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Quad Copter for Surveillance Observation

Mr. B.V.M. Sagar, Mrs. J. Subhashini

Abstract—**The Quad copter is a copter which can be hover and fly in the air with the four motors and propellers, facing top side, placed vertically and opposite each other. It can be designed for multiple purposes depending on the applications. In this paper, a complete system is designed and implemented, in which the motion of a quad copter is stably controlled by a remote controller. To observe the surveillance, a wireless camera is mounted on the quad copter. The quad-copter design in this paper uses stabilization board with microcontroller ATmega328, electronic speed controllers, brushless DC motors, 2200mAh Lithium-Polymer battery, propellers, signal receiver module and remote controller. Using a 2.4GHz remote controller, the control signal is received by the receiver module, and then processed by the micro controller. The performance of the controllers is further improved by the use of inertial sensors of the quad copter.**

Index Terms— **Quad copter, Stabilization board, ESC, Wireless Camera, Atmega IC, Remote controller.**

I. Introduction

Quad-Copter is a vehicle, also known as quad-rotor. It is a copter with four rotors. The rotors are directed upwards and they are placed in a square formation with equal distance from the center of mass of the quad-copter. The quad-copter is controlled by adjusting the angular velocities of the rotors which are rotated by electric motors. Quad-copter is a typical design of a Unmanned Aerial Vehicles (UAV) / Micro Aerial vehicle (MAV) [7]. In comparison with quad copter, UAV/MAVs present unique characteristics that are challenging. First, these vehicles are difficult to control as they are inherently unstable systems with fast dynamics [5]. Second, given their small dimensions and light weight, MAVs have a restricted payload, i.e reduced computational power as well as noisy and limited sensors. Quad-copters are used in rescue operations, agricultural distillation, shoot the sports events or movies from almost any angle surveillance to several other applications. Their reliabilities in tough circumstances are much higher than their counter parts. In the last decade, due to the military and security reasons many attempts had been conducted related to this issue. In these days, the Quad copter is used as a safety and security robot in wide range area.

II. Basic Principle And Operation

This Quad-Copter applies the PWM frequency change to control the speed of brushless dc motor. There are four main parts which are important in this design including potentiometer as manual controller, ATMEL ATmega328 as the control system, Electronic Speed Controller (ESC) and Brushless DC (BLDC) motor. The Quad-Copter uses four propellers, each controlled by its own motor and electronic speed controller. By using a potentiometer, the Revolution Per Minute (RPM) of motor will be adjusted. Figure 1 shows the reaction torques on each motor of a Quad-Copter aircraft, due to spinning rotors [3]. Rotors F1 and F3 are spin in one direction, while rotors F2 and F4 spin in the opposite direction.

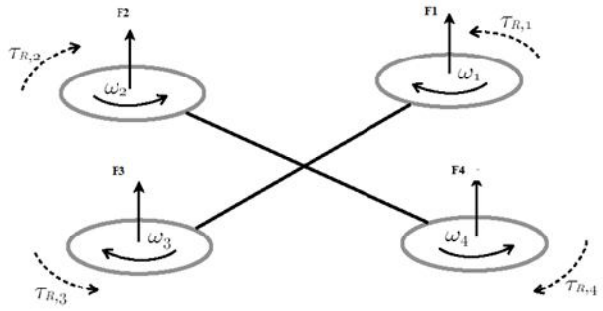

Figure 1: The rotation of propellers

In the flying robot each rotor produces both a thrust and torque about its centre of rotation axis also put the force opposite to the vehicle's direction of flight [1]. If all rotors are spinning at the same angular velocity, with motors one and three rotating clockwise and rotors two and four anticlockwise. The net aerodynamic torque, and hence the angular acceleration about the yaw axis is exactly zero [2]. The schematic movement of flying robot as shown in Figure1.

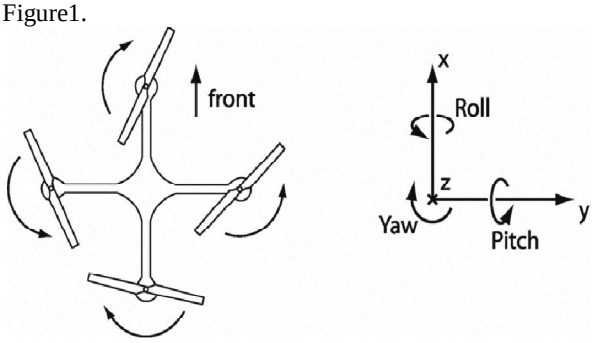

Figure 2: Basic design of the quad copter

Take-off is movement of flying robot that lifts up from ground to hover position and landing position is vertical of take-off position. Landing motion is controlled by increasing /decreasing speed of four rotors simultaneously thereby changing the vertical motion. To operate the Quad copter, there are three quad moments. Those are Roll, Pitch

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Mr. B.V.M. Sagar, Department of Electronics and Communication Engineering (Embedded System Technology), SRM University, Chennai, India

Mrs. J. Subhashini, Department of Electronics and Communication Engineering, SRM University, Chennai, India

and Yaw moments which are shown in the Figure 2. Based on these three moments quad will fly. The quad copters are controlled by four inputs(roll, pitch, yaw, thrust) by varying the lift forces and the balance of reaction torques through changing the rotating speed of the rotors.

III. Hardware Configuration Of A Quad Copter

A. Stabilization Board

For successful designing purpose of the flying robot the controller board called KK multicopter control board is used. The K.K multi controller is a flight control board for remote control flying robot with 2,3,4 and 6 rotors [9]. Its purpose is to stabiles the aircraft during flight. This controller board have inbuilt Atmega IC controller in the center. To maintain the stability it takes the signal from the three gyros on the board (roll, pitch and yaw) and feeds the information into the Integrated Circuit (Atmega IC). The stabilization board with microcontroller as depicted in Figure 3 has been used as the brain or as the Microcontroller Unit (MCU) of the Quad-Copter system. This processes the information according to the KK software and sends a control signal to the Electronic Speed Controllers (ESCs) which are plugged onto the board and also connected to the motors. According to the signal from the IC the ESCs will either speed up or slow down the motors. The board also takes a control signal from the Remote Control Receiver and feeds this into the IC through the aileron, elevator, throttle and rudder terminal on the board. After processing this signals, then IC will transmit the signals to the motors to speed up or slow down to control the flight. The command signals from the RC Pilot sent via its Transmitter.

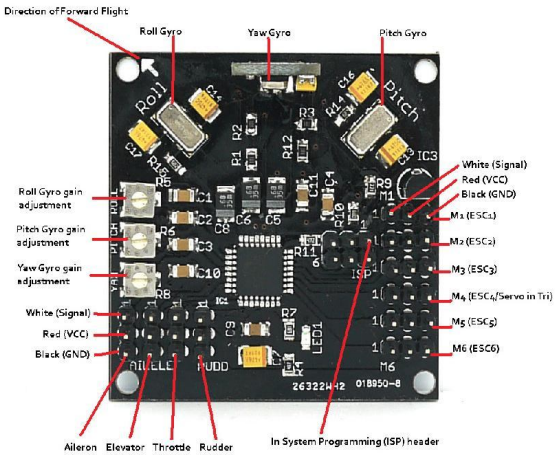

Figure 3: Stabilization Board

B. Electronic Speed Controller(ESC)

To design a Quad-Copter, four ESCs are used to control the speed of four Brushless DC (BLDC) motors based on PWM frequency signal from control system. This device encodes the PWM from microcontroller and produce pulse to the motor to run depending on the frequency of the pulse. The range of the frequency is depends on the type of the motor.

Figure 4: Electronic Speed Controller (ESC)

Electronic speed controller (ESC) plays an important role for controlling the movement of the dc brushless motor. ESCs used in the project needed to be calibrated to read the pulse width modulation (PWM) signal generated by the control board. Calibration of ESCs, defines how to set the max and min speeds of the motor in relation to the max and min width of the PWM signal sent by the control board. A PWM signal is simple a square wave signal consisting of high and low (5v and 0v) signals for certain durations. Some sample PWM waves are shown in the Figure 5.

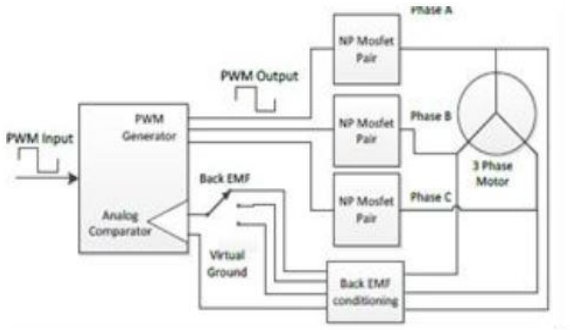

Figure 5: Internal schematic of ESC

The calibration involves programming the ESC to understand the PWM waves corresponding to the stop and maximum speeds of the motor. For the flying robot, however, the range to be as wide as possible to allow for greater incremental control of the motor.

C. Brushless DC Motor

There are two types of dc motor, brush and brushless dc motor. For the quad copter design, brushless dc motor is preferred compared to the regular brushed dc motor [6]. The advantages of this motor are it has high thrust that is important in quad copter design and it also can last longer compared to brushed dc motor. It is due to the rotation of brushless DC motor does not need commutator between the windings and the current conductor. Compared to brushed dc motor, brushless dc motor has static core windings and rotating permanent magnet which is shown in the Figure 6. The brushless DC motor is a DC motor that use electrical commutation system instead of mechanical commutation system such as brush. In brushless DC motor, relation between current and torque are linearly equivalent. Relation between voltage and speed are linearly equivalent too. BLDC has permanent magnet with many poles at its stator.

Those poles will create a difference of polarity, so the stator could move from one pole to other and create a rotation.

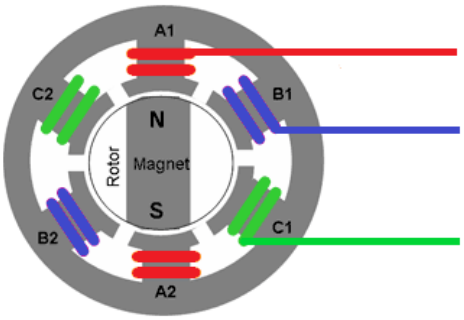

Figure 6: Internal Structure of Brushless DC Motor

D. Wireless Camera

The main objective is to observe the surveillance using a wireless camera mounting on the top of the Quad-copter. Camera is the main part of the quad copter for surveillance observation. To capture the data and watch it in a computer screen a 1.3GHz wireless camera is used which has an inbuilt transmitter. This camera is connected to power supply to capture the surrounding frames. Camera captures the data and transmits it to computer screen which is connected to the receiver end.

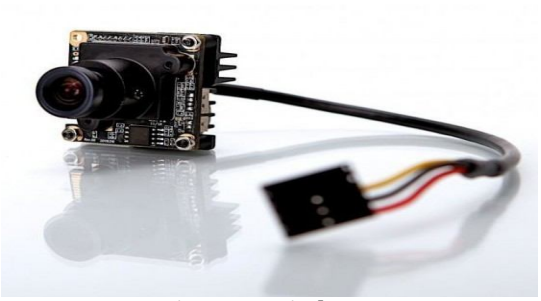

Figure 7: Wireless Camera

E. Propeller

The Quad copter is described as a small vehicle with four propellers attached to rotor located at the cross frame. The propellers are attached directly on the top of the motors. Here, 4 propellers are used at the 4 edges. Out of 4 propellers, 2 propellers rotates in Clock Wise (CW-called as pusher) and remaining 2 rotates in Counter Clock Wise (CCW-called as puller). One of the important specification is that the propeller balance reduces the vibrations. In this quad design, the propellers with the dimensions of 10*4.5 with two blades are used which is shown in the below Figure 8.

Figure 8: Propellers

IV. QUAD COPTER DESIGN PROCESS

The quad copter design is challenging due to its unique requirements of synchronization of four rotors and stability during flight. Before designing a quad with the hardware components, it is designed in a software 3D tool called CATIA (Computer Aided Three-Dimensional Interactive Application). CATIA tool is used to design, simulate, analyze, and manufacture products in a variety of industries including aerospace, automotive, consumer goods, and industrial machinery. It enables the creation of 3D parts, from 3D sketches and offers a solution to shape design, styling, surfacing workflow and visualization to create, modify surfacing technologies. By using this CATIA design software, all the dimensions and sizes of the quad copter parts are measured. Here, each and every part individually designed and then combined to form a final quad copter by assembling all the individual parts. The 3 dimensional views of the Quad copter in CATIA tool shown in the Figure 9.

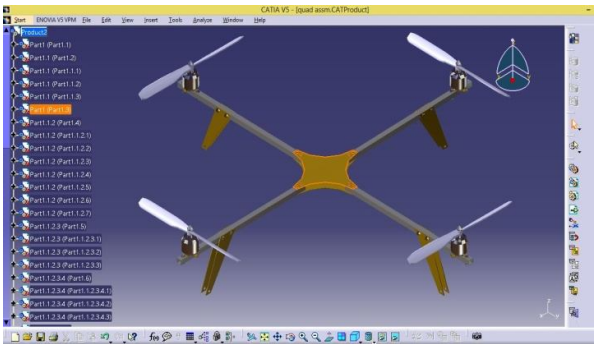

Figure 9: Quad Copter in CATIA design tool

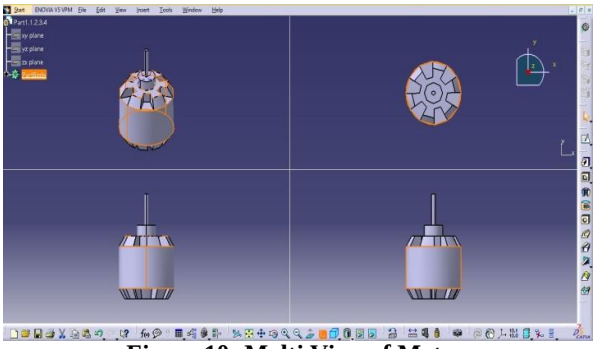

Figure 10: Multi View of Motor

The Quad-copter components with correct measurements assembled together to design a successful Quad copter. After designing, assemble the components with the hardware. The reason to design quad copter using CATIA is to reduce the cost by controlling hardware damages. The hardware connections between the components are connected like shown Figure 11. The controller board is placed in the center and four ESC's are connected to the pins of the board from four sides of the quad rotor. The other end of the ESC's are connected to the brushless DC motors. The propellers are attached on the top of the DC motors. And the power supply is given to each ESC from the power source.

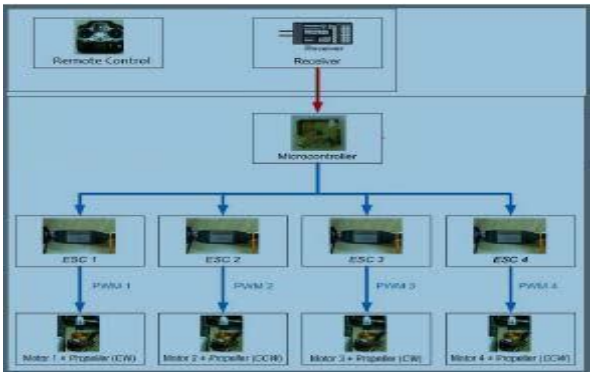

Figure 11: Connections of the Quad Copter

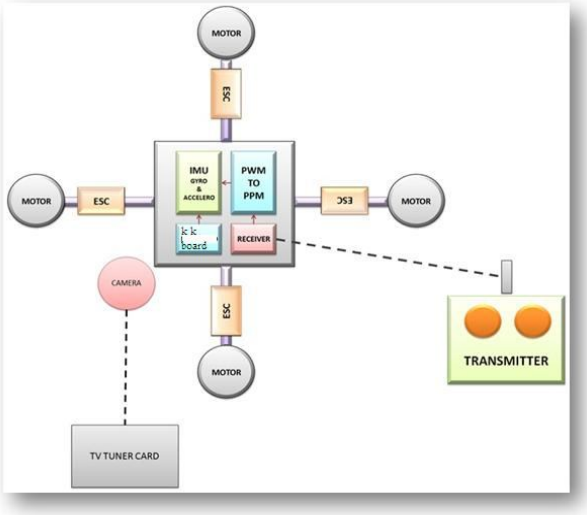

Figure 12: Block diagram of Quad copter

The KK multicontroller board is placed in the flying robot which receive the signal from the RC controller .The control board connected with four ESC. The ESC will process the PPM signal from the receiver and covert that signal into the PWM signal. According to variation in the width of signal as shown in Figure 13, the ESC will circulate the current to brushless motor.

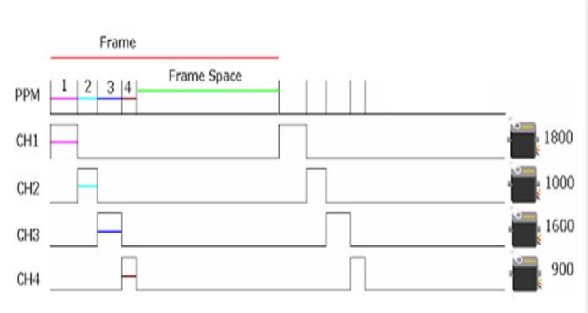

Figure 13: PPM signal send by R.C transmitter

The controller has on board accelerometer and gyro sensor. As per the movement of module it will calculate yaw, pitch and roll calculation and send to the microcontroller. According to received signal it produces control signal and makes variation in power distribution. The module also assembles a wireless camera for surveillance observation. The camera module also transmit video signal to computer. The video signal from the camera will be fed to the computer by external USB TV tuner kit.

V. OUTPUT

The final designed quad copter is shown in the Figure 14.

Figure 14: The Quad Copter with Complete Hardware

The snap shot by the surveillance camera of the quad copter is shown in Figure 15. The surroundings captured by the camera can be observed in the computer using USB TV tuner kit.

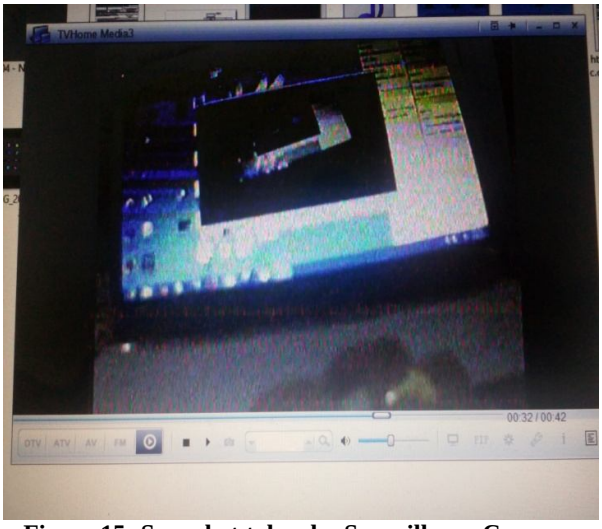

Figure 15: Snapshot taken by Surveillance Camera

VI. RESULT

In this paper, Quad copter capable to lift more pay load with stable flight. To lift more pay load, 1800kva out runner motors used and to increase flight hovering Lithium polymer battery of capable 2200mAh with constant discharge 10c rating is used. The quad copter with 2200mAh battery can fly for 20 to 30 minutes. By increasing the capacity of battery, flight hover time can be increased. Aluminium frames are used to design arms of the Quad. For the surveillance observation camera is mounted on the quad but it requires extra power supply of 5V. It will increase weight. So, power supply of the camera should coincide with board power supply which will help to reduce the weight on Quad-copter. The real time video information is transmitted to the ground receiver point (computer) from the surveillance camera of the flying robot system.

VII. CONCLUSION

The Quad copter system has been successfully designed as per decided objective and requirements. This Quad-copter system module will take aerial photography and also send the video signal to the base station continuously. It has a capability of carrying out surveillance from 50 meters height for duration of 20 minutes with 2200mAh Lithium polymer battery. The Quad-copter is stabilized all motors and produced the correct and harmonic speed.

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B.V.M. SAGAR received his Bachelor of Engineering in Electronics and Communication Engineering from Avanthi Institute of Engineering And Technology, India in 2013. He is currently pursuing his M.Tech. (Embedded System Technology) in SRM University, Kattankulathur, Chennai, India. His interests include Embedded Systems, Robotics, Wireless Communication.

Subhashini. J received her Bachelor of Engineering in ECE from National Engineering College, Kovilpatti, India in 2001. She was a gold medalist in her M.Tech degree in Embedded Systems from SRM University, Chennai in 2008. Her research interests include Wireless Communications. Currently, she is an Assistant Professor (Senior Grade) in the Department of Electronics and Communication Engineering at S.R.M. University, Kattankulathur, Chennai, India, working here since 2001. She is currently pursuing her doctoral degree in the field of Wireless MIMO Communications. Her research interests include Wireless MIMO, OFDM, and Digital Signal Processing. She has published Six International Journal papers, and presented Four International Conference papers.