POWER-VOLTAGE AND REACTIVE-VOLTAGE CURVES FOR VOLTAGE STABILITY ANALYSIS ON THE 58 BUS, 330kV NIGERIAN NETWORK.

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF ENGINEERING DEGREE (M.Eng.) IN ELECTRICAL AND ELECTRONICS ENGINEERING IN THE DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING, COLLEGE OF ENGINEERING, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA

SEPTEMBER, 2022

ACCEPTANCE

This is to attest that this dissertation is accepted in partial fulfilment of the requirements for the award of the degree of Master of Engineering in Electrical and Electronics Engineering, Department of Electrical and Information Engineering, College of Engineering, Covenant University Ota Nigeria.

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(Dean, School of Postgraduate Studies) **Signature and Date**

DECLARATION

I, **EKONG, KENNEDY KENNEDY (12CK013764),** declares that this research was carried out by me under the supervision of Dr. Isaac A. Samuel of the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Nigeria. I attest that the dissertation has not been presented either wholly or partially for the award of any degree elsewhere. All sources of data and scholarly information used in this dissertation are duly acknowledged.

EKONG, KENNEDY KENNEDY

Signature and Date

CERTIFICATION

We certify that this dissertation titled "**POWER-VOLTAGE AND REACTIVE-VOLTAGE CURVES FOR VOLTAGE STABILITY ANALYSIS ON THE 58 BUS, 330kV NIGERIAN NETWORK.**" is an original research work carried out by **EKONG, KENNEDY KENNEDY (12CK013764)** in the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Ogun State, Nigeria under the supervision of Dr. Isaac A. Samuel. We have examined and found this work acceptable as part of the requirements for the award of Master of Electrical and Electronics Engineering.

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DEDICATION

This dissertation is dedicated, first and foremost, to the Almighty God for His mercies, grace, wisdom, and favour throughout the Masters' program. It is especially dedicated to my parents (Hon.) Barr. And Mrs. Kennedy Ekong, and my lovely siblings Florence, Favour, and Joyce.

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LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
CCA	Critical Clearing Angle
CCT	Crtitical Clearing Time
CPF	Continuation Power Flow
DC	Direct Current
DG	Distribution Generators
E_s	Voltage Source
ELD	Eigenvalues of Linearized Dynamic Equations
FVSI	Fast Voltage Stability Index
GDP	Gross Domestic Product
GS	Generation Station
IEEE	Institute of Electrical and Electronics Engineers
IPP	Independent Power Producers
LFFI	Load Flow Feasibility Index
Lmn	Line Stability Index
LQP	Line Stability Indices
LVSI	Line Voltage Stability Index
LCPI	Line Collapse Proximity Indicator
MLP	Maximum Loading Point
NLSI_1	New Line Stability Index 1
NEPA	Nigerian Electric Power Authority
NIPP	National Integrated Power Projects
NNG	Nigerian National Grid

NR	Newton-Raphson
NPS	Nigerian Power System
PSN	Power System Network
PHCN	Power Holding Company of Nigeria
P_s	Sending end Real Power
Q_r	Receiving end Reactive power
Q_s	Sending end Reactive Power
S_{ij}	Loss Sensitivity Index
SVJ	Jacobian Matrix Singular Value
SM	Synchronous Machines
TCN	Transmission Company of Nigeria
VS	Voltage Stability
VSL	Voltage Stability Limit
VC	Voltage Collapse
VSI	Voltage Stability Indices
V_s	Sending end Voltage
VCPI	Voltage Collapse Point Indicator
ZLD	Supplied Load
ZLN	Series Impedance
Z	Line Impedance

ABSTRACT

Voltage instability is an undesirable phenomenon in power system networks, resulting from a system being severely loaded causing a gradual voltage drop which eventually leads to a blackout in the system. It frequently has to do with the power system's reactive power supply. Therefore, it is essential to comprehend the critical loading point in order to make sure the power system operates securely. The study helps identify weak buses and lines that are in the connected buses to determine the best location for mounting compensating devices on the power system's transmission line network. First, a load flow analysis is performed for all of the buses in the test system, they are simulated using NEPLAN software, and the suspected weak buses in the system are found, along with safe loading margins for real and reactive power for both networks. The Newton-Raphson load flow method is used to assess the condition of the network's buses, and the real power against voltage magnitude (P-V) and reactive power against voltage (Q-V) curves which reveals the maximum loadability at each candidate buses. The IEEE 14-Bus and Nigerian National Grid 330kV 58-Bus systems, which served as the study's case studies, were used to assess the recommended approach. Base case and contingency analysis were the two situations that were examined for the two systems listed above. The IEEE 14-Bus system's buses and lines were all stable in the basic scenario. With a reactive loading margin of 74.6MVAr, the 14th bus was discovered to be the most vulnerable bus in the network during the contingency analysis simulation. The loss sensitivity index was calculated for all lines in the IEEE 14-bus network, and it was discovered that lines linking bus 14 had the lowest valuation. During base case simulation for the 330kV 58-Bus Nigerian network, Birnin-Kebbi, Gombe, Makurdi, Yola, Maiduguri, and Jos buses were found to be very close to the lower limit of 0.95 p.u. During contingency simulation, it was discovered that the Maiduguri Bus was the weakest in the network, with a reactive loading margin of 385MVAr. Finally, the loss sensitivity index of the 58-Bus network was evaluated, and Line 15 to 53 was discovered to have the lowest sensitivity index in the network and the ideal position for suitable compensating device installation. According to the research presented in this dissertation, the P-V and Q-V curves are particularly helpful for determining how consistently voltage levels are maintained across a power system network.

KEYWORDS: Voltage Stability, Voltage Instability, NEPLAN, Loss Sensitivity Index, Nigerian Network, P-V Curve, Q-V Curve.