MODELLING AND SIMULATION OF PWM SWITCHED AUTOTRANSFORMER FOR VOLTAGE SAG MITIGATION USING MATLAB/SIMULINK

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DEDICATION

Dedicated, in thankful appreciation for
support, encouragement and understandings
to my beloved parent, brothers and sisters.
Thanks for everything

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ABSTRACT

For some decades, power quality did not cause any problem, because it had no effect on most of the loads connected to the electric distribution system. When an induction motor is subjected to voltage sag, the motor still operates but with a lower output until the sag ends. With the increased use of sophisticated electronics, high efficiency variable speed drive, and power electronic controller, power quality has become an increasing concern to utilities and customers. Voltage sags is the most common type of power quality disturbance in the distribution system. It can be caused by fault in the electrical network or by the starting of a large induction motor. Although the electric utilities have made a substantial amount of investment to improve the reliability of the network, they cannot control the external factor that causes the fault, such as lightning or accumulation of salt at a transmission tower located near to sea. Custom power device like Dynamic voltage restorer and STATCOM are normally employed as a solution for mitigation of voltage sag. This project presents modelling and analysis of PWM switched autotransformer as a mitigating device for voltage sag disturbances. The proposed system has less number of switching devices and has good compensating capability in comparison to commonly used compensators. Simulation analysis of three-phase compensator is perfomed in MATLAB/SIMULINK software. Simulation results are presented for various conditions of faults and also the comparison result with and without of the PWM switched autotransformer.

ABSTRAK

Untuk beberapa dekad, kualiti kuasa tidak menyebabkan apa-apa masalah, kerana ia tidak mempunyai kesan ke atas sebahagian besar beban disambungkan ke sistem pengagihan elektrik. Apabila motor induksi adalah tertakluk kepada voltan lendur, motor masih beroperasi tetapi dengan keluaran yang lebih rendah sehingga lendur berakhir. Dengan peningkatan penggunaan peralatan elektronik canggih, kecekapan tinggi pemacu kelajuan boleh ubah, dan kuasa pengawal elektronik, kualiti kuasa telah menjadi kebimbangan yang semakin meningkat untuk utiliti dan pelanggan. Voltan lendur adalah jenis gangguan kualiti kuasa yang berlaku dalam sistem pengagihan. Ia boleh disebabkan oleh kerosakan dalam rangkaian elektrik atau permulaan motor induksi yang besar. Walaupun utiliti elektrik telah membuat sejumlah besar pelaburan untuk meningkatkan kebolehpercayaan rangkaian, mereka tidak dapat mengawal faktor luaran yang menyebabkan kerosakan, seperti kilat atau pengumpulan garam di menara pemancar yang terletak berhampiran laut. Peranti kuasa adat seperti pemulih voltan dinamik dan " Static Synchronous Compensator " (STATCOM) biasanya bekerja sebagai penyelesaian bagi mengurangkan voltan lendur. Projek ini membentangkan pemodelan dan analisis dihidupkan alat ubah auto "Pulse Width Modulation "(PWM) sebagai peranti kawalan yang sempurna untuk gangguan voltan lendur. Sistem yang dicadangkan mempunyai jumlah peranti pensuisan yang rendah dan mempunyai keupayaan pampasan yang baik berbanding dengan pemampas yang biasa digunakan. Analisis simulasi pemampas tiga fasa di laksanakan dalam perisian MATLAB / SIMULINK. Keputusan simulasi memaparkan pelbagai keadaan kerosakan dan juga perbandingan keputusan di antara penggunaan tanpa dihidupkan alat ubah auto PWM dan dihidupkan alat ubah auto PWM.

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LIST OF ABBREVIATIONS

ITIC	-	Information Technology Industry Council
CBEMA	-	Computer Business Equipment Manufacturers Association
PQ	-	Power Quality
STATCOM	-	Static Synchronous Compensator
DVR	-	Dynamic Voltage Restorer
PWM	-	Pulse Width Modulation
IGBT	-	Insulated Gate Bipolar Transistor
SLG	-	Single Line To Ground
LL	-	Line To Line
LLG	-	Double Line To Ground
LLLG	-	Three Line To Ground
RMS	-	Root Mean Square
GTO	-	Gate Turn Off Thyristor
VSC	-	Voltage Source Converter
VG	-	Voltage Gate
THD	-	Total Harmonic Distortion
FL	-	Fuzzy Logic
SVC	-	Static Var Compensator
HVC	-	Hysteresis Voltage Control
PI	-	Proportional Integral

LIST OF SYMBOLS

L	-	Inductor
C	-	Capacitor
R	-	Resistor
Z	-	Impedance
M_a	-	Modulation Index
δ	-	Phase Angle
V_L	-	Load Voltage
V_P	-	Primary Voltage
I_S	-	Current Source
I_L	-	Current Load
N_1	-	Turn Of Ratio
N_2	-	Turn Of Ratio

CHAPTER 1

INTRODUCTION

1.1 Background

Now a day, many of the electronic device are used in the industrial or any place in the world. Actually the electronic device mostly based on the electronic driver and also have programmable logic controller. The electronic devices disturbances is occur in the circuit, the power quality problem must be consider because it can may become less of the tolerant to the power quality[1] such as voltage sags, swell and harmonics. Some references is to uses as a guide to determine the problem of the voltage sag like the Information Technology Industry Council (ITIC) where as published at the ITIC curve. The information the duration of the disturbance events can get from the ITIC curve where its relate to the voltage magnitude [2]. For the sensitive equipment that can operated on the power grid usually used the CBEMA curve as a standard to design the sensitive equipment. One of the method to classification the primary and secondary distribution problem must be consider of the duration, type, and severity[2],[3].

Many methods have been suggest to solve the problem of power quality based on the increasing the reliability of a power distribution [4],[5]. The voltage sags are

considered are most significant and critical at the disturbance condition occur. The main characteristic that explain of the voltage sag are duration and the voltage magnitude. According to the Standard IEEE 1159-1995, sag is a decrease of the rms voltage between 0.1 and 0.9 pu or current at the power frequency for duration 0.5 cycles to 60 seconds.[6] This classification is based on IEEE standard 1159-1995.

Many the mitigation schemes of the voltage sag based on the inverter systems. The inverter system that consists switches and energy storage [7]. The D-STATCOM is proposed to mitigating the voltage sag and also to solve another problem of the power quality such as voltage fluctuations [8]. The D-STATCOM which the system based on the voltage source inverter and thyristor. That thyristor system in the AC system to control the output current independently [8]. The system of the dynamic voltage restorer (DVR) require to inject voltage of the sufficient magnitude. It can be to maintain constant voltage based on the duration of voltage sags. The dynamic voltage restorer (DVR) can operate in boost mode [9]. By using the PWM- switched autotransformer that uses to control circuit based on RMS voltage is to identify the voltage sag. The voltage of load and reference of voltage are always compare together to make sure that the system stable where is the error of voltage is not more than 10 %. One thing for the new mitigating technique of PWM switched autotransformer only used are IGBT switches per phase and also the circuit topology is very simple compare to other method. That why the PWM switched autotransformer is very more economical compared to DVR and D-SATCOM. [10], [11].

1.2 Problem Statement

With the increased use of modern electronics such as speed drive, high efficiency variable and power electronic controller, the power quality issue has become concern to customers and utilities. Voltage sags is one of a kind of problem in power quality. It will cause large losses in a production cost even though it is a

reduction in voltage for a very short time. As we know there are many mitigation techniques available and can be applied to both customer and utility side in order to reduce the effect of the voltage sags, such as distribution static compensator (D-STATCOM) and dynamic voltage restorer (DVR).

The concept of the mitigation technique of DVR and D-STATCOM must uses energy storage and also must uses two switched per phase. To calculate the cost of power electronics in the circuit topology, the total of number switches nearly linearly dependent on the equipment. That means it not economical and not simple.

1.3 Objectives of the study

There are few objectives in this project which are as follow:-

1. To study the concept of voltage sag and investigate the sources, effect and mitigation technique of voltage sag.
2. To perform voltage sag analysis on the power distribution network using MATLAB software.
3. To model and simulate of PWM switched Autotransformer for voltage sag mitigation.

1.4 Scope of work

The scopes of work for this project are divided into below:-

1. Simulation for different type of fault (SLG, LL, LLG, LLLG).
2. Analysis using MATLAB software.
3. Compare the data with different type of fault in the system.

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