International Journal of Engineering Research in Electrical and Electronics Engineering (IJEREEE) Vol 1, Issue 3, May 2015

Design and implementation of wireless control system for unmanned aerial vehicle

[1] Anjaly K Thankachan, [2] [3] [4] [5] Deepak Thomas' Harikrishnan S.P' Jinu Mary John, Jithin J Mundupalam
[1][2][3][4][5] Department of Electrical and Electronics Engineering,Amaljyothi College of Engineering, Kanjirapally, Kottayam
[1] anjalykt@gmail.com, [2] deepudeepamdeepak@gmail.com, [3] harihh3@gmail.com, [4] johnjinumary@gmail.com, [5] jithinjames92@gmail.com

Abstract: **This paper mainly focuses on designing and implementation of the wireless control system of Unmanned Ariel Vehicle. An Unmanned Aerial Vehicle also known as UAV is an unpiloted aircraft which can either be remotely operated or flown autonomously based on pre-programmed flight plans. Usually these types of vehicles are used in military applications for missions that are too dangerous for manned aircraft. They are also used in a growing number of civil applications such as aerial photography and the transport of various goods. UAV is built of brushless DC electric motor, driven rotor which is an embedded on-board computer that helps in power distribution system and various sensor units. The hardware platform utilized for the on board computer was a ATmega328p microcontroller with a clock frequency of 16MHz 14 Digital I/O pins 6Analog I/O pins , 32KB of Flash memory, 2KB of RAM with programming done predominately in C++ to express the control commands and overall system.**

Keywords: **Arduino, RC Aircraft, Brushless DC Motor, Microcontroller, Servo motor**

I. INTRODUCTION

The Unmanned Aerial Vehicle market has grown into a multi-billion dollar industry, with the UAV market worth over $4.9 billion in 2010 — largely due to the growing application domain for UAVs. A UAV is an aircraft without an on-board human pilot. Instead the aircraft may be piloted remotely or using an autopilot system. Emerging applications in South Africa require UAVs to operate for long uninterrupted durations — typically between than 4 and 24 hours. Some of these applications include:

- Wildlife tracking
- Traffic monitoring
- Border patrols
- Environmental research
- Geographical mapping
- Numerous military applications

This paper is aimed to design a wireless control for electric RC Airplane. The embedded system used is an Arduino Uno R3 project development platform which is powered by an ATMega328p Microcontroller. The pilot could control the RC plane using a remote control. Inside the remote control an Arduino Uno R3 is programmed so as to send the control signal to the aircraft. As the command signal is received at the aircraft, Arduino Uno inside the flight will process the signal and send proper commands to the servo motors or the BLDC motors to take necessary Actions. The acknowledgement for the received Control signal will be send back to the command Station.

I. RC AIRPLANE

RC planes are small model radio-controlled airplanes that fly using electric motor, gas powered IC engines or small model jet engines. The RC Airplanes are flown remotely with the help of a transmitter with joysticks that can be used to fly the aircraft and can be used in different applications.

The transmitter is installed inside the Model RC Airplanes which receives the commands send by the transmitter and controls servos and propeller. The servos are small motors which are mechanically linked to the control surfaces e.g., ailerons for roll control, elevator for pitch control and rudder for yaw control. The servos moves the control rods (which are small rods that connect the servo to different flight control e.g. to elevator etc.) which in turn moves the control surface be it elevator, flaps, aileron or rudder.

An RC Airplane can be controlled in flight by using the transmitter from where you can control pitch, yaw and roll of your RC Airplane and you can also control the

throttle settings. The receiver which accepts the transmitter signal and the servos attached to it are run on rechargeable batteries. Most popular rechargeable batteries for RC Airplanes use include Ni-Cad (Nickel Cadmium) and Li-Po (Lithium Polymer). Lithium Polymer lasts longer and more powerful than there Ni-Cad counterparts but a bit more expensive. RC airplanes come under the category of Unmanned Aerial Vehicles (UAV).

The military use of unmanned aerial vehicles (UAVs) has grown because of their ability to operate in dangerous locations while keeping their human operators at a safe distance. The larger UAVs also provide a reliable long duration, cost effective, platform for reconnaissance as well as weapons. They have grown to become an indispensable tool for the military. The questio posed for our project was whether small UAVs also had utility in military and commercial/industrial applications. We postulated that smaller UAVs can serve more tactical operations such as searching a village or a building for enemy positions. Smaller UAVs, on the order of a couple feet to a meter in size, will be able to handle military tactical operations as well as the emerging commercial and industrial applications.

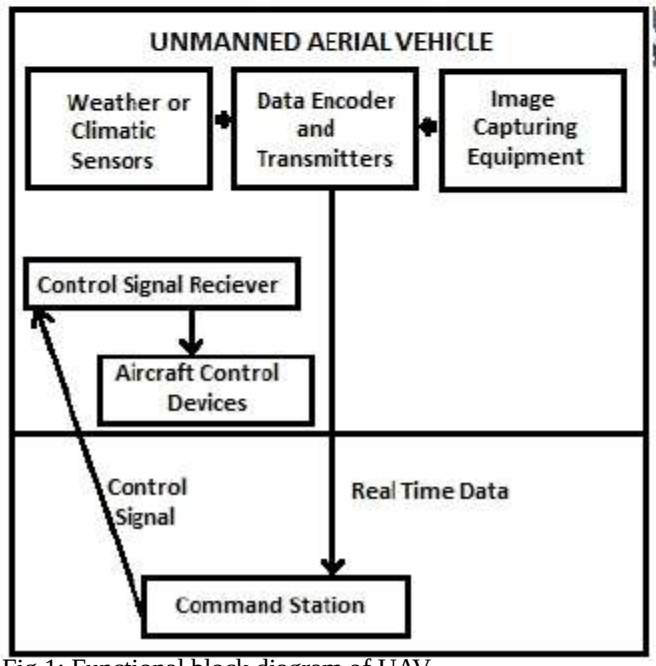

Fig 1: Functional block diagram of UAV

II. WORKING PARTS OF RC AIRPLANE

The fundamental working parts of an aircraft are explained below, each of these parts play a vital role in stabilized flying of an aircraft. To ensure a safe flight, functioning of parts should be proper and efficient

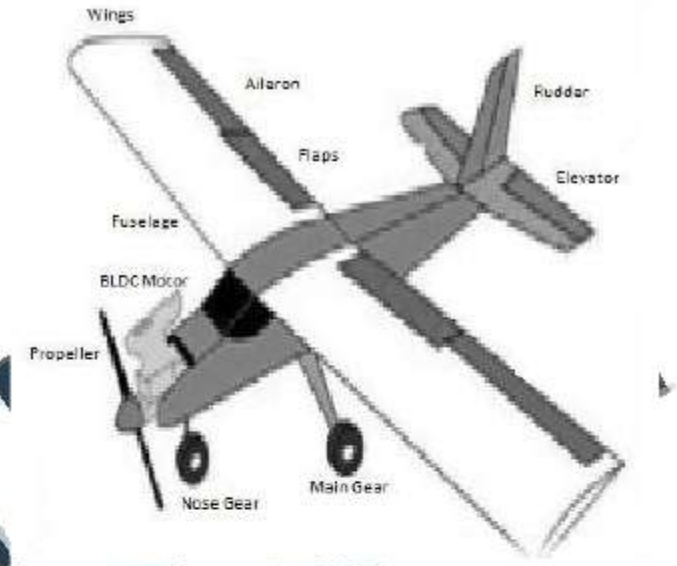

Fig 2: Parts of an aircraft

i. Propeller

The propeller is basically a wing section made of aerofoil sections just like a wing but twisted along the span. The propeller is mounted tothe engine in propeller driven RCengine RC Airplanes don't have a prgenerates thrust by means of the jet engine.

ii. Horizontal Tail

The horizontal tail or the horizontalstabilizer provides pitch control to the RCAirplane. Elevator is mounted on the horizontalstabilizer or horizontal tail of RCNormally, the Horizontal tail is set at aangle of attack (AOA) relative to the

iii. Vertical Tail

The Vertical tail or the vertical stabilizer provides the yaw control to the RCRudder is mounted to the vertical tail or verticalstabilizer of the RC Airplanes.

iv. Empennage

Horizontal and Vertical tail are collectively known as the empennage of RC Airplanes

v. Ailerons

Ailerons are roll-control control surfaces of the RC Airplanes. Ailerons provide roll byin opposite direction to each other. Whenaileron moves down the other moves up thusproviding more lift on one side as opposeother causing the RC Airplane to roll. Ailerons areat the trailing edge of RC Airplanetowards the wing tips.

vi. Flaps

Flaps provide additional lift to the RCAirplane by increasing the maximum coefficient of the RC Airplanes. The flaps can

be used to increase the lift during landing to better take advantage of the ground effect. When both flaps move down it is known as flaps and increases lift of the wing.

vii. Elevators

Elevators are the pitch-control control surfaces of the RC Airplanes. Elevators provide pitch control by moving either up or down simultaneously causing the airplane to pitch the centre of gravity of RC Airplane. When elevator is moved up the nose of the airplane rises and is known as pitch up. When moved down the nose of the RC Airplane moves down and is known as pitch down.

viii. Rudder

Rudder is the yaw-control control the RC Airplanes. Rudder provides yaw moving to either side be it left or right. The rudder yaws the RC Airplane about the centre Cg of RC Airplane causing the RC Airplane nose to move right or to move left. A right rudder makeover causes the RC Airplane to move to the right. A left rudder makeover causes the RC Airplane to the left.

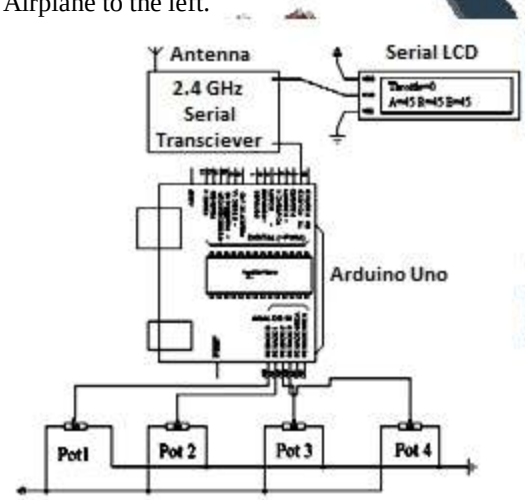

Fig 3: Remote control circuit diagram

III. TRANSMISSION OF CONTROL SIGNALS

Transmission of control signals is very important in controlling of an RC aircraft. Easy and unfailing controlling of aircraft could be ensured only if the transmission of the control signals is fast and proper. The control signals are transmitted from command station to the aircraft control system. The functions of the command station and the aircraft control system are explained below.

i. Command Station

The flight controls are installed inside the command station, it is a remote control used to transmit control signal to the aircraft. The movements of throttle, ailerons, rudder and elevator of the flight can be controlled by using the remote. A 16*2 display is there on the remote which gives out the acknowledgement from the flight control system. Joysticks on the remote are connected to potentiometers placed inside the remote. There are four joysticks to control movements of the wings and throttle. As the joysticks are turned up or down the output of the corresponding potentiometer will vary. This output voltage of each potentiometer is fed to the microcontroller. Microcontroller is programmed to process the input from the potentiometer. Microcontroller will scale analog input from 0 to 1023 into different sets of range of numbers which distinguishes t the throttle, ailerons, rudder and elevator as shown.

- Throttle: 0 to 10
- Elevator: 20 to 30
- Rudder: 0 to 50
- Ailerons: 60 to 70

These numbers are sending 2.4GHz serial transceiver (Xbee module) through the TX pin of the microcontroller. Serial transceiver will transmit the received signal from the microcontroller to the serial transceiver inside the aircraft control system

ii. Aircraft control system

The signal send by the command station is received at the serial transceiver inside the flight. This signal is then fed to microcontroller. Microcontroller is programmed to distinguish the received signal as input to each servo motor which controls the pitch, roll, yaw or the BLDC motor which controls the throttle. Control signals to ailerons, rudder and elevator are scaled to values ranging between 0 and 180 and this scaled value will determine the angle to be turned by the servo motors. The throttle signal is scaled to a value ranging between 0 and 90 and it determines the speed of the BLDC motor so as to vary the throttle. The flight control system will send back the acknowledgement to the command station according to the received signal after the of the command received. If there is no signal to the flight control system or if these is any problem in full duplex communication between the command station and flight control system the flight control system will send th regarding that to the command station.

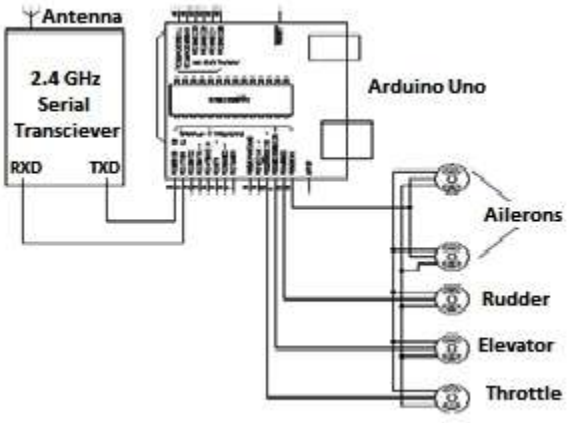

Fig 4: Circuit diagram for aircraft control system

IV. TESTING AND EXPERIMENTAL SETUP

The remote control circuitry was tested in laboratory. Servo motors and BLDC motor were responded correctly according to the test signals. Testing of the circuitry was successful and required output obtained. Electronic Speed Controller of the BLDC motor was programmed to pair with the RC setup. No load test was conducted for the BLDC motor and found that the speed control is working properly and the rotation of the motor was smooth and stable.

Fig. 5: Remote Control test setup

Fig. 6: LDC motor no load test

V. REMOTE CONTROL

Remote Control for the RC aircraft was fabricated and tested. It houses Arduino UNO, Xbee module, 16*2 serial LCD Display and regulated power source. The controlling is done using four potentiometric switches. Range test of the remote control was done, the obtained result was good.

The remote was able to transmit the signals to the flight control system within 700m radius. The remote control circuitry was tested in laboratory. Servo motors and BLDC motor were responded correctly according to the test signals.

Testing of the circuitry was successful and required output obtained. Electronic Speed Controller of the BLDC motor was programmed to pair with the RC setup. No load test was conducted for the BLDC motor and found that the speed control is working properly and the rotation of the motor was smooth and stable.Depending on the control signal servo motors respond clearly to the signal without any trouble. Response of the servo motor was fast and reliable.

Fig.7 Remote Control (Casing opened)

Fig.8: Remote Control

Remote control unit consists of Xbee radio transceiver, a 16*2 serial LCD display and a supply of 7.4V Lithium polymer.

The embedded system used for wireless serial communication is 2.4GHz Serial link, high-speed and reliable communication. RF 2.4HGhz Serial Link module is an embedded solutions providing wireless end-point connectivity to devices. These modules use a simple proprietary networking protocol for fast Point-to-multipoint or peer-to-peer networking The Arduino UNO R3 is an open source project development platform powered by ATMega328p microcontroller which is based on Advanced RISC Architecture. Arduino IDE is

used to program the board, after compiling and debugging, through USB 2.0 cable the program can be directly loaded on to the board. The Serial LCD is cheap, with lots of functionalities and they are extremely easily to interface. It can be connected with PCs, microcontrollers or any other device which can send the serial commands. Lithium Polymer battery used as supply for remote control unit has high discharge rate and less weight comparing to other types of batteries

CONCLUSION

The project on designing the control system for RC airplane was completed and the system worked properly. While performing experimental test, different control signals were send to the aircraft control system. Depending on the control signal servo motors respond clearly to the signal without any trouble. Response of the servo motor was fast and reliable. The transmitted acknowledgement from the flight was acceptable and it was properly displayed on the LCD screen. Transmission of the control signal and the return of acknowledgement signal form the flight control system were satisfactory. The wide applications of UAVs have been increased in this modern age. Applications ranging from civilian to military fields increase the demand of UAVs in the future.

ACKNOWLEDGEMENT

First of all we sincerely thank God the Almighty who is the most efficient and merciful for giving us knowledge and courage to complete the project successfully.

We derive immense pleasure in expressing our sincere thanks to the Principal Rev. Dr. Jose Kannampuzha, for his permission and infrastructural facilities for the successful completion of our project.
We extend our sincere gratitude to Prof. P. C. Thomas, Head of the department for his encouragements and motivation during our project.

We express our heartfelt gratefulness to Mr. Anish Benny, Assistant Professor, Department of EEE, project guide, for his valuable guidance and suggestion during the project.

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