School of Information Technology and Engineering at the ADA University

School of Engineering and Applied Science at the George Washington University

DEVELOPMENT OF DIGITAL SUBSTATIONS AND MODERN NETWORKS

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THESIS ACCEPTANCE

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has been approved as meeting the requirement for the Degree of Master of Science in Electrical and Power Engineering of the School of Information Technology and Engineering, ADA University.

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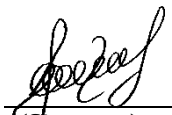
Ayshan Hamidova Mirza		25.12.2023
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ABSTRACT

A link for the effective integration of renewable energy sources into electrical networks is provided by substations, which have been used extensively over the past few years in the application of renewable energy sources. The amount of power generated determines how well RES are incorporated into the utility grid.[1] The digitization of substations has therefore grown even more in demand and desirable. The security of resources and labor are given the greatest consideration, along with economic aspects. Utilizing new instruments, methods, and processes at substations to improve operational efficiency is possible for the power industry thanks to digitization.[2]

The simplest definition of "intelligent networks" might be defined as electric grids that effectively integrate the behavior and attempts of all linked points (those who generate electricity, those who consume it, and those who perform both actions) to supply a safe, affordable electricity consumption.[3] Process monitoring, power flow regulation, and electrical system component protection are among the functions of these integrated systems. For example, communication networks are used to link electrical system automation devices with supervisory systems and other devices in order to exchange data. One of the important areas of research is the study of the problem of reliability and efficiency of energy supply to consumers, and the determination of the main influencing factors. The development of industrial, agricultural and household sectors directly depends on the reliability of energy supply. Schemes of electric networks should ensure the necessary reliability of electric power supply, the transmission of the required amount with indicators of the quality of electric power to consumers, further development of the network and the connection of new consumers, convenience and safety of operation. Electrical installations used for the transformation, transmission and distribution of electric energy are subject to the influence of many factors.

These factors can be environmental, operational, accidental, design and construction defects.[3]

Delivering dependable and secure electricity to consumers is the goal of the contemporary electrical network. As dispersed generation becomes more prevalent and technology advances, the current distribution system becomes increasingly decentralized and complex. As carbon emissions and global warming rise, the integration of renewable energy sources into the electrical grid is accelerating. Because the distribution system has a direct line to the clients, reliability is one of its most crucial components. The current distribution system is having numerous issues as a result of system malfunctions. [4]. This paper examines aspects of reliability and sustainability for the further improvement and development of digital substations and transmission systems. Thus, the digital substation operates better in addition to medium-sized sources being established and solar panels being used.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
ICT	Information & Communication Technology
HMI	Human-Machine İnterface
DS	Digital Substation
EMS	Energy Management System
IEC61850	International Electrotechnical Commission
IP	Integrated Protection
MMS	Maintenance Management Systems
GOOSE	Generic Object Oriented Substation Event
IED	İntelligent Electronic Devices
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
CAIDI	Customer Average Interruption Duration Index
SCADA	Supervisory Control And Data Acquisition
IEEE	Institute of Electrical and Electronics Engineers
PLC	Programmable Logic Controller
VT	Voltage Transformer
CT	Current Transformer
RTU	Remote Terminal Unit
KPI	Key Performance Indicator
PV	Photovoltaic
GHG	Greenhouse Gas
RTSPV	Roof Top Solar Photovlatic
RES	Renewable Energy Sources

CHAPTER ONE

Introduction

1.1. İntroduction

In addition to allowing operators to monitor and repair equipment, manage connections between various grids and power lines, deploy and maintain protection, control, automation, and communication functions, digital substations give the power grid secure, centralized facilities for the transformation of voltage levels [5]. A smart substation can, however, provide extra functions like self-healing apps, intelligent electronic device integration, feeder automation, and remote maintenance, which will ultimately enhance power quality, reliability, and stability.

Rugged computing platforms with faster processors and dependable storage capacity are necessary for an aging power utility to evolve into a modern substation automation system with smart grid technologies. To ensure safe operation, high performance hardware is needed for the many applications found in a digital substation, such as intelligent HMI for communication and operator terminals, as well as supervisory control and data acquisition (SCADA) systems.

Substations need an increasing number of industrial computers because different applications require different levels of redundancy, which in turn requires separate servers. At this time, adding additional equipment to the system may affect the stability and reliability of the system. Therefore, the analysis of system reliability indicators becomes more relevant.

1.2. Definition of terms

When developing and improving electricity distribution systems, system planning and operations must take the reliability of distribution networks and systems into account.

Utilities must work to increase reliability while cutting costs in order to meet the goal of minimizing disruptions for customers. It is well recognized that distribution system failures account for the majority of consumer disruptions. On the other hand, obtaining reliable performance statistics and obtaining legitimate data are not simple tasks. The reliability of the distribution network is never completely certain. Data on the quantity and range of the equipment under examination are required for the assessment and analysis of reliability.

Since digital substations will act a major step in the future of the electric power sector, testing them is essential to ensuring that the grid will function with the necessary security and dependability. When substations are highly automated due to digitalization, they are referred to as "Digital Substations" using IEC 61850. The main topic of the thesis is the approach to the improvement of the operation of digital substations by the reliable analysis of stability and the use of solar panels, which are one of the renewable energy sources for the specific consumption of the substation.

1.3. Significance of the study

The bulk power system is connected to the utilities or customers through a distribution network. The system's dependability is evaluated based on its performance at the load points, or customer end. The dependability of the power grid, which is inversely associated to the length of a power supply interruption, determines the quality of electricity with continuity. It depends on a few anticipated or unforeseen system flaws or breakdowns, system protection system speed, preventive maintenance, and technical staff motivation. A thorough analysis of the distribution system is even more important because the utility's reputation, customer satisfaction, quality of service, and overall revenue are all impacted by its dependability.