UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ASSESSMENT ON POTENTIAL ENERGY STORAGE TECHNOLOGIES FOR URBAN RAIL TRANSPORTATION SYSTEMS

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

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ABSTRAK

Selama lebih dari satu abad, simpanan tenaga telah digunakan untuk menangkap tenaga untuk banyak tujuan. Teknologi ini sentiasa bergerak ke arah masa depan untuk peningkatan baru. Teknologi ini mempunyai pertumbuhan untuk kualiti yang lebih baik dan lebih banyak kelebihan. Terdapat banyak jenis simpanan tenaga dengan spesifikasi dan fungsi yang berbeza. Terutamanya, teknologi ini wujud kerana menangkap tenaga yang boleh diperbaharui kerana tidak terkawal. Tenaga yang dihasilkan boleh tinggi atau rendah bergantung pada keadaan. Oleh itu, simpanan tenaga membantu menyimpan tenaga yang dihasilkan untuk digunakan kemudian. Penyelidikan ini memfokuskan pada "supercapacitor" sebagai simpanan tenaga untuk sistem pengangkutan rel bandar. "Supercapacitor" boleh di kategorikan sebagai komponen terkini yang ada. Penyimpanan tenaga ini dipilih kerana mempunyai ciri-ciri yang lebih baik daripada teknologi lain seperti kuasa berkepadatan tinggi, pengecasan / pelepasan cepat, jangka hayat yang panjang, dan banyak lagi. Tujuan penyimpanan tenaga ini dalam sistem pengangkutan rel bandar adalah untuk menangkap tenaga brek regeneratif untuk mengelakkan pembaziran tenaga ketika tidak dapat digunakan kembali. Dengan merujuk pada literatur sebelumnya, penyelidikan ini akan mengkaji ukuran penyimpanan tenaga "supercapacitor" yang sesuai untuk "Kelana Jaya Line". Simulasi pemodelan litar dilakukan dengan menggunakan perisian PLECS untuk tujuan data dan analisis. Beberapa jenis ukuran akan di analisis untuk menentukan yang paling sesuai.

ABSTRACT

For over a century, energy storage has been used to capture energy for many purposes. This technology always moves towards the future for new improvement. These technologies have growth for better quality and more advantages. There are a lot of energy storage types with different specifications and functions. Mainly, this technology exists due to capture renewable energy as it is uncontrolled. Energy generated can be high or low depends on the condition. Hence, energy storage helps to store the generated energy for later use. This research paper focuses on the supercapacitor as energy storage for the urban rail transportation systems. The supercapacitor is one of the latest technologies available. This energy storage selected as it has better characteristics over other technologies such as high-density power, fast charging/discharging, long life span, and many more. The purpose of this energy storage in the urban rail transportation systems is to capture regenerative braking energy to prevent energy-wasting when not able to reuse. By referring to previous literature, this research will study the appropriate sizing of supercapacitor energy storage for the Kelana Jaya line. The circuit modelling simulation is performed by using PLECS software for data and analysis purposes. Several types of sizing will be analyzed to determine the most suitable one.

DEDICATION

I devoted all my works especially for my family members, lecturers, and friends for always believe in me through thick and thin.

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LIST OF SYMBOLS

V	-	Voltage
A	-	Ampere
W	-	Watt
MW	-	Mega Watt
Km	-	Kilometre
kV	-	kilo Volt
kA	-	kilo Amp
s	-	second
mA	-	mili Amp
Wh	-	Watt hour
kWh	-	kilo Watt hour

LIST OF ABBREVIATIONS

SC	SuperCapacitor
ESS	Energy Storage System
OESS	Onboard Energy Storage System
WESS	Wayside Energy Storage System
KJ	Kelana Jaya
HSCB	High Speed Circuit Breaker
AARU	Automatic Assured Receptivity Unit
AC	Alternating Current
DC	Direct Current
Ni-Cd	Nickel Cadmium
Ni-MH	Nickel-metal hydride
Li-ion	Lithium-ion
BSS	Bulk Supply Substation
TPSS	Traction Power Substation
KLAV	Kuala Lumpur Additional Vehicle
ESR	Equivalent series resistance

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CHAPTER 1

INTRODUCTION

1.1 Background

To improve the typical overall performance of the rolling stock is key to accomplishing electricity savings in urban rail transportation. Rolling stock operation divided into two modes: acceleration, deceleration. A rolling stock moves by extracts power from the third and fourth rail throughout the acceleration phase. During constant speed, motor power is almost constant. The pace of the rolling stock is nearly consistent within the constant speed, and it consumes a few quantities of power. The rolling stock decelerates by using brake until it stops.

There are contrast forms of rolling stock braking structures, which includes regenerative, disc, and track braking. To slow down a rolling stock, regenerative braking used by its motor which works on the opposite operation. A rolling stock's motors work as generators throughout braking, transforming mechanical energy into electrical energy. Energy generated used by other rolling stock available nearby. The distance of the urban railway station usually short, and it will make rolling stock always use the brake to make a stop, and a high amount of energy will be generated.

Energy generated, which transfers to the third and fourth rail via a current collector, can be consumed through nearby rolling stock, which should be accelerated using the energy generated by the braking rolling stock. There is no guarantee that the rolling stock will accelerate at the matching time as well as where it is available. The energy consumed by other rolling stock influenced by the headway and age of the system. If there are no close by rolling stock to use this energy generated, third and fourth rail voltage tends to increase. The urban rail transportation system has an overvoltage restriction to protect the equipment. Because of an overvoltage restriction, the braking rolling stock may also no longer be in a position to supply energy generated into the third and fourth rail. When overvoltage occurs, it needs to dump through resistors bank.

Throughout the literature, many of methods suggested to optimize the recovery of regenerative braking energy are train frequency optimization, Energy Storage Systems (ESS), and reversible substation. For train frequency optimization, which required the coordination of different train operations. This method needs to make sure when one train braking, another train will be available to consume generated energy. For ESS, the generated energy is stored when charging, storage technologies available include a SuperCapacitor (SC), battery, and flywheel, then discharged to the third and fourth rail when required. ESS configuration can be set as Onboard ESS or Wayside ESS. Lastly, a reversible substation that provides a way for power to flow and to recycle the power.

1.2 Problem Statement

The urban rail transportation system in Malaysia consumed a lot of energy to operate. High energy consumption will make the bill will be higher over time and need to spend more cost to operate this system. Moreover, this system expected to be upgraded for future passenger increments in a way to reduce personal transportation on the main road. The system upgrade will make the load increase for the urban rail system, and the energy will become unstable to support the entire additional load. Finally, while consumed energy, urban rail transportation able to generate energy. The generated energy will be wasted if not used entirely.

1.3 Project Objectives

1. Identify the way in which regenerative energy recovered by using a SC in Malaysia's urban rail transportation system.
2. Analyze the charging and discharging behavior of the SC during regenerative braking using simulation software.
3. Evaluate the appropriate size of the ESS for the urban rail transportation system in Malaysia.

1.4 Scope of Projects

This paper will fixate on the implementation of the SC as an energy storage mechanism. SC selected as the ESS due to its characteristic to fast charging/discharging repeatedly without degradation of performance and compared to the conventional battery, the specific power of the SC is higher, and it can discharge high energy in a short time.

CHAPTER 2

LITERATURE REVIEW

2.1 KJ Line Overview

As noted by Hirahara, (2012) the total track length for the Kelana Jaya (KJ) Line is 29.4Km and have 15 Traction Power Substations (TPSSs) installed. 132kV from the main grid is supplied at two Bulk Supply Substations (BSSs) and then it stepped down by transformer to 33kV. BSSs supplied 33kV for 15 TPSSs, 33kV is stepped down into 750V DC and fed to the positive 375V DC third and negative 375V DC fourth rails. "New LRT Kelana Jaya line extension to open June 30 as scheduled", (2016) stated the track length expand another 17.4Km when KJ Line extension project completed and add another 13 stations. Figure 2.1 shown BSSs and TPSSs, figure 2.2 shown the single line diagram for TPSS.

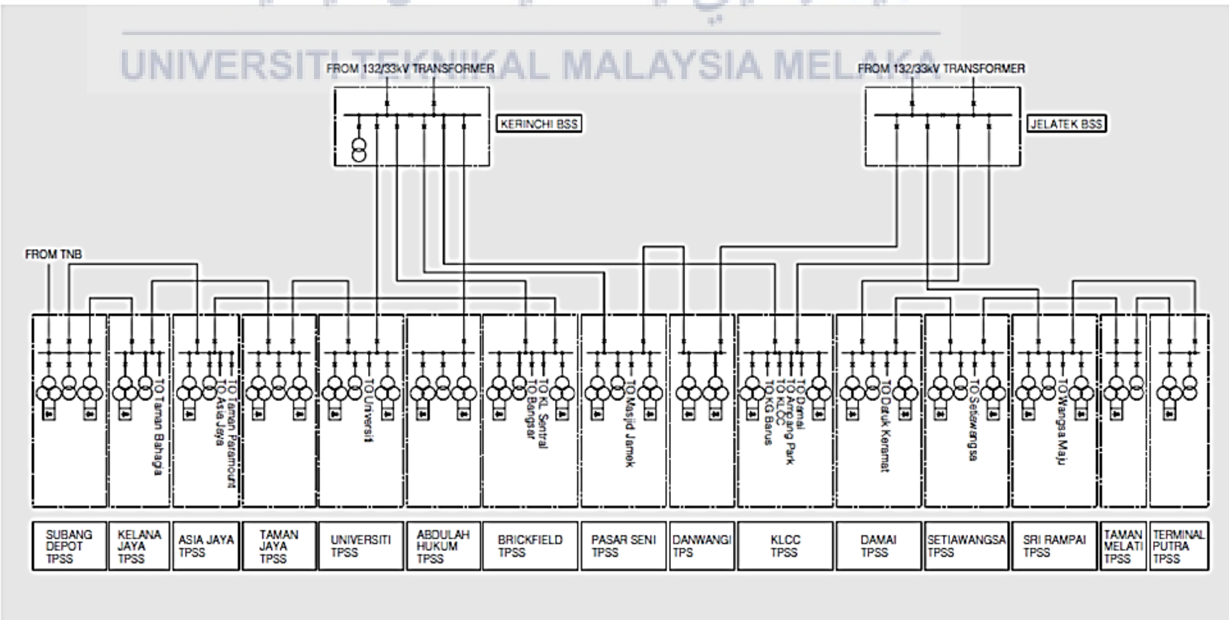

Figure 2.1: BSSs and TPSSs network system configuration (Hirahara, 2012)