A
Project Report
On

‘ARDUINO FLIGHT CONTROL SYSTEM’

Submitted to

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, VISHNUPURI, NANDED

In partial fulfillment of the requirement for the degree of

BACHELOR OF ENGINEERING
In
INFORMATION TECHNOLOGY

By

SAURABH JONDHALE

Under the Guidance
Of

Mr. S P Bandewar.

(Department of Information Technology)

DEPARTMENT OF INFORMATION TECHNOLOGY
MAHATMA GANDHI MISSION’S COLLEGE OF ENGINEERING
NANDED (M.S.)

Academic Year 2019-2020

<u>*Certificate*</u>

This is to certify that the project entitled

“ARDUINO FLIGHT CONTROL SYSTEM”

*Being submitted by **Saurabh Jondhale** to the **Swami Ramanand Teerth Marathwada University, Nanded**, for the award of the degree of Bachelor of Engineering in **Information Technology**, is a record of bonafide work carried out by them under my supervision and guidance. The matter contained in this report has not been submitted to any other university or institute for the award of any degree.*

Mr.S P Bandewar.
Project Guide

Mr.Hashmi S.A.
H.O.D
Information Technology

Dr.Mrs. G.Lathkar
Director
MGM’s College of Engg.Nanded

ACKNOWLEDGEMENT

We are greatly indebted to our project guide **Mr. S P Bandewar** for his guidance throughout the course of this work. It has been an altogether different experience to work with him and we would like to thanks for his help, suggestions and numerous discussions.We gladly take this opportunity to thank **Mr. Hashmi S.A.** (Head of Information Technology, MGM's College of Engineering, Nanded.) for her help and guidance.

We are heartily thankful to **Dr.Mrs.Lathkar G. S.** (Director, MGM's College of Engineering, Nanded.) for providing facility during progress of project, also for her kindly help, guidance and inspiration.

Last but not least we are also thankful to all those who helped directly or indirectly to develop this project and complete it successfully.

With Deep Reverence,

Saurabh Jondhale.

[BEIT]

ABSTRACT

This ARDUINO FLIGHT CONTROL SYSTEMproject enables the user to control the GLIDER or any flying object that is able to fly.In this project the user can send and receive the transmission control signals to control the flying object. The transmitter system by which a user can send the signals are received by the receiver which is embedded to the flight controller. This gives the complete flight control in the hands of the user. Three channels are used on the flight control systems which are as follows:

1:- Turning left.

2:- Turning right.

3:- Moving forward by controlling the thrust of the engine by using ESC [Electronic Speed Control].

The three channels are acquired by using Arduino Pro Mini on both ends i.e. one on Transmitter end and one on Receiver end.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

This ARDUINO FLIGHT CONTROL SYSTEM project enables the user to control the GLIDER or any flying object that is able to fly. In this project the user can send and receive the transmission control signals to control the flying object. The transmitter system by which a user can send the signals are received by the receiver which is embedded to the flight controller. This gives the complete flight control in the hands of the user. Three channels are used on the flight control systems which are as follows:

1:- Turning left.

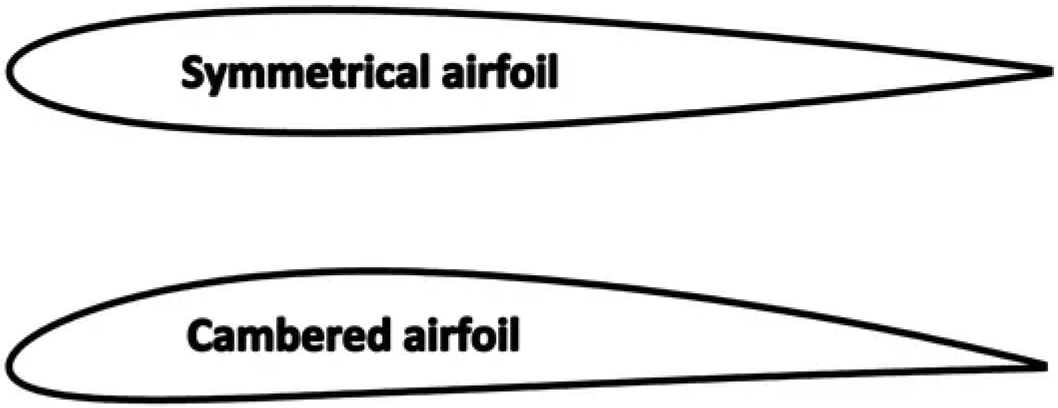
2:- Turning right.

3:- Moving forward by controlling the thrust of the engine by using ESC [Electronic Speed Control].

The three channels are acquired by using Arduino Pro Mini on both ends i.e. one on Transmitter end and one on Receiver end.

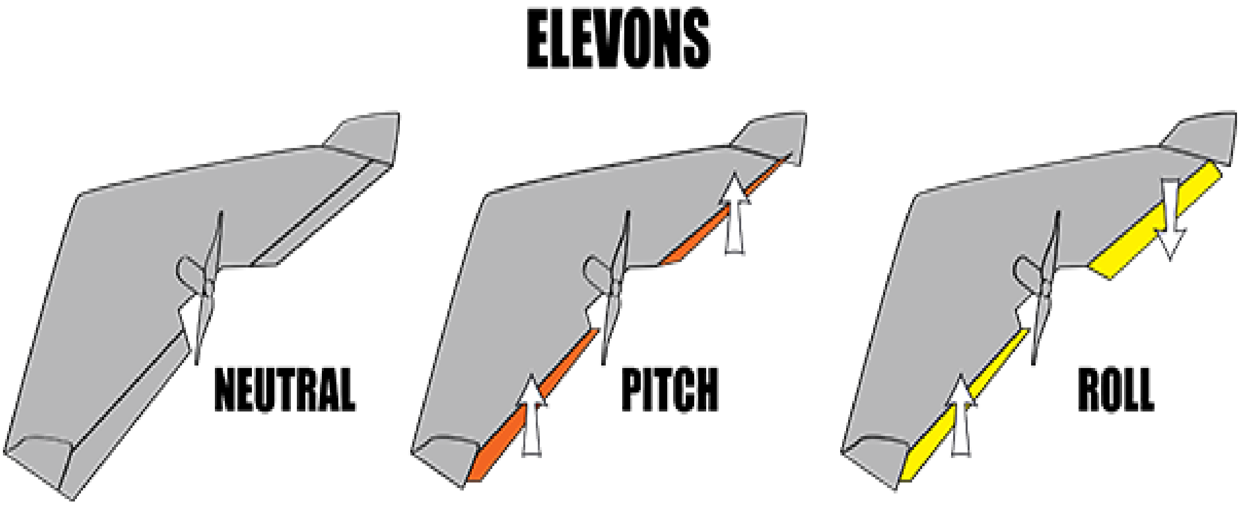
1.1 WING PROFILE:

Tailless planes and flying wings can be equipped with almost any aerofoil, if sweep and twist distribution are chosen accordingly. Thus, the one and only "flying wing aerofoil" does not exist. However, if we want to design a tailless plane with a wide operating range, the wing should have a small amount of twist only, or none at all, to keep the induced drag at reasonable levels throughout the whole flight envelope. Under these conditions, the wing must not create a large variation in moment coefficient, when the angle of attack is varied. This makes it necessary, to use aerofoils with a low moment coefficient. In the case of an upswept wing ("plank"), even an aerofoil with a positive moment coefficient is necessary, to avoid upward deflected flaps under trimmed flight conditions. Such aerofoils usually have a reflexed camber line.



1.2 Aerodynamics of the Wing:

Flying wings are one of the most promising concepts for the future of commercial aviation, regarding the market, technology and environmental driving factors. The research reported here is part of a long term project on the 300 seats category flying wings. In several previously published works the feasibility, efficient performance and airport compatibility of the concept have been assessed. The present paper concentrates on the flight dynamic aspects of the aircraft, which have been scarcely analysed in open literature. The results obtained show that the flying wing configuration can be dynamically stable; however, the longitudinal and lateral directional oscillations decay so slowly that a stability augmentation system would be required to assure an acceptable dynamic response of the aircraft.



1.3 Category of Flying Object:

An **unmanned aerial vehicle** (**UAV**) (or **uncrewed aerial vehicle**,[2] commonly known as a **drone**) is an aircraft without a human pilot on board and a type of unmanned vehicle. UAVs are a component of an unmanned aircraft system (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs may operate with various degrees of autonomy: either under remote control by a human operator or autonomously by on-board computers.[3]

Compared to crewed aircraft, UAVs were originally used for missions too "dull, dirty or dangerous"[4] for humans. While they originated mostly in military applications, their use is rapidly expanding to commercial, scientific, recreational, agricultural, and other applications,[5] such as policing and surveillance, product deliveries, aerial photography, infrastructure inspections, smuggling,[6] and drone racing. Civilian UAVs now vastly outnumber military UAVs, with estimates of over a million sold by 2015.

Multiple terms are used for unmanned aerial vehicles, which generally refer to the same concept.

The term **drone**, more widely used by the public, was coined in reference to the early remotely-flown target aircraft used for practice firing of a battleship's guns, and the term was first used with the 1920s Fairey Queen and 1930's de Havilland Queen Bee target aircraft. These two were followed in service by the similarly-named Airspeed Queen Wasp and Miles Queen Martinet, before ultimate replacement by the GAF Jindivik.[7]

The term *unmanned aircraft system* (**UAS**) was adopted by the United States Department of Defence (DoD) and the United States Federal Aviation Administration in 2005 according to their Unmanned Aircraft System Roadmap 2005–2030.[8] The International Civil Aviation Organization (ICAO) and the British Civil Aviation Authority adopted this term, also used in the European Union's Single-European-Sky (SES) Air-Traffic-Management (ATM) Research (SESAR Joint Undertaking) roadmap for 2020.[9] This term emphasizes the importance of elements other than the aircraft. It includes elements such as ground control stations, data links and other support equipment. A similar term is an *unmanned-aircraft vehicle system* (UAVS), *remotely piloted aerial vehicle* (RPAV), *remotely piloted aircraft system* (RPAS).[10] Many similar terms are in use.

A UAV is defined as a "powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload".[11] Therefore, missiles are not considered UAVs because the vehicle itself is a weapon that is not reused, though it is also uncrewed and in some cases remotely guided.

Under new regulations which came into effect June 1, 2019, the term RPAS (Remotely Piloted Aircraft System) has been adopted by the Canadian Government to mean "a set of configurable elements consisting of a remotely piloted aircraft, its control station, the command and control links and any other system elements required during flight operation".

The relation of UAVs to remote controlled model aircraft is unclear.[citation needed] UAVs may or may not include model aircraft. Some jurisdictions base their definition on size or weight; however, the US Federal Aviation Administration defines any uncrewed flying craft as a UAV regardless of size. For recreational uses, a drone (as opposed to a UAV) is a model aircraft that has first-person video, autonomous capabilities, or both.

CHAPTER 2

HARDWARE REQUIREMENTS SPECIFICATIONS

The electronics and hardware components required for The Wing are as follows:

1: Arduino UNO R3

2: Arduino NANO.

3:HC12.

4: ESC [Electronic Speed Controller].

5: Engine [1400kv motor]Brushless DC motor.

6: 8inches Propeller.

7: Joysticks.

8: Servo Motors.

9: Gyro Sensors (optional).

10: FPV [First Person View] Camera.

2.1Arduino UNO R3

Arduino UNO R3

This is the **Arduino Uno R3**. In addition to all the features of the previous board, the Uno now uses an ATmega16U2 instead of the 8U2 found on the Uno (or the FTDI found on previous generations). This allows for faster transfer rates and more memory. No drivers needed for Linux or Mac (inf file for Windows is needed and included in the Arduino IDE), and the ability to have the Uno show up as a keyboard, mouse, joystick, etc.

The Uno R3 also adds SDA and SCL pins next to the AREF. In addition, there are two new pins placed near the RESET pin. One is the IOREF that allow the shields to adapt to the voltage provided from the board. The other is a not connected and is reserved for future purposes. The Uno R3 works with all existing shields but can adapt to new shields which use these additional pins.

The **Arduino Uno** is a microcontroller board based on the ATmega328. Arduino is an open-source, prototyping platform and its simplicity makes it ideal for hobbyists to use as well as professionals. The Arduino Uno has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

The Arduino Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 microcontroller chip programmed as a USB-to-serial converter.

Features of the Arduino UNO:

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

2.2Arduino NANO

The Arduino Software (IDE), is used to program Arduino Nano. The Arduino Software is an Integrated Development Environment that is common to all Arduino boards and runs both online and offline.
The detailed specification of the **Arduino Nano** board is as follows:

- Microcontroller ATmega328
- Operating Voltage (logic level): 5 V
- Input Voltage (Recommended): 7-12 V
- Input Voltage (limits): 6-20 V
- Digital I/O Pins : 14 (of which 6 provide PWM Output)
- Analog Input Pins: 8
- DC Current per I/O Pin: 40 mA
- Flash Memory 32 KB (ATmega328) of which 2 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz
- Measurements: 0.73" x 1.70"

2.3 HC12

HC-12 Wireless Transceiver Modules 433Mhz – 1000 Meters

HC-12 Wireless Transceiver Modules 433Mhz are wireless serial port communication modules, It is based on SI4463 RF chip, it has built in microcontroller, and can be configured using **AT commands**, Maximum output power is 100mW (20dBm) and receiver sensitivity differs from -117dBm to -100dBm, depending on transmission speed. It accepts 3.2V-5.5V and can be used with 3.3V and 5V UART voltage devices (3.3V safe).

Each *HC-12* can work in one of following modes:

1. FU1 – moderate power saving mode with 250000bps “over the air” baud rate. Serial port baud rate can be set to any supported value
2. FU2 – extreme power saving mode with 250000bps “over the air” speed. Serial port rate is limited to 1200bps, 2400bps, 4800bps
3. FU3 – default, general purpose mode. “Over the air” speed differs depending on serial port speed. The same goes for maximum range:
    - 1200bps ~ 1000m
    - 2400bps ~ 1000m
    - 4800bps ~ 500m
    - 9600bps ~ 500m
    - 19200bps ~ 250m
    - 38400bps ~ 250m
    - 57600bps ~ 100m
    - 115200bps ~ 100m
4. FU4 (available in version 2.3 or newer) – long range mode. “Over the air” speed is limited to 500bps and serial port speed to 1200bps. Because air speed is lower than port speed, only small packets can be send: max 60 bytes with interval of 2 seconds. In this mode range is increased to 1800m.

Pair of HC-12 that creates a wireless link has to work in the same mode (FU1, FU2, FU3, FU4) and with the same speed.

Configuration

HC-12 can be configured using AT command. The best way to do it, is to use USB-to-serial converter like CP2102. To put HC-12 into AT mode, pull *SET* pin to GND like this:

Most important commands:

1. `AT` – test command. It will return `OK` if AT interface is enabled
2. `AT+Bxxxx` – set serial port baud rate. For example, `AT+B57600` set baud rate to 57600bps
3. `AT+Cxxx` – set radio channel. Channels start from `001` at 433,4MHz. Each next channel adds 400kHz. Channel `100` is 473,0MHz. `AT+C002` will set frequency to 433,8MHz. Two HC-12 devices that creates a wireless link have to operate on the same frequency
4. `AT+FUx` – set device mode: FU1, FU2, FU3 or FU4. Two HC-12 devices that creates a wireless link have to use the same mode
5. `AT+Px` – set device transmitting power. For example `AT+P2` sets power to 2dBm (1.6mW)
    1. -1dBm (0.8mW)
    2. 2dBm (1.6mW)
    3. 5dBm (3.2mw)
    4. 8dBm (6.3mW)
    5. 11dBm (12mW)
    6. 14dBm (25mW)
    7. 17dBm (50mW)
    8. 20dBm (100mW)
6. `AT+RX` – retrieve all parameters: mode, channel, baud rate, power
7. `AT+V` – retrieve module version
8. `AT+DEFAULT` – reset module parameters to default settings

Features

- Long-distance wireless transmission (1,000m in open space/baud rate 5,000bps in the air)
- Working frequency range (433.4-473.0MHz, up to 100 communication channels)
- Maximum 100mW (20dBm) transmitting power (8 gears of power can be set)
- Three working modes, adapting to different application situations
- Built-in MCU, performing communication with external device through serial port
- The number of bytes transmitted unlimited to one time

Specification

- Working frequency: 433.4MHz to 473.0MHz
- Supply voltage: 3.2V to 5.5VDC
- Communication distance: 1,000m in the open space
- Serial baud rate: 1.2Kbps to 115.2Kbps（default 9.6Kbps）
- Receiving sensitivity: -117dBm to -100dBm
- Transmit power: -1dBm to 20dBm
- Interface protocol: UART/TTL

2.4 ESC [Electronic Speed Controller]

This is fully programmable 30A BLDC ESC with 5V, 2A BEC. Can drive motors with continuous 30Amp load current. It has sturdy construction with heatsink on the MOSFETs for better heat dissipation. It can be powered with 2-4 lithium Polymer batteries or 5-12 NiMH / NiCd batteries. It has separate voltage regulator for the microcontroller for providing good anti-jamming capability. It is most suitable for UAVs, Aircrafts and Helicopters.

Note: This BLDC ESC is factory programmed and ready to use. You should program it only to customize it as per your requirements.

Specifications

- Output: 30A continuous; 35Amps for 10 seconds
- Input voltage: 2-4 cells Lithium Polymer / Lithium Ion battery or 5-12 cells NiMH / NiCd
- BEC: 5V, 2Amp for external receiver and servos
- Max Speed: 2 Pole: 210,000rpm; 6 Pole: 70,000rpm; 12 Pole: 35,000rpm
- Weight: 22gms
- Size: 47mm x 27mm x 12mm

Features

- High quality MOSFETs for BLDC motor drive
- High performance microcontroller for best compatibility with all types of motors at greater efficiency
- Fully programmable with any standard RC remote control
- Heat sink with high performance heat transmission membrane for better thermal management
- 3 start modes: Normal / Soft / Super-Soft, compatible with fixed wing aircrafts and helicopters
- Throttle range can be configured to be compatible with any remote control available in the market
- Smooth, Linear and Precise throttle response
- Low-Voltage cut-off protection
- Over-heat protection
- Separate voltage regulator IC for the microcontroller to provide anti-jamming capability
- Supported Motor Speed (Maximum): 210000RPM (2 poles), 70000RPM (6poles), 35000RPM (12 poles)

2.5Engine [1400kv motor] Brushless DC motor

BRUSHLESS MOTOR 1400 KV BLDC motor is best used for airplane, aircraft or quad copter. This brushless motor comes with 80% maximum efficiency, 4-10A max current efficiency and 12A / 60s current capacity?

Specifications:

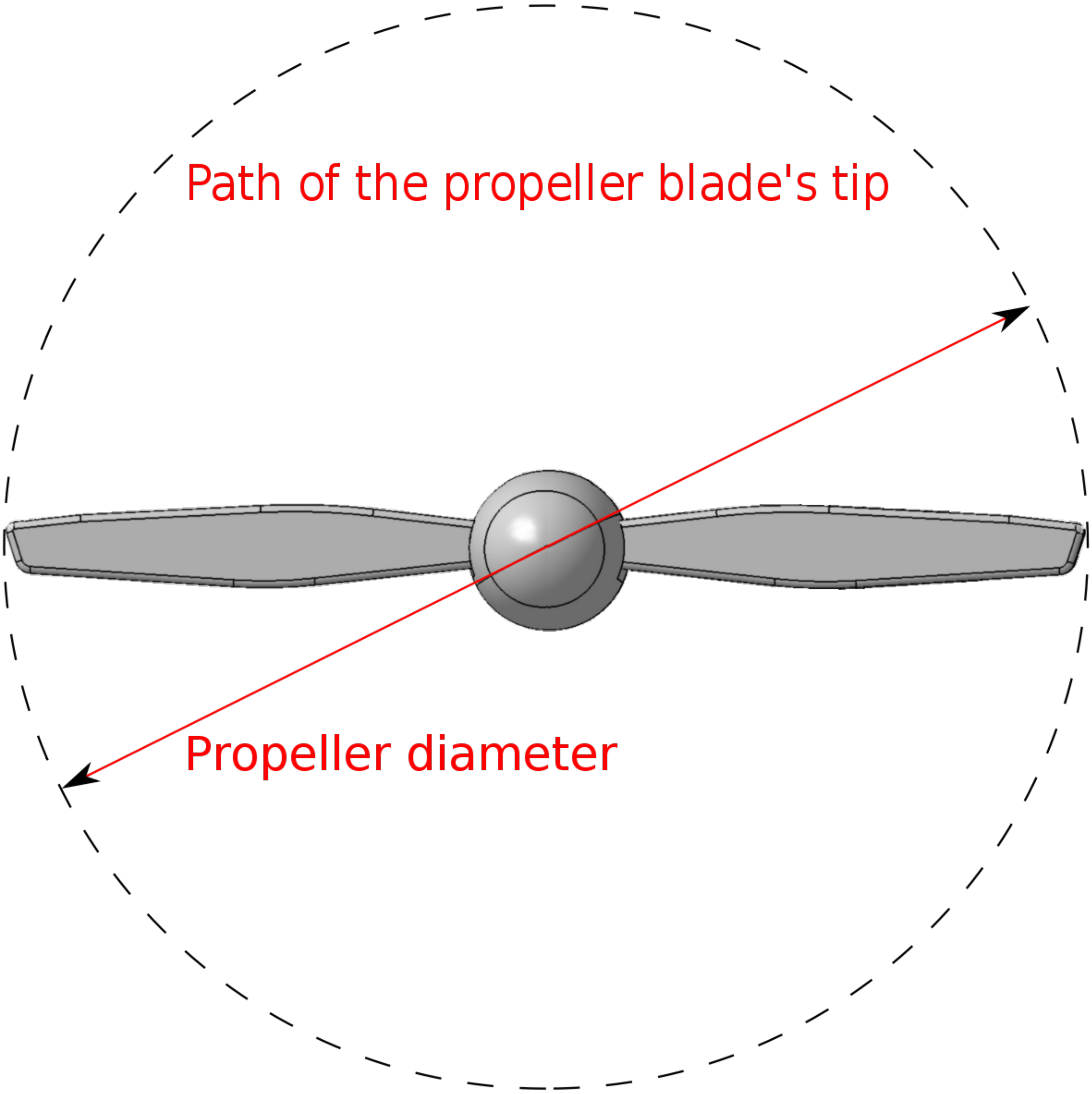
- RPM/V: 1400
- Stator Diameter (mm) :22
- Stator length (mm) : 13
- Stator Arms (mm) : 12
- RPM (KV) : 1400
- Idle Current (A): 0.68/8
- Max Current (A): 20
- Max Power (W): 220/3
- Rotor Dia (mm): 28
- Shaft Dia (mm): 3.17
- Motor Length (mm): 28
- Overall Length (mm): 42
- Biggest Thrust g/S: 1265/4

2.6 8inches Propeller

This is 8045(80×4.5) SF Propellers Black. They are for lower RPM motor and slow flying drone models.

They have wide and thin blades in their size category which makes them much flexible in crash conditions where they do not break easily. 8045(80×4.5) SF Propellers **Black especially draws larger currents and in results will give you a considerable amount of thrust.**

8045(80×4.5) SF Props have high-quality propellers specially designed for multi-copters. 8045(80×4.5) SF Props has a 15° angle design at the end of the propeller to avoid whirlpool multi-copter flying.

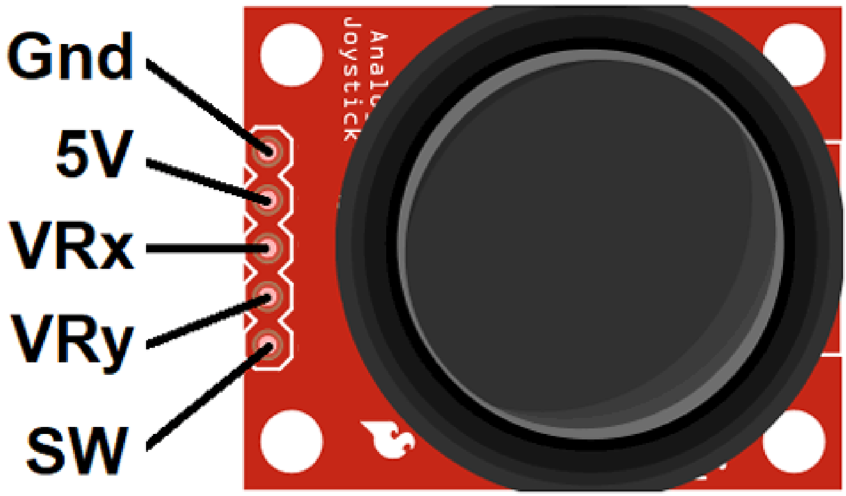


2.7: Joysticks

Pin Configuration

Pin No.	Pin Name	Description
1	Gnd	Ground terminal of Module
2	+5v	Positive supply terminal of Module
3	VRx	Voltage Proportional to X axis

4	VRy	Voltage Proportional to Y axis
5	SW	Switch



Features

- Two independent Potentiometer: one for each axis (X and Y)
- Auto return to center position
- Low weight
- Cup-type Knob
- Compatible to interface with Arduino or with most microcontrollers

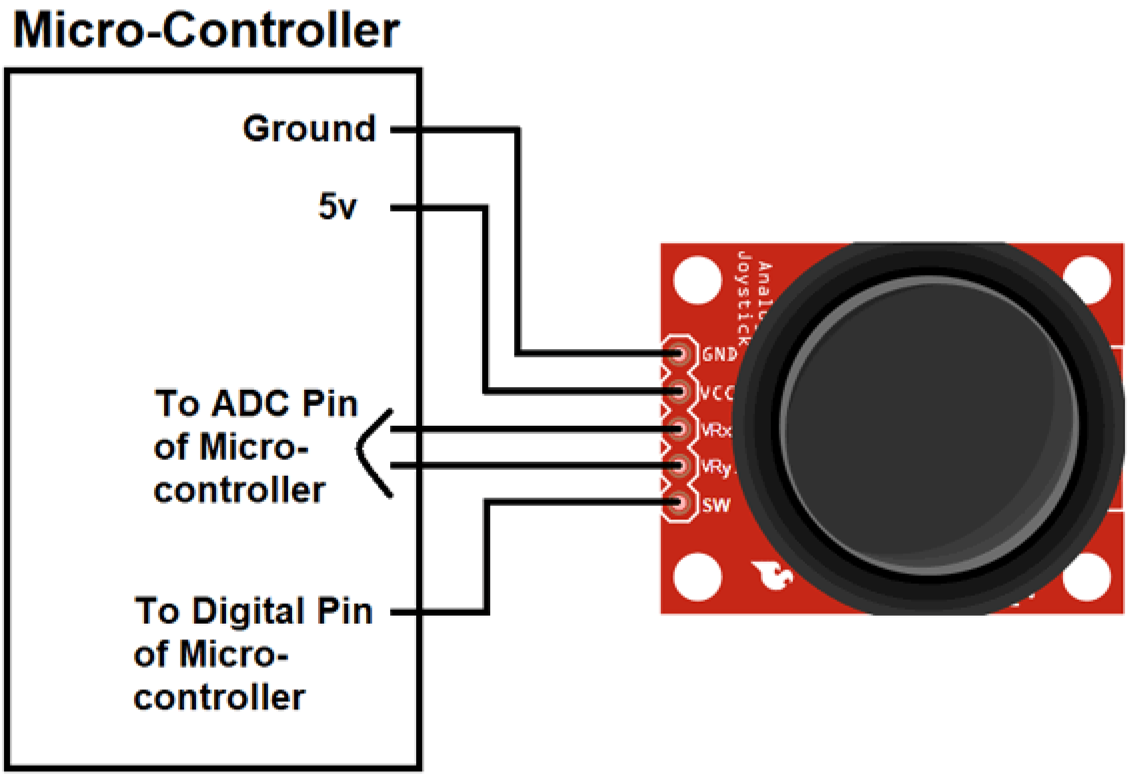
Technical Specifications

- Operating Voltage: 5V
- Internal Potentiometer value: 10k
- 2.54mm pin interface leads
- Dimensions: 1.57 in x 1.02 in x 1.26 in (4.0 cm x 2.6 cm x 3.2 cm)
- Operating temperature: 0 to 70 °C

When we listen the word "**Joystick**" we think of Game controllers. If we talk about Electronics there are many useful application of Joystick. These type of module are mostly used in Arduino based DIY projects and Robot Control. As we know, the module gives analog output so it can be used for feeding the analog input based on direction or movement. It can also be connected to a movable camera to control its movement.

We can use a Joystick Module with Arduino, Raspberry Pi and any other Micro-controllers.

We just have to connect the axis Pins VRx and VRy to the ADC Pins of the micro-controller. If you want to use the switch then connect it to the digital Pin of the Micro-controller. Follow the below block diagram to connect Joystick Module with Microcontroller.



2.8 Servo Motors

Micro Servo is ideal for applications where small weight and size are a key factor. The servo uses standard PWM control signals and operates from 4.8V - 6V with a power consumption of <500mA.

Specifications

- Weight: 9g
- Size: 23 x 12.3 x 25.6 mm
- Torque: 1.5 kg.cm @ 4.8V; 2.0 kg/cm @ 6V
- Speed: 0.08sec/60°
- Gear Type: Plastic
- Motor Type: Coreless
- Operating Voltage Range: 4.8V-6V

- Operating Temperature Range: 0°-60°
- Current: < 500mA
- Wire Length: 170mm
- Includes: 5 servo arms.

Specification	**Value**
Motor Drive Type	Sub-Micro Servo
No-Load Speed (4.8V)	0.08 sec/60°
Stall Torque (4.8V)	20.83 oz.in (1.5 kg.cm)
Stall Torque (6.0V)	27.77 oz.in (2.0 kg.cm)
Rotation	Clockwise
Direction Type	180 Degree
Current Drain mA- Idle/No Load	<500 mA
Dimensions (L" x W" x H")	1.3 x 0.5 x 1.1

2.9 Gyro Sensors [MPU6050]

The MPU-6050 is a serious little piece of motion processing tech! By combining a MEMS 3-axis gyroscope and a 3-axis accelerometer on the same silicon die together with an onboard Digital Motion Processor™ (DMP™) capable of processing complex 9-axis MotionFusion algorithms, the MPU-6050 does away with the cross-axis alignment problems that can creep up on discrete parts.

Features

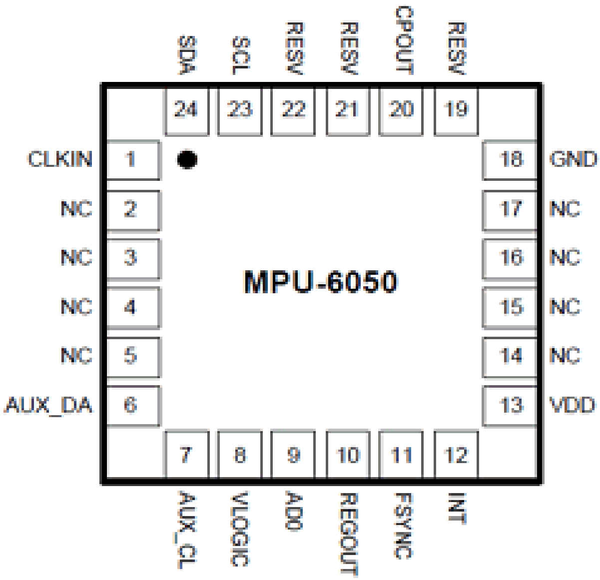
- I2C Digital-output of 6 or 9-axis MotionFusion data in rotation matrix, quaternion, Euler Angle, or raw data format
- Input Voltage: 2.3 - 3.4V
- Selectable Solder Jumpers on CLK, FSYNC and AD0

- Tri-Axis angular rate sensor (gyro) with a sensitivity up to 131 LSBs/dps and a full-scale range of ±250, ±500, ±1000, and ±2000dps
- Tri-Axis accelerometer with a programmable full scale range of ±2g, ±4g, ±8g and ±16g
- Digital Motion Processing™ (DMP™) engine offloads complex MotionFusion, sensor timing synchronization and gesture detection
- Embedded algorithms for run-time bias and compass calibration. No user intervention required
- Digital-output temperature sensor

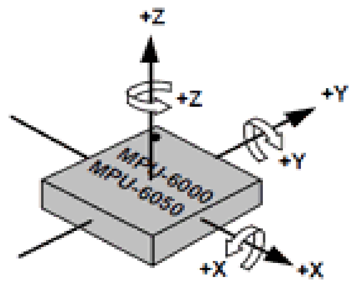
Specifications

- Chip: MPU-6050
- Power supply: 3~5V Onboard regulator
- Communication mode: standard IIC communication protocol
- Chip built-in 16bit AD converter, 16bit data output
- Gyroscopes range: +/- 250 500 1000 2000 degree/sec
- Acceleration range: +/- 2g, +/- 4g, +/- 8g, +/- 16g
- Pin pitch: 2.54mm

MPU-6050



QFN Package
24-pin, 4mm x 4mm x 0.9mm



Orientation of Axes of Sensitivity and
Polarity of Rotation

2.10 FPV [First Person View] Camera

First-person view (**FPV**), also known as **remote-person view** (**RPV**), or simply **video piloting**, is a method used to control a radio-controlled vehicle from the driver or pilot's view point. Most commonly it is used to pilot a radio-controlled aircraft or other type of unmanned aerial vehicle (UAV). The vehicle is either driven or piloted remotely from a first-person perspective via an onboard camera, fed wirelessly to video FPV goggles [1][2] or a video monitor. More sophisticated setups include a pan-and-tilt gimbaled camera controlled by a gyroscope sensor in the pilot's goggles and with dual onboard cameras, enabling a true stereoscopic view.

FPV ground vehicles

Any remote-controlled vehicle capable of carrying a small camera and video transmitter can be operated by FPV. Accordingly, FPV systems are also commonly used on remote-control cars and other ground-based models, though the effective range of such setups will typically be much less than a similar aerial system due to ground obstructions blocking the radio signal.

CHAPTER 3

CHANNEL ESTABLISHMENT

CHANNEL 1= LEFT AILERON

CHANNEL 2= RIGHT AILERON

CHANNEL 3= THRUST CONTROL

The above three channels are used to control the wing by accessing the ailerons to change the directions in mid-air. The Servo Motors on each aileron provide the control as per the instructions given by the transmitter which is driven by Arduino UNO R3 connected by HC12 wireless transmitter.

The receiver on the wing is connected by HC12 receiver which is driven by ArduinoNANO. When the user transmits the signal through transmitter towards the wing, the receiver receives the signal and performs as desired.

The engine i.e the Brushless DC motor is connected with Electronic Speed Controller which gains instruction through Arduino NANO on the wing. The user can increase the throttle on the transmitter by moving the joy-stick in the forward direction and decrease the throttle by going backward direction of joy-stick.

The **Transmitter End** contains:

1: Arduino UNO R3.

2: Joy-Sticks.

3: HC12 wireless transmitter/receiver.

The **Receiver End** contains:

1: Arduino NANO.

2: Servo Motors [one each on both ailerons].

3: Brushless DC Motor.

4: HC12 wireless transmitter/receiver.

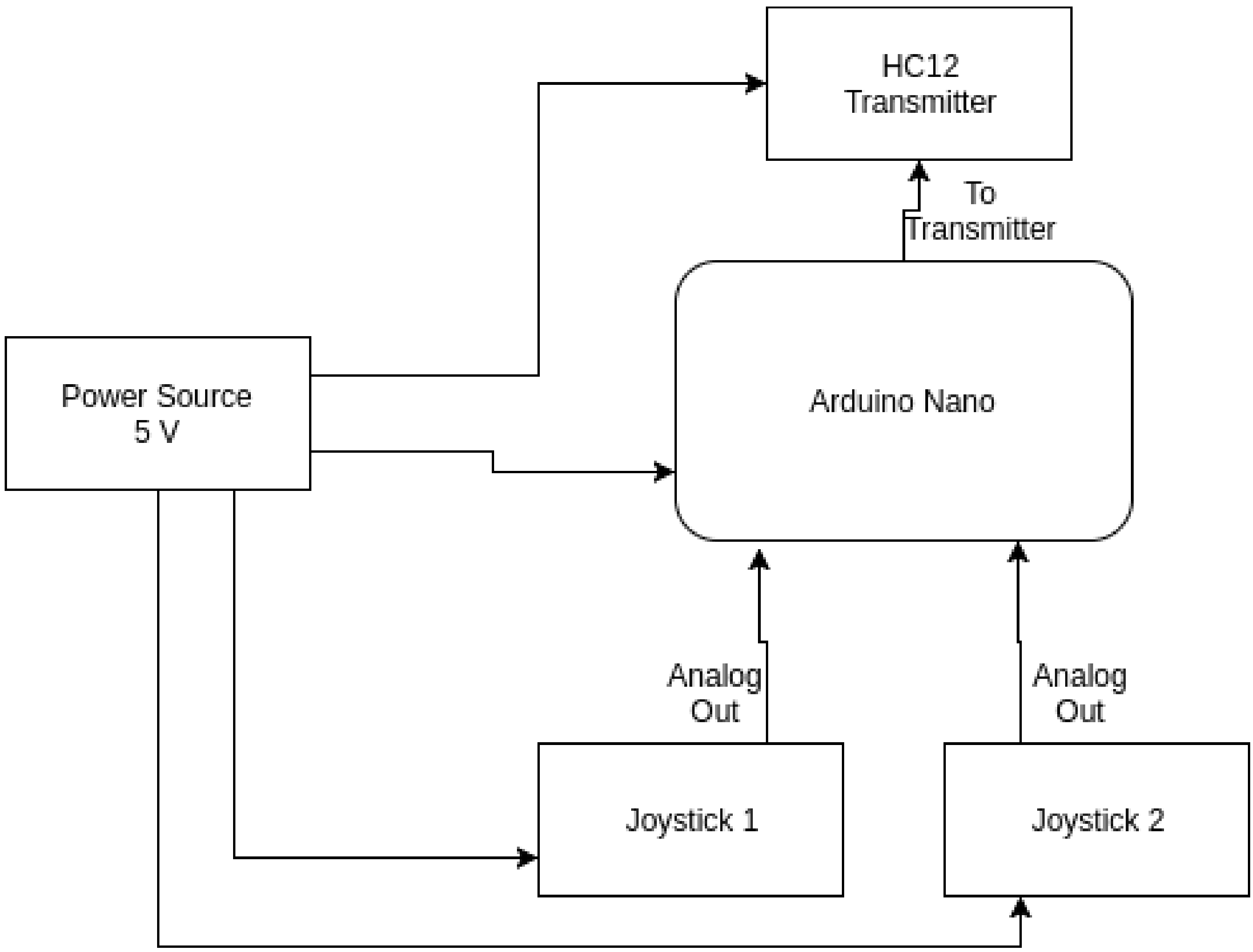
5: Gyro Sensor MPU6050 (optional).

6: First Person View Camera.

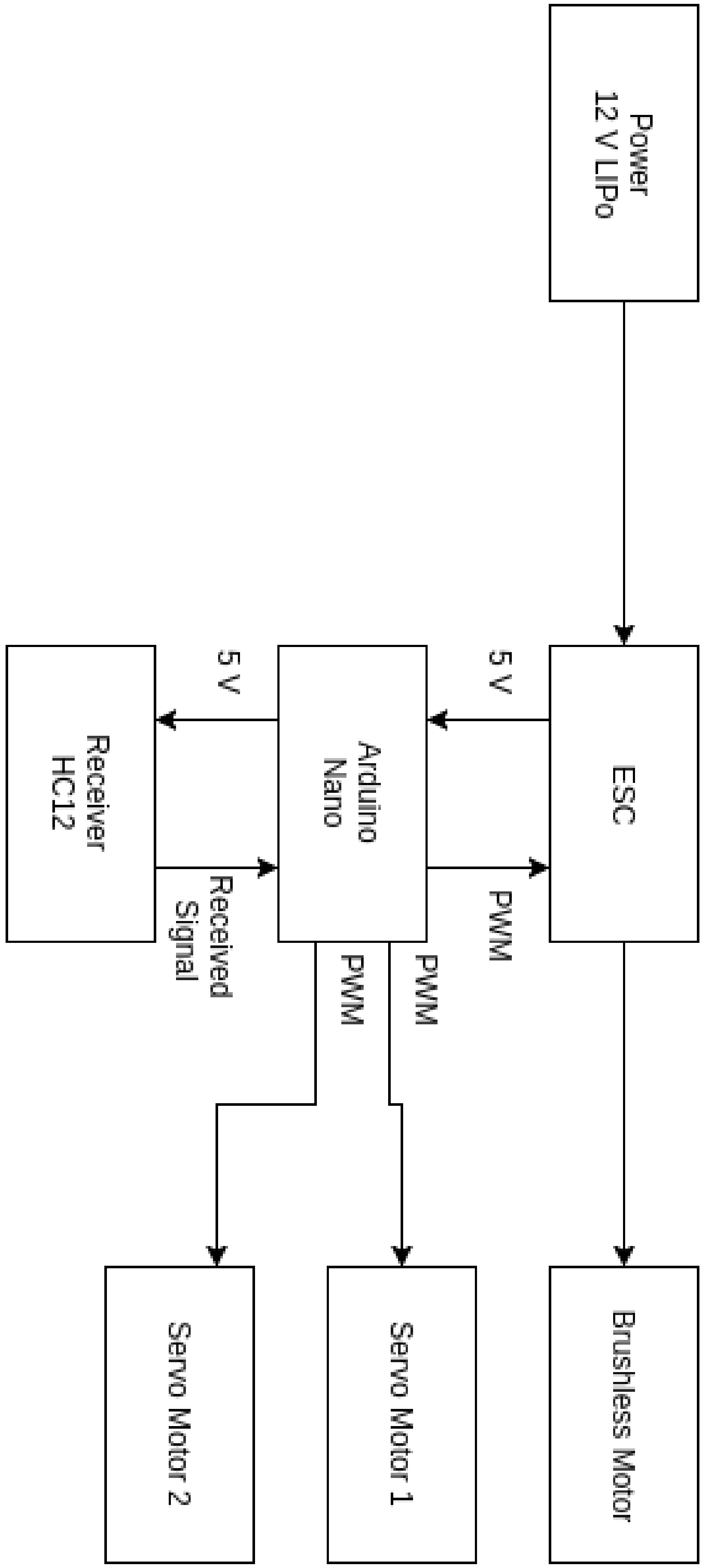
The Receiver End is on The Wing and The Transmitter End is in the user’s hand.

3.1 HC12 Transmitter/Receiver

HC12 Transmitter Driven by Arduino



HC12 Receiver Driven by Arduino



HC-12 Wireless Transceiver Modules 433Mhz – 1000 Meters

HC-12 Wireless Transceiver Modules 433Mhz are wireless serial port communication modules, It is based on SI4463 RF chip, it has built in microcontroller, and can be configured using **AT commands**, Maximum output power is 100mW (20dBm) and receiver sensitivity differs from -117dBm to -100dBm, depending on transmission speed. It accepts 3.2V-5.5V and can be used with 3.3V and 5V UART voltage devices (3.3V safe).

Each *HC-12* can work in one of following modes:

5. FU1 – moderate power saving mode with 250000bps “over the air” baud rate. Serial port baud rate can be set to any supported value
6. FU2 – extreme power saving mode with 250000bps “over the air” speed. Serial port rate is limited to 1200bps, 2400bps, 4800bps
7. FU3 – default, general purpose mode. “Over the air” speed differs depending on serial port speed. The same goes for maximum range:
    - 1200bps ~ 1000m
    - 2400bps ~ 1000m
    - 4800bps ~ 500m
    - 9600bps ~ 500m
    - 19200bps ~ 250m
    - 38400bps ~ 250m
    - 57600bps ~ 100m
    - 115200bps ~ 100m
8. FU4 (available in version 2.3 or newer) – long range mode. “Over the air” speed is limited to 500bps and serial port speed to 1200bps. Because air speed is lower than port speed, only small packets can be send: max 60 bytes with interval of 2 seconds. In this mode range is increased to 1800m.

Pair of HC-12 that creates a wireless link has to work in the same mode (FU1, FU2, FU3, FU4) and with the same speed.

Configuration

HC-12 can be configured using AT command. The best way to do it, is to use USB-to-serial converter like CP2102. To put HC-12 into AT mode, pull *SET* pin to GND like this:

Most important commands:

9. `AT` – test command. It will return `OK` if AT interface is enabled
10. `AT+Bxxxx` – set serial port baud rate. For example, `AT+B57600` set baud rate to 57600bps

11. `AT+Cxxx` – set radio channel. Channels start from `001` at 433,4MHz. Each next channel adds 400kHz. Channel `100` is 473,0MHz. `AT+C002` will set frequency to 433,8MHz. Two HC-12 devices that creates a wireless link have to operate on the same frequency
12. `AT+FUx` – set device mode: FU1, FU2, FU3 or FU4. Two HC-12 devices that creates a wireless link have to use the same mode
13. `AT+Px` – set device transmitting power. For example `AT+P2` sets power to 2dBm (1.6mW)
    1. -1dBm (0.8mW)
    2. 2dBm (1.6mW)
    3. 5dBm (3.2mw)
    4. 8dBm (6.3mW)
    5. 11dBm (12mW)
    6. 14dBm (25mW)
    7. 17dBm (50mW)
    8. 20dBm (100mW)
14. `AT+RX` – retrieve all parameters: mode, channel, baud rate, power
15. `AT+V` – retrieve module version
16. `AT+DEFAULT` – reset module parameters to default settings

Features

- Long-distance wireless transmission (1,000m in open space/baud rate 5,000bps in the air)
- Working frequency range (433.4-473.0MHz, up to 100 communication channels)
- Maximum 100mW (20dBm) transmitting power (8 gears of power can be set)
- Three working modes, adapting to different application situations
- Built-in MCU, performing communication with external device through serial port
- The number of bytes transmitted unlimited to one time

Specification

- Working frequency: 433.4MHz to 473.0MHz
- Supply voltage: 3.2V to 5.5VDC
- Communication distance: 1,000m in the open space
- Serial baud rate: 1.2Kbps to 115.2Kbps（default 9.6Kbps）
- Receiving sensitivity: -117dBm to -100dBm
- Transmit power: -1dBm to 20dBm
- Interface protocol: UART/TTL

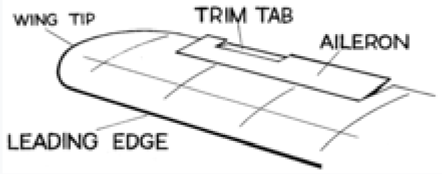
3.2 Thrust Control

The pilot controls thrust by adjustment of the control levers for the engine. In an aircraft with a reciprocating engine these can consist of a throttle, mixture control (to control the ratio of fuel and air going to the engine), and propeller control as well as secondary devices such as supercharger controls or water-alcohol injection. In a turbojet engine, the principal control is the throttle, with auxiliary devices such as water injection and afterburners. With water injection, a water-alcohol mixture is injected into the combustion area to cool it, which allows more fuel to be burned. With afterburners, fuel is injected behind the combustion section and ignited to increase thrust greatly at the expense of high fuel consumption. The power delivered by reciprocating and jet engines is variously affected by airspeed and ambient air density (temperature, humidity, and pressure), which must be taken into consideration when establishing power settings. In a turboprop engine, power is typically set by first adjusting the propeller speed with a propeller lever and then adjusting fuel flow to obtain the desired torque (power) setting with the power lever.

Propellers are basically rotating airfoils, and they vary in type, including two-blade fixed pitch, four-blade controllable (variable) pitch, and eight-blade contrarotating pitch. The blade angle on fixed-pitch propellers is set for only one flight regime, and this restriction limits their performance. Some fixed-pitch propellers can be adjusted on the ground to improve performance in one part of the flight regime. Variable-pitch propellers permit the pilot to adjust the pitch to suit the flight condition, using a low pitch for takeoff and a high pitch for cruising flight. Most modern aircraft have an automatic variable-pitch propeller, which can be set to operate continuously in the most efficient mode for the flight regime. If an engine fails, most modern propellers can be feathered (mechanically adjusted) so that they present the blade edgewise to the line of flight, thereby reducing drag. In large piston engine aircraft, some propellers can be reversed after landing to shorten the landing run. (Jet engines have thrust reversers, usually incorporating a noise-suppression system, to accomplish the same task.)

3.2 Aileron Control

Ailerons



Aileron surface

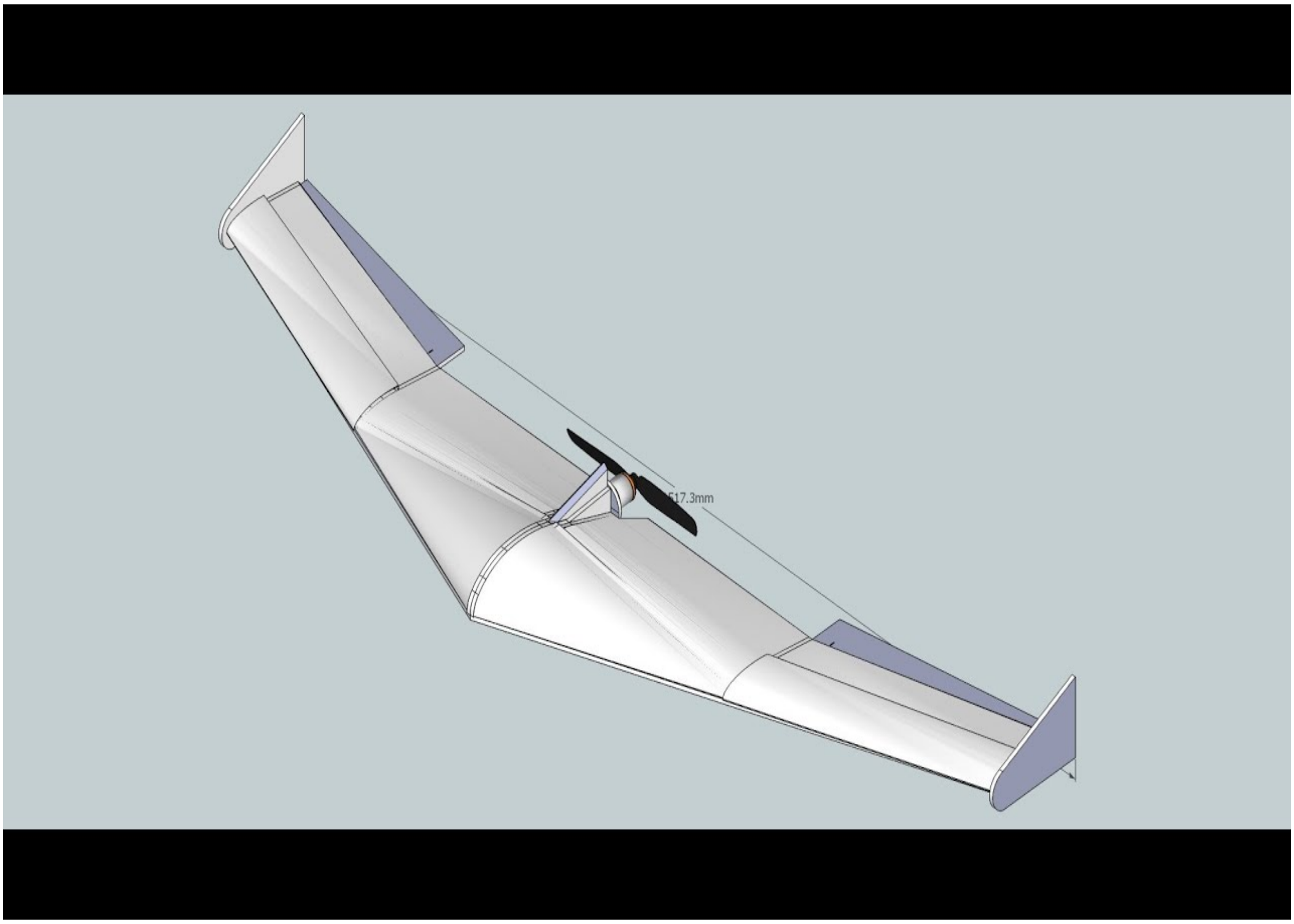
Ailerons are mounted on the trailing edge of each wing near the wingtips and move in opposite directions. When the pilot moves the stick left, or turns the wheel counter-clockwise, the left aileron goes up and the right aileron goes down. A raised aileron reduces lift on that wing and a lowered one increases lift, so moving the stick left causes the left wing to drop and the right wing to rise. This causes the aircraft to roll to the left and begin to turn to the left. Centering the stick returns the ailerons to neutral maintaining the bank angle. The aircraft will continue to turn until opposite aileron motion returns the bank angle to zero to fly straight.

Development of an effective set of flight control surfaces was a critical advance in the development of aircraft. Early efforts at fixed-wing aircraft design succeeded in generating sufficient lift to get the aircraft off the ground, but once aloft, the aircraft proved uncontrollable, often with disastrous results. The development of effective flight controls is what allowed stable flight

Pairs of ailerons are typically interconnected so that when one is moved downward, the other is moved upward: the down-going aileron increases the lift on its wing while the up-going aileron reduces the lift on its wing, producing a rolling (also called 'banking') moment about the aircraft's longitudinal axis (which extends from the nose to the tail of an airplane).[30] Ailerons are usually situated near the wing tip, but may sometimes also be situated nearer the wing root. Modern airliners may also have a second pair of ailerons on their wings, and the terms 'outboard aileron' and 'inboard aileron' are used to describe these positions respectively.

CHAPTER 4

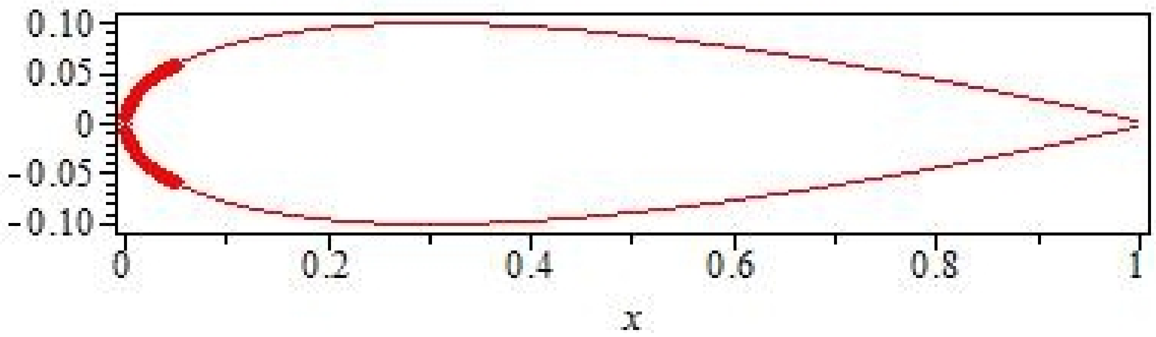
WING DESIGN



A **flying wing** is a tailless fixed-wing aircraft that has no definite fuselage. The crew, payload, fuel, and equipment are typically housed inside the main wing structure, although a flying wing may have various small protuberances such as pods, nacelles, blisters, booms, or vertical stabilizers.[1]

Similar aircraft designs that are not, strictly speaking, flying wings, are sometimes referred to as such. These types include blended wing body aircraft, and microlights (such as the Aériane Swift), which typically carry the pilot (and engine when fitted) below the wing.

4.1 The Leading Edge



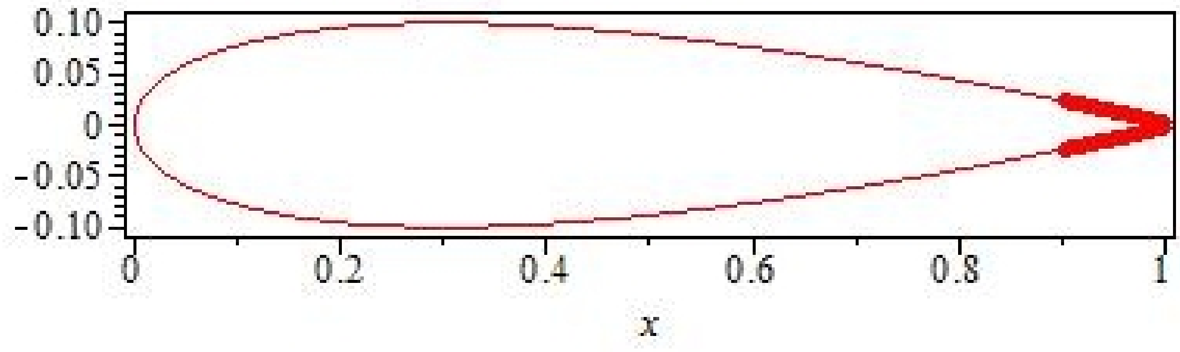
The **leading edge** is the part of the wing that first contacts the air;[1] alternatively it is the foremost edge of an airfoil section.[2] The first is an aerodynamic definition, the second a structural one. As an example of the distinction, during a tailslide, from an aerodynamic point of view, the trailing edge becomes the leading edge and vice versa but from a structural point of view the leading edge remains unchanged.

A **leading-edge cuff** is a fixed aerodynamic wing device employed on fixed-wing aircraft to improve the stall and spin characteristics. Cuffs may be either factory-designed or an after-market add-on modification.[1]

A leading-edge cuff is a wing leading-edge modification, usually a lightly drooped outboard leading-edge extension. In most cases of outboard leading-edge modification, the wing cuff starts about 50–70% half-span and spans the outer leading edge of the wing.[2]

The main goal is to produce a more gradual and gentler stall onset, without any spin departure tendency, particularly where the original wing has a sharp/asymmetric stall behaviour [1][3] with a passive, non-moving, low-cost device that would have a minimal impact on performance. A further benefit is to lowering stall speed, with lower approach speeds and shorter landing distances. They may also, depending on cuff location, improve aileron control at low speed.

4.2 The Trailing Edge



The **trailing edge** of an aerodynamic surface such as a wing is its rear edge, where the airflow separated by the leading edge rejoins.[1] Essential flight control surfaces are attached here to control the direction of the departing air flow, and exert a controlling force on the aircraft. Such control surfaces include ailerons on the wings for roll control, elevators on the tailplane controlling pitch, and the rudder on the fin controlling yaw. Elevators and ailerons may be combined as elevons on tailless aircraft.

The shape of the trailing edge is of prime importance in the aerodynamic function of any aerodynamic surface. George Batchelor has written about:

> " ... the remarkable controlling influence exerted by the sharp trailing edge of an aerofoil on the circulation."[2]

Other sharp-edged surfaces that are attached to the trailing edges of wings or control surfaces include:

- On control surfaces:
  - trim tabs
  - servo tabs
  - anti-servo tabs
- Other surfaces:
  - flaps

Other equipment that may be attached to the trailing edges of wings include:

- anti-shock bodies
- static dischargers

CHAPTER 5

GOVERNMENT IMPLEMENTATION

Applications of Unmanned Aerial Vehicle (UAV) based Remote Sensing in NE Region

Unmanned Aerial Vehicle (UAV), popularly known as Drone, is an airborne system or an aircraft operated remotely by a human operator or autonomously by an onboard computer. UAV based Remote Sensing (UAV-RS) is the new addition to the North Eastern Space Applications Centre (NE-SAC) for large-scale mapping and real time assessment and monitoring activities of various applications.

NE-SAC has taken the initiative for design and assembling of UAVs for various applications. Different components of the UAV are selected based on the design parameters (Table 1) and assembled as per the requirements. A Hex Copter was designed and assembled by NE-SAC, which can carry maximum payload up to 2.5 Kg of different sensors such as thermal, multispectral, optical, hyperspectral or LIDAR. The centre is also equipped with a Ready-to-fly Quad Copter with an integrated optical sensor, which can capture high-resolution geo-tagged aerial photos and high-definition videos.

In addition, NE-SAC has also indigenously developed a Fixed Wing UAV and the flight test was successfully carried out on November 01, 2016 at NE-SAC. The design parameters along with flight test results are given in the Table 2.

The multi rotor based UAV has been flown in different areas of NE states by NE-SAC as part of technology developmental activities. Few tests were made based on the demands from the respective District Administrations of NE region. Some of the important case studies made by the centre are highlighted below:

5.1 **Mapping of Landslide Affected Area**: Mapping of landslide affected area was taken at the request of District Disaster Management Authority of Nongpoh, Meghalaya. The NH-40 connecting Guwahati to Shillong city is considered to be the life line of Meghalaya State. A number of landslides had occurred there which caused loss of life and properties.

3D View of Landslide

5.2 Infested Crop Damage Assessment: Naramari village of Morigaon District, Assam, India had been reported severe infestation of Boro Paddy by Brown Plant Hopper (BPH) insect. As per the request from officials from State Government of Assam, an UAV flight was conducted in the affected area and a total area of 0.55 sq. km was covered with a 15 minutes flight. Figure shows the categorisation of BPH infested rice fields.

Infested Fields in Naramari Village, Morigaon District, Assam

Categorisation of BPH Infested Rice Fields

5.3 3-Dimensioinal Terrain Model Construction: The realistic and aesthetically pleasing 3D mesh models, accurate 3D models for volumetric analysis etc.,can be generated from the UAV imagery. Figure shows the 3D reconstruction of Municipal Urban Development Authority (MUDA) shopping complex of Nonghpoh town using the UAV images with a ground pixel resolution of 5 cms.

3D Reconstruction: MUDA Shopping Complex, Nongpoh

NE-SAC organised a two weeks advance course on "UAV Remote Sensing – Technological Advances and Applications", during October 31 – November 11, 2016 to provide in-depth understanding and knowledge in the field of UAV remote sensing and its relevant technologies and applications. A total of 26 participants from different parts of the country attended the training programme.

Operational Challenges and Issues

The imagery obtained from UAVs can immensely support in many applications ranging from large scale mapping, urban modelling to vegetation structure mapping. However, there are restrictions like – i) limitation in the size of the study area, ii) constraint in processing of large volume of data, iii) requirement of large scale processing and large storage space, etc. In addition, existing features capturing and extraction techniques need to be improved for processing of high dimensional UAV data. UAVs can perform efficient surveys for disaster prone or physically inaccessible areas, quick damage assessment of landslides, floods and earthquakes for enabling relief measures.

Table 1: Test Flight Results of Hex Copter

Sl. No.	Design Criterion	Design Parameter	Test Flight Results
1	Payload capacity	Up to 2.5 kgs	A maximum of 1.5 kgs was tested
2	Flight endurance	Up to 30 mins	15 mins for 1.5 kgs payload and 25 mins for GoPro/YI action camera (weight less than 100 gms)
3	Fly options	Manual, GPS aided, Autonomous	All tested successfully

4	Fly height	Up to 2 Kms	Tested up to 500 m which was good enough for required applications
5	Fly range	Up to 2 Kms	Tested up to 1.8 kms with clear line of sight

Table 2: Test Flight Results of Experimental Fixed Wing UAV

Sl. No.	Design Criterion	Design Parameter	Test Flight Results
1	Payload capacity	Up to 0.5 kgs	A maximum of 0.2 kgs was tested
2	Flight endurance	Up to 30 mins	Tested up to 20 mins with 0.2 kgs of payload
3	Fly options	Manual	Tested successfully
4	Fly height	Up to 0.5 Kms	Tested up to 300 m
5	Fly range	Up to 1 Kms	Tested up to 0.5 kms with clear line of sight

CONCLUSION

Hence The Arduino Flight Control System is successfully programmed and can be used in the field for the surveillance projects. The flying model which is used for this project is manufactured by The Flite Test Company [USA].The name of the model is FT Versa Wing which is specifically used for First Person View Drone Projects.

REFERENCES

1: Glider Designed by The Flite Test Company [USA].

2: Wikipedia

3:ISRO.gov.in

4:NASA.gov

5:code.org