

DESIGN AND FABRICATION OF A VACUUM CLEANER ROBOT

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Abstract—This paper presents the design and fabrication of a vacuum cleaner robot. This is not a new concept in the field of mechanical engineering, but when it comes about a robotic vacuum cleaner, it's something new and different. It has got an autonomous control with the ability of avoiding obstacle. The vacuum cleaner has an intake port where air enters and an exhaust port where air exits. A centrifugal blower used inside the cleaner forces air towards the exhaust port at a high velocity, which lowers the pressure of the air inside according to Bernoulli's Principle. This creates suction of air rushed from outside through the intake port of the VCR. The incoming air particles rub against any loose dust or debris from the floor or carpet and carry these in the exhaust port which is a glass box. There are two holes in the box covered with nets. The dirt is trapped in the nets, but the air passes right through the holes to the environment.

Keywords: Vacuum Cleaner Robot (VCR), Centrifugal blower, Bernoulli's principle, Intake port.

1. INTRODUCTION

A vacuum cleaner, commonly referred to as “vacuum” is a device that uses an air pump to create a partial vacuum to suck up dust and dirt, usually from floors, and optionally from other surfaces as well. [1] From time to time technology needs to come up and need to upgrade for easier human task. Cleaner Robots are among the first members of the service robot family to reach the marketplace with practical and economic solutions. Cleaning an indoor area is a challenging practical and theoretical problem whose solution involves all the basic research areas in robotics and lots of common sense. [2, 3] Vacuum Cleaner Robot is a combination of software and hardware. The hardware of VCR consists of microcontroller, motor, vacuum, sensor, power distributions and also the chassis of the robot. Software AVR Studio 4 was used to write the program for microcontroller and PonyProg2000 is used to download the hex file into the microcontroller. Most of the designations of vacuum robots in the market are expensive and large in size. So it is difficult to clean anywhere, under beds as well as kitchen baseboards. Therefore, this research is built to be one of the advantages of human to clean the floor within small period and more effective. For a VCR to randomly navigate through a room or a house with the minimum human assistance, the specifications found were: obstacle identification, floor detection, collision detection, battery monitoring, fan motor current monitoring, map creation and autonomous dust bag dump. These specifications correspond to some of the

expected behaviors that will be programmed into the VCR. [3, 4] This research is divided in several phase which are mainly the planning, material selection, constructing prototype and lastly testing all the integrated hardware that have been developed. The main objectives of this paper to present a model of VCR which saves time and power consumption by automatic control, makes the task of cleaning easier with minimal or no human assistance.

2. RESEARCH DESIGN AND METHODOLOGY

The typical shape of a robotic vacuum cleaner is a disk. The reasons they are disk-shaped is because of mobility. The problem with that is that they cannot clean the corners of rooms very well. To improve the overall cleaning efficiency, shape of the new VCR was changed from a circle to a square. The square design will allow our vacuum to clean the corners of rooms better. They can maneuver through narrow spaces and still clean effectively. When they bump into a wall or piece of furniture, since it is a circle, it can easily turn around and adjust its position and continue cleaning.

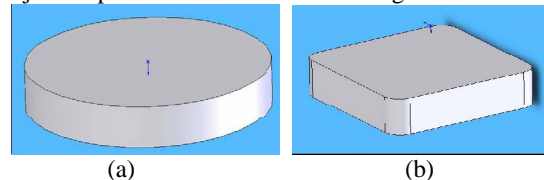


Fig.1 (a) Disk Shaped Design (b) Redesigned Square Shaped.

The major problem with the vacuum being a circle is that it cannot clean the corners of rooms very well but a square shaped VCR can get into the corners and clean better, but there are no square robot vacuums. The reason why there are no square vacuums is because of the pointed edges. As the vacuum is going along and cleaning it will bump into obstacles and then re-position itself. As the vacuum is re-positioning itself, the edges can come into contact with obstacles and will waste more time re-positioning itself instead of cleaning. That's why the new design for the shape of the vacuum was going to be a square with rounded edges. Having a square would get the corners to be cleaned much better and the rounded edges would allow the vacuum to have the same mobility to work its way through tight spots. Hence it was compromising some mobility in changing the shape to a square with rounded edges. The circle shaped vacuums right now can easily readjust when it comes in contact with an obstacle especially in tight spots. The only drawback is that it will lose some mobility and maneuverability. It is impossible to be able to make the robot clean corners 100%. It will never be able to clean corners and along walls perfectly. Having a square with rounded edges is the best design for the vacuum. It will be able to clean corners and along walls better than a circle shaped vacuum.

3. ROBOT CONSTRUCTION

Mechanical Components

Blower

To make necessary suction, blower was used driven by a DC motor. There are three types of blower- forward curved vane, backward curved vane and radial vane blower (figure2) [6]. Backward curved vane blower was used in this robot. A partial vacuum is created at the

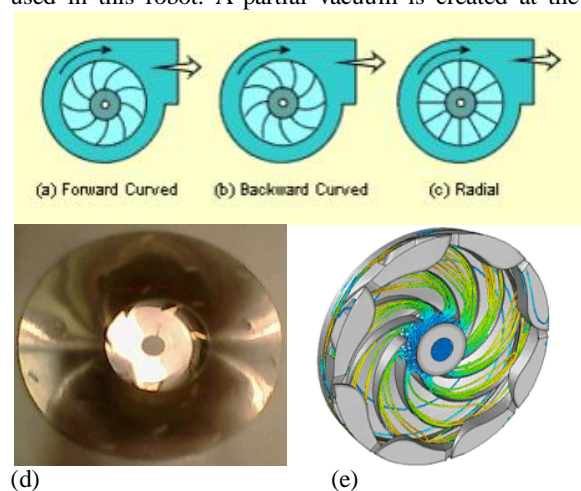


Fig.2 Centrifugal blower

centre of the impeller due to centrifugal action. Owing to this suction pressure air flows through the suction pipe towards the impeller eye to take the place of air which has left the impeller vanes. In this way, air is sucked in continuously at a constant rate. Speed of motor (rpm) plays a big role in how much suction is generated.

Wheels

Four wheels were used in this robot. Power from the

battery was given to two geared motors of the two front wheels. Two revolving wheels were used in the backside of the VCR to ease the rotation. The wheels are shown in figure 3.

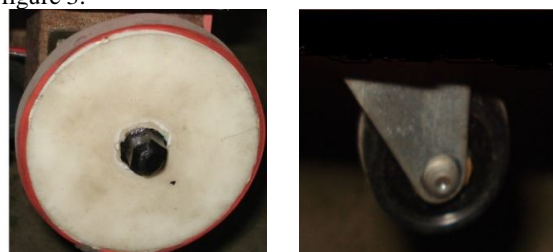


Fig.3: Nylon wheel and revolving wheel

Brush

For the improvement of cleaning a brush was used in front of intake port under the base of the VCR. It kicks out dust from the floor and loose dirt can easily be picked up by the air stream. Figure 4 shows the brush connection with the intake line of the VCR.

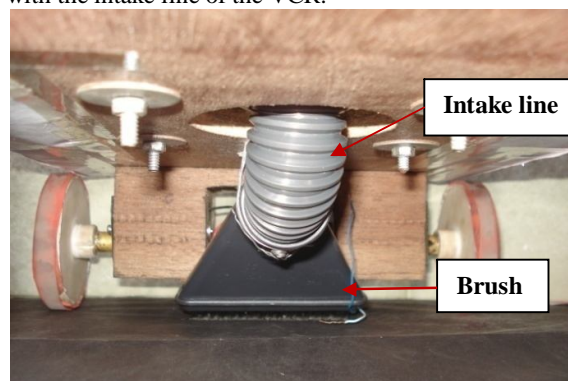


Fig. 4: Brush connection

Motor

An electric motor is a machine which converts electrical energy into mechanical energy. [7] The system needed motors to power the blower for cleaning and the wheels for motion. In the design, one DC motor was used to rotate blower and two DC geared motors were used to rotate the wheels. Two front wheels were individually controlled by two geared motors.

Electrical and Electronic components

Micro-controller

Basically, microcontroller is a small and compact chip which can reads input, process and produce output to control other electronic devices. There are so many brands of microcontroller available in the market today, such as PIC, Motorola, Philip, Hitachi and Atmel. There are a lot of similarities between the microcontrollers such as low cost, it is easy to get, where we can order the microcontroller from Cytron, Farnell, and electronics store. Various software are available such as MPLAB, AVR Studio, mikroC PRO, WinPIC, C compiler for microcontroller coding and the software is distributed as freeware. Another advantage of microcontroller is the program code can be loaded-reloaded frequently many times. ATmega8 microcontroller was used in this robot. The code was written in Programming language C in AVR Studio 4. PonyProg 2000 software was used to load the program from computer to the micro-controller. The

microcontroller and its pin configuration are shown in figure 5.

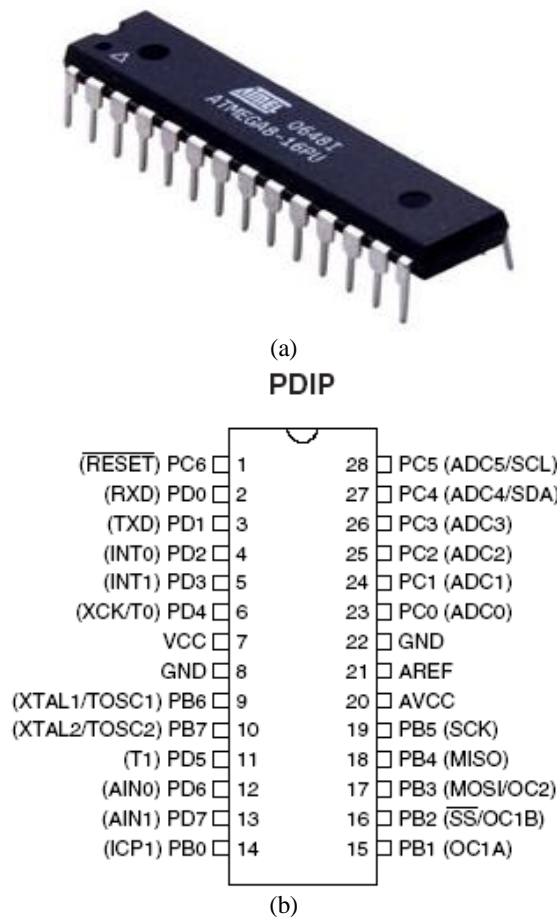


Fig.5: (a) ATMEGA8 Microcontroller (b) Pin configuration of the microcontroller

Resistor

It is a device which is used to resist the current flow in an electrical circuit. Resistors can be made from different material. But the most common is carbon composition (Graphite plus binding agent). Basically it is small and thin section of carbon composition with Lead at each end. Resistance is measured in Ohms & is represented by the Greek symbol Omega. To abbreviate a bit ,prefixes are generally used to indicate a multiplier or resistance value. Typically we see just two of these :

K=thousand ; $1K\Omega = 1,000 \Omega$

M=million ; $1M\Omega = 1,000,000 \Omega = 1000 K\Omega$

Variable resistor shows different values of resistance in different position within a predefined range. In this circuit a $100 k\Omega$ variable resistor was used along with two 50Ω and two 100Ω resistors. The resistor with a color code is shown in figure 6.

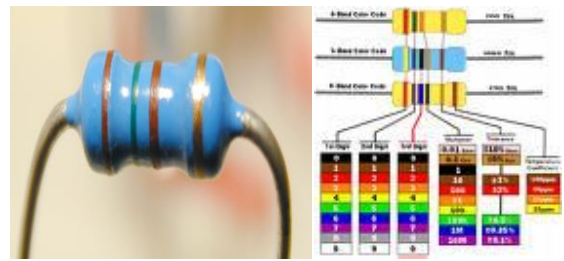
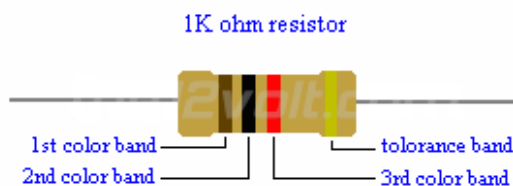


Fig.6: Resistor

LED (Light Emitting Diode)

It is one kind of color bulb. It emits visible light when current passes in forward direction. It also has polarity .Generally it can withstand 5 to 25 mA of current. So, a fixed variable resistor should be used in series for its safety. LED along with its electronic symbol is shown in figure 7.

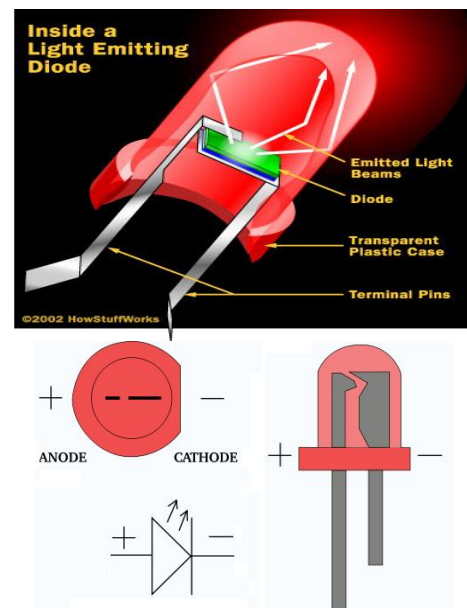
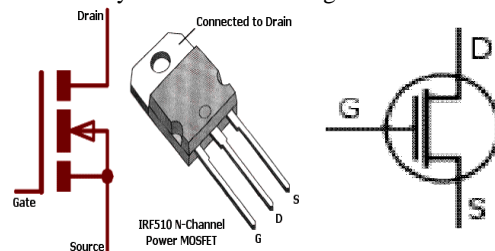


Fig.7: LED

MOSFET

The “metal oxide semiconductor field effect transistor” (MOSFET) is a device, used to amplify or switch electronic signals. It is composed of a channel of p-type & n-type semiconductor material & is accordingly called a PMOSFET & an NMOSFET. IRF840 MOSFET was used to drive each dc geared motor connected with two front wheels. A typical MOSFET along with its electronic symbol is shown in figure 8.



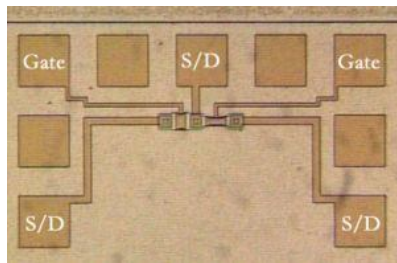


Fig. 8: MOSFET

IC7805

Some types of chips are particularly sensitive to voltage fluctuations. The IC7805 is a power regulator which takes any voltage between 6V and 12V DC and turns it into a smooth 5V which is required for other electrical components.

IR(Infra-Red) Transmitter and Receiver

IR transmitter (figure 9) sends infra-red continuously which will be reflected back if there is any object in front of the VCR. IR receiver (figure 9) receives the reflected Infra-red and makes a corresponding voltage change. If there is any obstacle in front of the VCR then IR will be reflected quickly which can be sensed by IR receiver and the VCR turns in other direction according to the change in voltage. Thus the VCR could be able to sense the obstacle in front of it.

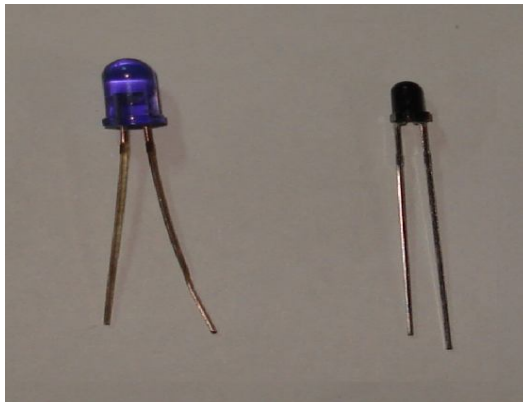


Fig. 9: IR transmitter & IR receiver

Other electrical elements

Battery: A 12V battery is used to supply the power required.

Wires: Wires are used to connect all the electrical components to make a complete circuit.

Project Board: All the circuit elements are mounted on a project board which is the easiest way of building the circuit that is available at all electronics stores.

Assembly

All the components are mounted on a base made of wood. The DC motor was coupled with blower and this assembly was mounted on the base (figure 10) by four nut-bolts connection. There was a hole in the base which coincides with the eye of the blower for sucking the air stream. Other mechanical components are assembled accordingly.

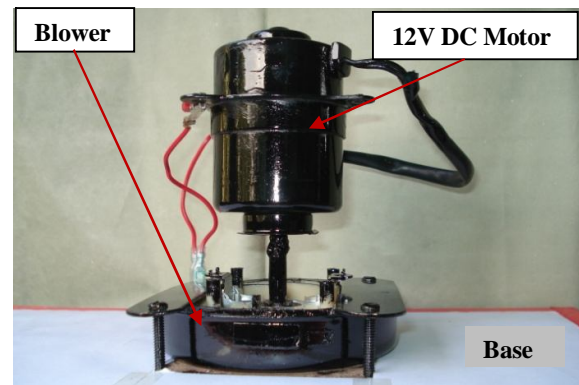


Fig. 10: Motor-Blower Assembly

Electrical components were connected according to the circuit design shown in figure 10 on a project board and finally it is placed on the wood base.

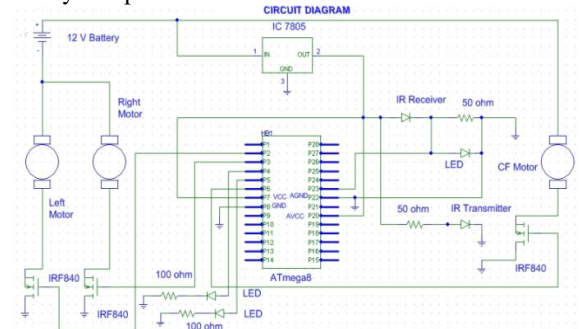


Fig. 11: Circuit diagram of controlling the VCR

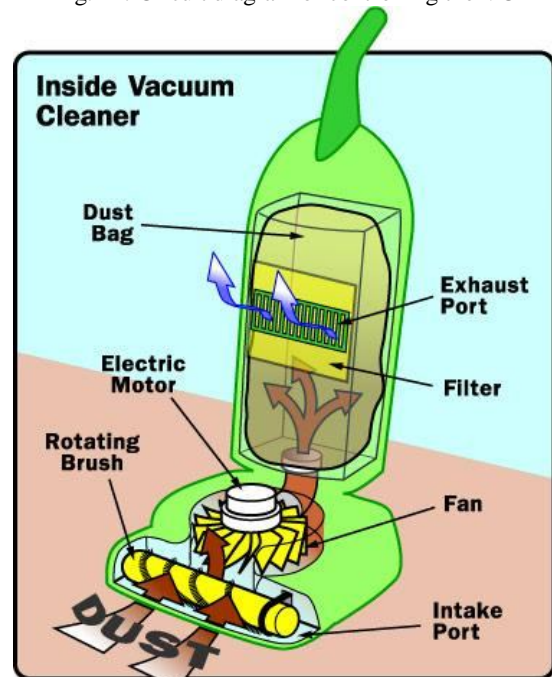


Fig.12 A Conventional Vacuum Cleaner

Figure 12 illustrates the conventional vacuum cleaner which has an intake port where air enters and an exhaust port where air exits. A fan inside the vacuum forces air toward the exhaust port at a high speed, which lowers the pressure of the air inside, according to Bernoulli's Principle. Assembling all mechanical and electrical components accordingly a final form of VCR was fabricated. The complete view of the VCR is shown in

figure 13.

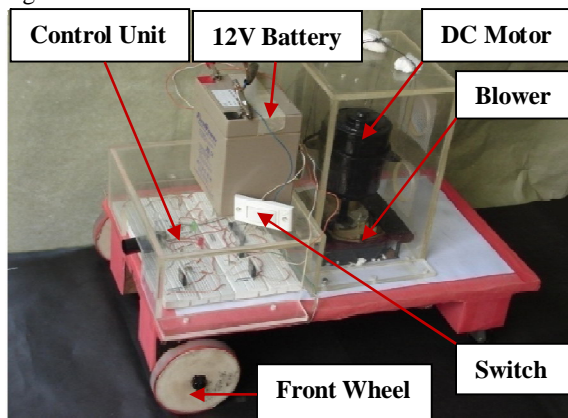


Fig. 13: Fabricated VCR

4. DISCUSSION

The VCR designed contains a brush at the intake port, which kicks dust and dirt loose from the carpet so it can be picked up by the air stream. So dust is sucked from bottom to upper portion & is stored at a particular place inside the transparent glass box. Two front wheels are controlled individually by two motor for movement at various places. Rear wheels are used just to bear the loads (Battery, Transparent glass box etc.) placed on the small vehicle. They are not given power. The VCR provide better performance considering square shape with round edge, moderate noise level and ergonomically designed. The office premises will be benefited by its use where recurrent use of human is not an option. It has less power consumption considering its effectiveness. It will cost only \$58 where a conventional vacuum cleaner requires \$110 with a human \$100 monthly payment. So VCR is very viable option for modern offices and busy households. So the high volume production of VCR will add up a new dimension in recent decades. The operational flexibility of it will enhance productivity in both urban and rural areas.

5. AREAS OF APPLICATIONS

- Automatic house cleaning
- Suitable for office and industries
- High scale production will reduce the per unit cost

6. CONCLUSION

A vacuum cleaner is now an essential accessory in homes and offices. Its capability to clean a large space within a limited span of time has made it almost inevitable. Besides as it needs less human effort in operation, it is considered handy. If an automatic navigation system can be incorporated in it, it will become a highly desired household device and this is the thing we wanted to develop in our research. A microcontroller based automatic navigation system has been meshed with the vacuum cleaner in our design. The microcontroller has been provided with a smartly written programming algorithm which can detect the presence of any obstacles

in his way of movement and according to it can change the direction immediately. Its smart navigation system is intelligent enough to move over the almost portion of floor of any room without colliding with other furniture or accessories. Vacuum cleaner portion has been designed so that it can suck major amount of the dust particles from the carpet or floor itself autonomously. After the completion of the cleaning, the VCR has the automatic power off option which relieves the owner from keeping concerned all the time to turn off the device. For research purpose, the design was made much simpler for the sake of fabrication. For large scale commercialization, this design can be made more sophisticated which will in turn increase the reliability and the ease of operation of the VCR. The authors also have further plan to develop the present model and to incorporate new top notch technologies in the present model.

6. REFERENCES

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7. NOMENCLATURE

Symbol	Meaning
VCR	Vacuum Cleaner Robot

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