Dynamic Voltage Stability Analysis of Port Harcourt Network in the Presence of Facts Devices

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***Abstract*:- Flexible Alternating Current Transmission systems (FACTS) devices have been proven to be a better approach in the improvement of the transmission of power , of which its major purpose is to compensate the reactive power of the Network. This is why this paper investigates the impact of FACTs device on Port Harcourt Network which is a State Network in Nigeria grid system. Continuation Power Flow (CPF) analysis and Eigenvalue analysis was done for proper investigation of both the impact on the load increment and behavior due to disturbances. CPF analysis shows that the Network without FACTS will violate all bus voltage with load increment of which the maximum loading is far lower as compared to when FACTS is installed. When FACTS was installed, though few of the buses voltages were violated, but, about 100% addition load improvement as compared to without FACTS. The Eigenvalue analysis done shows that the Network is prune to instability without the addition of FACTS with the presence of a negative real reduced Jacobian (J_R) matrix. With the inclusion of FACTS, the system became stable with all real J_R values being positive. An improvement was seen in the real and reactive power losses when using FACTS device up to the range of 0.0647pu and 0.49743pu from 1.3425pu and 1.9385pu respectively. This shows that there will be a greater advantage in using FACTS device to stabilize the Network.**

Keyword: FACTS, PortHarcourt, Voltage, Stability, Eigenvalue, loading factor.

I INTRODUCTION

Power system stability have been a major concern to Nigerians . This has led to so many closure of businesses, increase in the prize of goods and services, decrease in the number of investors, etc [1]. The major cause of the power problem has been poor management of the Network. Since the cause of voltage instability is reactive power, it will be wise to compensate the reactive power of the Network using FACTS devices. FACTS devices have been proven to be the best means to improve the transmission line for a better Network performance. So many FACTS device have been developed with its different properties, but, for the purpose of this paper Static Compensator (STATCOM) will be considered. STATCOM was used to investigate the strength of the Port Harcourt Network to ascertain if there is a significant impact on the Network. There are many methods of voltage stability analysis, but since our interest is on the ability of the Network to withstand disturbance and its behavior on load increment, it will be of great interest to use Continuation Power Flow (CPF) and Eigenvalue method. CPF analyzes a Network, based on load increment. It determines how much load can still be added to the Network without causing a collapse and the state of the Network at the point of maximum load, while Eigenvalue analysis gives the strength of the Network when a disturbance occurs. This is why these two methods were considered for the analysis of Port Harcourt Network to evaluate its performance for further recommendation.

II CONTINUATION POWER FLOW (CPF)

The CPF simulation was considered to determine the voltage behavior of the Network on a changing load. This analysis was necessary to checkmate the load input in the network [4]. At maximum loading, the network is expected not to accept more load or a system collapse is likely to occur. Load parameter λ is selected as continuation parameter in all prediction and correction steps. In this study, continuation power flow method without parameterization is utilized so as to analyze the voltage stability of systems since it gives satisfactory results

III NODAL ANALYSIS

This analysis is used to predict voltage collapse in complex power system. It computes the smallest eigenvalue and associated eigenvector of reduced Jacobian matrix gotten from load flow solution. Eigenvalues comprises of modes of voltage and reactive power changes which provides relative measure of proximity to voltage instability [2]. It can also be used to predict the weakest bus by determining the participating factor. The reduced Jacobian matrix J_R

$$J_R = \frac{\Delta Q}{\Delta V} \qquad (1)$$

The reduced jacobian matrix represents a linearized relationship between the increment changes in bus voltage (ΔV) and the changes in reactive power (ΔQ) [2]. Reduced Jacobian, eigenvalues and eigenvectors are used for voltage instability characteristics analysis. In a dynamic system, when the real part of the eigenvalue are positive, the system can be said to be stable, and can be considered unstable when, at least, one of the real part of the eigenvalue is negative. Once the minimum eigenvalue have been found, the highest participation factor value can be determined which can be seen as the weakest bus.

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IV RESULTS AND DISCUSSION

The stability analysis was done with Power System Analysis Toolbox (PSAT). The voltage profile, P-V curve and J_R real and imaginary, real and reactive power losses, voltage violation and maximum loading factor were gotten to justify the impact of adding FACTS device to the Network as shown in Table 1 and figure 1 – 7.

Table 1: Summary of voltage analysis done

Properties	Without FACTS	With FACTS
Voltage violation	4	0
Real power loss (p.u.)	0.12984	0.00703
Reactive power loss (p.u.)	1.5549	0.10156
CPF Voltage violation	7	4
CPF Real power loss (p.u.)	1.3425	0.0647
CPF Reactive power loss (p.u.)	1.9385	0.49743
Maximum loading (p.u.)	0.5234	2.567

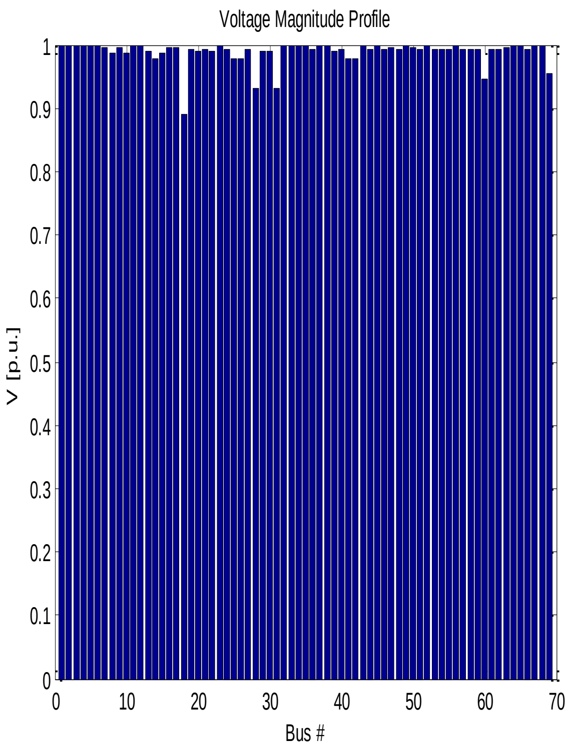

Figure 1: Voltage profile with DGs

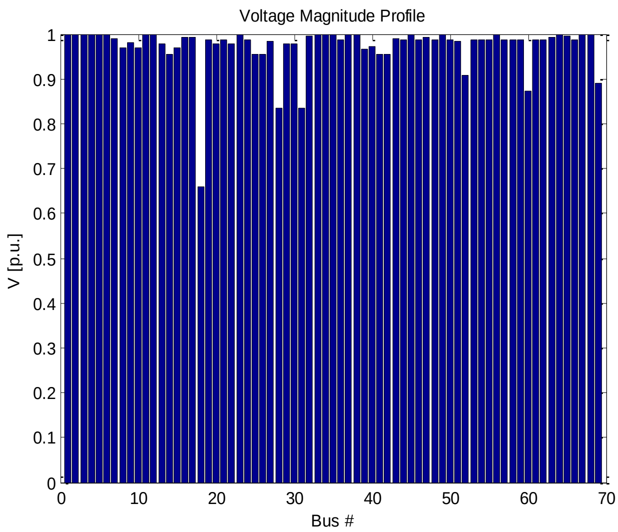

Figure 2: Voltage profile for CPF

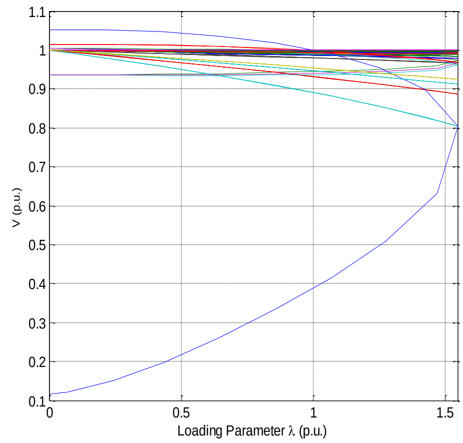

Figure 3: V-P curve with DG

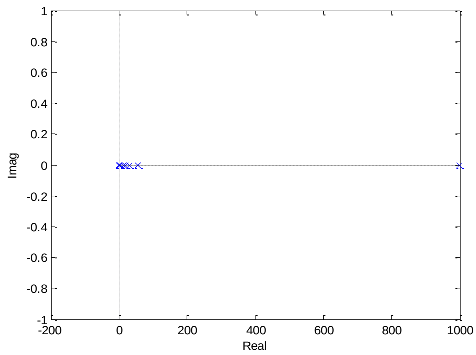

Figure 4: J_R real and imaginary values without FACTS

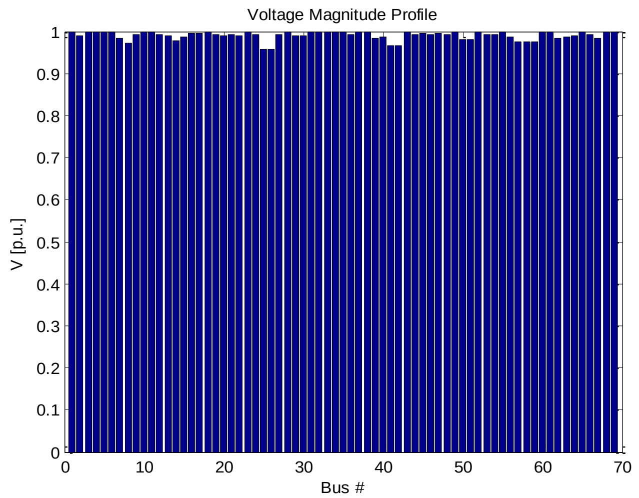

Figure 5: Voltage profile with STATCOM

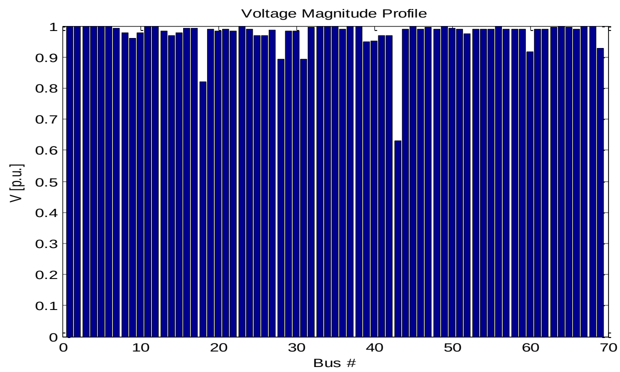

Figure 6: Voltage profile CPF with FACTS device

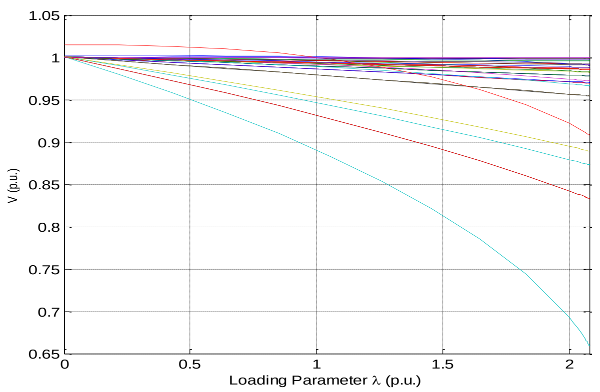

Figure 7: V-P curve for STATCOM

The result gotten shows an improvement in the voltage violation at the collapse point as shown in Table 1. Without using FACTS device, 2 buses were violated, but the introduction of FACTS device shows that there is no violation of any Bus. A notable improvement was also seen in the real and reactive power losses from 0.10156pu and 1.5549pu without FACTS to 0.00703pu and 0.12984pu respectively. The loading factor indicates that more load can be added to the Network when FACTS device is introduced to the Network which shows a significant improvement from 1.0561pu to 2.2184pu. This is about 100% above when FACTS is not added. For the eigenvalue analysis, a positive sign is seen at the real part when FACTS is not added which shows that there is every tendency the Network been stable with time. The weakest Bus was seen to be Bus 48 where the STATCOM was attached. For the CPF results, without using FACTS device, a voltage violation of 7 Buses were encountered which was reduced to 4 Buses with the introduction of FACTS devices. An improvement was seen in the real and reactive power losses when using FACTS device up to the range of 0.0647pu and 0.49743pu from 1.3425pu and 1.9385pu respectively.

V CONCLUSION

After investigating the impact of FACTS on the stability of Port Harcourt power Network, it can be concluded that it will be of a very great advantage to introduce FACTS device in the power Network to improve the efficiency of the Network. The Network showed a significant improvement on all the parameters considered. It shows that with the introduction of FACTS, more people can be served with minimal losses and a far better voltage stability. The paper gives a clear understanding on the advantages of using FACTS devices to improve the power system and minimize losses due to outages and damages. FACTS aid to compensate reactive power which is the major cause of voltage instability.

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