Design and Development of Microcontroller Based ROBO Cleaner

Ankit Jain[1], Rupendra Kumar Pachauri[2], Avantika Rana[3]

Shobhit Institute of Engineering & Technology, Gangoh, Saharanpur INDIA[1]

Electrical Engineering Department, School of Engineering, GBU, Gr. Noida INDIA[2]

Department of Electronic & Communication, Neelkanth Institute of Technology, Meerut INDIA[3]

Abstract: As strange as it might seem, there really is no standard definition for a robot. However, there are some essential characteristics that a robot must have and this might help you to decide what is and what not a robot is. It will also help you to decide what features you will need to build into a machine before it can count as a robot. Robo Cleaner is a machine that cleans room automatically. Once it starts then Robo cleaner cleaned whole room. Robo Cleaner which use two motors control rear wheels and the single front wheel is free. It has 8-infrared sensors, 6-infrared sensors (3 pair) in left, right and front side for detect wall or any obstructs, when the sensors detected any obstructs, output of comparator, LM324 is high logic and the other the output is low. Microcontroller AT89S51 and H-Bridge driver L293 were used to control direction and speed of motor. Sensing a obstructs and maneuvering the robot to stay on course, while constantly correcting wrong moves using feedback mechanism forms a simple yet effective closed loop system. As a programmer you get an opportunity to 'teach' the robot how to move when obstructs is come.

Keywords: Micro- controller, infrared sensor, vacuum cleaner, stepper motor, amplifier

I. INTRODUCTION

Robo Cleaner is a machine that can clean the surface or floor automatically. It's capable to clean the floor in such area where we are not able to go i.e. blow badly or sofa or any corner etc. In Robo Cleaner for Cleaning a surface or floor we use vacuum cleaner. For make more accurate we use 4 sensor pair in Robo Cleaner. One if for left side, one is for right side, one is for down (for sense stairs etc.) and one pair is in front which is most important to sense front obstruct [1]. Stepper motor is used for run Robo Cleaner. Well it is a system that contains sensors, control systems, manipulators, power supplies and software all working together to perform a task. Designing, building, programming and testing robots is a combination of physics, mechanical engineering, electrical engineering, structural engineering, mathematics and computing. In some cases biology, medicine, chemistry might also be involved. A study of robotics means that students are actively engaged with all of these disciplines in a deeply problem-posing problem-solving environment.

II. HARDWARE IMPLEMENTATION

Figure 1 show the Block Diagram of microcontroller based Robo Cleaner. First block is Sensor Unit, in this we use the IR sensor pair for obtain obstructs. Sensor detect obstruct and send signal to the amplifier unit for amplifier this signal. For amplification we are using LM 324 as an amplifier IC. It has 4 operation amplifiers. It amplifies the signal which is obtain from sensor unit and transmitted to the microcontroller. Microcontroller (AT89s51) is based on programming, it follow the instruction according to program and send signal to the driver unit. Driver IC (L293) received instruction from microcontroller and follows the instruction and move steeper motor. Power supply unit is for provided the power for all units. A dry battery is connected with 78xx IC for provided power supply. For cleaning we are using usb based vacuum cleaner. We are derived vacuum cleaner from microcontroller. For connecting vacuum cleaner to the microcontroller Max 232 and Db 9 connector are used. After connecting vacuum cleaner with the microcontroller it is operated from vacuum cleaner.
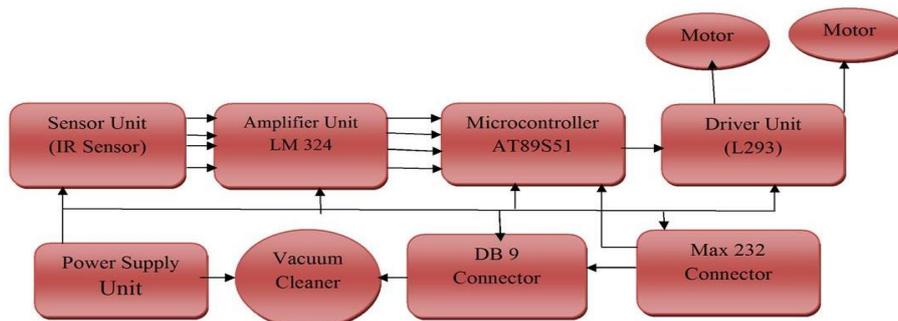

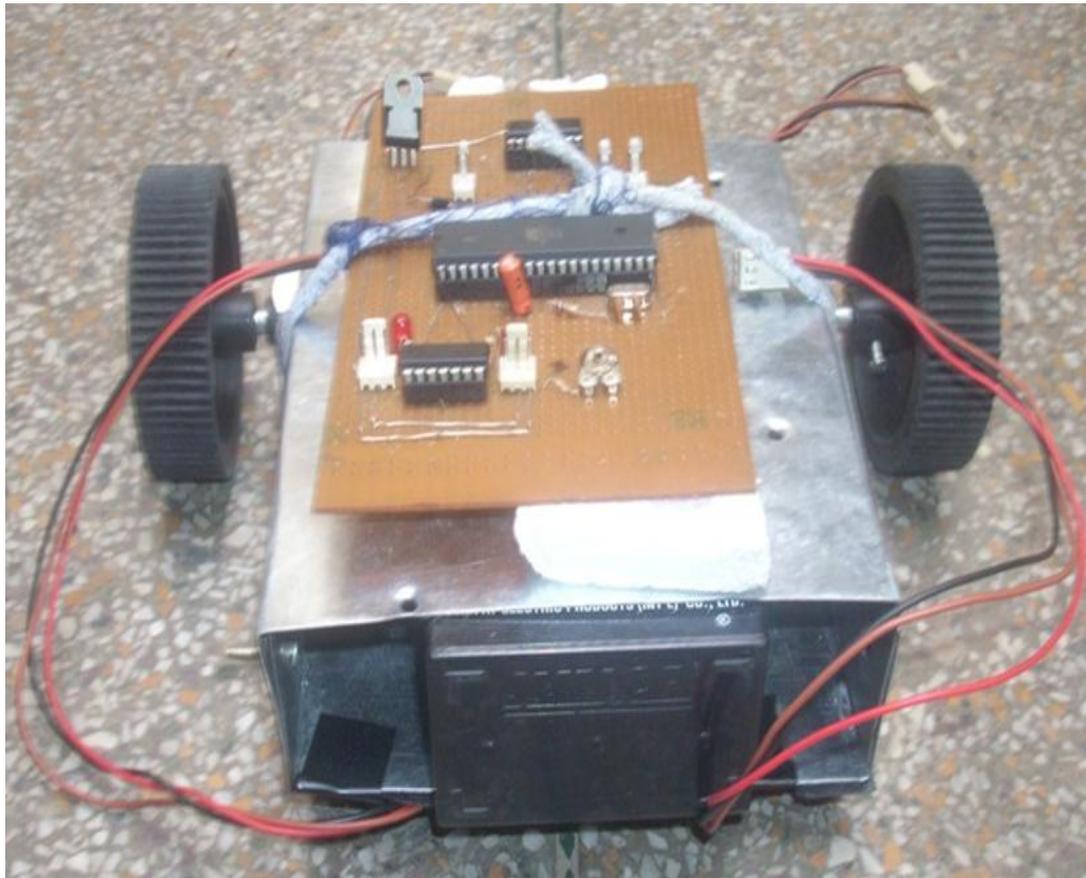Figure 1   Block diagram of microcontroller based Robo Cleaner

Figure 2 Designed hardware of the ROBO cleaner

A. Microcontroller

Microcontroller 89S51 is classified as an eight bit family CMOS microcomputer of mcs-51. It needs 3 capacitors, 1 resistor and 1 crystal as well as 5-volt power supply in operating. Microcontroller 89S51 is provided with memory not only RAM but also ROM, parallel and serial port (Universal Asynchronous Receiver/ Transmitter), etc which all are in one single chip With Flash EPROM in micro control 89S51 chip, the advantages are the designing of a system basis on micro controller can be more cheap and easier.[3,5] Flash EPROM is loaded with programs include the instructions that will be compiled by the micro controller. Besides that, it can be reused for many times. It is a low power, high Performance CMOS, 8-bit; 40-pin microcontroller with 4K bytes of flash programmable and erasable read only memory (EPROM). The on chip flash allows the program memory to be rapidly reprogrammed using a non-volatile memory programmer. [2, 3]

B. Driver Unit

The L293 Motor Driver has 4 inputs to control the motion of the motors and two enable inputs which are used for switching the motors on and off. To control the speed of the motors a PWM waveform with variable duty cycle is applied to the enable pins. Rapidly switching the voltage between Vs and GND gives an effective voltage between Vs and GND whose value depends on the duty cycle of PWM. 100% duty cycle corresponds to voltage equal to Vs, 50 % corresponds to 0.5Vs and so on.[4] The 1N4004 diodes are used to prevent back EMF of the motors from disturbing the remaining circuit. Many circuits use L293 for motor control, we chose L298 as it has current capacity of 2A per channel @ 45V compared to 0.6 A @ 36 V of a L293D. L293D's package is not suitable for attaching a good heat sink; practically you can't use it above 16V without frying it. L298 on the other hand works happily at 16V without a heat sink, though it is always better to use one.

C. Amplifier Unit

In our project we are using LM 324 Integrated Circuit as an amplifier unit.

General Description

The LM324 series consists of four independent, high gains; internally frequency compensated operational amplifiers which were designed specifically to operate

from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the Power supply voltage. Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM324 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.[4]

Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage
- The unity gain cross frequency is temperature compensated
- The input bias current is also temperature compensated

Advantages

- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and VOUT also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

Features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 Db
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range: Single supply 3V to 32V or dual supplies ±1.5V to ±16V
- Very low supply current drain (700 µA) essentially independent of supply voltage
- Low input biasing current 45 nA (temperature compensated)
- Low input offset voltage 2 mV and offset current: 5 nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
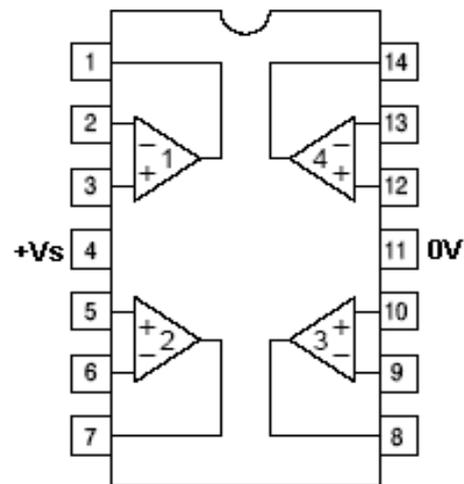- Large output voltage swing 0V to V+ − 1.5V

Figure 3 Pin Configuration of LM 324 amplifiers IC

D. Power Supply Unit

A battery is a type of linear power supply that offers benefits that traditional line-operated power supplies lack: mobility, portability and reliability. A battery consists of multiple electrochemical cells connected to provide the voltage desired. A nickel-cadmium battery has become more popular in recent years This battery cell is completely sealed and rechargeable. The electrolyte is not involved in the electrode reaction, making the voltage constant over the span of the batteries long service life. During the charging process, nickel oxide is oxidized to its higher oxidation state and cadmium oxide is reduced. The nickel-cadmium batteries have many benefits. They can be stored both charged and uncharged. They have a long service life, high current availabilities, constant voltage, and the ability to be recharged.

The Voltage Regulator 78xx (also sometimes known as LM78xx) series of devices is a family of self-contained fixed linear voltage regulator integrated circuits. The xx is replaced with a two-digit number, which indicates the output voltage the particular device is designed to provide (for example, the 7805 has a 5 volt output, while the 7812 produces 12 volts). The 78xx lines are positive voltage regulators, meaning that they are designed to produce a voltage that is positive relative to a common ground. [6]These devices typically support an input voltage which can be anywhere from a couple of volts over the intended output voltage, up to a maximum of 35 or 40 volts, and can typically provide up to around 1 or 1.5 amps of current .

E. IR Sensor Unit

Infrared radiation (IR) is electromagnetic radiation with a wavelength between 0.7 and 300 micrometers, which equates to a frequency range between approximately 1 and 430 THz. Its wavelength is longer (and the frequency lower) than that of visible light, but the wavelength is

shorter (and the frequency higher) than that of terahertz radiation microwaves. Bright sunlight provides an irradiance of just over 1 kilowatt per square meter at sea level. Of this energy, 527 watts is infrared radiation, 445 watts is visible light, and 32 watts is ultraviolet radiation. "Infra" meaning below our ability to detect it visually, and "Red" because this color represents the lowest energy level that our eyes can sense before it becomes invisible. Thus, infrared means below the energy level of the color red, and applies to many sources of invisible energy [8, 9].
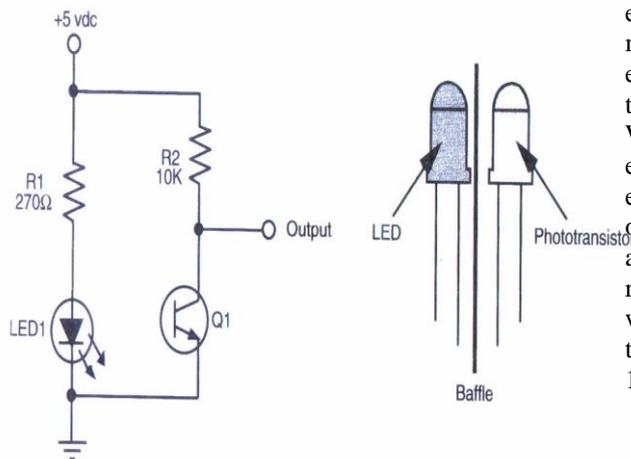

Figure 4 Basic design of the infrared proximity sensor [7]

TABLE1 SHOWS COMPARISON IN VARIOUS LIGHTS [8, 9]

Name	Wavelength	Frequency (Hz)	Photon Energy (eV)
Gamma ray	Less than 0.01 nm	more than 10 EHz	124 keV - 300+ GeV
X-Ray	0.01 nm to 10 nm	30 EHz - 30 PHz	124 eV to 124 keV
Ultraviolet	10 nm - 380 nm	30 PHz - 790 THz	3.3 eV to 124 eV
Visible	380 nm - 750 nm	790 THz - 405 THz	1.7 eV - 3.3 eV
Infrared	*750 nm - 1 mm*	*405 THz - 300 GHz*	*1.24 meV - 1.7 eV*
Microwave	1 mm - 1 meter	300 GHz - 300 MHz	1.24 μeV - 1.24 meV
Radio	1 mm - 100,000 km	300 GHz - 3 Hz	12.4 feV - 1.24 meV

F. *Stepper Motor*

A stepper motor (or step motor) is a brushless , synchronous electric motor that can divide a full rotation into a large number of steps. The motor's position can be controlled precisely without any feedback mechanism, as long as the motor is carefully sized to the application. Stepper motors are similar to switched reluctance motors.

Fundamentals of operation

Stepper motors operate differently from DC brush motors, which rotate when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor shaft turn, first one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are thus aligned to the first electromagnet, they are slightly offset from the next electromagnet .So when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a "step", with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle [2, 10].

Stepper motor characteristic

1. Stepper motors are constant power devices.
2. As motor speed increases, torque decreases. (most motors exhibit maximum torque when stationary, however the torque of a motor when stationary is of little use, torque is more important when the motor is actually spinning).
3. The torque curve may be extended by using current limiting drivers and increasing the driving voltage (sometimes referred to as a 'chopper' circuit, there are several off the shelf driver chips capable of doing this in a simple manner).
4. Motors with a greater number of phases also exhibit smoother operation than those with fewer phases (this can also be achieved through the use of a micro stepping drive.

III. **INTERFACING OF DIFFERENT HARDWARE SECTIONS**

Various interfacing between hardware is theirs. Mainly is interfacing with microcontroller with the amplifier IC, driver IC and amplifier with the sensor.

A. *Interfacing of microcontroller and amplifier IC*

There is 4 operational amplifier in LM 324(amplifier IC), which I use for amplification of IR sensor. Output of all 4 operational amplifiers is direct connected to the microcontroller serial port. Figure 5 show interfacing of 2

operational amplifiers with microcontroller. Output port 8 & 14 of amplifier IC is connected to the port P1.1 & P1.0. Led (D) is connecter to show the running status of the related output
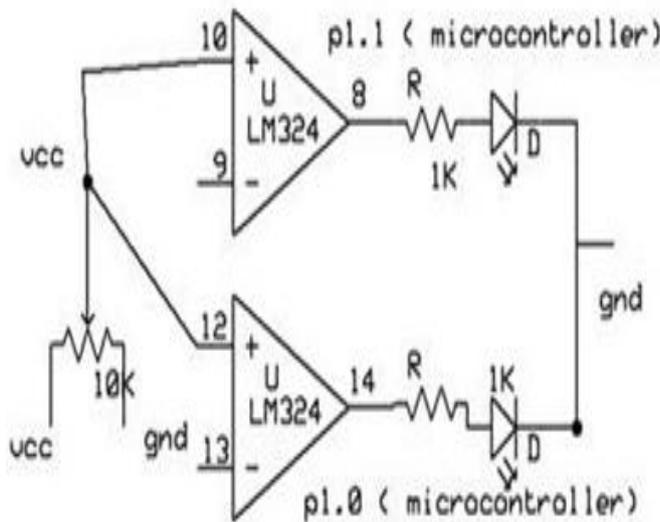

Figure 5 Interfacing Amplifier IC and microcontroller

B. *Interfacing driver IC and stepper motor*

Movement operations of both motors (left and right motors) showing in table 2.

TABLE-2 MOVEMENT OF BOTH MOTOR

Left Motor	Right Motor	Robot Movement
Straight	Straight	Straight
Stop	Straight	Left
Reverse	Straight	Sharp Left
Straight	Stop	Right
Straight	Reverse	Sharp Right
Reverse	Reverse	Reverse

The interfacing of driver (IC) and stepper motor or DC motor is shown in figure 6.
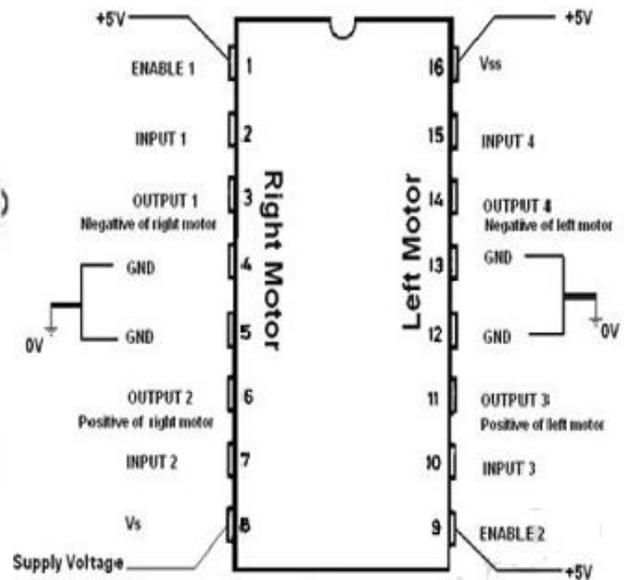

Figure 6 Interfacing driver IC and stepper motor[10]

C. *Interfacing IR sensor unit*

Output of sensor circuit is connected to the inverting end of operational amplifier for amplification and one led is connected to the op-amp out to show the status of sensor. Figure 7 shows the 2 pair of sensor unit interfacing with amplifier IC. All other sensor is connected as same this.
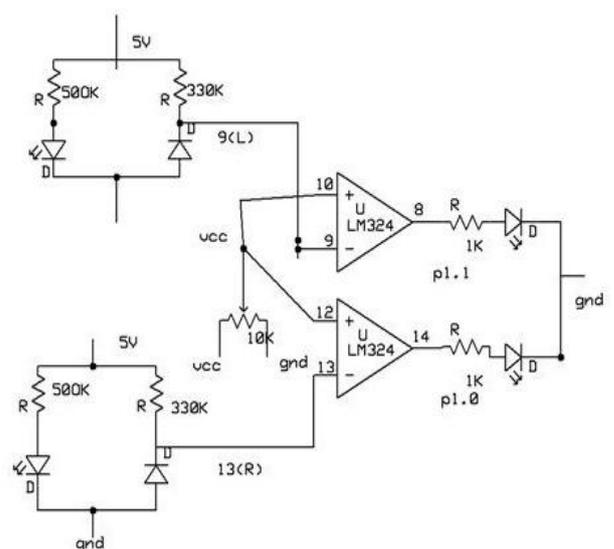

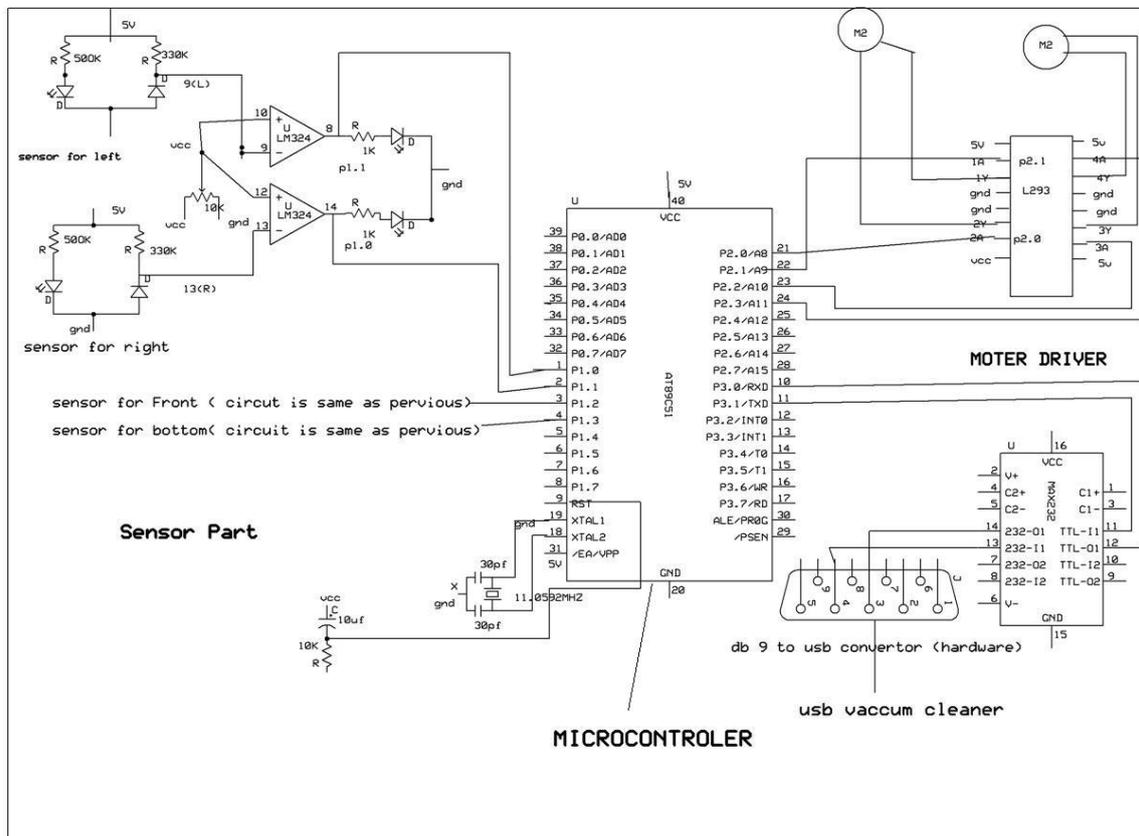Figure 7 Interfacing IR sensor unit with amplifier LM 324

Figure 8 Circuit diagram of microcontroller based Robo Cleaner

IV. SOFTWARE IMPLEMENTATION

A dedicated assembly language program for controlling the hardware is written into the flash memory of the microcontroller .which is then assembled using the assembler KEIL. The assembler checks the program for logical and syntax errors. Once the program has been checked for errors, a run command is issued that converts the assembled program into hex code. The microcontroller chip is then placed on a 40-pin flash programmer and the program is written into the flash memory in the form of a hex code [1]. The duration for valve actuation can be entered by the user using a 4x3 keypad. The microcontroller program checks whether robot detect any obstruct or not and movement of both motor is working or not. Once any IR sensor transmit signal, if receiver output is low (means receiver don't receive any signal) there is no any obstruct and if receiver output is high (means receiver receive any signal) and there is any obstruct and motor movement,

V. CONCLUSION AND DISCUSSION

The great advantage of course is that no longer do you have to worry about pushing or pulling a vacuum cleaner around the house, with the stress that often places on a bending back and shoulders. Neither now do you need to be constantly on the lookout for the right plug socket to plug in the vacuum cleaner and pulling the long mains lead out of the way of the vacuum cleaner constantly? Using a Robo Cleaner is as simple as placing it in the room that you want cleaned and telling it to go clean. The Robo cleaner works by a complicated algorithm which sends it about your room, and although it may take a while to do the job, it is not time that you have to set aside yourself, but you can let it do its own thing. Robo Cleaner is a versatile platform that allows developments of various applications. The modern structure, we can easily modify the possibility of functions and add some our new functions. The price the machine is a good choice for inventions and new applications in human life.

VI. REFERENCES

[1]   Shiwani Saini, C.R. Suri, "Design and Development of Microcontroller Based Auto Flow Assemble for Biosensor Application" International journal of computer application, Volume-6, number-1, September 2010, pp. 21- 27.

[2]   Muhammad Ali Mazzidi, Janice Gillespie Mazzidi: "The 8051 Microcontroller and embedded System", Pearson Education, PHI Publication, Chapter-01-09-05, pp- 25-223.

[3]   A   report   available   on   http:// www.ti.com/ds/symlink/lm324k.pdf

[4]   A   report   sheet   is   available   on http://www.datasheetcatalog.org/datasheet/texasinstruments/l293d.pdf

[5]   http://www.sinrace.com.cn/en/knowledge-base/323-battery-power-supply.html

[6]   Data available about the voltage regulator and specifications on http://srstansfield.com/electrical-engineering/hyperlinks/LinearDevices/78XX%20Voltage%20Regulators.htm

[7]   http://www.google.co.in/imgres?imgurl=http://www.pages.drexel.edu/~pyc23/IR_proximity_sensor.jpg&

[8]   Data and specifications of infrared sensors available on http://www.engineersgarage.com/articles/infrared-sensors

[9]   http://www.wisegeek.com/what-is-an-infrared-sensor.htm

[10]   http://www.absoluteastronomy.com/topics/Stepper_motor

[11]   A. Birk, "Fast robot prototyping with the cube system", In Proceedings of the IEEE International Conference on Robotics and Automation, 2004, pp. 5177-5182.

[12]   H. Bruyninckx. Open robot control software: the orocos project. In Proceed B. P. Gerkey, R. T. Vaughan, and A. Howard. The player/stage project: Tools for multi-robot and distributed sensor systems. In Proceedings of the Intl. Conf. on Advanced Robotics (ICARJ), 2003, pp. 317-323.

[13]   E. S ̇ahin, "Swarm robotics: From sources of inspiration to domains of application in Swarm Robotics", Springer, 2005, pp. 10-20.

[14]   Tariq Jamil, "Design and Implementation of a Parking Helper", Proceedings of the World Congress on Engineering and Computer Science, 2009.

[15]   Safia A. Kazmi, Rupendra K. Pachauri, "Design and Development of Microcontroller Based Ultrasonic Flaw Detector", International conference of business and technology education- ICBTE at IQRA University, Islamabad Pakistan. 2010.

[16]   Alessio Carullo and Marco Parvis, "An Ultrasonic Sensor for Distance Measurement in Automotive Applications", Senior Member IEEE, sensors journal, vol. 1, no. 2, August 2001, pp. 143-148.

[17]   Murugavel Raju, "Ultrasonic Distance Measurement with the MSP430" Application Report SLAA136A - October 2001, pp. 1-7.

[18]   Satish Pandey, Dharmendra Mishra, Anchal Srivastava, Atul Srivastava, R. K. Shukla:"Ultrasonic Obstruction Detection and Distance Measurement Using AVR Micro Controller", Sensors & Transducers journal, vol. 95, Issue 8, August 2008, pp. 49-57.

[19]   Yudhisther Kumar, Ashok Kumar and Rita Gupta: "Calibration of ultrasonic flaw detector", National Seminar of ISNT, Chennai, 2002, pp-1-7.

[20]   Mohamed Slim Masmoudi, Willie Tsui, Insop Song, Fakhreddine Karray, Mohamed Masmoudi, and Nabil Derbel, "Implementation of a Real-Time FPGA-Based Intelligent Parallel Parking System" -"Journal of Advanced Computational Intelligence and Intelligent Informatics", Vol.12 No.4, 2008, pp. 348-349.

[21]   ings of the 2001 IEEE International Conference on Robotics and Automation, 2001, pp. 2523-2528.

[22]   D. Floreano, S. Mitri, S. Magnenat, and L. Keller. Evolutionary Conditions for the Emergence of Communication in Robots. Current Biology, 2007, pp. 514-519.

BIOGRAPHY

Ankit Jain received the B. Tech degree at Department of Electronics Communication Engineering from UP Technical University, Lucknow, India, in 2010.

Rupendra Kumar Pachauri received the B. Tech (Merit Holder) degree from UP Technical University, Lucknow, India, in 2006, M. Tech (Hons.) degree at Department of Electrical Engineering from the ZHCET, Aligarh Muslim University, Aligarh, India, in 2009.

Avantika Rana received the B.Tech degree at Department of Electronic Communication from UP Technical University, Lucknow, India, in 2010. She is currently working toward the M. Tech degree at Department of Electronic Communication Engineering, Mahamaya Technical University, Noida, (INDIA).