**ECE 511: MICROPROCESSER**

A Project Report on

# Autonomous Ultrasonic Robot for Area Scanning (A.U.R.A.S)

Under the guidance of Prof. Jens Peter Kaps

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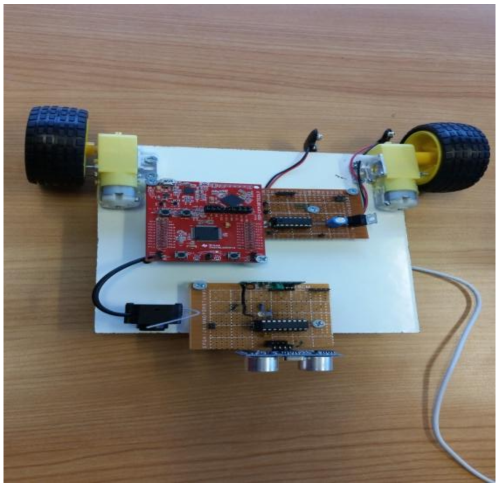


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# ABSTRACT

A.U.R.A.S (Autonomous Ultrasonic Robot for Area Scanning) is an intelligent robot that has the ability to operate autonomously as well as manually. The motivation for building an obstacle avoidance robot came from the fact that our team wanted to build something that is useful in the real environment and at the same time is fun and entertaining to use. We have tried to encapsulate the various exciting features of MSP430 in A.U.R.A.S.

The Autonomous Ultrasonic Robot for Area Scanning is built around a 16 bit microcontroller for fast and reliable operation. The aim of our project is to develop a robot that can operate autonomously and can also be controlled manually by the user through voice commands and push buttons respectively. Geared motors are used for the movement of the robot. The robot has the capability of navigating and tracking the obstacles through the use of ultrasonic sensors and it can effectively explore the area by capturing the visuals on the way through a wireless camera. Depending on the distance between the robot and the obstacle, the robot has the capability to halt and turn. The robot moves in any direction in response to the commands from the user.

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# 1. INTRODUCTION

## 1.1 MOTIVATION

The urge of human beings to make devices function autonomously is in vogue and is growing ever since their use. Time is of great essence in the 21st century and with A.U.R.A.S this requirement is appropriately accomplished. We wanted to build something that had practical applications and at the same time, fulfils the project requirements of ECE 511. The idea of the project came from the movie 'The Hurt Locker'. In the movie, the military made use of a robot to detect the bombs which is used to save human lives by using the robot as a First Response Unit. Likewise, A.U.R.A.S is capable of scanning the area for surveillance with real time video transmission. It can also be used as a fun toy for the kids.

## 1.2 SOLUTIONS

Keeping in mind the level of complexity allowed for the project, we tried to design A.U.R.A.S in a way so that it could utilize the maximum resources available on MSP430. The design for the A.U.R.A.S is represented in the form of two block diagrams as shown in figures 1 and 2. The various operations of the A.U.R.A.S is divided into different blocks which are then integrated and interfaced to the MSP430 with respect to their functionalities to achieve a fully operating obstacle avoidance robot. In the front end, the ultrasonic sensors are interfaced to achieve the ability of obstacle avoidance. The motion capability is achieved by interfacing the geared motors through L293D drivers at the rear end of the robot, thus making it a two wheel rear end drive. The wireless camera is attached in the front end of the robot to scan the surroundings.

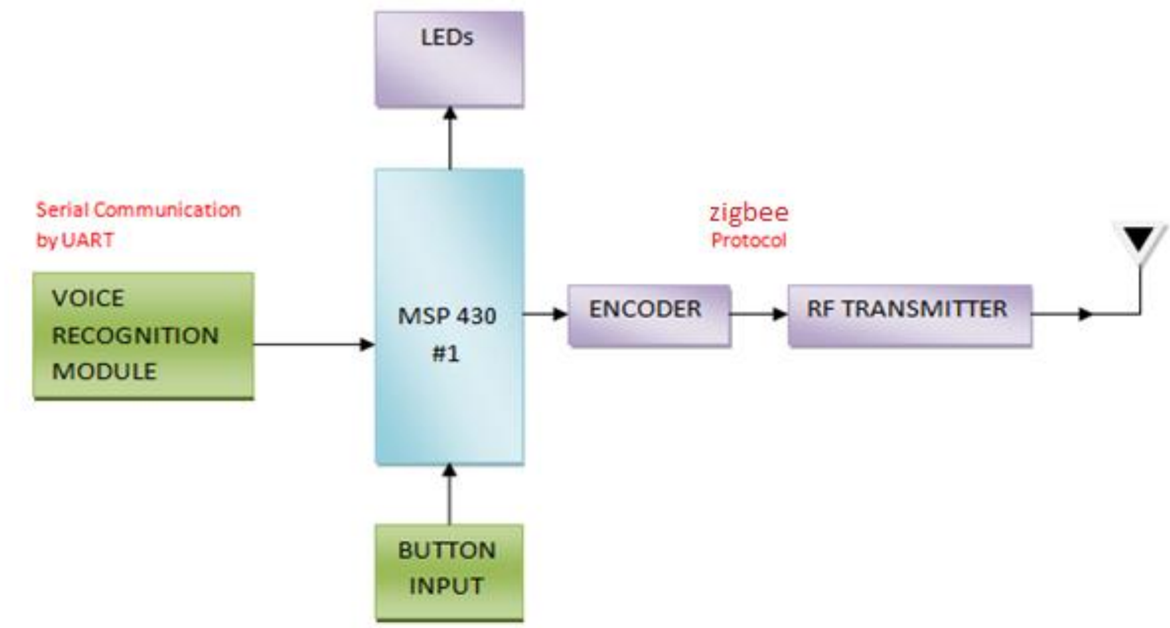


Figure1.Block Diagram1: Handheld Controller

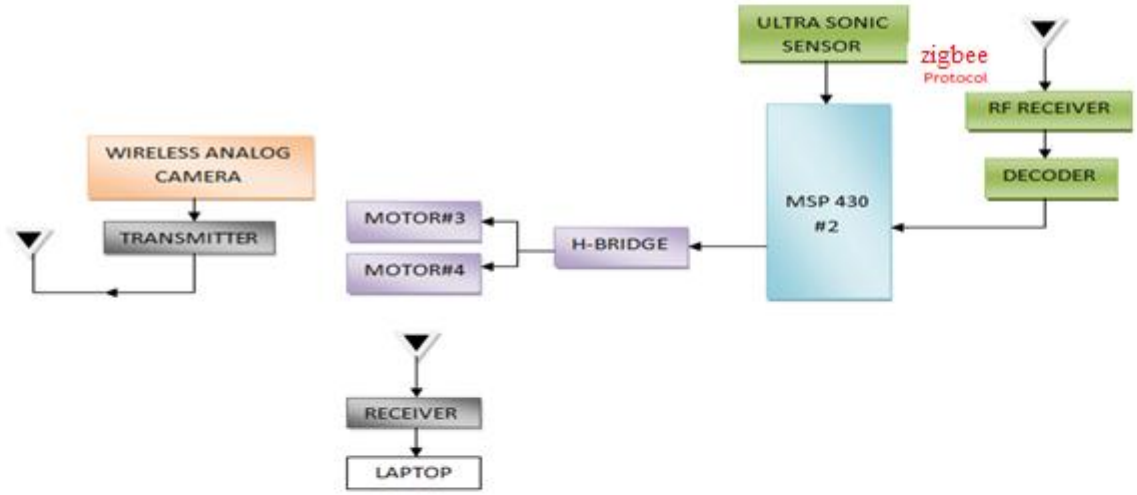


Figure2. Block Diagram 2: A.U.R.A.S

## 2. COMPONENTS DESCRIPTION

### 2.1 MSP430F5529 MICROCONTROLLER

The Texas instruments MSP430 belongs to an ultra low power microcontroller family. The device features a powerful 16 bit RISC CPU, 16 bit registers and constant generators that contribute to maximum code efficiency. The MSP430F5529 has 16 bit timers, 12 bit ADC, two USCI, hardware multiplier, DMA, real time clock and 63 I/O pins. It has a low supply voltage of 3.6V. It has 25 MHz clock frequency and 128 KB of programmable memory.

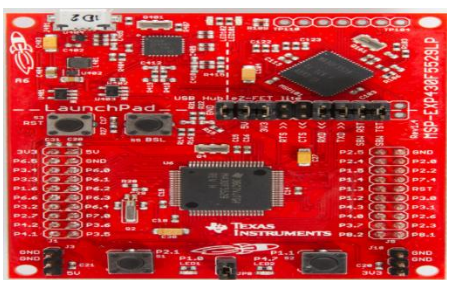

Figure3. MSP430F5529LP

### 2.2 ULTRASONIC SENSORS:

Ultrasonic ranging module HC-SR04 detects obstacles at the range from 2cm to 400 cm. The ranging accuracy can reach up to 3mm. It includes ultrasonic transmitter, receiver and control circuit. There are four pins in the module Vcc, Trigger, Echo, GND which make it very easy to interface it with the microcontroller. The module automatically sends a 40 KHz signal through the trigger pin and detects weather there is a pulse signal back. In case of obstacle detection, the reflected signal sets the echo pin high and thus the distance of the obstacle from the robot can be measured through the following formula:

Distance (obstacle from the robot) = Time (from trigger to echo pin= high) x speed of sound m/s) / 2

#### 2.2.1 HARDWARE INTERFACING

The trigger pin and echo pin of the ultrasonic sensor are connected to P8.1 and P8.2 pins of the MSP430 respectively. The P8.1 is configured as output pin whereas the P8.2 is configured as input pin. The ultrasonic sensor is given an external power supply of 5V.

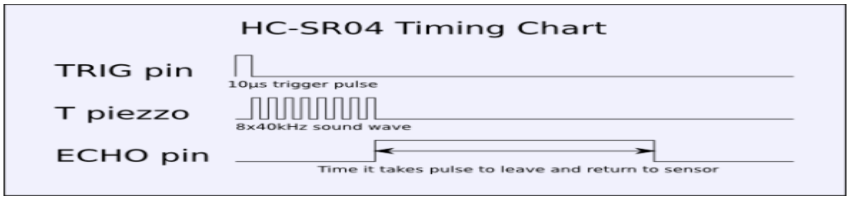



Figure4. HC-SR04 Timing Chart

Figure 5. Ultrasonic sensor

### 2.2.2 SOFTWARE INTERFACING

An internal timer of MSP430 is used to generate a 10µs PWM signal required to drive the trigger pin of the ultrasonic sensor. Ultrasonic pulses are generated which are received by the echo pin after a certain time duration when there is an obstacle in front. Using the earlier mentioned formula the distance is calculated. A software routine repeatedly checks if the distance becomes less than 20cm. The MSP430 is programmed to stop and turn the motors in case the distance between the obstacle and the robot becomes less than 20cm.

## 2.3 GEARED MOTORS

The electronic motors have an operating voltage ranging from 3V to 12V DC, maximum torque of 800g.cm at 3V. It operates at 170 RPM at 3V. The geared motor shown in figure 6 has a reduction ratio of 1:48. The motors are driven by L293D H-bridge IC.

Figure6. Geared motor

## 2.4 L293D H-BRIDGE IC

L293D is a dual H-Bridge motor driver integrated circuit. The L293D is used as a current amplifier as they take low current signals from MSP430 and provides sufficiently high current signals for driving the motors. The L293D circuit contains two built in H-bridges which are respectively used to connect two motors. The H-bridges are capable of driving the motors bi-directionally (forward and reverse direction).

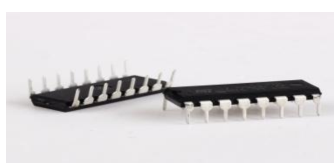

Figure7. L293D motor driver

### 2.4.1 HARDWARE INTERFACING

The enable pins of L293D are connected directly to 5V supply to always keep the H-bridges in enabled mode. The four input pins are connected to P2.4, P1.5, P1.4 and P1.3 respectively. The two motors are connected to the output pins of the L293D. L293D is powered by a 12V external power supply.

### 2.4.2 SOFTWARE INTERFACING

P2.4, P1.5, P1.4 and P1.3 are configured as input pins in the MSP430. By turning the input pins of L293D high and low the motors can be turned in the desired direction. The table 1 represents the logic that is used to turn the motors.

| DIRECTION | P2.4 | P1.5 | P1.4 | P1.3 |
|---|---|---|---|---|
| UP | HIGH | LOW | HIGH | LOW |
| DOWN | LOW | HIGH | LOW | HIGH |
| RIGHT | LOW | LOW | HIGH | LOW |
| LEFT | HIGH | LOW | LOW | LOW |
| STOP | LOW | LOW | LOW | LOW |

Table1. Logic for driving the two electronic motors

### 2.5 PUSH BUTTONS and LED's

The push buttons shown in the figure 8 have a momentary contact. They have four pins two of which are internally shorted. When the button is pressed the two pins are bridged together. It has a bouncing time of 10ms. 2mm LED's as shown in figure 9 are used across the output of the push buttons. They are used to signify that the button has been pressed. Power required is taken directly from the MSP430.

Figure8. Push buttons

Figure 9.LED's with resistors

#### 2.5.1 HARDWARE INTERFACING

A total of six push buttons are used and are connected to P3.0, P3.1, P2.6,P2.3, P8.1 and P8.2 respectively. 0.1 µf capacitors are connected across the push buttons to provide hardware de-bouncing. The push buttons are connected in source mode.

#### 2.5.2 SOFTWARE INTERFACING

The above mentioned pins are configured as input pins in the MSP430. When a push button is pressed a high signal is obtained across the corresponding pin of the MSP430. A routine in the MSP430 constantly checks which pin of the MSP430 goes high when the button is pressed and the corresponding command is executed.

### 2.6 VOICE RECOGNITION MODULE

The V2 voice recognition module shown in figure 10 has 15 commands in total which are divided into three groups. To use the voice recognition module, the group of choice is imported prior to the execution of the commands. If commands on other group are to be executed, then that group should be imported first. This is a speaker dependent voice module i.e. it can be operated only by the person who trained the module.

Figure10. Voice Recognition Module V2.0

#### 2.6.1 HARDWARE INTERFACING

The V2 voice recognition module interacts with the MSP430 serially via the UART port. In this project, the second UART port of MSP430 is used as the first UART port was used for debugging. 5V power supply is taken for the V2 voice recognition module directly from the MSP430.

### 2.6.2 SOFTWARE INTERFACING

The V2 voice recognition module is initialized to compact mode by passing the command AA37 and then command AA21 is used to import group 1 of the voice recognition module. The data from the voice recognition module is sent in hexadecimal form to MSP430. When a pre-programmed voice command is received by the voice recognition module it sends hexadecimal command ranging from 0x11 to 0x15. A.U.R.A.S recognizes only three voice commands. They are EXPLORE, LOOK and STOP.

## 2.7 TRANSMITTER AND RECEIVER

Generally, Serial Communication is used to transmit data between the transmitter and microcontroller using UART, whereas A.U.R.A.S uses the input/output pins of MSP430 to transmit the data in parallel. This is achieved by using an encoder and decoder. The transmitter and receiver which are used, operate on a voltage of 3V-12VDC and draw a current of 20-28mA. The transmitter can transmit signals up to 500m.

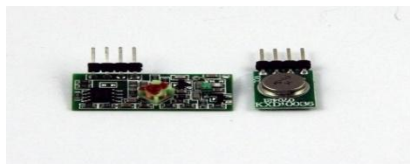

Figure 11. Encoder HT-12E    Figure 12. Transmitter and receiver RF link    Figure 13. Decoder HT-12D

### 2.7.1 HARDWARE INTERFACING

To provide a secure channel, an encoder and decoder (HT12E and HT12D) are interfaced to transmitter and receiver respectively. The encoder encodes and converts the parallel data from the MSP430 into serial data. This serial data is transmitted by the transmitter at 315MHz which is received by the receiver. The received serial data is decoded and converted back to parallel data and given to the MSP430. The encoder uses P1.3, P1.2, P1.5 and P1.4 of the microcontroller for its input. The received data is decoded and sent to pins P1.2, P4.3, P4.0 and P3.7 of the second MSP430.

### 2.7.2 SOFTWARE INTERFACING

In the handheld controller, a routine is written which sends parallel data to the encoder based on the button press or input voice commands. A.U.R.A.S also has a similar routine which accepts the data from the decoder and executes the corresponding commands. An IF conditional statement is used for this purpose. The data sent and received for the various commands are shown in Table 2.

| **COMMAND** | EN1/DE1 | EN2/DE2 | EN3/DE3 | EN4/DE4 |
|---|---|---|---|---|
| **MANUAL** | HIGH | LOW | LOW | HIGH |
| **AUTO MODE** | HIGH | HIGH | HIGH | HIGH |
| **UP** | HIGH | LOW | LOW | LOW |
| **RIGHT** | LOW | HIGH | LOW | LOW |
| **DOWN** | LOW | LOW | HIGH | LOW |
| **LEFT** | LOW | LOW | LOW | HIGH |
| **EXPLORE** | HIGH | HIGH | LOW | HIGH |
| **LOOK** | HIGH | HIGH | HIGH | LOW |
| **STOP** | HIGH | HIGH | LOW | LOW |

Table2. Truth table for encoder and decoder

**2.8 WIRELESS CAMERA**

The wireless camera is mounted on the robot that enables it to capture the visuals of its surroundings, so that the robot can be efficiently used for the surveillance purpose.

Figure14. Wireless mini CCTV camera

## 3. RESULTS

### 3.1 LESSONS LEARNED

a) Generating PWM pulses for ultrasonic sensors.

b) Voice recognition module is not ideal for noisy environments.

c) It is always better to provide an encoder and decoder to create a secure channel for RF communication.

d) It is not the voltage requirement of every component alone that matters but the entire power requirement of the circuit.

### 3.2 SHORTCOMINGS

Initially, we were using high torque motors for the movement of the A.U.R.A.S but couldn't get the wheels that could be attached to these motors. Consequently, we had to buy motors that were compatible with the wheels due to which we had to compromise on the torque.

### 3.3 CONCLUSION

Our project A.U.R.A.S is completed as per proposed and it overcomes all the challenges that were faced during its completion. It is able to operate successfully in manual as well as in autonomous mode. Through the use of a wireless camera, we were able to achieve surveillance from a safe distance.

## 4. BIBLIOGRAPHY

**http://www.trollmaker.com/?article3/arduino-and-hc-sr04-ultrasonicsensor**
**http://www.ti.com/product/msp430f5529**
**https://www.youtube.com/watch?v=PZ88GRXf578**

## APPENDIX A: TASK DIVISION

Devaraj : Interfacing voice recognition module, push buttons and LED's with MSP430

Ankita : Interfacing RF link module with MSP430

Gagandeep : Interfacing H-bridge and motors with MSP430

Nikhila : Interfacing Ultrasonic sensors with MSP430

## APPENDIX B: PART LIST

| PART | QUANTITY | VENDOR |
|---|---|---|
| Ultrasonic Sensor | 1 | Amazon.com |
| Geared Motor | 2 | Amazon.com |
| RF link | 1 | Amazon.com |
| Voice Recognition module | 1 | Cutedigi.com |
| Push buttons | 6 | Amazon.com |
| LED | 6 | Amazon.com |
| Resistors | 6 | Amazon.com |
| Capacitors | 6 | Amazon.com |
| Pin headers | 40 | Amazon.com |
| Single dot prototype board | 4 | Amazon.com |
| Mini wireless CCTV Camera | 1 | Amazon.com |

## APPENDIX C: SCHEMATIC DIAGRAMS

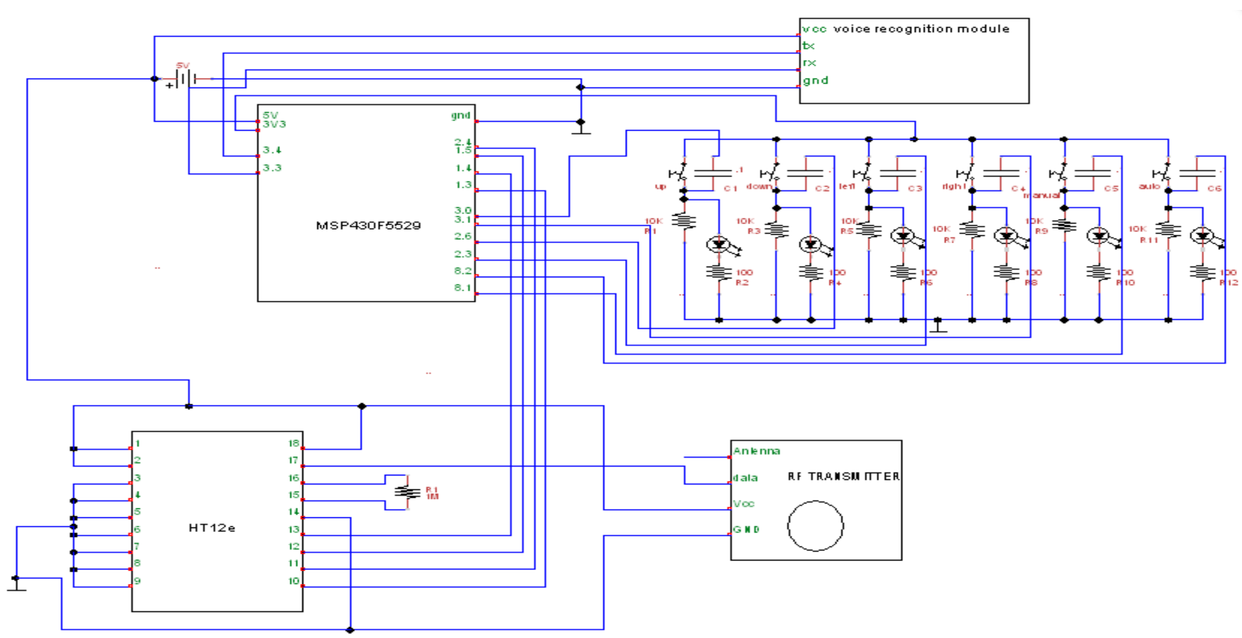


**Figure1. Schematic Diagram for Handheld Controller**

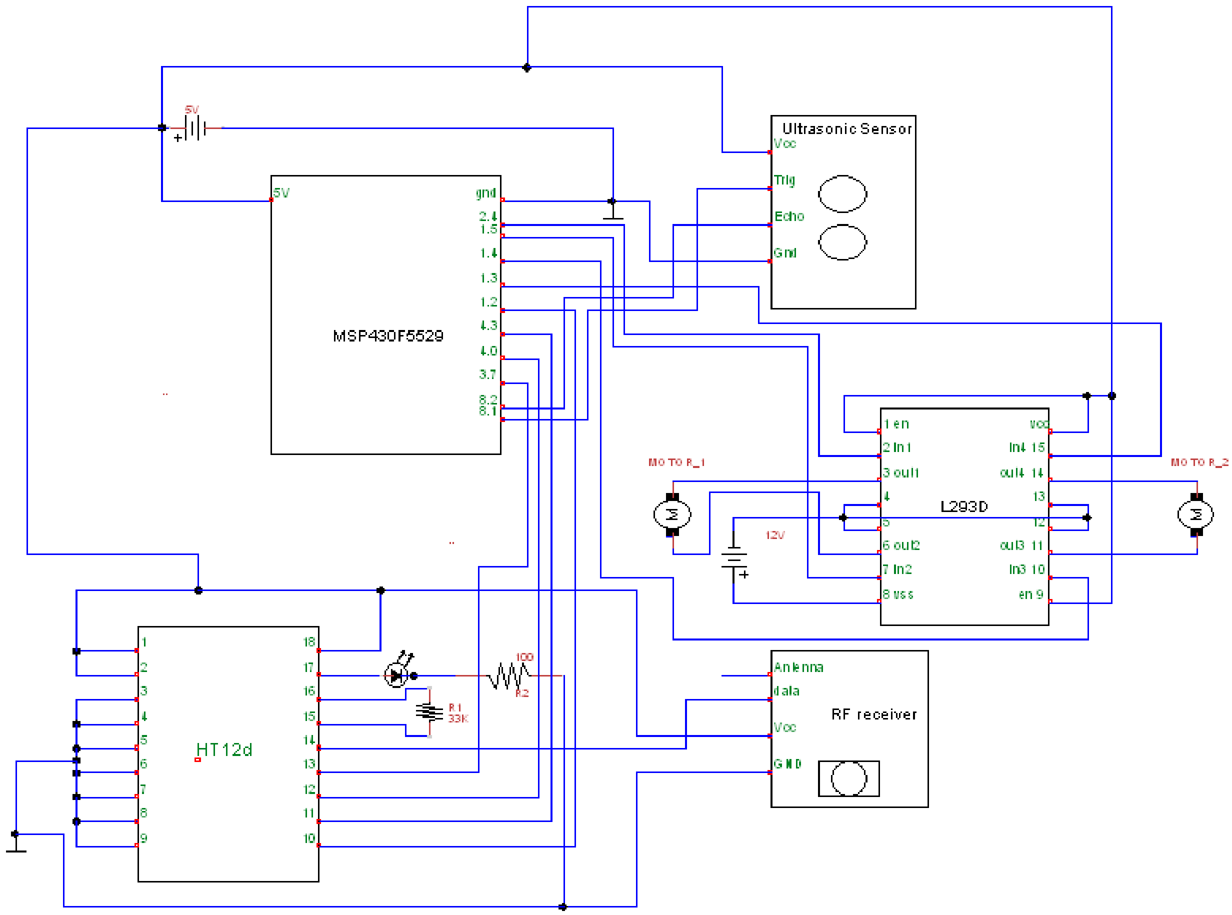


**Figure2. Schematic diagram for A.U.R.A.S**