

AUTOMATED GUIDED VEHICLE (AGC)

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We certify that the project entitled “Automated Guided Conveyor (AGC)” is written by Noor Azzah binti Abu Azmi. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

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Examiner

Signature



## **ABSTRACT**

This project is focused on development of the control system for Automated Guided Conveyor (AGC) by using PIC 18F4550. Two approaches are proposed for this project; hardware approach where involves the development and design of AGC prototype, line follower, sensor circuit and controller circuit and software approach when the system of AGC are write by using microcode studio programmed. This project concentrates on developing the automatic system for AGC which about how the AGC will operate, involve of the movement mechanism. This prototype takes into account when AGC travel and also tries to travel in order by following the line follower. This thesis also includes the test automatic system involving test program and test circuit for the AGC before proceed to the prototype AGC control system.

## **ABSTRAK**

Projek ini difokuskan pada pembangunan sistem kawalan automatik dipandu Konveyor (AGC) dengan menggunakan PIC 18F4550. Dua pendekatan yang dicadangkan untuk projek ini; pendekatan hardware di mana melibatkan pembangunan dan rekabentuk prototaip AGC, pengikut garis, rangkaian sensor dan rangkaian kawalan dan pendekatan perisian apabila sistem AGC yang menulis dengan menggunakan microcode studio diprogramkan. Projek ini menumpukan pada pembangunan sistem automatik untuk AGC yang tentang bagaimana AGC akan beroperasi, melibatkan mekanisme gerakan. Model ini digunakan untuk saat perjalanan AGC dan juga cuba untuk melakukan perjalanan dalam rangka dengan mengikuti pengikut garis. Tesis ini juga merangkumi sistem ujian automatik melibatkan program ujian dan rangkaian uji untuk AGC sebelum meneruskan ke sistem kawalan prototaip AGC.

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**LIST OF SYMBOL**

$V_{ss}$	Logic Supply Voltage
$V_s$	Power Supply Voltage
$V_{ref}$	Voltage Reference
$V_{en}$	Enable Voltage
$V_i$	Voltage Input
$R$	Resistor
$R_{SA}$	External Resistor A
$R_{SB}$	External Resistor B
$P_1$	Input 1
$P_2$	Input 2
$P_3$	Input 3
$M$	Motor
$I_o$	Peak Output Current

**LIST OF ABBREVIATIONS**

AGC	Automated Guided Conveyor
AGV	Automated Guided Vehicle
MHE	Material Handling Equipment
JIT	Just In Time
AS	Automatic Storage
RS	Retrieval System
IC	Integrated Circuit
AI	Artificial Intelligent
GND	Ground
CW	Clockwise
CCW	Counter-Clockwise
PWM	Pulse Width Modulation

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 PROJECT BACKGROUND**

The purpose of this project is to on create and develop an Automated Guided Conveyor (AGC) and it focus move on this project intended to continue and upgrade the previous AGV prototype based on two main parts: hardware approaches which are designed and developed of an AGC prototype, control circuit and line follower; and software approach that implement Microcode basic studio to program the PIC 18F4550.

#### **1.2 PROBLEM STATEMENT**

This AGC is designed to operate in the UMP FKM labs. This is to reduce the human power by applying robot to work. This AGC are functions to collect small components such as bolts and nuts.Futhermore, based on the previous project, there are also a few weakness regarding on the development. One of the weakness is when applying wiring system that limit the movement of AGC . Another weakness when it only can move forward and backward.

### **1.3 OBJECTIVES**

- I.** Develop an automatic AGC by using PIC18F4550.
- II.** Develop controller and programming.
- III.** Integrate and customizing the whole system.

### **1.4 SCOPE OF PROJECT**

The works undertaken in this project are limited to the following aspects:

#### **1.4.1 Hardware system**

- I.** Develop a controller circuit to ensure the AGC are run and meet the requirement.
- II.** Develop a line follower
- III.** Develop a prototype of AGC
- IV.** Develop sensor circuit

#### **1.4.2 Write MICROCODE STUDIO program**

- I.** Create the body program for whole operation easily
- II.** Easy connection automatic controller
- III.** Easily to handle

## **CHAPTER 2**

### **OVERVIEW OF AUTOMATED GUIDED CONVEYOR**

#### **2.1 INTRODUCTION**

The aim of this chapter is to give the overview information about the Automatic Guided Conveyor (AGC) which is part of the Material Handling Equipment (MHE) in the subject of its control system. In this chapter, the explanations will focus more on MHE and AGV from the previous research and findings, the theories are included. Combination reference from various sources as journal, thesis, references book, literature review has been carried out to collect information related to this project.

#### **2.2 MATERIAL HANDLING EQUIPMENT (MHE)**

Material handling is defined by the Materials Handling Institute as the movement of bulk packaged and individual goods, as well as their in process and post process storage, by means of manual labor or machines within the boundaries of a facility. Although this field of study includes the handling of bulk (solid- or liquid-phase) material and individual goods, this chapter will only focus on the latter (i.e., “unit loads”), with a primary emphasis on material handling equipment, as opposed to facility planning and movement control. Material handling does not add value to the product but only cost. Thus the objective of material handling is the efficient movement of goods for the on-time delivery of correct parts in exact quantities to desired locations in order to minimize associated handling costs. It is not uncommon



to have parts/subassemblies moving around a plant several kilometers prior to their shipment. Manufacturing plants must therefore eliminate all unnecessary part movements, as well as in process inventories, for just-in-time (JIT) production. Material handling equipment can be classified according to the movement mode: above-floor transportation (e.g., belt conveyors, trucks, etc.), on-floor transportation (e.g., chain conveyors), and overhead transportation (e.g., cranes). In the following sections, we will review industrial trucks (including automated guided vehicles), conveyors, and industrial robots as the primary mechanized/automated material handling equipment. We will also briefly review the automated storage and retrieval of goods in high density warehouses, as well as the important issue of automatic part identification (including bar codes). The chapter will be concluded with a discussion on automobile assembly.

### **2.3 REVIEW OF AUTOMATED GUIDED VEHICLE (AGV)**

Material handling is an important aspect of any production system. Material handling system have been prevalent since the beginning of mass production, either as manual system, mechanical system (forklifts, conveyors), or in more recent years as fully automated system (automated guided vehicle, (AGV), automatic storage and retrieval system (AS/ RS) etc). Technological advances and the need for flexibility and reliability have increased focused on automated material handling systems. The use of AS/RS and AGV systems are becoming commonplace in today's industries. AGVs have become increasingly popular as a means of horizontal material handling transportation system. They are used wherever there is a need for an autonomous transportation system. AGVs are particularly useful where products need to be handled carefully or the environment is potentially dangerous to humans. Examples include handling of telecommunication products, IC chips, voltage cables and radioactive materials. In the automotive manufacturing industry, AGVs have been combined with robots to perform welding and painting operations.

### **2.3.1 Description of an AGV system**

An AGV system is an advanced material handling system that involves one or more driverless vehicles each following a guide path and controlled by an off-board computer or microprocessor. AGV are typically used to carry unit loads in production and assembly operations. The advantages of AGVs include reliable, automatic operation, flexibility in adapting to changes in material flow, improved positioning accuracy, reduced handling damage, easily expandable layout and system capacity, and automated interfaces with other system. An AGV system allows automation of a certain portion of material handling and thereby, a reduction in the labor force. It also results in an increase in the efficiency of the material handling operation, resulting in better utilization of the work force and processing equipment. An AGV based material handling system also supports various tires of production systems and improves productivity.

The efficient material handling system also helps in reducing mistakes and improving quality. The improved system results in increased worker satisfaction as it is possible to change the material arrival rate to suit the workers pace. The main advantage that a discrete material handling system such as an AGV system offers is real-time control of material handling. This helps in identification of the parts, the routes they travel and the vehicles they travel in, resulting in a lower WIP inventory, reduced tardiness, lower inventory costs and better response to demands (Hammond (1986)). An AGV system also offers other benefits such as reduction in space requirements. Unlike conveyors or other material handling systems, AGVs are small in size and only move along the aisles. They minimize product damage and help in housekeeping. Changes in the layout and relocation of the material handling system are also much easier to accomplish when using AGVs. They also are combined with other existing material handling systems and offer flexibility.

The main disadvantage of an AGV based material handling system is its expense. The high cost of the control software used and the number of vehicles required in a system curtail the wide usage of AGVs as material handling systems. A trade-off analysis between the initial setup cost of an AGV system and the savings

involved is necessary before installation. Other limitations of an AGV include necessity for polished floor surfaces for smooth operation of the AGVs, guide path bed stability problems and restrictions such as height of metal floors that must be crossed and weather conditions that it can operate under when used outside the manufacturing plant. Obstructions in the facility layout and ramp gradients are other obstacles that need to be overcome when designing the guide path for the AGVs. Other issues that need to be considered when installing an AGV system are management support, worker attitudes towards the new system, maintenance problems and requirements. It can be seen from above that though the AGV has a number of benefits it also has its share of disadvantages and may not be applicable in all cases.

### **2.3.2 Component for an AGV**

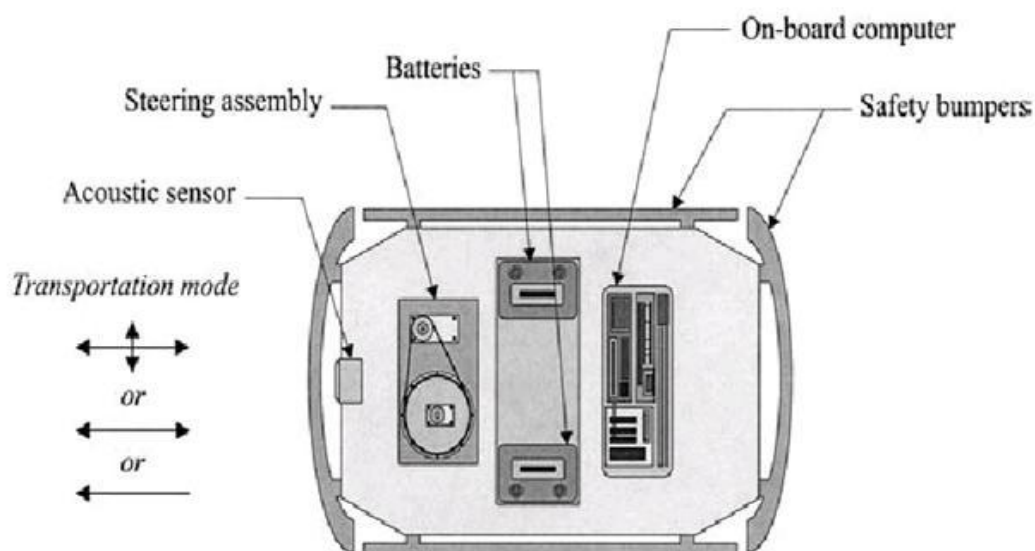
The different components of an AGV system are listed as below:

**2.3.2.1 Vehicles** – The vehicle or the AGV consists of the frame, batteries, on-board charging unit, and electrical system, drive unit, steering, precision stop unit, communication unit, safety system and work platform. The components mentioned above can each be further classified into different categories based on their capabilities and features. The application for which the AGV is used dictates the type of component that is to be used.

**2.3.2.2 Guide path and guidance systems** – Most AGVs need a guide path to follow. The guide path techniques used are known as passive or active tracking. Passive tracking occurs when optical or metal detection principles (wireless) are used for vehicle guidance whereas active tracking involves inductive principles (for example, guide wire is used to help tracking).

**2.3.2.3 Floor and system controls** – The controller is the brain of the whole system, tying the vehicle and the guide path together and integrating the system. The AGVs contains three levels of control architecture: vehicle control system, floor control unit and vehicle on-board processor. These control systems take care of the different tasks

such as lane selection, carrier selection, guide path frequency generation, blocking between vehicles, automatic routing, controlling speeds, displaying job information, monitoring floor equipment status, tracking loads and so on.



**Figure 2.1:** AGV Basic Components

### 2.3.3 AGV system design

The only current literature review on the Automated Guided Vehicle (AGV) flow path design problem is by Sinriech (1995). The general network design models for discrete material flow systems are reviewed. It concentrates more on the aspects of AGV flow path and reviewed individual papers very briefly. It also does not offer a classification scheme for the AGV flow path literature. However, the paper discusses various parameters involved in a material handling flow system and the different approaches that have been used to solve this problem. Peter, et al (1995) presents a control classification scheme for AGVs. They present a nice classification scheme for an AGV system in general, but concentrate more on the control aspects of the problem. They present the classification scheme with 3 basic level namely – guide path determination, vehicle capacity and vehicle addressing mechanism.

The paper does not concentrate as much on each of the individual levels, but gives a brief overview of each level and sublevel. It presents a cubic structure (based on the levels and sub levels) which partitions the AGV system into 12 different classes. Depending on the functionality requirement and the sublevel chosen, this structure helps identify the relative complexity involved in designing the required AGV system.

Vosniakos and Mamalis (1990) discussed the issues involved in an AGV system design with respect to flexible manufacturing system applications. An overview of the different aspects of an AGV is presented with emphasis on route control and collision avoidance. Docking, load transfer, traffic control, communication between the controller and the vehicle, AGV management policies, evaluation of the control policies and various other aspects that have to be considered before setting up an AGV based system are also discussed.

One of the more important areas in an AGV design is the guide path and guidance system. The area of interest in the guidance system and guide path is the guide path layout. There has been little research in the area of guide path layout. The research done in area of guide path layout in AGV systems can be explained better using the classification scheme presented in Rajagopalan and Heragu (1997).

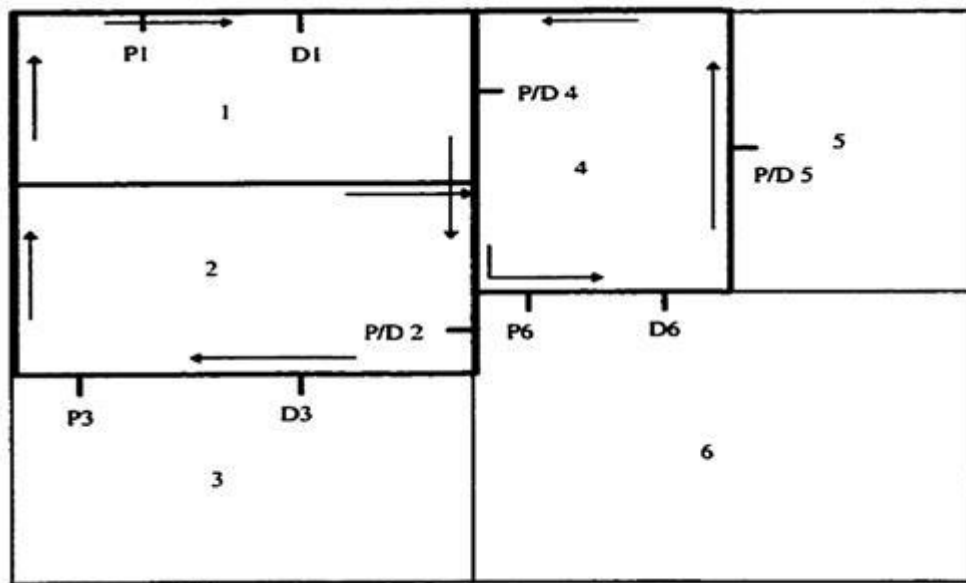
#### **2.3.4 Flow path type**

The type of flow path in an AGV system is its most important characteristic. The flow path for any AGV system dictates how the AGV will travel between the different pickup/drop-off (p/d) points. The classification is based on the type of flow path used.

##### **2.3.4.1 Traditional Layout**

Maxwell and Muckstadt (1982) first recognized the importance of AGV based material handling system design. They developed a model that determines the maximum number of AGVs needed to efficiently transfer material from one facility

to another. The problem was solved assuming the guide path was already installed and the best route had to be determined. The objective under consideration was to minimize total travel time. Figure 2.2 shows a traditional AGV flow path design.



**Figure 2.2:** Traditional AGV flow path design

Maxwell and Wilson (1981) had developed a dynamic network flow model earlier to analyze the effects of blocking in a fixed path system. A traditional flow path design involved determining the best path that connected all the given p/d points.

Gaskin and Tanchoco (1987) presented a binary integer model to determine the optimal flow path for an AGV system. They only considered the movement of loaded vehicles unlike Maxwell and Muckstadt (1982). They did not make any assumptions about the flow path except that movement was restricted to certain areas (such as the aisles), nor did they discuss any generic solution method to the model. An example is solved to illustrate the approach used, but this approach cannot be generalized.

Kaspi and Tanchoco (1990) considered a unidirectional AGV system and solved the optimal flow path design problem using a branch and bound technique. The formulation is the same as that presented by Gaskins and Tanchoco (1987). They formulate the problem as a graph network (node – arc network) with the pick-up/drop-off points as nodes and feasible guide paths as arcs. They also addressed the reach ability problem which tackles the situation where a group of nodes might end up as sink nodes.

Sinriech and Tanchoco (1991) developed a formulation to solve the traditional AGV flow path problem using a graph theory approach. They use the same node – arc formulation as Kaspi and Tanchoco (1990) and use the model to give directions to the undirected graph network. They then use an improved branch and bound technique to solve the problem. They consider both loaded and unloaded travel time in this formulation. Gaskins and Tanchoco (1989) developed a model to solve the virtual flow path problem. The virtual flow path arises in cases where the AGV guide path does not exist in reality. The AGV is guided by the controller without the need for a physical guide path. They formulate the problem as a multi commodity flow problem where the material to be transferred is substituted for people and unit loads. This results in an integer model based on the multi-commodity flow problem. Instead of Euclidean or rectilinear distance, they consider a path distance which takes into account the fact that rectilinear distances and Euclidean distances may not always be applicable when considering distance between two facilities.

A path distance is the actual distance taken by an AGV to travel from one point to another. Goetz and Tanchoco (1989) came up with an algorithm to solve layout design problem. The objective of this model is to minimize the total distance traveled. They reduce the problem size to be solved using a heuristic and the new reduced problem is used to determine the p/d points. Their heuristic determines the major flows into and out of each department and uses this as a base to prioritize the departments. It assumes that the flow data between departments is already known. Rectilinear distances are used and the flow is assumed to be between the departments centroids. It also uses the fact that in case of unidirectional AGV flow path design

only four paths need be examined when considering the route between any pick up and drop off point. A linear programming model obtained after simplifying certain nonlinear terms is presented in this paper. For larger problem sizes this model may be difficult to solve.

### **2.3.5 Language**

The language provided for the control of the bus master (and therefore the robot) is quite unusual as it provides low, high and very high level commands. The language definition itself only commons the low and high level commands while the very high level commands have to be added to the language by means of include and import files. When a module is acquired or constructed these files must be proved as well, containing all the commands that the module understands in the form of a command-code list for the include files and in the form of a procedure (probably containing bus access commands) written in the language in the case of import files. This feature of the language will allow its command set to increase as new developments are made and also provide ease of use for a purchased module as the operator will only have to know the command list the module understands rather than any complex codes that it needs to be passed. Therefore to use a module on a new system it would only be necessary to plug it in and add the relevant commands to any program at the standard input/output terminal.

## **2.4 Conveyor**

Conveyors are a broad class of material handling (conveying) equipment capable of transporting goods along fixed paths. Although conveyors are the least flexible material handling equipment (owing to their path inflexibility), they provide manufactures with a cost effective and reliable alternative. Conveying equipment is generally classified as above floor conveyors versus on-floor or overhead tow-line conveyors. Both classes allow horizontal and inclined conveying, while tow-line conveyors. Both classes allow vertical conveying (e.g, bucket elevators). In the following subsections, several examples of conveyors will be discussed with the emphasis being on conveying for manufacturing (Asfahl, Ray C.(1992)).