INTEGRATION OF AN AUTOMATED GUIDED VEHICLE SYSTEM WITH A PROGRAMMABLE LOGIC CONTROLLED MATERIAL HANDLING

This report submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotics and Automation)(Hons.)

by

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APPROVAL

This reported is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics & Automation) (Hons).
The members of the supervisory committed are as follow:

………………………………..
(Ir. Dr.-Ing. Azrul Azwan Bin Abdul Rahman CEng)

ABSTRAK

Pengendalian bahan termasuk pemindahan, perlindungan, penyimpanan dan pengawalan bahan dan produk sepanjang operasi pembuatan, pergudangan, pengedaran, penggunaan dan pelupusan. Sistem integrasi ialah gabungan pelbagai sub-sistem menjadi satu sistem utama. Sistem ini mampu mengintegrasikan sistem Automated Guided Vehicle (AGV) dan Programmable Logic Controller (PLC) untuk berfungsi secara automatik. Oleh itu, objektif utama dalam projek ini ialah membina dan memastikan sambungan antara AGV dan PLC dalam aplikasi sistem pengendalian bahan adalah tersedia. Sistem ini juga boleh meningkatkan produktiviti dan efisiensi dalam mengendali bahan. Projek ini menumpukan kepada sambungan antara Pioneer 3-AT AGV dan Omron CP1L PLC melalui program C++. Omron PLC akan menyambung ke penghantar. Projek ini boleh dibahagikan kepada tiga seksyen iaitu seksyen AGV, seksyen PLC dan seksyen sistem integrasi. Seksyen AGV akan menjelaskan hubungan antara perisian C++ dan AGV. Dapatan daripada projek ini, C++ telah berjaya berintegrasi dengan AGV melalui Advanced Robotics Interface for Application (ARIA). Seksyen PLC pula menumpukan kepada sambungan antara perisian C++ dan sistem PLC penghantar. C++ dapat berintegrasi dengan PLC melalui OLE for Process Control (OPC). Seksyen sistem integrasi akan menghuraikan sambungan antaran kedua-dua sistem yang telah dinyatakan sebelum ini. Oleh itu, C++ berjaya mencipta dua hala komunikasi dengan menberi arahan daripada AGV dan PLC. Namun begitu, projek ini hanya menjalankan percubaan melalui simulasi di komputer tetapi tidak akan berbeza dengan sistem yang sebenar. Objektif projek ini sudah tercapai dan disampaikan di laporan dengan terperinci.

ABSTRACT

In industry, material handling involves the movement, protection, storage and control of materials and products throughout manufacturing, warehousing, distribution, consumption and disposal. However, the system cannot be synchronized without integration between all machinery systems and work automatically. Integrated system is the combination of the sub-system becoming as one large system. The purpose of this project is to verify and establish the connection between the Automated Guided Vehicle (AGV) and Programmable Logic Controller (PLC) material handling system to directly or indirectly improving the productivity and efficiency. It focuses on the connection between the Pioneer 3-AT AGV and Omron CP1L PLC by using C++ language. The Omron PLC will connect to the conveyor. This project can be divided into third part which is AGV part, PLC part and combine part. AGV part focuses on the connection between the C++ software and AGV. From the result, C++ program able to connect the AGV through Advanced Robotics Interface for Application (ARIA) library. PLC part focuses on the connection between C++ software and PLC conveyor system. C++ program is connecting the PLC by using OLE for Process Control (OPC). For the combining part, it is focusing on the connection between both AGV and PLC system. From the results, C++ program able to call out each coding and establish the two-way communication. Due to some reason, the connection between each other only done in simulation. As a result, the objective is achieved. This can be proved by the scenario for verification.

DEDICATION

Only
my respected grandfather and grandmother, Chiam Ah Bak and Siah Geet Suan
my beloved father, Chiam Kok San
my appreciated mother, Lim Ai Tee
my adored sisters, Xue Chyi, Xue Mei and Xue Jing
for giving me moral support, money, cooperation, encouragement and also understandings
Thank You So Much & Love You All Forever

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADC	-	Analog-to-Digital Converter
AGV	-	Automated Guided Vehicle
CAN	-	Controller Area Network
CSMA/CA	-	Carrier Sense Multiple Access with Collision Avoidance
DAC	-	Digital-to-Analog Converter
DCS	-	Discrete Control System
FBD	-	Function Block Diagram
IC	-	Integrated Circuit
IL	-	Instruction List
IPCF	-	Industrial Point Coordination Functions
IPCF-MC	-	Industrial Point Coordination Function – Management Channel
ISO	-	International Organization for Standardization
I/O	-	Input and Output
IWLAN	-	Industrial Wireless LAN
LAN	-	Local Area Network
LAWN	-	Local Area Wireless Network
LD	-	Ladder Diagram
LED	-	Light Emitting Diodes
OLE	-	Object Linking and Embedding
OPC	-	OLE for Process Control
OS	-	Operating System
OSI	-	Open System Interconnection
PC	-	Personal Computer
PCMCIA	-	Personal Computer Memory Card Industry Association
PLC	-	Programmable Logic Controller
RF	-	Radio Frequency
ROI	-	Return of Investment
SCADA	-	Supervisory Control and Data Acquisition

SFC	-	Sequential Function Chart
ST	-	Structural Text
Wi-Fi	-	Wireless Fidelity
WLAN	-	Wireless LAN

CHAPTER 1

INTRODUCTION

1.1 Background

Manufacturing industry plays an important role and made a large influence in the economic growth. But, the manufacturing industry need to face a lot of challenges due to globalization in this 21st century (Ong, 2015). So, the manufacturing industry is always searching for improvement. To improve it directly or indirectly, one of the methods is to integrate the system each other to increase the productivity. There are a lot of systems in manufacturing industrial such as material handling system, packaging system, fabrication system and so on (Kajan *et at.*, 2013), (Jaiganesh *et at.*, 2014).

Material handling system involves short distance movement within the confines of a building or between a building and a transportation vehicle. It utilizes a wide range of manual, semi-automated, and automated equipment and included consideration of the protection, storage, and control of material throughout their manufacturing, warehousing, distribution, consumption, and disposal (Aized, 2010). In a simple way to explanation, material handling system is a system concerned about loading, moving and unloading of materials. Some example of the material handling system is Automated Guided Vehicle (AGV) system and conveyor system.

AGVs is a flexible manufacturing system (Butdee *et at.*, 2008). This system can improve response time for material movement due to it suitable for long and short distance moves (Hollier, 1985). There are a lot of industries choosing AGVs as material handling system (Wu *et at.*, 2012). The example of AGV are towing AGV, unit-load AGV, pallet truck AGV, fork truck AGV and others (Wu *et at.*, 2012).

Conveyor systems are especially useful in the application involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials which make them very popular in the material handling and packaging industries (Ong, 2015). There is a positive growth for conveyor system on manufacturing industry (TECHNAVIO, 2016). The example of the conveyor system likes pneumatic conveyor, vibrating conveyor, flexible conveyor, vertical conveyor and others. There are many conveyor systems is using Programmable Logic Controller (PLC) to control it.

PLC is an industrial digital computer which is flexible, ruggedized and adapted for the control of manufacturing processes, such as assembly lines, or robotic devices, or any activity that requires high-reliability control and ease of the programming and process fault diagnosis (MAKOX, 2014), (Aized, 2010). By using the PLC, the output results must be produced in response to input condition within a limited time.

In future, the material movement should be fully integrated to form a coordinated, operational system which including receiving, inspection, storage, production, assembly, packaging, unitizing, order selection, shipping, transportation and the handling of return (Aized, 2010).

1.2 Problem Statement

Currently, the problem that faced by manufacturing industry is most industry choose manual as product transfer. The worker or operator needs to take the product from the machine and send it to another section. Even they use AGV, the human operator still a needed for tasks like loading/unloading that are difficult to fully automate. To avoid non-value added activity, integration between systems is needed. Besides that, the whole system in the manufacturing industry is not synchronizing without integration between all machinery systems and work automatically. To link the whole system together, we need to do it step by step. So, the research starts from integrating the AGV and PLC material handling system. In addition, there are just a few of research being done about the integration system between AGVs and the material handling system. So, to prove the AGVs works on integrating with material handling system, we try to communicate each other through experimentation. By integration difference system together, it can be improving the productivity and decrease the cost efficiency while the whole system in the industry can be more synchronize without any operator interrupt after few years.

1.3 Objectives

The objectives of this project are:

(a) To establish the communication between AGV and PLC conveyor system using communication protocol.
(b) To verify the integration capability between AGV and PLC conveyor system through experimentation.

1.4 Scope

The scope works for this project are:

(a) The type of material handling system is using conveyor system and AGV system.
(b) The type of AGVs is using Pioneer 3-AT (P3-AT) research AGV.
(c) The conveyor system is using Omron PLC to control.
(d) The type of communication is using Local Area Network (LAN).

CHAPTER 2

LITERATURE REVIEW

2.1 Material Handling

Material handling is one of the basic components in manufacturing industry. Material handling means the loading, unloading, movement, protection, storage and control of materials and products throughout manufacturing, warehousing, distribution, consumption and disposal especially by the aid of mechanical devices. As a process, material handling incorporates a wide range of manual, semi-automated and fully automated equipment and systems that support logistics and make the supply chain work. Material handling helps with forecasting, resource allocation, production planning, flow and process management, inventory management and control, customer delivery, and after sales support and service. A company's material handling system and processes are put in place to improve customer service, reduce inventory, shorten delivery time, and lower overall handling costs in manufacturing, distribution and transportation (MHI, 2014). So, material handling system is becoming increasingly important to manufacturing industry nowadays due to this technique which can help system planners to measure the total productivity of a business and identify the full opportunity for economic improvement through the use of more efficient material handling activities (Hollier, 1985). There are a lot of type of material handling system such as conveyor system, AGVs and robot arm each (Lindsay *et at.*, 2000). Figure 2.1 shows that the example of the material handling system. The example of material handling system is cover by red circle.

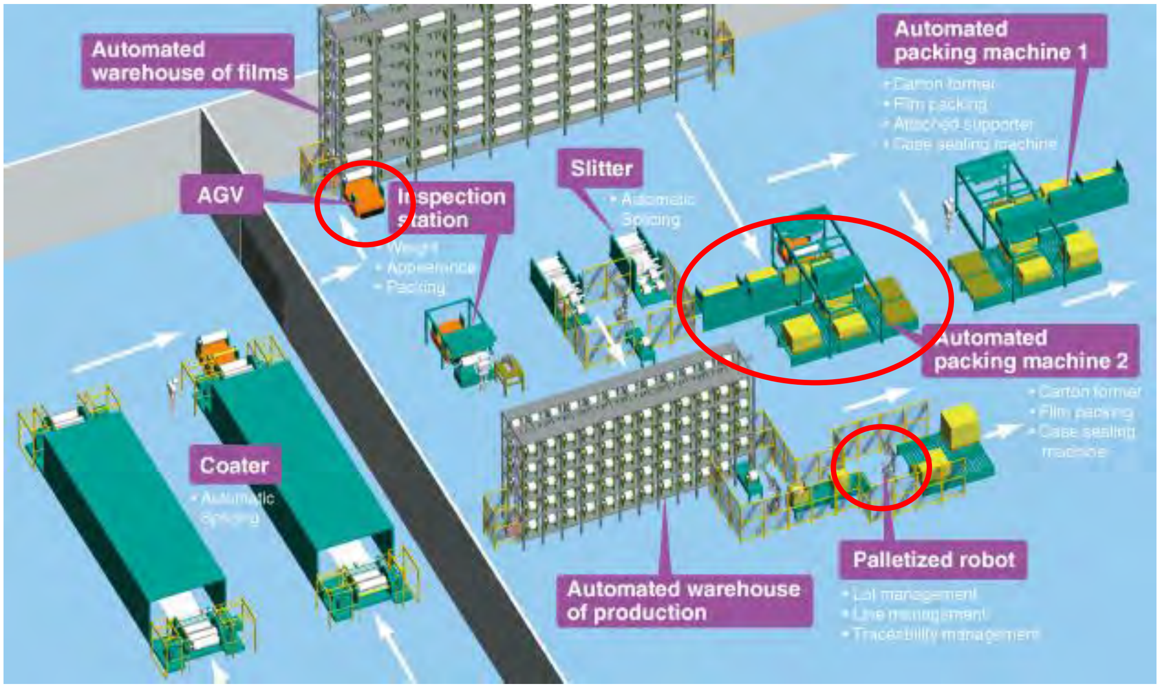

Figure 2.1: Simple example of material handling system (Toray, 2016)

2.1.1 AGVs

AGV is a type of driverless, steerable, wheeled industrial mobile vehicle designed primarily to carry material, tow objects behind them in trailers and transport individuals. According to the Vosniakos and Mamalis (1990), AGVs are an industrial transportation system equipped with electronic devices to follow a wire buried in the ground, pick up and deliver their load at work stations, communicate with each other hardware devices, and move around the network controlled by a supervisory computer and possible by microprocessors on-board. AGVs are commonly used in manufacturing plants, warehouses, distribution centres, paper industry, printing industry, textiles industry, steel industry and terminals (Kajan *et at.*, 2013), (Wu *et at.*, 2012). There are four important elements in AGVs which are:

(a) vehicles

Vehicles are the most important elements of an AGVs as they perform the actual transportation tasks. All vehicles are design individually according to their specific working tasks, working condition and working environment (Schulze *et at.*, 2008). Vehicle can be classified as toward AGV, unit load AGV, pallet truck AGV and fork truck AGV (Wu *et at.*, 2012), (Vosniakos and Mamalis, 1990).

(b) guidance and information transfer system

Most of them will using signal paths, lane paths or signal beacons for navigation. The examples of the sensors that AGV will use to senses are optical sensors, laser scanner, magnetic sensors and also camera (Wu *et at.*, 2012), (Vosniakos and Mamalis, 1990).

(c) traffic control system

The traffic control system covers superordinate control component. It tasks is administration of the transportation orders, the optimization of schedules, the communication with other control system. The system also provides graphical visualization and statistical analysis (Schulze *et at.*, 2008). The AGV routing method can be classified from the viewpoint of trajectory shape which is single loop or bi-directional (Kajan *et at.*, 2013).

(d) pick-up and deposit station and load transfer equipment (Vosniakos and Mamalis, 1990)

AGVs pick-up and deposit station and load transfer can be accomplished in many way such as manual load transfer, automatic couple and uncouple, power roller, belt, chain, power lift/lower and power push/pull (Ülgen and Kedia, 1990). Besides, a robot such as robot arm installed on an AGV, which can give the robot the mobility it lacks and the AGV the flexible manipulator it lacks (Vosniakos and Mamalis, 1990).

The advantages of AGVs is flexibility system, safety technology, and accuracy and productivity. It is a flexibility system due to the vehicle can quickly reprogram to change direction, path or operation. The system also can eliminate the need for expensive retrofitting and new directions, tasks, and work cells can be created almost instantaneously without the need for physical equipment installation. Besides, the AGVs is safety due to it can avoiding interference with human or building. It also can work at the environment that may be not suitable to human operators. In addition, the AGVs is accuracy after combined with Radio Frequency (RF) technology and it can operate at a fixed rate to meet a predictable metric for operational activity (Vosniakos and Mamalis, 1990), (Jaiganesh *et at.*, 2014). Development of the AGVs plays the major role in industry to improve the technology of the material handling system (Kajan *et at.*, 2013), (Jaiganesh *et at.*, 2014). Figure 2.2 show that an AGV is transporting the material.

Figure 2.2: Example of an AGV (Schafer, 2015)

2.1.1.1 Free Ranging and Autonomous

Todays, the AGVs is already update, compare to the classic ones which is floor based type AGV, it instead of using free ranging AGV and autonomous AGV (Wu *et at.*, 2012), (Vosniakos and Mamalis, 1990). Free ranging and autonomous AGV is an automatic machine that is capable of locomotion (Vosniakos and Mamalis, 1990). It means the AGV will use software to program without a physical path. The factory or warehouse must be installed