



**Sudan University of Science and Technology**  
**College of Graduate Studies**

***A thesis Submitted as partial fulfillment of the requirements  
for the Degree of Master of Mechatronics engineer***

***On Line Monitoring for High Voltage Power  
Transformer Bushing***

***المراقبه الخطية للجب الكهربائيه لمحولات الطاقة ذات الجهد العالي***

***By:***

***Osama Abdelwahab Abdelrahman Suliman***

***Supervisor:***

***Dr. Alla Edeen Awouda***

***August 2017***

الاية



قال تعالى :

وَمَا أُوْتِيتُمْ مِّنَ الْعِلْمِ إِلَّا قَلِيلًا )

صدق الله العظيم

سورة الإسراء - الآية (85)

## **Dedication**

To my father the first who teach me, he always motivated me to accomplish this goal.

To my mother for her unlimited care, may Allah forgive her and grant her highest paradise.

To my sisters and brothers for their never ending inspiration and support.



## **Acknowledgement**

I would like to give my beautiful thanks to supervisor Dr. ALAAEDEEN AWOUDA for his guidance and to express my gratitude to who has patiently and sincerely guided me towards various types of knowledge.

I also appreciate his willingness to devote his time and effort for every help whenever I needed, unlimited thanks are also extended to my colleagues and Staff in Sudanese Hydro Power Generation Company and Sudanese Electricity Transmission Company for their support, special thanks for my friends Eng. Khalid Mohammed Ahmed Alabass. For every help they endowed me with.

Finally deep thanks to any one present any help.

## **ABSTRACT**

Power transformers are essential parts of our electric power infrastructure, and transformer components such as bushings and tap changers are essential parts of transformers, ensuring they operate reliably and safely while at the same time minimizing environmental impact.

Bushings are designed for application on liquid filled power transformers and reactors. They are used to connect the power transformer or reactor to overhead lines or exposed bus in either outdoor or indoor conditions.

The objective of this thesis is to implement system to protect and monitor the power transformers high voltage side bushings oil temperature or pressure and to achieve effective electronic circuit to monitoring the oil temperature inside bushings on line.

The oil temperature monitoring system for three phase power transformer bushings will be implement using micro controller based electronic circuit which will send digital signal to mat lab Graphical User Interface (GUI) or using lab view software represent the Human Machine Interface (HMI) .this project will be execute in Rosaries Hydro Power Plant four power transformers bushing (100MVA) each by connected to existing control system Distributed Control System (DCS) as future work.



## المستخلص

محولات الطاقة هي أجزاء أساسية ومهمه من البنية التحتية للطاقة الكهربائية، ومكونات المحولات مثل الجلب الكهربائيه جانب الضغط العالي ومغيرات الفولت هي أجزاء أساسية في المحولات، ويجب ان يضمن أنها تعمل بشكل موثوق وآمن، وفي نفس الوقت يجب مراعاة تقليل التأثير البيئي.

تم تصميم الجلبه الكهربائيه لتطبيقها على محولات الطاقة والمفاعلات .وهي تستخدم لربط محول الطاقة أو المفاعل إلى الخطوط الهوائيه الناقله للطاقه الكهربائيه العامة أو عبر القضبان النحاسيه المكشوفه سوي كان التوصيل في الخطوط الهوائيه أو في المحطات المغلقة.

والهدف من هذه الأطروحة هو تنفيذ نظام لحماية ومراقبة محولات الطاقه جانب الجهد العاليي متمثله في مراقبه درجه حراره او ضغط الزيت داخل الجلب الكهربائيه لمحولات القدره بواسطه تصميم وتحقيق دوائر إلكترونية فعالة لمراقبه درجه حراره الزيت بصوره مستمر علي اجهزه المراقبه.

سيتم تطبيق نظام مراقبة درجه حراره او ضغط الزيت باستخدام دائرة تحكم الكترونيه صغيره تقوم على إرسال إشارة رقمية إلى مختبر واجهة المستخدم الرسومية او استخدام تمثّل واجهة الجهاز البشري. وسيتم تنفيذ هذا المشروع في محطة توليد كهرباء الروصيرص لتوليد الطاقة الكهربائيه من المصادر المائيه ممثله في عدد اربعة محولات للطاقه وسوف يتم لاحقاً كعمل في المستقبل ربط هذا المشروع بالنظام الموجود اصلا بالمحطه وهو نظام التحكم الموزع

## Table of Contents

No		
1	الآية	I
2	Dedication	II
3	Acknowledgement	III
4	Abstract	IV
5	مستخلص الدراسة (لغة عربية)	V
6	Table of Contents	VI
<b>CHAPTER ONE</b> <b>INTRODUCTION</b>		
1-1	Transformers	
1-2	Power Transformer bushings	
1-3	Power Transformer Bushings Monitoring System	
1-4	Problem Statement	
1-5	Proposed solution	
1-6	Methodology	
1-7	Research layout	
<b>CHAPTER TWO</b> <b>THEORETICAL BACKGROUND</b>		
2-1	Introduction	
2-2	Restructure review	
2-3	Sensor	

2-4	PIC Microcontroller 16 F 877A	
2-5	Lab view software overview	
2-6	advantages of lab view	
2-7	Overview of Serial Bus	
<b>CHAPTER THREE</b> <b>SYSTEM IMPLEMENTATION</b>		
3-1	Introduction	
3-2	System Hardware Implementation	
3-3	system software programs used	
<b>CHAPTER FOUR</b> <b>RESULTS AND DISCUSSION</b>		
4-1	Results and discussion	
<b>CHAPTER FIVE</b> <b>CONCLUSION AND RECOMMENDATION</b>		
5-1	Conclusion	
5.2	Recommendations	



## List of Figures

Figure (1-1) Power Transformer Components .....	1
Figure (1-2) Power Transformers Bushing.....	6
Figure (1-3) Power Transformers Bushing Components .....	7
Figure (1-4) Transformers Bushing Proposed Monitoring System.....	11
Figure (1-5) Power Transformers Bushing Sensor Position .....	12
Figure (2-1) Precision Centigrade Temperature Sensors .....	22
Figure (2-2) the piezoelectric sensor effect .....	23
Figure (2-3) the piezoelectric effect .....	27
Figure (2-4) PIC 16F877A Microchip .....	33
Figure (2-5) PIC 16F877A Microchip Architecture .....	34
Figure (2-6) Lab VIEW .....	42
Figure (2-7) Lab VIEW Serial Program Using NI-VISA.....	44
Figure (2-8) Virtual Serial Port Emulator .....	46
Figure (2-9) Micro Code Studio software .....	48
Figure (2-10) Microcode Studio .....	49
Figure (2-11) Electronic Circuit Diagram Designed By Proteus .....	53
Figure (2-12) PIC kit 2 Programmer Software .....	55
Figure (2-7) PIC kit 2 Programmer .....	56
Figure (3-1) Liquid Crystal Display LCD LM016L.....	59
Figure (3-3) Transistors 2N2222A .....	60
Figure (3-4) 8 MHz Crystal Oscillators .....	61
Figure (3-5) Show the practical electronic circuit .....	62

Figure (3-6) VISA Configure Serial Port .....	64
Figure (3-7) Property Node .....	64
Figure (3-8) VISA Read Function .....	64
Figure (3-9) Scan from String Function .....	65
Figure (3-10) VISA Close Function .....	65
Figure (3-11) While loop.....	65
Figure (3-12) Case Structure .....	66
Figure (3-13) Lab View block diagram .....	66
Figure (3-14) Lab View HMI Window .....	66
Figure (3-15) Electronic Circuit Designed by Proteus Software .....	70
Figure (3-16) PICKIT 2 USB PIC Microcontroller Programmer.....	71
Figure (3-17) Virtual Serial Ports Emulator .....	72
Figure (4-1) Normal condition .....	73
Figure (4-2) Alarm condition .....	74
Figure (4-3) Trip condition .....	75
Figure (4-4) Normal Condition .....	76
Figure (4-5) Alarm Condition .....	77
Figure (4-6) Trip Condition .....	78
Figure (4-7) Lab View Block Diagram .....	79
Figure (4-8) Normal condition .....	80
Figure (4-9) Alarm condition .....	81
Figure (4-10) Trip condition .....	82



## List of Abbreviations

ANSI	American National Standards Institute
BJT	Bipolar Junction Transistor
DCS	Distributed Control System
DFR	Dielectric frequency response
DGA	Dissolve Gas Analysis
GUI	Graphical User Interface
HMI	Human Machine Interface
ICD	In Circuit Debugger
ICSP	In-Circuit Serial Programming
IEEE	Institute of Electrical and Electronics Engineers
LAB VIEW	Laboratory Virtual Instrument Engineering Workbench
LCD	Liquid Crystal Display
MCU	Microcontroller
OIP	Oil-Impregnated Paper
RBP	Resin Bonded Paper
RIP	Resin-Impregnated Paper
PGC	Programming Clock
PGD	Programming Data
PROTEUS	Processor for Text Easy to Use
PVDF	Polymer Polyvinylidene Difluoride
VFPF	Variable frequency power factor/dissipation factor
VI	virtual Instruments
VSPE	Virtual Serial Port Emulator