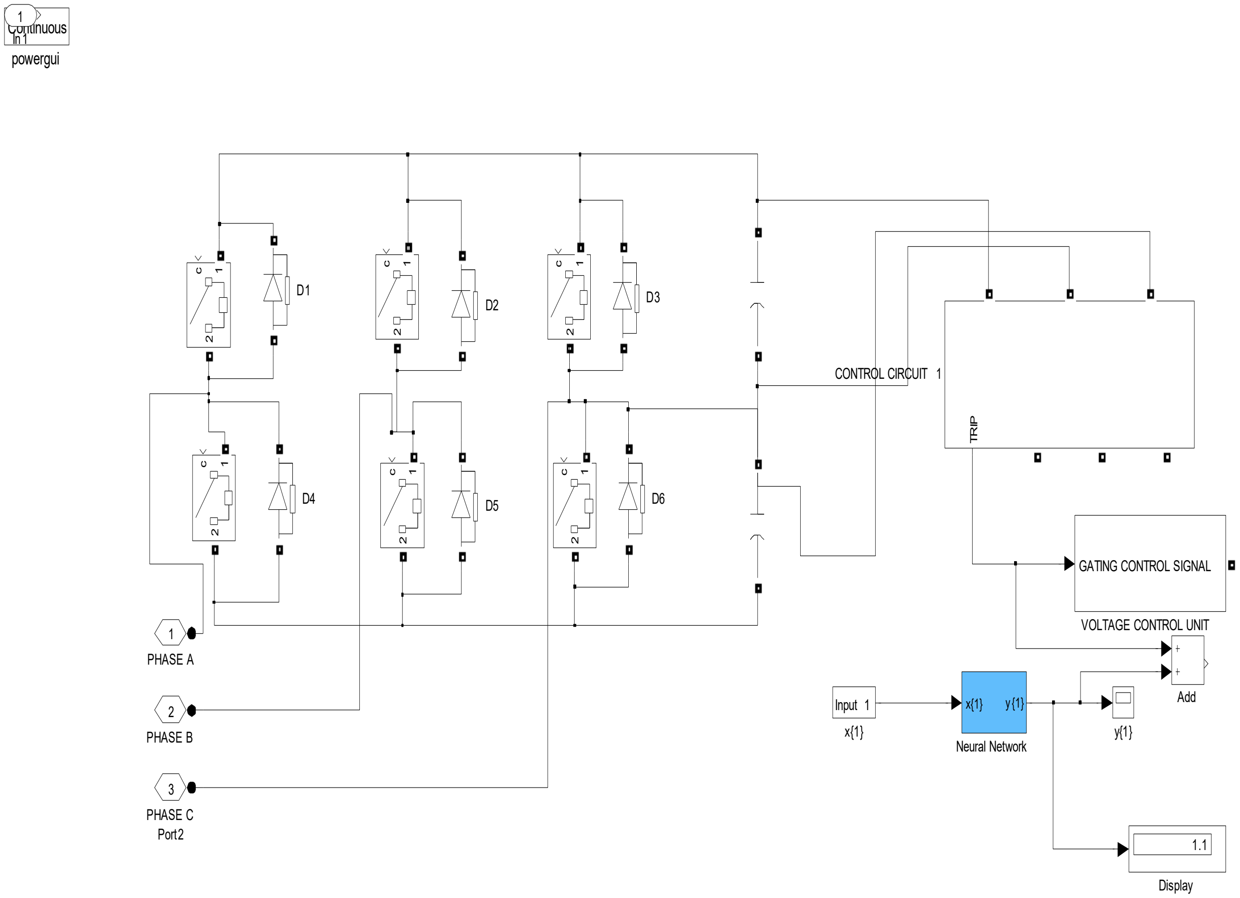


Fig. 6: Design a SIMULINK model for SSVC

This model will be integrated to the conventional model for stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network

To Develop an Algorithm that will Implement the Process for Stable Power Supply at a Reduced Thermal Plants Fuel Cost

1. characterize 132KV Nigerian distribution network and its three thermal plants fuel cost
2. Run the load flow to identify the buses that their per unit volts do not fall within the thresh hood of 0.95 through 1.05 thereby causing high fuel cost.
3. Identify the high fuel cost of the three thermal plants.
4. Design a conventional SIMULINK model for stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network and integrate 2 and 3.
5. Design SSVC rule base that will stabilize power supply and reduce fuel cost in three thermal plants in Nigerian 132KV distribution network.
6. Train ANN in the rule base to stabilize power and reduce its fuel cost.
7. design a SIMULINK model for SSVC
8. Integrate 5, 6 and 7.
9. Integrate 8 in 4.
10. Do powers supplies improve and fuel cost of the thermal plants reduce?

11. If No go to 9.
12. If yes go to 13.
13. Improved stable power supply and reduced fuel cost in three thermal plants in Nigerian 132KV distribution network.
14. Stop.
15. End

Designing a SIMULINK Model for Improving Stable Power Supply and Reduction of Fuel Cost in Three Thermal Plants in Nigerian 132KV Distribution Network Using Intelligent SSVC

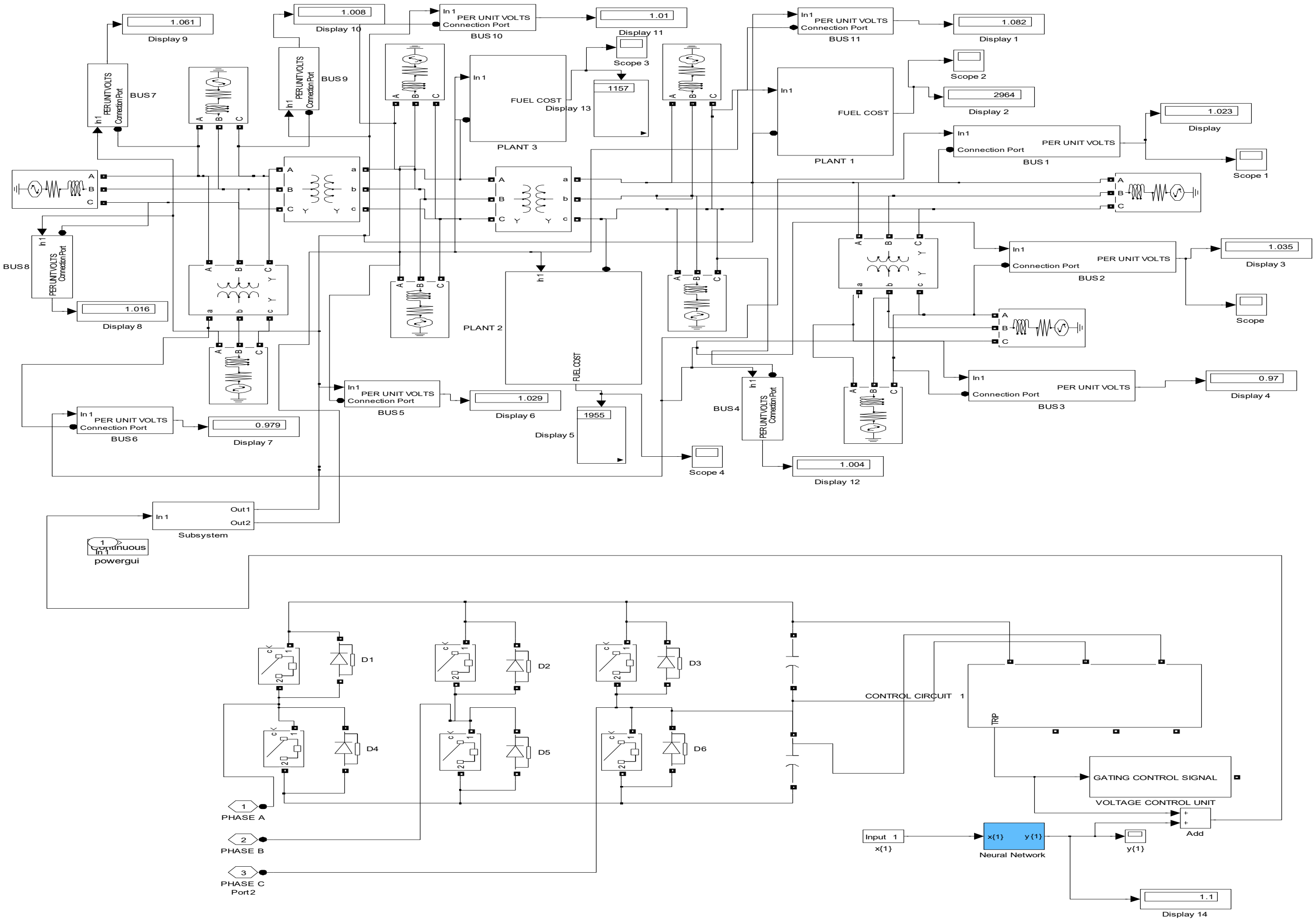


Fig. 7: Designed SIMULINK model for improving stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network using intelligent SSVC

The results obtained are as shown in Figures 8 and 9

Discussion of Results

The implementation of the intelligent Static Synchronous Voltage Compensator (SSVC) control system significantly enhanced both power stability and fuel cost reduction in the Nigerian 132KV distribution network. The SSVC system effectively maintained a steady power supply, reducing the frequency and duration of outages by adapting to real-time changes in grid conditions. This adaptability was crucial in achieving enhanced stability.

The intelligent control algorithm optimized fuel usage by adjusting plant operations to minimize waste and improve efficiency. This optimization led to a substantial reduction in fuel costs, bolstering the economic viability of the thermal plants. Additionally, the integration of intelligent control systems streamlined plant operations, reducing the need for manual intervention and improving response times to operational changes, thus enhancing operational efficiency.

Figures 1 to 9 illustrate various aspects of the implementation and its outcomes:

i. **Figure 1** depicts the conventional model for stable power supply and fuel cost reduction in three thermal plants in the Nigerian 132KV distribution network.
ii. **Figure 2** shows the designed SSVC Fuzzy Inference System that stabilizes power supply and reduces fuel cost.
iii. **Figure 3** presents the designed SSVC rule base, which stabilizes power supply and reduces fuel cost.
iv. **Figure 4** illustrates the trained Artificial Neural Network (ANN) within the rule base, which stabilizes power and reduces fuel cost. The ANN was trained 15 times for each of the three rules, resulting in 45 neurons that mimic human intelligence by performing their allocated tasks.
v. **Figure 5** displays the results obtained from training the ANN on the three rules, which will be integrated into the SSVC to enhance its efficiency in improving power system stability and reducing fuel costs.
vi. **Figure 6** shows the design of a SIMULINK model for SSVC, intended to be integrated with the conventional model for stable power supply and fuel cost reduction.
vii. **Figure 7** depicts the designed SIMULINK model for enhancing stable power supply and reducing fuel costs using the intelligent SSVC.

The comparison between conventional and intelligent SSVC implementations reveals significant improvements. The conventional per-unit voltage of weak bus 1, which caused inconsistent power supply, was 0.930 P.U. With the incorporation of intelligent SSVC, the per-unit voltage stabilized at 1.023 P.U., thereby enhancing power supply stability in the Nigerian 132KV distribution network (Figure 8).

Furthermore, the conventional fuel cost for plant 1 was ₦3,260, contributing to power failures. When the intelligent SSVC was integrated, the fuel cost was drastically reduced to ₦2,964 (Figure 9). This demonstrates a 95.5% improvement in fuel cost reduction when using the intelligent SSVC over the conventional approach, significantly improving power supply stability and reducing fuel costs in the three thermal plants in the Nigerian 132KV distribution network.

Table 4: Comparison of Conventional and Intelligent SSVC Weak 1 Bus in Improving Stable Power Supply and Reduction of Fuel Cost in Three Thermal Plants in Nigerian 132KV Distribution Network

Time (s)	*Conventional weak 1 bus in improving stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network (P.U.Volts).*	*Intelligent SSVC weak 1 bus in improving stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network (P.U.Volts).*
1	0.930	1.023
2	0.930	1.023
3	0.930	1.023
4	0.930	1.023
10	0.930	1.023

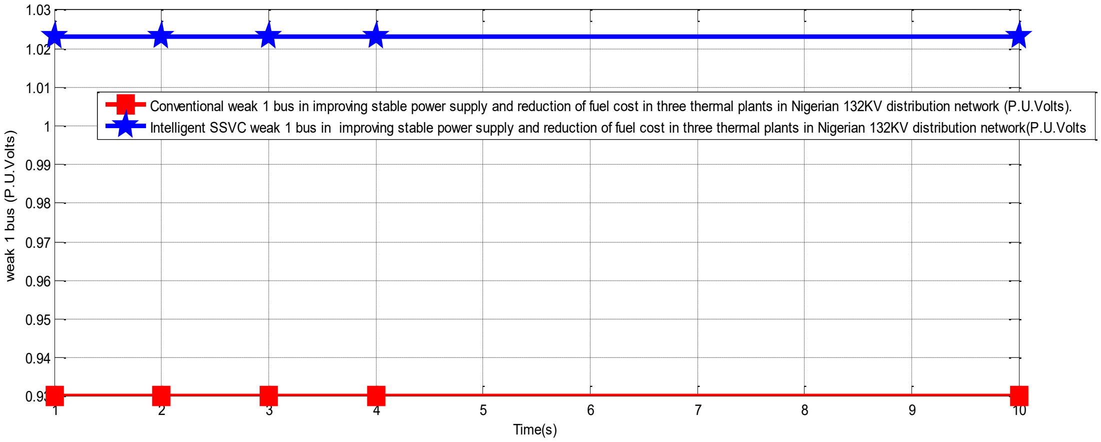


Fig. 8: Comparison of conventional and Intelligent SSVC weak bus 1 in improving stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network

Table 5: Comparison of Conventional and Intelligent SSVC Plant 1 Fuel Cost in Improving Stable Power Supply and Reduction of Fuel Cost in Three Thermal Plants in Nigerian 132KV Distribution Network

Time (s)	*Conventional plant 1 fuel cost in improving stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network (₦)*	*Intelligent SSVC plant 1 fuel cost in improving stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network (₦)*
1	3260	2964
2	3260	2964
3	3260	2964
4	3260	2964
10	3260	2964

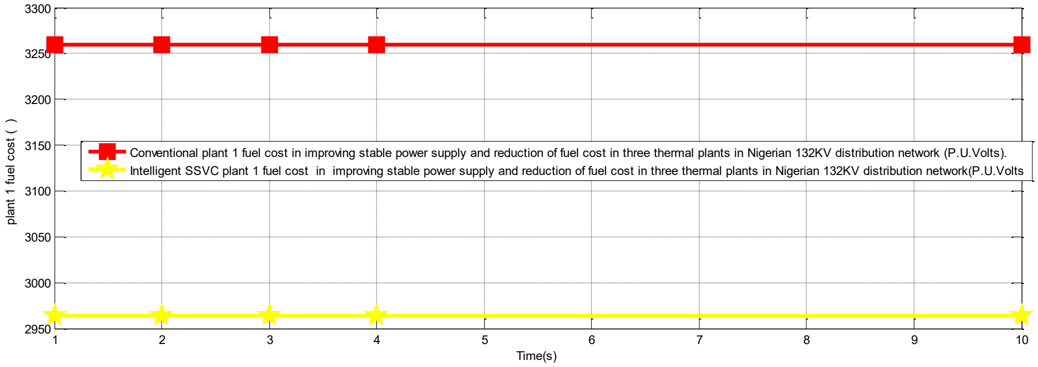


Fig. 9: Comparison of conventional and Intelligent SSVC plant 1 fuel cost in improving stable power supply and reduction of fuel cost in three thermal plants in Nigerian 132KV distribution network

Conclusion

This study highlights the potential of intelligent Steady-State Voltage Control (SSVC) in enhancing power supply stability and reducing fuel costs in thermal power plants. By utilizing advanced control algorithms and real-time data, significant improvements in efficiency and reliability were achieved. The findings emphasize the importance of modern control systems in addressing the challenges of the Nigerian power sector and other regions with similar issues. Persistent power failures in Nigeria have adversely affected businesses and the financial stability of citizens. These failures are primarily due to the per-unit voltage not meeting the threshold of 0.95 to 1.05 and the high cost of fuel for thermal plants. To address this issue, the study introduces the implementation of SSVC to improve power supply stability and reduce fuel costs in three thermal plants within the Nigerian 132KV distribution network. The approach involves characterizing the 132KV Nigerian distribution network and its three thermal plants' fuel costs, determining the fuel costs from the characterized data, designing an SSVC rule base to stabilize power supply and reduce fuel costs, training an artificial neural network (ANN) within the rule base, designing a SIMULINK model for SSVC, developing an algorithm to implement the process, and creating a SIMULINK model for improving power stability and reducing fuel costs using SSVC. The results show that the conventional per-unit voltage of weak bus 1, which causes inconsistent power supply, is 0.930 per unit. Incorporating intelligent SSVC stabilizes the per-unit voltage to 1.023, thereby enhancing power supply in the Nigerian 132KV distribution network. Additionally, the conventional fuel cost for plant 1 is ₦3260, which contributes to power failures. With intelligent SSVC, this cost is reduced to ₦2964. These results indicate a 95.5% improvement in reducing fuel costs for thermal plants using SSVC compared to conventional methods, thus improving power supply and reducing fuel costs in the Nigerian 132KV distribution network.

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