DESIGN AND DEVELOPMENT OF AN AGV USING RF MODULE

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
In
Mechanical Engineering

By

PRADEEP KUMAR PATI

Department of Mechanical Engineering
National Institute of Technology
Rourkela
2007

DESIGN AND DEVELOPMENT OF AN AGV USING RF MODULE

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
In
Mechanical Engineering

By

PRADEEP KUMAR PATI

Under the Guidance of

Prof. C. K. Biswas

Department of Mechanical Engineering
National Institute of Technology
Rourkela

2007

National Institute of Technology
Rourkela

CERTIFICATE

This is to certify that the thesis entitled, “Design and Development of an AGV using RF Module” submitted by Sri Pradeep Kumar Pati in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date

Prof. C.K. Biswas
Dept. of Mechanical Engineering
National Institute of Technology
Rourkela - 769008

National Institute of Technology
Rourkela

ACKNOWLEDGEMENT

I would like to articulate my deep gratitude to my project guide Dr. C.K. Biswas who has always been my motivation for carrying out the project.

I also extend my thanks to my seniors Mr. Ramana Reddy N. and Mr. Ware Shivkumar who furthered this project to this extent and documented the whole process.

It is my pleasure to refer Microsoft word 2003 of which the compilation of this report would have been impossible.

An assemblage of this nature could never have been attempted without reference to and inspiration from the works of others whose details are mentioned in reference section. I acknowledge my indebtedness to all of them.

Last but not the least to all of my friends who were patiently extended all sorts of help for accomplishing this undertaking.

Date

Pradeep Kumar Pati
Dept. of Mechanical Engineering
National Institute of Technology
Rourkela - 769008

CONTENTS

National Institute of Technology

Rourkela

ABSTRACT

Automated guided vehicles play an important role in the flexible manufacturing system. The project mainly deals with the design and development of an AGV and controlling it with computer through RF signals.

This includes several steps→

- Design of microcontroller on robot. Here ATMEGA 16 (AVR series of microcontroller) is used as it is enabled with all sorts of required features.
- Design of driving systems. Stepper motors are used.
- Design of communication systems. RF modules are to be used to communicate data between computer and AGV.

Driving system→

Stepper motors are used to drive the AGV. They are controlled by ATMEGA 16 microcontroller and a driver chip to amplify the current to the motor.

Communication→

The details of position and feedback should be sent to the central computer and instructions received to proceed to do further tasks. The communication has to be wireless to make things easier. Available RF modules are to be used which are serial in nature .But before that, the parallel data has to be converted into the serial data.

LIST OF FIGURES

Chapter 1

INTRODUCTION

History

Benefits

Cost

INTRODUCTION

An automatic guided vehicle (AGV), also known as a self guided vehicle, is an unmanned, computer-controlled mobile transport unit that is powered by a battery or an electric motor. AGVs are programmed to drive to specific points and perform designated functions. They are becoming increasingly popular worldwide in applications that call for repetitive actions over a distance. Common procedures include load transferring, pallet loading/unloading and tugging/towing. Different models, which include forked, tug/tow, small chassis and large chassis/unit load, have various load capacities and design characteristics. They come in varying sizes and shapes, according to their specific uses and load requirements. AGVs have onboard microprocessors and usually a supervisory control system that helps with various tasks, such as tracking and tracing modules and generating and/or distributing transport orders. They are able to navigate a guide path network that is flexible and easy to program. Various navigation methods used on AGVs include laser, camera, optical, inertial and wire guided systems. AGVs are programmed for many different and useful maneuvers, such as spinning and side-traveling, which allow for more effective production. Some are designed for the use of an operator, but most are capable of operating independently. Currently, AGVs are fairly pricey, and this discourages some companies, but in truth, the money is quickly earned back through reduction of other costs. Manufacturers of AGVs are working on reducing costs and making the units easier to understand to attract more potential buyers. Research on these vehicles is on-going, and new developments on software and movement techniques are frequently being made.

Types of AGV→

Automated guided vehicle systems consist of the computer, software and technology that are the "brains" behind the AGV. Without computer software systems and communications networks, only the simplest AGV functions can be performed.

- **Camera guided AGVs** are used when precise guidance accuracy is needed, such as in crowded environments and smaller sized facilities. An on-board camera focuses and guides the AGV while performing.
- **Forked AGVs** are used to pick up and deliver various loads, such as pallets, carts, rolls and others. These can be manually driven as well as used automatically, and have the ability to lift loads to many levels.
- **Inertial guided AGVs** use a magnet sensing device, a gyroscope that measures the unit's heading and a wheel odometer that calculates the distance traveled. Magnets mounted beneath the floor are detected by the on-board magnetic sensing device and combine with the first two readings to give an accurate positional location.
- **Large chassis/ unit load AGVs** are used to transport heavier loads with various transfer devices such as roller beds, lift/lower mechanisms and custom mechanisms.
- **Laser guided AGVs** use mounted laser scanners that emit a laser and reflect back from targets. The vehicle's location can be determined based on distance to the target and time of reflection information.
- **Optical guided AGVs** use a latex-based photosensitive tape on a facility's floor for guidance. Distance is measured by use of wheel odometers, which establish stop locations for the AGV along the course.
- **Outrigger AGVs** have two horizontal stabilizing legs (outriggers) to provide lateral support, and are used to handle pallets, rolls and racks.
- **Small chassis AGVs** are able to maneuver through crowded workplaces through laser sensing, while transporting smaller loads.
- **Smart vehicle AGVs** are capable of determining their own traffic control and routing without necessitating a central controller.

- **Tug/tow AGVs** are used to pull trailers and are usually manned by an operator who adds and removes the trailers at designated stops. These can follow a basic loop or a more complicated path.
- **Wire guided AGVs** use a charged wire that is buried beneath the floor for proper guidance and has small antennae composed of metal coils mounted on their bottoms. The stronger the field between the buried wire and antennae, the higher the voltage induced to the coils.

History of AGVs→

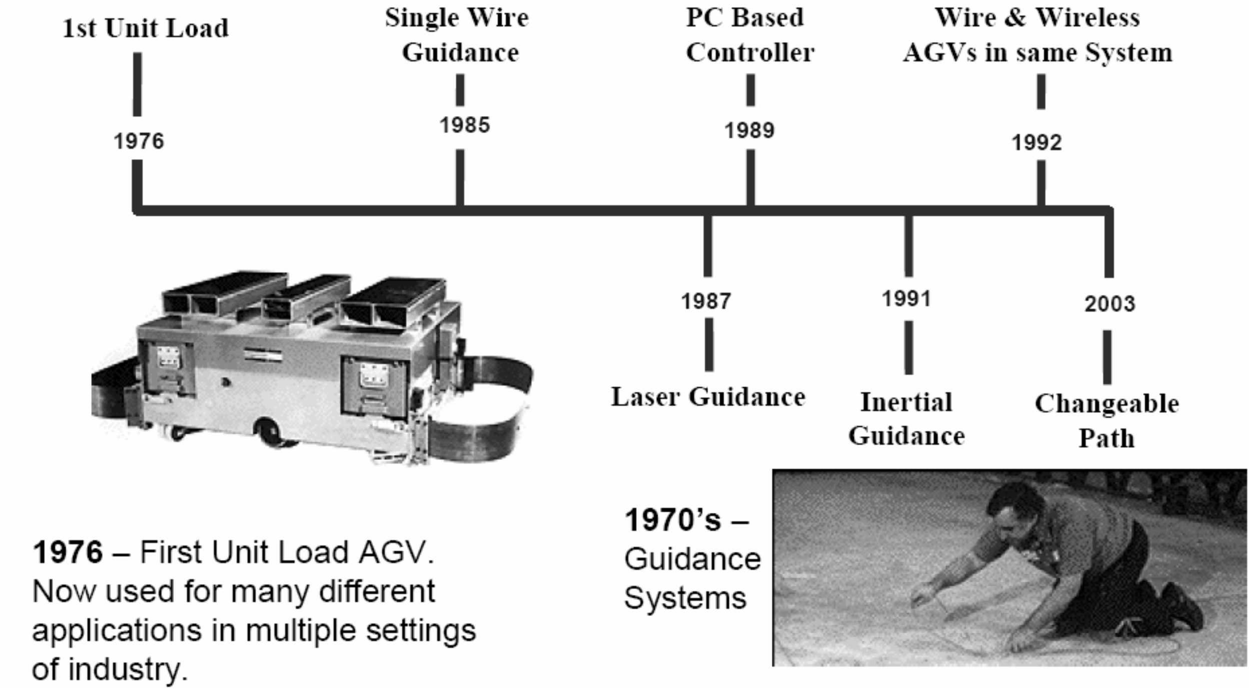

1st Unit Load
1976
Single Wire Guidance
1985
PC Based Controller
1989
Wire & Wireless AGVs in same System
1992
1987
Laser Guidance
1991
Inertial Guidance
2003
Changeable Path
1976 – First Unit Load AGV. Now used for many different applications in multiple settings of industry.
1970's – Guidance Systems

Figure 1.1
History of AGV

Benefits of AGVs→

Corporations that use AGVs, often factories, warehouses, hospitals and other large facilities, benefit from the many advantages AGVs have to offer. One of the most beneficial is reduced labor costs. AGVs do not tire like human workers, and when their batteries are drained, charging the AGVs easily replenishes their energy. Loads that AGVs carry are far heavier than any single human could manage, which makes transporting heavy objects quick and simple. AGVs help give companies a competitive edge because they increase productivity and complete the job in an effective and time-efficient manner. They are flexible and can be adapted to many different needs. Also, using AGVs reduces damage to products and increases safety among workers. Some typical advantages of any AGVs can be pin pointed to:

- Reduced labor and associated costs.
- Increased dependability and productivity.
- Fewer products handling damage.

Cost→

- Typically an AGV will cost about Rs.25lakh.

Maintenance costs are typically 3-5% of the overall system price.

Chapter 2

DESIGN

Objectives

ATMEGA16 Microcontroller

Navigation

Drive/Steering

Power Supply

DESIGN

Objectives→

The main design objectives of this work are:

- ❖ To control the mobile robot wirelessly with a computer
  - ➢ Initially the robot is controlled with wire using parallel port and it is planned to replace wire with Bluetooth device.
- ❖ To establish a system that allows many devices communicate simultaneously
  - ➢ Since the number of AGVs is not limited to one, it is necessary to have a system which allows more than one devices interact simultaneously with the server and the same is provided by Bluetooth.
- ❖ To have a sensor arrangement that can identify each machine uniquely.
  - ➢ Initially it is planned to place different number of sensors in each machine so that it can be identified easily.
- ❖ To trace the right paint strip when there is a branch.
  - ➢ When there is a branch, each strip is extended as shown in the figure so that it is easy for sensor to identify the right one.

ATMEGA16 Microcontroller→

The inseparable part of the designed AGV are the ATMEGA 16. The microcontroller is the heart of the AGV. It manipulates all the system and environment variables to take decision and hence drives the vehicle accordingly.

Some of its notable features are→

- Consumes very less power
- Has an instruction set of 131 and most of them execute in a single clock cycle.
- Has a 16KB of programmable flash with In-System Programmability.
- Has an 8channel, 10 bit ADC, helpful for getting digital feedbacks.

ATMEGA16 Microcontroller Features:

• High-performance, Low-power AVR® 8-bit Microcontroller

• Advanced RISC Architecture

– 131 Powerful Instructions – Most Single-clock Cycle Execution

– 32 x 8 General Purpose Working Registers

– Fully Static Operation

– Up to 16 MIPS Throughput at 16 MHz

– On-chip 2-cycle Multiplier

• Nonvolatile Program and Data Memories

– 16K Bytes of In-System Self-Programmable Flash

Endurance: 10,000 Write/Erase Cycles

– Optional Boot Code Section with Independent Lock Bits

In-System Programming by On-chip Boot Program

True Read-While-Write Operation

– 512 Bytes EEPROM

Endurance: 100,000 Write/Erase Cycles

– 1K Byte Internal SRAM

– Programming Lock for Software Security

• JTAG (IEEE std. 1149.1 Compliant) Interface

– Boundary-scan Capabilities According to the JTAG Standard

– Extensive On-chip Debug Support

– Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface

• Peripheral Features

– Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes

– One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode

– Real Time Counter with Separate Oscillator

– Four PWM Channels

– 8-channel, 10-bit ADC

– Byte-oriented Two-wire Serial Interface

– Programmable Serial USART

– On-chip Analog Comparator

• I/O and Packages

– 32 Programmable I/O Lines

– 40-pin PDIP

• Speed Grades

– 0 - 16 MHz for ATmega16

• Power Consumption @ 1 MHz, 3V, and 25°C for ATmega16L

– Active: 1.1 mA

– Idle Mode: 0.35 mA

– Power-down Mode: < 1 µA

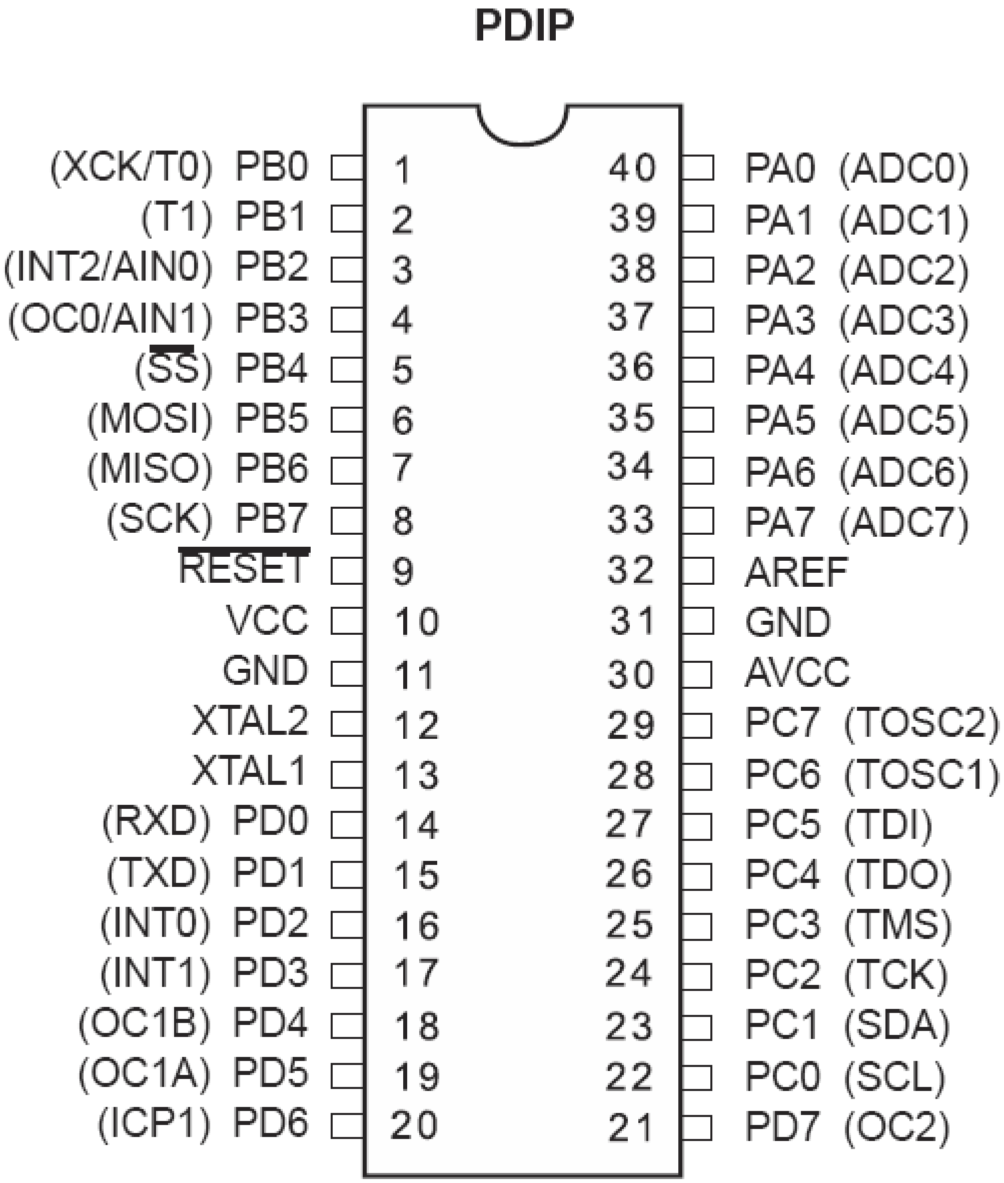


Figure 2.1
Pin configuration of ATMEGA16

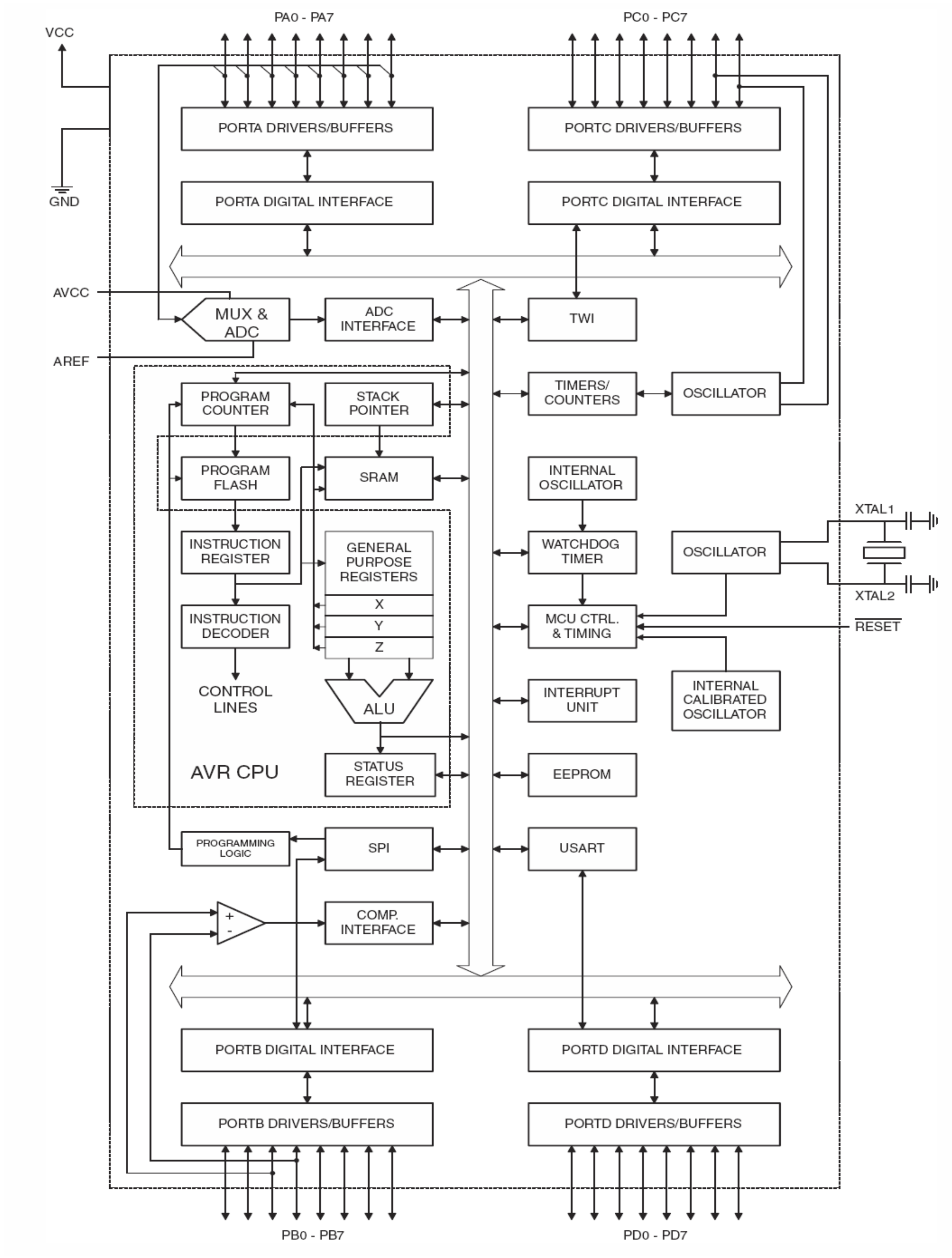


Figure 2.2
Block diagram of ATMEGA16

In-system programmer for ATMEGA16:

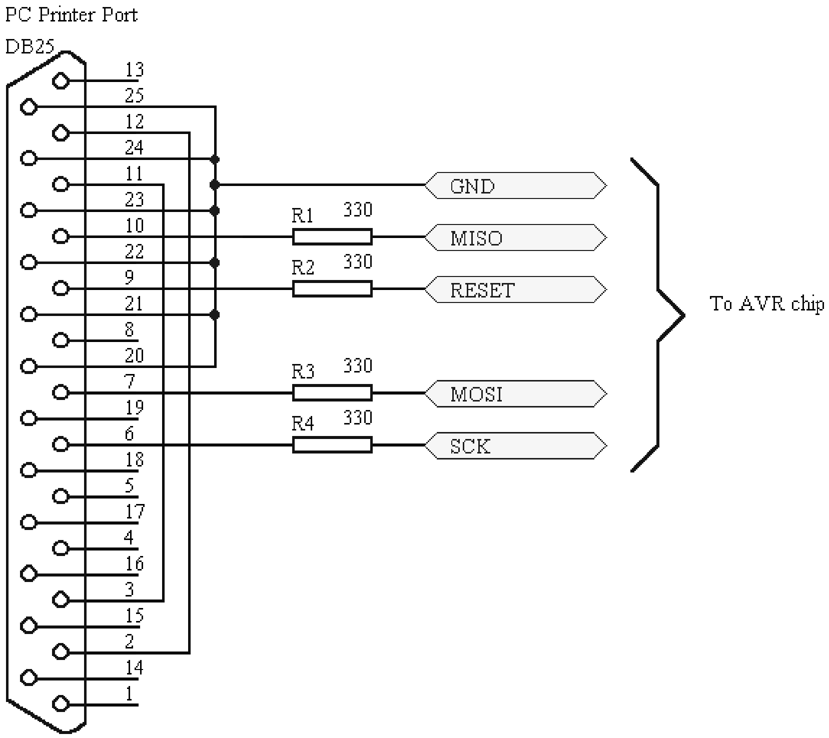


Figure 2.3

In-system-programmer circuit for ATMEGA16

The in-system programmer for ATMEGA16 is connected to parallel port on PC side. The programmer is compatible with a wide range of AVR devices.

Navigation→

Navigation of an AGV is basically concerned with the mechanism of locating the target of it. Various existing methods for navigation are:

- IR sensors – Tracks contrasting color
- Wire – Embedded in floor
- Laser – Triangulation from reflective targets

IR sensor arrangement:

In order for the robot to determine its position over the paint strip and identify any particular machine, some kind of proximity sensing device is needed. After some consideration, an infrared system was chosen for its simplicity. Other types of sensors (specifically ultrasonic) do give higher degrees of accuracy when measuring distance; however, infrared remains a simple and sufficient solution at a lower price tag. Additionally, the infrared sensing devices are available locally. Simple IR LEDs and IR receivers are used. Here it is planned to use 4 sets of IR sensors. They are mounted to the bottom of the vehicle in a single line perpendicular to the paint strip. Usually, two sensors lie to one side of the strip and two to another side. If the vehicle deviates from its path, any of the sensors detect the paint strip and the microcontroller controls the motion accordingly.

Drive / Steering→

Stepper Motors and Stepper Driver Circuit:

In this project, 2 stepper motors each with a coil resistance of 5ohm and 1.2A current rating is used.

When deciding how to move the robot, we realized that precision movement would be necessary in order to avoid touching the undesirable components and machines. In order to achieve the required precision in movement, it was decided that the robot would utilize stepper motors. The main benefit of stepper motors is that they are able to turn a specific number of degrees for every step. A four phase stepper motor has four coils that, when energized in a specific sequence, rotate a driving magnetic field which, consequently, rotates a set of permanent magnets. These permanent magnets are attached to a rotor which drives an output shaft. Thus, by pulsing the coils in a certain sequence, a clockwise or counterclockwise movement can be attained.

The following table shows a typical stepping sequence for a four phase stepper motor:

Step Sequence

	1	2	3	4
Coil A	on	off	off	off
Coil A'	off	on	off	off
Coil B	off	off	on	off
Coil B'	off	off	off	on

Table2.1
Step Sequence in Stepper Motor

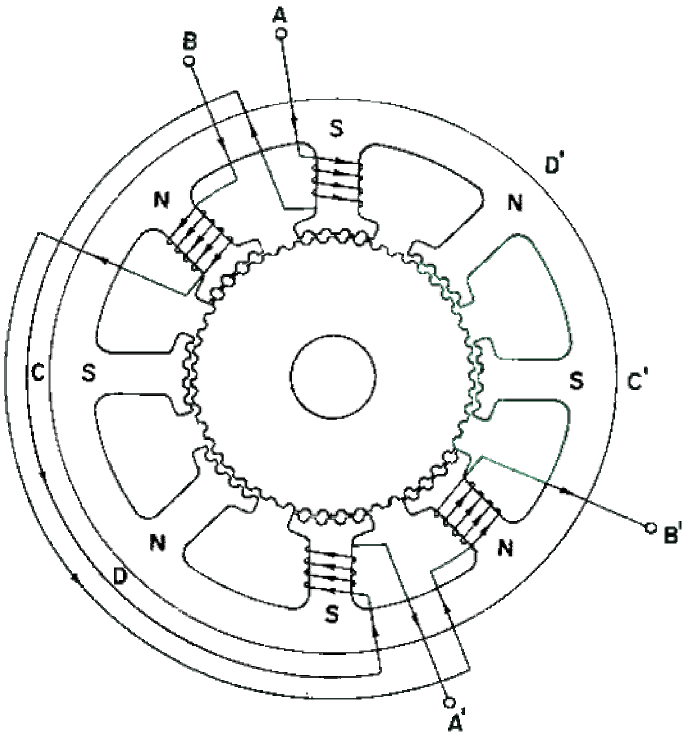


Figure 2.4
Internal Diagram of A Typical Four Phase Stepper Motor

The circuit shown in Figure is used to drive the motor coils. Because there are a total of eight motor coils in the robot, eight of these circuits are needed. The circuit functions by receiving a digital input from the microcontroller. This signal is fed to an opto-isolator in order to separate the low-voltage, low-current microcontroller from potentially dangerous signals in the motor driver circuit. In other words, the opto-isolator allows the 89C51 to control the motors without any physical connection to the driver circuit. The output side of the opto-isolator then drives the base of the TIP122 driver transistor.

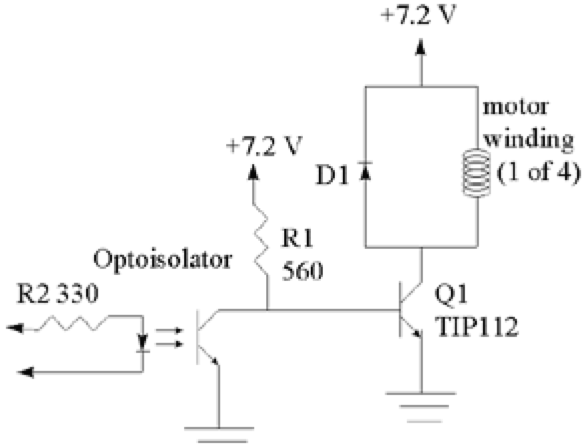


Figure 2.5
Stepper Motor Driver Circuit

Steering

Differential driving mechanism is used for steering.

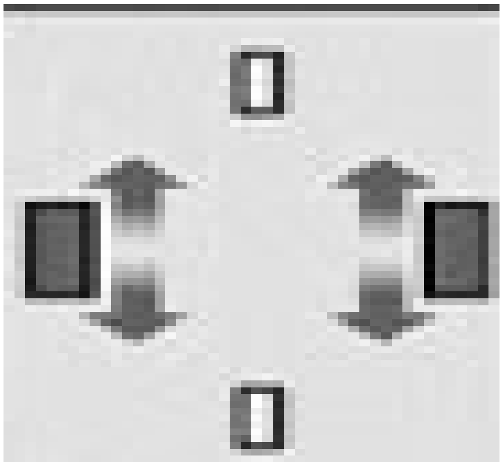


Figure 2.6
Differential driving mechanism

Power Supply→

- Almost all AGVs use batteries. Most of them are one among the below
- Flooded lead acid (~80% of the industry)
- Valve-regulated lead acid
- Nickel Cadmium
- Batteries need recharging
- Manual swap
- Automatic swap
- Onboard opportunity charge
- Off-board opportunity charge

Here, 12V, 7Ah Lead Acid battery is used and power supply is made external to the vehicle.

The block diagram of the AGV is as follows.

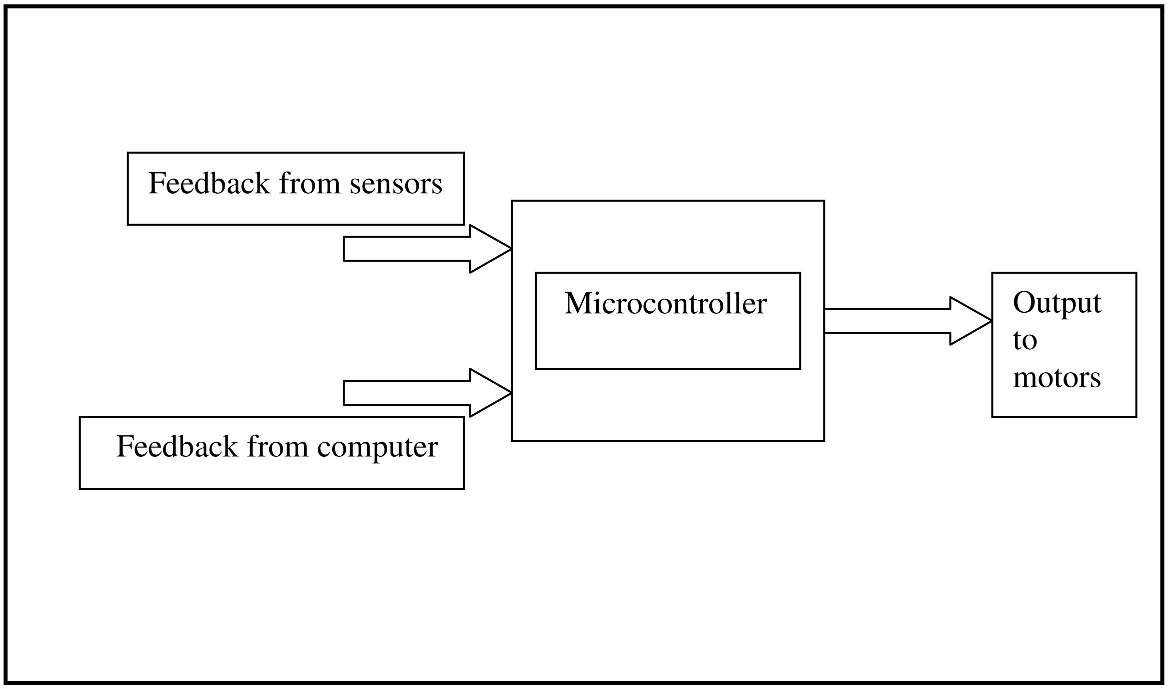


Figure 2.7
Block Diagram of AGV

Chapter 3

COMMUNICATION SYSTEMS

Communication Systems

In the current setup of AGV, the communication between the computer and the AGV is done by a parallel ink, i.e. the data emerges from the parallel port of the computer and goes into the microcontroller through 8 of the 32 I/O pins.

Advantages→

There are a few advantages in such system of communication. Such as

- It is cheap.
- Very easy to implement. No complexity involved.
- Ease f programming.

Disadvantages→

The main disadvantages are

- As it is a wired system, it is not a standalone machine.
- It looses maneuverability due to the wire.
- The wire may strangle with the machines in the shop floor too.

To overcome these hurdles, the communication has to be wireless. Various methods of wireless communication are

- Infrared
- Wi-Fi
- Bluetooth
- Radio Frequency

Infrared→

In this method of communication, Infrared (IR) rays are used as the carrier of data. An IR transmitter beams the data to an IR receiver and the data gets communicated.

Advantages→

The advantages are

- It is cheap.
- Easily implement able.
- Quite easy to find out the faults.
- Easy to operate.

Disadvantages→

The disadvantages are

- The transmitter and receiver have to be in line-of-sight in order to facilitate communication.
- Very short range.
- Probable data loss.

As the AGV is not always in the line of sight with the controlling computer in a shop floor, we detest ourselves from using this kind of wireless communication.

Wi-Fi→

This stands for Wireless Fidelity. Its aim is not to transfer data between 2 nodes, rather establish a network between them. Wi-Fi is the standard defined by IEEE 802.11 and is widely used for establishment of computer networks.

Advantages→

The advantages are

- Highly reliable
- Good compatibility, interoperability between vendors.
- High speed of data transfer

Disadvantages→

The drawbacks are

- Costly
- Requires high processing power
- Difficult to implement
- Operation requires high technical skills.

Bluetooth→

Bluetooth is a particular form of radio transmission system that operates at 2.4GHz and has a set of rules defined by the IEEE. These set of rules include both connectivity and security ones.

Advantages→

The advantages are

- Quite cheap
- Easily available

Disadvantages→

The drawbacks include

- Difficult to implement
- Unduly high security
- Requires high technical skills for operation
- Very short range-10 meters

The short range of Bluetooth restricts it from being the ideal choice for communication.

RF Communication→

RF stands for Radio Frequency. It is defined as the frequency between 12 KHz to 30 MHz. This is the basis of all other communications. Some of its main advantages follow.

Advantages→

- Easily available.
- Easily implement able.
- Low power consumption.
- High range with less power.
- Reliability.

Disadvantages→

1. Works with serial data only.

So RF is found out to be the ideal method for communication.

RF for Industrial use→

The most widely used industrial RF frequency is 433MHz as it is easy to produce and cheap along with a range of about 1kM. This comes under Ultra High Frequency range. And this frequency doesn't interfere with other wireless products like Mobile phones, walkie-talkies etc.

By this frequency both analog and digital data can be transmitted, but as we are concerned with digital data only, we will stick to that.

Yet another problem in RF communication is it uses serial data only, where as it is easy to work with parallel data and our existing setup uses parallel data only. For this matter, we have to convert the parallel data to serial data before transmission and again convert it back to parallel data after receiving before feeding it to the microcontroller.

This can be done by a method known as Shift Register.

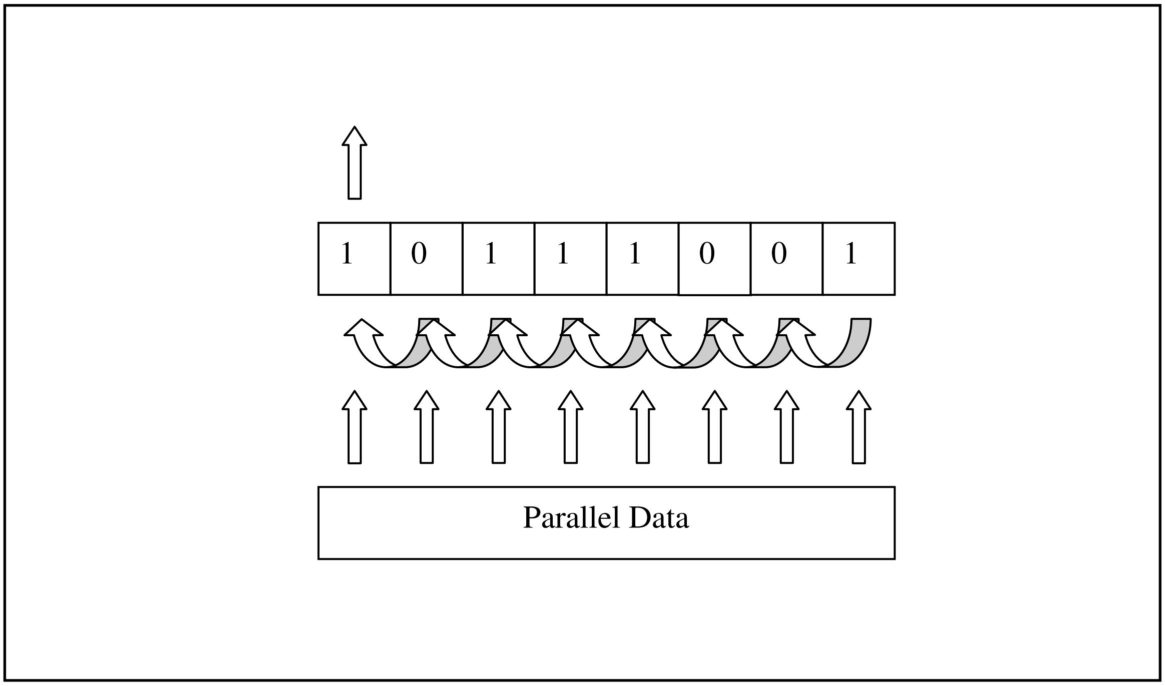


Figure 3.1
Shift register to convert parallel data to serial data

The above diagram explains how a shift resister converts parallel data to serial data. First of all, the parallel data is entered into the resister, then the first bit is sent through the serial out. After that, the second bit is shifted to the location of 1st bit,3rd to 2nd and so on. Then the second bit is sent. This way the parallel data is converted into serial data.

Similarly serial data can be converted to parallel data too.

Digital RF Communication→

There are three methods in which digital RF transmission takes place. Such as

1. ASK→ Amplitude Shift Keying
2. FSK→ Frequency Shift Keying
3. PSK→ Phase Shift Keying

ASK→ In this method, the amplitude is varied according to the data sent.

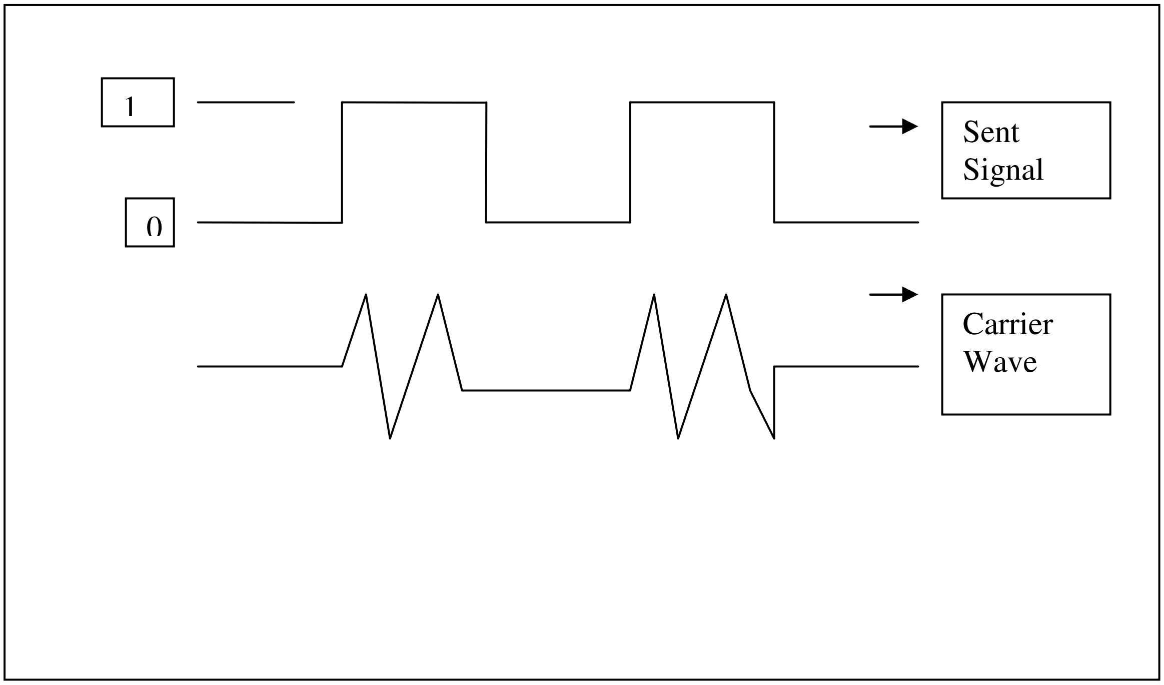


Figure 3.2
Amplitude Shift keying

The above diagram explains the modulation of the carrier wave according to the signal.

FSK→ In this method, frequency is varied according to the signal sent, i.e. high frequency for high (1) and low frequency for low (0).

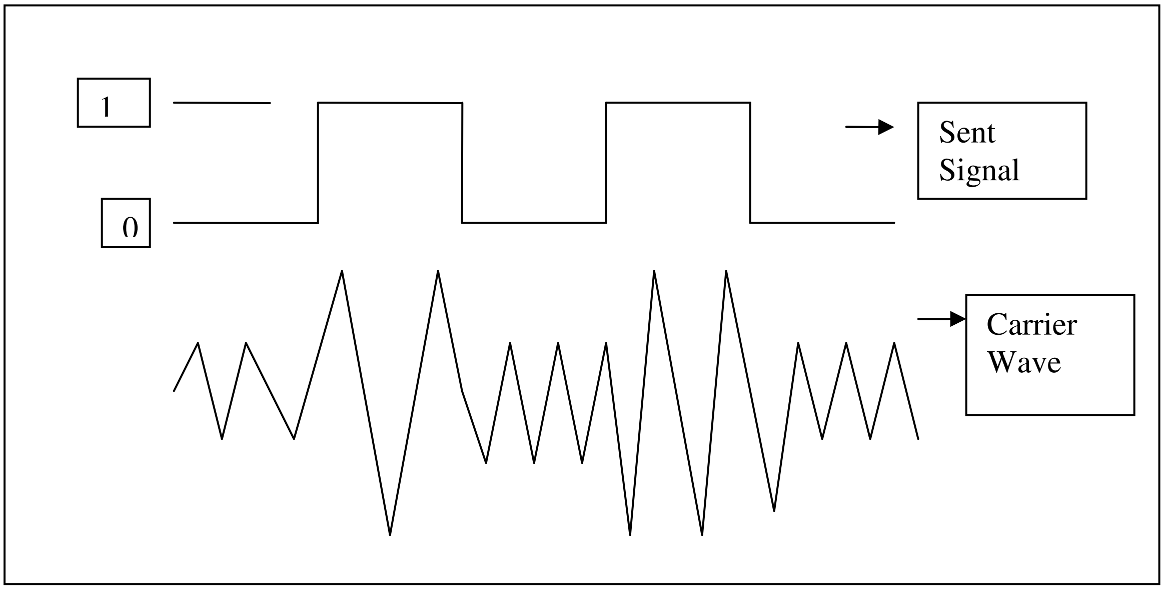


Figure 3.3
Frequency Shift Keying

The preceding diagram explains the carrier wave's shape for the shown digital signal.

PSK→In this method, the phase is changed for a change in the data.

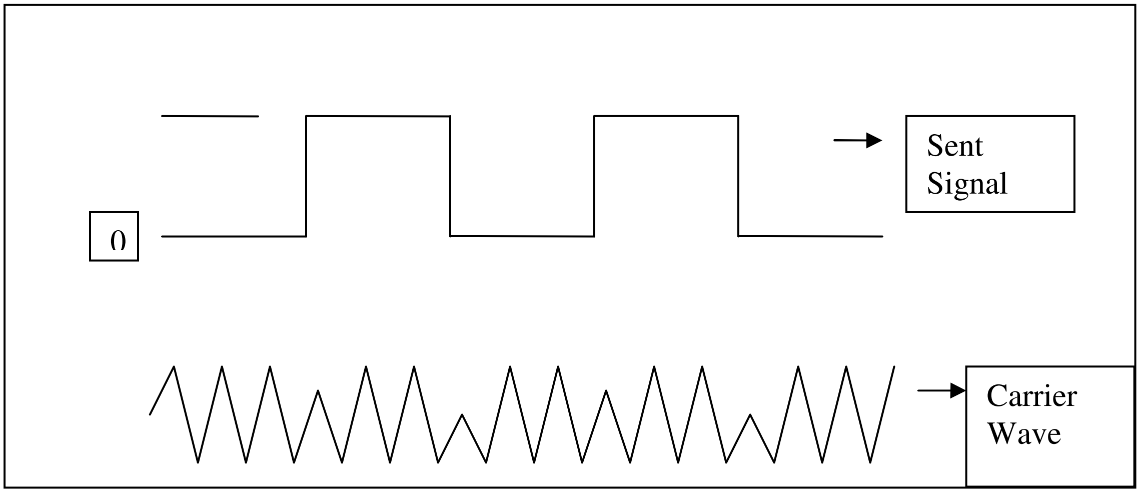


Figure 3.4
Phase Shift Keying

The above diagram shows how the phase of the carrier wave is changed according to the variation in signal.

The chosen RF solution→

The ZiRF RS-232 9-pin link is chosen to be the RF solution to be used on the AGV.

Some of its features are

- It is very cheap.
- It is a 2-way transmission system.
- It uses Serial DB-9 connector.
- This has been designed to be a wire replacement.

The current design of the AGV uses parallel data from the computer. But to make it wireless, we need to change it to serial data.

At the PC end, to enable it with serial data, we need to program it to use RS-232 standard.

The RS-232 standard was defined by Electronic Industries Association back in 1960's. It uses UART (Universal Asynchronous Receive / Transfer). The data sent by UART isn't synchronized, as no clock signal is sent. Rather both the sending and receiving terminal have a clock that takes care of the synchronization after sending of the 1st data bit.

Chapter 4

USART ON ATMEGA16

Introduction

Registers

USART on ATMEGA16

Introduction→

The USART (Universal Synchronous/Asynchronous Receive/Transfer) enables us to receive and transmit serial data which, in case of other microcontrollers, requires a specifically designed chip, such as MAX-232, to do the same thing.

The advantage of using serial data is, it requires only 2 pins to handle both transmission and reception, whereas had it been parallel data, it would have taken a whopping 16 pins i.e. half of the usable pins of the microcontroller.

The main features of USART are

- Full duplex operation (i.e. independent serial receive and transmit registers)
- Asynchronous and synchronous operation
- Master and slave clocked synchronous operation
- Supports serial frames with from 5 to 9 data bits and 1 or 2 stop bits
- Odd and even parity bit generation and check supported

The USART comprises of 3 main parts, namely clock generator, transmitter and receiver. The clock can be set to internal or external for synchronous operations. The transfer clock pin is only used for synchronous transfer mode.

The transmitter consists of a single write buffer, a serial shift register, parity generator and control logic for handing different frame formats. The buffer allows continuous data transfer without any delay.

The receiver is more complicated than the transmitter due to its clock and data recovery units. The recovery units are used for asynchronous data reception. The recovery units include parity checker, a control logic, a shift register and a two level receiver buffer.

The following figure is the frame formats that show how the UART transmits and receives data. It starts when the falling edge of first bit is detected and then low for a few clock cycles. The following bit is the least significant data bit. Then the next bit up, until all the bits are transmitted. One or two stop bits can be generated depending upon the setting. Parity bit is also optional, depending upon the setting.

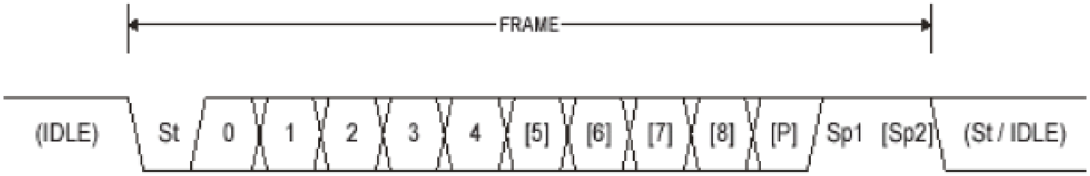


Figure 4.1
Frame format for UART

St → Start bit, always low

0-8→ Data bits

P→ Parity bit, can be even or odd

Sp→ Stop bits

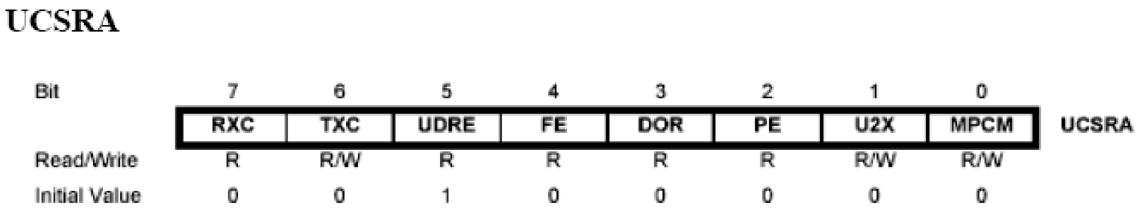
[]→ This denotes that the enclosed bit is dependent on setting

Registers→

UDR→

UDR is the I/O address for USART data transmit buffer register and USART data receive buffer register. The transmit buffer is the destination for the data written to UDR. Reading UDR will return the contents of a data receive buffer register.

The UCSRA register→



UCSRA

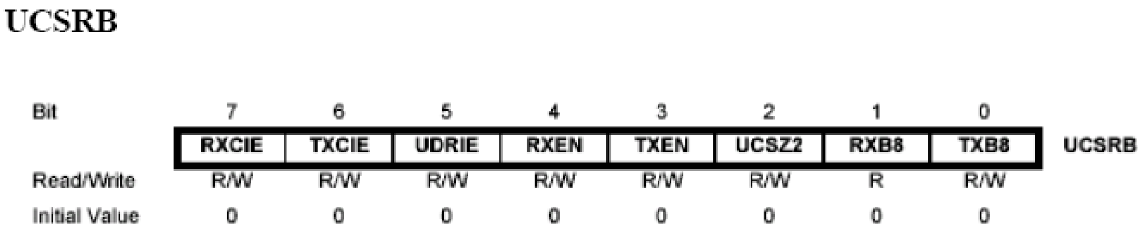
Bit	7	6	5	4	3	2	1	0	
	RXC	TXC	UDRE	FE	DOR	PE	U2X	MPCM	UCSRA
Read/Write	R	R/W	R	R	R	R	R/W	R/W	
Initial Value	0	0	1	0	0	0	0	0	

Figure 4.2

The UCSRA register

RXC flag will be set when the receiver completes receiving data. On the other hand, TXC will be set if the transmission of the data is complete. Both the flags can be used to generate an interrupt though we are not using this feature. The UDRE is 1 if UDR is empty and the UDR is ready to be written.

The UCSRB register→



UCSRB

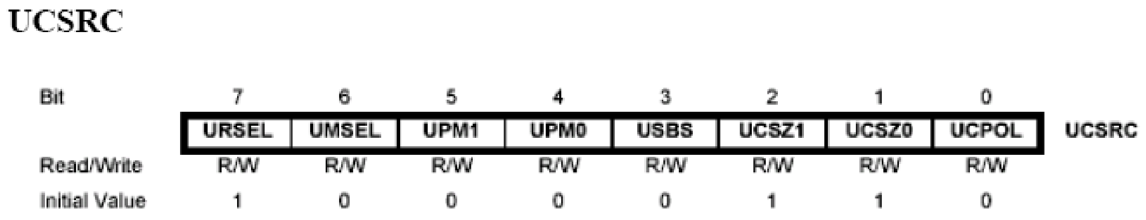
Bit	7	6	5	4	3	2	1	0	
	RXCIE	TXCIE	UDRIE	RXEN	TXEN	UCSZ2	RXB8	TXB8	UCSRB
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Figure 4.3

The UCSRB register

RXEN and TXEN are the receiver enable bit and Transmitter enable bit respectively. RXB8 and TXB8 are the receiver data bit 8 and transmitter data bit 8 respectively. The data bit 8 is the 9th bit in the bit stream. This enables USART to transmit or receive more than 8 data bits in one data frame.

The UCSRC register→



UCSRC

Bit	7	6	5	4	3	2	1	0	
	URSEL	UMSEL	UPM1	UPM0	USBS	UCSZ1	UCSZ0	UCPOL	UCSRC
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	1	0	0	0	0	1	1	0	

Figure 4.4

The UCSRC register

UMSEL sets the synchronous or asynchronous operation.UPM1:0 sets the parity bit even or odd or no parity to be generated. USBS sets one or two stop bits in the data frame.

UBRRH / UBRRL→

The UBRRH and UBRRL are used to set the baud rate. To ensure correct information will be sent are received, the baud rates of both party has to be the same. Where UBRRL contains the 8 least significant bits, UBRRH contains rest 4 bits.

In this project 8 data bits and one stop bits without parity are used. The baud rate is set to 9600 bps.

Chapter 5

CONCLUSION

Results and Discussion

Conclusion

Scope for further enhancement

CONCLUSION

Results and Discussion→

The velocity of the vehicle while moving straight is 8cm/s and it is 1.14rad/s while taking turn. Wheel track of the vehicle is 12cm and wheel base is 18cm. width of wheel is 0.6cm and material used for wheels and chassis is acrylic. In development stage, power supply was initially given through 1.2V Ni-mH battery pack. Hence it is replaced with a 12V 7Ah Lead acid external battery commonly used in portable UPS. To minimize slip of wheels, the motors are placed along the centre of gravity of the vehicle. Initially TSOP IR sensors are used which are later replaced with IR receivers as the prior give digital output and the latter give analog output. The AGV was being controlled from Computer though Parallel port. From now on, it will be controlled through Serial port. The controlling program used at the PC end was running in text mode. A new program is developed to provide the users with a Graphical User Interface (GUI) for better appearance and control. As each and every circuit is manual made, these are prone to loose contact with a little endurance.

Conclusion→

Automated guided vehicles play an important role in flexible manufacturing systems. The project mainly deals with building of an AGV and controlling it with computer. The simplified plant layout is considered in the work and the vehicle is successfully controlled from one machine unit to the other with machine number as the only input.

Scope for further Enhancements→

Till date we are able to build a robot that is controlled by computer using serial port with wire. The prospective improvements can be

- Replacing external battery with on-board batteries.
- Replacing wire with RF module.
- Providing obstacle collision avoidance by implementing ultrasonic range finders.
- Replacing stepper with servo motors to increase torque per unit weight of motor.
- All circuits onboard the vehicle are manual made. Hence its advisable to make them replaced wit industrial made printed circuit boards to have better reliability and performance.

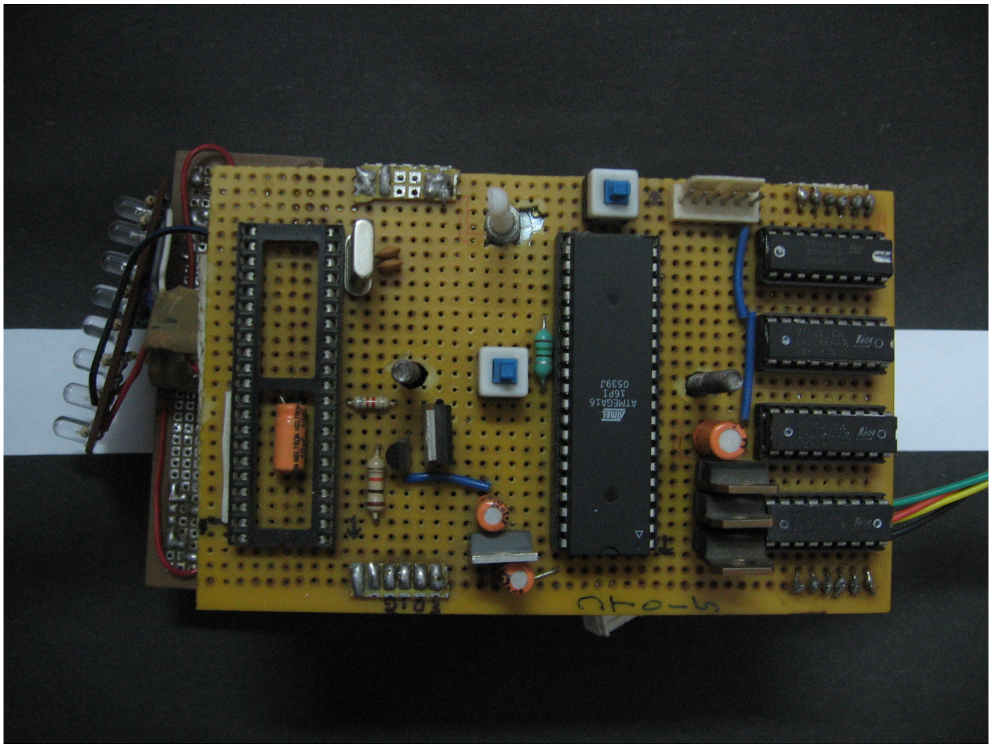


Figure 5.1
Top view of AGV

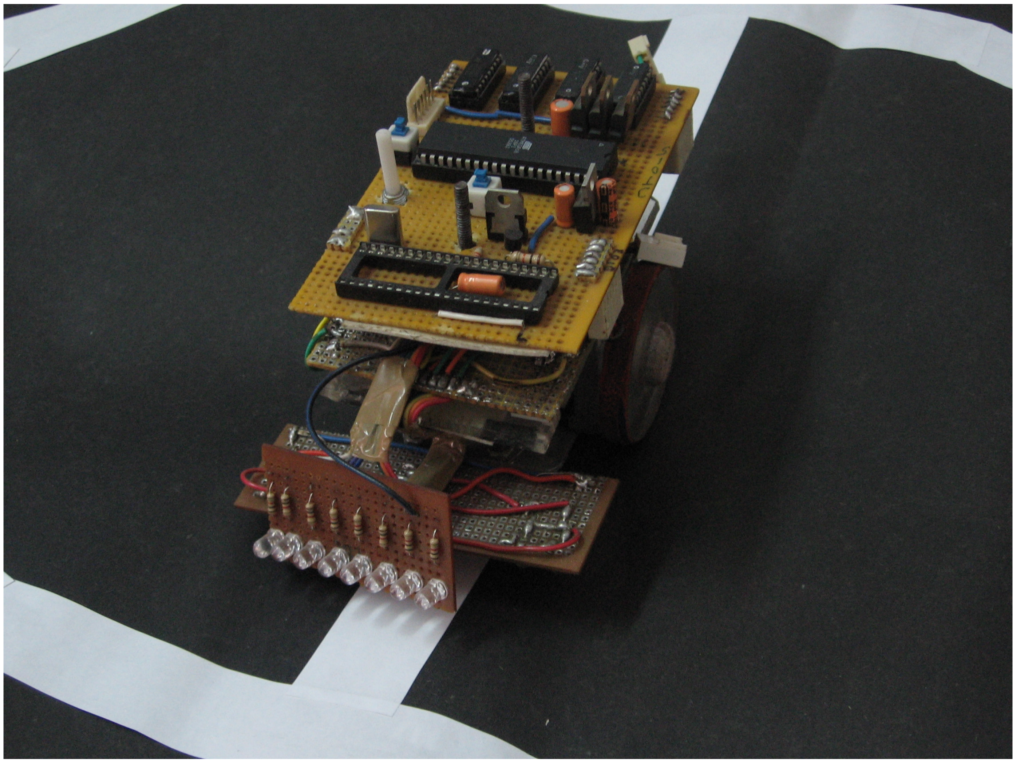


Figure 5.2
Isometric view of AGV

APPENDIX

A: Program for the main Microcontroller

B: Program for the auxiliary Microcontroller

C: The control program for the PC

Appendix

A: Program for the main Microcontroller→

Main.c

```
#include"iom16.h"
#include"intrinsics.h"
#include"direction_contrl.h"
#include"ADC.h"
#include"tracking.h"
//To be compiled on IAR Embedded Workbench

int main( void )
{
        __delay_cycles(7000000);

         DDRA=0X00;
         PORTA=0XFF;

         DDRB=0X18;              //data direction register(0-input,1-output)
         PORTB=0Xe7;

         DDRD=0XFF;
         PORTD=0X00;

        DDRC=0XFF;
        PORTC=0Xff;

        ADCSRA_Bit7=1;          //ADC ENABLE

         one2();
```

```
    while(1)
    {
        PORT.B=PINB;
        if(PORT.PIN.B_1)
        one2();
        if(PORT.PIN.B_2)
        one3();
    }
    return 0;
}
```

Direction_control.h

```
__near char x;
__near int p=0,q=0;

forward(void)                    /*FORWARD*/
{
    char seq[4];
    seq[0]=0x11;
    seq[1]=0x88;
    seq[2]=0x44;
    seq[3]=0x22;

    for(char i=0;i<2;i++)
    {
        PORTD=seq[x];
        __delay_cycles(60000);
          p=p+1;
          q=q+1;
        x=x+1;

        if(x==4)
        x=0;
    }
}

right(void)                             /*RIGHT*/
{
    char seq[4];
    seq[0]=0x10;
    seq[1]=0x80;
    seq[2]=0x40;
    seq[3]=0x20;

    for(char i=0;i<2;i++)
    {
         PORTD=seq[x];
        __delay_cycles(60000);
        p=p+1;
        x=x+1;
        if(x==4)
        x=0;
    }
}
left(void)                              /*LEFT*/
{
    char seq[4];
    seq[0]=0x01;
    seq[1]=0x08;
    seq[2]=0x04;
```

```
        seq[3]=0x02;
        for(char i=0;i<2;i++)
        {
                PORTD=seq[x];
                __delay_cycles(60000);
                q=q+1;
                x=x+1;
                if(x==4)
                x=0;
        }
}
```

ADC.h

```
char left1,left2,right1,right2;
read_left1()
{
        ADMUX_Bit6=1;           //AREF=AVCC
        ADMUX_Bit5=1;           //LEFT ADJUST

        ADMUX_Bit0=0;           //SELECT INPUT
        ADMUX_Bit1=0;

        ADCSRA_Bit6=1;          //START CONVERSION
        check:  if(ADCSRA_Bit4==1)      //CHECK FOR END OF CONVERSION
                        left1=ADCH;             //READ DATA
        else
                goto check;
        ADCSRA_Bit4=0;          //CLEAR INTERRUPT
}
```

```
read_left2()
{
          ADMUX_Bit6=1;           //AREF=AVCC
          ADMUX_Bit5=1;           //LEFT ADJUST

          ADMUX_Bit0=1;           //SELECT INPUT
          ADMUX_Bit1=0;

          ADCSRA_Bit6=1;          //START CONVERSION
          check:  if(ADCSRA_Bit4==1)       //CHECK FOR END OF CONVERSION
                          left2=ADCH;             //READ DATA
          else
                    goto check;
  ADCSRA_Bit4=0;          //CLEAR INTERRUPT
}

read_right1()
{
          ADMUX_Bit6=1;           //AREF=AVCC
          ADMUX_Bit5=1;           //LEFT ADJUST

          ADMUX_Bit0=0;           //SELECT INPUT
          ADMUX_Bit1=1;

          ADCSRA_Bit6=1;          //START CONVERSION
          check:  if(ADCSRA_Bit4==1)       //CHECK FOR END OF CONVERSION
                          right1=ADCH;            //READ DATA
          else goto check;
  ADCSRA_Bit4=0;          //CLEAR INTERRUPT
}
```

```
read_right2()
{
        ADMUX_Bit6=1;           //AREF=AVCC
        ADMUX_Bit5=1;           //LEFT ADJUST

        ADMUX_Bit0=1;           //SELECT INPUT
        ADMUX_Bit1=1;

        ADCSRA_Bit6=1;          //START CONVERSION
        check:  if(ADCSRA_Bit4==1)      //CHECK FOR END OF CONVERSION
                        right2=ADCH;            //READ DATA
        else
                goto check;
        ADCSRA_Bit4=0;          //CLEAR INTERRUPT
}

readall()
{
 read_left1();
 read_right1();
 read_left2();
 read_right2();
}
```

Tracking.h

```
int a=0,b=385,r=503;
__near union abc
{
        char B;
        struct cba
```

```
 {
           char B_0:1;
           char B_1:1;
           char B_2:1;
           char B_3:1;
           char B_4:1;
           char B_5:1;
           char B_6:1;
           char B_7:1;
  }PIN;
}PORT;

one2()
{
 a=0;
 PORT.B=PINB;
 while(1)
 {
           readall();
           while((left1<200)&&(right1<200)&&(a<b))
           {
                      readall();
                      forward();
                      PORT.B=PINB;
                      a++;
           }
           while((left1>200)&&(right1<200)&&(a<b))
           {
                      readall();
                      left();
                      PORT.B=PINB;
```

```
                a++;
        }
        while((left1<200)&&(right1>200)&&(a<b))
        {
                readall();
                right();
                PORT.B=PINB;
                a++;
        }
        while((left1>200)&&(right1>200)&&(a<b))
        {
                readall();
                right();
                PORT.B=PINB;
                a++;
        }
        PORT.B=PINB;
        if(a>=b)
                break;
  }

}

one3()
{
        a=0;
        PORT.B=PINB;
        while(1)
        {
                readall();
                while((left1<200)&&(right1<200)&&(a<r))
                {
                        readall();
                        forward();
                        PORT.B=PINB;

                }
                while((left1>200)&&(right1<200)&&(a<r))
                {
                        readall();
                        left();
                        PORT.B=PINB;
                }
                while((left1<200)&&(right1>200)&&(a<r))
                {
                        readall();
                        right();
                        PORT.B=PINB;
                }
                while((left1>200)&&(right1>200)&&(a<r))
                {
                        readall();
                        forward();
                        PORT.B=PINB;
                }
                PORT.B=PINB;
                if(a>=r)
                        break;
        }
}
```

B: Program for the auxiliary Microcontroller→

Main.c

```
//To be Compiled on CodeVision C compiler
#include <mega16.h>
#include <stdio.h>

void USART_INIT(void);
unsigned char usart_receive(void);

void main(void)
{
        unsigned char ch;
        USART_INIT();
        while(UCSRA.7==0)
        {
                ch=usart_receive();
                switch(ch)
                {
                        case 'w':
                                PORTB=0X04;
                                break;
                        case 's':
                                PORTB=0X07;
                                break;
                        case 'a':
                                PORTB=0X05;delay
                                break;
                        case 'd':
                                PORTB=0X06;
                                break;
                        default:
                                    break;
                  }
         }
}


void USART_INIT(void)
{
         UCSRA=0x20;
         UCSRB=0x18;
         UCSRC=0x8E;
         UBRRH=0X00;
         UBRRL=0x17;
         DDRB=0X07;
         PORTB=0X07;
}

unsigned char usart_receive(void)
{
         while(UCSRA.7==0)
         ;
         return UDR;
}
```

C: The control program for the PC→

(To be compiled on Visual Basic)

```
Private Sub Form_Load()
MSComm1.CommPort = 4
MSComm1.Settings = "9600,N,8,1"
MSComm1.PortOpen = True
End Sub

Private Sub Forward_Click()
MSComm1.Output = "w" & vbCr
End Sub

Private Sub Frame1_DragDrop(Source As Control, X As Single, Y As Single)
End Sub

Private Sub Left_Click()
MSComm1.Output = "a" & vbCr
End Sub

Private Sub Right_Click()
MSComm1.Output = "d" & vbCr
End Sub

Private Sub Stop_Click()
MSComm1.Output = "s" & vbCr
End Sub
```

```
Private Sub Text1_KeyDown(keycode As Integer, shift As Integer)

If keycode = vbKeyA Then
MSComm1.Output = "a" & vbCr
Else
If keycode = vbKeyS Then
MSComm1.Output = "s" & vbCr
Else
If keycode = vbKeyD Then
MSComm1.Output = "d" & vbCr
Else
If keycode = vbKeyW Then
MSComm1.Output = "w" & vbCr
Else
End If



End If
End If
End If
End Sub
Private Sub Text1_Keyup(keycode As Integer, shift As Integer)

If keycode = vbKeyW Then
MSComm1.Output = "r" & vbCr
Else
If keycode = vbKeyS Then
MSComm1.Output = "t" & vbCr
Else
If keycode = vbKeyD Then
MSComm1.Output = "u" & vbCr
```

```
Else
If keycode = vbKeyA Then
MSComm1.Output = "v" & vbCr
Else
End If
End If
End If
End If
End Sub
```

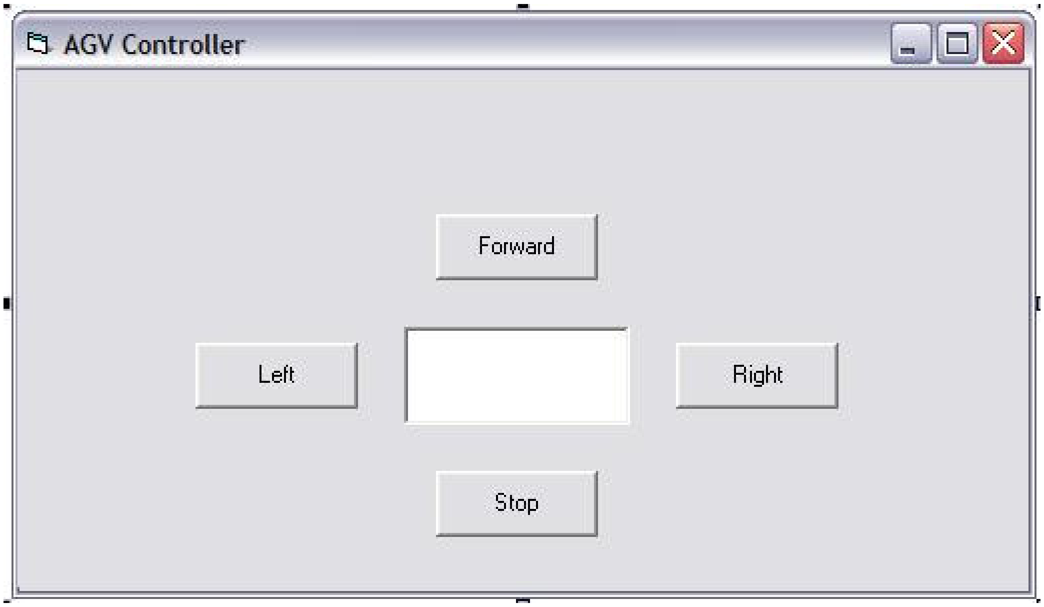


Figure A.1

GUI of AGV Controller

REFERENCE

1. Jaworska, Irena, Laski, Tomasz “Student-oriented program for introductory robotics education” Robotics and Autonomous Systems Volume 8, Issue 4, 1991, Pages 275-280.
2. Joseph J. M. Evers and Stijn A. J. Koppers, “Automated guided vehicle traffic control at a container terminal” Transportation Research Part A: Policy and Practice Volume 30, Issue 1 , January 1996, Pages 21-34
3. Vladimir R.Milai and Goran D.Putnik,” Steering rules for AGV based on primitive function and elementary movement control”, Robotics and Computer-Integrated Manufacturing Volume 5, Issues 2-3 , 1989, Pages 249-254
4. Michiko Watanabe,Masashi Furukawa,and Yukinori Kakazu, “Intelligent AGV driving toward an autonomous decentralized manufacturing system”, Robotics and Computer-Integrated Manufacturing Volume 17, Issues 1-2 , February 2001, Pages 57-64(problems in navigation)
5. Stuart J. Russell, “Prior knowledge and autonomous learning”, Robotics and Autonomous Systems Volume 8, Issues 1-2 , November 1991, Pages 145-159
6. Hofner.C, Schmidt.G, “Path planning and guidance techniques for an autonomous mobile cleaning robot”, Intelligent Robots and Systems '94. 'Advanced Robotic Systems and the Real World', IROS '94. Proceedings of the IEEE/RSJ/GI International Conference on Volume 1, 12-16 Sept. 1994 Page(s):610 - 617 vol.1
7. Enxiu Shi, Yumei Huang, Yizhong Lin, “Research on the method of composite navigation for AGV”, Fifth World Congress on Intelligent Control and Automation, 15-19 June 2004, IEEE.
8. Andersen.N, Henriksen.L, Ravn.O,” Design of navigation and control for an AGV”, Intelligent Autonomous Vehicles 1995. Postprint Volume from the 2nd IFAC Conference, 1995, 175-80
9. Dr. T. Tempelmeier, “Microprocessors in factory automation — A case study of an automated guided vehicle system and its integration into a hierarchical control structure”, Microprocessing and Microprogramming Volume 18, Issues 1-5 , December 1986, Pages 647-656

10. Yvan J. Beliveau,Jeffrey E. Fithianc, and Michael P. Deisenrothd, “Autonomous vehicle navigation with real-time 3D laser based positioning for construction”, Automation in Construction Volume 5, Issue 4 , October 1996, Pages 261-272
11. Steven H. -Y. Lai, “On the design of AGV travel mechanisms”, Computers & Industrial Engineering Volume 23, Issues 1-4 , November 1992, Pages 181-185
12. http://www.automaticguidedvehicles.com/info/articles.htm