"I hereby declare that I have read through this report entitle "Development of Heavy Duty Automatic Guided Vehicle for Industrial Application" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)"

Signature : .....

Supervisor's Name : Muhamad Riduwan Bin Md Nawawi

Date : 31th May 2016

DEVELOPMENT OF HEAVY DUTY AUTOMATIC GUIDED VEHICLE FOR INDUSTRIAL APPLICATION (AGV)

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This Report Is Submitted In Partial Fullfillment Of Requirements For The Bachelor Of Electrical Engineering (Control, Instrumentation, and Automation)

Fakulti of Electrical Engineering
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2016

I declare that this report entitle “Development of Heavy Duty Automatic Guided Vehicle for Industrial Application (AGV)” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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ACKNOWLEDGEMENT

Firstly, I would like to express my gratitude and appreciation to all those who gave me the possibility to complete this report. Deepest thanks to my supervisor, Mr. Muhamad Riduwan for his invaluable guidance, stimulating suggestions and encouragement to complete this project. During under his supervision, lot of valuable information is obtained in order to coordinate and complete this project and thesis in the time given.

Special thanks and higher appreciation to my parents, family and special mate of mine for their cooperation, constructive suggestion and also supports from the beginning until the ends during the period of the project. Also thanks to all my friends and others, that has been contributed by supporting and helps myself during the final year project progress till it is fully completed.

Last but not least, greater appreciation to BEKC classmates and Electrical Engineering Faculty UTeM for great commitment and cooperation during my Final Year Project. Besides, I would like to appreciate the guidance given by the panels especially in our project presentation that has improved our presentation skills by their comment and tips.

ABSTRACT

With the improvement of robotic technologies nowadays, industrial application is adopting more aspect of automation to enhance product quality and accuracy to reduce product cost. Entitled as the development of heavy-duty Automatic Guided Vehicle (AGV), this project is about to develop a vehicle without drivers. It consists of mechanical body, rotational mechanism, microcontroller, sensor, and DC motors. AGV in this project is a mobile robot that follows line on the floor. An Arduino Uno Microcontroller will be used to reduce a cost and increase system performance instead of traditional AGV using PLC as controller. It is used to sequence the movement of the wheels by controlling the motors. The motor driver BTS7960 43A are used to controlled the movement of motor by adjusting the Pulse Width Modulation (PWM) to control the speed and direction. AGVs are widely used for transporting material in manufacturing and warehousing applications. On the development of heavy duty automatic guided vehicle, the specification is to implement the AGV to be used in industrial application. It is 1 meter in length, 0.6 meter in width and 0.3 meter in height. Its weight is about 8kg without load and the maximum weight it can carry is 30kg load on the top speed and low torque condition. In addition, a 255 Pulse Width Modulation (PWM) value is set up in the Arduino Uno coding, the motor is said to be on the top speed condition which is equal to 60 rpm and 2.724 N.m in torque for each motor.

ABSTRAK

Dengan peningkatan teknologi robotik pada masa kini, aplikasi industri sedang menerapkan aspek automasi dalam meningkatkan kualiti produk dan ketepatan untuk mengurangkan kos produksi. Berdasarkan tajuk 'Development of Heavy-duty Automated Guided Vehicle for Industrial Application (AGV)', projek ini adalah untuk membina kenderaan tanpa pemandu. Ia terdiri daripada konsep mekanikal, mekanisme putaran, mikropengawal, sensor, dan motor arus terus. AGV dalam projek ini adalah sebuah robot mudah alih yang bergerak mengikut garisas yang ditampal diatas lantai. Mikropengawal Arduino Uno akan digunakan untuk mengurangkan kos dan meningkatkan prestasi sistem dan bukannya mengikut sistem AGV tradisional menggunakan PLC sebagai pengawal. Ia digunakan untuk mengawal pergerakan motor supaya mengikut urutan. Pemandu motor BTS7960 43A digunakan untuk mengawal arah pusingan serta kelajuan motor dengan melaraskan 'Pulse Width Modulation (PWM)'. AGV digunakan secara meluas untuk mengangkut barang dalam sektor pembuatan dan di dalam gudang.Mengenai 'Development of Heavy-duty Automated Guided Vehicle for Industrial Application (AGV), spesifikasi AGV yang akan digunakan dalam aplikasi industri adalah 1 meter panjang, 0.6 meter lebar dan 0.3 meter tinggi. Beratnya kira-kira 8kg tanpa beban dan berat maksimum ia boleh membawa beban adalah 30 kg pada kelajuan tertinggi serta keadaan tork yang rendah. Tambahan lagi, nilai 255 perlu diubah didalam kod Arduino Uno yang merupakan nilai maksima bagi Pulse Width Modulation (PWM) untuk kelajuan tertinggi motor. Ia bersamaan dengan 60 rpm dan tork bernilai 2.724 N.m untuk setiap motor.

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AGV	**-**	Automatic Guided Vehicle
AGC	**-**	Automatic Guided Chart
PLC	**-**	Programmable Logic Control
PIC	**-**	Peripheral Interface Controller

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, Automated Guided Vehicle (AGV) is widely used especially in industry. AGV is a vehicle that is fully automated to carry load, handle load or do some tasks in factory or warehouse.

In industrial, AGV brings a lot of advantages to industry. One of the advantages of using industrial AGV is it can carry a big capacity of load without any human's guidance. The AGV nowadays is very advance in the mechanism structure and most of the AGVs can carry a big capacity of load, like pallets, carts, rolls and others. Besides, it can work 24 hours per day and this helps to increase the productivity of a company [1].

Early AGV is customized and guided by wires embedded in floor. The AGVs were also very expensive and cost about USD 100k per vehicle. Nowadays, there is demand to have a low cost AGVs with high power. The AGVs are very advances in software and most of them are controlled by wireless communication. In addition, most the AGVs also equipped with the advance sensor technology [1].

For industrial usage, AGV can carry a high capacity of load, like pallets, cart, rolls and others. On the other hand, it can save the space of the warehouse as it can lift the load to higher position neatly. Although the initial cost of an AGV is very high, it saves money in the aspect of production and labour cost [2].

A Development of Automated Heavy-duty Guided Vehicle for Industrial Application (AGV) is widely being used in industry. AGV is a transport that is fully automated and works to carry load, handle load or do a task in an industry. With the advancements of robotic technologies, the industrial environments are adopting more and more aspects of automation to enhance product quality and accuracy which is gaining importance in industrial logistics and transportation system [2]. These systems provide for asynchronous movement of material through the system. They offer many advantages relative to other types of material handling systems, including reliable automatic operation, flexibility to changes in the material handling requirement, improved positioning accuracy, reduced handling damages and automated interfaces with other systems.

This project is a development an Automated Heavy-duty Guided Vehicle for Industrial Application (AGV) prototype. Traditionally, AGVs are mostly used at manufacturing systems. AGVs are also used for repeating transportation tasks in other areas, such as warehouses, container terminals and external transportation system [3].

The important things in this development of AGVs are the integration between Arduino Uno microprocessor, sensor, Direct Current (DC) motor, and rotational mechanism. This project is divided into two sections which are mechanical part and electrical part. The mechanical parts are consisting of mechanical drawing using Solid Work software, measuring, and fabrication process. The electrical parts are consisting of electrical drawing and analysis using Proteus / Multisim / PSpice , electrical wiring and programming a microcontroller.

After the fabrication process and assembly, the AGVs will be ready to be tested in the outdoor and indoor field. The first approach is to run the vehicle individually and observe their responses to the environment. Wheels are adjusted and the couplings and bearings are set to correct alignment as they are showing deviations after the very first few test runs. Then the individual sensors will be tested for their accuracy and corrected wherever required. The drive electronics will go through some load tests where the AGVs are loaded and the corresponding current flow through the motors are measured. This was done to incorporate the electronic safety actions in the circuits [4].

AGVs development has a bright future in many industry and they should come forwards in such research works instead of becoming too much depend on foreign technology.

1.2 Objective

The Development of Automated Heavy-duty Guided Vehicle for Industrial Application (AGV) is to help the industries delivery the load from one section to another section automatically. The AGV prototype has been designed and constructed for a heavy-duty application. Thus, the title a Development of Automated Heavy-duty Guided Vehicle for Industrial Application (AGV) is chosen for PSM and the objectives of the project are :

a) To investigate the parameter involve that can be used to be implemented in AGV.

b) To design a control algorithm for a smooth AGV operation system.

c) To develop an AGV prototype by using Arduino Uno microcontroller as control unit in AGV operation system.

d) To analyse the performance of the AGV.

1.3 Motivation

The field of robotics and automation holds enormous potential as a key transformative technology to positively impact the manufacturing industries. From traditional and well-established applications in the automotive industry to emerging applications such as material handling, palletizing, and logistics in warehouses, the use of robots can increase productivity whilst ensuring personnel safety. A Development of Automated Heavy-duty Guided Vehicle for Industrial Application (AGV) represents an integral component of today industries. AGVs can be widely use in the factory, warehouses, hospital or any needs industry for transportation goods between conveyors to assembly section, parts to frame movements, and truck loading or unloading. In this development of Automated Heavy-duty Guided Vehicle (AGVs), the main goal is to get it implemented in the industries that can do an outdoor and indoor job with variety application such as transporting goods in hospital, warehouses, and store without the needs of many workers.

1.4 Problem Statement

The Development of Automated Heavy-duty Guided Vehicle for Industrial Application (AGV) is still new and not much applied in local industry especially in Small Medium Enterprises (SME) and the application is rarely used in local industry compare with multinational country.

The AGV is developed to replace the older method where the load is delivered manually by using man power or used a fork lift. Usually, there will be some random error due to human fault. The workers maybe forget which station for loading and waste the production time. By using AGV, the company maybe can save their production cost that is deducted from labour charge and also can increase the production because AGV can work 24 hours a day compared to labour.

The AGV for market price is very expensive. The only suitable market is mostly focuses in manufacturing factories. The AGV project is the best chance to build a low cost but flexibility prototype. With the lower cost AGV product, it may widely commercialize in medium or small company for future planning.

The AGV system uses in industry has produce a good efficient output than workforce. The system can deliver the load automatically from one section to another section. This system will save a lot of working space as the path is fixed. The user also can save the labour charge and money.

1.5 Scopes

Generally, all projects have their own scope or limitation as a guideline. The Development of Automated Heavy-duty Guided Vehicle for Industrial Application (AGV) aspires to construct a vehicle automatically guided with intelligence way to choose the correct path of travel.

Firstly, the major scope of this project is to build up and construct a prototype of AGVs to carry the load up for 30 kg load. It should be in heavy-duty condition so that it can endure much load to carry.

Secondly, the AGV system is controlled by using the Arduino UNO microcontroller board. It's used to integrate the sensor and motor to move through the line. The microcontroller must be working effectively as a brain of the AGV system.

Thirdly, the selection of effective sensor range is set as navigation guidance for the AGV. The sensor is used for the left and right manoeuvring as well as enable to move forward and reverse track.

Lastly, there will be several of motor being used in order to control the movement of AGV. DC motor is implemented for AGV moving on the setting track.

CHAPTER 2

LITERATURE REVIEW

2.1 Automated Guided Vehicle (AGV)

AGV system essentially consists of vehicles, peripheral and on-site components as well as the stationary control system. Only the faultless interaction of all these components ensures efficiently working plants.

Vehicle component is the central element of AGVs as it performs the actual transportation task. The vehicle has to be designed following the specific conditions of the environment to be implemented. This including loads handling equipment, the navigation system, the drive configuration and other aspects [3].

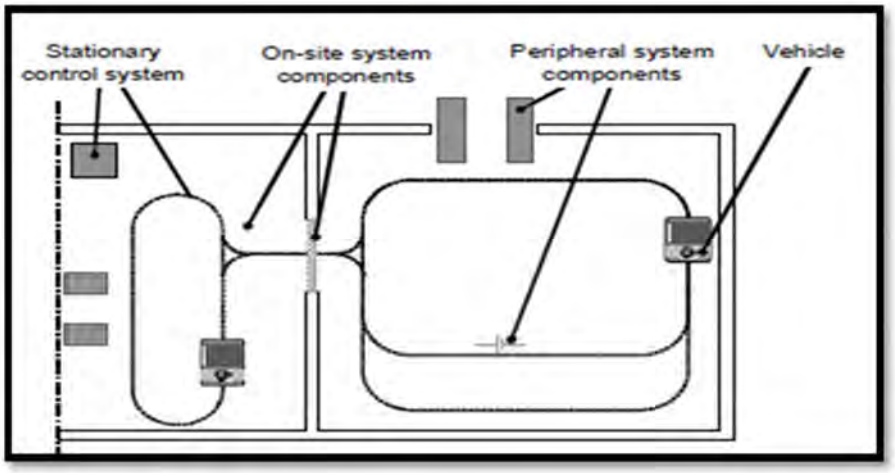

Figure 2.1: Component of an AGVs system

Figure 2.1 briefly shows the component in basic working area of AGV. With the advancements of robotic technologies, the industrial environments are now focusing on aspect of automation to enhance quality of production and accuracy with better time management. Back then, AGVs are mostly used in manufacturing area. Nowadays, AGVs are used for repeating transportation tasks in many other areas application, such as warehouses, store and many other indoor or outdoor applications. Figure 2.2 below shows the example of working area of AGVs in laboratory.

Figure 2.2: Example of AGV working area [4]

According to Garcia et al. (2007), with the rapid modernization of the First World, new types of services are being required to maintain a certain quality of life. A new, promising robotics sector is arising to serve the human being [4]. Schulze and Zhao (2007) performed research on the usage of AGVs in Europe and China. In the developing country, application of robotics is very popular in the field of industry [4]. High labour cost plays an important role for this situation in such countries. It increases the production speed and accuracy.

In the industries, there are many components need to be transferred from one place to another during the manufacturing process. These components are divided according to their size and shape. AGVs are designed to meet the needs of definite industry. As an example, the operations of an interaction of the AGVs is based on imaginary industrial environment where one of the AGVs picks up a block from a predefined loading place and supply it to another AGVs after manoeuvring at a certain distance. Then the other AGVs sensed the delivery and travelled a linear trajectory to perform final delivery of the block to unload it [4].

As the years passing by, AGV are characterized by significant technological advancements. They contributed to increase attractiveness for the user's essential concern, navigation systems, automation of series vehicles and safety system. Significant technological advancements contributed to increase the attractiveness of Automated Guided Vehicle (AGV) system for the users [5].

There are a bunch of research conducted by many higher learning institutes around the world to study about Automated Guided Vehicle (AGV) and improve it in terms of the mechanical arms, the movement speed, the stability and many others. For this project, the industrial AGVs were studied before the AGV prototype is designed.

Generally, there are two type of application related to AGV. Firstly is the Automated Trailer Loading (ATL). As shown in Figure 2.3 below. ATL is a type of AGV that are widely used in the warehouse and factory to pick up and deliver load such as pallets, carts and rolls [6].

Figure 2.3: Automatic Trailer Loading [6]

ATL can carry much load and carry any conventional trailer without any modification. It can also interlace load patterns. ATL is guided by using laser and it uses sonic guidance in trailer. The side forks of the ATL can shift independently and both the left and right forks can rise independently. The fork tip sensors of the ATL can detect whether there is any space available.

ATL does not have an obstacle avoidance system and even the protective bar to protect itself from collisions. Besides, ATL does not have an auto parking system and rechargeable battery. It has to be changed manually when the battery is finished [6].

Secondly, is the Automatic Guided Cart (AGC). As shown in Figure 2.4, AGC is used to carry the trolley from one place to another and it is basically used in the warehouse.

Figure 2.4: Automatic Guided Cart (AGC) [6]

It is not expensive in price where the cost is about USD 10k to USD 30k per vehicle. It is versatile which is easy to be changed from one job to another. It is guided by magnetic tape and the systems of AGC can be installed and easily configured [6]. Figure 2.5 below are the AGC Modular component.

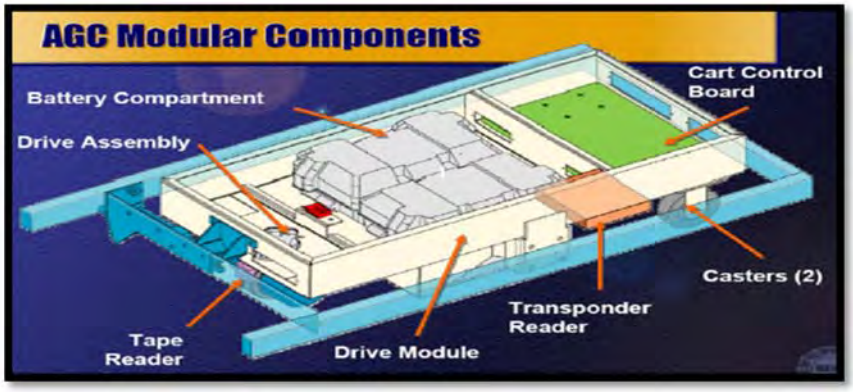

Figure 2.5: AGC Modular Component [6]

One of the disadvantages of the AGC is that the AGC does not have an obstacle avoidance system. It uses the protective bar to protect itself from collision with the walls and the obstacles. Hence, it requires an amount of repairing cost for the AGC when it collides with any obstacle.

2.2 Type of AGV Guidance System

AGVs are used to transport an object from one point to another. AGVs navigate manufacturing areas with the implementation of sensors. There are two main sensors that AGV use for guidance system, a wired and a wireless sensor. There are several types of guidance system of AGV. Firstly is a Laser Guidance System. It uses the integration of a laser beam with the receiver that is plucked on the wall of the room.

Figure 2.6: Laser Guidance AGV [7]

As shown in Figure 2.6, the area is mapped and stored in the computer memory attached in the AGVs. Multiple fixed reference points and reflective strips located within the operating area can be detected by a laser head that is mounted on the vehicle. By using laser guidance technology, the guide path can easily be changed and expanded. It is very flexible for vehicle movement, accurate and reliable in the form of navigation. Other than that, the system can be expanded without alteration to the facility. Generally, it is being used for most dynamic control of blocking and traffic management [7].

Secondly is the Magnetic Spot Guidance Technology. As shown in Figure 2.7, Magnetic Spot Guidance is the technology where the guide path is marked with magnetic pucks that are placed on the floor.

Figure 2.7: Magnetic Spot Guidance AGV [7]

The guide path sensor is mounted on the vehicle. The mounted sensor will integrate with the guide path that is marked with magnetic pucks and move accordingly. If the path is open, the systems guide path can be changed. Other than that, extensive layouts can complicate the layout of magnetic pucks. The navigation of the AGV is depending on the accuracy of the magnetic sensor and the calibration of the position may be required for different vehicles. The advantage of this system, it can be expended without damage or major alteration to the facility [7].

Figure 2.8 shows the application of Magnetic Tape Guidance Technology. It is the technology where the vehicle follows the guided path that is marked with a magnetic tape. It is placed on the floor surface. Commonly, the guide path sensor is mounted on the vehicle. The AGV will follow the tape that is marked on the floor. Moreover, the path is continuous and fixed to its direction. The system guide path can be changed easily and quickly. In addition, the tape has to be epoxy coated to floor so that it can be long lasting. This type of navigation is recommended for Automatic Guided Carts (AGC) that is shown in Figure 2.9 [7].