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Design And Implementation Of Dual Band Antenna Based Unmanned Vehicle For Search And Rescue Operations

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Abstract-In the event of large crisis, a primordial task of the search and rescue services is the searching for human survivors on the incident site, which is a dangerousand complex and task. The remotely operated Search and Rescue (SAR) robots offers a valuable tool to save human lives and to speed up the searchand rescue process. The Small Unmanned Ground Vehicle is designed to enter small enclosures, hazardous environments and Urban SAR operations such as location and positioning of victims trapped in structural collapse, mines and tragic accidents.

A new dual band antenna is designed and implemented for GPS and GSM frequencies (1.2 GHz and 2.1 GHz), which is used for communication and navigation of Unmanned Vehicle. The GSM module connected can do the required tasks like locomotion of an unmanned vehicle in all the directions and location of victims through camera by sending commands from cell phone. Digital camera module updates the surrounding location to the user. Temperature and Humidity sensor detects the temperature and humidity of surroundings. GPS module present in GSM module will help to locate the survivors and live location of UGV. In case of disaster, temperature and humidity values exceed threshold values. The results obtained show that the unmanned vehicle could locate the victims through proper human-machine interaction.

Keywords— Dual band micro-strip circular patch antenna, Global System for Mobile communication (GSM),Global Positioning System (GPS), unmanned ground vehicle (UGV)and search and rescue (SAR)

I. INTRODUCTION

Unmanned ground vehicles (UGVs) are robotic systems that operate on land without an onboard human operator. They are used for a wide variety of civilian and military applications, particularly in environments that are hazardous or unpleasant to humans and for tasks that are difficult, dull or pose unacceptable risks. UGVs are used for a wide range of civilian applications such as urban search and rescue, fire-fighting, nuclear plant operations, crowd control and agricultural spraying and harvesting.

A Micro-strip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. The GSM module used in this project has in-built helical antenna which supports quad band applications i.e., the antenna operates at four different frequencies (850 MHz, 900 MHz, 1.8 GHz, 1.9 GHz). This antenna is replaced by designed dual band circular patch micro-strip antenna for GSM/ GPS applications (1.2 GHz and 2.1 GHz).

II. LITERATURE SURVEY

The Defence and Security Symposium, Unmanned Systems Technology VIII, 2006, suggest that autonomous UGVs are still new and quite expensive. A user controls the UGV using tele-operations sends commands to the UGV remotely from the relative safety and comfort of a control station . This semi-autonomous UGV is mainly used to explore theremote places where human interference is least and check the surrounding environment for further detailed research [1].

In the paper published at Institute of Electronics and Electrical Engineering, 2011, a versatile UGV is designed which leverages the existing GSM mobile telephony network establishesa long range, secure, fast and reliable connection with the remote base station is presented. The camera is also used to send the visual information back to the base station in real-time, allowing accurate control of and monitoring over long distances [2].

In the paper published at International conference on unmanned aircraft system, 2016, the discussion is on the cooperative forest monitoring using UAV and UGV where the UAV will detect the forest fire and send the location coordinates to UGV which reaches the designated location by shortest possible path. This project utilizes this idea without UAV support [3].

III. OVERVIEW

This paper is divided into following sections: section IV describes the implementation of the project, block diagram, circuit diagram; section V explains about methodology and flowchart; section VI describes the experimental results of the project, section VII describes the conclusion and further enhancements of the work.

IV. IMPLEMENTATION

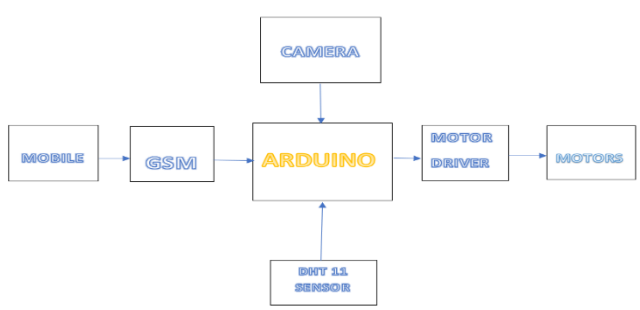

Figure 1: Block diagram of proposed system

Overall block diagram of the model as shown in the figure 1. The user uses the mobile phone to give commands to the unmanned ground vehicle. The GSM module present in the mobile phone sends the commands through Short Messaging Services (SMS) to the GSM module present in the unmanned ground vehicle. Here, the GSM module itself acts as a basic mobile phone.

The commands from the user are obtained from the dual band circular patch micro-strip antenna which is connected to the GSM module of the unmanned ground vehicle. These commands are sent to the ATMEGA328P microcontroller present in Arduino board. The direction and speed of the unmanned ground vehicle is controlled by motor through commands given by the user. The temperature and Humidity sensor senses the surrounding temperatures and humidity and updates the user for every 10 seconds. The digital camera module provides continuous live stream and images of the surrounding regions of the unmanned ground vehicle.

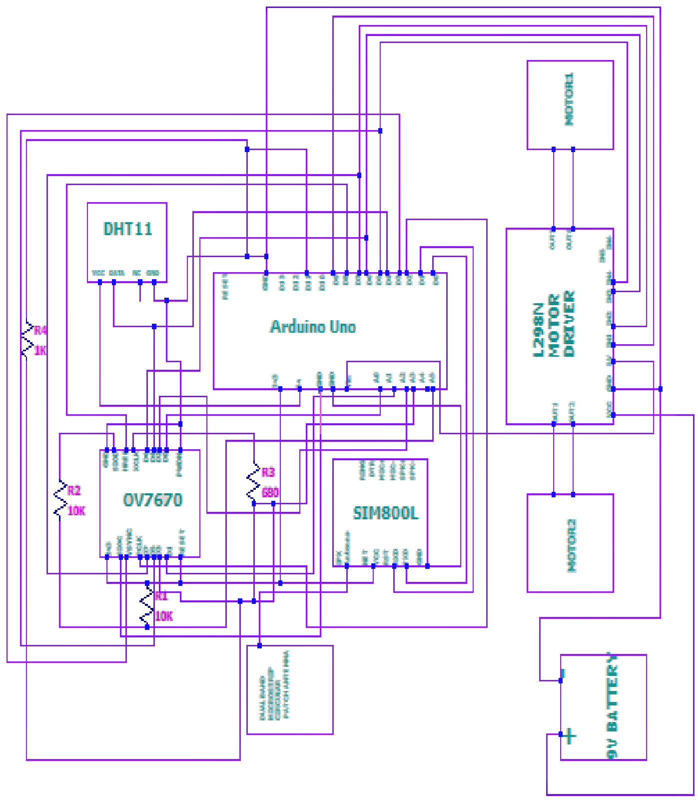

Figure 2: Circuit diagram of the proposed system

The circuit diagram of the proposed system is as shown in the figure 2. The best way to control DC motors is to interface L298N Motor Driver with Arduino. VCC pin supplies power for the motor. IN1, IN2 and IN3, IN4 pins are used to control spinning directions of Motor A and Motor B. OUT1, OUT2 pins are connected to Motor A and OUT3 & OUT4 pins are connected to Motor B.The SIM800L module has total 12 pins whereNET is a pin in which the designed Dual band micro-strip circular patch antenna is attached along with the module. Vcc supplies power for the module. RxD (Receiver) pin is connected to D0andTxD (Transmitter) pin is connected to D1. GND is connected to GND pin on the Arduino.

In temperature and humidity sensor, VCC pin is connected to 5V of Arduino.Data pin is connected to D5 pin of microcontroller. GND should be connected to the ground of Arduino.The camera module is powered by 3.3V supply provided by the 3.3V pin in Arduino. The 8-bit RGB video component digital outputs (D0-D7 pins) are connected to A0-A4 and D4-D7 pins of the microcontroller.

V. METHODOLOGY

A basic micro-strip antenna consists of Substrate, Feed-line, Patch, Ground Plane and Radiation Box. The dimensions of these parameters is calculated using the following formulas.The effective dielectric constant of micro-strip antenna is calculated using the equation(1):

$$\epsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}[1 + 12\frac{h}{W}]^{-1/2}, \frac{W}{h} > 1 \text{...... (1)}$$

Where W= width of the substrate
h= height of the substrate (i.e. 2mm for FR4 substrate)
The circular patch radius and effective radius is calculated using the equation:

$$R= \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{-1/2}} \text{............... (2)}$$

$$\text{where } F = \frac{8.791\times10^{9}}{f_{r\sqrt{\varepsilon r}}} \text{.......................... (3)}$$

fr= resonant frequency
h= height of the substrate
εr= dielectric constant of the substrate (4.4 for FR4 material)

(1) (2) and (3) equations are used to calculate design parameters of the proposed antenna using εreff, R, fr values. The dimensions of the dual band circular patch micro-strip antenna are mentioned in the Table 1.

Table 1: Design Parameters of Dual band Micro-strip circular patch antenna

Design Parameter	X axis	Y axis	Z axis
Substrate	90mm	90mm	2mm
Feedline	1.8mm	20mm	0
Ground	90mm	90mm	0
Lumped Port	1.8mm	0	-2mm
Radiation Box	100mm	120mm	50mm
Slot 1	5mm	15mm	0
Slot 2	5mm	25mm	0
Slot 3	5mm	20mm	0

The rectangular slots added to the circular patch are unsymmetrical in nature. Using the above dimensions, an antenna model is designed using ANSYS HFSS v13.0 software as shown in the figure 3.

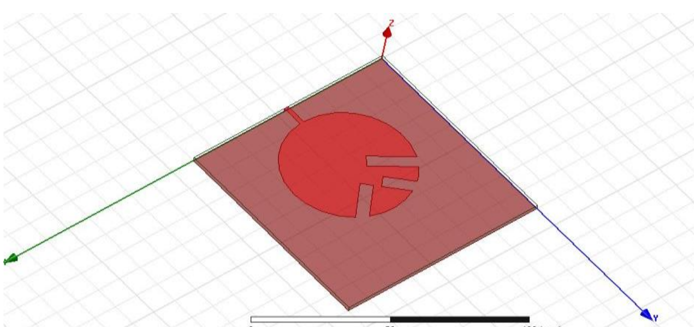

Figure 3: Antenna Model

Dual band antenna is designed based on the micro-strip line feed where feed is given at the end of the substrate.Antenna works at two different frequencies for GPS and GSM frequencies i.e. 1.2 GHz and 2.2 GHz. Unsymmetrical slots are used to obtain Multiband frequencies and better gain. The antenna is optimized to its antenna parameters for GPS (1.2 GHz) and GSM (2.1 GHz). Fabrication of designed antenna is carried out using FR4 substrate.The antenna parameters such as VSWR, return loss, reflection coefficient can be calculated using the equations below:

$$\text{VSWR} = \frac{1+\tau}{1-\tau} \qquad (4)$$

$$\text{Reflection coefficient} = -20\log_{10}(\tau) \qquad (5)$$

$$\text{Return loss} = -10\log_{10}(1-\tau^2) \qquad (6)$$

where τ = signal reflected back in the transmission line
(4) (5) and (6) equations are used to calculate antenna parameters which help in estimating the result values before simulation of the designed antenna.

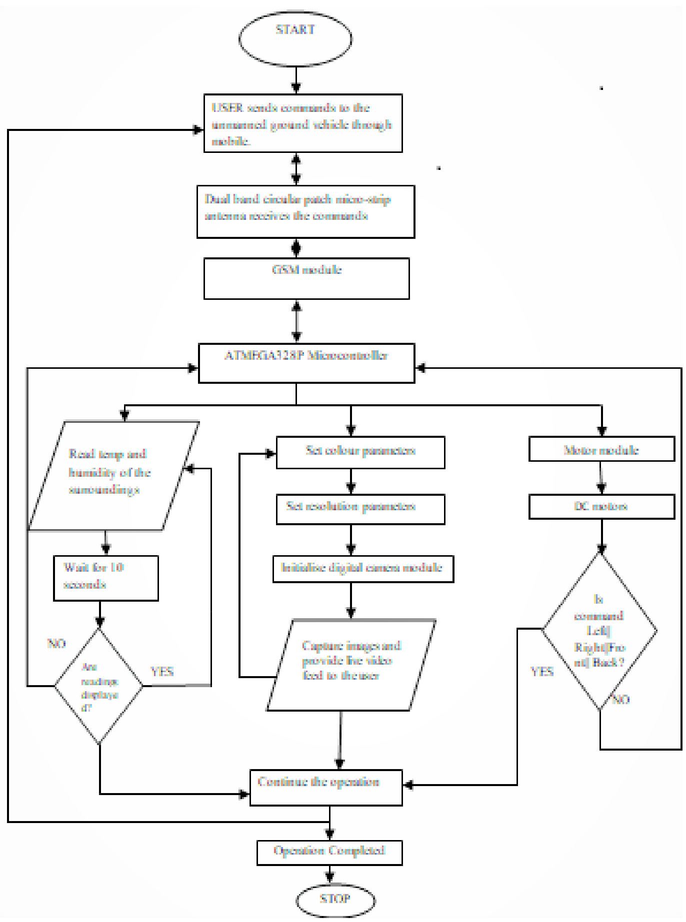

Figure 4: Flow chart of the system

Figure 4 depicts the flowchart of the system. The complete operation of the system can be described using this above flowchart. There are 3 divisions in the flowchart depicting 3 operations at same time i.e. sensing temperature and humidity, scan the surroundings using camera module and movement of the unmanned ground vehicle.

VI. RESULTS

The dual band circular patch micro-strip antenna is simulated using HFSS software and following results are obtained:

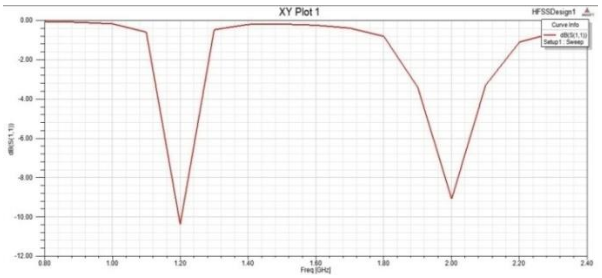

Figure 5: S-11 parameters

Figure 5 depicts the S-11 Parameters obtained through simulation of antenna model from HFSS software. S-parameters describe the response of an N-port network to signal(s) incident to any or all of the ports. In this figure, there are two depressions at 1.2 GHz and 2.1 GHz. The horizontal side represents the reflection/ transmission characteristics in dB and horizontal side represents frequency. At 1.2 GHz and 2.1 GHz, the reflection /transmission characteristic are -20.5 dB and -19 dB respectively. If the transmission characteristic is less than -10 dB, the transmission level of antenna is quite good.

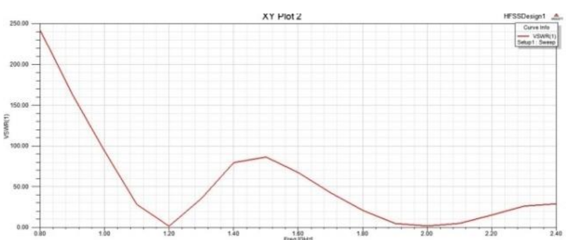

Figure 6: VSWR

Figure 6 shows VSWR graph obtained through simulation of antenna model through HFSS software.VSWR is a function of the reflection coefficient, which is the power reflected from the antenna. The smaller the VSWR, the better the antenna matched to the transmission lineand more power is delivered to the antenna. The minimum VSWR is 1.0. In the above graph, the VSWR is 1.186 at 1.2 GHz and 1.327 at 2.1 GHz.

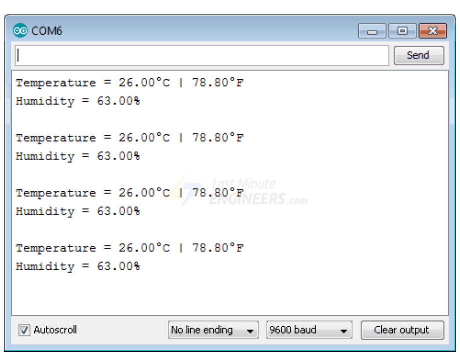

Figure 7: Sensor values from DHT11 sensor

From figure 7, the temperature values are displayed in Celsius and Fahrenheit scales and humidity is displayed in percentage. The sensor updates the values every 10seconds. This gives a clear picture about the surrounding environment of the robot.

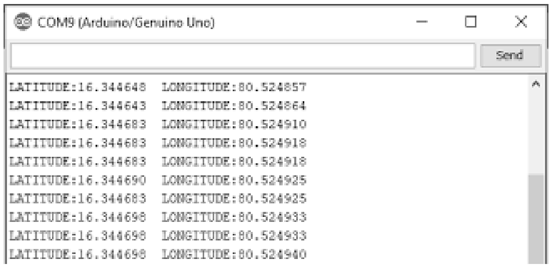

Figure 8: The latitude and longitude values obtained from GPS of GSM module

The figure 8 depicts the latitude and longitude GPS values obtained from GSM module. The SIM800L GSM module consists of in-built GPS module which provides live location of the unmanned ground vehicle by displaying Latitude and Longitude values. The readings are updated after every 10 seconds. These values help the user to locate survivors/ victims of the disasters and communicate the search and rescue team.

Figure 9: Image of survivors captured from digital camera module

Figure 9 displays a sample image from camera module. The images of the surroundings can be captured to provide the damage estimation to the user. The live video stream from digital camera module helps to locate the refugees during search and rescue operations. The video stream helps in locating and estimating the environmental and structural damages. The GPS in the unmanned ground vehicle is used to provide latitudes and longitudes of the unmanned ground vehicle to locate the damaged structures, buildings and stranded victims, which further help in search and rescue operations.

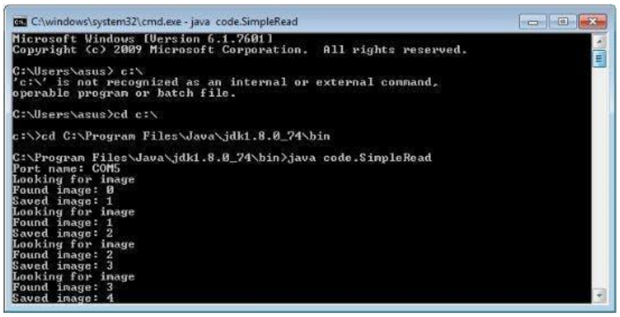

Figure 10: Checking the images captured from camera module and saving them in memory register

Figure 10 shows the check on the captured images and saving it in the memory. The images captured by the digital camera module are checked from memory location and are saved if it contains important information else the images are discarded. Once the process of saving images is completed, the images are stored in the computer. These saved images are shared with search and rescue team for the immediate action on the particular region of disaster.

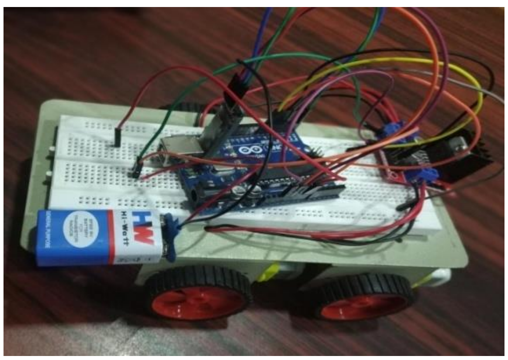

Figure 11: Prototype implementation of proposed model

Figure 11 depicts the integration of different sensors with Arduino Uno and Dual band Micro-strip circular patch antenna for search and rescue operations

VII. CONCLUSION AND FURTHER SCOPE

This paper presents the design and implementation of Dual band circular patch micro-strip antenna for Search and Rescue operations. The UGVprototype is capable of controlling and works according to the commands from the mobile using GSM, GPS, camera and mobile. It uses GPS to find the locations and also send the longitude and latitude positions of the robotto the user. The Dual band antenna designed works for both GSM and GPS frequency which is replaced with manufactured helical antenna is interfaced with Arduino. Using all the available components interfaced the robot is used for SAR operation.

The future work is on developing arm controlled mode along with command control mode and automatic mode. Additional sensors such as gas sensor, Thermal imaging and Infrared sensor can be added to enhance the capabilities of the UGV. The robot can undertake missions like surveillance, detection and can be used as standalone unit along with human soldiers.

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