

**APPLICATION OF STATCOM TO MITIGATE VOLTAGE SAG**

**NUR SYAZWANI BINTI SHAFIE**

**FACULTY OF ELECTRICAL ENGINEERING**

**UNIVERSITI TEKNOLOGI MARA**

**MALAYSIA**

## **ACKNOWLEDGEMENT**

First and foremost, I would like to express my gratitude to the Most Gracious and Most Merciful ALLAH s.w.t. for helping me to complete this thesis.

It has been an honor and a pleasure to have Assoc. Prof. Dr. Noraliza Hamzah as supervisor. In addition to her huge knowledge and experience, I also enjoy her support, advice and patience during the hardest moments of the project and writing of the thesis. Her broad technical skills and constructive criticism have been very instrumental and will remain with me as a model for the future.

Next, I would like to express my thousand of appreciation to my parents for giving me their support, ideas, best wishes, love, time, money, and encouragement thru my life. Thanks to my friend, Benny who provided me with all kinds of help either academically or morally.

I would like to express special thanks to power electronic research assistant for being helpful in preparation of the research project.

## **ABSTRACT**

The main objective of this research is to analyze the capability of STATCOM to mitigate the voltage sag due to starting of induction motor. The starting period of induction motor depends upon the factors such as, motor construction, its condition and its loading condition. Typically, the starting period is about 1 sec.; therefore there is a voltage sag in the supply voltage during this period. The solutions approached for compensation of voltage sag are either shunt injection of reactive current or series injection of voltage. The shunt injection of reactive current for voltage sag mitigation can be implemented by using custom power device like STATCOM. The setup of this circuit consists of inverter with capacitor in its dc side, coupling transformer, and a control system. The self commutate thyristor inverter has been used. Thyristor feature have very low losses, making them attractive devices to efficiently control very high currents and energies. The circuit is design and simulated by using Matlab/Simulink program.

## TABLE OF CONTENT

CHAPTER	DESCRIPTION	PAGE
	DECLARATION	i
	APPROVAL SHEET	ii
	ACKNOWLEDGEMENT	iii
	ABSTRACT	iv
	TABLE OF CONTENT	v
	LIST OF FIGURE	vii
<b>1</b>	<b>INTRODUCTION</b>	
	1.1 RESEARCH BACKGROUND	1
	1.2 PROBLEM STATEMENT	2
	1.3 OBJECTIVE	2
	1.4 SCOPE OF WORK	3
	1.5 ORGANIZATION OF THE THESIS	3
<b>2</b>	<b>LITERATURE SURVEY</b>	
	2.1 POWER QUALITY	5
	2.2 POWER QUALITY PROBLEMS	6
	2.2.1 HARMONIC DISTORTION	6
	2.2.2 MOMENTARY INTERRUPTION	6
	2.2.3 TEMPORARY INTERRUPTION	6
	2.2.4 LONG TERM OUTAGE	7
	2.2.5 NOISE	7
	2.2.6 SAG	7
	2.2.7 SPIKE	7
	2.2.8 SURGE	7
	2.2.9 TRANSIENT	8
	2.2.10 UNDERVOLTAGE	8
<b>3</b>	<b>VOLTAGE SAGS</b>	
	3.1 VOLTAGE SAG DEFINITION	9
	3.2 WHERE DO VOLTAGE SAG OCCUR	10
	3.2.1 UTILITY SYSTEM	10
	3.2.2 INSIDE INDUSTRIAL PLANTS	11
	3.3 CAUSES OF VOLTAGE SAG	12
	3.3.1 INDUSTRIAL PLANT	12
	3.3.2 UTILITY SYSTEM	13
	3.3.2.1 OPERATION ON RECLOSERS AND CIRCUIT BREAKER	13
	3.3.2.2 EQUIPMENT FAILURE	13
	3.3.2.3 BAD WEATHER	14
	3.3.2.4 ANIMAL AND BIRDS	14
	3.3.2.5 CONSTRUCTION ACTIVITY	14

<b>4</b>	<b>INDUCTION MOTOR</b>	
4.1	PRINCIPLE OF OPERATION	15
4.2	STARTING OF INDUCTION MOTOR	18
4.2.1	DIRECT ON LINE STARTING	18
4.2.2	STAR-DELTA STARTER	18
4.2.3	SERIES REACTOR STARTER	19
<b>5</b>	<b>THE STATCOM</b>	
5.1	OPERATING PRICIPLE	20
5.2	CONTROL SYSTEM BLOCK DIAGRAM	22
5.3	STATCOM V-I CHARACTERISTIC	24
<b>6</b>	<b>METHODOLOGY</b>	
6.1	PROCEDURE	25
6.1.1	LITERATURE STUDY	25
6.1.2	ANALYZE THE CIRCUIT	25
6.1.2.1	STATCOM	25
6.1.2.2	SIX-PULSE VSI	27
6.1.3	SIMULATE THE CIRCUIT	28
6.1.4	ANALYZE THE SIMULATION CIRCUIT	28
6.1.5	MAKE A CONCLUSION	28
6.2	FLOWCHART	29
6.3	MODELING OF INDUCTION MOTOR	30
6.4	MODELING OF PROPOSED CIRCUIT	31
<b>7</b>	<b>RESULT AND DISCUSSION</b>	
7.1	STATCOM CURRENT	32
7.2	SIMULATION OF 3 PHASE LINE VOLTAGE	33
7.3	SIMULATION ON MOTOR CURRENT	35
7.4	SIMULATION ON ELECTROMAGNETIC TORQUE	37
<b>8</b>	<b>CONCLUSION AND FUTURE DEVELOPEMENT</b>	
8.1	CONCLUSION	39
8.2	FUTURE DEVELOPMENT	40
	<b>REFERENCES</b>	41