MCTA 4372

UNDERWATER AND AERIAL ROBOTS

SECTION 1

PROJECT: HEXACOPTER

GROUP 2

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INTRODUCTION

Hexacopters are six-rotor unmanned aerial vehicles (UAVs) that provide enhanced stability, greater payload capacity, and improved redundancy compared to traditional quadcopters. Their design makes them well-suited for a variety of applications, including aerial surveillance, precision agriculture, mapping, environmental monitoring, and research projects.

The objective of this project is to design and develop a **hexacopter from scratch using 3D printing technology** for its structural components. The use of 3D printing enables cost-effective customization, lightweight construction, and rapid prototyping. Additionally, leveraging open-source flight controllers and modular designs enhances flexibility and scalability for future improvements.

2. Executive Summary:

a) The purpose of the executive summary is to provide key information up-front, such that while reading the report, a reader has expectations that are fulfilled on a continuous basis. Key to a good Summary is the first sentence, which must contain the most essential information that you wish to convey.

b) The Executive Summary is to be one page or less with one figure maximum.

3. Table of Contents: Include section titles and page numbers.

4. Design problem and objectives: Give a clear and concise definition of the problem and the intended objectives. Outline the design constraints and cost implications.

a) Include appropriate background on the project for the reader to be able to put the information provided in context.

b) The final project objectives must also be presented in the form of a set of technical specifications.

5. Detailed design documentation: Show all elements of your design including an explanation of

a) Assumptions made, making sure to justify your overall design decisions.

b) Ability of meet Engineering Specifications

c) Function of the Proposed System which includes:

    i) Components Specifications consist of:

        i) Locomotion

        ii) System Architecture

        iii) Support System

        iv) Path Planning & Navigation

    ii) Human factors considered

    iii) All diagrams, figures, and tables should be accurately and clearly labeled with meaningful names and/or titles.

6. Safety: Provide a statement of the safety consideration in your proposed design to the extent that is relevant.

7. Conclusions: Provide a reasoned listing of only the most important hardware components.

PROPOSED SYSTEM DEVELOPMENT

To develop a fully functional hexacopter, the project will be divided into several critical stages:

- **Design Phase:**
  - Utilize **CAD modeling software** (Fusion 360) to design the frame, motor mounts, and landing gear.
  - Ensure **lightweight yet durable** structural integrity.
  - Perform aerodynamics simulations for optimized performance.
- **3D Printing & Assembly:**
  - Print structural components using high-strength materials such as **PETG, ABS, or carbon fiber-infused PLA**.
  - Assemble **brushless motors, electronic speed controllers (ESCs), and propellers** onto the printed frame.
  - Integrate landing gear and protective casing for electronics.
- **Electronics Integration:**
  - Implement a **flight controller** (e.g., Pixhawk, Betaflight, or ArduPilot) for drone stabilization.
  - Install **GPS and telemetry modules** for navigation and real-time tracking.
  - Configure **battery management and power distribution systems** to ensure efficiency and safety.
- **Software & Testing:**
  - Install and configure drone firmware (ArduPilot, Betaflight, or iNav).
  - Conduct **sensor calibration** for IMU, barometer, and compass.
  - Perform initial test flights and fine-tune PID settings for stability.

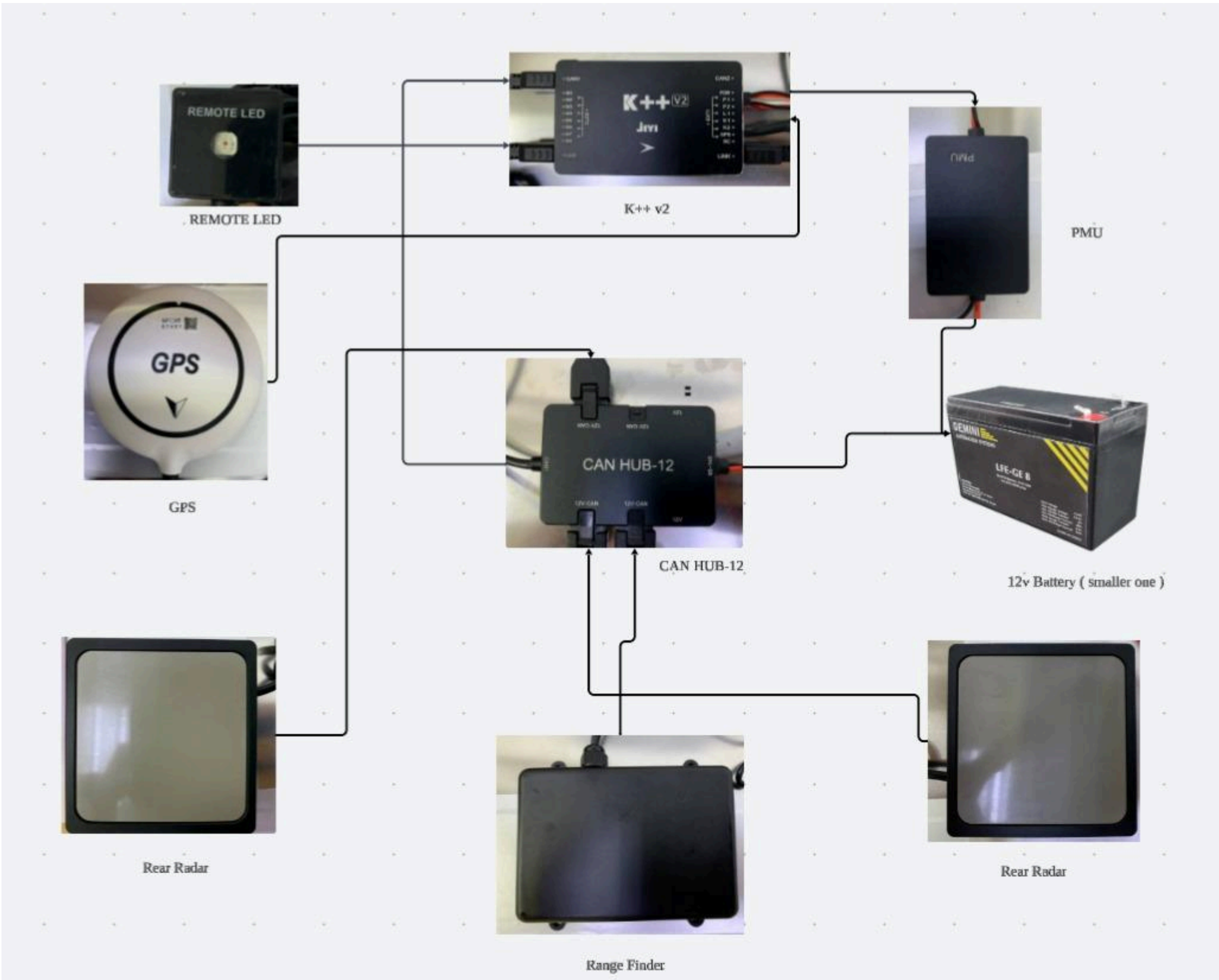
<u>FEASIBILITY ANALYSIS</u>

Feasibility Aspect	**Evaluation**
Technical Feasibility	- 3D printing ensures rapid prototyping and design flexibility
	- Open-source flight controllers simplify software implementation
	- Lightweight materials improve efficiency but require reinforcement
	- Battery efficiency and weight considerations are crucial
Operational Feasibility	- Requires knowledge of CAD modeling, 3D printing, and drone assembly
	- Availability of components and community support simplifies troubleshooting
	- Regular maintenance is necessary (firmware updates, battery care, and repairs)

COMPONENTS

COMPONENT	QUANTITY	PRICE (RM)
JiYi k++ v2 Flight Controller Kit	1	From dr
F550 Drone Kit	1	355
Remote LED	1	From dr
GPS	1	From dr
PMU	1	From dr
CAN HUB-12	1	From dr
Rear Radar	2	From dr
Range Finder	1	From dr
12V Battery	1	RM59.00
3D Filament	1	RM50.00
Booster Pump	1	RM29.43

<u>**Control System Architecture**</u>



TIMELINES

WEEK	PHASE	TASK DESCRIPTION
4	Design	CAD modeling & aerodynamics simulation
5-6	3D Printing	Printing structural components
7-8	Assembly	Installing motors & electronic components
9	Software setup	Configuring the flight controller & firmware
10-11	Testing and Optimization	Flight calibration & tuning

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MATHEMATICAL CALCULATIONS

COMPONENT	QUANTITY	WEIGHT/UNIT	TOTAL WEIGHT (g)
JiYi k++ v2 Flight Controller Kit	1	68	68
Rasberry	1	49	49
GPS	1	48	48
PMU	1	33	33
CAN HUB-12	1	90	90
Rear Radar	2	90	180
Range Finder	1	89	89
12V Battery	1	1200	1200
3D Filament	1	200	200
Booster Pump	1	43	43
Wires	10		129
550mm flame	1	600	600
Arms	6	30	180
30A Esc	6	20	120
1000kv Brushless Motor	6	30	180
XT60 Plug Male Cable Set For Main Lipo Battery	1	15	15
JST Plug Cable Set	1	10	10
Velco Lipo Battery Strap 300mm	2	5	10
2-8s Buzzer Alarm	1	20	20
High Landing Gear	4	30	12
TOTAL			**3276**

1) **Overall drone setup**

Parameter	Value
Total Weight	3276 kg
Number of Motor	6
Motor KV Rating	1000KV
Propeller	10 x 4.5”
Battery	3S (11.1V) or 4S (14.8V)

2) (i) Thrust requirements

Required Thrust = Total Weight = 3276g

Thrust per motor = 3276/6
= 546 g/motor

(ii) Recommended: 2:1 Thrust-to-Weight Ratio (for stability and maneuverability)

Thrust per motor = 546×2 = 1092g/motor

Total Required Thrust= 1092×6 = 6552g

3) Thrust estimation of 1000kv motor

Propeller	Voltage	Thrust (g)	Current (A)	Power (W)
10x4.5	3S (11.1V)	~850–900 g	~10A	~110 W
10x4.5	4S (14.8V)	~1050 g	~13–14A	~190 W

(i) Total thrust on 3S

Total Thrust = 6×900 = 5400g

T/W ratio = 5400/3276 = 1.65 : 1

(ii) Total thrust on 4S

Total Thrust = 6×1050 = 6300g

T/W ratio = 6300/3276 = 1.92 : 1

On **4S**, drone are close to the **ideal ratio of 2:1**.

4) Power consumption

(i) On 3S (11.1V, 10A per motor):

Power per motor = 11.1V×10A = 111W

Total Power = 111×6 = 666W

(ii) On 4S (14.8V, 13A per motor):

Power per motor = 14.8V×13A = 192.4W

Total Power = 192.4×6 = 1154.4 W

5) Battery sizing

(i) 3S 11.1V 5200mAh (5.2Ah)

Energy in Wh = 11.1 × 5.2 = 57.72 Wh

Estimated Hover Time = 57.72/666 × 60 = 5.2 minutes (on 3S)

(ii) 4S 5200mAh:

Energy in Wh = 14.8×5.2=76.96Wh

Estimated Hover Time = 76.96/1154.4 × 60 = 4.0minutes (on 4S)

6) Lift Margin & Payload

(i) Lift margin

Total thrust = 5400g (on 3S)

Current drone weight = 3276g

Excess Thrust = 5400 − 3276 = 1924g

Total thrust = 6300g (on 4S)

Current drone weight = 3276g

Excess Thrust = 6300 − 3276 = 3024g

(ii) Payload

Max Total Weight = 5400g / 1.5 = 3600g
Max Payload = 3600g - 3276g = 324g

Max Total Weight = 6300g / 1.5 = 4200g
Max Payload = 4200g - 3276g = 924g

So drone can technically **carry up to ~3 kg more(4S)**, but performance will suffer. Realistically, keep payload under **924 g**.

7) Component Power Consumption (at 12V)

Component	Current (A)	Power (W)
JiYi k++ v2 Flight Controller	0.25 A	3.0 W
Raspberry Pi	1.20 A	14.4 W
GPS Module	0.06 A	0.72 W
PMU	0.10 A	1.20 W
CAN HUB-12	0.10 A	1.20 W
Rear Radar (x2)	0.30 A	3.60 W
Range Finder	0.15 A	1.80 W
Booster Pump	1.50 A	18.0 W
30A ESC x6 (idle only)	0.30 A	3.60 W
XT60 Plug Set	0 A	0 W
JST Plug Cable Set	0 A	0 W
Buzzer Alarm	0.05 A	0.60 W

High Landing Gear (active est.)	0.10 A	1.20 W
Total (Components Only)	—	**49.32 W**

8) Total estimated power consumption

Power System	Components (W)	Motors (W)	Total (W)
3S (12V)	49.32 W	666 W	715.32 W
4S (14.8V)	49.32 W	1154.4 W	1203.72 W

9) Calculation Summary

Parameter	3S Battery (11.1V)	4S Battery (14.8V)
Total Drone Weight	3276g (3.276kg)	3276g (3.276kg)
Required Hover Thrust per Motor	546g	546g
Required Thrust for Safe TWR 2:1 per Motor	1092g	1092g
Thrust per Motor	~900g	~1050g
Total Thrust	5400g	6300g
Excess Thrust (Lift Margin)	+2124g	+3024g
Thrust-to-Weight Ratio (TWR)	1.65	1.92
Power Total (6 Motors)	666W	1154.4W
Battery Capacity	57.7 Wh	77.0 Wh
Estimated Flight Time	~5.2 mins	~4.0 mins

Student's Declaration

Certificate of Originality and Authenticity

This is to certify that we are responsible for the work submitted in this report, that the original work is our own except as specified in the references and acknowledgment, and that the original work contained herein has not been untaken or done by unspecified sources or persons.

We hereby certify that this report has not been done by only one individual and all of us have contributed to the report. The length of contribution to the reports by Each individual is noted within this certificate.

We also hereby certify that we have read and understand the content of the total report and no further improvement on the reports is needed from any of the individual contributor to the report.

We, therefore, agreed unanimously that this report shall be submitted for marking and this final printed report has been verified by us.

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