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Design and Implementation of an Automated Guided Vehicle Model in Production Line Control System Using Wi-Fi

تصميم وتنفيذ نموذج مركبة مقادة اتوماتيكيا في خط انتاج باستخدام نظام تحكم الواي فاي

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Mechatronics Engineering

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(وقلْ رَبِّ زدْنِي عِلْمًا)

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(طه : 114)

Dedication

To the spirit my dear mother

To the spirit my dear father

To my family

ACKNOWLEDGMENTS

Primary, I would thank god for being able to complete this thesis with success , and I would like to express my sincere gratitude to my supervisor Dr.Fath Elrahman Ismael for his support, outstanding guidance, and encouragement throughout my senior thesis , and to the other members of his department .

I would like to special thank my parents, sisters and brothers for their encouragement, patience, and assistance over the years. I am forever indebted to my parents whom have always kept me in their prayers .

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ABSTRACT

The Automated Guided Vehicle(AGV) or a programmable mobile vehicle is capable of transportation task fully automated at limited area such as using in industrial applications to transfer material and production around a manufacturing unit. In the traditional industry materials and products are transported and moved using workers which lead to waste of the time and increase labour cost. Also its unsafe for the workers themselves by exposing them to bone and muscle diseases and exposing materials and products to breakage and scratching which lead to damage and increase cost. So using AGV to solve the problems related to traditional industry to developed it and to became more modernization. A thesis concentrates of design, implementation, and testing of the AGV system. The proposed system designed by using a software approach such as configuration of each components by downloading their libraries and copy them to library of arduino IDE/Proteus program. The overall AGV system drown by using the Proteus program. The design model programmed by using adruinoIDE program. And the AGV system simulated. Then the system design implemented by using hardware approach such as installation and connection of the hardware components. The code uploaded to arduinoMEGA2560/ESP8266 board. Finally the operation of the AGV tested without/with Wi-Fi mode. So the AGV operation works properly to handle material in the production line without Wi-Fi mode or outside the production line with Wi-Fi mode through Wi-Fi Robot Control App.

المستخلص

المركبة المقادة او الموجه اتوماتيكيا او احيانا تسمي المركبة المتنقلة اليا وقابلة للبرمجة هي مركبة قادرة علي اداء مهمة النقل اتوماتيكيا في مساحة محددة فمثلا تستخدم في التطبيقات الصناعية الحديثة لنقل وتحريك المواد حول وحدة التصنيع. في البيئة الصناعية التقليدية يتم نقل وتحريك المواد والمنتجات باستخدام العمال مما يودي الي هدر الزمن وزيادة تكلفة العمالة وايضا غير امن للعمال انفسهم بتعرضهم لامراض العظام والعضلات وتعرضهم للحوادث الناتجة من النقل والتحريك وكذلك من ناحية اخري يعرض المواد و المنتجات للكسر والخدش مما يودي الي تلفها وتتعاظم الخسارة وتذداد التكلفة. تم استخدام المركبة الموجه اتوماتيكيا لحل المشاكل المتعلقة بالبيئة الصناعية التقليدية للمساهمة في تطويرها وجعلها اكثر حداثة. ركزت الاطروحة علي تصميم وتنفيذ النموذج واختبار حالات التشغيل. اتبعت في عملية التصميم توفير مكتبة المكونات ونسخها في مكتبة برنامج البروتس اوبرنامج الاردوينو. تم استخدام برنامج البروتس لرسم النظام المصمم وبرنامج الاردوينولبرمجة النظام المصمم بناء علي حالات التشغيل. ثم تمت عملية محاكاه للنظام المقترح. وفي عملية التنفيذ تم تنفيذ النظام المقترح بتثبيت وتوصيل جميع المكونات الصلبة للنظام. ثم تحميل الكود الي بورد الاردوينوميقا او بورد الواي فاي موديول . اخيرا تم اختبار حالات التشغيل بواي فاي او بدون واي فاي . وجد أن تشغيل المركبة يعمل جيدا بالطريقتين بدون واي فاي لنقل وتحريك المواد في خط انتاج او باستخدام الواي فاي لنقل وتحريك المواد خارج خط الانتاج عبر تطبيق واي فاي روبوت كنترول .

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
AGC	Automated Guided Car
AGF	Automated Guided Forklift
AGV	Automated Guided Vehicle
AMR	Autonomous Mobile Robot
AP	Access Point
API	Application Programming Interface
CAD	Computer Added Design
CMOS	Complementary Metal Oxide Semiconductor
DC	Direct Current
EEPROM	Electrically Erasable Programmable Read Only Memory
EN 1525	Safety of Industrial Vehicles and AGV Systems
ERP	Material Requirements Planning
FLP	Facility Layout Problem
FTP	File Transfer Protocol
GPS	Global Position System
HTTP	Hyper Text Transfer Protocol
ICSP	In Circuit Serial Program
IDE	Industrial Development Environment
IEEE	Institute of Electrical and Electronic Engineering
IOT	Internet Of Things
IPv4	Internet Protocol version 4
LAN	Local Area Network
LED	Light Emitted Diode
MHIA	Material Handling Institute Of America

PC	Personal Computer
PCB	Printed Circuit Board
PSK	Phase Shift Keying
RFID	Radio Frequency Identification
RS	Retrieval System.
SDK	Software Development Kit
SRAM	Static Random Access Memory
TCP	Transmission Control Protocol
TTL	Transistor Transistor Logic
UART	Universal Asynchronous Receiver Transmitter
UDP	User Data gram Protocol
USB	Universal Serial Bus
WEP	Wired Equivalent Privacy
Wi-Fi	Wireless Fidelity
WLAN	Wide Local Area Network
WMS	Warehouse Management System
WPA	Wireless Protected Access

Chapter One : Introduction

Chapter One

Introduction

1.1 Preface

A production line is a set of sequential operations established in a factory where components are assembled to make a finished article or where materials are put through a refining process to produce an end product that is suitable for onward consumption [1]. Material handling is defined by Material Handling Institute of America (MHIA) as "the movement, storage, protection and control of material throughout the manufacturing and distribution process including their consumption and disposal". The cost of material handling is a significant portion of total production cost estimating average around 20-25% of total manufacturing cost, so direct cost of material handling cannot be measured. The handling of material must be performed safely, efficiently, at low cost in timely manner, accurately without damage to the material that by using an automated guided vehicle (AGV). AGV is a programmable mobile vehicle, used in industrial application to move material around a manufacturing unit, and capable of transportation task fully automated at low expanses[1].

Wireless Fidelity (Wi-Fi) is the name given by the Wi-Fi alliance to the IEEE 802.11 suite of standards. 802.11 defined the initial standard for wireless local area network (WLAN), but it was considered too slow for some applications and so was superseded by the extensions 802.11a and 802.11b, and later by 802.11g. At its most basic, Wi-Fi is an alternative network to wired network which is commonly used for connecting devices in wireless mode [2].

1.2 Problems Statement

In the traditional industrial environment materials and products transported and moved using workers which lead to waste of the time and labour cost increased. Also it is unsafe for the workers themselves by exposing them to bone and muscle diseases and exposing them to accidents resulting from transportation and

movement. And on the other hand exposing materials and products to breakage and scratching which leads to damage and increase lost and cost.

1.3 Proposed Solution

This thesis proposed a design of AGV model that capable of handling the material in predetermined production line and in a Wi-Fi mode to handle material outside the production line.

1.4 Research Objectives

The objectives of a thesis are :

- To design and simulation the designed AGV.
- To implement the simulated AGV
- To test the operation of the AGV under various cases.

1.5 Methodology

The proposed system designed by using software approach such as configuration of each components by downloading their libraries and copy them to library of arduino IDE/Proteus program. The overall AGV system drawn by using Proteus program. The design model programmed by using adruinoIDE program. And the AGV system simulated. Then the AGV system implemented by using hardware approach such as installation and connection of the hardware components. And the code uploaded to arduinoMEGA2560/ESP8266 board. Finally the AGV operation tested without Wi-Fi or with Wi-Fi through Wi-Fi Robot Control App.

1.6 Thesis Layout

A thesis includes five chapters their outlines are as follows: Chapter one includes introduction of production line, AGV, and Wi-Fi. Then it defines the problem statement, proposed solution, objectives, and methodology of a thesis. Chapter two discusses literature review of the AGV system. Chapter three discusses the system design such as hardware system and software development of the AGV system. Chapter four discusses the AGV system operation under varies cases. Chapter five discusses conclusion and recommendations of a thesis.

Chapter Two : Literature Review

Chapter Two

Literature Review

2.1 Background

The first AGV used overhead wire to navigate the vehicle in grocery shop. The use of AGV has grown enormously since their introduction, the number of area of application and variation type has increased significantly. Recently AGV extended their popularity to other application. Developed an AGV to betterment public health care system . AGV can used as serving robot in hotel, material handling robot in warehouse and improve the health care system. At manufacturing area AGV are capable to transport all type of material related to manufacturing process [1].The next pages discuss the AGV system.

2.2 The AGV System

The AGV system consist of guidance control system, fixed and open navigation , obstacle avoidance , safety , and energy supply such as battery and charging scheme consequently discuss in next pages.

2.2.1 AGV Guidance System

The AGV execute the operational tasks but as they are not fully autonomous and rarely take independent decisions, they need a coordinating system that helps them communicate with each other and with their surroundings. The AGV also needs to communicate with the internal logistics operating system. the Warehouse Management System (WMS), Material Requirements Planning (MRP) or Enterprise Resource Planning (ERP) to receive orders and information about the entire process. This is done through the guidance control system [3]. Besides these two areas of practice the guidance control system also provides the user with an interface to visualize and interact with the AGVS [3]. The Guidance control system as shown in figure (2.1) connects the different vehicles, the peripheral equipment and the internal logistic operating system. It is connected to the internal logistics operating system via a Local Areal Network (LAN) connection and with the vehicles and equipment by a Wireless Local Area Network (WLAN) connection [3].the guidance

control system need to use transport order processing and service function discuss below.

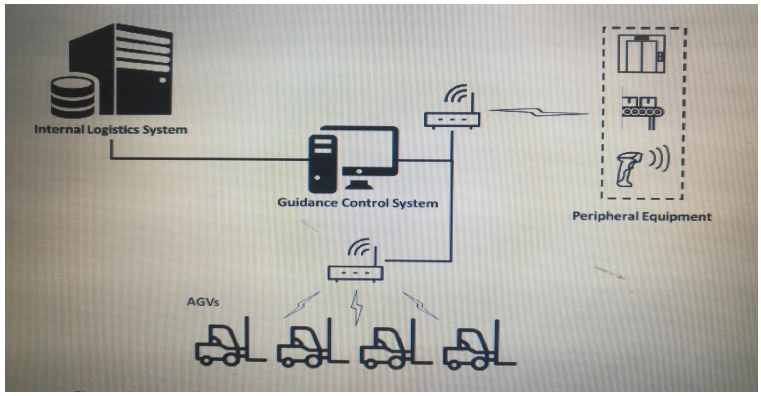

Figure (2. 1) : An illustration of the guidance control system[3]

2.2.1.1 Transport Order Processing

The main task of the AGV is to fulfil transport orders. The guidance control system receives the transporting orders from the user. These can be issued in many different ways, it could be manually by the employees, via the internal logistics operating system or with the use of sensors placed on the load transfer stations where a demand can be recognized [3]. The information that is received needs to be processed by the guidance control system since the transport order is not clearly defined. It could be “article A at machine B”which needs to be completed with additional information, such as “ up from C and bring to D”[3]. After this step the transport order is processed in three Steps:

1. Transport order administration
2. Vehicle dispatching
3. Travel order processing

2.2.1.2 Service Function

Except for its main task to process transport orders, the guidance control system aids the user with visualization and changes to the layout of the operation. It also supports the user with different service functions. When the AGV is first set up a map has to be created. The map describes the operating area and the paths that the AGV has to follow, also called the road map [17]. The map is based on a Computer Added Design (CAD) layout of the facility that describes how the facility is structured [3]. The road map contains all the rules for how the AGV can move on

the map in order to fulfil their tasks. The road map is designed to connect the different operational positions with paths that take all the specific environmental aspects into consideration. These can be tasks such as avoiding collision with infrastructure, the direction of certain lanes, load transfer points or stopping points, in other words everything that the AGV must know to safely travel between two locations [3].

2.2.2 AGV Navigation System

An AGV navigates between different locations in the operating area to fulfil its tasks. In order to do so it must know its own position in its fixed coordination system which is done through different navigation methods [3]. Here it is important to note that there is a difference between the terms position and location. A position is an exact set of coordinates that can be matched to the global coordination system of the operating area. A location contains more information than this. It could for example be information on what the AGV has to do in that position such as stop, communicate with the guidance control system or perform a certain task [3]. The navigation methods for AGV can roughly be separated into two different groups, fixed path navigation and open path navigation [18]. What is common for the two different group is that they are both using two methods for knowing their position, dead reckoning and taking bearings. Which method the emphasis lays on is decided by the navigation method [3].

2.2.2.1 AGV Fixed Navigation

With fixed navigation the AGV is guided with the help of physical guidelines on or underneath the floor. This can either be by inductive guidance or optical guidance [3]. For fixed navigation the paths are predefined and navigation is easy as only a sensor is required to detect the guideline. Modifications of the path require physical changes and the system has to be shut down [18]. The locations in the system are also physical and require special markings that contain additional information for the system. The markings could be metal strips, magnets, tape strips or coloured markings where the AGV is programmed to know what to do when the marking is recognized [3]. It can also be more advanced technology such as Radio Frequency

Identification (RFID) tags that can give different instructions depending on the task or the traffic situation [19]. These markings act as bearing points for systems with physical guide paths and are added to the road map. In Figure (2.2) shows an that navigates along an optical guide path with the help of RFID tags (the green squares next to the coloured line) that give the AGV information on how to act, for example in the crossing that it is moving towards.

Figure (2.2) : The AGV uses optical guiding to following its path[20].

2.2.2.1.I Inductive Guidance

Inductive guidance works by creating a magnetic field along the guide path. The AGV measures the magnetic flux and if it measures that it is deviating from the guide path it steers back to the path [21]. Inductive guidance can be both active and passive, where the difference is whether the guide path actively creates a magnetic field or not. With active inductive guidance a current bearing conductor is inserted into the floor, about two inches down, which creates a magnetic field. Two coils are mounted under neath the AGV that measures the deviation from the guide path as shown in figure (2.3) [3].

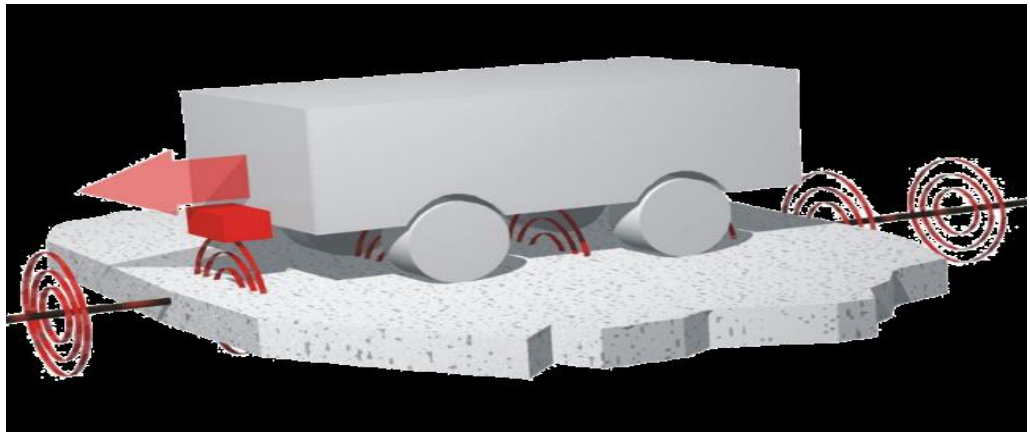

Figure (2.3) : Example of an AGV with active inductive guidance [22].

Passive inductive guidance uses either a metal/magnetic strip or magnetic tape affixed to the floor. The AGV is equipped with two or three magnetic field sensors that detect the strip or the tape, as shown in figure(2.4). The AGV can operate without the guide path with dead reckoning which makes it possible to travel between different paths and makes the AGV less dependent of the condition of the tape or strip [19].

Figure (2.4): An AGV following a magnetic strip [23].

The two techniques have different advantages. The embedded wire is more robust since the guide path is protected from tearing caused by overlapping traffic and is

not affected by dirt. However, the passive alternative is more flexible since it is easier to modify the path and does not require as much manual work [8]. Neither passive nor active inductive navigation is suitable if there is metal in the floor since this will affect the magnetic field [3].

2.2.2.1.II Optical Guidance

Optical guidance works similarly compared to passive inductive guidance. With a camera sensor underneath the vehicle, the AGV follows a guide path that is either a coloured tape or a painted line. The colour has to contrast the floor in order to detect the edge of the line. This is illustrated in figure (2.5). As passive induction navigation, optical navigation is flexible and is able to operate Without the guide path with dead reckoning. It also has the advantage of not being affected by Other metals in the floor that would disturb a magnetic field [3].

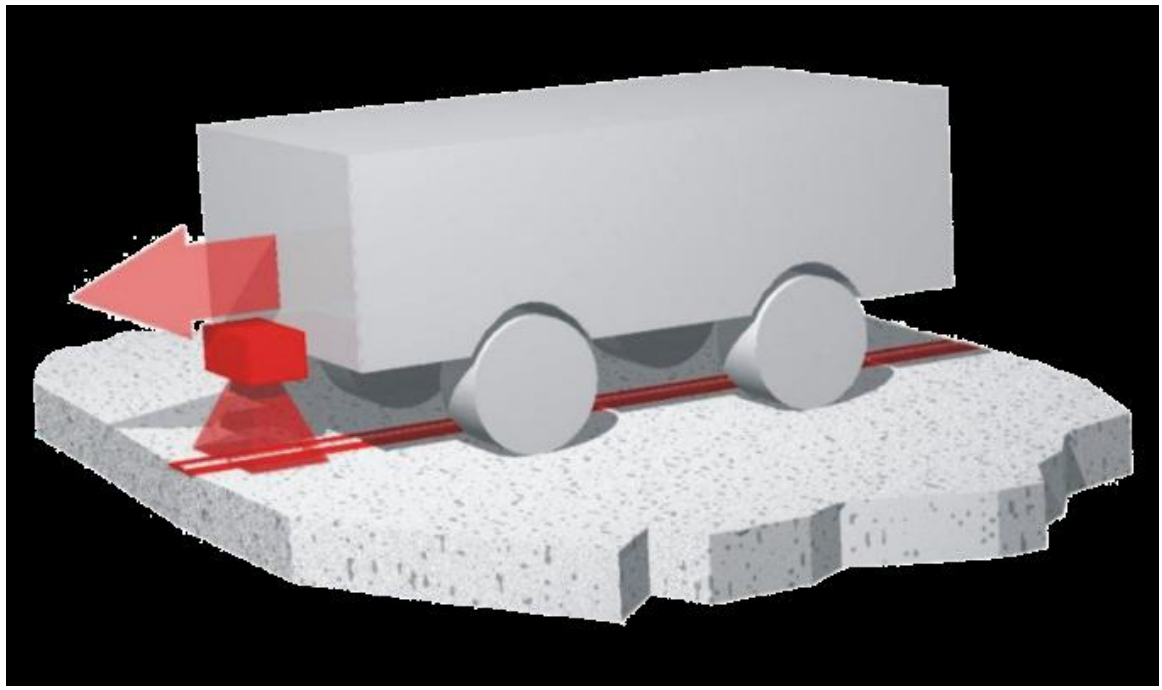

Figure (2.5) : An AGV with optical navigation [22].

2.2.2.2 AGV Open Navigation

Open navigation, also called free navigation [3], is a navigation method with no physical guide paths. The guide paths are completely virtual in the road map and when changes in the path are required the AGV only need to be reprogrammed. This results in no extensive manual labour required to change the guide paths [18]. Even if free ranging AGV in reality can take any path a road map is needed. The

limitation to follow certain paths makes the system less flexible but it is required to reduce the Complexity of the system [17]. open navigation technology examples:

1-Anchoring point navigation

2-.Magnet spot navigation

3- Radio Frequency Identification (RFID) navigation

4- Laser navigation

5- Artificial laser navigation

6- Contour navigation

7- GPS navigation

2.2.3 AGV Obstacle Avoidance System

Flexibility is one of the main goals with AGV. AGV is designed to move from one location to the next, and since they are moving in real environments unforeseen events will occur [17].An issue with the technology today is how to avoid obstacles in a secure manner. With today's applications the robot is designed to stop if an obstacle blocks the guide path. The two applications navigation and safety are not combined Which results in the AGV moving as a blind person, moving along its path until the safety sensor detects an obstacle and the AGV stops. This can be compared to how humans instead are able to predict future obstacles and can alter their paths before they have to stop [3]. According to [3] the blind navigation has its advantages as well. Even If the system is less flexible it becomes more predictable which is an important factor for safety reasons. When operating in the same environment as manual driven forklifts or pedestrians it is important for personnel to be able to know how a robot will act [3]. Does however mention that avoiding obstacles is a function that is important for the future of AGV. When the AGV is working in a restricted environment where only adults and trained personnel are operating today' technology is sufficient, but if the AGV could be able to "pen its eyes" as call it in [3], and were able to combine the navigation and safety applications a whole new scope of use for the AGV could be identified [3]. In the article obstacle avoidance for industrial AGC by [17] a method for obstacle avoidance is presented and simulated.

2.2.4 AGV Safety System

Safety is an extremely important aspect of an AGV to ensure that no harm is done to people or objects several regulations are strongly recommended to be followed by suppliers. These state the minimum safety technology that an AGV should have. The most central regulation is called EN 1525. This regulation is quite old, from 1997, but is still in use [3].

lists what he thinks are the key technological safety features from the EN 1525 that an AGV should have. These are [3]:

1. An emergency stop switch. This has to be accessible and easily recognizable to everyone.
2. A combination of optical (rotating warning lights) and acoustic warning signals. This includes blinkers to indicate change of direction as with automobiles but often with acoustic support.
3. Mechanical independently operating brakes to ensure proper stopping. They should be intrinsically safe which means that they need an energy supply in order not to activate while driving. The brakes must be able to stop the AGV with a maximum payload and incline of the drive path or slope.
4. Kick plates and special safety equipment for load handling. This is to ensure safe operations.
5. A personnel protection system. It has to ensure that people or objects located in the drive path are recognized and that the AGV stops before these are injured or damaged. These systems can either be mechanical that react to contact or contact-free sensors that scan the area ahead using laser, radar, infrared or ultrasound and stop if there is something in the pathway. If mechanical the contact with a human may not exceed 750 N and the AGV needs to shut off at contact.

A couple of decades ago this consisted of tactile sensors. This meant physical bumpers and emergency arrest handles with mechanical switches [3]. They consisted of Plastic bales and soft foam in the 70s and 80s, as shown in figure (2.6)

Figure (2.6) : Personnel safety feature : Plastic bales and soft foam [3].

The safety features have now been modernized and consist of advanced laser sensors. Most of these are produced by a company called SICK [3].

Figure (2.7) shows an example of what some safety sensors from SICK look like.

Figure (2.7) : The s3000, s300 standard and s300 mini [3].

The safety fields are illustrated in figure (2.8) The yellow and orange areas are warnings fields. When the AGV detects a person or an object in this field it slows down. If a person or an object is detected in the red field, called the protective field, it stops [24].

Figure (2.8) : Safety fields for an AGV [24].

2.2.5 AGV Energy Supply System

The energy supply feed the AGV system by power to operate , it consists of battery , and charging scheme discuss in next pages.

2.2.5.1 Battery of AGV System

AGV is usually run on electrical power with a battery that has to be charged. Outdoor and larger AGV that can transport loads of several tons are sometimes run on diesel [3]. The most common batteries found in AGV is according to as below :

1-lead-acid batteries (liquid electrolyte)

2-lead gel batteries (bound electrolyte)

3-nickel-cadmium batteries (liquid electrolyte) .

4-nickel metal-hydride

5-lithium-ion

In table (2.1) the different battery types are compared to each other based on information from [27]. The specific energy is the amount of electrical energy stored for every kilogram of battery mass and the energy density is the amount of electrical energy stored per cubic metre of battery volume. The specific power is the amount of power obtained per kilogram of battery.

Table(2.1) : Types of the different batteries [27].

	Lead-acid	**Nickle-cadmium**	**Nickle-hydride**	**Lithum -ion**
Specific energy (wh-kg-1)	20-35 depending on usage	40-55 depending on current	~65 depending on power	140
Energy density (whi-1)	54-95	70-90 depending on current	~150	250-620
Specific power (wh-kg-1)	~250	~125	200	300-1500
Operating temperature	ambient	(-40 to +80) C	ambient	ambient
Number of life cycle	Up to 800 to 80% capacity	1200 to 80 % capacity	~1000 to 80% discharge	>1000
Recharge time	8h , but 90% recharge In 1h	1h , charge 60% in 20 min	1h , charge 60% in 20 min	2-3h, 80% in 1h

2.2.5.2 Charging Of Battery

AGVs have to be supplied with energy for the purposes of navigation, sensory systems, the mechanical moving components and the load transfer equipment [3].

The AGV is charged can have a significant impact on the way a material handling system operates. Charging at inconvenient times can affect operational time and increase the size of the AGV fleet needed [28]. According to [28], battery usage is often omitted in AGV research which can lead to misleading simulations. He does however also argue that there are certain circumstances where battery constraints do not affect operational output. These instances include systems with naturally

occurring breaks, shift changes coinciding with battery swapping or charging, systems with high amounts of idle time and systems where charging can be regulated and ensured to take place without impacting the system. If AGV can be fitted with batteries sufficiently sized to last an entire shift and if arrangements can be made to swap or charge AGV batteries during 35 off-shift time, this will not impact the system and charging does not need to be taken into account when considering the size or type of the AGV fleet.

2.2.5.2.I Charging Method

According to [3] there are three usual methods of charging used by the AGV that are in use today. These are Charging traction batteries , non-contact energy Transfer , and hybrid systems.

2.2.5.2.II Charging Schemes

According to (28) presents five different charging schemes for AGVs. These will be presented as shown in figure (2.2) and are manual battery swap, automatic battery swap, opportunity charge, automatic charge and combination charge [28].

Table (2.2) : the AGV charging schemes.

usage / **Charging**	**Can be Used if**	**Battery type**
manual battery swap	person available to do swap	Lead-acid
Automatic battery swap	AGV fleet and many shifts (to make the installation of the swapping station profitable)	
automatic charge	batteries can be charged at night	
opportunity charge	AGV has many short predictable stops so that the nature idle time can be used charging	Lithium - ion

2.3 Types of AGV

The way to categorize AGV is by looking at the loads they transport divided to [3]:

1- Forklift AGV (Specially designed forklift AGVs, forklift AGV as automated serial equipment)

2- Piggyback AGV

3- Towing vehicle

4- Under ride AGV

5- Assembly line AGV

6- Heavy load AGV

7- Diesel AGV

8- Toyota Material Handling has for example divided the different types as illustrated in figure(2.9). They call forklift AGVs without space for a human AGVs, and with space for a human AGFs

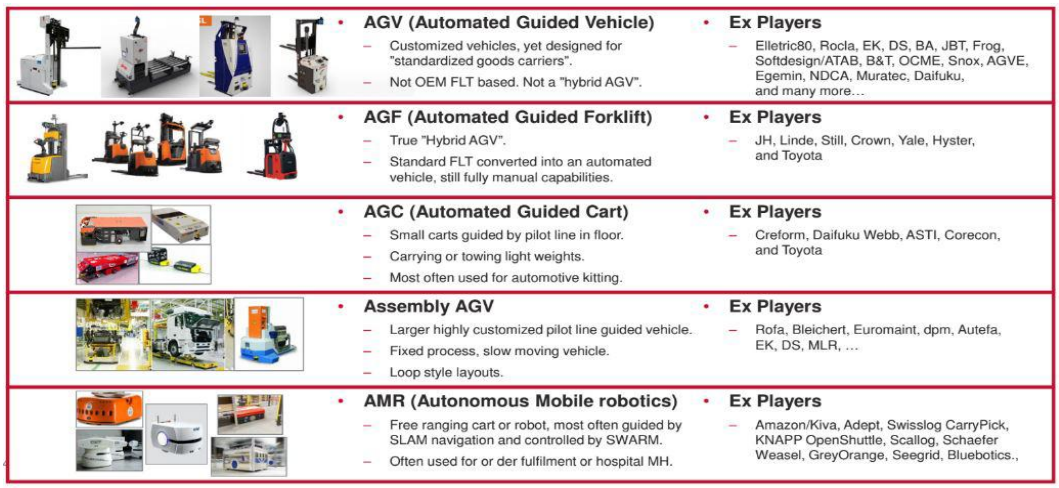

Figure (2.9) : Toyota Material Handling's categorization [29].

2.4 AGV Applications

Autonomy is the key factor for using AVG in different field. It will achieve high degree of accuracy and precision which will lead to minimize the error of the complete system and improved lead time. Flexibility is the key issue which will help AGV to be popular from other material handling system [6]. The AGV not only used inside the production house but also increase its premises to other service sector [1].

1. Material handling: used in highly automotive and electronic factories, loading unloading station .
2. Warehouse: used in e commerce warehouse for transporting the material
3. Commercial: baggage transport inside airport, supermarket, mall , floor treatment like wash ,swap, scrub unpleasant job like washing warehouse .
4. Energy and defense: transport the material human unreachable place , bomb and mine mapping , retrieval and disposal nuclear plant inspection, and steam generator, pipeline inspection .
5. Medical service:deliver food water and medicine ,administrative reports ,handling hazardous material, disposal of biological waste

2.5 Related Works

The first big development for the AGV industry was the introduction of a unit load vehicle in the mid-1970s. This unit load AGVs gained widespread acceptance in the material handling marketplace because of their ability to serve several functions, a work platform, a transportation device and a link in the control and information system for the factory. Since then, AGVs have evolved into complex material handling transport vehicles ranging from mail handling AGVs to highly automated automatic trailer loading AGVs using laser and natural target navigation technologies. Material handling in manufacturing system is becoming easier as the automated machine technology has improved [4]. One of the material handling methods that has been widely used in most industry nowadays is the Automated Guided Vehicle System or better known as the AGVS. It has become one of he fastest growing classes of equipment in the material handling industry [4]. The AGV is a materials handling system that uses independently operated, self propelled vehicles known as the AGV that moves along defined pathways between delivery points or stations. A typical AGV will consist of the frame, batteries, electrical system, drive unit, steering, on board controller and work platform[4].

The papers in next pages concentrates about the AGV system design, implementation, simulation, controlling by using micro-controller or arduino. AGV operation through Bluetooth /Wi-Fi to improving the system in order to

achieve more productivity and flexibility in manufacturing unit. The author in [5] described results of the research project and at the same time, it was introduced the method of the determination of number of automated guided vehicles and choosing of optimal internal company logistics track. New technologies are fundamentally changed the internal logistics and internal logistics is therefore gradually becoming adaptive, and that require changes in the whole concept of future solutions. One example is automated logistics system of planned operation of manufacturing semi products intro process of components production in the automotive industry. The simulation results of the logistics system were variants for increasing the use of the operation areas, optimized material supply and created layout that would be able to flexibly response to the future company requirements. The author in [6] discussed the advancement of automated/computerized guided vehicle assumes a noteworthy part in designing businesses to enhance the material taking care of procedure for late year. Also the author in[6] focused on the design and different methodology of line follower automated guided vehicle systems and provided an overview on line follower AGV discussed recent technological developments. The essential components of line follower robot and their modification are described in the paper. The author in [7] explained how researchers have focused their optimization studies in AGVs design and control optimization. The article discussed comprehensive approaches identified in other research papers. The four features examined were focus problem, solution methodology, manufacturing environment, and metrics. The five different optimization environments recognized and used to explore the AGV performance was facilities design, production planning, scheduling of machines, manufacturing system and design control. Based on statistical tools, trends are identified in integrated approaches and maps of the conditions of the approach and solution methodologies. The author in [8] discussed the AGV implemented by using ATmega328 controller which has a remarkable EPROM compared to other controllers. The controller is being assisted by the ultrasonic sensor that enables the obstacle detection capability in the bot. The AGV can be further promoted to the elevation of automation by its artificial intelligence that is

being controlled by Bluetooth / Wi-Fi. The author in [9] concentrated on wireless guidance mechanism which made using if guide tape (colored in this case) for navigation. Basically this type of AGVs act as a line follower robot which follows the guide tape which is imprinted on the shop floor. The guide tape is sensed by the on board sensors which are present on the AGV, the sensor used for this purpose is an optical sensor which uses Infrared LED's. The author in [10] provided the requirements and technical specifications of AGV cart designed for health care facility. The second part described the application and benefits of AGV implementation in selected health care facility gained from computer simulation that is used as a verification tool. The part also contained the economic evaluation of this implementation and summary of further investments related to this technology. The author in [11] dealt with the demands in manufacturing industry and industry 4.0. the AGV has immense demand in the manufacturing industry .Internet of Things (IOT) based AGV is connecting the AGV through the internet which is part of industry 4.0 . the AGV follows given path allocated for it. This happens with the help of arduino and different sensor configured with it which can reduce the human errors, increase efficiency and maintain the quality of manufactured product or raw material which is carry in the plant. The author in [12] designed a line follower and obstacle avoidance bot using IR sensor and ultrasonic sensor. The IR sensor mounted to trace a particular line and ultrasonic sensors are meant to detect obstacles which it encounters. Robot has sufficient intelligence to cover the maximum area of space provided. It will move in a particular direction specified by the user and avoids the obstacle which is coming in its path. Autonomous intelligent robots are robots that can perform desired tasks in unstructured environments without continuous human guidance. The path can be visible like a black line on the white surface (or vice-verse). The base of the robot is arduino UNO R3 which is a micro-controller board based on the ATmega328 .The author in [13] talked about the advancement of industrial robots relies on the development and progress of multiple technologies, among which sensors are the indispensable part. They can acquire abundant information to help industrial robots

implement their functions. The author in [14] focused on the AGV included the material transfer system located on the top and driving device at the bottom to move the vehicle as desired. The vehicle is a customized AGV in which it will do the special material handling task and also used for custom applications. The vehicle works on its own once the program is feed into the control device. The control device is common to both driving device and transfer device which are connected together. Control device operates the vehicle and maintains the ultimate process of AGV. The author in [15] talked about development of automated guided vehicle play a major role in engineering industries to improve the material handling-technique for recent years. Additionally, the applications of these sensors in diverse functions of industrial robots are also presented. Finally, the developing direction and challenges of industrial robots in the future are discussed in the last part of this article . All of the above papers did not discuss the overall AGV system. Some papers talked about guidance. Other papers discussed the navigation. Then other papers explained avoid obstacles and safety. And finally some papers talked about energy supply. This thesis discussed design and implementation of AGV model and operation through Wi-Fi as explain in next chapters.

Chapter Three : System Design

Chapter Three

System Design

3.1 Introduction

The AGV system consists of the guidance control system which provides the user with an interface to visualize and interact with the AGV [3]. Also fixed navigation of the AGV guided with the help of physical guidelines on or underneath the floor. For fixed navigation the paths are predefined and navigation is easy as only a sensor is required to detect the guideline [3]. Then obstacle avoidance technology today is how to avoid obstacles in a secure manner, with today's applications the AGV designed to stop if an obstacle blocks the guide path. The two applications navigation and safety are not combined which results in the AGV moving as a blind person, moving along its path until the safety sensor detects an obstacle and the AGV stops [3]. So safety is an extremely important aspect of an AGV to ensure that no harm is done to people or objects several regulations are strongly recommended to be followed by suppliers [3]. And finally energy supply which feed the AGV system by power. It consists of batteries and charging scheme.in next pages discuss the proposed system design, hardware selection, software development, system simulation, and hardware implementation.

3.2 Proposed System Design

The AGV controlled by using arduino micro-controller. Also the AGV guided by using push button switch or Wi-Fi. The AGV navigated in the production line by using tracking sensor. So for safety and obstacle avoidance used ultrasonic sensor. And finally for energy supply used un-chargeable batteries. The figure (3.1) describes the block diagram of the proposed system design which consists of ultrasonic sensor (HC-SR04), tracking sensor (KY-33) as an input devices, arduino mega2560 as the controller, DC motor as an actuators, motor driver (L293D), ESP8266 as a Wi-Fi

module, Wi-Fi Robot Controller App, and finally un-chargeable batteries for power supply of the AGV system.

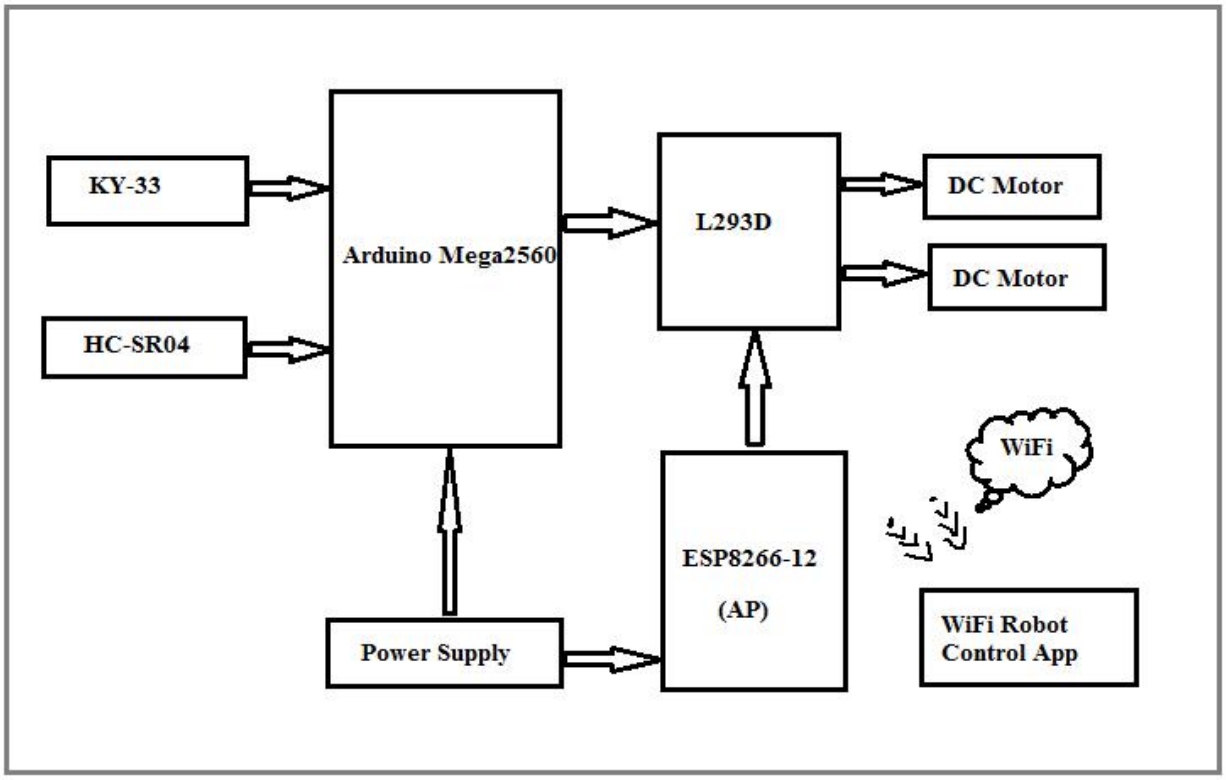

Figure (3.1) : Block Diagram of the Proposed System Design

3.3 Hardware Selection

This section discusses hardware selection such as arduinoMEGA2560, ESP8266, DC motors, tracking /ultrasonic sensors, and power supply of AGV system respectively .

3.3.1 Arduino Mega 2560 Module

The arduino Mega 2560 in figure (3.2) using to Control The AGV is a micro-controller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UART (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the micro-controller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible

with most shields designed for the Arduino Due milanove or Diecimila [16]. For more details look in Appendix A .

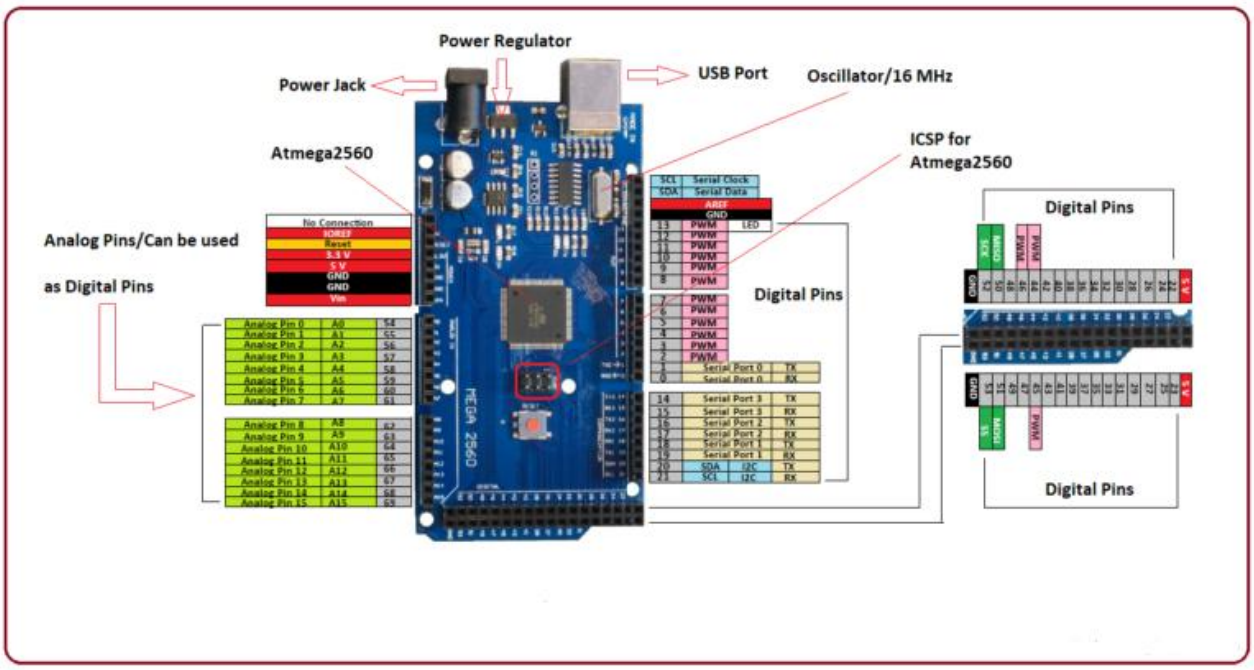

Figure (3.2) : Arduino Mega2560 Pinout and Overview [16].

3.3.2 Wi-Fi Module (NODEMCU)

Wireless Fidelity (Wi-Fi) is generic term that refers to IEEE802.11 standard for LAN or WLAN. It is an alternative network to wired network which is commonly used for connecting devices in wireless mode, it uses radio technology to transmit and receive data at high speed [2]. Node MCU as shown in figure (3.3) is an open source IOT platform or Wi-Fi module . It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term (NODEMCU) by default refers to the firmware rather than the DevKit. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson, and spiffs [25]. For more details look in Appendix B.

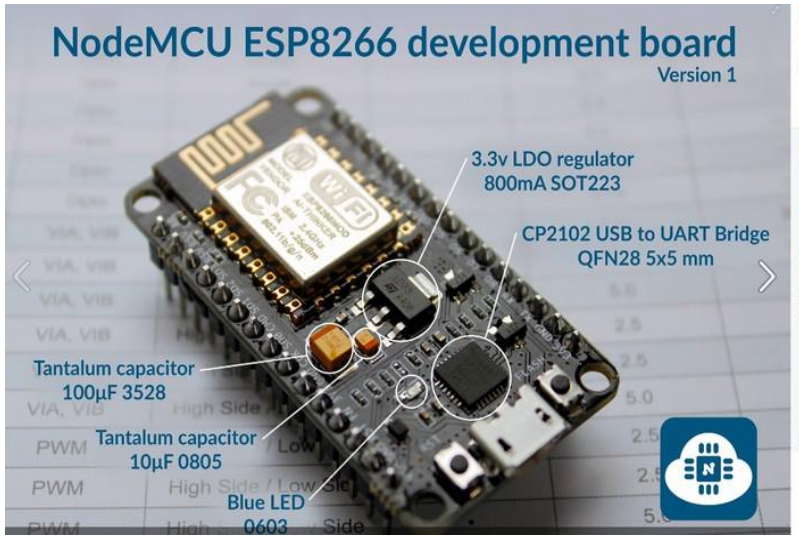

Figure (3.3) : ESP8266 Module overview [25].

3.3.2.1 Wi-Fi Module (NODEMCU) Pin out

The figure (3.4) describes the pins definition of ESP8266 - 12

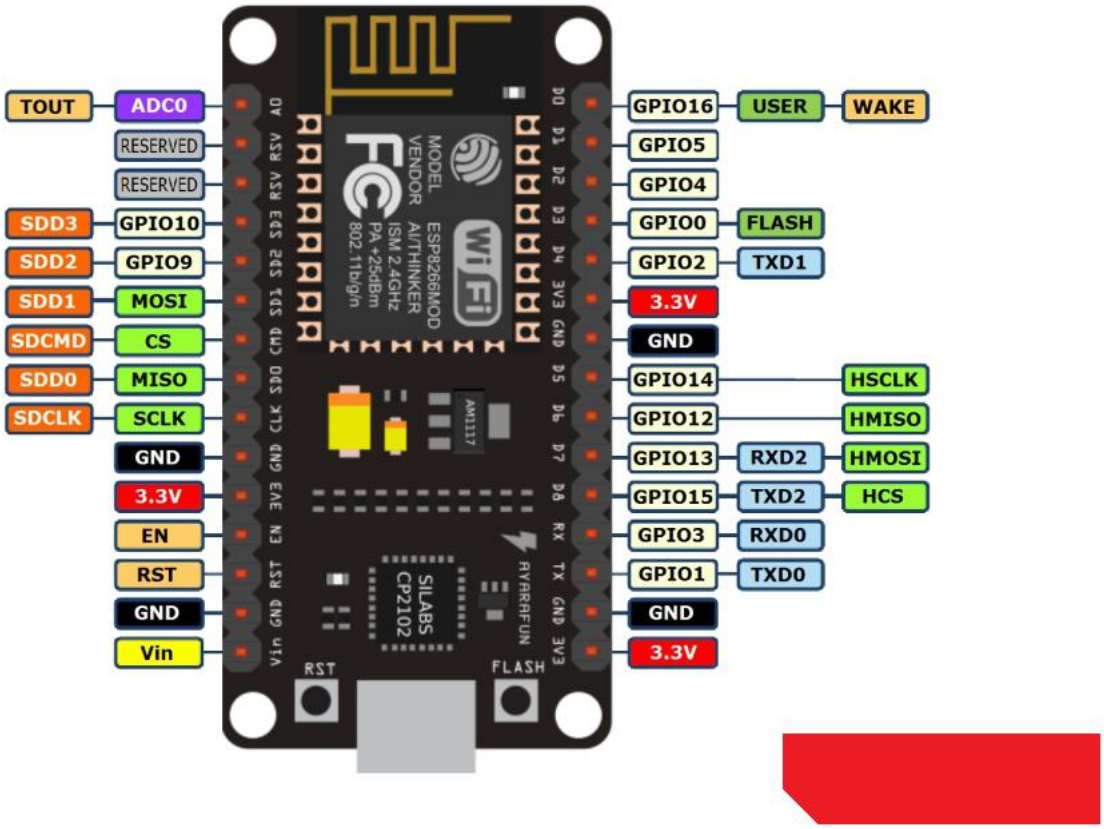

Figure (3.4) : ESP8266-12 pin out diagram [25].

3.3.3 DC Motor of AGV System

A direct Current (DC) motor is a rotating electrical device that converts direct current, of electrical energy, into mechanical energy. An inductor (coil) inside the DC motor produces a magnetic field that creates rotary motion as DC voltage is applied to its terminal. Inside the motor is an iron shaft, wrapped in a coil of wire. This shaft contains two fixed, north and south, magnets on both sides which causes both a repulsive and attractive force, in turn, producing torque. ISL Products designs and manufactures both brushed DC motors and brushless DC motors [30]. Geared DC motor in figure (3.5) is specially designed DC motor whose geared assembly helps increasing the torque and reducing the speed compared to a normal DC motor , maximum rpm a gear motor can produce is less , but they have by using the correct combination of gears , its rpm can be reduced to any desirable value , unlike servo motor , gear motor can also be rotated continuously . the direction of the gear motor can be reversed b simply reversing the polarity of the battery connection and the speed of the motor can be controlled by changing the voltage level across it , a motor driver IC named L293D [30]. For more details look in Appendix C.

Figure (3.5): DC geared Motor [30].

3.3.4 Motor Driver Module (L293D)

It consists of two H-bridge designed using four transistor circuit that helps us to reverse the direction of rotation and to control the speed of the DC motor.it is using for interfacing the DC motor with arduino as shown in Appendix D [16].

The figure (3.6) explains the general overview of L293D and how using it control two DC motor or one stepper motor unipolar or bipolar

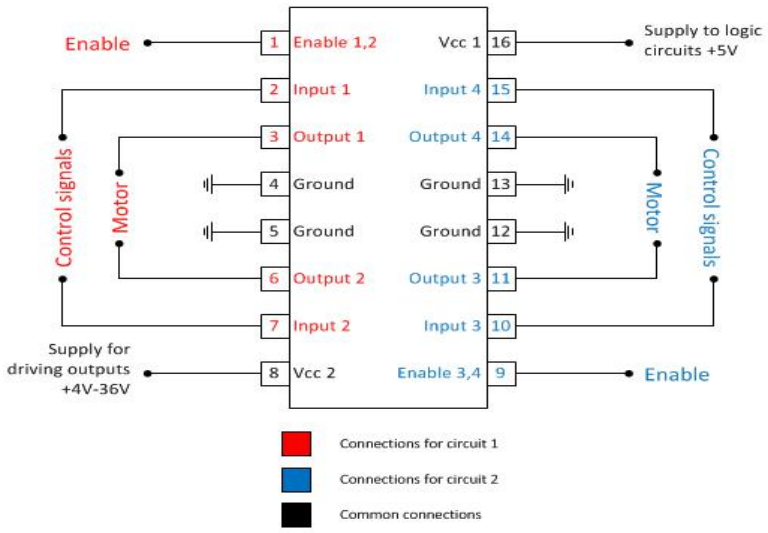

Figure (3.6) : L293D Module Overview[16]

3.3.4.1 Motor Driver Module (L293D) Pin out

The table (3.1) describes the pin out of L293D

Table (3.1) : L298D pins description

Pin No	Name	Description
4,5,12,13	GND Pin	Ground (It grounds the Input and completes the circuit path)
16	+5V Pin	It is the Recommended Voltage
8	+9/12V Pin (VSS)	It is R ecommended Power Supply(36V is Maximum)
1	EN	Enable 1,2 ,connect to 5 volts
2,7	IN1 & IN2	Input Pin1,2 (To rotate the motor in Clock-wise direction. It is for Motor1 Inputs)
3,6	MTR1&MTR2	It is for the Input of Motor 1
10,15	IN3 & IN4	Input Pin3,4 (To rotate the motor in Anti-clockwise direction. It is for Motor1 Inputs)
11,14	MTR3&MTR4	It is for the Input of Motor 2
9	EN	Enable 3,4 ,connect to 5 volts

3.3.5 Line Tracking Sensor (KY - 033)

The KY-33 in figure (3.7) detects if a light reflecting or absorbing area is infront of it . It shows which of the two area it is via the sensitivity of the sensor can be adjusted by the controller. The behavior can be automatically follow a line with an AGV [26]. tracking sensor module is using to navigate the AGV in line for more details look in Appendix F.

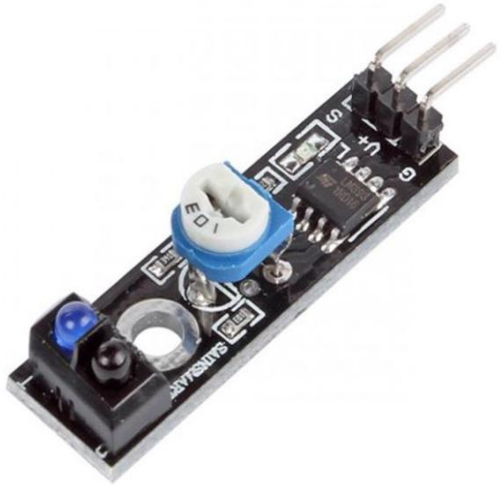

Figure (3.7) : KY- 33 Overview[26].

3.3.5.1 Line Tracking Sensor (KY - 033) Pin out

The table (3.2) describes the pin out of KY - 33

table (3.2) : KY - 33 pin out description

Symbol	Description
+V	5 VDC power supply
G	Ground
S	Signal to controller

3.3.6 Ultrasonic Sensor (HC - SR04)

The Ultrasonic sensor module in figure (3.8) is a convenient way for measuring distances from objects. This module has a lot of applications such as parking sensors, obstacle and terrain monitoring systems, industrial distance measurements, etc. It has a stable performance and high accuracy ranging from 2cm to 450cm with a resolution

of 0.3 cm. The module sends an ultrasonic signal, eight pulses of 40kHz square wave from the transmitter; the echo is then picked up by the receiver and outputs a waveform with a time period proportional to the distance[26]. for more details look in appendix E.

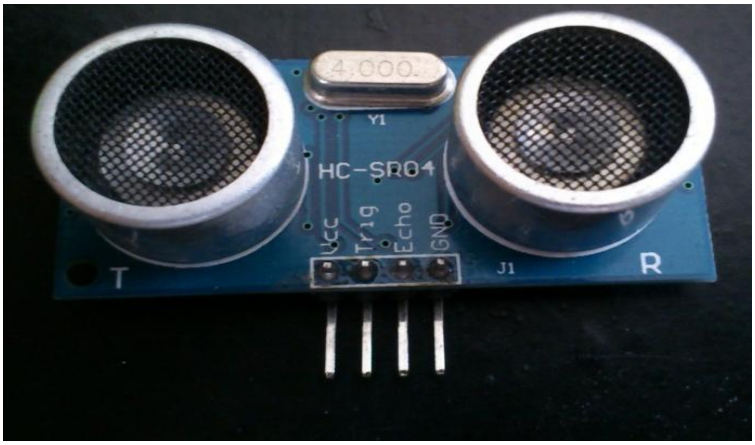

Figure (3.8) : HC - SR04 Overview[26]

3.3.6.1 Ultrasonic Sensor (HC - SR04) Pin out

The table (3.3) describes the pin out of HC-SR04

The table (3.3) : HC-SR04 pins out description

Symbol	Description
VCC	5V DC power supply
Trig	trigger signal for starting the transmission with 10μs high time
Echo	output
GND	Ground

3.3.7 Power Supply of AGV System

The power supply system feeds the AGV system by using (3-5-6-12) VDC to operate DC motor, motor driver, ESP8266 module, tracking sensor, ultrasonic sensor, and arduinoMEGA2560 respectively.

3.3.8 Overall Hardware of AGV System

Figure (3.9) describes the overall hardware of system design, it contains tracking sensor, Ultrasonic sensor, arduinomega2560, DC motor, L293D, ESP8266, and power supply.

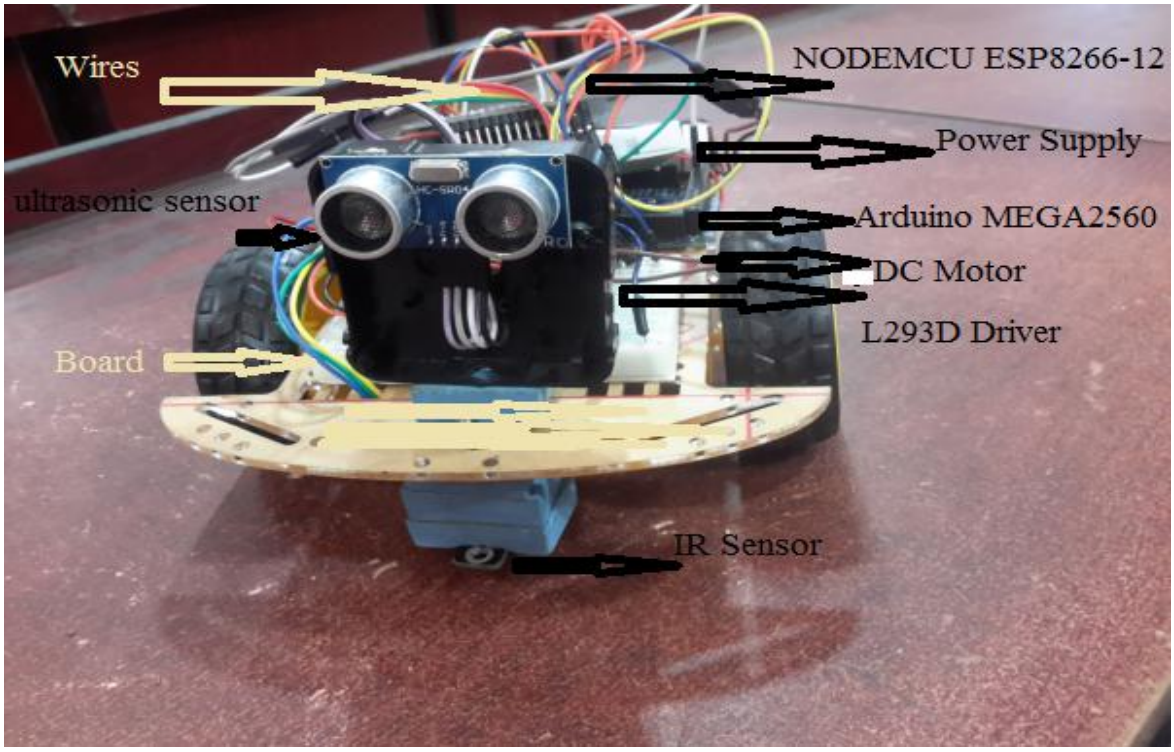

Figure (3.9) : Overall Hardware System Overview

3.4 Software Development

This section explains Proteus /arduino IDE program and Wi-Fi Robot Control App .

3.4.1 Proteus Program Definition

Proteus ISIS is a circuit designing and simulation software, it is developed by Lab center Electronics for electrical and electronic circuit design, it also possess 2D CAD drawing feature, it deserves to bear the tag line. It is a software suite containing schematic simulation as well as PCB designing [31]. The system design drown by using Proteus program as shown in figure (3.10) which includes arduinoMEGA2560, tracking sensor, ultrasonic sensor, L293D, DC motor, and ESP8266.

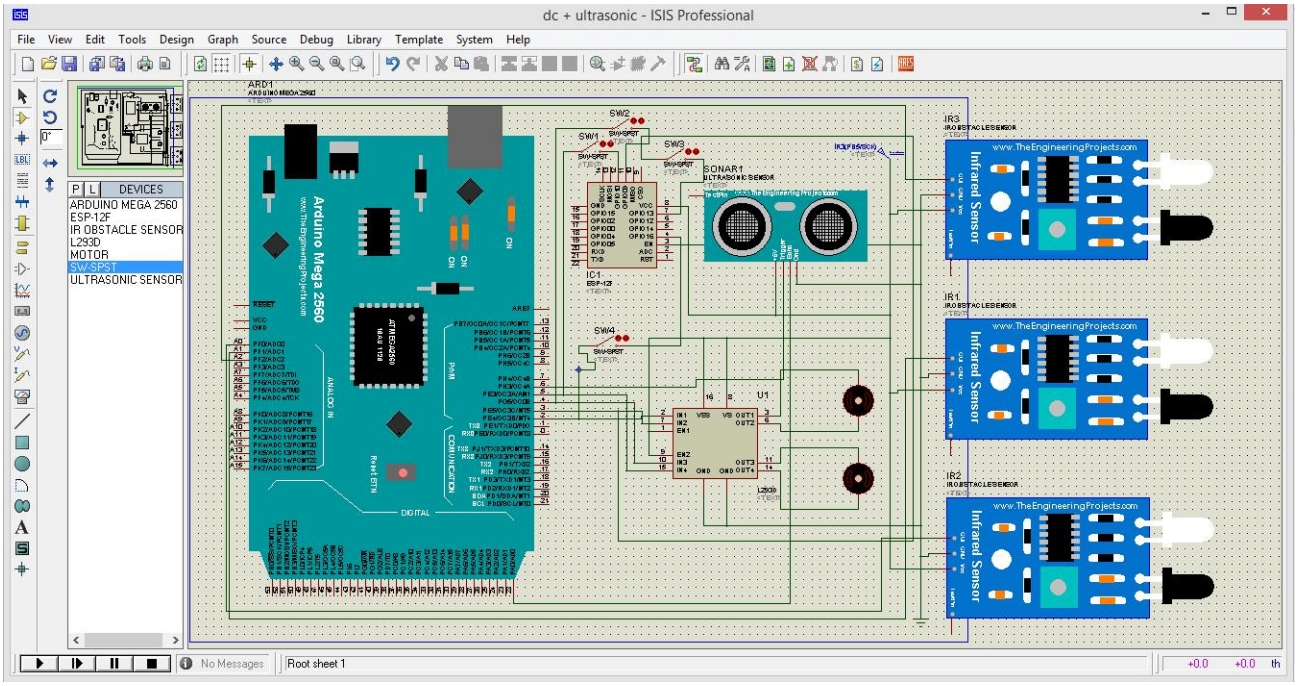

Figure (3.10) : Overall Software System Overview

3.4.2 Arduino IDE Program Definition

Arduino first and foremost is an open-source computer hardware and software company. The arduino community refers to the project and user community that designs and utilizes microcontroller based development boards. These development boards are known as arduino modules which are open-source prototyping platforms. The simplified microcontroller board comes in a variety of development board packages.The most common programming approach is to use the arduino IDE which utilizes the C programming language. This gives you access to an enormous arduino library that is constantly growing thanks to open source community [32].

3.4.2.1 Arduino IDE Initial Setup

The arduino IDE in figure (3.11) opens into a blank sketch where you can start programming immediately. First, it should configure the board and port settings to allow us to upload code. Connect your arduino board to the PC via the USB cable[32].

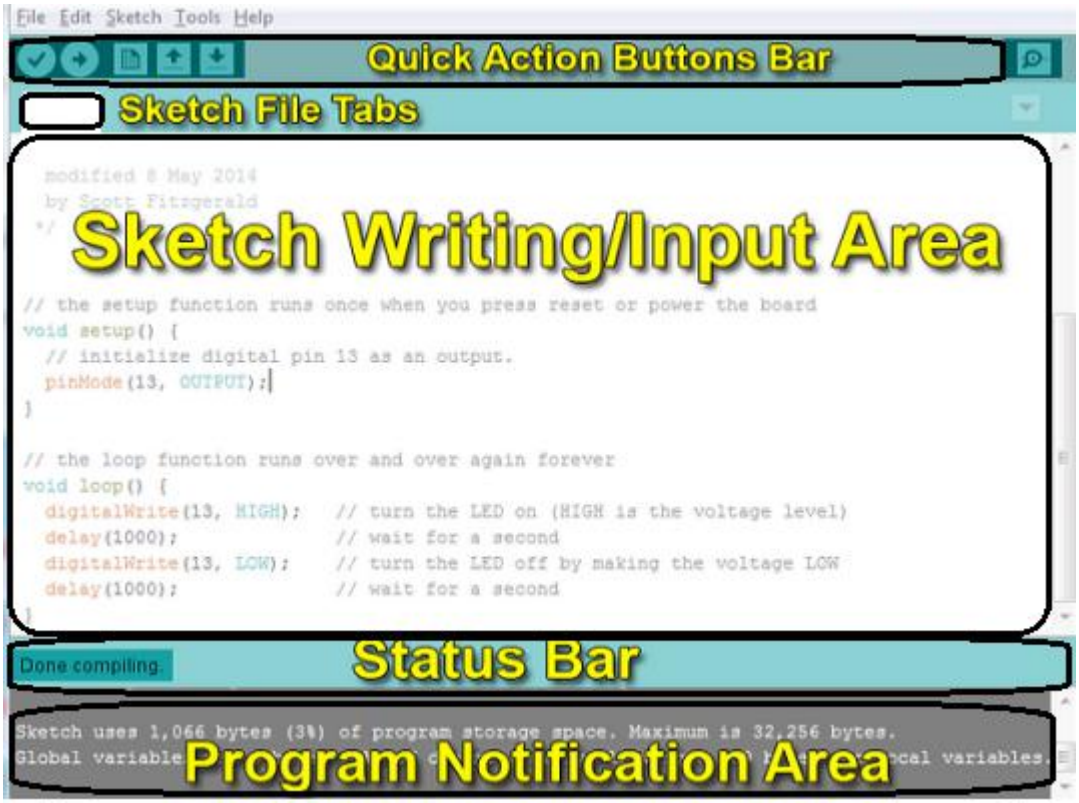

Figure (3.11) : Arduino IDE Default Window

3.4.2.2 Arduino IDE Board Setup

Figure (3.12) has to tell the arduino IDE what board you are uploading to. Select the Tools pull down menu and go to board .This list is populated by default with the currently available arduino boards that are developed by arduino[32]. If you are using an arduinomega2560 select Arduinomega2560. If you are using another board/clone select that board.

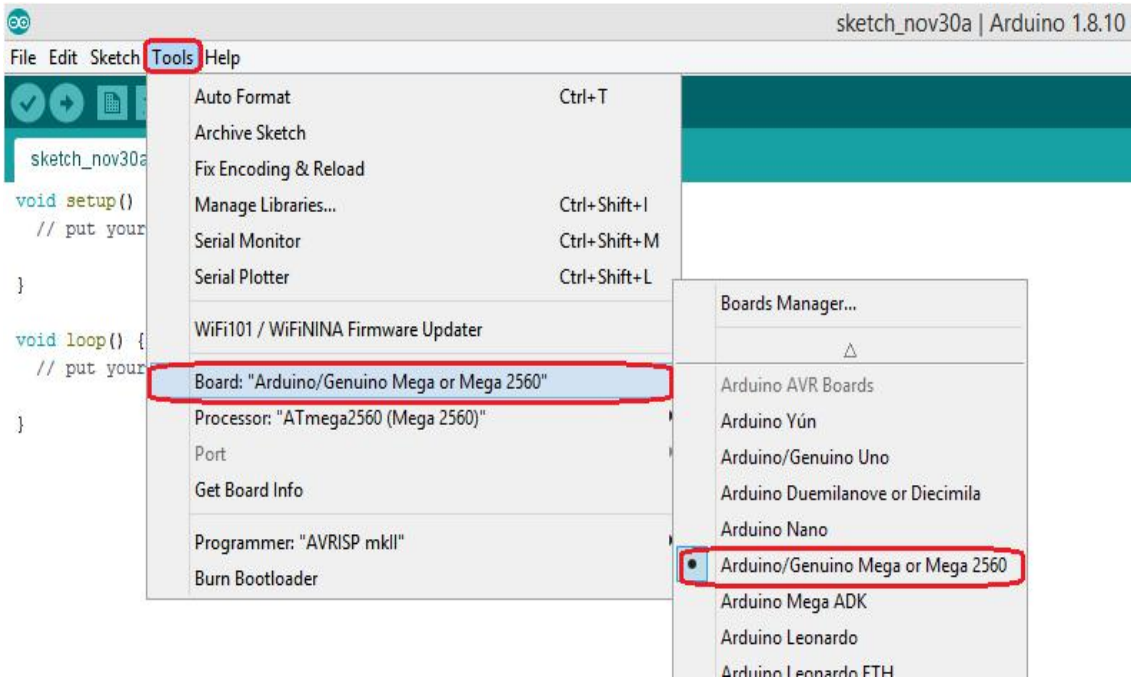

Figure (3.12) : Arduino IDE Board Setup Procedure

3.4.2.3 Arduino IDE COM Port Setup

The most recent arduino IDE should recognize connected boards and label them with which COM port they are using. Select the Tools pull down menu and then Port. Figure(3.13) should list all open COM ports, and if there is a recognized arduino Board, it will also give its name. Select the arduino board that you have connected to the PC. If the setup was successful, in the bottom right of the arduino IDE, in figure (3.13) should see the board type and COM number of the board you plan to program. If you downloaded the arduino IDE before plugging in your arduino board, when you plugged in the board, the USB drivers should have installed automatically[32]. in figure (3.13) arduino mega2560 occupies the next available COM port, it will not always be COM3.

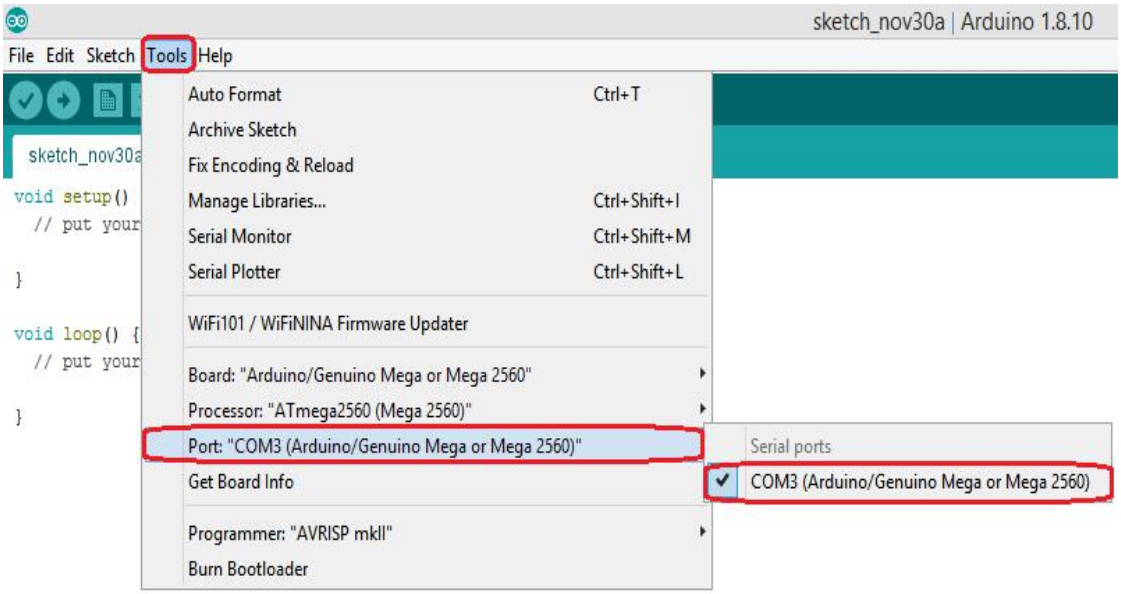

Figure (3.13) : Arduino IDE COM Port Setup

3.4.3 Wi-Fi Robot Control Application

Wi-Fi Robot Control App uses to guide the AGV through Wi-Fi mode as shown in figure (3.14). The App was used as shown in pages 49/50/51.

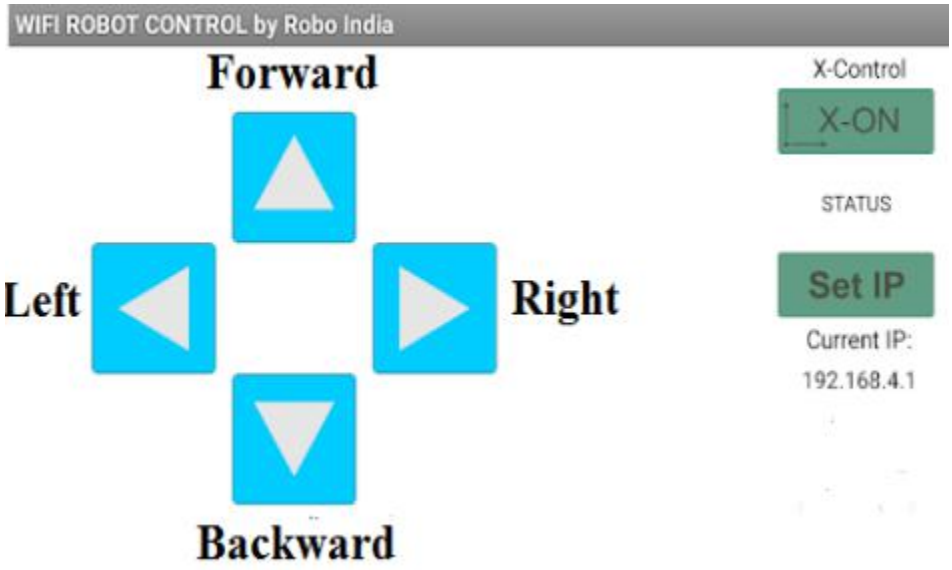

Figure (3.14) : Wi-Fi Robot Control App platform [33]

3.5 System Simulation

This section discusses configuration of the components. Then drawing of the AGV system by using Proteus program. Also programming of the AGV system such as the code writing, verifying/compiling, and uploading by using arduino IDE program. And finally simulation of the AGV system.

3.5.1 Configuration of the AGV Components

It means library of the components added to library of Proteus program as shown in figures(3.15, 3.16, 3.17, 3.18, 3.19) respectively. Such as Arduino library added to library of the Proteus program as shown in figure(3.15).

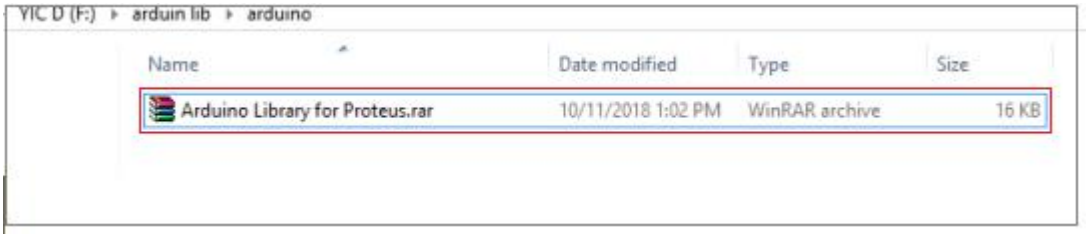

Figure (3.15) : Arduino Library

Also Infrared sensor library added to library of Proteus program as shown in figure(3.16).

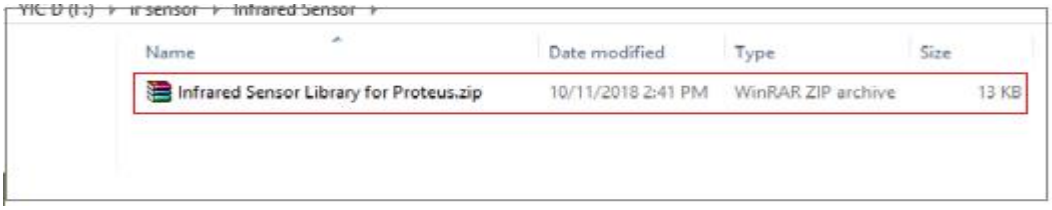

Figure (3.16) : Infrared Sensor Library

Then ultrasonic sensor library added to library of Proteus program as shown in figure(3.17).

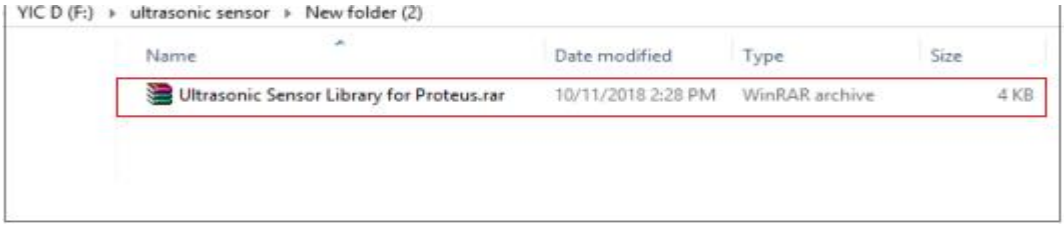

Figure (3.17) : Ultrasonic Sensor Library

L293D library added to library of Proteus program as shown in figure(3.18).

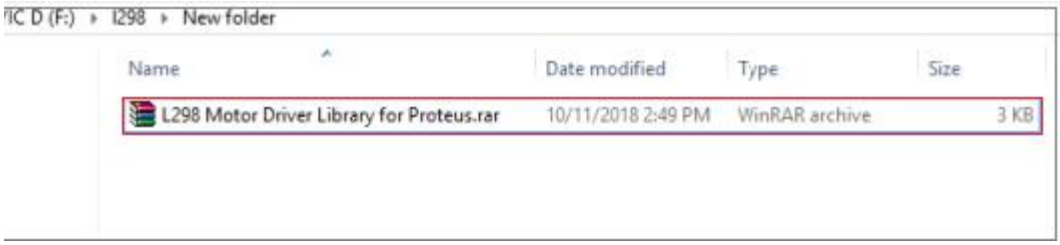

Figure (3.18) : L293D Library

Finally, the libraries of all components such as arduino, ir sensor, ultrasonic sensor, and L293D added to library of Proteus program as shown in figure (3.19).

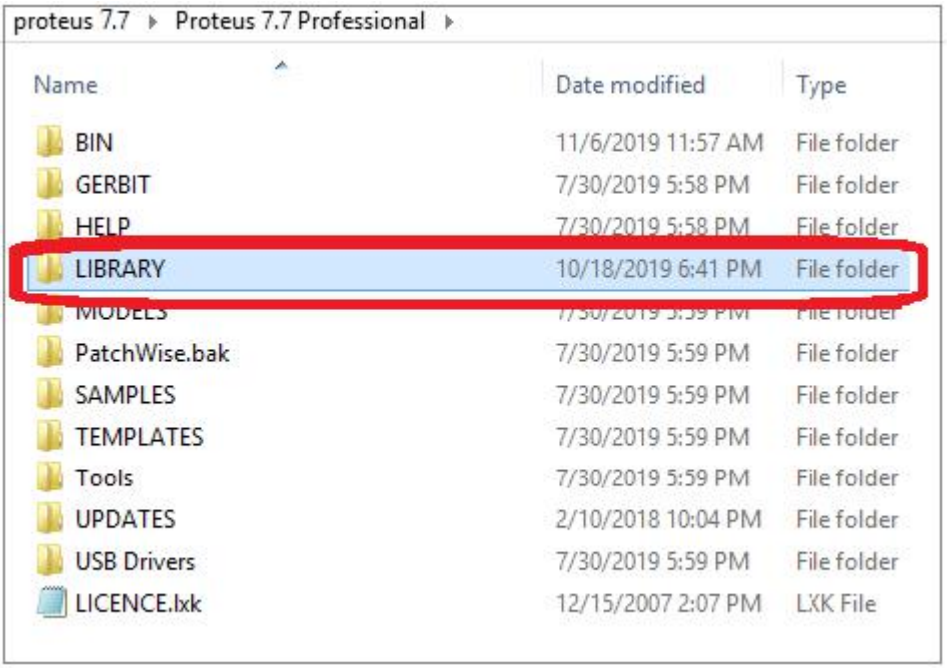

Figure (3.19) : Proteus Library

Also library of arduino components added to library of arduino IDE program such as adding ESP8266 board to Arduino IDE program as shown in next instructions:

1.In Arduino IDE program, go to File > Preferences as shown in figure (3.20)

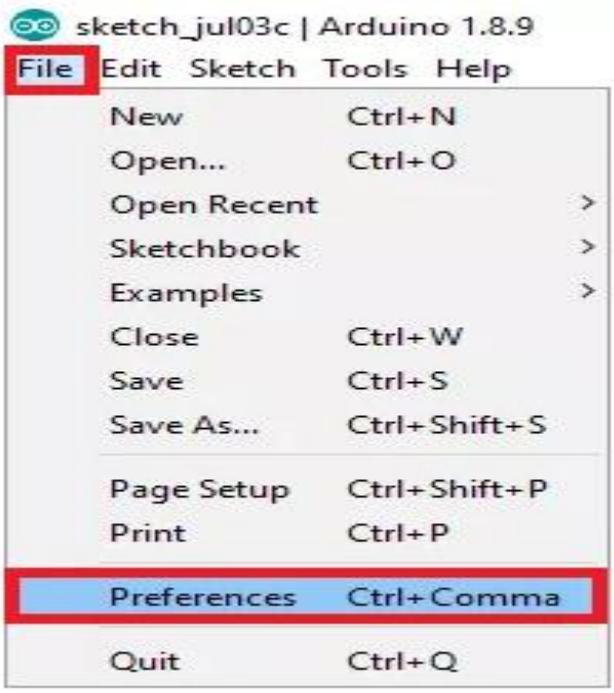

Figure (3.20) : Preferences Overview

2. To install the ESP8266 board or other Wi-Fi board in arduinoIDE program insert **http://arduino.esp8266.com/stable/package_esp8266com_index.json** into the "Additional Boards Manager URLs" field and click "OK" button as shown in figure (3.21).

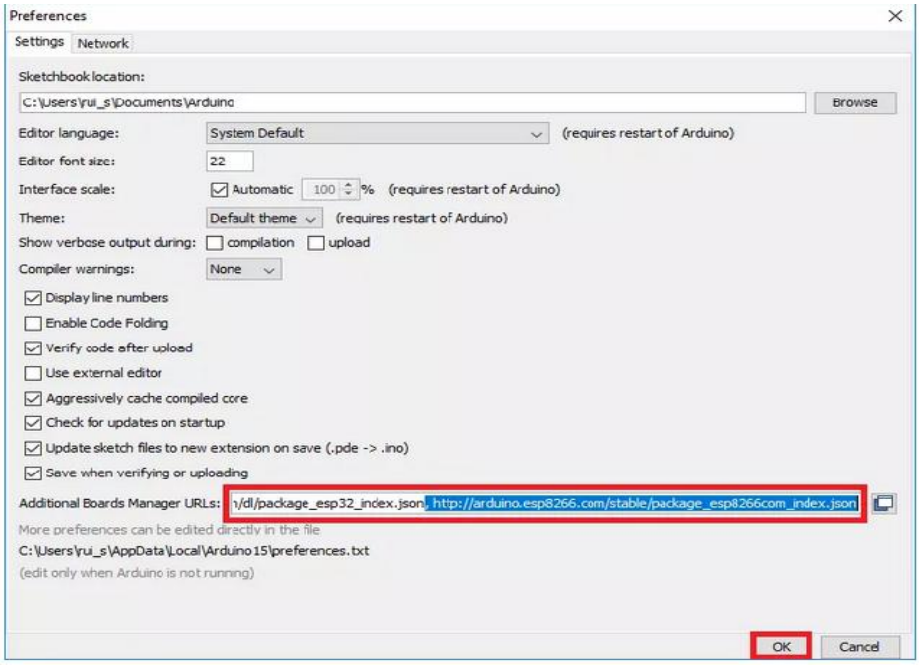

Figure (3.21) : Preference - Board Manger URLs Overview

3.Open the Boards Manager. Go to Tools > Board > Boards Manager as shown in figure (3.22).

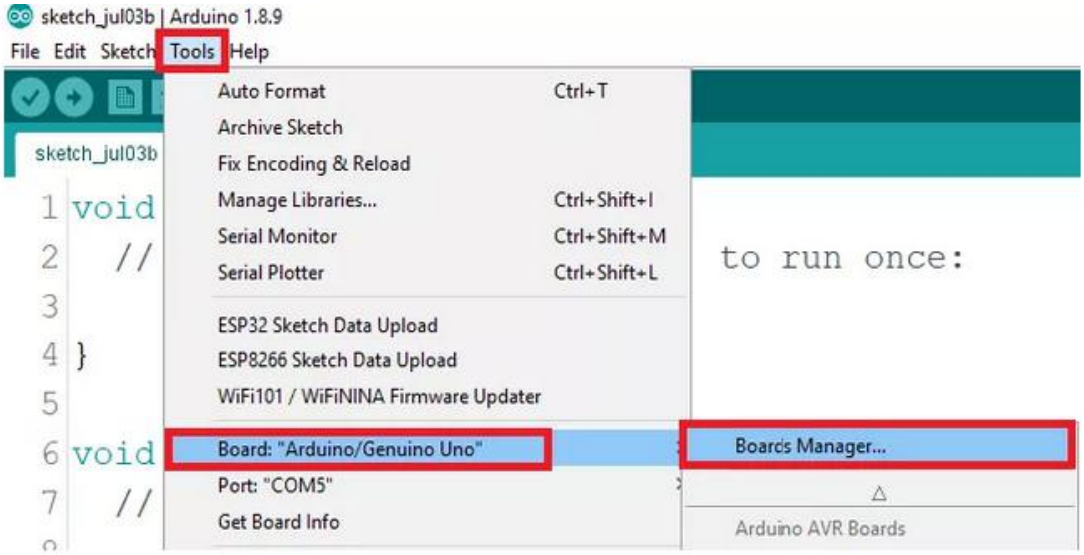

Figure (3.22) : Board Manger Overview

4.Search about ESP8266 and click install button for the “ESP8266 by ESP8266 Community“ as shown in the figure (3.23) .

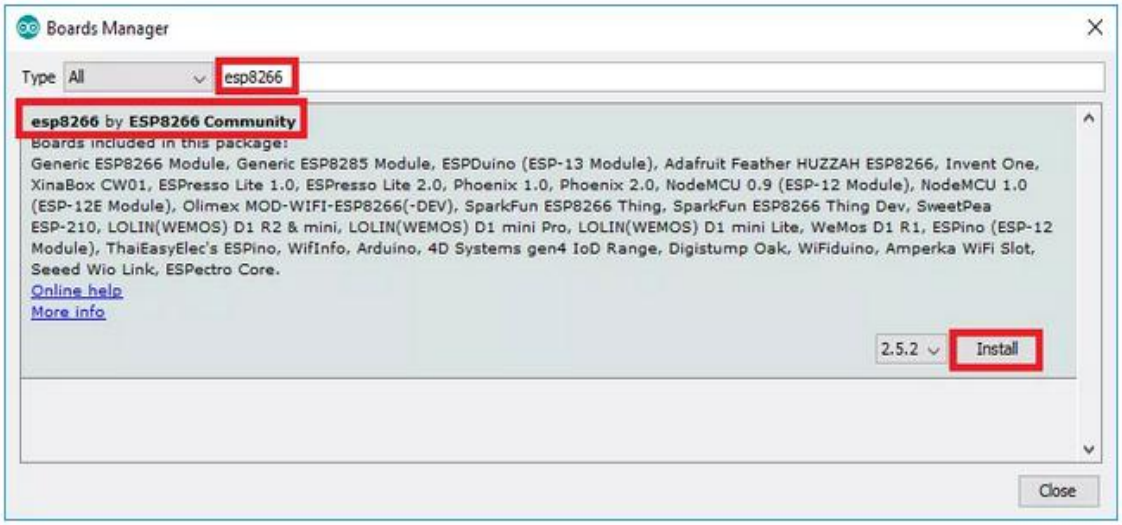

Figure (3.23) : Board Manger - Install ESP Community Overview

5.ESP8266 community should be installed after a few seconds as shown in figure (3.24)

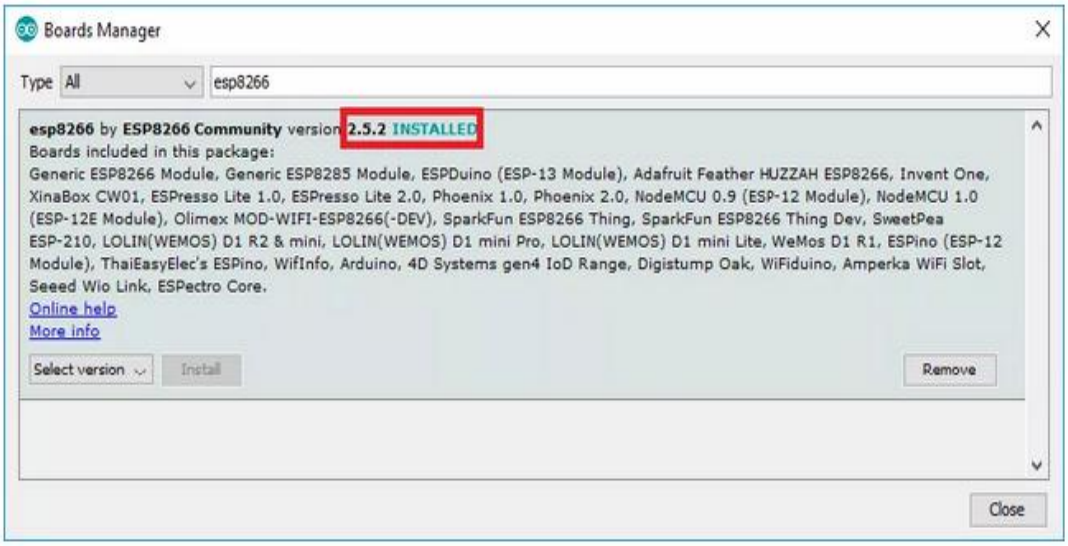

Figure (3.24) : ESP Community Installed

3.5.2 Drawing of the AGV System

It explains the general AGV model drawn by using Proteus program after library configuration of the system components as shown in next steps :

1.Click on **P** button it stands for place as shown in figure (3.25)

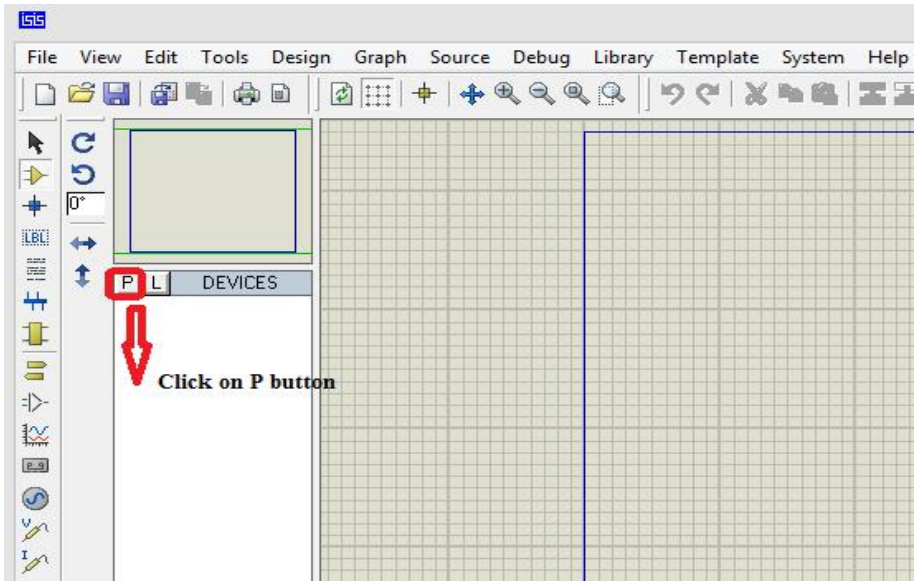

Figure (3.25) : **P** button it stands for place

2.After Click on **P** button a new window would appears then search for the components as shown in figure (3.26).

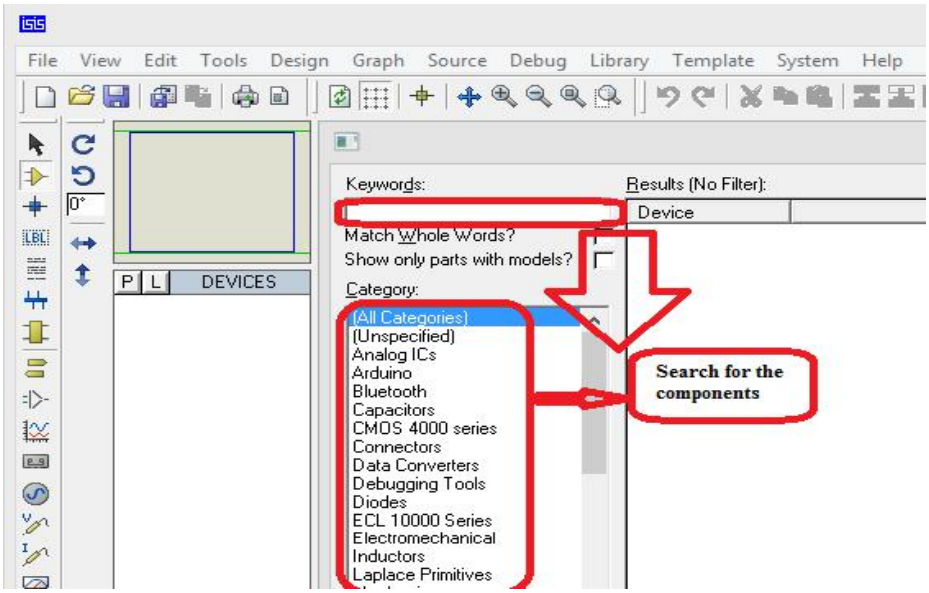

Figure (3.26) : search for the components

3.After search for the components for example arduinomega2560, then select the components and press OK as shown in figure (3.27).

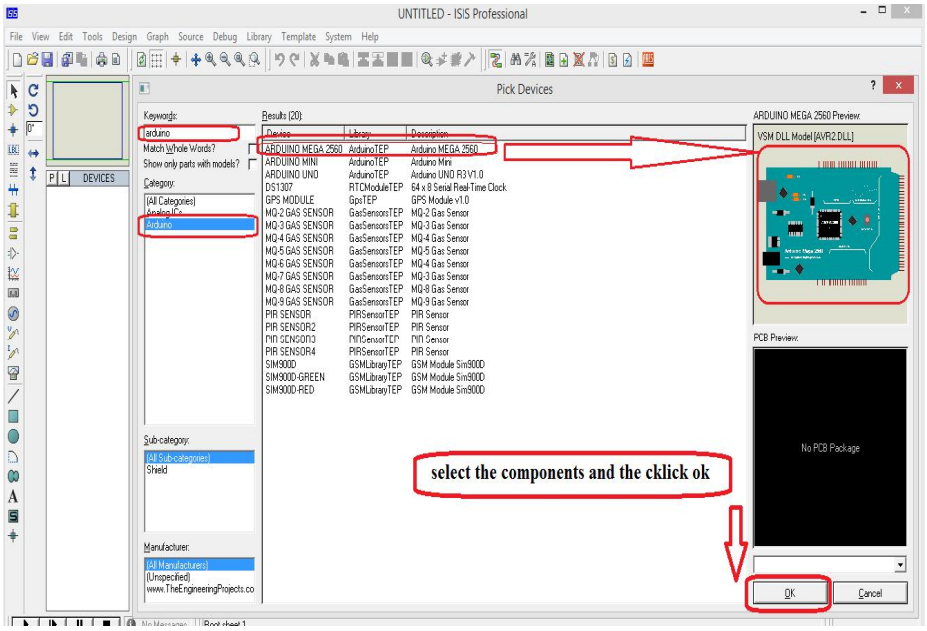

Figure (3.27) : select the components

4.Show the components in the scheme capture after components selection as shown in figure (3.28)

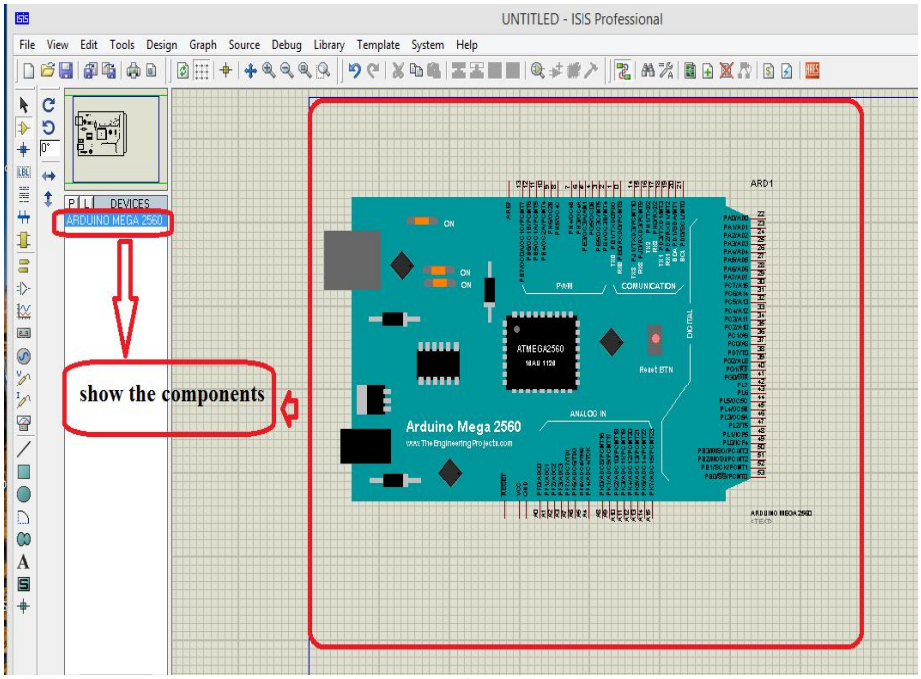

Figure (3.28) : show the components in scheme capture

5.Joint between the components such as joint arduinomega2560 with ultrasonic sensor in scheme capture as shown in figure (3.29)

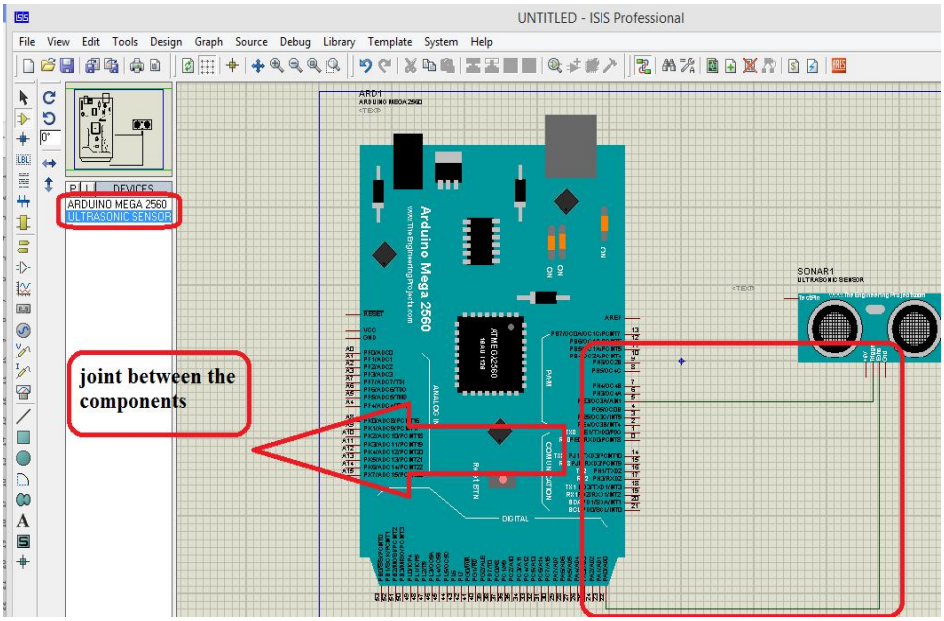

Figure (3.29) : Joint between the components

Finally can joint between the AGV components such as IR sensor, ultrasonic sensor, L293D, DC motor, Arduino MEGA2560, and ESP8266 as shown in figure (3.10) .

3.5.3 Programming of the AGV System

This section explains the code writing, verifying/compiling , and uploading to arduinoMEGA2560/ ESP8266 by using arduino IDE program as shown in next steps :

1.The code created by programmer. The programmer creates two codes based on the design model and its operation status. So one of the code for control the AGV by using arduino MEGA2560 to follow the production line without Wi-Fi. And other code for control the AGV by using Wi-Fi module outside the production line via Wi-Fi Robot Control App for more details look in Appendix G.

2.The code verified/compiled by using arduino IDE program. Compiling means check it over for mistakes and then translate it into arduinoMEGA2560/ESP8266 board. Verifying means the arduino IDE program will check over and look for typos, common errors, it can't catch all errors. When arduino compiles as shown in figure(3.30) your sketch, it is putting/arranging it together into the right order for your arduinoMEGA2560/ESP8266 board to be able to run.

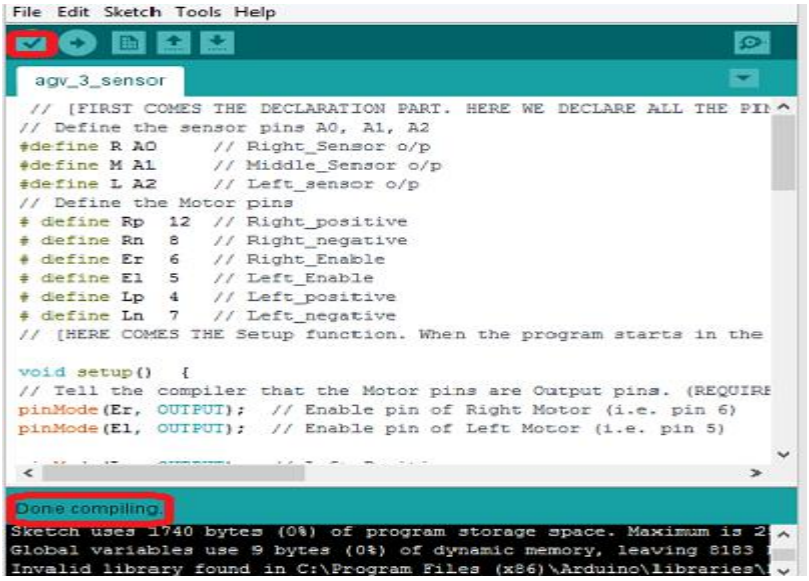

Figure (3.30) : done compiling the code Overview

After a few seconds,it should see the message done compiling. in the status bar and sketch uses ... bytes (x%) of program storage space (or something similar) in the

program notification area.This means the sketch was well-written and is ready for uploading to the arduinoMEGA2560/ESP8266 board.

3. The code uploads to arduinoMEGA2560/ESP8266 board as shown in page 44

3.5.4 Simulation of the AGV System

this section discusses simulation of the AGV system after the system design is configuring, drawing, and programming. The hex file brought after verify/compile the code from arduinoIDE program in simulation section. Then it is asking how to locate the compiled hex file . So follow these steps:

1.In the Arduino IDE select Sketch > Export Compiled Binary. This performs a compile. Once complete, this command places a copy of the compiled. Hex file into the directory of your sketch as shown in figure(3.31)

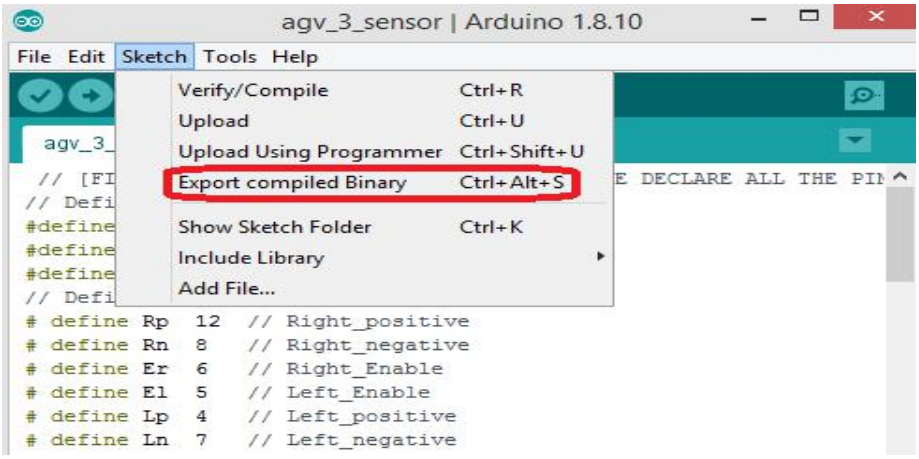

Figure (3.31) : Export Compiled Binary

2.Then either browse to the sketch folder or in the IDE select Sketch >Show Sketch Folder. as shown in figure (3.32).

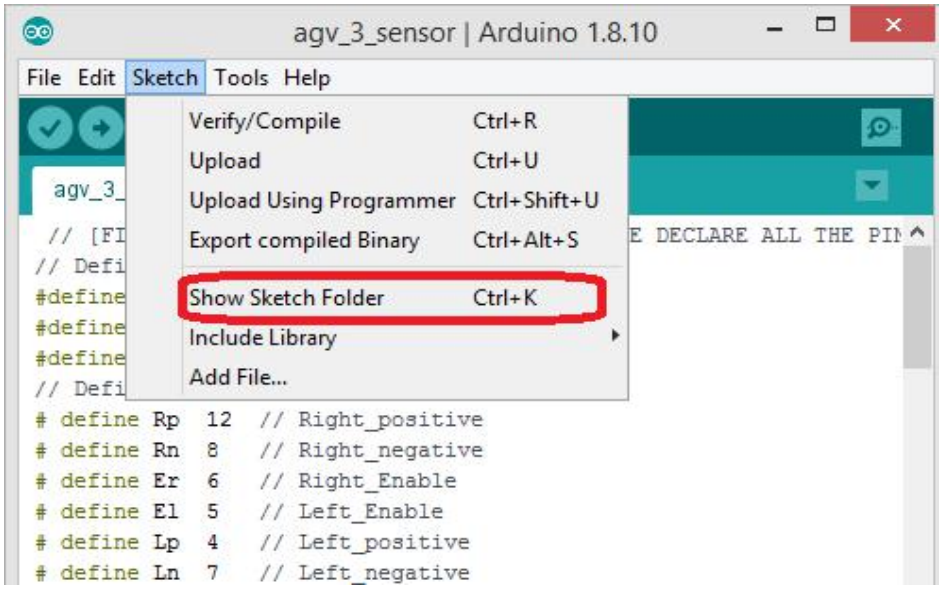

Figure (3.32) : Show Sketch Folder

3.This generates two hex files for the target arduino. One with the boot loader and one without the boot loader. The hex file without the boot loader in figure(3.33) can be add to the arduinoMEGA2560 board in proteus program.

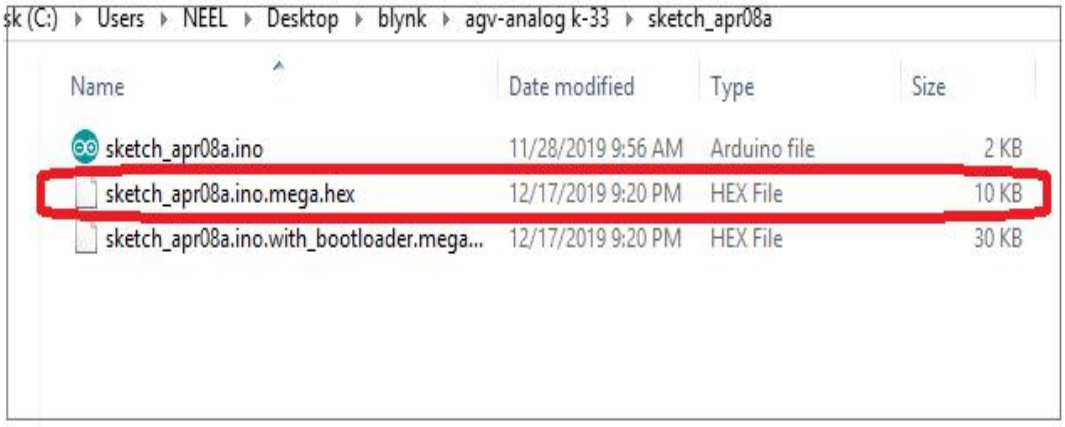

Figure (3.33) : Hex File Overview

2.press double click in Arduino board in proteus program then paste the Hex File and click ok as shown in figure (3.34)

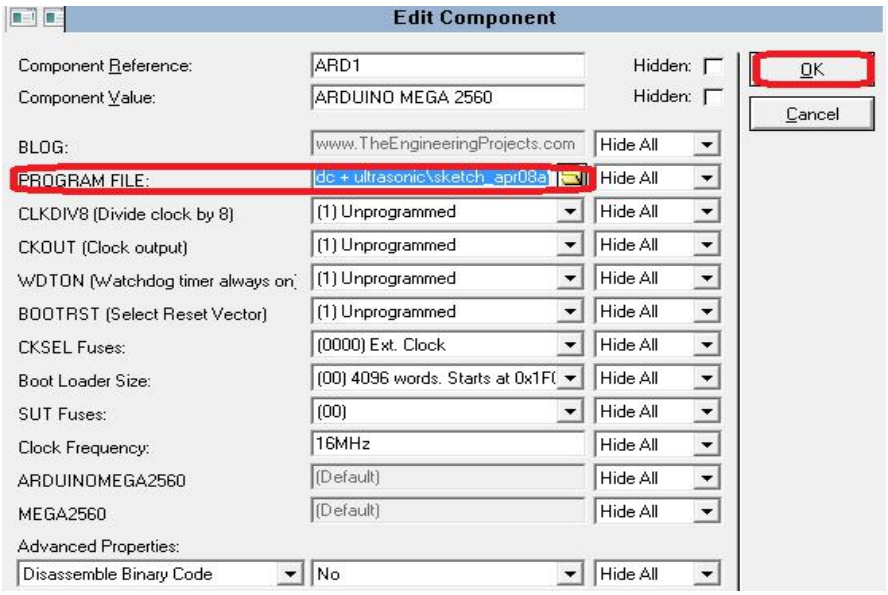

Figure (3.34) : Paste Hex File in Arduino Board overview

3.Press run key in Proteus program as shown in figure (3.35) to check configuration or show simulation if the components work well or not

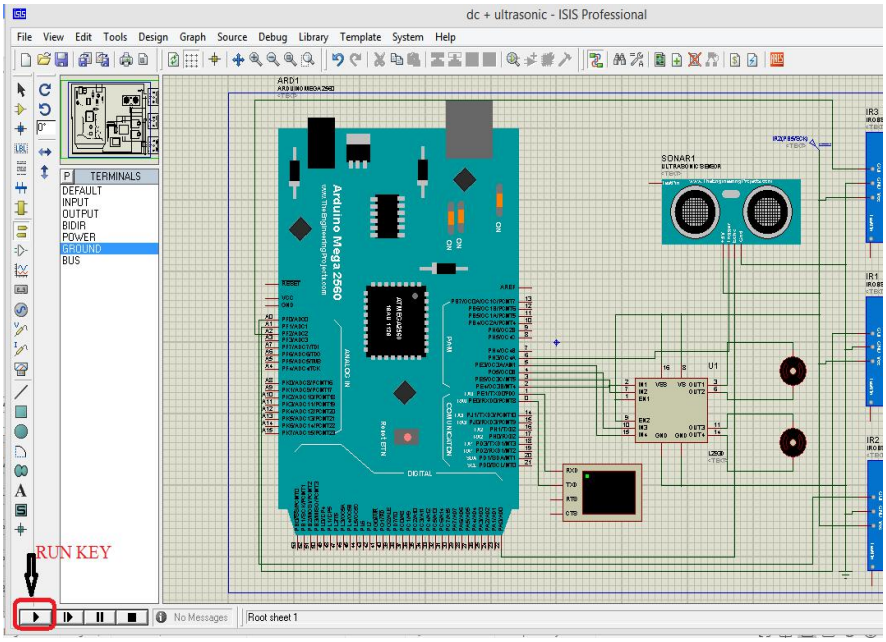

Figure (3.35) : Run Soft Keys in Proteus program

3.6 Hardware Implementation

This part explains the hardware approach such as components installation and hardware wiring after the AGV model is configuring, drawing, and programming as shown in next steps :

1.The hardware components installed and connected based on the block diagram of the system design with arduinoMEGA2560/ESP8266 board as shown in figure (3.9).

2. the code uploaded to arduinoMEGA2560/ESP8266 board using arduino IDE as shown in figure(3.36) . But before it uploads can select the board as shown in figure (3.12) and the also select the com port as shown in figure (3.13).

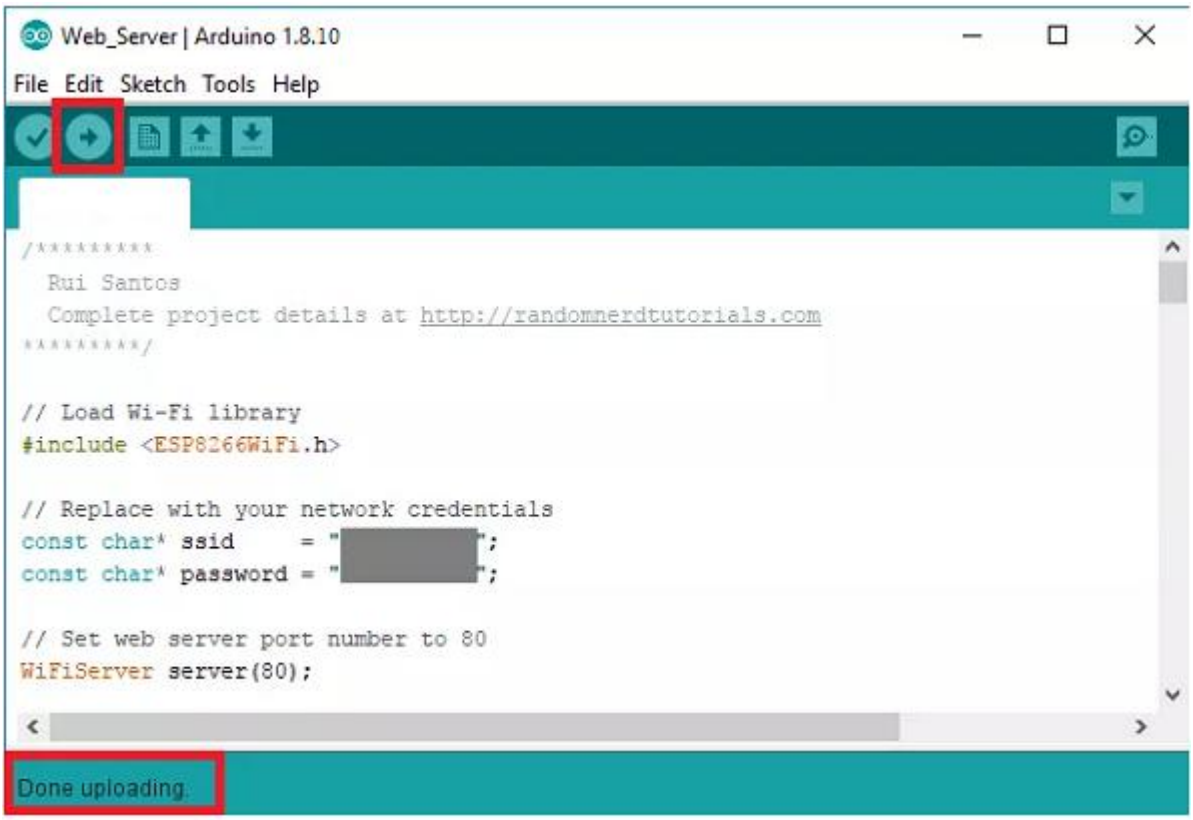

Figure (3.36) : upload the code to the board

After a few seconds you should get this screen, with the message done uploading in the status bar. Then operation of the AGV with/without Wi-Fi. the next chapter discuss that.

Chapter Four : AGV System Operation

Chapter Four

AGV System Operation

4.1 AGV Operation Mode

This section describes AGV operation by using two mode without Wi-Fi in the production line or with Wi-Fi outside the production line via Wi-Fi Robot Control App.

4.1.1 AGV Operation Without Wi-Fi

In this mode AGV follows the production line without Wi-Fi. Figure(4.1) explains the basic idea behind a line following AGV, left sensor, middle sensor, and right sensor.

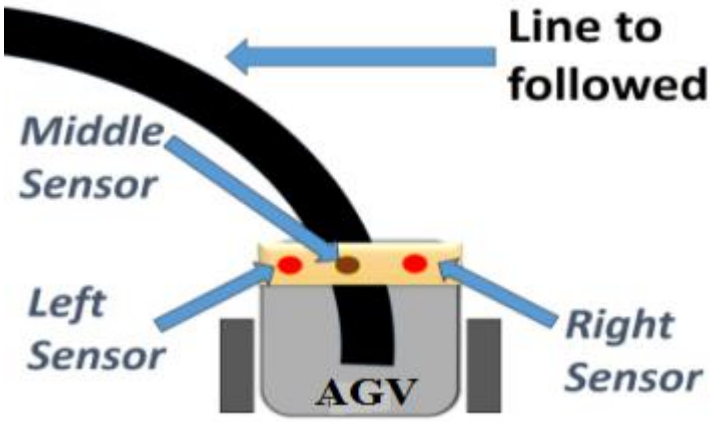

Figure (4.1) : Top View Showing the Line, the AGV,and the Sensors.

Based on the next cases the AGV must move to follow the production line according to the sensor output :

4.1.1.1 AGV Move Straight

In figure (4.2) the line is under the middle sensor. That is mean only the middle sensor can sense the line. So it tells the arduinoMEAG2560 to run the AGV goes straight to follow the production line.

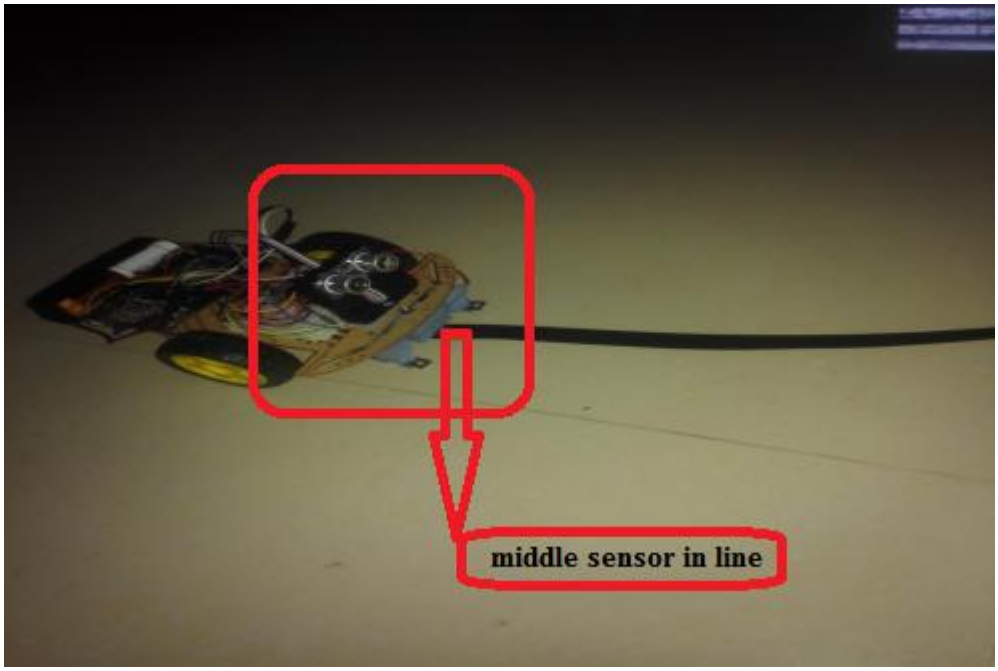

Figure (4.2) : AGV Goes Straight

4.1.1.2 AGV Turn Left

The AGV moves straight until the line is under the left sensor as shown in figure (4.3). And then it turns to the left. In order to keep the AGV on the production line.

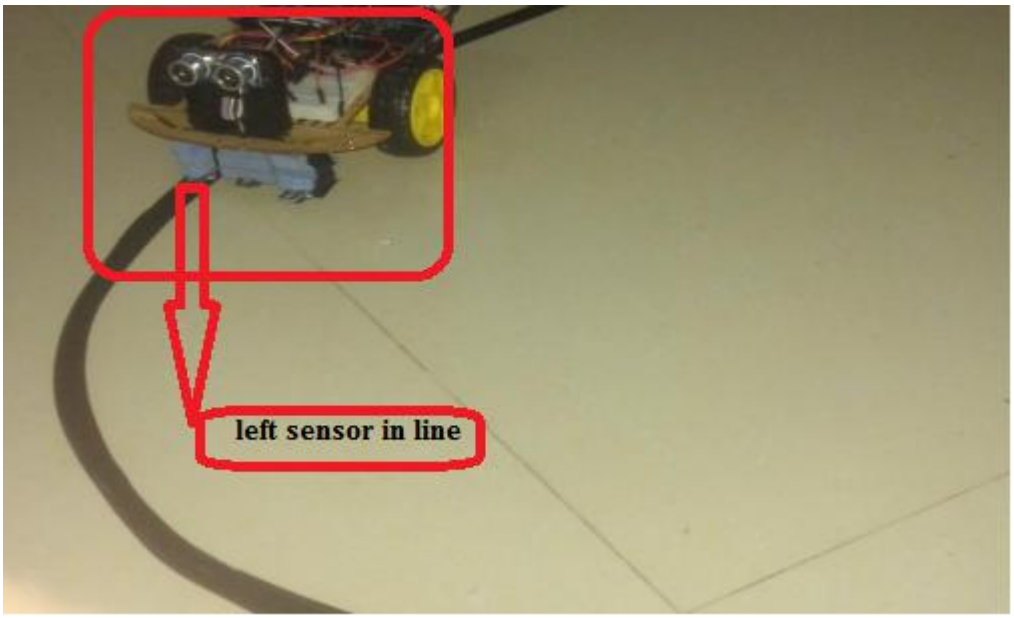

Figure (4.3) : AGV Turns to Left

4.1.1.3 AGV Turn Right

The AGV moves straight until the line is under the right sensor as shown in figure (4.4). And then it turns to the right. In order to keep the AGV on the production line.

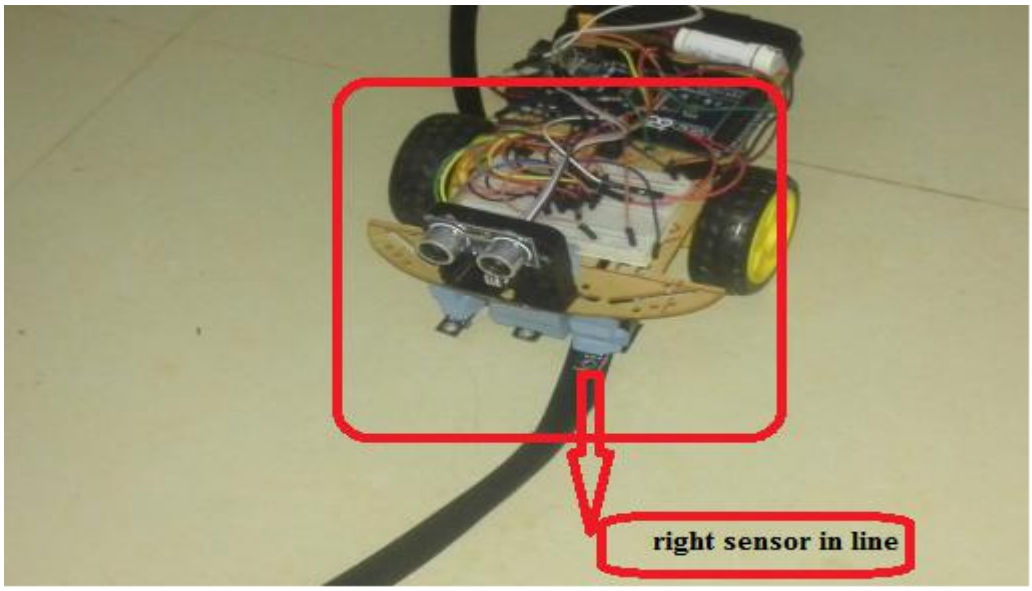

Figure (4.4) : AGV Turns to Right

4.1.1.4 AGV Stop

In this case AGV stops for two purpose. One for its station arrived and other for avoiding obstacle from objects respectively. in next step explains This two status :

1.If the AGV arrives its station that means the left, right, and middle sensor is becoming outside the production line as shown in figure (4.5). So the three sensors can not sense the line.Then the arduinoMEGA2560 tells the AGV goes to stop in its station.

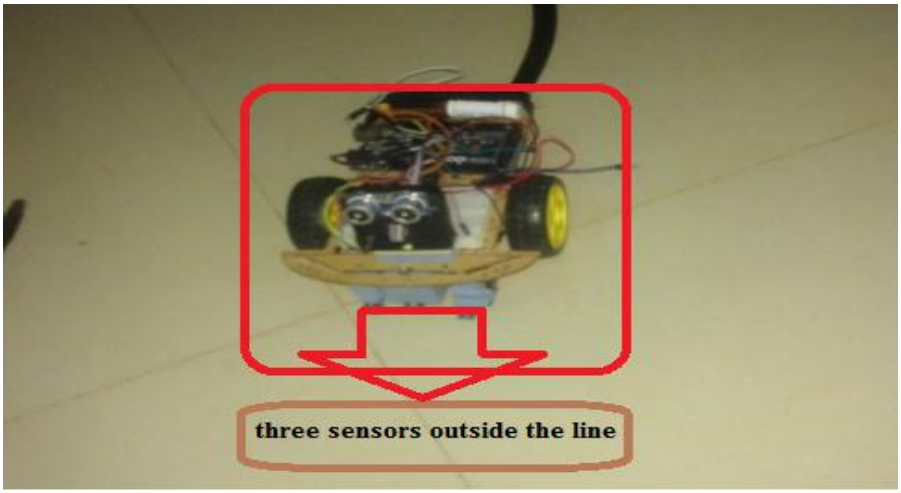

Figure (4.5) : AGV Stop

2. ultrasonic sensor used in AGV system to avoid obstacle from objects. So if the distance from AGV to any objects less than 10 cm the arduinoMEGA2560 tells AGV goes to stop as shown in figure (4.6) .To keep AGV or any object safe.

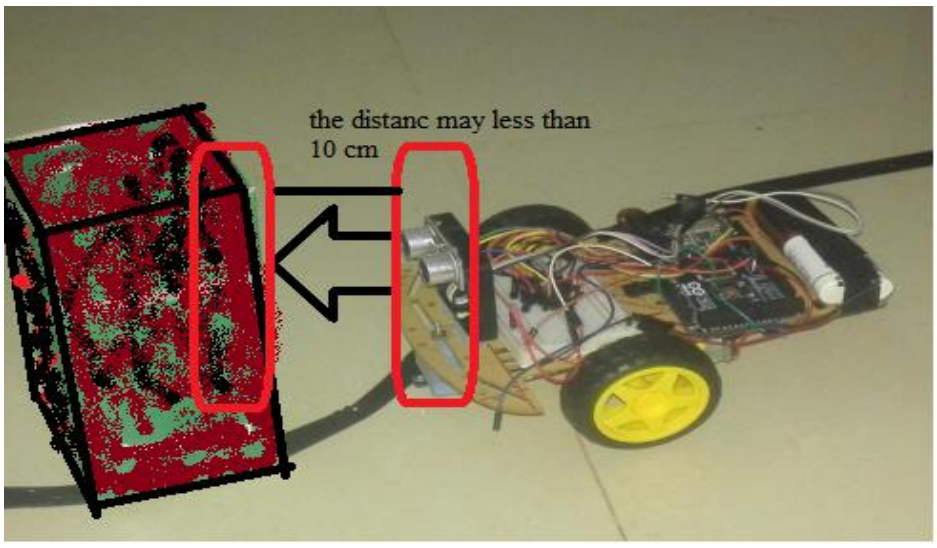

Figure (4.6) :AGV Stop

4.1.2 AGV Operation Through Wi-Fi

This section explains how using Wi-Fi mode to guidance the AGV system outside the production line through Wi-Fi Robot Control App to move materials or products. In next steps explain AGV operation using Wi-Fi :

1.the code uploads to the ESP8266 board as shown in figure (3.36) to get IP address on serial monitor as shown in figure (4.7)

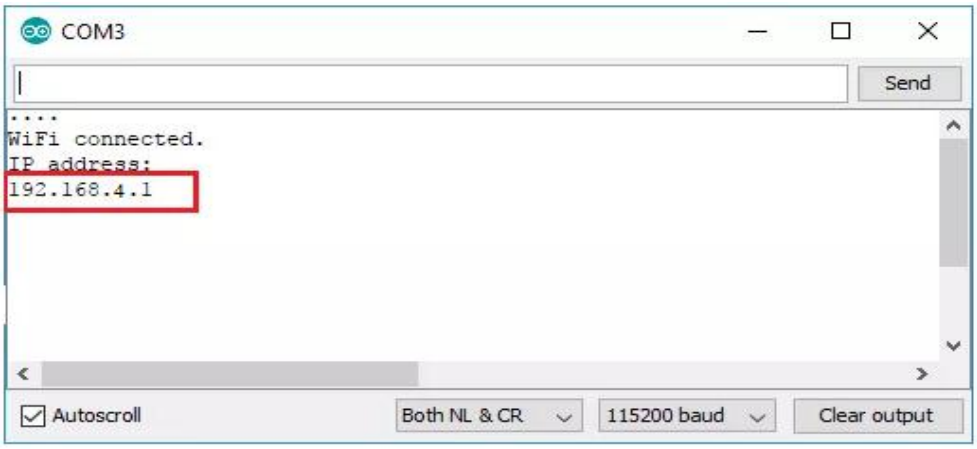

Figure (4.7) : Getting IP Address on Serial Monitor

2.Now the ESP6266 board became access point (AP) as shown in figure (4.8) Based on SSID name which created in the code as shown in Appendix (G).

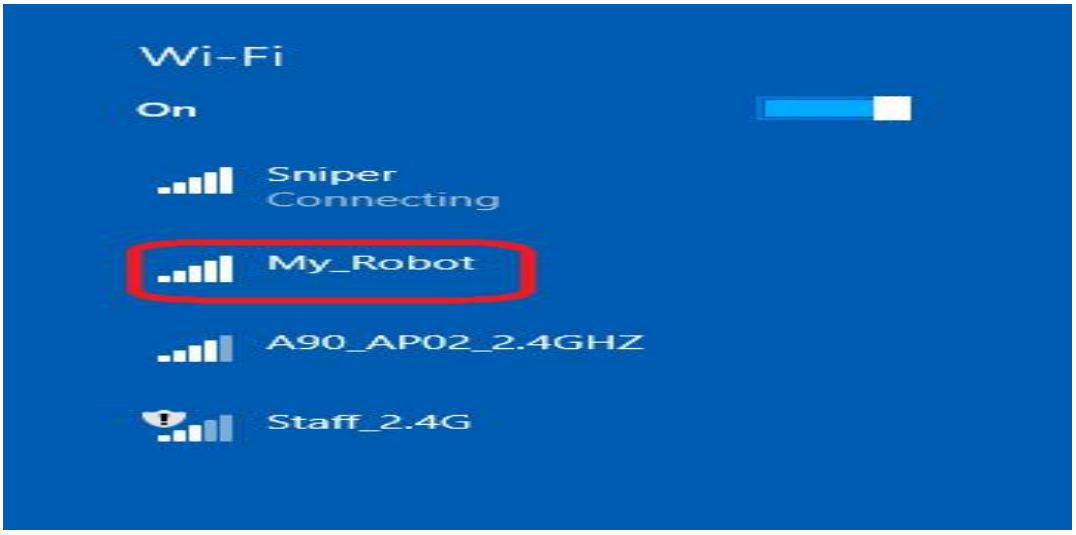

Figure (4.8) : AP of ESP8266

3.Then the user can access to AP of ESP8266 and then connecting to it as shown in figure(4.9)

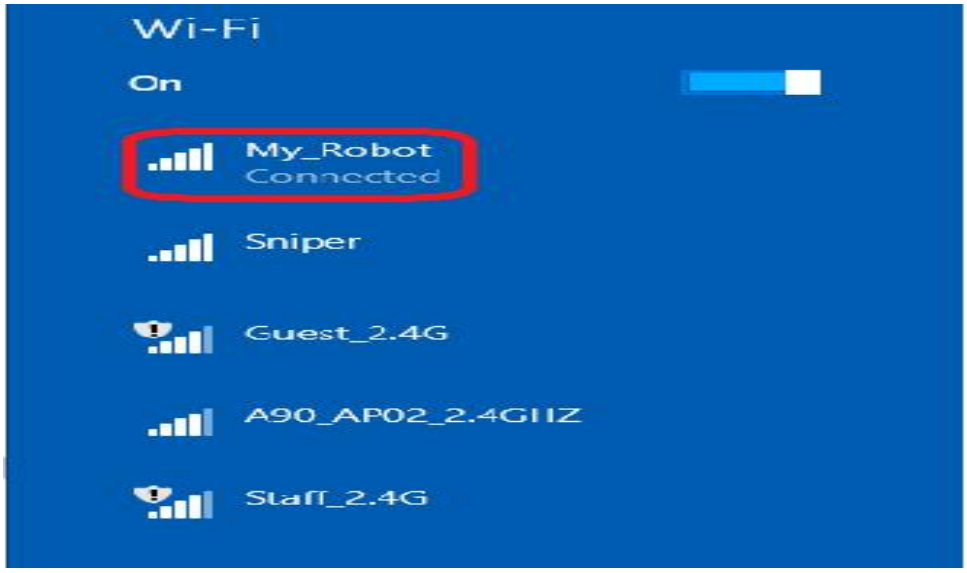

Figure (4.9) : AP of ESP8266-12 access and connected by user

4.after AP creation. User need the app to operate AGV by using Wi-Fi. So user brings Wi-Fi Robot Control App from Google play. Then install it in mobile phone for android users as shown in figure (4.10).

Figure (4.10) : install Wi-Fi Robot Controller App [33].

5.Open the Wi-Fi Robot Control App and insert IP address as shown in figure (4.11) and then press OK

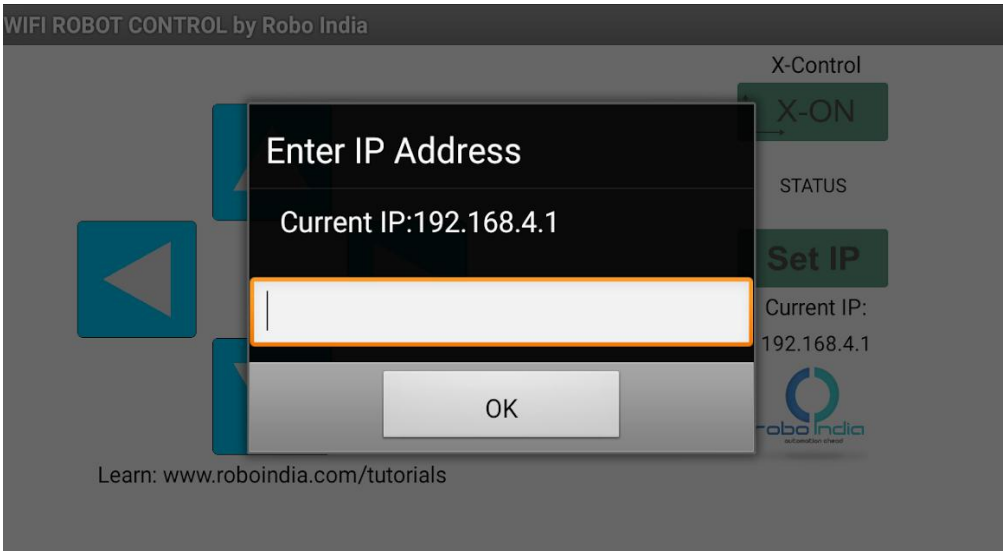

Figure (4.11) : insert IP address in Wi-Fi Robot Control App

6.Finally press to any soft key to move the AGV (Forward , Backward , Right , Left) as shown in figure (4.12).

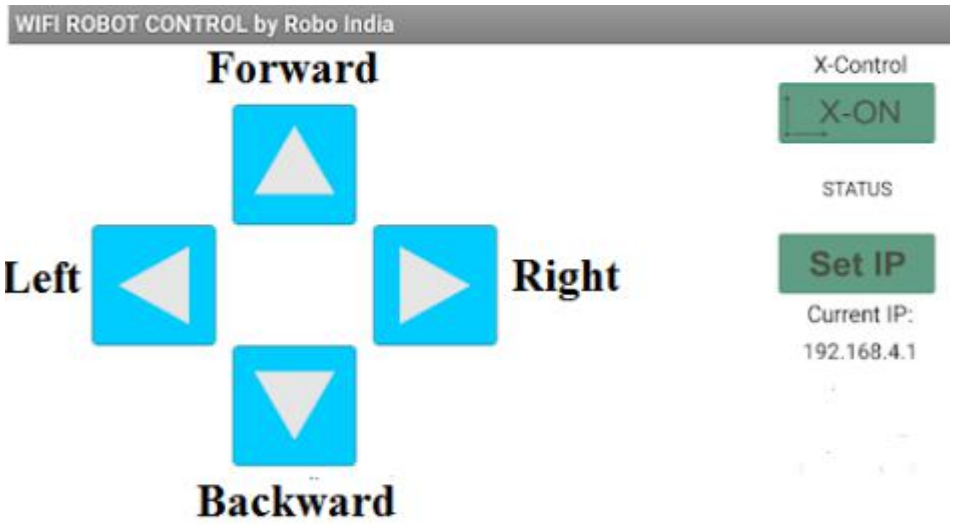

figure (4.12) : AGV operation using Wi-Fi Robot Control App

The design model faced some difficulties such as the system design used the fixed navigation system. It makes the system less flexible, motion of the AGV in its path un-smooth, and it tends to move out of the line. A thesis used Wi-Fi to increase the flexibility of the system design. But Unfortunately Wi-Fi at distance of 90 meters the connection lost and no reconnect succeed. AGV used obstacle avoidance only in forward direction . AGV does not use rechargeable battery.

Chapter Five : Conclusion and Recommendations

5.1 Conclusion

Based on a thesis objectives of design, implementation, and testing of the AGV system. The proposed system designed by using a software approach such as configuring components by downloading their library and add them to arduino IDE/ Proteus program library. Also the proposed system drawn by using Proteus program as shown in figure (3.10). Then the AGV programmed by using arduino IDE program. And finally AGV system simulated. Then the proposed system implemented by using hardware approach such as components installation and wiring connection as shown in figure (3.9). And the code uploaded to arduinoMEGA2560/ESP8266 board. Finally the two mode without/with Wi-Fi tested to guide AGV. So the AGV operation works properly to handle material in the production line without Wi-Fi mode or outside the production line with Wi-Fi mode through Wi-Fi Robot Control App.

5.2 Recommendations

According to the result of AGV system operation a thesis suggests using speech guidance to develop the AGV guidance system .Also It recommends using lithium-ion batteries for power supply system, and 3D obstacle avoidance for safety in the future. Then it suggests using open navigation in the indoor such as RFID, and laser navigation. And the outdoor such as GPS navigation.

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Appendix A

Arduino Mega2560

Arduino Mega2560 Specifications

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UART (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the micro-controller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the arduino Due milanove or Diecimila.

Summary

Micro-controller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by boot loader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

3.1.1.1 Power

The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

The power pins are as follows:

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.

Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each

pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15
(RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2). These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt() function for details.
- PWM: 0 to 13. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS). These pins support SPI communication using the SPI library. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Uno, Duemilanove and Diecimila.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- I^2C: 20 (SDA) and 21 (SCL). Support I^2C (TWI) communication using the Wire library (documentation on the
Wiring website). Note that these pins are not in the same location as the I^2C pins on the Duemilanove or Diecimila.

The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analogReference().

- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication. An ATmega8U2 on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Mega2560's digital pins.

The ATmega2560 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation on the Wiring website for details. For SPI communication, use the SPI library.

Programming

The Arduino Mega can be programmed with the Arduino software (download). For details, see the reference and tutorials.The ATmega2560 on the Arduino Mega comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega8U2 firmware source code is available in the Arduino repository. The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See this user-contributed tutorial for more information.

Automatic (Software) Reset

Rather then requiring a physical press of the reset button before an upload, the Arduino Mega2560 is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega2560 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader canhave a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.This setup has other implications. When the Mega2560 is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Mega2560. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Mega2560 contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled

"RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Over current Protection

The Arduino Mega2560 has a reset table poly fuse that protects your computer's USB ports from shorts and over current. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics and Shield Compatibility

The maximum length and width of the Mega2560 PCB are 4 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.The Mega2560 is designed to be compatible with most shields designed for the Uno, Diecimila or Duemilanove. Digital pins 0 to 13 (and the adjacent AREF and GND pins), analog inputs 0 to 5, the power header, and ICSP header are all in equivalent locations. Further the main UART (serial port) is located on the same pins (0 and 1), as are external interrupts 0 and 1 (pins 2 and 3 respectively). SPI is available through the ICSP header on both the Mega2560 and Duemilanove / Diecimila

A ppendix B

ESP6288-12 (NODEMCU)

ESP6288-12 Specifications

Wireless Standard	IEEE 802.11 b/g/n
Frequency Range	2.412 - 2.484 GHz
Power Transmission	802.11b : +16 ± 2 dBm (at 11 Mbps) 802.11g : +14 ± 2 dBm (at 54 Mbps) 802.11n : +13 ± 2 dBM (at HT20, MCS7)
Receiving Sensitivity	802.11b : -93 dBm (at 11 Mbps, CCK) 802.11g : -85 dBm (at 54 Mbps, OFDM) 802.11n : -82 dBm (at HT20, MCS7)
Wireless Form	On-board PCB Antenna
IO Capability	UART, I2C, PWM, GPIO, 1 ADC 3.3 V Operated 15 mA output current per GPIO pin 12 - 200 mA working current
Electrical Characteristic	Less than 200 uA standby current
Operating Temperature	-40 to +125 ºC
Serial Transmission	110 - 921600 bps, TCP Client 5
Wireless Network Type	STA / AP / STA + AP
Security Type	WEP / WPA-PSK / WPA2-PSK
Encryption Type	WEP64 / WEP128 / TKIP / AES
Firmware Upgrade	Local Serial Port, OTA Remote Upgrade
Network Protocol	IPv4, TCP / UDP / FTP / HTTP
User Configuration	AT + Order Set, Web Android / iOS, Smart Link APP

ESP8266-12 (NODEMCU) Features

- Version : DevKit v1.0
- Breadboard Friendly
- Light Weight and small size.
- 3.3V operated, can be USB powered.
- Uses wireless protocol 802.11b/g/n.IEEE 802.11b.

Appear in Late 1999

2.4Ghz radio spectrum

11Mbps (theoretical speed) within 30m range 4-6Mbps (actual speed)

100-150 feet range

Most popular and Less expansive

Interference from mobile phones and Bluetooth devices which can reduce the transmission speed Built-in wireless connectivity capabilities. Built-in PCB antenna on the ESP-12E chip.

- Capable of PWM, I2C, SPI, UART, 1-wire, 1 analog pin. Uses CP2102 USB Serial Communication interface module. Arduino IDE compatible (extension board manager required).
- Supports Lua (alike node.js) and Arduino C programming language.

A ppendix C

DC Geared Motor

DC Geared Motor Specification

It is ideal for small robots – for Omniwheel build. This motor is small, works well using a 3 or 4 AA battery pack, and it is very reliable provided you don't overload it.

Brand Name: contact

Model Number: MF-2

Usage: Toy Car, Robot

Certification: ROHS

Type: Gear Motor

Torque: 1~5 kgf.cm

Construction: Permanent Magnet

Commutation: Brush

Protect Feature: Explosion-proof

Speed(RPM): 125rpm-208rpm

Continuous Current(A): 2.8 A , customized

Application: for smart toy car or robot ect.

Material: Metal/Plastic

Output Mode: 2 sides

Output Torque: 1~5 kgf.cm

Gear Ratio: 1:48 1:120 or customized

Operating Temperature: -10~+60 ℃

Voltage: 3--12V

Rated load : 0.8 kgf.cm

A ppendix D

L293D

L293D Description

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit,with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications. On the L293, external high-speed output clamp diodes should be used for inductive transient suppression. A VCC1 terminal, separate from VCC2, is provided for the logic inputs to minimize device power dissipation. The L293and L293D are characterized for operation from 0°C to 70°C.

L293D Features

¨ Wide Supply-Voltage Range: 4.5 V to 36 V

¨ Separate Input-Logic Supply

¨ Internal ESD Protection

¨ Thermal Shutdown

¨ High-Noise-Immunity Inputs

Functional Replacements for SGS L293 and

SGS L293D

Output Current 1 A Per Channel (600 mA for L293D)

Peack Output Current 2 A Per Channel (1.2 A for L293D)

Transient Suppression (L293D)

Appendix E

HC-SR04

HC-SR04 Specifications

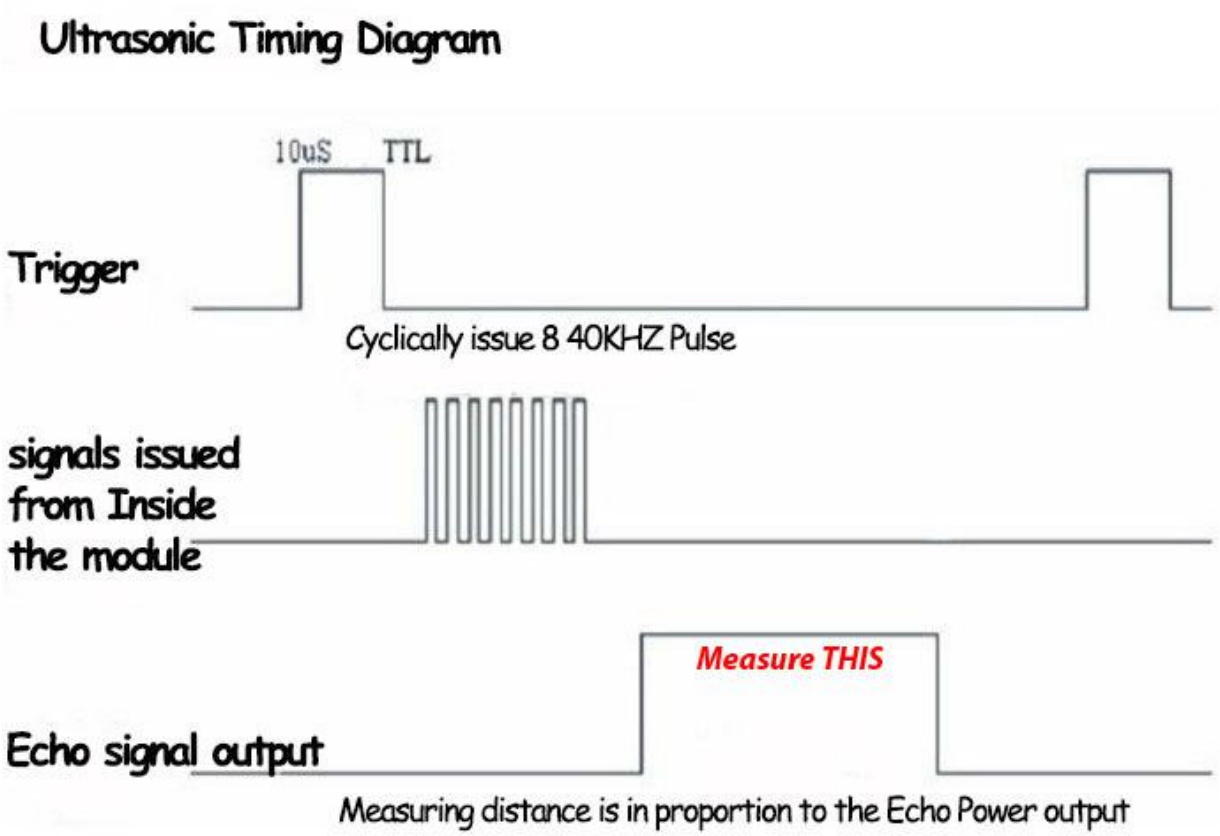
The sensor chosen for the Firefighting Drone Project was the HCSR04. Thissection contains the specifications and why they are important to the sensor module. The sensor modules requirements are as follows.

a) Cost
b) Weight
c) Community of hobbyists and support
d) Accuracy of object detection
e) Probability of working in a smoky environment
f) Ease of use

The HCSR04 Specifications are listed below. These specifications are from the

Working Voltage: 5V DC

Working Current: 15mA
Static Current: Less than 2mA
Output Signal: Electric Frequency signal, high level 5V, low level 0V
Sensor angle: not more than 15 degrees
Detection Distance: 2cm to 450cm
High Precision: Up to 3mm
Mode of Connection: VCC / Trig / Echo / GND
Adopt I/O trigger through supplying at least 10μs sequence of high level signal
Dimensions: 1.77in x 0.79in x 0.51in (4.5cm x 2.0cm x 1.3cm)
Weight: 10g


Ultrasonic Timing Diagram
10uS
TTL
Trigger
Cyclically issue 8 40KHZ Pulse
signals issued
from Inside
the module
Measure THIS
Echo signal output
Measuring distance is in proportion to the Echo Power output

Appendix F

KY-033

KY-033 Specifications

1. Working voltage: DC 3.3V-5V
2. Working current: ≥ 20mA
3. Operating temperature: -10℃~+50℃
4. Detection distance: 2-40cm
5. I/O Interface: 3-wire interfaces (-/+/S)
6. Output signal: TTL level (low level there is an obstacle, no obstacle high)
7. Adjustment: adjust multi-turn resistance
8. Effective angle: 35°
9. Size: 28mm×23mm
10. Detection angle : 35 degree

Appendix G

AGV System Code

Code (1) : control the AGV to folow the production line without Wi-Fi

```
int M_A1 = 2; //Right Backward motor
int M_A2 = 3; //Right Forward motor
int M_B1 = 4; //Left Forward motor
int M_B2 = 5; //Left Backward motor
int trig = 6; //    ultrasonic trig
int echo = 24; // ultrasonic echo
int R_S = A0; // Right Sensor
int M_S = A1; //Middle Sensor
int L_S = A2; // Left Sensor
int duration = 0;
int distance = 0;
void setup()
{
pinMode(M_B1, OUTPUT);
pinMode(M_B2, OUTPUT);
pinMode(M_A1, OUTPUT);
pinMode(M_A2, OUTPUT);
pinMode(trig, OUTPUT);
pinMode(echo,INPUT);
pinMode(L_S, INPUT);
pinMode(M_S, INPUT);
pinMode(R_S, INPUT);
delay(200);
}
void loop()
```

```
{
   digitalWrite(trig , LOW);
   delayMicroseconds(1000);
   digitalWrite(trig , HIGH);
   delayMicroseconds(1000);
   digitalWrite(trig , LOW);
   duration = pulseIn(echo , HIGH);
   distance = (duration/2) / 29;
   Serial.println("distance :");
   Serial.println(distance);
   if( distance < 10)
   {
    digitalWrite(M_A1, LOW);
    digitalWrite(M_A2, LOW);
    digitalWrite(M_B1, LOW);
    digitalWrite(M_B2, LOW);
    delay(100);
   }

else if ((digitalRead(L_S)==0)&&(digitalRead(M_S)== 1)&&(digitalRead(R_S) == 0)){forword();}
if ((digitalRead(L_S) == 1)&&(digitalRead(M_S) == 1)&&(digitalRead(R_S) == 0)){turnLeft();}
if ((digitalRead(L_S) == 1)&&(digitalRead(M_S) ==0)&&(digitalRead(R_S) == 0)) {turnLeft();}
if ((digitalRead(L_S) == 0)&&(digitalRead(M_S) == 1)&&(digitalRead(R_S) == 1)){turnRight();}
if ((digitalRead(L_S) == 0)&&(digitalRead(M_S) == 0)&&(digitalRead(R_S) == 1)){turnRight();}
if ((digitalRead(L_S) == 1)&&(digitalRead(M_S) == 1)&&(digitalRead(R_S) == 1)){Stop();}

}

void forword(){
```

```
digitalWrite(M_A1, LOW);
digitalWrite(M_A2, HIGH);
digitalWrite(M_B1, HIGH);
digitalWrite(M_B2, LOW);
}
void turnRight(){
digitalWrite(M_A1, LOW);
digitalWrite(M_A2, LOW);
digitalWrite(M_B1, HIGH);
digitalWrite(M_B2, LOW);
}

void turnLeft(){
digitalWrite(M_A1, LOW);
digitalWrite(M_A2, HIGH);
digitalWrite(M_B1, LOW);
digitalWrite(M_B2, LOW);
}
void Stop(){
digitalWrite(M_A1, LOW);
digitalWrite(M_A2, LOW);
digitalWrite(M_B1, LOW);
digitalWrite(M_B2, LOW);
}
```

Code (2) : control the AGV using wifi through Wi-Fi Robot Control App

```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
/* Set these to your desired credentials. */
const char *myrobotSsid = "My_Robot";
const char *password = "6363003neel";
const int leftforward       = D2;
const int leftbackrward     = D3;
const int rightforward      = D0;
const int rightbackrward = D1;
ESP8266WebServer server(80);
/* Just a little test message.    Go to http://192.168.4.1 in a web browser
  * connected to this access point to see it.
  */
void handleRoot()
  {
    server.send(200, "text/plain", "hello from Robot!");
}
void motor_forward()
{
       digitalWrite(rightforward      , HIGH);
       digitalWrite(leftbackrward     , LOW);
       digitalWrite(leftforward       , HIGH);
       digitalWrite(rightbackrward , LOW);
    }
void motor_stop()
```

```
{
      digitalWrite(rightforward     , LOW);
      digitalWrite(leftbackrward    , LOW);
      digitalWrite(leftforward      , LOW);
      digitalWrite(rightbackrward , LOW);
   }
void motor_back()
{
      digitalWrite(rightforward     , LOW);
      digitalWrite(leftbackrward    , HIGH);
      digitalWrite(leftforward      , LOW);
      digitalWrite(rightbackrward , HIGH);
   }
void motor_left()
{
      digitalWrite(rightforward     , HIGH);
      digitalWrite(leftbackrward    , HIGH);
      digitalWrite(leftforward      , LOW);
      digitalWrite(rightbackrward , LOW);
   }
void motor_right()
{
      digitalWrite(rightforward     , LOW);
      digitalWrite(leftbackrward    , LOW);
      digitalWrite(leftforward      , HIGH);
      digitalWrite(rightbackrward , HIGH);
   }
void setup()
```

```
{
  // prepare Motor Output Pins
  pinMode(rightforward , OUTPUT);
  digitalWrite(rightforward , LOW);
  // prepare GPIO5 relay 1
  pinMode(leftbackrward , OUTPUT);
  digitalWrite(leftbackrward , LOW);
  pinMode(leftforward, OUTPUT);
  digitalWrite(leftforward , LOW);
  pinMode(rightbackrward , OUTPUT);
  digitalWrite(rightbackrward , LOW);
   delay(100);
   Serial.begin(115200);
   Serial.println();
   Serial.print("Configuring access point:");
   Serial.print(myrobotSsid);
  /* You can remove the password parameter if you want the AP to be open. */
  WiFi.softAP(myrobotSsid, password);
  IPAddress myIP = WiFi.softAPIP();
  Serial.print("AP IP address: ");
  Serial.println(myIP);
  server.on("/", handleRoot);
  server.on("/inline", []() {
     server.send(200, "text/plain", "this works as well");
  });
  server.on("/fw", []() {
     motor_forward();
     server.send(200, "text/plain", "Forward");
```

```
  });
  server.on("/bk", []() {
    motor_back();
    server.send(200, "text/plain", "Back");
  });
  server.on("/st", []() {
    motor_stop();
    server.send(200, "text/plain", "Stop");
  });
  server.on("/lt", []() {
    motor_left();
    server.send(200, "text/plain", "Left");
  });
  server.on("/rt", []() {
    motor_right();
    server.send(200, "text/plain", "Right");
  });
  server.begin();
  Serial.println("HTTP server started");
}
void loop() {
  server.handleClient();
}
```