NARROW BAND STATE OF CHARGE CONTROLLED ENERGY MANAGEMENT SYSTEM FOR HYBRID RTG CRANES BASED ON STATE MACHINE CONTROLLER

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Degree of Master of Science by Research

Department of Electrical Engineering

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

This research evaluates possibility of using a new hybrid system based on variable speed diesel generator (VSDG), Li-ion battery bank and supercapacitor bank (SC) for a rubber tire gantry crane (RTGC) used in container terminals. Existing commercial hybrid systems face difficulties producing high efficiencies, higher life span and lower initial investment cost due to inheriting characteristics of batteries and supercapacitors. In the proposed power system, a variable speed diesel generator act as the principal energy source, while a Li-ion battery bank and SC bank act as an energy storage system. The battery supports the diesel generator during steady demand and further, it absorbs a part of energy during regeneration. The energy management strategy controls the power flow from different sources while maintaining battery SOC level within a narrow band. Unlike most battery systems, this narrow band operation of battery system increases its life span while reducing capacity fade. The originality of this study can be emphasized from this narrow band SOC control technique. Simulation results for real operational load cycles are presented showing a stable system operating under defined current limits which can enhance lifetime of battery system and increase fuel saving by downsizing 400kW constant speed diesel generator to 200kW VSDG.

Keywords— RTG cranes, Hybrid energy storage, Energy management, narrow SOC band

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During research, I learned a lot more than designing systems and hybrid applications. Actually, modeling complex systems in simulation environment is much harder and I gained much knowledge about Matlab and Simulink which I never had chance during my graduate period.

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LIST OF ABBREVIATIONS

STS : Ship to Shore

AGV : Automated Guided Vehicles

RTG : Rubber Tire Gantry

RMG : Rail Mounted Gantry

SWL : Standard Weight Limit

ICE : Internal Combustion Engine

SC : Supercapacitor

EMS : Energy Management System

RTGC : Rubber Tire Gantry Crane

DG : Diesel Generator

VSDG : Variable Speed Diesel Generator

AC : Alternating Current

DC : Direct Current

BSFC : Brake Specific Fuel Consumption

CCM : Controlled Current Mode

CVM : Constant Voltage Mode

OCV : Open Circuit Voltage