Design and Implementation of Quadcopter

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Abstract
This paper explains our work of the Quad copter for agriculture purpose. Our objective is to create a small robust quad copter that can fly and used for Fertilizer sprayer application. The aim of this project is to develop a machine which would help agriculture producers improve productivity and efficiency to maintain their profit margins.The quadcopter can be controlled using RF technology (RC Receiver and RC Transmitter). The Onboard camera with flying quadcopter to perform image processing to identify the infected crops and water flow on the field.For smooth performance of the copter, we used a flight controller called KK multi-copter controller board. This controller board has inbuilt gyro and accelerometer sensor. The signals form these sensors are processed and executed by the microcontroller (Atmel 164 IC) and output from controller board used to control the motors.

Keywords
Quad copter, KK multi-copter board, Brushless motors, Electronic speed controllers.

I. Introduction

In recent years, there are numerous researchers taking efforts which are directed towards flying of inventive systems. Those systems are generally named as flying robots or unmanned air vehicle (UAV).In this, there is no onboard presence of Today, different UAV models are available, and these structures are named with respect to rotor number. This UAV are used in all fields such as military applications, search and rescue operations, agricultural distillation, shoot the sports events or movies from almost any angle and transporting or controlling equipment. Their reliabilities in tough circumstances are much higher than their counterparts.As it is unmanned it can be used in any hazardous areas without risking of human lives.This Flying robot also called as the quadcopter, is a vehicle that flies with an electric motor(4 rotors moving in the direction of 2-clockwise and 2- counter clockwise). These quadcopters can be used in above-mentioned applications with the help of flight controllers such as kk multi-copter board, pixhawk, ardupilot etc.

II. Basic Principles

Flight Dynamics

The quadcopter has four rotors, equally placed at corners of the frame. It has six degrees of freedom (3- translational and 3-rotational) in which the rotational and translational motion are coupled for achieving the degrees of freedom. Stabilizing the quadcopter is very complex as it is three dimensional unlike other vehicles like cars or boats which move only in two dimensions. These three types of motion are interdependent as a small change in any one motion will affect the other.
The three main motion control terminologies of the quadcopter are:

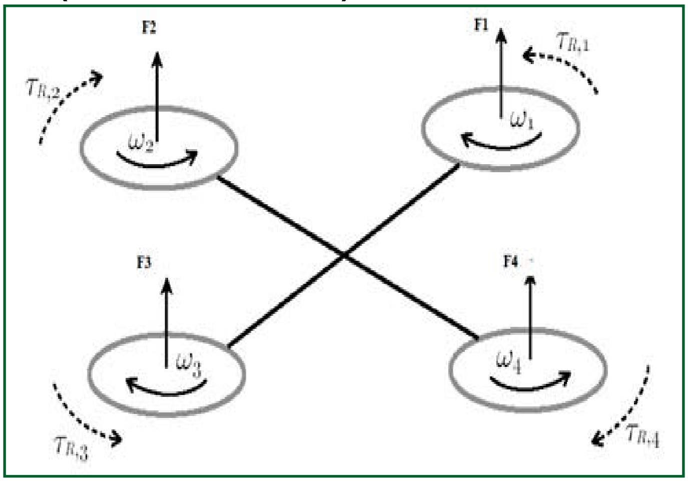
Roll (Front to Back Axis Rotation)

Sideward flying of the quadcopter is known as roll. Aileron stick is used to control the roll motion by moving it to either left (for moving left) or to right(for moving right).When we make the quadcopter fly high above the sea level by using the throttle stick (pushing it forward) it is known as Uplift. If we bring down the quadcopter to the sea level by using the throttle stick (pushing it downward) it is known as Downfall.

Pitch (Side To Side Axis)

Forward and Backward movement of the quadcopter is known as pitch. Aileron stick is used to control the pitch by pushing the stick forward (for moving forward) or backward (for bringing quadcopter towards you).

Yaw (Vertical Axis Rotation)



Deviation of the quadcopter head to right/left is known as Yaw motion. It can be controlled with the Throttle stick also known as Rudder. This stick can be used to achieve left or right motion.

TR1,TR2,TR3,TR4 – Motor Thrust F1,F2,F3,F4 – Motor Forces.
ω1, ω2, ω3,ω4 – Angular Frequency.

III. Hardware Description

A. KK 2.1.5

For a great flying experience of the Quadcopter, we used the open source flight controller board called KK 2.1.5.The KK 2.1.5 is a multi-copter flight control board for a remote control flying rotors with 2,3,4,6 and 8 motors. This board is mainly used for the stabilization of the aircraft during flight. To maintain the stability of the aircraft it reads the signal from the three gyros on the board (roll, pitch, and yaw) and writes the information into the Microcontroller (Atmega 164 IC). According to these signals, KK software sends out a control signal to the ESCs which are connected onto the board and also connected to the motors. The

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signal from the IC to ESCs will either increase in speed or decrease in the speed of the motors. The board reads a control signal from the Remote Control Receiver (RX) and writes into the IC through the aileron, elevator, throttle and rudder terminal on the board. After executing these signals, IC will then send the signals to the motors to increase in speed or decrease to achieve controlled flight. The command signals are sent via Remote Control Transmitter (TX).

B. Brushless DC Motor

Brushless motors rotate at very higher speeds and consume very less power compared to the other types of DC motors. It is very energy efficient and also it does not need much energy to run like DC motors. KV rating on the BLDC motors indicates how many rotations the motor can rotate for a given number of volts. The motors (iPOWER) used for this project have a higher power system. Each motor has poles, good quality parts, very well for smooth running and it is designed in such a way to provide a better performance.

C. Electronic Speed Controllers

Normally all Brushless DC motors are three-phased, so it won't run in a direct power supply with DC connections. In this case, the electronic speed controllers come into the picture. These are connected with the motors which create three high frequency with continuously controllable phases. These controllable phases are entirely different for each frequency. This enables the motors to rotate. The pulse width modulation signal generated by the microcontroller which is present in the multi-copter flight controller board is fetched directly to the ESC which is used to rotate the motors.

D. Frame

The frame is the one which contains all the things together. Frames are available in different shapes and materials. The frame material should possess very good characteristics physically. It should be very strong enough to bear the vibrations comes from motors. Carbon fiber is one of the best material options for the frame since it is very expensive we chose glass fiber.

Q450 is the frame we used for this project. This frame built from good quality materials, the main frame is made of glass fiber and the arms are made of polyamide nylon. This frame has integrated PCB connections for direct soldering of ESCs and battery. Assembly was very easy and it is provided with one size bolts which making the things very easy to keep in order and safe.

E. Battery

The battery is one of the main sources for this project. Lithium Polymer (Li-Po) is considered because it is very light in weight. Its current rating should meet the motor power requirements. Turnigy 2200mAh is the battery we used for our project. The battery comes with 3 cell configuration and it is having a discharge rate at 25C.

Selection of Hadware

Power=Propeller Constant * RPM^ (Power Factor) Power=Torque * Rotational Speed

Rpm Max = Kv * 0.5 * Battery Volts/2 Flight Time = Battery Capacity / Amps

IV. Block Diagram

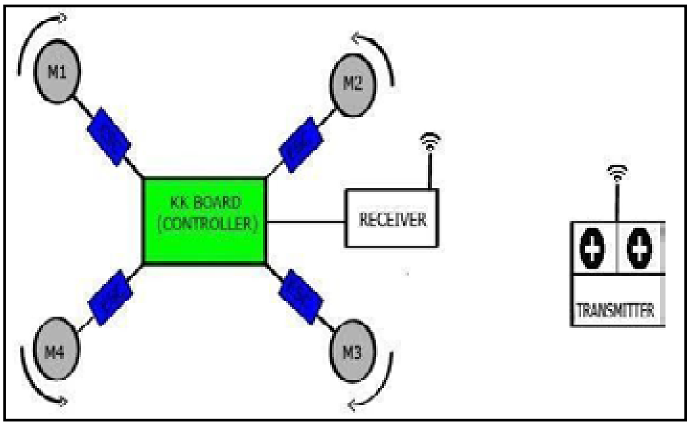


Fig.1 : Block Diagram of the Quadcopter

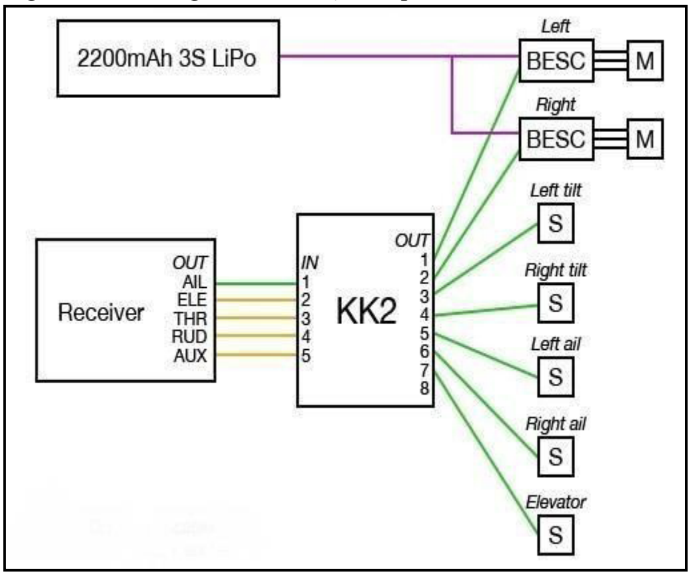
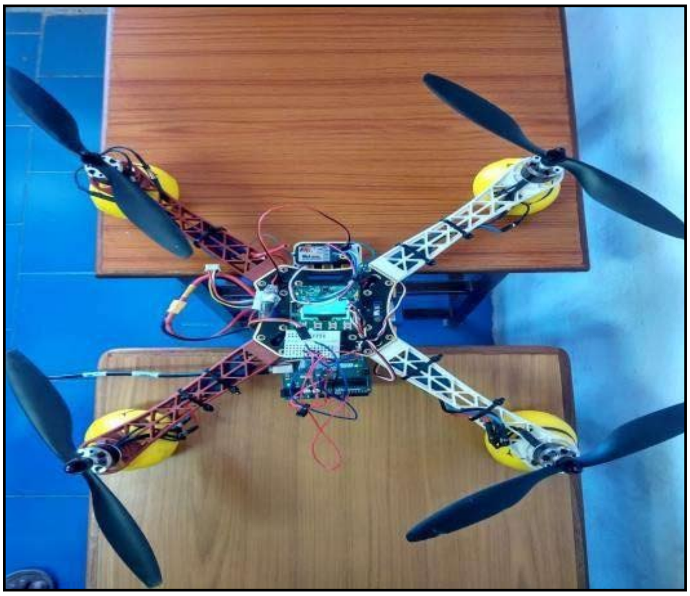


Fig.2 : Wiring Connections for KK

V. Implementation

The goal of our project is to implement it in the field of agriculture. In order to achieve better stability we have used kk2.1.5 flight controller board, and to lift more payload 1000kva brushless dc motor is used. As the load increases the consumption of power increases which is directly proportional to the flight time (duration of flying).So 2250mAH Lipo battery (Turnigy-3s) battery is used. The lesser the weight of the quadcopter more is the efficiency , so the frame is designed with the help of glass fibre.The fertilizer and pesticide spraying process is performed by the quadcopter with the help of a servo motor which is controlled by Arduino. The entire process is monitored with the help of a mobile application created using MIT App Inventor (open source android platform). A camera is mounted on the drone in order to get the clear view of the entire field. It makes the drone user friendly and triggers the younger generation to get involved in the field of agriculture.

VI. Overall setup



VII. Performance Analysis

Motor Thrust and Efficiency Calculation: Motor Thrust Formula:

T= [(ETA*P) ^2*2*PI*R^2*RHO] ^0.3333

T= [(0.72*11.1*22*0.75)^ 2*2*3.14*0.127*0.127*1.22] ^0.3333

T=12.9 N or T=1315.43g

Efficiency Formula:

Efficiency = Thrust / P

Where, **Thrust** is the force generated expressed in grams.

P is the power consumed expressed in Watts

Power, P = V * I

Where, V is the voltage and I is the current.

P=11.1 * 22 * 10^-3 P=24.42W

Efficiency=1315.4/24.42

Efficiency=53.8%

VIII. Acknowledgement

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IX. Conclusion

A Quad copter for **"Fertilizer Sprayer"** purpose has been successfully designed as per our objective. This quad copter simultaneously sends the video signal to the base station. The gain values should have needed an adjustment to provide a stable flight.

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