ANALYZING THE FREQUENCY RESPONSE OF SOLAR PHOTOVOLTAIC PENETRATION INTO COVENANT UNIVERSITY MICROGRID

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JULY, 2023

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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 (M.Eng) DEGREE IN ELECTRICAL AND ELECTRONICS ENGINEERING IN THE DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING, COLLEGE OF ENGINEERING, COVENANT UNIVERSITY, OTA, OGUN STATE

JULY, 2023

ACCEPTANCE

This is to attest that this dissertation has been 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, **OKEY PETERS, VICTOR (21PCK02427)**, declare that this dissertation is a representation of my work, and is written and implemented by me under the supervision of Dr. A. F. Agbetuyi of the Department of Electrical and Information Engineering, Covenant University, Ota, Nigeria. I attest that this dissertation has in no way being submitted either wholly or partially to any other university or institution of higher learning for the award of a masters' degree. All information cited from published and unpublished literature has been duly referenced.

OKEY PETERS, VICTOR

Signature and Date

CERTIFICATION

This is to certify that the research work titled "**ANALYZING THE FREQUENCY RESPONSE OF SOLAR PHOTOVOLTAIC PENETRATION INTO COVENANT UNIVERSITY MICROGRID**" Is an original research work carried out by **VICTOR, OKEY PETERS (21PCK02427)** in the Department of Electrical and Information Engineering Covenant University, Ota, Ogun State, Nigeria under the supervision of Dr. A. F. Agbetuyi. We have examined and found this work acceptable as part of the requirements for the award of Master of Electrical and Electronics Engineering.

Dr. Felix A. Agbetuyi
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DEDICATION

I dedicate this Dissertation to the ONE TRUE GOD.

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ABBREVIATIONS

AC	Alternating Current
AFDB	African Development Bank
ALDC	African Leadership Development Centre
BSRN	Baseline Surface Radiation Network
DC	Direct Current
DES	Distributed Energy Sources
DG	Distributed Generation
ESS	Energy Storage Systems
GHI	Global Horizontal Irradiation
GWDC	Giga-watt Direct Current
IAE	International Energy Agency
IRENA	International Renewable Energy Sources
LFS	Load Flow Studies
LDA	Load Demand Analysis
NASENI	National Agency for Science and Engineering Infrastructure.
NEMSA	Nigerian Electricity Management Services Agency
NESI	Nigerian Electricity Supply Industry
RE	Renewable Energy
RES	Renewable Energy Sources
SERC	Sokoto Energy Research Centre
PCC	Point of Common Coupling

PV	Photovoltaics
VAR	Volt-Amp Reactive
VSC	Voltage Source Converter

ABSTRACT

Frequency response is a crucial aspect of power quality, representing the system's response to generated power and applied loads. Understanding frequency variations when integrating renewable energy into a microgrid is essential, considering the variability of renewable sources due to weather conditions. This study focuses on Covenant University as a case study, aiming to identify the optimal renewable energy source and permissible penetration levels in relation to the average hourly peak load, without disrupting the existing system's operations. The study calculates the average peak load demand at Covenant University as 1.42MW, with a generation capacity of 4.5MW. The MATLAB-Simulink software was employed to design and simulate the solar PV system, while maintaining a constant average peak load throughout the simulations. Penetration levels of 5%, 10%, 15%, 20%, and 25% were considered. Simulation results indicate that the system's frequency response remains within permissible limits up to a solar PV penetration level of 21% (289.2kW) relative to the average hourly peak load. Beyond this point, the frequency starts deviating beyond the acceptable limits. The findings of this study provide valuable guidance for integrating solar PV into Covenant University's existing campus system, revealing that the maximum solar PV penetration without energy storage is 21% (298kW) of the average hourly peak load, resulting in frequency deviations of 50.89Hz and 49.22Hz.

KEYWORDS: Frequency Response, Microgrid, MATLAB, Renewable Energy, PV Penetration Levels