FUZZY BASED BIDIRECTIONAL CONVERTER FOR ELEVATOR SYSTEM WITH SUPERCAPACITOR

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DEDICATION

This thesis is dedicated to both my parents,

Mohamad Azhar bin Zainal & Noraida binti Hashim,

who have always believed in me and supported me through every stage of my life.

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ABSTRACT

The dissipation of the energy regenerated by the motor is the primary source of energy waste in elevators. Extra energy created in various ways must be stored for a period of time in order to be used later for the efficient operation of an elevator. An energy storage system is now prevalent in applications for energy conservation and traction. This research proposed to design an elevator system with a supercapacitor (energy storage) controlled by fuzzy based bidirectional DC-DC converter. The supercapacitor is used to store the regenerated energy from the motor during braking mode and releases the stored energy during motoring mode. The bidirectional DC-DC converter controls the power flow to the elevator motor, power supply, and supercapacitor bank. The system introduced two fuzzy-logic controllers for voltage and current which to provide a control to bidirectional DC-DC converter in storing and recovering the energy from supercapacitor. The purpose of this research is to analyze the performance of bidirectional DC-DC converter with fuzzy logic controller in optimizing the generated energy into supercapacitor during the operation of the elevator system. Based on the simulation result, with the present of supercapacitor in elevator system, the energy from the motor during generating mode will not be wasted. The energy stored in supercapacitor and can be use during motoring mode.

ABSTRAK

Pelesapan tenaga yang dijana semula oleh motor adalah sumber utama sisa tenaga dalam lif. Tenaga tambahan yang dicipta dalam pelbagai cara mesti disimpan untuk satu tempoh masa untuk digunakan kemudian untuk operasi lif yang cekap. Sistem penyimpanan tenaga kini lazim dalam aplikasi untuk pemuliharaan dan daya tarikan tenaga. Penyelidikan ini mencadangkan untuk mereka bentuk sistem lif dengan supercapacitor (penyimpanan tenaga) dikawal oleh penukar DC-DC dwiarah berasaskan kabur. Kapasitor super digunakan untuk menyimpan tenaga yang dijana semula daripada motor semasa mod penjanaan dan membebaskan tenaga yang disimpan semasa mod permotoran. Penukar DC-DC dwiarah mengawal aliran kuasa ke motor lif, bekalan kuasa dan bank superkapasitor. Sistem ini memperkenalkan dua pengawal logik kabur untuk voltan dan arus yang menyediakan kawalan kepada penukar DC-DC dua arah dalam menyimpan dan memulihkan tenaga daripada supercapacitor. Tujuan penyelidikan ini adalah untuk menganalisis prestasi penukar DC-DC dwiarah dengan pengawal logik kabur dalam mengoptimumkan tenaga yang dijana kepada superkapasitor semasa operasi sistem lif. Berdasarkan hasil simulasi, dengan kehadiran supercapacitor dalam sistem lif, tenaga daripada motor semasa mod penjanaan tidak akan dibazirkan. Tenaga yang disimpan dalam supercapacitor dan boleh digunakan semasa mod permotoran.

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LIST OF ABBREVIATIONS

PMSM	-	Permanent Magnet Synchronous Motor
AC	-	Alternating Current
DC	-	Direct Current
SC	-	Supercapacitor
SoC	-	State of Charge
IM	-	Induction Motor

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CHAPTER 1

INTRODUCTION

1.1 Background

Elevators are a type of vertical transportation used to carry people and commodities in high-rise or low-rise buildings such as apartments, condominiums, shopping malls, and so on. Elevators are the most important piece of vertical transportation equipment and one of the greatest energy consumers in buildings. Around the last few decades, there has been a substantial advance in the quality and safety of modern elevators all over the world. Furthermore, lowering energy consumption has become a critical aspect in elevator competitiveness since it can significantly enhance a building's overall energy efficiency.

An elevator works on the same concept as a pulley system. The elevators are built so that the combined weight of the car and the predetermined passenger weight is balanced by a counterweight. Typically, the basic components of elevator system are including car, counterweight, hoist way, drive system, control system and safety system as shown in Figure 1.1 below.

In elevator technology, there are many improvements and development that have been done for the efficiency for elevator drive system. The technology of traction machine of elevator started with Induction Machine (IM) in the early stage of elevator but now, modern elevators are more into Permanent Magnet Synchronous Motor (PMSM) which it boasts a strong and simple design, a high efficiency factor and great torque control across a wide speed range. Other benefits of PMSM are include a high-power density and low noise level. Although many improvements been seen, the energy consumption are still higher.

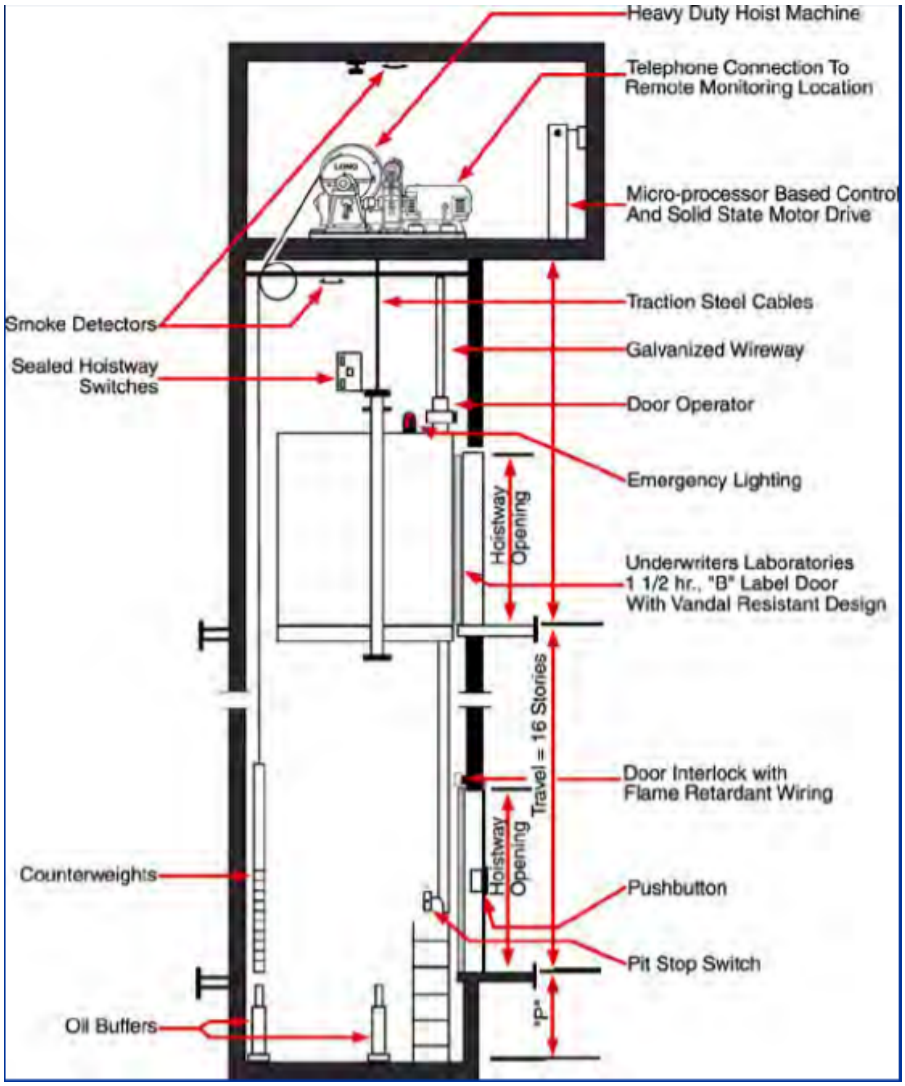

Figure 1.1 Basic components of elevator system. [27]

The reduction of energy consumption by the elevator can be done with the presence of kinetic energy produced by the motor. Depending on the movement direction of the car cabin and its weight in relation to the counterweight, an elevator's traction machine can either consumes or generates electric energy. Unfortunately, the generated energy is usually being wasted where the energy will be dissipated into the braking resistor.

In recent studies, the energy generated from the traction machine could be briefly stored in an energy storage device before being retrieved when the elevator resumes driving function. Due to this reduction in energy consumption, the elevator motion system becomes more efficient and the energy provided by the grid is reduced. The use of supercapacitors as a storage device in elevators is more suitable than battery storage. The reason is that in each operating cycle, the stored braking energy can be recovered in the next motoring operation and would not be accumulated. Also, supercapacitors are substantially more efficient than batteries: they require minimal maintenance, can manage a high-power load due to low internal resistance, can perform multiple charging and discharging cycles, can operate in a wide temperature range, and can tolerate overcharging and overheating.

As to have an optimum result for the energy storage, a DC-DC converter with a good controller also have a main role in the system as to optimize the charging and discharging state of the energy storage. A fuzzy logic controller has been proposed in this research for bidirectional DC-DC converter as to optimize the efficiency of the energy saving in elevator system with supercapacitor.

1.2 Problem Statement

In conventional elevator system, the regenerative energy from the motor drive has been wasted through braking resistor. There is huge amount of wasted energy that could be stored in energy storage and reuse it for the elevator operation.

1.3 Objectives

The objectives are a set of supporting actions to ensure that the goals are achieved. The objectives of this project are:

(a) To design and simulate an elevator system with supercapacitor.

(b) To design a fuzzy logic controller for bidirectional DC-DC converter as to optimize the charging and discharging the supercapacitor

(c) To analyze the energy generated from the motor drive and the energy stored in supercapacitor

1.4 Scope of Work

The research will only focus on designing fuzzy logic controller for bidirectional DC-DC converter and elevator system with supercapacitor. Also analyzing the performance of bidirectional DC-DC converter with fuzzy logic controller on optimizing in storing the generated energy into supercapacitor. This research will only be based on simulation using MATLAB Simulink.

1.5 Significance of the Project

Even though there are other research have been done in improving the energy saving of elevator system with supercapacitor using fuzzy logic controller for bidirectional converter, the analysis and findings of this project are significant to have a better understanding and compare the differences of elevator system with and without energy storage.

1.6 Thesis Organization

Chapter 1 discussed the background of the energy wastage and the needs of improving the energy saving in elevator system. The problem statement has given the strong reasons to analyze the energy optimization by adding supercapacitor controlled by fuzzy based bidirectional converter into an elevator system.

Chapter 2 provides a brief introduction of the elevator system, supercapacitor, bidirectional DC-DC converter, fuzzy logic controller and some previous research that related to the topic. This chapter reviews and explained every part in this project especially on the working principle of the elevator system, fuzzy logic controller and bidirectional DC-DC converter.

Chapter 3 presents the research methodology for this project. There are two designs which are conventional elevator system and elevator system with supercapacitor controlled by fuzzy based bidirectional DC-DC converter. The operations of the elevator system are limited to motoring and generating mode. The rule matrixes and membership functions of fuzzy logic controller are also provided. The simulation is done by using MATLAB Simulink.

Chapter 4 analyzes the performance of the elevator system with and without supercapacitor. All the results of simulation are displayed in graphical form. The results are discussed to evaluate the behaviour of the supercapacitor and also the dc link where the energy dissipated.

Chapter 5 is the last chapter of the thesis with a conclusion that is made based on the performance of overall elevator system when supercapacitor is added and controlled by fuzzy based bidirectional DC-DC converter. Several recommendation are given to improve the system in future work.

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