

Android Based Roomba: A Prototype For Home And Office Automation.

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Abstract: This document provides information about the Roomba which has mechanism that allows to change its direction before it bumps into any obstacle and detect dirty spots on the floor and clean them. This paper provides practical approach towards building such robot which will work automatically. We have used Android technology and camera interface for manual control which is an extra feature not available in original Roomba. The following robot is first of its kind as we are adding extra features which will reduce the tedious process of floor cleaning. It uses IR-sensors to detect obstacles. Sensors detect obstacles like walls and edges and prevent the vacuum cleaner robot from hitting the objects in front. It's compact enough to clean the tightest corners, and it has an easy-to-empty reusable dustbin. No bags are required. An application in Android in association with camera is used for manual control of Roomba.

Key Words: Microcontroller 89S51, IR Sensor, Bluetooth Module BTM20, Bluetooth Controller, DC motor, VGA Camera, H-Bridge.

1. INTRODUCTION

Our team designed and built a vacuum cleaner robot which is equipped with an automatic robot to clean the floor by using 89S51 to control all the movement. Vacuum cleaner robot is a robot that is used to vacuum dust. The robotic vacuum cleaner will be placed in the corner of a dirty room with a fully charged battery and empty vacuum bag. The user will then turn on the robotic vacuum using the on/off switch. The robotic vacuum will begin to move forward and vacuum at the same time. It will progress throughout the room, beginning from the outer perimeter and ending in the center of the room. If an object is obstructing the path of the robot, it will detect and avoid with the use of its sensors. Once the robot completes the mission or the battery is running low, it will automatically shut-off at its current location. If the Robot misses any dirty spot then robot can be switched to manual mode to clean that dirty spot. Camera is used to if the user is in another room and from there he can manually control the robot through his Android based mobile which acts as remote control for robot.

2. RELATED WORK

The project can be divided into four parts that are Controller, IR sensor, Bluetooth unit and dc motor. The structure of robot is circular in shape with all the circuits mounted in circular box. For the output, the robot will move forward if no obstacle detected. If obstacle detected in the front by using IR sensor,

the robot will move right for 1 second and again right for 1 second. It will start moving in straight direction and when it again detects obstacle it will move left for 1 second and again left for 1 second. Thus, it covers room in Zig-Zag fashion.

The power of the system is coming from the 12V DC battery to give power to output like vacuum and power supply unit along with voltage regulator is used to give power to other units of robot.

3. MICROCONTROLLER 89S51

The AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4Kbytes of In-System Programmable Flash memory. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. The controller requires 11.0593 MHz clock frequency which is given by crystal oscillator. The controller consists of 4 ports designated with specific applications. Also the ROM holds the working algorithm of the robot. The controller conducts the working of the robot as per the predefined algorithm which decides the path, the intelligent actions when the robot comes in contact with obstacles; also it obeys to the control actions given from the keypad.

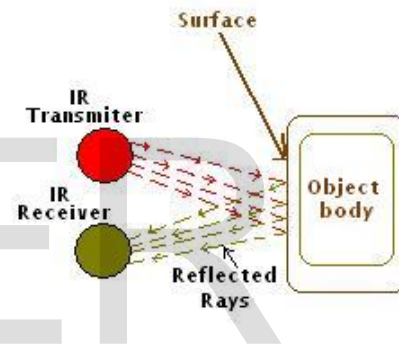
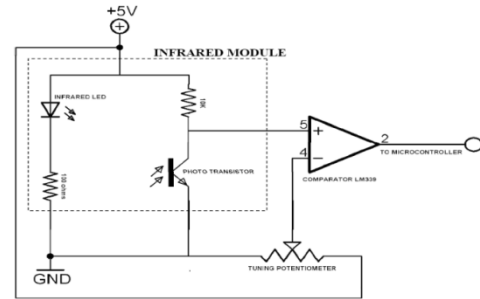
about 5mm. The sensor can measure in the range from 10-80 cm.

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BASCOM AVR IDE [2.0.5.0] [D:\BASCOM AVR\code\bas]
File Edit View Program Tools Options Window Help
code.bas
Sub Label
Dim T As Byte
Dim S As Bit
Dim D As Bit
Dim R As Bit
Port2 = 0
T = 2
Cls
Cursor Off
Lcd " (Sonabel)"
Lowerline
Lcd "At Your Service."
Wait 2
Cls
Lcd " (<-)"
Lowerline
Lcd "
Main:
S = P1 0
In = Inkey
If S = 1 And R = 0 Then
P2 = 0
P2 = 1
P2 = 1
Cls
Lcd " (<-)"
Lowerline
Lcd "
End If
If S = 0 And D = 0 And R = 0 Then
P2 = 0
P2 = 1
P2 = 1
Wait T
P2 = 0
P2 = 1
P2 = 1
Wait T
P2 = 0
P2 = 1
P2 = 1
Wait T
D = 1
    
```

COMPILED OUTPUT OF 89S51 IN BASCOM BASIC COMPILER

Detecting Obstacle with IR (Infrared) Sensor



4. IR SENSORS

Infra-Red emitter sends out IR pulses. Position calculation is done through intensity of reflected light received by the detector. . A Photodiode is a p-n junction or p-i-n structure. When an infrared photon of sufficient energy strikes the diode, it excites an electron thereby creating a mobile electron and a positively charged electron hole. If the absorption occurs in the junction's depletion region, or one diffusion length away from it, these carriers are swept from the junction by the built-in field of the depletion region, producing a photocurrent. Photodiodes can be used under either zero bias (*photovoltaic mode*) or reverse bias (*photoconductive mode*). Reverse bias induces only little current (known as saturation or back current) along its direction. But a more important effect of reverse bias is widening of the depletion layer (therefore expanding the reaction volume) and strengthening the photocurrent when infrared falls on it. There is a limit on the distance between I.R. L.E.D. and infrared sensor for the pair to operate in the desired manner. In our case distance is

The basic concept of IR(infrared) obstacle detection is to transmit the IR signal(radiation) in a direction and a signal is received at the IR receiver when the IR radiation bounces back from a surface of the object.

Here in the figure the object can be anything which has certain shape and size, the IR LED transmits the IR signal on to the object and the signal is reflected back from the surface of the object. The reflected signals is received by an IR receiver. The IR receiver can be a photodiode / phototransistor or a readymade module which decodes the signal.

Once the transmitter and receiver is complete, both should be placed at a certain angle, so that the obstacle detection happens in a proper way. This angle is nothing but the directivity of the sensor, which is generally +/- 45 degrees.

Also remember, that a thick enclosure is necessary for both IR transmitter and IR receiver, because the IR radiation may bounce back from the surrounding objects which may not help when you want to detect obstacle in one direction. Sometimes, if you don't have a thick enclosure then the signal may

directly reach the receiver even without having an obstacle. The enclosure can be made out of plastic or even metal material which is painted black in color.

5.1 SERIAL BLUETOOTH MODULE

This module enables you to wireless transmit & receive serial data. It is a drop in replacement for wired serial connections allowing transparent two way data communication. You can simply use it for serial port replacement to establish connection between MCU or embedded project and PC for data transfer. The Bluetooth module works on 3.3V level only. High voltage like 5V will permanently damage the module, so please take care in using it. Our application requires to be operated at 5V then use a LM1117-3.3 regulator to convert the 5V level to 3V3 level as required by module. Also protect the RXD pin against 5V TXD signal by inserting 1K resistor in series to module RXD pin.



5.2 CAMERA

This is a wireless web cam which is responsible for provision of live-footage of the area being scanned. The camera can send video for 12 hours non-stop. No duration limit when using the DC adaptor supplied. The camera can run 24-hours without overheating. Range of 100m "straight-line of sight" can go through walls. Resolution is 380 TV lines. Output power: 200mW.

5.3 REMOTE CONTROL

ANDROID APP-BLUETOOTH CONTROLLER

It is a module which is used by the house care taker to maneuver the robot according to the video data seen on the television which forms a crux part of the application of baby

monitoring and surveillance. The application called Bluetooth controller in Android based mobiles acts as remote control whose special combination executes the actions of moving the robot forward backward left and right, switching the robot to manual and automatic mode.

6. TELEVISION AND LCD FOR DISPLAY

Television unit used may be 14" one with color picture display tube. Output can be easily recorded with an ordinary VCR without the need for any other accessories. Liquid crystal Display (LCD) displays temperature of the measured element, which is calculated by the microcontroller. We use this display to check the output we get from controller 89S51.

- Display size: 16 character * 2 lines
- Internal automatic reset circuit at power ON.
- Built in oscillator circuit.

7. DC MOTOR

30 RPM DC Gear Motor is suitable for bigger robots and small automation systems. It has sturdy construction with large gears. Gear box is built to handle the stall torque produced by the motor. Drive shaft is supported from both sides with metal bushes. Motor runs smoothly from 4V to 12V and gives 30 RPM at 12V. Motor has 8mm diameter, 19mm length drive shaft with D shape for excellent coupling. This motor is bit noisy while running. Two 4Inch bore wheel thick wheels are used along with castor wheel for movement of robot.

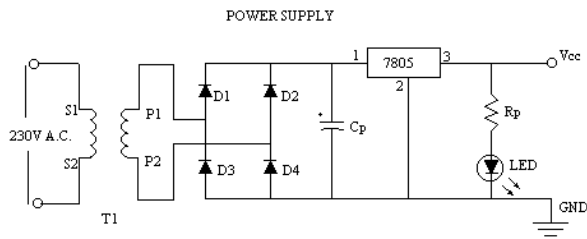
Specifications

- RPM: 30 at 12V
- Voltage: 4V to 12V
- Stall torque: 42.90 Kg-cm at stall current of 4.8 Amp
- Shaft diameter: 8mm
- Shaft length: 25 to 30mm
- Gear assembly: Spur
- Brush type: Carbon

➤ **Motor weight: 380gms**

8. REGULATED POWER SUPPLY

Power supply is the first and the most important part of our project. For our project we require +5V regulated power supply with maximum current rating 500ma.



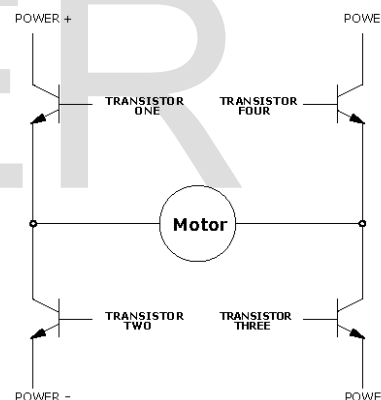
Step down transformer is the first part of regulated power supply. To step down the mains 230V A.C. we require step down transformer. Rectifier unit is a ckt. which converts A.C. into pulsating D.C. Generally semi-conducting diode is used as rectifying element due to its property of conducting current in one direction only.

We use full wave bridge type rectifier, in which four diodes are used. In each half cycle, two diodes conduct at a time and we get maximum efficiency at o/p. Generally a rectifier is required to produce pure D.C. supply for using at various places in the electronic circuit. However, the o/p of rectifier has pulsating character i.e. if such a D.C. is applied to electronic circuit it will produce a hum i.e. it will contain A.C. and D.C. components. The A.C. components are undesirable and must be kept away from the load. To do so a filter circuit is used which removes (or filters out) the A.C. components reaching the load. Obviously a filter circuit is installed between rectifier and voltage regulator. In our project we use capacitor filter because of its low cost, small size and little weight and good characteristic. Capacitors are connected in parallel to the rectifier o/p because it passes A.C. but does not pass D.C. at all. A voltage regulator is a ckt. that supplies constant voltage regardless of change in load current. IC voltage regulators are versatile and relatively cheaper. The 7800 series consists of three terminal positive voltage regulator. These ICs are designed as fixed voltage regulator and with adequate heat sink, can deliver o/p current in excess of 1A. These devices do not require external component.

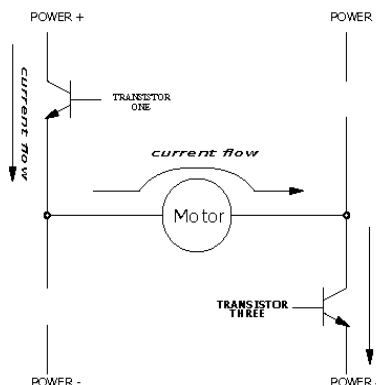
This IC also has internal thermal overload protection and internal short circuit and current limiting protection. For our project we use 7805 voltage regulator IC.

9. RESULTS

For vacuum cleaner robot, Proteus software was used to simulate the program. This project use IR sensor as a input to measure the distance and detect obstacle. Motors are high-powered devices in the world of digital electronics. A typical digital output can supply about 10 to 20 milliamperes (mA) of current a small permanent-magnet motor requires anywhere from 500 to 4000 mA of current. Special circuits are therefore required to drive motors



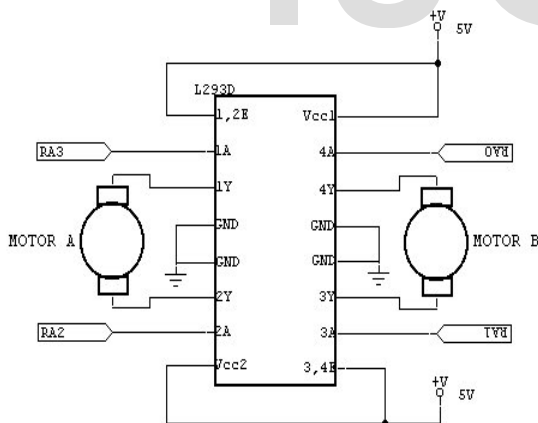
A circuit known as the *H-bridge* (named for its topological similarity to the letter "H") is commonly used to drive motors. In this circuit (depicted in Figure 1), two of four transistors are selectively enabled to control current flow through a motor.



As shown in Figure , an opposite pair of transistors (Transistor One and Transistor Three) is enabled, allowing current to flow through the motor. The other pair is disabled, and can be thought of as out of the circuit.

By determining which pair of transistors is enabled, current can be made to flow in either of the two directions through the motor. Because permanent-magnet motors reverse their direction of turn when the current flow is reversed, this circuit allows bidirectional control of the motor.

The L293D is a dual h-bridge driver IC. The IC is also referred to as a push-pull four channel driver. An h-bridge is ideal for driving motors. The L293D provides two h-bridges for driving both motors on the robot base. The motor direction is controlled by logic signals from the microcontroller. Two signals per motor are required to control the direction.



Motor Driver L293D

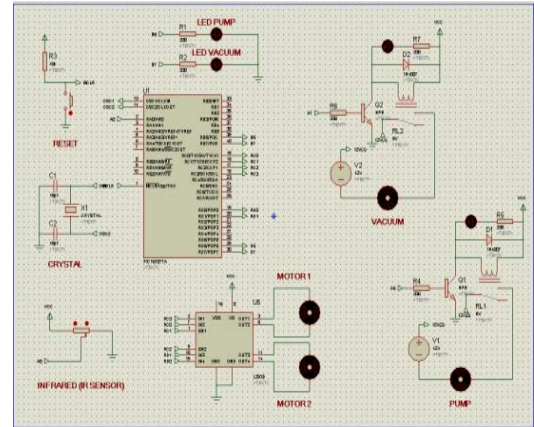


Figure 1: Circuit Diagram

When the IR sensor does not detect the obstacle, Motor 1 and Motor 2 will be forward to move the robot forward and the same time vacuum will be on .When the IR sensor detect obstacle Motor 1 and motor 2 will be off for 2 second. After 2 second, Motor 1 will be forward and motor 2 will be reverse to take turn for 2 second to allow the robot to u-turn.If IR sensor does not detect the obstacle, Robot will be function in normal condition.

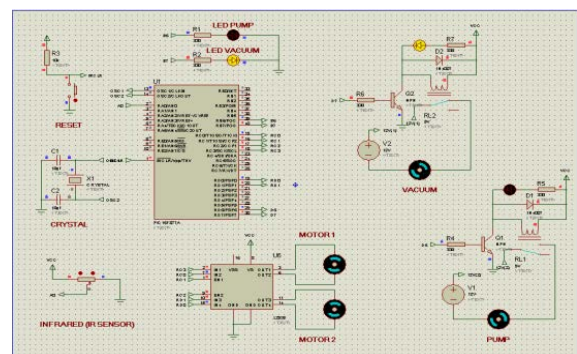


Figure 2: Simulate the program using Proteus

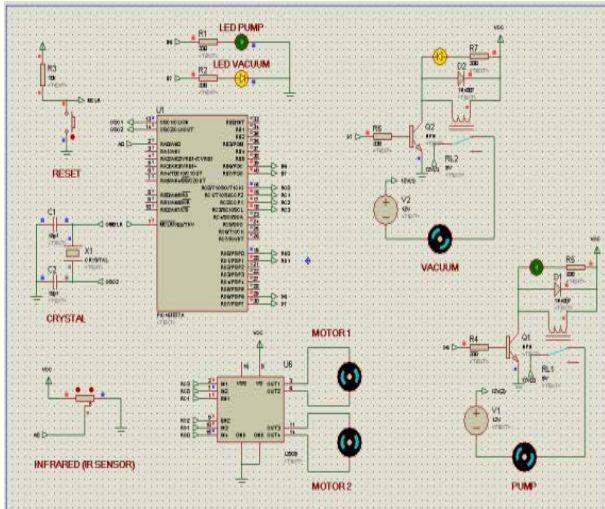


Figure 3: Vacuum on



Figure 5: Shows the finished project. Entire system is functioning accordingly. The sensors can detect the obstacle. The 89S51 also can control the output device correctly like vacuum and switching Robot to Manual control.

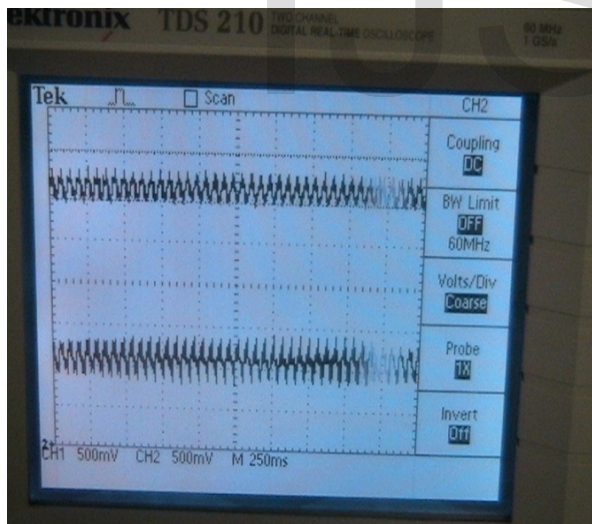


Figure 4: Figure shows Output Of Robot Movement. First waveform shows robot movement in zigzag pattern. Second waveform shows robot movement when obstacle is detected. We get higher amplitude when obstacle is detected.

10. CONCLUSION

After various challenges and obstacles, our project turned out to be a success. Every idea proposed in the proposal was successfully completed and functioned accordingly. We were able to demonstrate all of features and functions constructed and introduced in our vacuum cleaner robot. The automated Vacuum cleaner robot system was very efficient in performing the required functions for cleaning the floor. Since our robot essentially mimicked the random walk algorithm incorporated in the most common commercial automatic sweeper, the Roomba, we can say from experience that the electronics required to implement such a design were certainly within our ability to reproduce for this project. However, the mechanical aspects were very difficult to perfect in our rough prototype. Since commercial robots are manufactured from robust materials it is no surprise that they would probably be more reliable than our home made sweeper robot.

11. ACKNOWLEDGEMENTS

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