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RF BASED ORNITHOPTER USING BLDC MOTOR

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Abstract: *In recent years, Ornithopters, or flying vehicles propelled by flapping wings, have garnered significant interest, particularly in the realm of micro aerial vehicles (MAVs). These MAVs aim to emulate the agility of small birds and insects, presenting novel challenges in vehicle dynamics and control. This ornithopter, dubbed 'Garuda', is designed with careful consideration for payload capacity, crash survivability, and field repair capabilities. Originating from a need for close-range surveillance in defense operations, the 'Garuda' integrates a microcontroller, sensor package, and live surveillance camera, facilitating real-time intelligence gathering without arousing suspicion. Our ornithopter model prioritizes maximum lift and minimal drag, achieved through meticulous design considerations such as gear reduction, aspect ratio, tail importance, center of mass, and power requirements. Our design process, conducted using SolidWorks, culminated in Computational Fluid Dynamics (CFD) analysis in ANSYS Fluent to evaluate lift and drag forces across various angles of attack and flow velocities. This comprehensive approach ensures the 'Garuda' excels in both performance and versatility, serving diverse applications ranging from defense surveillance to scientific exploration.*

I. INTRODUCTION

A bird that flies by flapping its wings is called an ornithopter (Greek: ornithos, meaning "bird," and pteron, meaning "wing"). The flapping wing flight of bats and birds is a common inspiration for designers. Despite their potential differences in form, machines are typically constructed to a similar size as these aerial beings. An airplane that flaps its wings to fly is called an ornithopter. Our objective is to create a remote-controlled ornithopter, using inspiration from the natural world. This marks the start of a new age in flying with flapping wings. We could only adjust the speed; the wings could only move in a predetermined range. This system imitates the actual bird found in the wild. In this project, the flapping mechanism of the wings was powered by an Arduino-controlled motor and gears. Because of the way they soar, natural flyers have always captivated me. The idea of incorporating such distinctive qualities into an artificial model attracted researchers. These fall under the category of micro aerial vehicles (MAV) action. Includes creating a miniature model that was designed to resemble real-size natural fliers. Although there are already some small aerial vehicles on the market, they all operate via rotating mechanisms, but an ornithopter's system involves flapping, or fluttering, in order to accomplish flight. However, in comparison to other aerial vehicles that can reach their objective without being picked up by radar, these smaller variants are more stealthy and have higher maneuverability. This prototype's primary flaw is its static lift off. The model is not supported by the spring leg system in the same way that wheels do when gaining speed during lift-off. Full flapping movement for static lift increases the burden on the model by placing undue strain on other systems.

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II. LITERATURE REVIEW

"In recent years the topic of flying vehicles propelled by flapping wings, conjointly referred to as ornithopters have been a vicinity of interest thanks to its application to Micro Aerial Vehicles (MAVs). These miniature vehicles request to mimic little birds and insects to attain never before seen lightweight on the wing. This revived interest has raised a bunch of latest issues in vehicle dynamics and management to explore, (Zachary John Jackowski, 2009)" [1]. "Hovering is employing a horizontal wing path to lift; bees, wasps, and helicopters use this system. Dragonflies hover employing the distinctive technique, by flutter on Associate in Nursing inclined stroke plane. They look to form the next potency than is feasible for traditional hovering. This project aims to create a mechanical model to mimic the mechanical properties and hovering motion of dragonflies, (John H Lienhard V, 2007)" [2]. "Control physics is integrated with a microcontroller, mechanical phenomenon and visual sensors, communication physics, and motor drivers. It was needed to develop a simplified mechanical model of ornithopter flight to scale back the order of the system. The mechanics model and also the orientation estimation from aboard mechanical phenomenon sensors gift control of Associate in nursing ornithopter capable of flying toward target victimization aboard sensing and machine resources solely. To this finish, a dead-reckoning algorithmic program developed to pass through the temporary loss of the target that may occur with a visible detector with a slender field, (Stanley Seunghoon Baek, 2011)" [3]. Therefore, many aspects were taken into consideration during the research required for the model.

III. METHODOLOGY

A flapping wing mechanism serves as the foundational technology in this model. They include the essential components needed for the prototype to take off. Even while it seems hard to replicate the precise moment of wing actions using a model's mechanical behaviour, some features of insurance working can be imitated. Furthermore, even when their wing design influences how they behave in the air. For instance, a pelican's wings are not the same shape as a swallow's. Because of their greater wingspan, pelicans can stay in the air longer than swallows, who are faster at making abrupt turns and short distances. Therefore, choosing the right wing shape is essential depending on the kind of application the model needs.

IV. BLOCK DIAGRAM

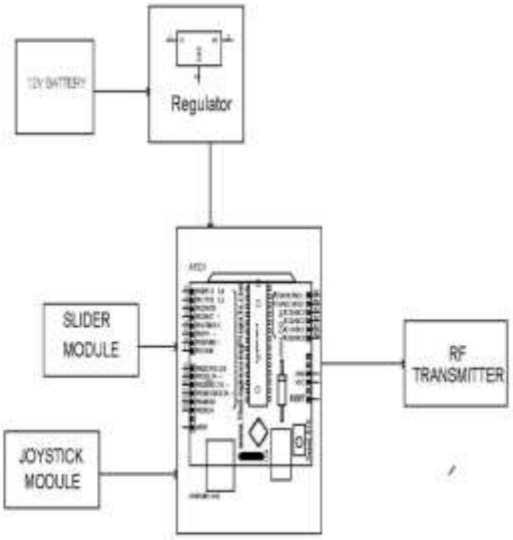

FIG. BLOCK DIGRAM OF REMOTE CONTROL

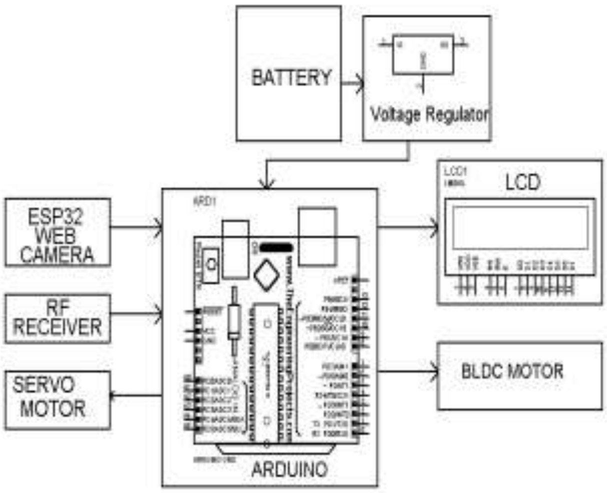

FIG. BLOCK DIAGRAM OF ONBOARD CONTROL

In this project we operate ornithopter using remote control. The slider module and joystick module gives input to the arduino in RC. Arduino Uno decodes and sends the data to the flight using RF transmitter. The transmitted data is received by RF receiver and the data is encoded by Arduino in the flight and then the BLDC motor and Servos are operated accordingly for the movement of bird.

VII.COMPONENTS REQUIRED

4.1 VOLTAGE REGULATOR IC 7805

7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

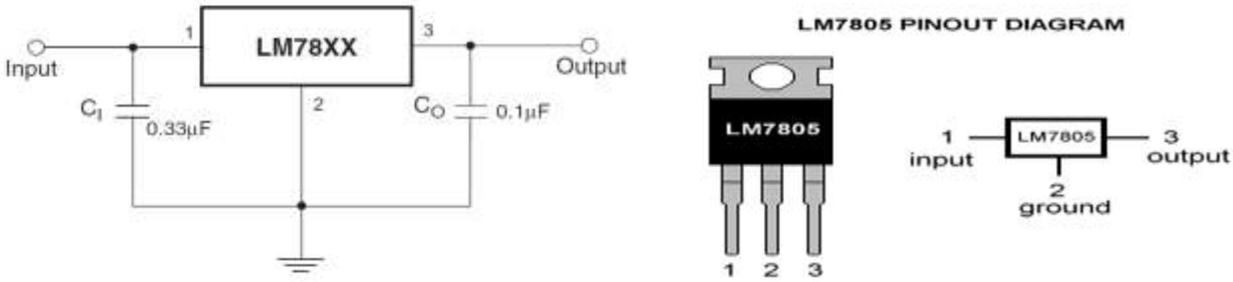

FIG. VOLTAGE REGULATOR IC 7805

4.2 ARDUINO

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible pack.

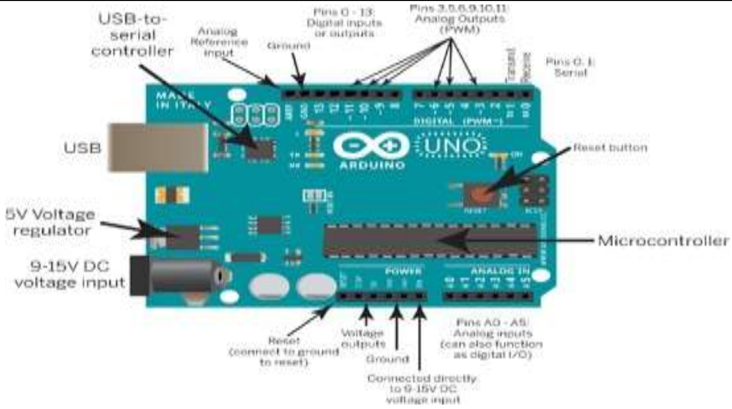

FIG. ARDUINO

4.3 RF MODULE

This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps – 10Kbps. The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

FIG.RF MODULE

4.4 SERVO MOTORS

Servo motors are DC motors that allow for precise control of the angular position. They are DC motors whose speed is slowly lowered by the gears. The servo motors usually have a revolution cut off from 90° to 180°. A few servo motors also have a revolution cutoff of 360° or more. It is used to control the motion of the tail.

FIG.SERVO MOTOR

4.5 BLDC MOTOR

A brushless DC electric motor (BLDC motor or BL motor), also known as electronically commutated motor (ECM or EC motor) and synchronous DC motors, are synchronous motors powered by direct current (DC) electricity via an inverter or switching power supply which produces electricity in the form of alternating current (AC) to drive each phase of the motor via a closed loop controller. The controller provides pulses of current to the motor windings that control the speed and torque of the motor. It is used to create flapping mechanism

FIG.BLDC MOTOR

4.6 ESP 32 CAM

ESP32-CAM is a low-cost ESP32-based development board with onboard camera, small in size. It is an ideal solution for IoT application, prototypes constructions and DIY projects. The board integrates Wi-Fi, traditional Bluetooth and low power BLE, with 2 high performance 32-bit LX6 CPUs. It adopts 7-stage pipeline architecture, on-chip sensor, Hall sensor, temperature sensor and so on, and its main frequency adjustment ranges from 80MHz to 240MHz. Fully compliant with Wi-Fi 802.11 and Bluetooth 4.2 standards, it can be used as a master mode to build an independent network controller, or as a slave to other host MCUs to add networking capabilities to existing devices. It is suitable for home smart devices, industrial wireless control, wireless monitoring, QR wireless identification, wireless positioning system signals and other IoT applications.

FIG.ESP32 CAM

4.7 ELECTRONIC SPEED CONTROL

An electronic speed control or ESC is an electronic circuit that controls and regulates the speed of an electric motor. It may also provide reversing of the motor and dynamic braking. Miniature electronic speed controls are used in electrically powered radio-controlled models. Full size electric vehicles also have systems to control the speed of their drive motors. It is used to control the speed of BLDC motor on the command of slider potentiometer. In an ornithopter, the Electronic Speed Controller (ESC) serves as a crucial component responsible for controlling the speed and direction of the Brushless DC (BLDC) motors driving the flapping motion of the wings. The ESC acts as an intermediary between the flight controller or remote transmitter and the BLDC motors, translating control signals into precise adjustments of motor speed. As the ornithopter's wings mimic the flapping motion of birds, the ESC plays a pivotal role in synchronizing the movement of multiple motors to achieve stable and efficient flight. By regulating the timing and amplitude of the electrical pulses delivered to the BLDC motors' stator windings, the ESC ensures that the wings generate the appropriate lift and thrust required for controlled flight maneuvers. Additionally, the ESC provides features such as braking and reverse capabilities, allowing for quick and responsive changes in wing motion to maintain stability and adjust trajectory. Furthermore, the ESC may incorporate safety features such as overcurrent protection and temperature monitoring to prevent damage to the motors and ensure reliable operation throughout the flight. Overall, the ESC in an ornithopter enables precise and coordinated control of the flapping motion, contributing to the ornithopter's agility, maneuverability, and overall flight performance.

FIG.ELECTRONIC SPEED CONTROL

4.8 BATTERY

The battery used is a three cell lithium polymer pack, the standard for high performance machines like airplanes on this scale because it has the best power and energy to weight ratios available. Power density is the main concern at the initial stages of the project because flights aren't expected to last for long which would make power output the limiting factor for the battery. A lithium polymer battery can be discharged at up to 10 times its capacity (commonly referred to as 10C) with specially selected batteries capable of continuous discharge up to 25C which makes it able to deliver the short bursts of power that the ornithopter needs to flap during short test flights. Lithium phosphate batteries produced by A123 were also investigated because they have similar characteristics but the cell sizes available are too large to make a suitably lightweight pack at the correct voltage. The cell price of the lithium phosphate batteries works out to a pack at about half the price of the lithium polymer pack. In addition to this the lithium phosphate cells are much less sensitive to overcharging which causes lithium polymer batteries to violently explode. Because of potential cost and safety advantages of the lithium phosphate cells over the lithium polymer cells they may be further investigated in the future. As the current drawn from the motor wasn't yet known a standard battery, 1200mAh at 11.4V and 93 grams, is chosen for the weight calculation.

FIG. BATTERY

V.CALCULATIONS

The calculations are based on the data acquired from the Components used,
Dc motor – 3700 kV or 4200 kV
Battery – 7.4 V or 11.1 V
1) The speed of the model can be determined by the data obtained,
Speed = 3700 × 7.4
= 444 Rps.
Speed = 4200 × 11.1
= 777 Rps.
2) Gear teeth ratio of the gear mechanism is required to find out the flapping rate for the motor,
W.K.T n1 = 444 Rps. n2 =?
Using the gear teeth of 72, 8, 9 and 84.
444 / n2 = 84 / 9
n2 = 47.57 Rps.
Therefore,
47.57 = n2 / n3 = 72/8
n3 = 5.285 Rps.
Hence, the number of flaps are found to be 5.285 flaps per second.
3) For the battery used in mAh, it depends on the model, If the average current drawn is 15 A for 10 minutes, then
c = I × t. (2)
15 × 10 / 60 = 2500 mAh.
4) For current rate ‘C’,
If peak current drawn is 30 A from 3000 mAh
C = 30 A / 3000 mAh
= 10 C.

VI. FUTURE WORK

The resources that were available and limited were used to complete this project. Additional notable advancements in the selection of materials, machining techniques, and aerodynamics expertise. This project requires electronics control and their appropriate implementations. Finding the right rubber, motor and gearing for the gearbox system of these models was a major challenge. In addition, the assembly was supposed to be both lightweight and strong; hence, the rubber-powered model utilized a bamboo frame, and the electric model used a plastic rod frame with a thermocol body. Future advancements would entail researching various mechanisms and evaluating the benefits and drawbacks they present, locating suitable materials and machining techniques to fabricate the delicate components, and developing gearbox systems with increased loading capacity.

VII. FUTURE SCOPE

In recent years, the science of ornithology has witnessed significant advances. Even the construction and design of these tiny aircraft are intricate, there is greater room for possibilities in ornithology and other associated fields. Currently, the United States of America and China are among the nations using ornithopters. Ornithopters might be used for a number of reasons in the future. By using a different body material with a higher melting point, we may send it to the locations of fire incidents and keep an eye on the situation. In certain circumstances, acting right away is simple. In the future, using ornithopters for military purposes will be another important use. It assists in keeping an eye on the circumstances in future.

VIII. CONCLUSION

One of the most intriguing models is the ornithopter, which has countless applications, including crop protection and surveillance. Additionally, when the ornithopter's functional skills increase, a large number of attachments can be added. Installing the camera will allow you to take pictures of the area or object under monitoring. Prototypes and barriers can be distinguished from one another using sonar transmitters that can generate ultrasonic waves. It's also possible to create extremely low frequency ultrasonic waves to frighten birds off of airport runways and fields. With an efficient power source, the prototype can use the same energy during the day to recharge thanks to the usage of a solar power battery. Additionally, this solar electricity can be used if nighttime surveillance is needed. Even though there are currently a lot of surveillance drones on the market, they are noticeable and costly. An ornithopter is a mechanical flying robot with wings that imitates the movements and system of an innate flyer. It covers the type of mechanism, how it works, and the materials and design that were employed in its construction. These come under the Micro Ariel Vehicle (MAV) category, which is primarily concerned with shrinking more substantial models and using them in real-world scenarios across several industries. Numerous studies have been done on this subject to incorporate these natural systems into a mechanical model that was made artificially and shows the functionality of the chosen specimen. A dearth of knowledge on the topic has made it challenging to get the models to produce the necessary outcomes.

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