OVERHEAD CRANE CONTROL UPGRADED TO VARIABLE FREQUENCY DRIVE AND WIRELESS REMOTE CONTROLLER FOR PROGRAMMING LOGIC CIRCUIT

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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MASTER OF SCIENCE IN ELECTRONIC ENGINEERING

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Faculty of Electronics and Computer Technology and Engineering

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MUHAMAD NAZRI BIN OMAR

A thesis submitted
in fulfillment of the requirements for the degree of
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2024

DECLARATION

I declare that this thesis entitled "Over Head Crane Circuit Control Updated to Variable Frequency Drive & Wireless Remote Controller for Programming Logic Circuit (PLC)" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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Date : 10th January 2024

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature : 

Supervisor Name : *Dr. Mohd Muzafar Bin Ismail*

Date : 10th January 2024

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DEDICATION

I dedicate this work to Almighty Allah SWT for bestowing upon me health and blessings when I was writing it, as well as to my loving parents, Omar Bin Din and Rubiah Binti Kaus, for their constant moral support throughout the course of the study. Finally, I thank my supervisor, Ir. Dr. Mohd Muzafar Bin Ismail, for his willingness to assist me in completing the research requirement by dedicating this thesis to him. For her endurance and constant support, I am grateful to my sweet wife Nurul Wajihah Binti Ramezan. Not to mentioned my senior managers Vijayan Subramaniam and Rakhidin Bin Osman, who consistently provide their technical know-how and understanding of the Over Head Crane system in Steel Manufacturing Factory.

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ABSTRACT

Radio Frequency (RF) remote controllers are widely used in manufacturing, construction, transportation, and many other industrial applications. Cranes, drills, and miners, among others, are commonly equipped with Radio Frequency (RF) remotes. In this thesis focused on overhead crane in steel manufacturing industry. Installation wired communication takes a long time to set up the connection as compared to the wireless connection. The installation becomes very lengthy and complex to get connected with each router. In future to connect one more device with the network, then it must do the setup again. However, in the wireless connection, don't have to perform all the setup again. Only must access the network with the authorized passcode. Radio-controlled devices are ubiquitous in all sorts of industries. In fact, many cranes are now being equipped with radio-controlled technology, which is revolutionizing the way crews move materials around a warehouse or job site. On the same time, in steel manufacturing industry is still used old technology which is the motor starter of existing cranes is using Rotor Resistance Starter with AC Slip Ring motor type which are need to be improve to Inverter or Variable Frequency Drive (VFD) in this thesis presented. Most of the industries nowadays are using VFD or Inverter with their electrical equipment such as overhead crane as for purpose is Energy Saving, High Operational Efficiency, easy for Maintenance and easy to link with advance technology application such as Programming Logic Circuit (PLC). The study's few main goals are to investigate the overhead crane performance based on Steel Manufacturing Overhead Crane failure and downtime, upgraded motor starter from Rotor ResistanceStarter to Variable Frequency Drive (VFD) with Slip Ring AC motor type and design new Remote Controller with wireless communication system including Transmitter (Tx) and Receiver (Rx). The research was divided into three parts. First, is to design new Remote Controller with Wireless Communication System based on Transmitter (Tx) and Receiver (Rx) communication in order to replace existing controller which is Pendant and Joystick Controller which to improve the demand of more manpower (operator to conduct crane activity), enhance safety and simplify the wiring design. Second is to investigate theoverhead crane performance of base on previous of motor starter design which is Rotor Resistance Starter before implement new motor starter which is Variable Frequency Drive (VFD). Third is to upgrade motor starter from Rotor Resistance Starter to Variable Frequency Drive (VFD) in order to improve motor start up, hoisting anti-sway for safety concern and cost saving for purchase maintenance spare part in in steel manufacturing industry. Through the surveillance and monitoring of wireless remote control motor starter control for crane that done at Ann Joo Steel (AJSB), Prai, Penang, Malaysia. The findings and analysis on the application of wireless remote controllers and variable frequency drives (VFDs) to overhead cranes in the steel manufacturing sector. Following that, a methodology for estimating system upgrading of the overhead crane in the steel manufacturing industry is established by utilising the transmitter (Tx) and receiver (Rx) with a new complete set of Variable Frequency Drive (VFD). The suggested systemestimation method's applicability is demonstrated through case studies. The design of the new control system wire is divided into three components, each based on the current design of the old control wiring.

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ABSTRAK

KAWALAN KREN ATAS DIPERTINGKAT KEPADA PEMACU FREKUENSI BOLEH UBAH DAN KAWALAN JAUH WAYERLES UNTUK LITAR LOGIK PENGATURCARAAAN

Alat kawalan jauh Radio Frekuensi (RF) digunakan secara meluas dalam pembuatan, pembinaan, pengangkutan dan banyak lagi aplikasi perindustrian. Kren, gerudi dan pelombong, antara lain, biasanya dilengkapi dengan alat kawalan jauh Radio Frekuensi (RF). Dalam tesis ini tertumpu kepada kren atas dalam industri pembuatan keluli. Komunikasi berwayar pemasangan mengambil masa yang lama untuk menyediakan sambungan berbanding dengan sambungan wayarles. Pemasangan menjadi sangat panjang dan rumit jika berhubung dengan setiap penghala. Jika kemudian kita ingin menyambungkan satu lagi peranti dengan rangkaian, mesti melakukan persediaan semula. Walau bagaimanapun, dalam sambungan wayarles, tidak perlu melakukan semua persediaan sekali lagi. Hanya perlu mengakses rangkaian dengan kod laluan yang dibenarkan. Peranti kawalan radio terdapat di mana-mana dalam semua jenis industri. Malah, banyak kren kini dilengkapi dengan teknologi kawalan radio, yang merevolusikan cara krew memindahkan bahan di sekitar gudang atau tapak kerja. Pada masa yang sama, dalam industri pembuatan keluli masih menggunakan teknologi lama iaitu motor starter kren sedia ada menggunakan Rotor Resistance Starter dengan jenis motor AC Slip Ring yang perlu diperbaiki kepada Inverter atau Pemacu Frekuensi Berubah (PFB) dalam hal ini tesis dibentangkan. Kebanyakan industri pada masa kini menggunakan Pemacu Frekuensi Berubah (PFB) atau Inverter dengan peralatan elektrik mereka seperti kren atas kerana tujuannya adalah Penjimatan Tenaga, Kecekapan Operasi Tinggi, mudah untuk Penyelenggaraan dan mudah dihubungkan dengan aplikasi teknologi canggih seperti Litar Logik Pengaturcaraan (LLP). Beberapa matlamat utama kajian ini adalah untuk menyiasat asas prestasi kren overhed pada kegagalan Kren Overhed Pembuatan Keluli dan masahenti, pemula motor yang dinaik taraf daripada Pemula Rintangan Rotor kepada Pemacu Frekuensi Berubah (PFB) dengan jenis motor AC Gelang Gelang dan mereka cipta bentuk Alat Kawalan Jauh baharu dengan komunikasi tanpa wayar. Sistem Pemancar (Tx) dan Penerima (Rx) adalah sistem Komunikasi Tanpa Wayar berasaskan komunikasi antara Pemancar (Tx) dan Penerima (Rx) bagi menggantikan pengawal sedia ada iaitu Loket dan Pengawal Kayu Bedik yang meningkatkan permintaan lebih ramai tenaga manusia (operator untuk menjalankan aktiviti kren), kurang keselamatan dan reka bentukpendawaian yang rumit. Kedua adalah untuk menyiasat prestasi kren overhed asas pada reka bentuk penghidup motor sebelum ini iaitu Rotor Resistance Starter sebelum melaksanakan penghidup motor baharu iaitu Pemacu Frekuensi Berubah (PFB). Ketiga adalah untuk menaik taraf starter motor daripada Rotor Resistance Starter kepada Pemacu Frekuensi Berubah (PFB) untuk menambah baik pemulaan motor, pengangkat anti goyang dan penjimatan kos untuk pembelian alat ganti penyelenggaraan dalam industri pembuatan keluli. Pengawasan dan pemantauan kawalan pemula motor kawalan jauh wayarles untuk kren dilakukan di Ann Joo Steel (AJSB), Prai, Pulau Pinang, Malaysia. Penemuan dan analisis mengenai penggunaan pengawal jauh tanpa wayar dan pemacu frekuensi berubah- ubah (PFB) kepada kren overhed dalam sektor pembuatan keluli. Berikutan itu, satu

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metodologi untuk menganggarkan peningkatan sistem kren overhed dalam industri pembuatan keluli ditubuhkan dengan menggunakan pemancar (Tx) dan penerima (Rx) dengan set lengkap baru Pemacu Frekuensi Boleh Ubah (PFB). Kebolehgunaan kaedah anggaran sistem yang dicadangkan ditunjukkan melalui kajian kes. Reka bentuk wayar sistem kawalan baru dibahagikan kepada tiga komponen, masing-masing berdasarkan reka bentuk semasa pendawaian kawalan lama.

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LIST OF SYMBOLS AND ABBREVIATIONS

Tx	-	Transmitter
Rx	-	Receiver
VFD	-	Variable Frequency Drive
LED	-	Light Emiting Diode
I G BT	-	Insulate ate Bi-Polar Transistor
USB	-	Universal Serial Bus
RPM	-	Rotation Per Minutes
RF	-	Radio Frequency
HP	-	Horse Power
PLC	-	Programming Logic Circuit
IoT	-	Internet of Thing
NO / NC	-	Normally Open / Normally Close
MCB	-	Mould Circuit Breaker
COM	-	Common Supply
E/S	-	Emerency Stop
R1	-	Relay No.1
R2	-	Relay No.2
R13	-	Relay No.13Close
2P	-	2 Pole (Breaker)
L	-	Live (Supply)
N	-	Natural (Zero)
1S / 2S	-	First Step (low speed) / Second Step (high speed)
S/N	-	South / North
ID	-	Identification
AP	-	Access Point
IP	-	Industrial Protocol
DO / DI	-	Digital Output / Digital Input
DC	-	Direct Current

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LIST OF PUBLICATIONS

Research Papers

Muhamad Nazri Omar, Mohd Muzafar Ismail, Mohd Nasir Ayob, Faiz Arith. Wireless Control Modelling for Overhead Crane. *Journal on Physic., Conf. Ser.* 2107012033, 2021. (SCOPUS indexed).

Muhamad Nazri Omar, Mohd Muzafar Ismail, Mohd Nasir Ayob, Faiz Arith.Upgrading for overhead crane anti-sway method using variable frequency drive. *Bulletin of Electrical Engineering and Informatics*, Vol. 11, No. 4, August 2022, pp.1837~1844ISSN: 2302-9285, DOI: 10.11591/eei. v11i4.3731, 2022. (SCOPUS indexed).

Conference Proceedings

Muhamad Nazri Omar, Mohd Muzafar Ismail, Mohd Nasir Ayob, Faiz Arith. Wireless Control Modeling for Overhead Crane. *ICoMMS 2021 The 7th International Conferences (UniMAP), 2021*, pp 215. (Participation with Best Presenter Award).

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CHAPTER 1

INTRODUCTION

1.1 Background

An overhead crane is a form of heavy-duty machinery capable of lifting extremely heavy loads and equipment from one point to another in a safe and exact manner by utilising the overhead area of a steel manufacturing industry facility. It is made composed of two parallel runways that hold a horizontal beam (often referred to as the bridge or simply the crane) on which a main hoist or auxiliary hoists running. The supportingrunways can be joined at a raised level to the building walls. Overhead cranes make it possible to move loads that would otherwise be difficult or hard to position.

The wireless radio communication provides more reliability even in a harsh environment, which is specifically used in critical and industrial applications. Wireless communication provides cost-effective, easy installation and mobility as compared towired communication. When compared with a wired connection, a wireless connection requires minimum maintenance. If an underground cable is damaged. Then we need to repair or replace the cable, which will cost high.

Whereas wireless communication does not require such kind of maintenance. To communicate over long distances through wireless communication, Access Points (AP) are installed to amplify the signals. So, over a long distance, the signal does not get weak, or some distortion is not created in that signal. However, wired communication is more

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reliable and stable as compared to wireless communication. It also provides better security than the wireless one.

Wireless control and motor starter technology is now widely used to eliminate the need for cables and reduce power consumption to make sure daily efficiency of productivities. Wireless control is made up of Transmitter (Tx) and Receiver (Rx) is used as one of the devices to transmits the control of signal. While motor starter is used as one of the devices to transmits the power for motor start up and continue running. This study is to evaluate the potential of novel investigation on the performance of wireless signal processing of crane control system and crane motor starter system by designing of new control circuit that is reliable with current technology for crane control function in steel manufacturing industry.

Analysis on Transmitter (Tx) & Receiver (Rx) for wireless control and motor starter at control cable termination, new control circuit design such as relays, contactors, and incoming power supply cable by measuring voltage and current to make sure in control range and within motor rated.

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The final stage of analysis is test run the crane movement by wireless crane and motor starter to see any interrupting on the new design system for troubleshooting. It is expected the novel design of wireless control and motor starter for crane will be established. Three goals must be prioritised in this research study. First, a new remote controller with a wireless communication system based on Transmitter (Tx) and Receiver (Rx) communication must be designed to replace the pendant and joystick controller that iscurrently in use.

This will reduce the need for more manpower (an operator to operate the crane), improve safety, and simplify the wiring design. Before implementing a new motor starter, a Variable Frequency Drive (VFD), it is important to first analyse the performance of overhead cranes using the Rotor Resistance Starter design from the past. Third, switching to a Variable Frequency Drive (VFD) from a Rotor Resistance Starter will increase performance of motor startup, hoisting anti-sway, and cost-effectiveness of purchasing maintenance spare parts in of Steel Manufacturing Industry.

1.2 Problem Statement

The study's three main goals are to investigate overhead crane downtime, design a new remote controller with a wireless communication system, and design a motor starter upgrade from a Rotor Resistance Starter to a Variable Frequency Drive (VFD) for AC Motor (Slip Ring Type) in the steel manufacturing industry.

The first problem statement is a lack of mobility; a wired connection does not provide mobility when compared to a wireless connection. If the user wishes to relocate, we will require new cables and switches to connect the devices. The second disadvantageis that wired communication takes longer to set up than wireless communication. If wewish to connect to each router, the installation becomes very lengthy and complex. If we want to connect another device to the network later, we must repeat the setup process.

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However, in the case of a wireless connection, we do not need to repeat the entire setup process. We only need to enter the authorised passcode to gain access to the network. Third is maintenance; if the user just needs a small network frame, there is no need for a server.