PROJECT REPORT
On
Controller of an AGV

The mini project report is submitted in partial fulfillment of the requirement of Fourth semester B.E in Mechanical Engineering

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CERTIFICATE

This is to certify that Anurima Chakraborty, Aditya Narnoli, Ishaan Tiwari, Rehan Sheikh, Rohitraj Nair has completed the mini project work on Controller of Automatic Guided Vehicle in partial fulfillment of the requirements of forth semester B.E in Mechanical Engineering as prescribed by S.R.C.O.E.M, Nagpur under Autonomous status.

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Mini Project Guide	Mini Project Guide	H.O.D
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Abstract

Any industrial production plant works on the principle of manufacturing aproduct piece by piece. The requirement of accurate and efficient material handling has been catered to, by the creation of Automated Guided Vehicles (AGVs). Our project is titled Design of Controller for an AGV. An **automated guided vehicle** or **automatic guided vehicle** (**AGV**) is a mobile robot that follows markers or wires in the floor, or uses vision, magnets, or lasers for navigation. They are most often used in industrial applications to move materials around a manufacturing facility or warehouse. They safely transport all kinds of products without human intervention within production, logistic, warehouse and distribution environments: the clear way to reduce costs and to increase efficiency and profitability. The AGV for which we have tried to design a controller would basically be a 4 wheel driven trolley that would use mecanum wheels to get the desired diagonal and lateral motions in addition to moving back and forth. To demonstrate this we have used a basic trolley with 4 normal wheels and motors that are programmed using an ARDUINO UNO board. The **Arduino Uno** is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The program commands for the desired motions are uploaded from a computer to the ARDUINO micro-controller which delivers the output to the motors via ICs. There are 2 ICs, mounted on the bread-board, that drive 2 motors each. The various combinations of these motors result in motions in the desired directions.

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LIST OF ABBREVIATIONS:

1) AGV – Automated Guided Vehicle

2) DOF - Degree of Freedom

3) IC - Integrated Circuit

4) DC – Direct Current

5) IDE – Integrated Development Environment

6) LED – Light Emitting Diode

7) mA – milliamperes

8) PWM – Pulse Width Modulation

1. <u>Introduction</u>

AUTOMATED GUIDED VEHICLE

An Automated Guided Vehicle (AGV) is an autonomous mobile robot. It is usually employed as a fixed-input service bot in industries, responsible for carrying out specific tasks. It follows markers or wires on the floor for navigational assistance. They are most often used in industrial applications to move materials around a manufacturing facility or a warehouse. One of the primary functions of Automatic Guided Vehicles (AGVs) or mobile robots is the automatic motion planning required for their autonomous navigation.

The environment in which the AGV or mobile robot navigates is uncertain and is constantly changing. The configuration and orientation of the obstacles vary along with the landscape or topography of the surroundings. The objective of autonomous mobile robot navigation is to build a mobile platform which is capable of successfully navigating in these environments without any human assistance. Automated guided vehicles increase efficiency and reduce costs by helping to automate a manufacturing facility or warehouse. The AGVs can tow objects behind them in trailers to which they can autonomously attach. The trailers can be used to move raw materials or finished product. The AGV can also store objects on a bed. The objects can be placed on a set of conveyors and then pushed off by reversing them.

The applications of AGVs are seemingly endless as capacities can range from just a few kilograms to hundreds of tons.

Our project aims at developing a controller for an AGV, to enable us to deliver commands to it continuously rather than producing a fixed path following robot.

2. Literature Review

2.1 Industrial Robots

An industrial robot is a general-purpose, programmable machine possessing certain anthropomorphic characteristics. Making decisions, capability to communicate with other machines, and capability to respond to sensory inputs are the important attributes of an industrial robot. These capabilities allow the robots to be more versatile in nature.

The various reasons for the commercial and technological importance of industrial robots include the following:

(i) Robots can be substituted for humans in hazardous or uncomfortable work environments.

(ii) Robots can be reprogrammed.

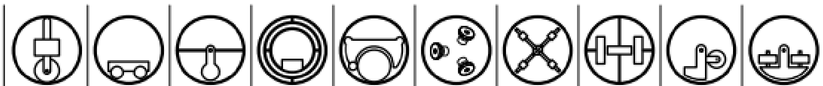
(iii) Robots are controlled by computers and can therefore be connected to other computer systems to achieve computer integrated manufacturing.

2.2 Locomotion of robots

Robot locomotion is the collective name for the various methods that robots use to transport themselves from place to place. Although wheeled robots are typically quite energy efficient and simple to control, other forms of locomotion may be more appropriate for a number of reasons e.g. traversing rough terrain, moving and interacting in human environments.

2.3Principle of Omni-directional mobility

The term Omni-directional is used to describe the ability of a system to move instantaneously in any direction from any configuration. Robotic vehicles are often designed for planar motion; they operate on a warehouse floor, road, lake, table etc. In such a two dimensional space, a body has three degrees of freedom. It is capable of translating in both directions and rotating about its center of gravity. Most conventional vehicles however do not have the capability to control every degree of freedom independently. Conventional wheels are not capable of moving in a direction parallel to their axis. This so called non-holonomic constraint of the wheel prevents vehicles using skid-steering, like a car, from moving perpendicular to its drive direction. When a vehicle has no non-holonomic constraints, it can travel in every direction under any orientation. This capability is widely known as omni directional mobility. Omni-directional robots, or holonomic robots, add the ability to move sideways.



Robot Configuration	Single wheel	Hamster car	Pendulum on rotating axis	Gimbal mechanism	Single ball	Omni wheels	Mass movement	Orthogonally mounted flywheels	Flywheel on pendulum	Parallelly mounted flywheels
Driving mechanism	D	D	D		D	D	G	A	D/A	A/G
Input needed/ Output DOFs	2/2	⩾ 2/2	2/2		2/2	3/3	4/2	2/2	3/2	2/2
Sharp turn	V	V	V*		V	V	V	V*	V	
Omnidirectional locomation			V*		V	V	V	V*		

Table 1.

2.4 Degrees of freedom (DOF)

Degree of freedom (DOF) is a term used to describe a robot's freedom of motion in three dimensional space—specifically, the ability to move forward and backward, up and down, and to the left and to the right. For each degree of freedom, a joint is required. A robot requires six degrees of freedom to be completely versatile. The number of degrees of freedom defines the robot's configuration. For example, many simple applications require movement along three axes: X, Y, and Z. See Figure ___. These tasks require three joints, or three degrees of freedom. The three degrees of freedom in the robot arm are the rotational traverse, the radial traverse, and the vertical traverse. For applications that require more freedom, additional degrees can be obtained like pitch, yaw, and roll.

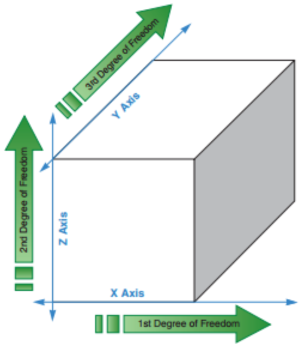


Figure 1.

2.5 Types of Omni-directional wheel systems

Omni-directional vehicles are divided into two categories that describe the type of wheel arrangement they use for mobility: conventional wheel designs and special wheel designs.

Conventional wheel designs

1. Caster wheels
2. Steering wheels

Special wheel designs

1. The Universal wheel,
2. The Mecanum (Swedish) wheel,
3. The Ball Wheel mechanism.

Universal wheel (simple)	+ low weight, compact design + simple mechanical design + commercially available	- discontinuous wheel contact or variable drive-radius - sensitive to floor irregularities
Mecanum wheel	+ compact design + high load capacity	- discontinuous wheel contact - high sensitivity to floor irregularities - complex wheel design
Powered steered wheel	+ continuous wheel contact + high load capacity + robust to floor conditions	- heavy and bulky design - high friction and scrubbing while steering - complex mechanical design
Castor wheel	+ continuous wheel contact + high load capacity + low scrubbing force during steering + robust to floor conditions	- voluminous design - transmit power and signal across rotational joints - complex mechanics

Table 2.

2.6 Mecanum wheels

One of the more common omni directional wheel designs is that of the Mecanum wheel, invented in 1973 by Bengt Ilon, an engineer with the Swedish company Mecanum AB (Ilon, 1975). The wheel itself consists of a hub carrying a number of free moving rollers angled at 45° about the hub's circumference (Fig.2). The angle between the rollers' axis and central wheel axis can have any value but in the case of a conventional Swedish wheel it is 45˚. The angled peripheral rollers translate a portion of the force in the rotational direction of the wheel to a force normal to the wheel direction. Depending on each individual wheel direction and speed, the resulting combination of all these forces produce a total force vector in any desired direction thus allowing the platform to move freely in the direction of the resulting force vector, without changing the direction of the wheels themselves.

A Swedish omni directional wheel has 3 DOFs composed of wheel rotation, roller rotation, and rotational slip about the vertical axis passing through the point of contact.

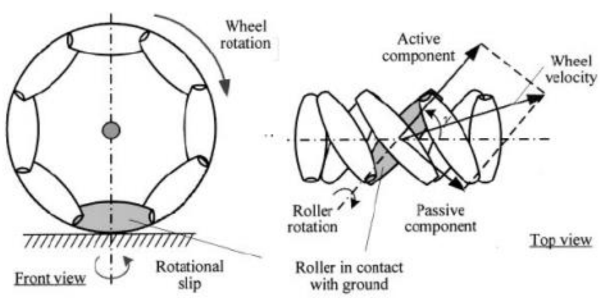


Figure 2.

2.7 Kinematics

When Mecanum wheels are actuated, the angled peripheral rollers translate a portion of the force in the rotational direction of the wheel to a force normal to the wheel direction.

If we consider a xOy frame attached to the robot chassis (see Fig. 17), we can write the body speed equations as follow:

$$\begin{matrix}\upsilon x\\ \upsilon y\\ \omega z\end{matrix} = \frac{R}{4} \times \begin{matrix} 1 & 1 & 1\\ 1 & -1 & 1\\ \frac{-1}{l1+l2} & \frac{1}{l1+l2} & \frac{-1}{l1+l2}\end{matrix} \times \begin{matrix}\omega 1\\ \omega 2\\ \omega 3\end{matrix}$$

Where: R is the wheel radius; ω_i is the angular velocity of the wheel (i = 1..4); l_1 , l_2 are the distances between wheel axis and body center.

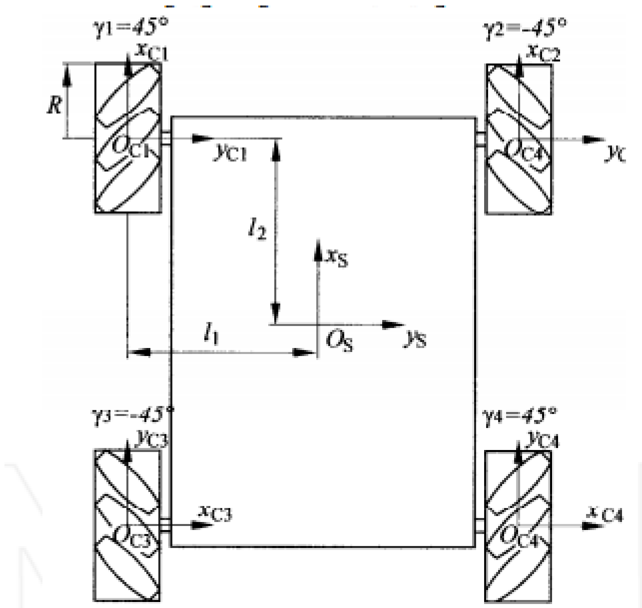


Figure 3.

2.8 Electronics

As we have mentioned before, the robot can be remote controlled, using a command system or it can follow a line or to be autonomous, using an ultrasonic sensor for obstacle avoidance. In order to receive commands from the system and to drive the motors, an electronics board based on a L293D microcontroller is placed on the robot and used.

3.<u>Robot Construction</u>

3.1 Materials

The materials used in the fabrication of the AGV model and the controller have been listed below:

1. Robot body:
    a. Metal chassis.
    b. DC motors (200 RPM).
    c. Fasteners (nuts, bolts, washers).
    d. Wheels (Simple wheels Diameter: 6.5cm).
2. Robot Controller unit
    a. Arduino Uno microcontroller board.
    b. BB400 Solder less Plug-in Breadboard.
    c. **L293D** dual H-bridge motor driven Integrated Circuit(IC).
    d. Battery case and battery.
    e. Connecting wires.

3.2 Costing

The individual costs of materials and the total expense incurred during the fabrication of the project has been tabulated below:

Sr. No.	COMPONENT	COST (in Rs.)	QUANTITY
1	Metal Chassis	150	1
2	DC motors (200 RPM)	200	4
3	Wheels (Dia 6.5cm)	50	4

4	Arduino Uno microcontroller & Bread-board	3500	1
5	**L293D** dual H-bridge motor driver Integrated Circuit(IC)	80	2
6	Battery case and batteries	80	1
7	Connecting Wires	299	1 Bundle
	TOTAL(in Rs.)	5189	

Table 3.

3.4 Assembly of robot

The robot is assembled by attaching the different mechanical components onto the metal chassis. Originally the wheels to be attached should be Mecanum wheels, but for demonstration purposes, classical wheels can also be employed.

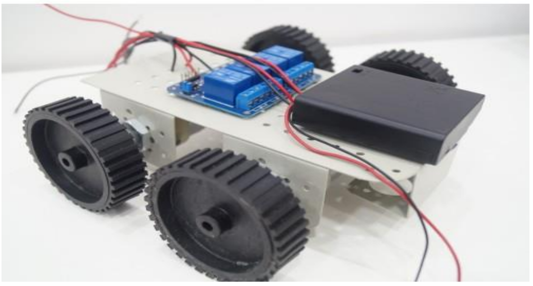


Figure 4.

As can be seen from figure the DC motors have been fastened to the metal chassis in a parallel fashion. The battery kit is mounted atop the chassis and fixed to its place by use of adhesives. The microcontroller board is also set up and the required connections are made. A detailed discussion on the electrical and electronic circuitry of the robot controller has been provided in the next chapter.

4. Robot controller

The aim of this project was to provide the platform with motion control that could be programmed to accommodate various robotic behaviors specified. This purpose has been done by formulating programs for the different motions of the robot on Arduino platform. Arduino is an open-source computer hardware and software company that designs and manufactures kits for building digital devices.

4.1 Arduino programming

The microcontroller chosen for electronic system of the robot is the Arduino UNO microcontroller board. The Arduino board has been selected because of the following advantages:

- Debugging:-The Arduino Environment provides easiest debugging environment.
- Simple functions like delay or interrupt are included separately in the syntax of Arduino.
- Design of the board is of very high quality.
- Peripherals and Modular Design: Arduino Ecosystem has good modular design, one can simply add the already designed shields to the board without any wire.
- Libraries: A lot of libraries and IC's have already been built for the same which is crucial a lot of times.
- Arduino IDE allows software development on all major platforms (Mac, PC, Linux) with an easy-to-use subset of C/C++.

Since the Arduino microcontroller board is highly compatible with running codes formulated in Arduino programming software, we have made use of the Arduino software to write the commands for the robot. The IC selected for robot control is IC L293D.

Figure 5.

Core functions of arduino 1.0 and later:

Simple programs that demonstrate basic Arduino commands are listed below. These are included with the Arduino environment.

1. Basics

- BareMinimum: The bare minimum of code needed to start an Arduino sketch.
- Blink: Turns an LED on and off.
- DigitalReadSerial: Reads a switch, prints the state out to the Arduino Serial Monitor.
- AnalogReadSerial: Reads a potentiometer, prints its state out to the Arduino Serial Monitor.
- Fade: Demonstrates the use of analog output to fade an LED.
- ReadAnalogVoltage : Reads an analog input and prints the voltage to the serial monitor

2. Digital

- Blink Without Delay: Blinking an LED without using the delay function.
- Button: Uses a pushbutton to control an LED.
- Debounce: Reads a pushbutton, filtering noise.
- Button State Change: Counting the number of button pushes.
- Input Pullup Serial: Demonstrates the use of INPUT_PULLUP with pinMode().
- Tone: Plays a melody with a Piezo speaker.
- Pitch follower: Plays a pitch on a piezo speaker depending on an analog input.
- Simple Keyboard: A three-key musical keyboard using force sensors and a piezo speaker.
- Tone4: Plays tones on multiple speakers sequentially using the tone() command.

3. Analog

- AnalogInOutSerial: Reads an analog input pin, maps the result, and then uses that data to dim or brighten an LED.
- Analog Input: Uses a potentiometer to control the blinking of an LED.
- AnalogWriteMega: Fades 12 LEDs on and off, one by one, using an Arduino Mega board.
- Calibration: Defines a maximum and minimum for expected analog sensor values.
- Fading: Uses an analog output (PWM pin) to fade an LED.

The following is a code for the FRONT command:-

```
const int motor11 = 13;

const int motor12 =  12;

const int motor21 =  11;

const int motor22 =  10;

const int motor31 =  9;

const int motor32 =  8;

const int motor41 =  7;

const int motor42 =  6;

void setup() {

 pinMode(motor11, OUTPUT);

  pinMode(motor12, OUTPUT);

  pinMode(motor21, OUTPUT);

  pinMode(motor22, OUTPUT);

  pinMode(motor31, OUTPUT);

  pinMode(motor32, OUTPUT);

  pinMode(motor41, OUTPUT);

  pinMode(motor42, OUTPUT);
```

```
}

void loop() {


  digitalWrite( motor11, LOW);

  digitalWrite( motor12, HIGH);

 digitalWrite( motor22, HIGH);

 digitalWrite( motor21, LOW);

 digitalWrite( motor41, HIGH);

 digitalWrite( motor42, LOW);

 digitalWrite( motor31, LOW);

 digitalWrite( motor32, HIGH)

}
```

Similarly the other 7 motion commands have been coded.

4.2 Integrated Circuit for the Robot

We cannot connect a motor to a microcontroller directly because microcontrollers cannot give sufficient current to drive the DC motors. A motor driver is a current enhancing device which can also be act as switching device. Thus we insert motor driver in between motor and microcontroller. Motor driver takes the input signals from microcontroller and generates corresponding output for motor.

4.3 Motor Driver IC L293D

This is a motor driver IC that can drive two motors simultaneously. L293D IC is a dual H-bridge motor driver IC. One H-bridge is capable of driving a DC motor in bidirectional sense. L293D IC is also a current enhancing IC, as the output from the sensor is not able to drive motors itself so L293D is used for this purpose. It is a 16 pin IC having two enable pins which should always remain high to enable both the H-bridges. L293D can run a motor up to 600 mA and also has a protection diode.

The following is the pin diagram of IC L239D:

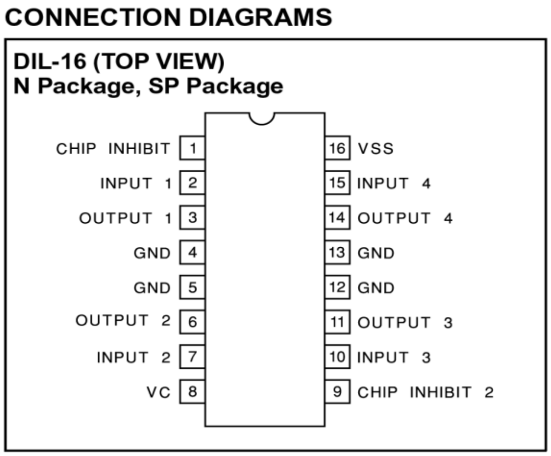


Figure 6.

Connecting L239D to the motors

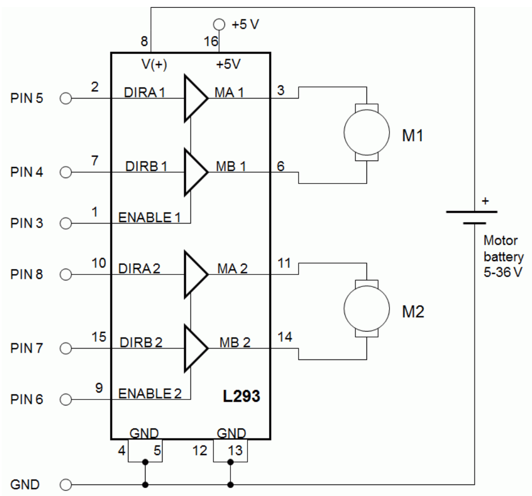


Figure 7.

Supply voltage (V_{ss}) is the Voltage at which we wish to drive the motor. Generally we prefer 6V for DC motors and 6-12V for gear motors, depending upon the rating of the motor. Logical Supply Voltage will decide what value of input voltage should be considered as high or low .So if we set Logical Supply Voltage equal to +5V, then -0.3Vto 1.5V will be considered as Input Low Voltage and 2.3 V to 5V will be considered as Input High Voltage.

L293D has 2 Channels

- Channel 1 - Pin 1to 8
- Channel 2 - Pin 9 to 16

Enable Pin is used to enable or to make a channel active. Enable pin is also called as Chip Inhibit Pin.

All Input (Pin No. 2,7,10 and 15) of L2939D IC is the output from microcontroller (ATmega8).

All Output (Pin No. 3, 6,11and 14) of L293D IC goes to the input of Right and Left motor.

If Enable pin low, the output will be at 0 always.

Output Connections:

- OUTPUT 1 (Pin No 3) --- Negative Terminal of Right Motor
- OUTPUT 2 (Pin No 6) --- Positive Terminal of Right Motor
- OUTPUT 3 (Pin No 10) --- Positive Terminal of Left Motor
- OUTPUT 4 (Pin No 14) --- Negative Terminal of Left Motor

Input 1	***Input 2***	***Input 3***	***Input 4***	***Output 1***	***Output 2***	***Output 3***	***Output 4***	***Motors Output***		***Movement***
								Right	***Left***	
Low	High	High	Low	0	Vss	Vss	0	Straight	Straight	Straight
Low	High	Low	Low	0	Vss	0	0	Straight	No move	Left Turn
Low	Low	High	Low	0	0	Vss	0	Nomove	Straight	Right Turn
Low	High	Low	High	0	Vss	0	Vss	Straight	Reverse	Sharp Left
High	Low	High	Low	Vss	0	Vss	0	Reverse	Straight	Sharp Right
High	Low	Low	High	Vss	0	0	Vss	Reverse	Reverse	Backward

Table 4.

4.4 Circuitry for programming:

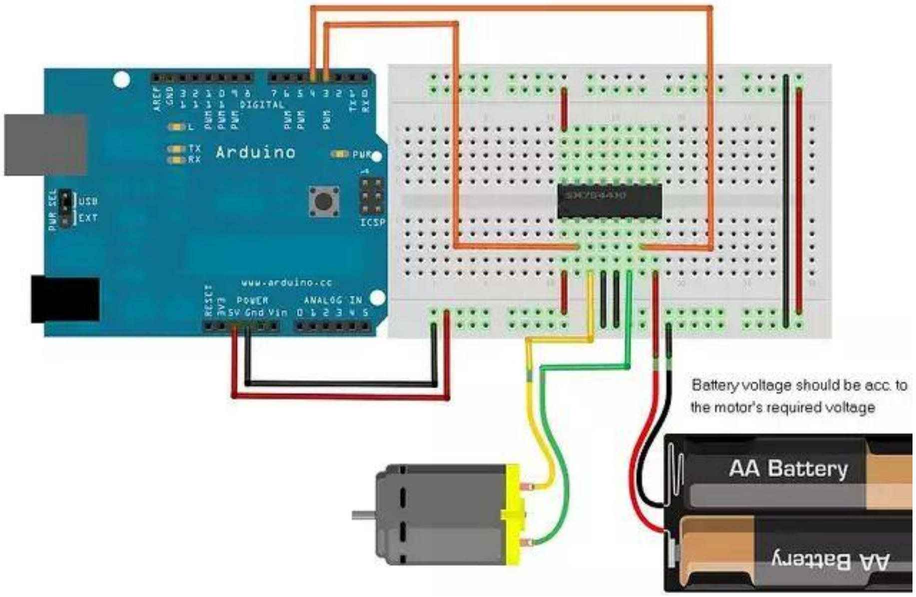


Figure 8.

The shown IC, L293D, has 8 pins on either side. The pins 4 & 5 are connected to the ground. The pins 2 & 7 are used for providing the input from the Arduino chip, and pins 3 & 6 provide the output to the motor. Likewise the circuit works on the other side of the IC. One IC is used to drive 2 motors, therefore the AGV uses 2 ICs.

5. APPLICATIONS OF AGV

- *Automated guided vehicles for receiving & distribution*

  Automated guided vehicles reliably transport raw materials in receiving areas to production lines and finished goods from order picking workstations to consolidation and shipping.

- *Efficient automatic truck loading solutions*

  Truck loading AGVs automatically load and unload common over-the-road trailers with pallets or other unit loads.

- *Automated guided vehicles for production applications*

  Automated guided vehicles and AGV systems for production and work-in-process movement are one of the repetitive transport of materials in between production and processing lines and supply of materials from storage to production areas.

- *Automated guided vehicles for warehouse storage applications*

  Automated guided vehicles handle all kinds of storage applications in warehouses and distribution centers. The use of AGVs in warehouses directly reduce labour costs and increase the efficiency and reliability of your storage process.

- *And-of-line automation with automatic guided vehicles (AGV)*

  Automatic guided vehicles constitute the perfect link in an end-of-line automation chain. Our AGVs exchange handshake signals with end-of-line equipment like robot palletisers and stretch wrappers to pick finished pallets from conveyors.

- *Automatic roll handling for paper, print, plastics and steel*

  Roll handling automatic guided vehicles take care of the reliable transport and storage of rolls in paper mills, printing, paper conversion, packaging and steel and plastics production. Thanks to the use of intelligent transport scheduling software they make sure your rolls get in time where they need to be. The accurate positioning and navigation system of the automated guided vehicle systems rule out any damage to the rolls during transport.

6. CONCLUSION

Omni directional vehicles have great advantages over conventional (non-holonomic) platforms, for moving in tight areas. These robots are capable of easily performing tasks in environments with static and dynamic obstacles and narrow aisles. Flexible material handling and movement, with real-time control, can be made more efficient with these.

The working model of the controller for the proposed AGV has been successfully fabricated. With this controller, the desired octa-directional motion of the AGV can be achieved, provided the wheels in our model are replaced by mecanum wheels.

The following motions can be obtained from the mecanum wheels :-

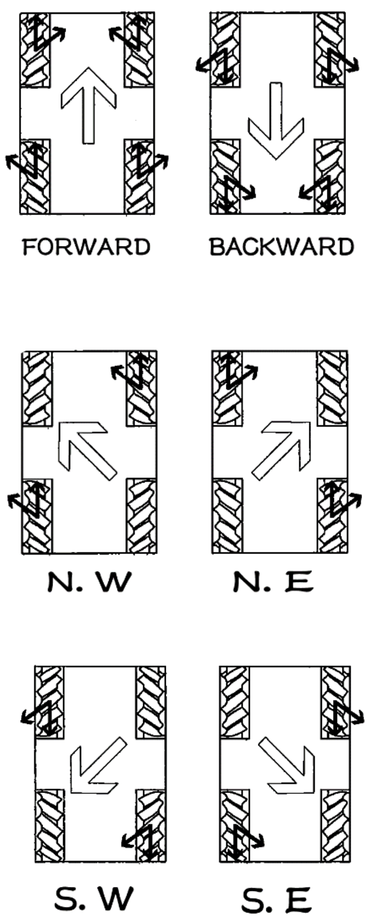


Figure 9.

7. <u>FUTURE SCOPE</u>

AGV's are generally very scalable and flexible for the future changes

- In our project, if the normal wheels are replaced by mecanum wheels, then the vehicle can be navigated in all the eight directions
- If, the concept of the AGV is introduced in passenger vehicles, it can solve parking problems.
- The diagonal & lateral motions of the AGV, if implemented on a larger scale, can be used to transport materials in factories and workshops with ease.
- AGV's can replace conventional conveying systems in factories.
- The controller for the proposed AGV can be made wireless, with a larger range.
- Automatic truck unloading devices.
- Military applications.

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