



شبكة المعلومات الجامعية

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ





شبكة المعلومات الجامعية



شبكة المعلومات الجامعية

التوثيق الالكتروني والميكرو فيلم

جامعة عين شمس

التوثيق الالكتروني والميكرو فيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأفلام قد اعدت دون أية تغيرات



يجب أن

تحفظ هذه الأفلام بعيداً عن الغبار

في درجة حرارة من 15 – 20 مئوية ورطوبة نسبية من 20-40 %

To be kept away from dust in dry cool place of
15 – 25c and relative humidity 20-40 %



شبكة المعلومات الجامعية



بعض الوثائق الأصلية تالفة



شبكة المعلومات الجامعية



بالرسالة صفحات
لم ترد بالأصل



Mansoura University
Faculty of Engineering
Elect. Power & Machines Dept.

COMPUTER-AIDED, REAL-TIME DATA ACQUISITION SYSTEM FOR OPERATION AND CONTROL OF REACTIVE POWER COMPENSATORS

By

Eng. Khalid Ali Abdel-momen Ali

A thesis submitted in partial Fulfillment

*For The Requirements of a Master Degree in
Electrical Power Engineering*

Supervisors

Prof. Dr.

Ahmed Abdel-mageed Hassan

Elect. Power & Machines Dept.

Faculty of Engineering

Mansoura University

Prof. Dr.

Soliman Ahmed Farghal

Elect. Power & Machines Dept.

Faculty of Engineering

Mansoura University

Assoc. Prof. Dr.

Gabr Mohamed Abdel-salam

Elect. Power & Machines Dept.

Faculty of Engineering

Mansoura University

B 9.02

1995



Mansoura University
Faculty of Engineering
Elect. Power & Machines Dept.

COMPUTER-AIDED, REAL-TIME DATA ACQUISITION SYSTEM FOR OPERATION AND CONTROL OF REACTIVE POWER COMPENSATORS

By

Eng. Khalid Ali Abdel-momen Ali

*A thesis submitted in partial Fulfillment
For The Requirements of a **Master Degree** in
Electrical Power Engineering*

Supervisors

Prof. Dr.

Ahmed Abdel-mageed Hassan

*Elect. Power & Machines Dept.
Faculty of Engineering
Mansoura University*

Prof. Dr.

Soliman Ahmed Farghal

*Elect. Power & Machines Dept.
Faculty of Engineering
Mansoura University*

Assoc. Prof. Dr.

Gabr Mohamed Abdel-salam

*Elect. Power & Machines Dept.
Faculty of Engineering
Mansoura University*

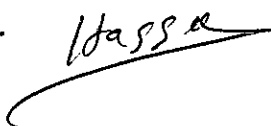
1995

SUPERVISION

RESERCHER NAME : KHALID ALI ABDEL-MOMEN ALI

THESIS TITLE: COMPUTER-AIDED, REAL-TIME DATA ACQUISITION SYSTEM
FOR OPERATION AND CONTROL OF REACTIVE POWER
COMPENSATORS.

SUPERVISORS

	NAME	POSITION	SIGNATURE
1	Prof.Dr. Ahmed Abdel-mageed Hassan	Prof. of Elect. Power & Machines Faculty of Engineering Mansoura University	
2	Prof. Dr. Soliman Ahmed Farghal	Prof. of Elect. Power & Machines Faculty of Engineering Mansoura University	
3	Asso. Prof. Dr. Gabr Mohamed Abdel-salam	Dr. of Elect. Power & Machines Dep. Faculty of Engineering Mansoura University	

EXAMINATION COMMITTEE

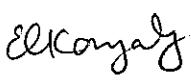
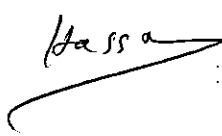
RESERCHER NAME : KHALID ALI ABDEL-MOMEN ALI

THESIS TITLE: COMPUTER-AIDED, REAL-TIME DATA ACQUISITION SYSTEM
FOR OPERATION AND CONTROL OF REACTIVE POWER
COMPENSATORS.

EXAMINATION DATE:

THESIS GRADE:

EXAMINATION COMMITTEE

	NAME	POSITION	SIGNATURE
1	Prof. Dr. El-sayed H. El-konyaly	Head of Aut. Control & Computers Dep. Faculty of engineering Mansoura University	
2	Dr. Kamel Yassen Ali Mostafa	Maniger of control center for operation	
3	Prof.Dr. Ahmed Abdel-mageed Hassan	Prof. of Elect. & Machines Dep. Faculty of Engineerning Mansoura University	
4	Prof. Dr. Soliman Ahmed Farghal	Prof. of Elect. & Machines Dep. Faculty of Engineerning Mansoura University	
5	Ass. Prof. Gabr Mohamed Abdel-salam	Dr. of Elect. & Machines Dep. Faculty of Engineerning Mansoura University	

ACKNOWLEDGEMENTS

Thanks to GOD who creates this work by guiding me to the frank way and by offering assistance of honest professors.

The author wishes to express my sincere gratitude to *Prof. Dr. Ahmed Abdel-mageed hassan* for his supervision, courtesy, guidance, valuable advices and contributions in developing this work.

The author wishes to express my sincere gratitude to *Prof. Dr. Soliman Ahmed Farghal* for his supervision and helpful advices.

The author wishes to express my sincere gratitude to *Asso. Prof. Dr. Gabr Mohamed Abdel-salam* for his supervision, helpful guidance and valuable advices.

Finally, it is my pleasure to record my sincere thanks to my parents for supporting and encouraging me through out my work.

CONTENTS

GLOSSARY OF ABBREVIATIONS	1
INTRODUCTION	4
1-1 GENERAL	4
1-2 HISTORICAL BACKGROUND	5
1-3 OBJECTIVES	6
1-4 CONTRIBUTIONS	7
1-5 SCOPE OF THE THESIS	7
REACTIVE POWER COMPENSATION	10
2-1 REACTIVE POWER FUNDAMENTALS	10
2-1-1 NETWORK COMPONENT CHARACTERISTICS	10
2-1-2 RELATIONSHIP OF VOLTAGE WITH REACTIVE POWER	11
2-2 REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS	13
2-2-1 TRANSMISSIONS WITH LONG OVERHEAD LINES	13
2-2-2 EXTENSIVE CABLE NETWORKS	19
2-2-3 HVDC TERMINAL STATIONS	20
2-3 REACTIVE POWER COMPENSATION IN DISTRIBUTION SYSTEMS	20
2-3-1 URBAN, RESIDENTIAL, AND RURAL SYSTEMS	21
2-3-2 HIGH-POWER INDUSTRIAL SYSTEMS	21
2-3-3 POWER FACTOR CORRECTION AND PHASE BALANCING OF UNSYMMETRICAL LOADS	22
2-4 REACTIVE POWER COMPENSATION DEVICES	24
2-4-1 GENERATORS	24
2-4-2 SHUNT CAPACITORS	24
2-4-3 SYNCHRONOUS CONDENSERS	25
2-4-4 THYRISTOR-CONTROLLED STATIC COMPENSATORS	25
2-4-5 SERIES CAPACITORS	27
2-5 THYRISTOR CONTROLLER	27
2-5-1 METHODS OF TURN ON	28
2-5-2 RATINGS OF THYRISTOR	28
2-5-3 TRIAC	29
2-5-4 THYRISTOR PROTECTION CIRCUITS	30
2-5-5 GATING ENERGY	32

DATA ACQUISITION SYSTEM	40
3-1 GENERAL	40
3-2 FUNDAMENTALS OF DAS	40
3-2-1 BASIC ELEMENTS OF DAS	40
3-2-2 SERIES SYSTEM	41
3-2-3 SIMULTANEOUS SAMPLING SYSTEM	42
3-2-4 PARALLEL SYSTEM	42
3-2-5 RESOLUTION	42
3-2-6 SAMPLING RATE AND ALIASING	43
3-2-7 SOFTWARE PROGRAMS	44
3-3 SYSTEM OVERVIEW	44
3-3-1 THE MEASUREMENT SYSTEM	45
3-3-2 INSTALLATION AND SETTING UP THE DAS	46
3-3-3 SYSTEM CONSIDERATIONS	47
3-3-4 HARDWARE DESCRIPTION	47
3-3-5 SYSTEM SOFTWARE	49
DEVELOPMENT OF STATIC VAR COMPENSATOR AND THE CONTROL TECHNIQUE TO REDUCE HARMONICS AND SWITCHING TRANSIENTS	53
4-1 GENERAL	53
4-2 DEVELOPMENT OF SVC TO REDUCE GENERATED HARMONICS AND SWITCHING TRANSIENT	53
4-2-1 THYRISTOR-CONTROLLED REACTOR (TCR)	53
4-2-2 REDUCTION OF TRANSIENT OVERVOLTAGE	55
4-2-3 THE SUBSTEPS OF THYRISTOR-SWITCHED CAPACITOR	56
4-2-4 INTEGERIZATION PROBLEM	56
4-2-5 REDUCTION OF DYNAMIC SWITCHING OPERATIONS	58
4-2-6 OPERATION STRATEGY FOR PROPOSED SVC	59
4-3 ON-LINE CONTROL TECHNIQUE OF THE DEVELOPED SVC	60
4-3-1 PROPOSED OPERATION AND CONTROL SYSTEM FOR SVC	60
4-3-2- ZERO-CURRENT DETECTOR	61
4-3-3 FIRING CIRCUIT	62
4-3-4 ELECTRONIC MEASUREMENT OF POWER FACTOR	63

IMPLEMENTATION AND EXPERIMENTAL INVESTIGATION OF SVC AND CONTROL CIRCUIT	75
5-1 GENERAL	75
5-2 MODEL OF TRANSMISSION LINE	75
5-3 DEVELOPED SVC	75
5-4 SIMPLE LOAD MODEL	77
5-5 THE PERSONAL COMPUTER AND DATA ACQUISITION SYSTEM	77
5-6 CONTROL CIRCUIT	78
5-6-1 ZERO-CURRENT DETECTOR CIRCUIT	78
5-6-2 FIRING CIRCUIT	79
5-7 POWER FACTOR MEASURING CIRCUIT	79
5-8 THE SOFTWARE PROGRAM	81
5-9 OFF-LINE STUDY	82
5-10 RESULTS	82
5-11 APPLICATION ON AN INDUSTRIAL FACTORY AT MANSOURA	86
5-12 DISCUSSION OF RESULTS	86
 OPERATING OF SVC WITH PRESENCE OF HARMONICS	 108
6-1 GENERAL	108
6-2 SOURCES OF HARMONICS	109
6-3 PROBLEMS CAUSED BY HARMONICS	109
6-4 CAPACITORS AND RESONANCE PROBLEMS	110
6-5 CONSIDERATIONS OF THE SVC INSTALLATION	111
6-6 HARDWARE REQUIREMENTS FOR DATA ACQUISITION AND MEASUREMENTS	112
6-7 LOAD MODELING AT FUNDAMENTAL AND HARMONIC FREQUENCIES	113
6-7-1 MODELING AT THE FUNDAMENTAL FREQUENCY	113
6-7-2 CALCULATION OF FEEDER RESISTANCE AT HARMONIC FREQUENCIES	114
6-7-3 MODELING AT HARMONIC FREQUENCIES	115
6-8 PROPOSED GENERAL OPERATING STRATEGY OF SVC FOR REACTIVE POWER COMPENSATION WITH PRESENCE OF HARMONICS AND RESONANCE AVOIDANCE	116
CONCLUSIONS	120
APPENDIX A	123
APPENDIX B	125
REFERENCES	143

GLOSSARY OF ABBREVIATIONS

V	: Line voltage
V ₁	: Sending end voltage
V ₂	: Receiving end voltage
E _m	: Peak applied voltage
I	: Line current
ϕ	: Phase angle between voltage and current
PF	: Power factor
Y	: Load admittance
G	: Load conductance
b	: Load susceptance
R	: Line resistance
X	: Line reactance
Z	: Line impedance
L	: Inductance of circuit
P	: Real power
Q	: Reactive power
θ	: Power angle
p _o	: Surge impedance load (SIL)
SVC	: Static var compensator
TCR	: Thyristor controlled reactor
TSC	: Thyristor switched capacitor
TSR	: Thyristor switched reactor
SS	: Substep of thyristor switched capacitor

FC : Fixed capacitor
 ΔQ : Change in reactive power injection
 S_{sc} : Short circuit capacity
 S.C : Short circuit
 B^{γ} : Compensating susceptance
 DAS : Data Acquisition system
 AMUX : Analog multiplexer
 SHA : Sample and hold amplifier
 ADC : Analog to digital converter
 RMS : Root mean square value
 f : Normal frequency
 f_a : The fundamental aliasing frequency
 f_s : Sampling frequency
 N : Number of samples
 I/O : Input/Output
 RAM : Read only memory
 ROM : Random access memory
 PC : Personal computer
 BCD : Binary coded decimal
 Q_s : Reactive power rating of substep
 N_s : Number of substeps
 Q_t : Net reactive power required to arrive at unity PF and to balance load between phases.
 Q_t' : Transmitted reactive power after compensation
 x : Fraction ranged from 0 to 0.5
 UJT : Unijunction transistor
 f_o : Resonant frequency of capacitor-inductor circuit