International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 8 Ver IV || Aug 2018 || PP 16-21

A Real-Time Design Model for Monitoring Electrical Power Transformers from Substations to the Consumers

Katumbi Nicodemus Musyoka[1], Benard Kipkorir Ng'eno[2]
[1](*Technology Education department, University of Eldoret, Kenya)*
[2](*Electrical & Electronics Engineering Department, Wote technical training institute, Kenya)*
Corresponding Author: Katumbi Nicodemus Musyoka

Abstract: *Widely used in industry for Supervisory Control and Data Acquisition of industrial processes, SCADA systems are now also penetrating the experimental physics laboratories for the controls of ancillary systems such as cooling, ventilation, power distribution, etc. SCADA systems have made substantial progress over the recent years in terms of functionality, scalability, performance and openness such that they are an alternative to in house development even for very demanding and complex control systems as those of engineering experimental research. This research is focused on bringing out vividly the design model and its major components and controls of the electrical power transformer monitoring. It addresses the application of a distributed management system geared towards attaining smart grid functionality. Moreover the research seeks to describe the key electrical equipment and also the operation of the various electrical power transmission and distribution systems. It also underscores the impacts of SCADA application on grid design, with a view to achieving reliability, effective performance, and operation. It also describes the security challenges associated with the deployment of this technology in power systems transmission, distribution and control. The use Supervisory Control and Data Acquisition (SCADA) system (LabView 2013) to monitor Power transformer parameters remotely as applied to other industrial applications has been brought out in the discussion. Remote monitoring of power transformers with the help of SCADA system is achievable because of the capability of LabView 2013 to transmit data over internet. This therefore means that every personnel with access privileges can log in to the MTUs - master server anywhere he or she is. This has been discussed a screen printout of the web page a simulated example has been showed. Security concerns associated with communication networks for the Industrial Control Systems (ICS) have been discussed comprehensively. The ultimate objective is to come up with a model of remotely controlling transformers and hence network connectivity is the backbone of data transmission. Issues to do with in-depth defense strategy for such networks have therefore been looked at in detail. For efficient operation of a power transformer some key parameters should be kept within the acceptable levels. The quantities to be measured and monitored include temperature, a.c phasor components (voltage, frequencies and currents), loading and bushing condition. Temperature and voltage inputs and outputs have been solely selected in the design model because of the complexity of the system that would need to monitor other parameters. The major signals obtained from the remote locations include signaling alarms, indication of status conditions, time varying values, and total metered values. However, an extensive range of information can be gathered using the available signal types.*

Keywords *- Industrial Control Systems (ICS), SCADA systems, Remote Monitoring, Real Time Transmission, Electrical Power Transformers, Electrical Power Grid.*

Date of Submission: 09-08-2018 Date of acceptance: 23-08-2018

I. Introduction

The current desire and plans for most nations is to achieve a satisfactory level of industrialization. A case in point is the nation of Kenya whose vision 2030 is to ensure that it attains its highest level of economy comparable to the presently-first world countries. The key pillars for Kenya's vision 2030 include economic social and political. Behind the economic pillar lie the key sectors detailed as Tourism, Agriculture, Wholesale and Retail Trade, Manufacturing, ICT and Business Process ICT and Business Process Outsourcing (BPO), Financial Services. The driving force for a greater percentage off these sectors of economy is the provision of efficient and sustainable energy. (NESC, 2007) Electrical energy is the main source of energy that drives the economy of our country Kenya. In the modern Kenya there has been increasing need for substantial energy to run the economy and hence delivering such electrical power to these ends has their own challenges. Many facilities (e.g. medical, manufacturing, financial and security) frequently suffers from power outages. These have been orchestrated by poor and inefficient electrical power controls, both in the generating plants and transmission systems. The power outage got me to thinking about the kinds of practical steps which all of us could take to prepare for and cope with such a situation should it recur in the future. Industries records millions shillings of losses when there is power outage that that persist for long that takes hours and even for electrical technicians to locate and troubleshoot the faults. The electrical grid is a critical infrastructure that could have a major impact on human lives, economics and politics. This therefore means that any unreliability due to design and functional characteristics of the existing power Grid, equipment failures (i.e. transformers) blackouts, poor communication and lack of effective monitoring of the infrastructure create additional challenges to the power utilities.

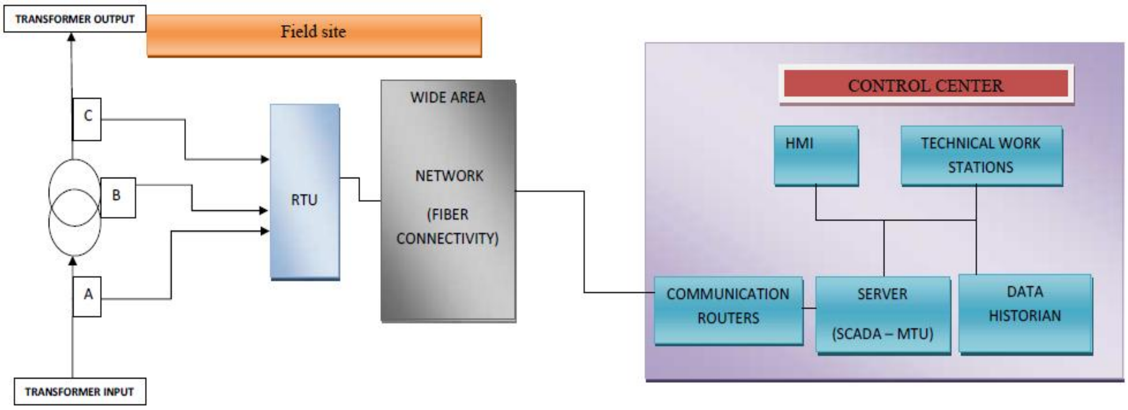
II. Materials and Methods

This method refers to the real implementation of the processes and systems with a view to solving the real world problems in the corresponding discipline of study. With respect to my area study, it involves assembly of electrical power equipment and putting them into a control system or process. The process is quite tedious and costly however it yields many results on the functionality of the system weighed against the expected outputs Firstly I will use a survey method with a view to establishing the extent to which SCADA system has contributed to electrical power control with reference to electrical power generation and also finding out its usage to ensure that national Grid Power system is in good operation. The characteristic of a good performing power grid is the ability to meet the customers' active power requirements and power system balance. Surveys represent one of the most common types of quantitative, social science research. In survey research, the researcher selects a sample of respondents from a population and administers a standardized questionnaire to them. The questionnaire, or survey, can be a written document that is completed by the person being surveyed, an online questionnaire, a face-to-face interview, or a telephone interview (Writing@CSU, 1993- 2015). Survey research does not belong to any one field and it can be employed by almost any discipline. According to Angus and Katona, "It is this capacity for wide application and broad coverage which gives the survey technique its great usefulness….." (Katona & Angus, 1953). Secondly and most important is simulation approach. By definition, Simulation implies enabling a model of a system with suitable inputs and taking note of the corresponding outputs (Bratley & Schrage, 1987) Simulation advocates for many diverse purposes. These include prediction performance proof and discovery. Through prediction, simulation can take in complex inputs. These are then processed taking hypothesized mechanisms into account and giving feedback as predictions. Regarding to performance, simulation can be used to demonstrate activities in the domain of artificial intelligence, e.g. medical diagnosis, speech recognition and function optimization. Furthermore simulation can be used for purposes of proof. According to Poundstone, simulation approach can be applied in providing an existence of proof. For instance, Conway's Game of life shows that an extremely complex behavior is a consequence of application of very simple rules (Axelrod, 2005). The "game" is a zero-player game, meaning that its evolution is determined by its initial state, requiring no further input. One interacts with the Game of Life by creating an initial configuration and observing how it evolves or, for advanced players, by creating patterns with particular properties (Wikipedia). As a scientific methodology, simulation's value is principally based on prediction, proof, and discovery. The applications of simulation for prediction purposes help qualify or improve the model for which the simulation is anchored upon. The use of simulation approach for Prediction is what most people think of when they consider simulation as a scientific technique. Nevertheless the use of simulation approach for the discovery of new relationships and principles is momentous as proof or prediction. From the above insight, it is beyond doubt that simulation best fit the research study of SCADA for monitoring electrical power transformers.

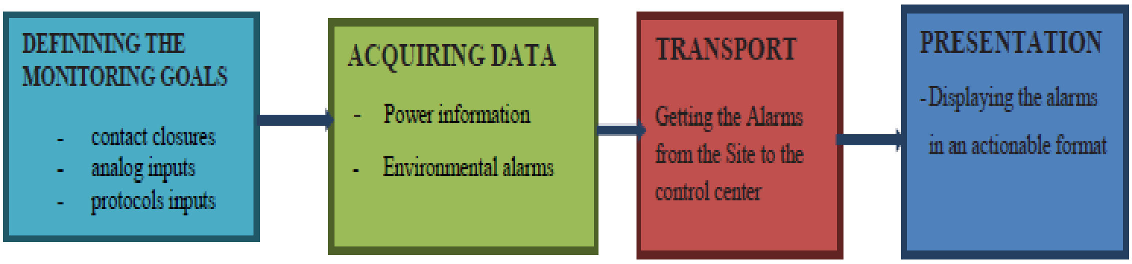
Simulation software: *Lab View 2013* - This is a software package that contains programs also called virtual instruments, or VIs. They are so called because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. Lab View contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools to help you troubleshoot code you write. (National- Instruments, June 2010) The functions of a SCADA system are fourfold; Data acquisition, Networked data communication, Data presentation and Control.

III. Results and Discussions

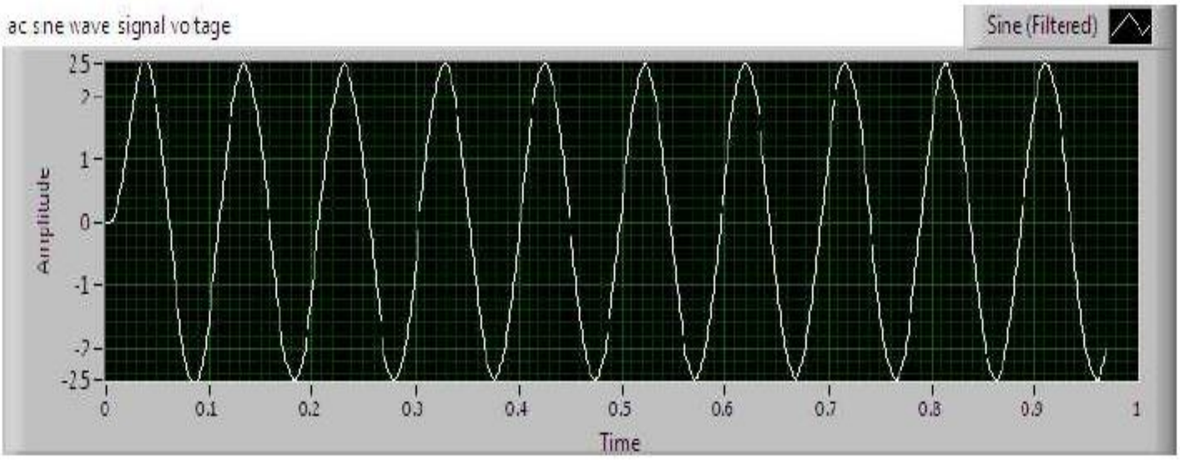
A Real-Time Design Model for Monitoring Electrical Power Transformers from Sub-Stations to the Consumers is anchored principally on SCADA control system. A SCADA control center functions as a centralized monitoring point of the field devices interlinked via a communications network, including monitoring of alarms and subsequent processing of status data. Generally, looking into the design model of these control system, there exist the presence of key sub-systems /components which are interconnected in a way as to share data through a communication channel.



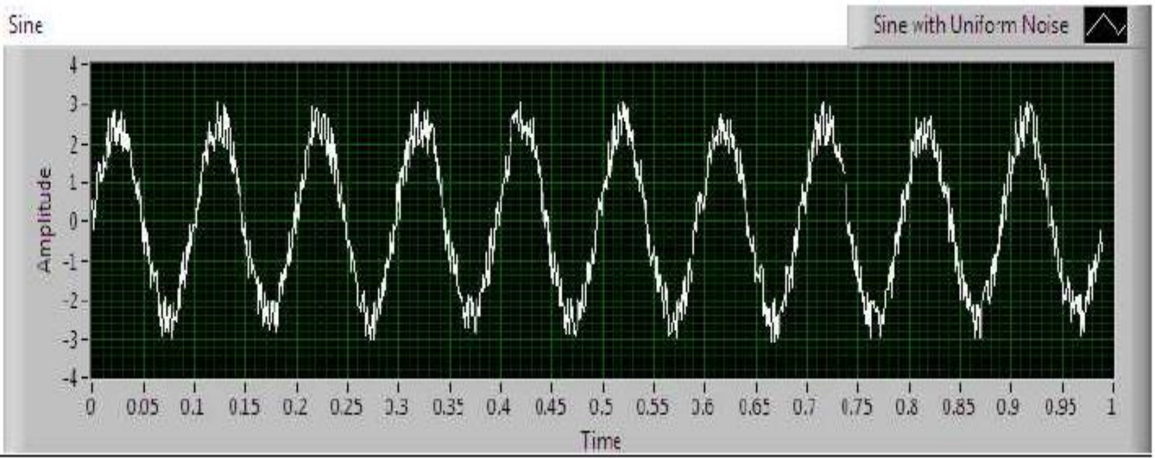
The figure above shows a block diagram of transformer monitoring model. The figure below shows a block diagram of stage of implementation model.



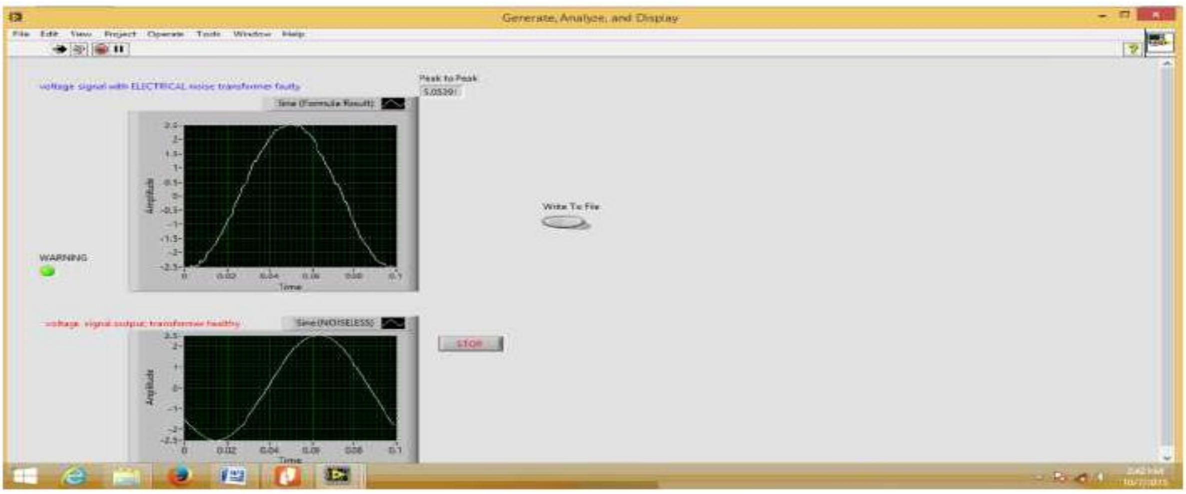
A contact closure accepts digital inputs. A contact closure is a digital electrical device taking status inputs as ON/OFF pulses. Because of its simplicity in design and operation they are widely used in many control systems. Analog inputs accept analog quantities such as current or voltage level inputs over. They are the major quantities to be measured for monitoring physical quantities like temperature humidity, velocity among others. Protocol inputs are electrical signals encoded into a formal code that can represent much more complex digital information as compared to contact closures. The widely used telemetry protocols include the open source standards such as SNMP, TL1, and ASCII, but there are also manufacturer-specific proprietary protocols. Electrical Power and environmental alarms are gathered with the help of sensors connected to physical electrical devices such as circuit breaker points, transformer input and output points (primary and secondary terminals), temperature sensors and so on. The outputs fed to a remote telemetry unit (RTU) that encodes contact closure and analog inputs information into a protocol output for subsequent transmission to the alarm the HMI. Every model of RTU posses a capacity of the supported number of contact closures and analog inputs. The alarm capacity of an RTU is the hindering factor for the quantity of data to be acquired from the remote site (Network Alarm Monitoring Fundamentals, December 18, 2012). Once alarm data is acquired at the remote sites, they have to be transmitted over a telecommunication network to the control center (the Network Operations Centre (NOC)). Alarm data transmission is achieved via almost all kinds of available protocols; Ethernet LAN/WAN, dial-up modem, dedicated circuit switching, overhead telephone lines among others. Fiber optics technology is employed as it offers better signal quality and acceptable data transfer speeds. The final phase in alarm monitoring is displaying the alarm information in a useful way so that the information can be read and used to for informed decision making. This is done through a specialized computer referred to as an alarm presentation master. The unit collects the alarm reports acquired and relayed by RTUs at the remote site and then formats, sorts and displays the information for a technical operator. The figure below shows the expected simulated voltage signal output/input.



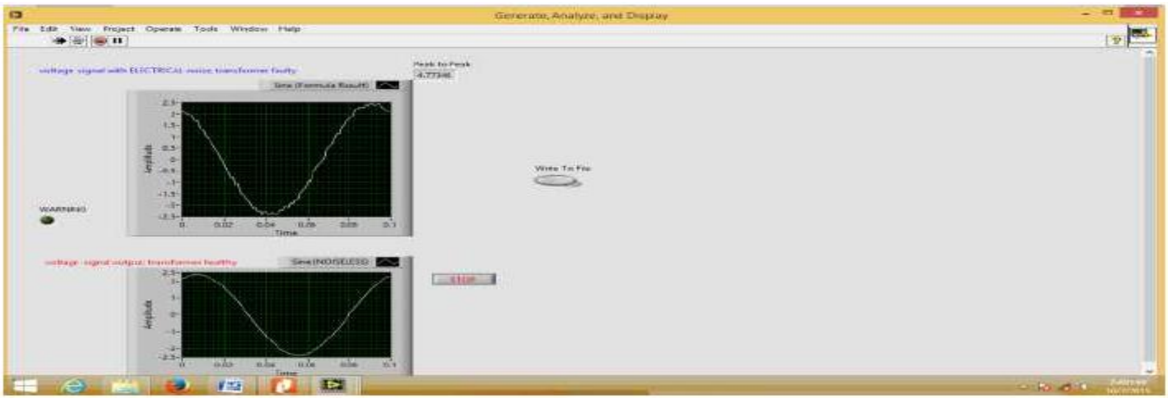
The figure below shows voltage output/input with noise signals superimposed on the measured signal voltage indicating that there is a problem with the transformer system (has unusually much electrical noise**).**



When the transformer is powered the secondary output voltage is sensed and acquired by the DAQ taking in a maximum of 5V varying from an integer 1 to 5. Any superimposed noise voltage appears above the true 5V secondary output. When a value above 5 is recorded an alarm warning will be enabled indicating unhealthy transformer. This is showed below; front panel (i) and (ii).



Front Panel (i); the warning lamp is ON; received voltage values are above the accepted limits.



Front Panel (ii); the warning lamp is OFF; received voltage values are within the accepted limits. The data acquired are display on the FRONT PANEL of the LabView. This is then published on the web and this is how it looked like.

IV. Conclusion and recommendations

Conclusion: Remote monitoring system applied in electrical power transmission using Supervisory Control and Data Acquisition (SCADA – LabView 2013) has been underscored. Electrical power transformers have been the key equipment in the power grid that needs real-time monitoring. The parameters monitored were zeroed in as outlined in a research study by [5] which outlined that the key causes of failure occurring in an electrical power transformer are short circuiting of the windings, overvoltage, overloading, excessive operating temperature and bushing failure. Both hardware and software components, including the means of communication over the internet have also been discussed. The research findings shows that KenGen company has been able to manage the wide spread power stations using SCADA system with its main goal of obtaining proper generator excitation and synchronization. The SCADA software in place is *SCADA -SIMATIC WINCC Explorer vendor- Siemens*. It was commissioned in the year 2009 with WSNs being pilot telecommunication infrastructure. Currently there is a rolling out of fiber technology. Besides, there have been strides made by the Kenya power and lighting company (KP&LC) to monitor power transmission only up to main substations (control of substation circuit breakers for schedule maintenance load balancing). The key causes of transformer failures, as discussed, are both electrical and non-electrical. A design of an electrical circuit model that would interface the transformer and DAQ was achieved. The design model is able to extract these parameters and passed through a transducer to convert them into a format which the DAQ devices can accept and feed it to the analyzing software platform for onwards transmission over a telecommunication network. It is also worth noting that these measured parameters were successfully uploaded to internet and could be accessed remotely on in real time, as this was the main objective of the study.
Recommendation: The system can be improved by designing it in a way capable of reporting on the physical security of the transformer, and of importance is to design a better model that would take, in addition, video inputs so as to monitor the transformer against theft and vandalism.

Acknowledgements

Special thanks go to Dr. Okeyo for his worthy noting input during the research. Similar heartfelt gratitude goes to the Managing Director of Centurion System- Kenya, Dr Kevit Desai, for allowing access to the automation laboratory of the company. Lastly, appreciation is made to the Faculty of Computing & Information Management- KCA University, under the ably leadership of Prof. Ddembe Williams where the research was based.

References

[1]. Antoine, M., & Nani, G. (2013). *Remote Services for Power Generation Equipment.* Switzerland: ABB Power Products.
[2]. Boyer, S. A. (2004). *SCADA Supervisory Control and Data Acquisition.* USA.
[3]. Bratley, & Schrage. (1987). *CPNI-securing the move to IP-based SCADA/PLC networks.* (n.d.).
[4]. Hossain, E., & Han, Z. (2012). *Smart Grid Communication and Networking.* United Kingdom: Cambridge University Press.
[5]. Katona, & Angus. (1953). Survey Research. 16.
[6]. National-Instruments. (June 2010). *LV Getting Started.*
[7]. Network Alarm Monitoring Fundamentals. (December 18, 2012). *Version 1.7.*

[8]. Siemens. (2013). *Common Remote Service Platform (cRSP).* Siemens Industry 2013.

BIO-DATA

Nicodemus Musyoka Katumbi is currently pursuing PhD in Engineering (Renewable Energy Technology) at

Kenyatta University and holds a Master of Philosophy in Technology Education (Electrical and Electronics Technology) as well as a Bachelor of Technology Education (Electrical and Electronics Technology). He has taught at Kenya Technical Trainers College, Technical University of Kenya, Moi University and currently is a lecturer at University of Eldoret in the department of Technology Education. His research areas are mainly in Engineering, Technology and Sustainable Energy.

Benard Kipkorir Ng'eno holds a Master's Degree in Data Communications and a Bachelors' Degree in

Technology Education (Electrical & Electronics). He has previously taught at Nairobi Technical Training Institute (Kenya) and currently is a lecturer at Wote Technical Training Institute (Kenya) in the Department of Electrical and Electronics Engineering. He is also a trained expert in Solar PV and Solar Thermal Technologies.

Katumbi Nicodemus Musyoka "A Real-Time Design Model for Monitoring Electrical Power Transformers from Substations to the Consumers." International Journal of Engineering Science Invention(IJESI), vol. 7, no. 8, 2018, pp. 16-21