

## الآية

اعوذ بالله من الشيطان الرجيم

(إِنَّا عَرَضْنَا الْأَمَانَةَ عَلَى السَّمَاوَاتِ وَالْأَرْضِ وَالْجِبَالِ فَأَبَيْنَ أَنْ يَحْمِلْنَهَا وَأَشْفَقْنَ مِنْهَا وَحَمَلَهَا الْإِنْسَانُ ۗ إِنَّهُ

كَانَ ظَلُومًا جَهُولًا)

(72) (الأحزاب)

# **DEDICATION**

To our parents who always inspiring and devising us, May Allah saves them.

To our dears, all of our families members,

To our best friends & colleagues who are always with us step

by step, supports us to go forward.

To everyone who helped us, we dedicate this work.

# ACKNOWLEDGMENT

The greatest thanks to Allah always before and after.

We would like to express our deep gratitude to everyone who helps us throughout this work at any step of it.

Most grateful and appreciation to our supervisor:

Dr. Abd Alaziz Yusuf Mohammed Abbas

For their expertise support and endless valuable advices which guided us throughout this work and our engineering career life.

We also would like to thank all of our teachers in the school of electrical and nuclear engineering for all the help & knowledge that they gave to us.

# **ABSTRACT**

This project describes modeling of impedance protection relays when the STATCOM is used in the power system, and simulation results for investigating the operation of impedance based protection relays in a power system containing a flexible alternating current transmission system (FACTS) controller such as the static synchronous compensator (STATCOM). The impact of the FACTS device on protection relays is studied using MATLAB/SIMULINK for normal operating conditions as well as for fault conditions.

## مستخلص

يصف هذا المشروع عملية نمذجة مراحل الحماية المعاقية في حالة استخدام جهاز المعوض المتزامن الثابت (STATCOM) في نظام القدرة، ونتائج المحاكاة للتحقيق في عمل مراحل الحماية التي تعتمد على المعاقية في نظام قدرة يحتوي على المتحكمات المرنة لانظمة نقل التيار المتردد (FACTS) كجهاز المعوض المتزامن الثابت (STATCOM). تمت دراسة تأثير هذه المتحكمات على مراحل الحماية باستخدام MATLAB/SIMULINK لحالات التشغيل الطبيعي بالاضافة لحالات العطل.

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## LIST OF SYMBOLS

$Z_{calc}$	Calculated impedance, $\Omega$
$V_{meas}$	measured voltage, V
$I_{meas}$	measured current, A
$Z_{set}$	Setting impedance, $\Omega$
ZLF1	Impedance of the line from the relaying point to the fault point F1
ZLF2	Impedance of the line from the relaying point to the fault point F2

$R_{F1}$	Resistance of the fault at fault point F1
$R_{F2}$	Resistance of the fault at fault point F2
$Z_{F1}$	Impedance of the fault at Fault point F1
$Z_{F2}$	Impedance of the fault at Fault point F2
$I_Q$	load current
$V_{XG}$	Line to ground voltage( $V_{AG}, V_{BG}, V_{CG}$ )
$I_X$	Line current( $I_A, I_B, I_C$ )
$Z_{error}$	the error measured impedance when the STATCOM is connected
$I_{res}$	Residual current

## LIST OF ABBREVIATIONS

FACTS	Flexible Alternating Current Transmission System
STATCOM	Static Synchronous Compensator
VSC	voltage sourced converter
CSC	current-sourced converter
VAR	Volt-ampere reactive
AC	Alternating Current
DC	Direct Current
CT	Current Transformer
VT	Voltage Transformer
SSG	Static Synchronous Generator
BESS	Battery Energy Storage System
SMES	Superconducting Magnetic Energy Storage
SVC	Static VAR Compensator

TCR	Thyristor Controlled Reactor
TSR	Thyristor Switched Reactor
TSC	Thyristor Switched Capacitor
SVG	Static VAR Generator or Absorber
SYS	Static VAR System
TGBR	Thyristor Controlled Braking Resistor
SSSC	Static Synchronous Series Compensator
IPFC	Interline Power Flow Controller
TCSC	Thyristor Controlled Series Capacitor
TSSC	Thyristor Switched Series Capacitor
TCSR	Thyristor Controlled Series Reactor
TSSR	Thyristor Switched Series Reactor
UPFC	Unified Power Flow Controller
TCPST	Thyristor Controlled Phase Shifting Transformer
IPC	Inter Phase Power Controller
PWM	Pulse Width Modulation
MOSFET	Metal-oxide semiconductor field-effect transistor
IGBT	Insulated-gate bipolar transistor
SCR	Silicon controlled rectifier