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INPROEKT ARKHANGEG

2024

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METHODOLOGY

TYPES OF DRONES | DEVICE | ASSEMBLY

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DRONES | DEVICES

FPV (FIRST PERSONAL VIEW)

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS

An unmanned aerial vehicle, abbreviated as UAV or ”DRONE” is an aircraft designed to PERFORM A FLIGHT WITHOUT THE PHYSICAL PRESENCE OF A PILOT ON BOARD,

All flight control and monitoring is carried out remotely:

- the corresponding program, previously “loaded into the memory” on board the UAV;
- . the appropriate program using a special control station located outside the aircraft;
- using a special control station (remote control) located outside the aircraft.

FPV. FPV

FPV (First Person View) is an abbreviated name for the first-person view flight control system.

- . FPV in the drone industry is the transmission of real-time video from a drone's camera to a monitor, goggles or helmet of the pilot
- In other words, this technology allows you to see what the drone “sees” while it is flying.
- To carry out such a flight, a camera, a video transmitter and an antenna are installed on the drone.
- This technology allows the UAV to receive video images transmitted by the course camera.
- The FPV course camera is a camera located in the nose of the drone, it transmits video to the video transmitter, and it to the video receiving device - FPV helmet, glasses or LCD display.
- Quadcopters are the most common and developed designs of aircraft, having four engines. The main disadvantage of aircraft of this group is low fault tolerance, in case of loss of one of the engines, the quadcopter loses balance and falls. When installing powerful engines, it is possible to carry a payload of up to 5 kg.

GENERAL DESIGN DIAGRAM

The designs of all unmanned aerial vehicles are similar in their construction and operating principle, and consist of several components.

PAMA The base, frame – is the basis (body) of the entire drone, to which all other elements are attached.

POPETNY COUNTERTROPPER The flight controller is an integrated circuit (printed circuit board) on which sensors are placed. Based on the information from the sensors, the controller regulates the rotation speed of the motors, is responsible for the coordination, stabilization and control of the drone.

• Based on information from sensors, the controller regulates the speed of rotation of the motors and is responsible for coordination, stabilization and control of the drone.

The main functions and tasks of the controller:

- collecting data from sensors;
- calculation of one's position in space;
- receiving commands from external controllers via the control panel;
- sending control signals to speed controllers (ESC electronic speed controller);
- keeping the drone at a given altitude;

The controller controls the rotation speed of the motors by sending PWM pulses to the speed controllers. PWM (Pulse Width Modulation) is a process

power control by pulsating switching on and off of the energy consumer. The rotation speed of the motors is determined by the duration of the PWM pulses transmitted from the controller.

The direction and flight of the drone in manual control mode are set by the throttle joysticks and rotation of angles in three planes: roll, pitch, yaw.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS GENERAL DESIGN DIAGRAM

ACCESSORY METER Accelerometer: As the name suggests, accelerometers measure linear acceleration in three axes (let's call them: X, Y, and Z). Usually measured in "G". The standard (normal) value is g = 9.80665 m/s². To determine position, the accelerometer output can be integrated twice, although due to losses in the output, the object may be subject to drift. The most significant characteristic of three-axis accelerometers is that they detect gravity, and as such, can know which direction to "slump". This plays a major role in ensuring the stability of a multi-rotor UAV. The accelerometer must be mounted on

the flight controller so that the linear axes coincide with the main axes of the drone.

GYROSCOPE The gyroscope measures the rate of change of angles along three angular axes (let's call them alpha, beta, and gamma). Typically measured in degrees per second. Note that the gyroscope does not measure absolute angles directly, but you can iterate to get an angle, which, like an accelerometer, contributes to drift. The output of a real gyroscope tends to be analog or 12C, but in most cases you don't need to worry about this, since all incoming data is processed by the flight controller code. The gyroscope should be mounted so that its rotation axes are aligned with the axes of the UAV.

MAGNETOMETER An electronic magnetic compass is capable of detecting the Earth's magnetic field and using that data to determine the drone's compass direction (relative to magnetic north). This sensor is almost always present when GPS input is available and one to three axes are available.

PRESSURE/BAROMETER Since atmospheric pressure changes with distance from sea level, a pressure sensor can be used to obtain fairly accurate readings of the UAV's altitude. To calculate the most accurate altitude, most flight controllers receive data from both a pressure sensor and a satellite navigation system (GPS). When assembling, pay attention - it is better to cover the hole in the barometer housing with a piece of foam rubber to reduce the negative effect of wind on the chip.

GLONASS POSITIONING SYSTEM (GPS) To determine your specific geographic location using signals sent by multiple satellites orbiting the Earth.

The flight controller can have either a built-in GPS module or a connected one via a cable. The GPS antenna should not be confused with the GPS module, which can look like a small black box or a regular Duck antenna.

To obtain accurate location data, the GPS module must receive data from several satellites, and the more the better.

OTHER SYSTEMS AND DEVICES A system for receiving and transmitting radio waves of the corresponding range, usually: 2.4; 2.4 – 5.8 GHz;

Devices that provide drone flight:

- engines,
- propellers,
- . speed control.

Batteries Modern electronic devices use two main types of batteries:

- lithium-ion;

- lithium polymer.

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DRONE ZIDS | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, UPPA QUALIFICATION

BPPA CATEGORY

RUSSIAN CATEGORY OF BPPA

CATEGORY	EXHAUST MASS /KG/	RANGE OF ACTION /KM/
MICRO AND MINI UAVS	0-5	25-40
LIGHT UAVS /small/	5-50	10-70
LIGHT UAVS /medium/	50-100	70-150 /250/
MEDIUM UAVS	100-300	150-1000
MEDIUM UAVS /heavy/	300-500	70-300
HEAVY DUTY UAVS /medium range/	< 500	70-300
HEAVY DUTY UAVS /long range/	< 1500	1500
UNMANNED PLANES	< 500	1500

The Russian classification differs from the one proposed by AUVSI in a number of parameters:

- UAV groups have been abolished,
- Some classes of foreign classification are not available in Russia,
- UAVs considered light in Russia have a significantly greater range, etc.

BAPP QUALIFICATION BY DESIGN THE MAIN TYPES OF UNMANNED LOOP VEHICLES (UPV) ARE DISTINGUISHED BY 6 DESIGN FEATURES:

- AEROSTATIC UAVS
- JET UAVS
- AIRCRAFT TYPE UAV /fixed wing/
- HELICOPTER TYPE UAV /single-rotor/
- MULTICOPTER UAVS /multi-rotor/
- HYBRID UAVS /convertoplanes/

AEROSTATIC BPPA Aerostats have a shell filled with gas or heated air to create lift (Archimedes' force). They are used for long-term observation, communications, meteorology and other tasks. In the military sphere, they are mainly used to install repeaters on them, less often - surveillance and reconnaissance equipment. Advantages:

- Flight duration over several days or weeks
- High load capacity

Flaws:

- Limited maneuverability and speed
- Highly dependent on weather conditions
- Large size and weight

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REACTIVE BPPA Jet UAVs (guided missiles) move in space due to the action of jet thrust of engines autonomously or under external control. They are used mainly as a means of destroying ground and air targets.

Advantages:

- High speed, range and altitude.
- Independence from weather conditions

Flaws:

- Large dimensions and weight
- High cost and complexity of maintenance
- Difficulty of management

SELF-PROPELLED TYPE PSU Fixed-wing UAVs are capable of flying due to the lift created by the aerodynamic shape of the wing when moving forward at a certain speed, the development of which is achieved in various ways. They are used for reconnaissance, surveillance, and strikes against ground and air targets.

- Advantages:
- High altitude and flight duration
- Easy to maintain and repair.
- Cheapness

Flaws:

- Often the requirements for the launch site .

- Difficulty of control and landing.
- Dependence on weather conditions

HELICOPTER TYPE UAV Single-rotor UAVs, lift and thrust for forward motion are created using two rotors or a pair of rotors and a steering rotor. Due to their high cost and complexity in control, they are used only as small-sized short-range reconnaissance vehicles. Advantages:

- Vertical takeoff and landing
- High maneuverability and small dimensions.
- The ability to hang in place
- Flaws:
- High cost.
- Complexity of maintenance and repair.
- Short flight duration.
- Dependence on weather conditions

HYBRID BPPA A hybrid UAV is an aircraft with rotary (or fixed) propellers that act as lift propellers during takeoff and landing, and as tractor propellers during horizontal flight; the lift force in flight is provided by a fixed wing. They combine the advantages of fixed-wing and multirotor UAVs, which provides flexibility in performing various tasks. Advantages:

Vertical takeoff and landing, hovering.

- High speed and maneuverability.
- Greater flight time and payload than multi-rotors
- Flaws:
- Complexity of maintenance and repair
- Dependence on weather conditions
- High cost, difficult to manage

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In GUSTROIS

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, VARIETIES AND MATERIALS OF THE FPV FRAME

TYPES OF FRAMES The main purpose of multicopters is photo and video shooting of various objects, so they are usually equipped with controlled camera suspensions. Multicopters are also used as devices for operational situation monitoring, agricultural work (for example, spraying), for the delivery of lightweight cargo.

TRICOPTER "Tricopter" is a UAV that has three beams, each of which is connected to a motor. The front part of the tricopter is considered to be the side where the two beams meet (Y3). The angle between the beams can vary, but is usually 120°. To counteract the gyroscopic effect of the uneven number of rotors, as well as to change the angle of rotation, the rear engine must be able to rotate (achieved by installing a conventional RC servo motor). To eliminate the need for a servo drive from the assembly, a design (Y4) is used, which involves coaxial installation of an additional motor on the rear beam. Advantages:

- Unusual appearance of the drone.
- It achieves its best flight characteristics when flying in a straight direction.
- Price (less motors and ESCs required for assembly). Disadvantages:
- Requires the use of a servo drive.
- Difficulty in making the rear beam (since the servo must be mounted along the axis).
- Not all flight controllers support this configuration.

QUADROCOPTER "Quadcopter" is a drone that has four beams, each of which is connected to a motor. For the front part of the quadcopter, the side where the two beams meet is considered to be the front, for the configuration, the longitudinal beam can be considered the front. Advantages:

- The most common multi-rotor design.
- The simplest and most universal design.
- . In the standard configuration, the beams/motors are symmetrical about

two axles.

All flight controllers available on the market can work with this .

- multirotor assembly.
  Disadvantages:

Lack of redundancy (if the system fails, especially in the power plant elements, the drone falls).

HEXACOPTER The "hexacopter" has six beams, each of which is connected to a motor. The front part of the hexacopter is usually considered to be the side where two beams meet, but the longitudinal beam can also be considered the front. Advantages:

If necessary, the hexacopter design allows you to easily add two additional beams and motors, which will increase the total thrust, as a result of which the drone will be able to lift more payload.

In the event of failure of one of the motors, there is a possibility that the drone will be able to make a soft landing rather than crash.

- Modular frame design.
- . Almost all flight controllers support this configuration.

Flaws:

- Bulky and expensive design.
  Additional engines and parts increase the weight of the copter, so to get the same flight time as a quadcopter, you need to install more capacious batteries.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, VARIETIES AND MATERIALS OF THE FPV FRAME

UB DESIGN The "Y6 design" is a type of hexacopter that is based on three beams instead of six, each of which is connected to a pair of coaxially mounted motors (a total of 6 motors). It is worth noting that the lower propellers project thrust downwards.

- Advantages:
- Fewer components than a hexacopter.
- . Lifts more payload than a quadcopter.
- . When using counter-rotating propellers, the gyroscopic effect, as in the YZ, is eliminated.

If one of the motors fails, there is a chance that the drone will be able to make a soft landing rather than crash.

- Flaws:
- Requires the use of a servo drive.
- . Difficulty in making the rear beam (since the servo must be installed
- along the axis).

Not all flight controllers support this configuration.

OCTOCOPTER "Octocopter" is a drone that has eight beams, each of which is connected to a motor. The front part of the oktocopter is considered to be the side where the two beams meet. Advantages:

More motors = more thrust, and therefore increased redundancy, allowing the drone to confidently move with heavy and expensive DSLR cameras.

Flaws:

- More motors = higher price and bigger battery.
- Due to its high cost, it is only relevant for the professional sphere.

design hv The ”X8 design” is still an octocopter, only with four arms instead of eight, each connected to a pair of coaxially mounted motors (8 motors in total). Advantages:

- More engines = more thrust, and therefore increased redundancy
- . More chances to land the drone softly in case of motor failure.

Flaws:

- More motors = higher price and bigger battery.
- Due to its high cost, it is only relevant for the professional sphere

activities.

QUADROCOPTER

”Quadcopter” is the most common scheme for constructing multicopters. The presence of four rigidly fixed rotors makes it possible to organize a fairly simple scheme for organizing movement. There are two such schemes of movement: the ”+” scheme and the ”x” scheme. In the first case, one of the rotors is the front one, the opposite one is the rear one, and two rotors are lateral. In the ”x” scheme, two are simultaneously front

rotor, the other two are rear, and the lateral displacements are also realized simultaneously by a pair of corresponding rotors. The algorithm for controlling the propeller rotation speeds for the “+” scheme is somewhat simpler and clearer than for the “x” scheme, but the latter is still used more often due to its design advantages: with this scheme, it is easier to place the fuselage, which can have an elongated shape, and the onboard video camera has a freer view.

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DRONE TYPES | DEVICE | ASSEMBLY

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, SETTINGS TYPES OF QUADROCOPTER FRAMES

FRAME TYPE ”X” IPI ”TRUE-X” The fuselage of the frame is made short, in the form of a square. All electronics are collected in the center, and the beams are located precisely at the corners of the square. Frame

is the same in length and width. Since the weight is concentrated in the center and distributed evenly, the drone becomes more maneuverable, but the limited space in the center makes assembly more difficult. All components have to be placed in layers one under another, which is not always convenient.

FRAME TYPE EXTENDED "X" The extended "X" frame is similar to the "X" frame in terms of fuselage, but has an increased "body" length compared to its width. Another feature of this frame is the offset of the front propellers from the rear ones. This eliminates turbulent swirls, which allows the quadcopter to fly more stably.

Due to its high cost, it is only relevant for the professional sphere.

The attachment of the beams to the fuselage at the front and back makes the frame look like the letter "H". The central part of this frame is longer than that of the "X" frame, which makes assembly and repair of components easier and more convenient. The camera and battery in such a frame are placed on the top plate, distributing everything in one direction, which leads to an uneven distribution of the moment of inertia, especially in pitch. That is, tilting forward / backward will consume more energy than tilting right / left.

Such frames are distinguished by non-removable beams - the lower fuselage plate and the beams are connected into one part. This is done in order to simplify assembly and eliminate the weight of the parts for fastening. However, the disadvantage of such a frame is that if one beam breaks during the flight, then the entire part will have to be replaced. This can take a lot of time.

This frame has the fuselage of the H frame, and the beams are connected as in the X frame. From a physical point of view, the weight distribution remains the same as in the H frame, which makes it similar to a regular H frame, but the difference will be in the transmission of vibrations from the motors to the flight controller.

HYBRID X-TYPE FRAME

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DRONES | DEVICE |

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, SETTINGS TYPES OF QUADROCOPTER FRAMES

SQUARE TYPE FRAME If you add connecting beams "ribs" to the "X" frame, you get a "Square" frame. Due to the rigidity of the connections, you get a fairly strong frame that is difficult to break, but at the same time it has increased air resistance and is heavy. Suitable for beginner pilots, but not suitable for maneuverable flights.

VARIETIES OF FRAME MATERIALS REVOLUTION

Wood - if the priority is the cheapness of the design, then wood is an excellent option that will significantly reduce the time of assembly and production of spare parts. Wood is quite hard and is a time-tested material. It is important

that when making the frame, perfectly straight wood is used (without bends and deformations).

Plastic - For most users, only available in plastic sheets. Tends to bend and is not ideal as such. Great for making a protective frame or chassis. If you are considering 3D printing, consider the manufacturing timeframe (it may be easier to buy a retrofit kit). Plastic and 3D printing of parts have proven themselves to be excellent for creating small quadcopters

Aluminum - comes to the consumer in various shapes and sizes. You can use sheet aluminum to make the body, or extruded aluminum to implement the drone's rays. Aluminum is not as light as carbon fiber or G10, but the price and durability are the main advantages of the material. Instead of breaking or cracking, aluminum has a tendency to bend. All you need to work with the material is a saw and a drill.

G10 is a type of fiberglass - although the appearance and basic properties are almost identical to carbon (carbon fiber), it is a less expensive material. It is mainly available in sheet format and is used to make the top and bottom plates of the frame. Also, unlike carbon fiber, G10 does not block radiofrequency waves.

ANGULAR WINDOW Carbon fiber is the most popular material due to its light weight and high strength. The manufacturing process is still exclusively manual. As a rule, simple forms such as flat sheets and tubular components are mass-produced; complex three-dimensional forms are made to order.

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DRONES | DEVICE

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, MOTOR SETTINGS. GET IN

MOTORS The maximum load the drone can lift and how long it can fly will depend on the motors you use in your assembly. The power plant must necessarily consist of motors of the same brand and model, this approach will ensure its balanced operation. At the same time, it should be noted that even absolutely identical (Brand/Model) motors may have a slight difference in speed, which is subsequently leveled by the flight controller.

Coupled and Non-coupled In brushed motors, the rotor and winding rotate inside the stator, where the magnets are firmly fixed. In brushless motors, everything is the other way around; the winding is firmly attached to the inside of the stator, and the magnets are mounted on the shaft and rotate. In most cases, you will only be considering brushless DC motors. These types of mo-

tors are widely used in the hobby industry to assemble products ranging from helicopters and airplanes to drive systems in cars and boats.

Inrunner motor

Brushless Motor

Brushless Pancake Motor

Brushless motors of the "Rapsake" type have a larger diameter, are flatter, and generally have high torque and a lower KV value (details below). Although brushless motors come in different sizes and have different characteristics, choosing a smaller size does not necessarily mean it will be cheaper.

INRUNNER VS OUTRUNNER

There are several types of brushless DC motors: Inrunner - internal rotor. The winding is fixed to the stator, the magnets are mounted on the rotor shaft, which rotates (usually used in radio-controlled boats, helicopters and cars due to high KV). Outrunner - external rotor. The magnets are fixed to the stator, which rotates around the stationary winding. The lower part of the motor is fixed (usually, motors of this type have more torque). Hybrid Outrunner - technically it is an "Outrunner", but implemented in an "Inrunner" case. This approach allowed to combine in one type the torque of "Outrunner" and the absence of external rotating elements like "Inrunner" type motors.

The size of brushless motors for drones is usually indicated by a 4-digit number - AABB:

- AA refers to the stator width (stator diameter).
- BB means stator height. Both parameters are in millimeters,

The stator is the stationary part of the motor, consisting of "poles" wrapped with copper wires (obiots). These poles include several layers of thin metal plates glued together, with an ultra-thin insulating layer between them.

ENGINE TRANSMISSION COMPONENTS. Motor Stator: The stationary part of the motor consists of many metal coils. The coil wire is enameled to prevent short circuits as it is wound in several turns. When electric current passes through the stator coils, it generates a magnetic field that interacts with permanent magnets on the rotor, resulting in rotation.

Magnets: Permanent magnets create a fixed magnetic field. In FPV drone motors, they are attached to the inside of the motor bell using epoxy.

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CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, MOTOR SETTINGS, HOOKUPS

ENGINE POWER COMPONENTS: Bellow: Serves as a protective enclosure for the motor's magnets and windings. Typically made from lightweight metals such as aluminum, some bellows are designed like miniature fans to direct more air onto the motor's windings for additional cooling as the motor spins.

Motor Shaft: Connected to the motor bell, the shaft is the working component of the motor that transmits the torque generated by the motor to the propeller.

Increasing the width or height of the stator increases the volume of the stator, the size of the permanent magnets, and the size of the stator's electromagnetic coils. This increases the overall torque of the motor, allowing it to spin a heavier propeller faster and produce more thrust (at the expense of drawing more current). However, the downside of a larger stator is that it is heavier and less responsive.

KV rating is the maximum RPM that a motor can achieve without losing power at a given voltage. For most multi-rotor UAVs, a low KV rating (e.g. 500 to 1000) is desirable as it helps ensure stability.

While for aerobatic flight a KV value between 1000 and 1500 will be relevant, in tandem with smaller diameter rotors (propellers).

Let's say the KV value for a particular motor is 650 RPM, then at 11.1V the motor will spin at: 11.1 x 650 = 7215 RPM, and if you run the motor at a lower voltage (say 7.4V), the speed will be: 7.4 x 650 = 4810 RPM.

It is important to note that using low voltage generally means that the current consumption will be higher (Power = Current $\times$ Voltage).

traction

Some brushless motor manufacturers may specify in their specifications the maximum possible thrust (Thrust) that the motor can produce when paired with the recommended rotor. The units of thrust are usually kilograms (Kg), pounds (lbs), or Newtons (N). For example, if you are building a quadcopter and you know that the thrust of a single motor is up to 0.5kg paired with an 11-inch rotor, then four such motors will be able to lift at maximum thrust: 0.5kg $\times$ 4 = 2kg.

Accordingly, if the total weight of your quadcopter is slightly less than 2 kg, then with such a power plant it will soar only at maximum speed (max. thrust). In this case, it will be relevant to either choose a more powerful "motor + rotor" combination, which will provide greater thrust, or reduce the total weight of the drone. With max. thrust of the power plant = 2 kg, the weight of the drone

should be no more than half of this value (1 kg, including the weight of the motors themselves). A similar calculation can be made for any configuration.

Let's assume that the weight of the hexacopter (including frame, motors, electronics, accessories, etc.) is - 2.5 kg. This means that each motor for such an assembly should provide (2.5 kg ÷ 6 motors) × 2 = 0.83 kg of thrust (or more). Now you know how to calculate the optimal motor thrust based on the total weight, but before making a decision, we suggest that you familiarize yourself with the sections below.

ADDITIONAL CONSIDERATIONS Connectors: DC brushed motors have two connectors, "+" and "-". Reversing the wires changes the direction of rotation of the motor.

Connectors: Brushless DC motors have three connectors. To learn how to connect them, as well as how to change the direction of rotation, see the "ESC" section below.

Windings: The windings affect the KV of the motors. If you need the lowest KV value, but still prioritize torque, it would be best to look at the brushless DC motors of the "Pancake" type.

Mounting: Most manufacturers have a general mounting pattern for DC motors, which allows frame companies to avoid making so-called adapters. The pattern is usually metric, with two holes spaced 16mm apart, and two more holes spaced 19mm apart (at 90° to the first).

Thread: The mounting threads used to attach the brushless motor to the frame can vary. Common metric screw sizes are M1, M2, and M3, while imperial sizes can be 2-56 and 4-40.

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DRONE TYPES | DEVICE | ASSEMBLY

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, MOTOR SETTINGS, HOOKUPS

CARRYING SCREWS (PROPELLER) The propellers (abbreviated prol) for multi-rotor UAVs originate from the propellers of radio-controlled aircraft. Many will ask: why not use helicopter blades? Although this has already been done, imagine the size of a hexacopter with helicopter blades. It is also worth noting that the helicopter system requires changing the pitch of the blades, and this significantly complicates the design.

You may also ask, why not use a turbojet, turbofan, turboprop, etc? Sure, they are incredibly good at providing a lot of thrust, but they also require a lot of energy. If the primary purpose of the drone is to move very quickly, rather than hover in a confined space, one of the above engines may be a good option.

FITS AND DIAMETER

The propellers of most multirotor UAVs have two or three blades. The most widely used propellers are those with two blades. Do not think that adding more blades will automatically increase thrust; each blade operates in the flow disturbed by the previous blade, reducing the efficiency of the propeller. A small diameter propeller has less inertia and is therefore easier to accelerate and decelerate, which is important for aerobatic flight.

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DRONE TYPES | DEVICE | ASSEMBLY

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, MOTOR SETTINGS, HOOKUPS

ROTATION The rotors are designed to rotate clockwise (CW) or counter-clockwise (CCW). The direction of rotation is indicated by the tilt of the blade (look at the propeller from the end). If the right edge of the blade is higher - CCW, if the left edge - CW. If the design of your drone implies an inverted motor arrangement (as in the case of Vtail, Y6, X8 configurations), be sure to change the direction of rotation of the rotors so that the thrust is directed downwards. The front side of the rotor should always face the sky. The documentation that comes with the flight controller usually contains information about the direction of rotation of each rotor for each multi-motor configuration supported by the controller.

MATERIALS OF FUNERAL The material(s) used to make the propellers can have a moderate impact on flight performance, but safety should be a top priority, especially if you are a beginner and inexperienced.

PPASTMASSA Plastic (ABS/Nylon etc.) - is the most popular choice when it comes to multi-rotor UAVs. This is largely due to its low cost, decent flight characteristics and exemplary durability. Typically, in the event of a crash, at least one propeller is broken, and while you are mastering the drone and learning to fly, you will always have many broken propellers. The rigidity and impact resistance of a plastic propeller can be improved by reinforcing it with carbon fiber, this approach is maximally effective and less expensive compared to a fully made carbon propeller.

FIBRE REINFORCED POLYMER

Fiber-reinforced polymer (carbon fiber, carbon-reinforced nylon, etc.) is a "leader" technology in many ways. Carbon fiber parts are still not very easy to manufacture, and therefore you pay more for them than for a regular plastic propeller with similar parameters. A propeller made of carbon fiber is harder to break or bend, and therefore, in a crash, it will cause more damage to everything

it comes into contact with. At the same time, carbon propellers are usually well made, are stiffer (providing minimal loss in efficiency), rarely require balancing, and are lighter than any other material. It is recommended to consider such propellers only after the user's piloting level becomes comfortable.

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DRONES | DEVICE |

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, MOTOR SETTINGS, HOOKUPS

TREE Wood is a rarely used material for the production of multi-rotor UAV rotors, since their manufacture requires mechanical processing, which subsequently makes wooden propellers more expensive than plastic ones. At the same time, wood is quite durable and never bends. It should be noted that wooden propellers are still used on radio-controlled aircraft.

SCARED PROPS

Folding propellers have a central part that connects to two rotating blades. When the center (which is connected to the motor output shaft) rotates, centrifugal forces act on the blades, pushing them outward and essentially making the propeller "rigid", with the same effect as a classic non-folding propeller. Due to low demand and the large number of required parts, folding propellers are less common. The main advantage of folding propellers is their compactness, and when combined with a folding frame, the transport dimensions of the drone can be significantly smaller than the flight ones. An additional advantage of the folding mechanism is that in the event of a crash, there is no need to replace the entire propeller; it will be enough to replace only the damaged blade.

INSTALLATION Like UAVs, propellers can come in a wide range of sizes. Thus, there are a number of "standard" motor shaft diameters in the industry. For this reason, propellers often come with a small set of adapter rings (look like washers with holes of different diameters in the center) that are installed in the central mounting hole of the propeller, in case the diameter of the bore of the propeller is larger than the shaft diameter of the motor used. Since not all developers supply propellers with a set of such adapter rings, it is recommended to check the bore diameter of the propellers you purchase against the shaft diameter of your motor in advance.

The screw can be fixed on the motor depending on which mounting method your motor supports. If the motor shaft does not imply any mounting options (threaded connection, various mounting devices, etc.), then special adapters are used, such as propsavers and collet clamps.

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BUTTOCK

DRONE ZIDES | DEVICE | ASSEMBLY

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, MOTOR SETTINGS, HOOKUPS

PROPSAVER

Propsaver - is a sleeve with symmetrically located side holes into which screws are screwed. The sleeve is put on the motor shaft and fixed with side screws. A propeller is installed on top of the sleeve, which in turn is fixed with a rubber ring included with the sleeve (usually there are several in the kit). Due to its unreliability, but at the same time quick installation, it is best suited for short-term test flights during the assembly of the drone.

Collet clamp - compared to the propsaver, it is a more balanced and reliable adapter. The collet clamp consists of a split cone-shaped sleeve with a threaded connection (collet), a clamping sleeve, a washer and a spindle nut. First, the collet is put on the motor shaft, then the clamping sleeve, then the bearing screw (propeller) with a washer, the spindle nut closes the clamp structure.

CORPORLESS MOTORS Brushless motors with an external rotor (type "Outrunner"), as a rule, have several threaded holes in its upper part designed for the installation of various adapters and fasteners. An equally popular option for attaching the propeller to the shaft of the BC motor is a self-tightening nut. The shaft of such a motor has a thread at the end, the direction of which is opposite to the direction of rotation of the rotor. This approach eliminates spontaneous unscrewing of the locking nut, ensuring safe and reliable operation of the drone.

PROTECTION OF ROTORS Propeller protection - is designed to prevent direct contact of the UAV power plant with an oncoming object, thereby preserving its integrity and operability, as well as preventing injuries from rapidly rotating propellers as a result of a collision with people and animals. Propeller protection is attached to the main frame. Depending on the design, it can either partially cover the working area of the power plant or completely (ring protection). Propeller protection is most often used on small (toy) UAVs.

The use of protective elements in the assembly also carries a number of compromises, including:

- May cause excessive vibration.
- As a rule, it does not withstand strong impacts.

- May reduce thrust if too many propeller supports are placed under the propeller.

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DRONES | DEVICE |

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, MOTOR SETTINGS. GET IN

BAPANSING

Poor balancing is common with most inexpensive propellers. You don't have to go far to see this, just insert a pencil into the central mounting hole of the propeller (usually, if there is an imbalance, one side will be heavier than the other). In this regard, it is strongly recommended to balance your propellers before installing them on the motors. An unbalanced propeller will cause excessive vibrations, which in turn will negatively affect the operation of the flight controller (manifested in incorrect behavior of the drone in flight), not to mention increased noise, increased wear of the power plant components and deterioration in the quality of shooting of the suspended camera.

A propeller can be balanced in a number of ways, but if you are building a drone from scratch, an inexpensive propeller balancer is a must-have tool in your toolbox, as it allows you to easily and simply determine the weight imbalance in the propeller. To balance the weight, you can either sand the heaviest part of the prop (evenly sand the center of the blade, and do not cut off any part of the propeller), or you can balance by sticking a piece of tape (thin) to the lighter blade (add pieces evenly until balance is achieved). Note that the further from the center you make the balancing upgrade (sanding or adding tape) to the propeller, the greater the effect will be based on the principle of torque.

ADDITIONAL INFORMATION

CALCULATION OF DRONE WEIGHT AND FRAME SIZE

When calculating the total weight of your FPV drone, be sure to include all components: frame, flight controller (FC), speed controller (ESC), motors, propellers, radio receiver (RX), video transmitter (VTX), antenna, Pyro battery, GoPro action camera, etc. The weight does not have to be 100% accurate, but careful calculations are still necessary. It is better to overestimate the weight and have extra power than to underestimate the power and have problems during takeoff.

ENGINE THRUST REQUIREMENTS To calculate the minimum thrust required for your motor and propeller combination, you need to know the approximate total weight of your drone. A general rule of thumb is that the maximum thrust produced by all motors should be at least twice the total weight of the quadcopter. Insufficient thrust can result in poor control response and difficulty climbing.

For example, if your drone weighs 1 kg, the total thrust of all engines at 100% throttle should be at least 2 kg. That is, each of the four quadcopter motors should produce a thrust of 500 g. Of course, having additional thrust, beyond what is necessary, never hurts.

If you are going to fly slowly and do aerial photography in a smooth mode, aim for a thrust/weight ratio higher than 3:1 or even 4:1. This will not only provide better control, but will also allow you to carry additional loads on board.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

COMPARISON OF HIGH AND WIDE STATORS

Wider motors have more inertia when rotating because the motor mass is further from the axis of rotation and it takes more energy to change the speed. Therefore, wider and shorter motors are usually less responsive than narrower and taller motors, even if they have the same stator volume and generate the same torque. Wider and shorter motors also have smaller magnets on the motor bell, which can reduce the motor's power,

However, wider motors offer better cooling due to the larger surface area on the top and bottom. Temperature is critical to motor performance. As the motor heats up, its ability to generate magnetic flux decreases, which impacts efficiency and torque production. Essentially, the width and height of the motor stator is a balance between responsiveness and cooling. The decision depends on your flying style. For example, for slow cinematic drones with a heavy GoPro camera, you may want motors with wider stators for better cooling. Faster, more responsive racing or freestyle drones may benefit from taller stators. Wider stators also allow for larger bearings, which can increase

efficiency, smoothness and durability,

Larger stators are not always better. For example, 2207 motors may work with standard 5” propellers, but using much heavier 2506 motors with the same KV may not provide a noticeable benefit. They will produce the same thrust with the same propellers, or may even provide worse response due to the increased weight. To improve performance without increasing weight, consider motors

with higher KV values. However, the 2506 motor in this example will likely perform better with 0" propellers than the 2207 due to the increased torque requirements.

TORQUE

High torque motors provide quick RPM changes and faster response times, resulting in less propeller vibration and faster response. Several factors determine the torque of a motor, including:

stator size (volume);

- materials (type of magnets and quality of copper winding);
- . motor design (air gap, number of poles, etc.).
- Since FPV motors have similar specifications and designs in recent years, stator size is the easiest way to calculate torque.

The stator size can be calculated using the cylinder volume formula:

Volume = pi x radius^2 x height

For example, for a 2207 motor, the stator volume will be

pi x (22/2)^2 x 7 = 2660.93 The larger the stator volume, the greater the torque the motor can generate. Compared to the 2306 motor (its volume is 2492.85), the 2207 will have greater torque.

When choosing a motor, compare stator volume and weight. Lighter motors with the same volume are better, all other things being equal. So why not choose the largest motor available? The answer lies in weight. Motors with larger stator volumes are heavier, so your choice depends on the application.

For example, lightweight drones do not require high throttle to stay in the air. When combined with lower pitch propellers, the motors can turn them with less torque. In this case, the torque requirement is low, allowing for smaller, lighter motors and overall lower drone weight. A less powerful motor (with less torque) is preferable in one case - when smoothness is more important than responsiveness. High-torque motors can change speed so quickly that it causes jerkiness and reduces smoothness. They also create more voltage spikes and electrical noise in the power system, potentially affecting gyro performance and overall flight performance. And if the noise filtering is not functioning properly, this leads to mechanical vibrations.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

POPYUSA AND MAGNETS When choosing a motor for your FPV drone, you may come across specifications on the box such as 12N14P. Here's what these numbers mean: the number before the N indicates the number of electromagnets (poles) in the stator, and the number before the P indicates the number of permanent magnets in the bell.

Motors of different sizes have different numbers of poles. For example, 22XX and 23XX motors typically have 12 poles (electromagnets) and 14 permanent magnets.

The number of poles directly affects the motor's performance. If there are fewer poles, more iron content can be incorporated into the stator, resulting in higher output power. However, a higher number of poles results in a more uniform distribution of the magnetic field. This, in turn, ensures smoother motor operation with more precise rotation control.

In short:

More poles = More smoothness.

Less poles = More power. Since FPV drone motors are usually 3-phase, the pole configuration is usually a multiple of 3 (me 9, 15, 18, etc.). This is due to the three wires that connect to the motor. Therefore, the number of poles is not easy to change and is not a critical factor when choosing motors, especially for FPV drones. But you should pay attention to the number of poles, as this is the number that needs to be entered into Betaflight when you enable the RPM filter. If you can't find this number, you can simply count how many magnets are in the bell.

MOTOR WINDING The number of copper windings or "turns" on a stator pole determines the maximum current the motor can draw. At the same time, the thickness of the wire affects the motor's ability to handle current before it reaches the point of overheating.

In simple terms, fewer turns means less resistance, which results in a higher KV. However, this also results in a smaller electromagnetic field on the stator, and therefore lower torque.

On the other hand, when there are more turns in the coil, the increased volume of copper creates a stronger magnetic field at the stator pole, generating more torque. But there is a catch - longer wires and higher resistance lead to a lower KV value.

So how do manufacturers solve these problems when increasing the power of motors for FPV drones? The answer is to increase the number of windings using thicker copper wires. This ingenious approach effectively reduces the winding resistance, thereby increasing power without compromising efficiency and torque. Moreover, a motor with larger diameter wires can withstand higher currents without burning out.

However, it is important to note that using thicker wires and additional windings increases the weight of the motor. In addition, the winding takes up more physical space, which requires a larger stator. This is why larger and heavier motors are now appearing on the market, which also explains their increased power.

MULTI-WINDING VS. SINGLE-WINDING As for the motor windings, there are two main types: single-core and multi-core. Each of them has its own advantages and disadvantages, so it is suitable for different application conditions.

Single core winding uses thicker wires that can handle heat more efficiently, making this option ideal for higher voltage applications such as 6S. However, thick wires result in larger gaps between them, limiting the number of windings that can be wrapped around the stator.

On the other hand, multi-strand windings replace a single thicker wire with several smaller diameter wires. These thinner wires are not as effective at dissipating heat and are more susceptible to physical breakage. Despite these limitations, single-strand windings can offer superior performance compared to single-strand windings due to the tighter packing around the stator with smaller gaps between the wires. This results in a stronger magnetic field, which can lead to increased power and efficiency.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

MULTI-WINDING VS. SINGLE-WINDING However, stranded wires are generally more difficult to achieve as neatly as solid wires. Because stranded wires have more layers of insulation between them, this results in larger air gaps between the wires, which can negate the benefits mentioned earlier.

It is important to note that the neatness of the windings is vitally important both from an aesthetic and electrical point of view. Sloppy windings with many wire crossings generate less effective magnetic fields because the wires do not cross the stator perpendicularly. Therefore, when evaluating motor windings, do not overlook the importance of neat and well-made windings.

Finally, multi-core wire can overheat faster than single-core wire, which affects the overall power and efficiency of the motor. In general, as practice shows, the best choice is still single-core winding.

CHOOSING THE RIGHT MOTOR SIZE FOR YOUR FPV DRONE

To determine the ideal motor size for your drone, follow this sequence: Frame Size => Propeller Size => Motor Size. Once you have determined the frame size, you can estimate the appropriate motor size. The frame size limits the propeller size, and each propeller size requires a different RPM to produce effective thrust, which is where KV comes into play.

Additionally, make sure that the motors produce enough torque to turn the selected propeller. This consideration is related to the stator size. Generally, a larger stator and a higher KV value will result in higher current draw.

The table below provides general guidelines. It should not be taken as a hard and fast rule, as you may find people using motors with slightly higher or lower KV than the table indicates. However, it does provide a good starting point. The table assumes that you are powering your quadcopter with a 4S LiPo battery, and that the frame size matches the dm distance between the motors.

FPV DRONE ENGINE SIZE

FRAME SIZE	SIZE OF THE HOLES	ENGINE SIZE	KV
150mm and less	3” and less	1105-1306 and less	3000KV and more
180ww	…	1806, 2204	2600-3000KV
210mm	..	2205-2208, 2305-2306	2300-2600KV
250mm	— — — — — — — —	2206-2208, 2306	2000-2300KV
350mm	7”	2506-2508	1200-1600KV
450mm	8”, 9”, 10” and more	26XX and more	1200KV and more

blade size is given in inches

VOLTAGE AND CURRENT CONSIDERATIONS Understanding the role of voltage when selecting a motor is a very important factor. With higher voltage, your motor will try to spin faster, which will cause it to draw more current. Keep in mind the thrust your motors produce and the current they require.

Once you have a clear idea of the current your motor and propeller draw, you can confidently choose the right speed controller for your drone. Keep in mind that the speed controller must be able to handle the maximum current draw without going over it to ensure safe and reliable operation.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

HOW TO EVALUATE ENGINE PERFORMANCE Once you've figured out the motor size, you'll likely have several options to choose from. To determine the best motor for your specific needs, consider the following factors:

- Traction. .
- Efficiency and current consumption. .
- Weight.

Ultimately, your choice will be influenced by your intended application, flying style, and desired performance characteristics.

traction

When it comes to choosing a motor for an FPV drone, thrust is often the most important factor. After all, it is the power that moves your drone and allows it to perform impressive aerial maneuvers and stunts.

While more thrust translates into faster acceleration, it's important not to overlook other factors like current draw and efficiency. Opting for a motor and propeller combination that requires too much current can put too much strain on your batteries, potentially shortening their lifespan.

If your drone draws a significant amount of current at full throttle, you need to make sure that your battery's maximum discharge rate is appropriate for the task at hand.

While thrust is certainly a vital aspect to consider when choosing a motor for your FPV drone, it needs to be weighed against other factors that will be discussed below.

VIBRATIONS Vibration coming from the motors can have several undesirable effects on the performance of your quadcopter.

A poorly balanced or poorly assembled motor can generate vibrations that can affect your RID controller. Because the vibration frequency changes at different throttle levels, tuning your drone can be quite challenging.

Additionally, a motor that is subject to vibrations produces more electrical noise than a smoothly running motor. This electrical noise can interfere with your gyro, which can degrade your flight performance, and can even negatively impact the quality of your FPV video if your FPV system is powered directly by your drone's battery.

To help mitigate vibration issues, most flight controllers come with soft mounting solutions such as rubber seals, which can make a significant improvement. However, it is important to remember that damaged, bent, or unbalanced propellers can also contribute to problematic vibrations. Be sure to check your propellers regularly and replace them as needed to maintain optimal performance.

VAPE MOUNTINGS: C-CLAMPS/SCREWS

When it comes to shaft attachment, FPV drone motors use one of three methods: C-clamps, E-clamps, or screws. Each method has its own pros and cons, making it difficult to choose the best option.

In general, it can be said that screws are easier to remove and handle than C-clamps or E-clamps. However, there is an increased risk of overtightening the screws, which can cause the shaft to lock and make it difficult for the motor to turn.

On the other hand, there have been reports of C-clamps popping out during flight. This can cause the engine bell to fly off, causing the drone to crash. While propellers may seem like a safer option, they are not immune to this problem either.

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DRONE TYPES | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

LOWER PART CONSTRUCTION In engine base design, there is a more traditional ”closed bottom” approach and a more modern ”bare bottom” style. Both options have their pros and cons.

The 'closed bottom' design means a stronger base, however the 'bare bottom' is generally lighter due to the removal of excess material, saving around 2 grams in weight.

Closed-bottom motors are less likely to allow dirt to get into the bell. But bare-bottom advocates might argue that dirt is easier to clean out.

With a bare bottom, you can clearly see how deep the screws are, and you are less likely to short out the motor winding if the screws are too long. (This often

happens to beginners who decide to use closed base motors.)

However, the closed bottom provides better protection for wires from strain in case of breakage and displacement.

SPEED CONTROLLER

ESC - electronic speed controller, is translated as electronic speed controller. In the Russian-speaking community, they are usually called ”speed controllers”, in common parlance ”reguli” or ”regulators”.

OPERATING PRINCIPLE of ESC

The flight controller sends data to the speed controller that it needs to increase or decrease the throttle on the engine. But the quadcopter engine cannot simply be supplied with voltage, since it is three-phase and requires alternating voltage supply to certain sections of the winding. This is what the speed controller (ESC) does.

Depending on the required rotation speed, the controller will apply voltage to the motor windings in a strictly specified sequence at a certain speed, which will cause the rotor to rotate.

The windings of the brushless motor are wound and connected to each other according to a special scheme. They have three terminals. These terminals of the motor windings must be connected to the electronic controller, and power must be supplied from the battery. The wires can be connected in any order.

This will only affect the direction of rotation of the engine, which can then be adjusted in the program. This signal output is used to tell the controller at what speed the engine should be rotated.

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DRONE IDES | CONSTRUCTION | S

CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SPEED CONTROLLER

ESC SIGNAL OUTPUT When choosing a controller for a quadcopter, you will encounter the following parameters.

Maximum current.

This is the current strength that the controller's output transistors can hold for a long time, that is, constantly. Sometimes the value of the short-term peak current, permissible for several seconds, is indicated.

EXAMPLE OF CALCULATION OF MAXIMUM CURRENT

The picture shows a battery that can deliver a direct current of no more than 80 amperes.

We divide this value by 4 and get that each regulator has no more than 20 amperes of constant maximum current. Yes. the battery can briefly give a current of more than 80 amperes. but a good regulator can also withstand it for a short time. Thus. regulators with a maximum current of 20-25 amperes are needed.

or one for 50A.

If you don't want to take risks, buy with a reserve, but remember, the higher the maximum current, the more expensive and larger the regulator. The maximum working voltage is also indicated on the regulator.

MARK WHAT BATTERY THE ESC IS DESIGNED FOR

It is important to make sure that the ESC is designed for the number of cells that are in your battery. The faster the engine speed information is transmitted to the ESC, the higher the response of the power plant to the flight controller calculations and the better the quadcopter behaves in the air. Therefore, new and new protocols are constantly being developed to deliver information faster and faster.

4 - pulse-width modulation

pulse width modulation

The slowest protocol supported by all regulators is designated by the letters RIM or, in Russian, PWM, pulse width

modulation. It is not used in racing quadcopters, since it is very

slow.

The minimum for a racing quadcopter ESC is to support the OneShot 125 protocol. One data packet of this protocol is transmitted in 250 microseconds, which is 8 times faster than normal PWM. MultiShot is the fastest communication protocol and is 10 times faster than OneShot 125.

TYPES AND SPEED OF DATA TRANSFER PROTOCOPS IN ESC

Currently, a fundamentally new type of protocol, a digital one, called DSHOT, is being implemented everywhere.

The digital protocol features more accurate and noise-resistant data transmission and high resolution.

At the moment there are 3 variants of this protocol depending on the interface speed DSHOT 150, DSHOT 300 u DSHOT 600

As you can see, DSHOT 600 is comparable to MultiShot in terms of data transfer speed. However, the advantage of the digital signal is beyond comparison.

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CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SPEED CONTROLLER

DSHOT DIGITAL PROTOCOPS SPEED

What types of speed controllers are there?

Speed controllers come in "4 in 1" and separate types.

4 in 1 is one large board the size of a flight controller, which is suspended above or below it. It was designed to save space and weight. But there is one downside - if one controller fails, you will have to replace the entire board.

EXAMPLE OF CALCULATION OF MAXIMUM CURRENT The picture shows a battery that can deliver a direct current of no more than 80 amperes.

We divide this value by 4 and get that each regulator has no more than 20

amperes of continuous maximum current. Yes, the battery can briefly give out current and more than 80 amperes, but a good regulator can also withstand it for a short time.

Oneshot42 ..... 84us DShot300 ..... 53us DShot600 ..... 27us Multishot

OneShot125.....250us

DShot150 .

Thus, regulators with a maximum current of 20-25 amperes, or one for 50 A, are needed.

If you don't want to take risks, buy with a reserve, but remember that the higher the maximum current, the more expensive and larger the regulator.

The maximum operating voltage is also indicated on the regulator.

SPEED CONTROLLER "4 IN 1" Individual speed controllers are isolated boards with

components with individual power supply and connection.

Most often, regulators are purchased for mounting on the frame arms, since they are easier to change if necessary, and it is also easier to monitor their condition.

They are usually fastened with plastic ties:

Since each individual ESC is powered by the main battery, the main battery connector must be somehow divided among the four ESCs. This is accomplished using a power distribution board or power distribution harness.

PPATA POWER DISTRIBUTION The board has special power line contact pads to which the wires from the speed controllers are soldered. Inside this board, all positive and all negative contacts are connected to each other.

And they are brought out to a separate place for connecting the battery connector. It turns out a neat installation without any twists and overhead soldering. 4 in 1 regulators are, as a rule, 4 identical circuits on one board.

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LDO (VOLTAGE STABILIZER) This stabilizer reduces the battery voltage, serves to power the microcontroller and other components of the regulator (this is not the WEIGHT).

MICROCONTROPPER This is the brain of the regulator, it works under the control of firmware, for example BLHeli

GATE DRIVES

Old and cheap regulators used simple transistors instead of drivers. Therefore, their characteristics and braking capabilities were worse.

Instead of using three separate drivers for the three motor phases, modern BLHeli_32 ESCs use the FD6288 chip. This is three drivers in one chip.

MOSFET TRANSISTORS Or keys, they are like switches, only they turn on and off thousands of times a second, in fact, this is the control of the motor

POPETNY COUNTERPOPPER FC

Product name	SpeedyBee BLS F405 V3 BLS 50A 30x30 stacks
Flight controller	SpeedyBee BLS F405 V3 and the comments of the comments of the comments of the comments of the comments of the comments of the comments of the comments of the contraction of the contribution of the
ESC	SpeedyBee BLS 50A 4 in 1 ESC
Bluetooth	Supported. Used for FC and ESC parameters.
Wireless FC firmware flashing	NOT supported
Wireless black box	NOT supported..
Power consumption	3-6S LiPo
Installation	30.5 x 30.5mm (hole size 4mm)
Dimensions	45.6mm(L) x 44mn(W) x 18.3mm(B)
Bec	23.4 gr

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DIMENSIONS

When purchasing a stack, the box should contain:

- Delivery set:
- SpeedyBee F405 V3 50A 30x30 Stack.
- SpeedyBee F405 V3 Flight Controller x 1
- SpeedyBee BLS 50A 4 in 1 ESC x 1
- Low ESR Capacitor 35V 1500uF x 1
- Nylon nut M3 x 5
- Silicone sealing ring M3 x 5
- Silicone bushings MZ * 8 mm (for FC) x 5
- Silicone bushings M3*8.1mm (for ESC) x 5
- 8-pin SH 1.0mm cable, 15mm long (for connecting FC-ESC) x 1
- Hexagon socket head cap screws M3 * 30mm x 5 .
- DJJ 6pin Cable (80mm) x 1 .
- Power cable XT60 (70 mm) x 1.

CONNECTING A PC AND REGULATORS Use the included 8-pin cable to connect the FC and ESC. Or solder the 8 wires directly to the 8 pins on each end.

Method 1 - Using an 8-pin cable

Use either end of the 8-pin JST cable to connect the LK to the ESC.

Method 2 - Direct soldering

Solder 8 wires to the 8 pads on each end using the pad definition below as a guide.

F405 V3 Flight Controller

BLS 50A 4-in-1 ESC

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | FC POPET COUNTERPART

POPETA COUNTERPACKER F405 V3 RED LED: Power indicator. It lights up red continuously after power is turned on.

GREEN LED: Bluetooth status indicator. Solid green indicates Bluetooth connection.

BLUE LED: Flight controller status indicator, controlled by the flight controller firmware.

Orange LED: Control mode indicator LED. It indicates that the 4 sets of LED strips connected to the LED1 - LED4 pads on the corners of the flight controller are controlled by the Betaflight firmware (BF LED mode) or the Bluetooth chip (SB LED mode).

Solid orange: indicates that the 4 LEDs are in SB LED mode. In this mode, when the FC is powered on and in standby mode, press the boot button to switch the LED display modes.

OFF :: indicates that the 4 LEDs are controlled by the Betaflight firmware.

*Long press the button for 3 seconds to switch control modes between BF LED mode and SB LED mode.

LED INDICATOR DEFINITION

· Only if the flight controller is locked and cannot turn on, please follow the steps below to re-flash the firmware for it:

Connect the USB A-TYPE-C cable to your computer. Press and hold the download button, insert the USB cable into the flight controller, then release the download button. Open the Betaflight configurator on your PC, go to the firmware flashing page, select the target parameter "SPEEDYBEEF405V3" and flash the firmware

When the FC is powered on and in standby mode, the boot button can be used to control the LED strips connected to the LED panels 1-LED4 at the corners. Short press the boot button to switch the LED display mode. Long press the boot button to switch between SpeedyBee-LED and BF-LED mode. In BF-LED mode, all LED strips 1-LED4 will be controlled by Betaflight firmware. *BF-LED mode is the default.

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MISSING STORY

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | FC POPET COUNTERPILLAR

FC PERIPHERAL CONNECTION

RI IS Receive DJI Air Unit 1000uF Low ESF
Capacitor

*Note 1: To avoid stack burnout due to power-on voltage surges, it is highly recommended to use the low ESR capacitor included in the package. **Note 2: FC and ESC can also be connected with

using direct soldering. The definition of soldering pads is as follows.

CABLE CONNECTION TO DJI OZ AIR PSU Use the 6-pin cable supplied with the 03 air unit. *Figure 1

CABLE CONNECTION VS RUNCAM LINK / CADDX VISTA AIR UNIT Use the 6-pin cable that comes with the F405 V3 stack. *Figure 2

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | FC POPET COUNTERPILLAR

DPYA RECEIVER SBUS When using an SBUS receiver, the SBC-JS signal from the receiver must be connected to the SBUS panel on the front panel of the flight controller (the SBUS module is used inside this panel).

OART 2). If you are also using a DJI Air (03 / Link / Vista / Air Unit VI), you will need to disconnect the SBUS signal wire from the Air unit's wire harness. Failure to do so will result in the SBUS receiver not being recognized correctly by the flight controller. Use tweezers to remove the SBUS wire from the 6-pin connector of the wire harness (or directly cut this wire) and carefully insulate the exposed portion of the wire.

ELRS RECEIVER DEPARTMENT

We recommend connecting the TX and RX receivers of the ELRS receiver to the 72 and R2 connectors on the flight controller. However, when using the DJI Air at the same time, some ELRS receivers may not be recognized correctly by the flight controller. If you encounter this problem, you need to disconnect the SBC-JS signal from the air conditioner wire harness. Use tweezers to remove the SBUS wire from the 6-pin connector of the wire harness (or directly cut this wire) and carefully insulate the exposed part of the wire.

CHARACTERISTICS

NAME	POET COUNTER SPEEDYBEE F405
MCU	STM32F405
Gyroscope	BMI270
Barometer	Built-in
...	
Yun OSD	Yun OSD
60%	
Bluetooth	Supported. Used for flight controller configuration. (MSP must be enabled with 115200 baud on UART4)
17 Stand on filling filling full included with speed similarity similarity similarity on	
WIFI	Not supported

NAME	POET COUNTER SPEEDYBEE F405
and the giver and the acceptance for the acceptance for the acceptance and the acceptance and the acceptance and the completion and ima se podosrimavanti	
DJI Air Unit 6-Pin Plug	Supported. Fully compatible with DJI 03/RunCam Link/Caddx Vista/DJI Air Unit VI, no wiring required
Blackbox MicroSD card slot	*Betafilaht flashing requires the microSD card type to be standard (SDSC) or high capacity (SDHC), so the cards Extended Capacity (SDXC) cards are not supported (many high speed U3 cards are SDXC). Also the card MUST be formatted in FAT16 or FAT32 file system (recommended). So you can use any SD card with the capacity less than 32GB, but Betalight can recognize maximum 4GB

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DRONE TYPES | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | FC POPET COUNTERPILLAR

CHARACTERISTICS

NAME	POET COUNTER SPEEDYBEE F405
3S - 6S Upo (via G, contacts/BAT contacts from 8-pin connector	
Power consumption	or 8-pin contacts on the bottom side)
9 groups of 5V outputs, four +5V pads and 1 BZ+ pad (used	

NAME	POET COUNTER SPEEDYBEE F405
for the buzzer) on the front side, as well as 4 LED pads 5	
Output 5V	B (powered when OLED is turned on in the OLED tab). Total current the load is 2A
2 groups of 9V outputs, one +9V contact pad on the front side and Output 9V	another one, plugged into the connector on the bottom side. Total current load 2A.
Supported. Designed for receivers with 3.3 V input. Current Output 3.3V	load up to 500 mA
Supported. Designed for GPS receiver and module, even when Output 4.5V	FC is powered via USB port. Current load up to 1A.
ESC signal, M5 M6 M7 M8	M1 – M4 on the bottom side and M5-M8 on the front side.
6 sets (UARTI, UART2, UART3, UART4 (intended for connection UART	no Bluetooth)), UART5 (intended for ESC telemetry), UART6
ESC telemetry	UART R5 (UART5)
Supported. SDA and SCL panels on the front side. Used for GPS	magnetometer, sonar, etc.
Supported. At the bottom of the front panel are 5V, G and LED panels. Used for WS2812 LEDs, controlled OLED	Betaflight firmware.
Sound signal	BZ+ and BZ- pad are used for 5V audio signal
Beod RSSI	Supported. Marked as RS on the front side.
BAT	Direct line from battery (up to 36V)
9V	VTX Power
SBUS	For single-wire receiver
VTX	

NAME	POET COUNTER SPEEDYBEE F405
	Video transmitter
G. GND	Earth, common negative
TEL munumumumumumumumumu-mumumumumumumumumumumumu-mumumumumumumumu-mumumumumumumumumumumumumumumumumumumumumumumumumumumumumumumumumumumumumumun inimali	ESC telemetry

t.me/projectArchangel | project-archangel.slave

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DRONE TYPES | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

CHARACTERISTICS

NAME	POET COUNTER SPEEDYBEE F405
	Servo
T#	Tx - for data transmission
R#	RX - for receiving data
CAM	To connect the Camera

- UARTs have a division in the form of a dotted line on the PC

SETTING UP BETAFLIGHT

FIRST SETUP OF BETAFLIGHT

Important: Make sure all propellers are removed before setting up the quadcopter on the stand to avoid accidents.

CONNECT FC TO COMPUTER

By connecting USB cable to FC, it will also provide power, no need to connect LiPo battery

IMPORTANT Always click the Save Reload button before moving between tabs, otherwise the changed data will not be saved.

Be sure to save the factory settings in text format via the command line, write “dump” in the command line and save the information that appears in a text document.

When the FC is connected to the computer, a new COM port should appear in the Configurator. Select this new COM port and click ”Connect” If you do not find the COM port, this may be due to a driver problem

computer. Or perhaps your FC is ”bricked” (extremely rare).

INFO If you do not see the new COM port appearing or the configurator cannot connect, there are several ways to solve this problem:

Make sure you connect the USB cable to the flight controller and nothing else. Do not connect BetaFlight Configurator to the HD system. Do not connect BetaFlight Configurator to the radio transmitter. Betaflight Configurator is not intended for use with anything other than a flight controller.

Make sure you are using a USB cable that can transfer data. Some USB cables are designed for charging only.

You may need to install drivers for your flight controller. The configurator contains a download link for the ImpulseRC Driver Fixer tool.

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RONOV GCHSTROYS

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

INSTALLATION SETTINGS

Once you have successfully connected to Betaflight, you will be taken to the Setup tab with a 3D model of your quadcopter. Here you will get a basic overview of the flight controller status and access to several key features.

Setup

Setup WIKI

Ports

Setup		
Configuration	Calibrate Accelerometer	Place board or frame on leveled surface, proceed with calibration, ensure platform is not moving during calibration period
THE TITLE CALL BE CLASS OF CLASS OF CLASS OF CLASS OF CLASS OF CLASS OF CLASS OF CLASS OF CLASS OF COLLECTION OF COLLECTION OF CO		

BASIC SETTINGS

CAPITALIZATION OF THE ACCELERATION METER

The accelerometer is used to determine the orientation of the flight controller. It is used to determine pitch, roll, and yaw angles. You can calibrate it here by following the instructions

The accelerometer is used for self-stabilization features such as angle, horizon, acro-trainer, and even GPS rescue. If you don't intend to use these features, you can skip this step or even disable the accelerometer entirely.

MAGNETOMETER CAPITALIZATION The magnetometer (compass) is used to determine the flight controller's heading in 3D space. It is useful for getting more accurate information for GPS rescue. Calibrate it by following the instructions. The magnetometer calibration process is time-limited, you only have 30 seconds to complete all the movements.

RESET SETTINGS

DANGEROUS This will reset all settings to default, resulting in an empty configuration. This is not a "factory reset" for the drone or flight controller. It is used as a hard reset, and may lead to unpredictable results, or even require you to reflash the firmware to be able to connect again.

There are a few things you need to do here:

Place the quadcopter/FC on a flat surface, then click "Calibrate Accelerometer" - this only needs to be done once per firmware update.

Now move the quadcopter with your hands (try tilting forward and backward, turning left and right, yaw, etc.), the 3D model should follow the movements.

If the 3D model does not move the same as your quadcopter, it could mean a few things, maybe your FC is upside down, or it is mounted in the wrong direction (eg the arrow on the FC is not facing forward). Try rotating the board until it is correct. If you physically cannot rotate the PC, you can try setting the YAW offset in the config tab, board sensor alignment to fix this (usually 90/180/270 degrees).

On the right are some basic data from the on-board controller. These include: Arming Disable Flags - shows all "errors" that prevent the flight controller from being mounted on an ARM. This is useful to check if you are having problems mounting on an ARM.

Battery Voltage - Shows the current voltage of the battery, if the settings for it are correct Current Drawn - Shows the current drawn from the battery, if the settings for it are correct Current Draw - Shows the current the drone draws from the battery, if the settings for it are correct RSSI - Shows the current RSSI value (used as a rough estimate of the signal strength), if the settings for it are correct

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In the State Committee for Civil Defense

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

GPS Shows GPS data if a GPS module is connected and configured to the flight controller. These include:

3D Fix - shows whether the GPS has a 3D fix or not, fixation is necessary for the GPS to work properly. Sats - shows the current number of satellites the GPS is locked on. The more the better, usually 6 or more are needed for a good fix.

Lattitude/Longitude - shows the current latitude/longitude coordinates of the drone. Instruments:

Graphic copy of real aircraft instruments

INSERTION PORTS

The Ports tab allows you to configure all peripherals (external devices) connected to the flight controller via UART.

Ports		WW
	Neder not all combi- nations are wills! When the fixfre con- noller firmware detects this the serial port config- uration will be reset.	

Neet. Co. disable MSP on the first senal port unless you know what you are doing. You may have to redath and enase your config- uration fr you os

Identifier	Configuration/	Serial Rx	MSP	Telemetry Output	Sensor Input		Peripherals
USB VCP	@ 115200	O		Disabled v AUTO v	Disabled v AUTO v	Disabled	V AUTO V
UART1	O 115200 V	0		Disabled v AUTO v	Disabled v AUTO v	Disabled	V AUTO V
UART2	O 115200 V	O		Disabled v AUTO v	Disabled v AUTO v		VIX (TBS Sm V AUTO V
UART3	115200	THEIR		Disabled v AUTO v	GPS V AUTO V	Disabled	V CAR V

Ports							WW
LIART4	. 115200	THEIR	Disabled v AUTO v	Drabled v AUTO v	Disabled	V CAR V	
LIARTS	C 115200 v	THEIR	Disabled v AUTO v	Disabled v AUTO v	Disabled	V CAR V	

Identifier - Port label. The UART number responds to RX-TX pairs.

Configuration/MSP As the name suggests, it is usually used only for low-level communication using MSP (MultiWii Serial Protocol) for configuration by external devices or for a more direct control method. You can also set a specific baud rate.

ATTENTION! This should not be used as a "switch" for the current UART when configuring it (for example for Serial RX). This is a fairly common mistake and can cause your config to not be saved to prevent unwanted behavior when conflicting options are set.

Serial RX Used to configure the UART to accept serial data from the receiver. This is the most common use of the UART port. If you enable this option, you will not need to touch any other options for this port.

Telemetry Output Used in older radio systems where you want to send telemetry data back to the receiver via a UART separate from the one used for control. You may also need to set the baud rate for your device. This is not used for most modern radio systems such as ELRS. Modern receivers default to two-way communication with FC, allowing telemetry to be sent via the same port used for the serial Rx connection.

Make sure that in the Receiver tab you have set the Telemetry Output to On so that the FC sends telemetry to the receiver.

Sensor Input If you want the port to receive data from a sensor. This is used for things like BLHeli 32 ESC telemetry or GPS. You may have to manually assign the baud rate for GPS to work. ESC - should be connected automatically.

Peripherals Several options allow FC to control peripherals such as VTXs, cameras, external OSDs, or even digital VTXs along with MSPs. As with and , you may need to set the baud rate for your device, although common devices

such as SmartAudio, Tramp, and MSP VTXs should work fine with the default baud rate.

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TYPES OF DRONES | DEVICE | ASSEMBLY

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

INSERTION PORTS

Basically there are only 2 things you need to do: If you are using an analog VTX and you connect a SmartAudio or IRC Tramp cable to control the VTX, you should select "VTX (TBS SmartAudio)" or "VTX (IRC Tramp)" in the Peripherals section for the UART you connected the VTX to. If you are using an HD VTX such as DJI/Avatar/HDZero, you should select VTX (MSP + Displayport), this will also automatically enable MSP.

When using a serial receiver such as ExpressLRS and Crossfire, you need to enable "Serial RX" on the UART it is connected to.

SYSTEM CONFIGURATION INSERT

The Configuration tab contains the main system settings. Most of the settings can be left at default, only a few parameters need to be changed.

&		
Sesup	Configuration	WIKI
Ports		

& Sesup	Configuration		WIKI
Configuration		Notec Not all combinations of features are valid. When the flugit controller firmware detects invalid feasure combinations confficting features will be doabled	
	Note: Configure senal ports before enabling the features that will use the ports.		
Power & Battery			

& Sesup	Configuration		WIKI
Failsafe	System config- uration	Board and Sensor Align- ment	
	Note: Make sure your FC is able to operate at these speeds!	00	Yaw D.
Presers	Check CPU and cy- cletime stabil- ity. Chang- ing this may require PID re- tuning.		
PID Tuning	TiP: Disable Ac- celerom- eter and other sensors to gain more perfor- mance.	First v CW 0' v	

& Sesup	Configuration					WIKI
Receiver	3.20 kHz Gyro update frequency			Default V	MAG Alignment	
	3.20 kHz	> PID loap frequency	0			
		Accelerometes		Accelerometer Trim		
Adjustments		Barometer (if supported)		0 Accelerometer Roll Trim		
		Magnetometer (if supported)		Accelerometer Pitch Trim 0		
Motors						
OSD	Personalization			Dshot Beacon Configuration		
0 Video Transmitter		Craft name		3	Beacon Torie	
4 Sensors	Camera				Beeps when TX is turned off or signal lost (repeat	
Tethered Logging				until TX is clay)		

& Sesup	Configuration					WIKI
	0	FPV Camera Angle [degrees]		RX SET	Beeps when aux channel is set for beep.	
Blackbox CL	Arming			Beeper Configuration		
		Maximum ARM Angle (degrees)	0	GYRO CALIBRATED	Beeps when gyro has been calibrated	
	Other Features			RX LOST	Beeps when TX is turned off or signal lost (repeat until TX is okay)	
	Note: Not all features are supported by all flight controllers. If you enable					

& Sesup	Configuration					WIKI
	a specific feature, and it is disabled after you hit 'Save and Reboot', it					
		means that this feature is not supported on your board.				Beeps SOS when armed and
		INFLIGHT_ACC_CAL	In-flight level callbration		RX_LOST_LANDING	TX is turned off or signal-lost (autoland-ing/autodisarm)
		SERVO_TILT	Set to gimbal	0		
					DISARMING	Beep when disarming the Rightcontroller
		SOFTSERIAL	Enable CPU based serial ports			

& Sesup	Configuration			WIKI
			ARMING	Beep when arming the flightcontraller
	Sonar	SONAR		
	Multi-color RGB LED strip support	LED STRIP	ARMING GPS FIX	Beep a special tone when arming the board and GPS has fix
	OLED Screen Display	DISPLAY	0	
	Forward aux channels to servo outputs	CHANNEL FORWARDING	BAT_CRITICAL_LOW	Longer warning beeps when battery is critically low
	Race Transponder	TRANSPONDER	0	[(esients] Warning beeps when battery is
	Permanently enable Alrmode	AIRMODE	BAT LOW	getting low (repeats)

& Sesup	Configuration			WIKI
	On Screen Display	OSD	GPS STATUS	Use the num indicate how

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CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

SYSTEM CONFIGURATION INSERT

Gyro Update Frequency The frequency at which the gyro is sampled. In recent versions of Betaflight, the default will be set to the frequency at which the gyro works best (8 kHz for MPU6000, 3.2 kHz for BMI270, etc.).

PID Loop Frequency The frequency at which the PID loop calculations are performed. This is essentially all the math that is used to control the flight. When using dshot300 you may see the PID loop reset to 4K, if you manually try to set it to 8K, dshot300 does not send updates fast enough to use the 8K PID loop, so 4K is chosen to save CPU time.

The recommended combinations of PID loop and motor output with RPM filtering enabled are 2K/dshot150, 4K/dshot300 and 8K/dshot600. The exception is when using the BM/270 gyro, in which case the recommended values are 3.2K/1.6K.

INFORMATION It's usually best to set it to the same frequency as the gyro, or half that frequency if you're using a slower MCU and a high gyro frequency (8kHz gyro will be 4kHz PID cycle on the F411). Sensor Toggles:

Accelerometer - Enable or disable the accelerometer, which is used for self-stabilization features. Barometer - Enable or disable the barometer. If present, it is used to measure altitude. Magnetometer - Enable or disable the magnetometer. If present, it is used to determine orientation in the real world.

Accelerometer Trim - Adjusts the accelerometer to compensate for any errors in the accelerometer readings. Only visible when the accelerometer option is enabled

Board and Sensor Alignment Allows you to virtually move FC and other sensors if they are installed in a non-standard way COBET

If the 3D model preview does not react correctly to real-world movement, it is most likely due to incorrect board alignment. Use the alignment options to correct this. Move in 90 degree increments (45 if the board is mounted diagonally) and check the preview after each change.

Personalization Allows you to set the pilot name that will be displayed in the OSD, black box logs, and diff/dump outputs.

DShot Beacon Configuration Runs a high frequency signal on the motor output to make the motors resonate and make sound, A good alternative to a real zimmer, but it cannot be activated in flight (since the motors are spinning), is not as loud, and cannot be used for long periods of time as the motors may draw excessive current and overheat.

Beacon Tone - You can choose from 5 different tones. RX LOST - enable or disable signal when RX signal is lost

RX_SET - enable or disable the sound signal when BEEPER mode is turned on

OTHER FEATURES: A list of the various features that may be enabled or disabled, and may or may not be present on your flight controller.

NFLIGHT ACC CAL - Allows you to calibrate the accelerometer in flight

SERVO_TILT - Enables a mode that stabilizes the camera's tilt angle using up to two servos mounted in a CAMSTAB gimbal configuration

SOFTSERIAL - Emulates a serial port on another pin or splits the RX-TX UART pair. This allows it to be used as an additional UART

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DRONE TYPES | DEVICE | S

SYSTEM CONFIGURATION INSERT

INFO Softserial is useful for FCs that don't have enough UARTs to support all the features you want to use. However, there are some limitations.

It works at a lower data rate. Works well at 9600, but not so well at higher speeds.

Consumes more CPU resources and creates additional load on it. Therefore, it is not ideal for low-performance MS.

It is not recommended to run the receiver on a softserial port due to duty cycle limitations.

Some ports may work better than others. usually works all the time, but you may need to experiment with other LED STRIP

Finally, you cannot have more than two softserial ports active at the same time.

SONAR - Enables sonar support, but this feature is not recommended for use at this time LED STRIP - Enables the LED strip feature, which allows you to control the WS2812B RGB LEDs DISPLAY - Enables the display feature, which allows you to use a small OLED display to display various information. If this feature is enabled and no display is connected, the FC will take about 10 seconds longer to boot up. Not recommended for use at this time

OSD - Enables the on-screen display, you can configure it in the OSD tab that appears when you enable this option.

BLACKBOX - Enables the "black box" feature, which allows you to record flight data to the flash memory in the FC or to the SD card (if available). You can configure it in the Blackbox tab that appears when you enable this feature.

CHANNEL FORWARDING - Allows you to redirect the AIH channel to the motor/servo output

TRANSPONDER - Enables the racing transponder function if your equipment supports it. AIRMODE - Always on airmode, which gives the aircraft more control in the air at 0 throttle.

Set Home Point Once - if enabled, the home point will be set only once, when GPS data is first received.

Sound signal configuration Toggle different triggers for when the sound signal should be active

RX_LOST - beeps when RX signal is lost (repeats until signal is restored)

RX_LOST_LANDING - beeps when RX signal is lost and the craft is in the landing phase. Must be enabled!

BKPADKA POWER & BATTERY Take the battery and check its voltage using a battery tester or multimeter.

Then connect it to the drone (remove the propellers first!) If the voltage reported in the configurator (red circle in the image

below) does not match the measured voltage, then you need to calibrate the voltage sensor in Betaflight. To do this, go to the "Power and Battery" tab on the left side of the panel.

Click the Calibration button in the lower right corner.

Enter the measured voltage in the pop-up window, then click Calibrate, and you will be prompted to apply the new voltage scale. That's it.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

INSTALLATION RECEIVER

The receiver is the device that (as the name suggests) receives data from the transmitter, usually your radio controller. The receiver tab is used to configure the FC so that it can read the receiver data. The receiver tab is divided into two sections: Receiver Output Preview and Receiver Configuration.

On the Receiver tab you

You can set up and check if your receiver is working properly.

Output Preview The receiver output preview shows the current state of the receiver channels, both as channel values and as graphs, and how they affect the drone's movement.

Receiver Configuration Used to configure all parameters specific to your Receiver

Select the communication protocol used by your receiver. The following options are possible: PPM/CPPM is an outdated protocol that is unlikely to be used in modern devices.

Serial-based - Most modern receivers communicate via a serial interface using various protocols such as CRSF or SBUS.

RIM is an outdated protocol and is unlikely to be used in modern devices.

MSP is an advanced variant that uses the MSP protocol to communicate with the receiver.

SPI - used for most integrated receivers, such as the ExpressLRS on tinywhoop AIO boards.

ATTENTION Selecting the wrong protocol will result in the signal not being detected or being interpreted incorrectly. You must select the correct protocol for your receiver.

Telemetry Enable or disable telemetry output. Also required to control VTX from ELRS receivers

RSSI A mostly legacy option used to configure a separate RSS/0-3.3V analog input. Most modern receivers transmit RSSI (along with other telemetry data) over the same serial connection as control data. Do not enable this option for modern receivers.

RSSI Channel Some older receivers only output RSS/ on one channel. If you have an older receiver, you can set which channel to use to read the RSSI value. Typically, this is AUX 4 or 12. Leave this setting disabled if you have a modern receiver, such as one that uses the CRSF or GHST protocols.

"Stick" Settings Min/Center/Max values for the four main control channels. These are used to set the stick value range, usually for safety and calibration purposes.

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RONOV | CHSTROYS

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

INSTALLATION RECEIVER

Channel Map The various receivers output four main control channels:

- Aileron Roll (left/right) .
- Elevator Pitch (forward/backward)
- Throttle Throttle (up/down)
- Rudder Yaw (left/right)

ATTENTION If the radio's input signal does not match what you see in the preview, you will need to change the channel map. There are also preset options for some of the most common systems:

FrSky/Futaba/Hitec - FrSky, Futaba and Hitec receivers output channels in the same order as Betaflight by default (AETR1234)

Spektrum/Graupned/JR - Spektrum receivers display channels in a different order than Betaflight by default (TAER1234)

Deadband Settings Deadband is the range of stick movement that is ignored, Some radios/receivers may have a slight jitter and this setting can be used to

ignore it. You also have options to set it specifically for yaw and throttle in 3d mode

RC Smoothing

Enable or disable the RC anti-aliasing filter

IMPORTANT If you are using a serial RX, the two most popular serial receivers are Crossfire and ExpressLRS

In this case you should select "Serial (via UART)" in Receiver Mode.

In the Serial Receiver Provider item, select the appropriate receiver protocol:

TBS Crossfire - CRSF ExpressLRS - CRSF Tracer - CRSF Ghost - IRC GHOST Spektrum DSM2 - SPEKTRUM1024 Spektrum DSMX - SPEKTRUM2048 FrSky RX - SBUS Futaba RX - SBUS FlySky RX - IBUS Turnigv RX - IBUS

If you connect RX to FC via PPM, use "PPM RX Input" in receiver mode.

If you are using telemetry, make sure telemetry output is enabled.

Turn on the radio controller (TX) and radio receiver (RX), if they are already linked, then when you move the sticks the channel values should also change. If the wrong channels respond, you may need to change the "Channel Map", usually it should be AETR1234 or TEAR1234.

If the channels don't respond to your stick movements, here's how to troubleshoot:

Is RX connected to TX? (Do you see a steady green light on RX?)

Is RX soldered to FC correctly?

Is serial RX enabled for the desired UART?

Is the correct RX protocol selected?

Once you are sure that the channels are working properly, check the midpoints and endpoints of the first 4 channels (Pitch, Roll, Yaw, Throttle). When you take your hands off the sticks, the Pitch, Roll, and Yaw channels should be 1500. Some receivers may have a slight jitter, such as around 1498-1502, which is normal. The endpoints should be 1000 and 2000 (a small error of 8-12 is acceptable, such as 988 and 2012).

Before moving on to the next tab, make sure that the mode and setting switches on the ARM are working correctly, by switching them, you should see how the values of the AUX1, AUX2 or AUX3 channels change.

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RONOV | CHSTROYS

INSTALLATION MODES

Modes are used to enable or disable features and initiate FC actions using the AUX channel switches. Modes are enabled when bands or links are active.

Ranges - are activated when the receiver channel matches the specified input values. A receiver channel that gives readings in the min/max range activates the mode.

Add Link - Activated when another linked mode is active.

MODE TYPES

ARM - Activates the engine and allows you to fly.

ANGLE - a flight mode that maintains a level position using the accelerometer. Stick input affects the ship's angle

HORIZON - a flight mode in which the accelerometer remains level. Stick input affects the pitch angle of the ship, but at extreme pitch and roll angles the ship will flip upside down and then return to a horizontal position.

MAG - activates course fixation using a magnetometer (compass)

BEEPER - Activates the beep sound, either the dshot engine beep (if not enabled) or the external buzzer and the flashing on-screen beep element. Useful for locating a crashed drone

LEDLOW - turns off the LED strip

OSD - enable/disable the on-screen menu overlay function

TELEMETRY - enable/disable sending FC telemetry to the control channel receiver or another output port

SERVO1 - enable/disable the first servo output

SERVO2 - turn on/off the second servo output

SERVO3 - enable/disable the third servo output

BLACKBOX - Enable/Disable Black Box Logging. Useful for recording only the necessary data when the Black Box memory is limited.

AIRMODE - Enables/disables the air mode feature, which allows full PID adjustments at zero throttle to maintain control. See the setup notes for more information.

ACRO TRAINER - ACRO TRAINER flight mode, limiting the tilt angle of the drone when flying in ACGO mode LAUNCH CONTROL - launch assistance system. Rotates the motors and tilts the device forward to the desired angle without taking off

In the Modes tab you can assign switches to different functions.

Click ”Add Range” on the mode you want to use.

Select the switch you want to use to control this mode from the drop-down menu. If you don't know which AUX is your switch, just go to the Receiver tab and see which AUX channels respond when you switch. AUX1 is channel 5, AUX2 is channel 6, and so on.

Drag the slider to the desired range to activate

Flip the switch and the little yellow marker should move as well, see if it falls within the mode activation range when the switch is on.

Click ”Save”

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

INSERTION MOTORS

The Motors tab is used to configure the ESC and test the motors. For safety, please make sure you remove all propellers before using the Motors tab.

Adjust the motor and ESC parameters. Mixer Mixer controls the motor placement and how the FC will use the motors to maintain stable flight. Quadcopters typically use the ”QUAD X” setting, so set this if you are unsure.

Motor rotation direction changed - normal setting

assumes that your props will rotate towards the camera at the front of the quadcopter ”props in”, the opposite setup means that the props will rotate away from the camera ”props out”.

INFORMATION Pilots use ”props out” to prevent debris from entering the camera by instead sending it into the body of the quadcopter.

Motor direction - Open the motor direction check tool, which allows you to gently rotate the motors and easily change the direction of the motors to match the direction of your mixer. Remove the porps and be careful!!!

ESC/Motor Protocol - DShot is standard on modern builds and provides the best flight performance and features.

INFORMATION The speed of DShot depends on the PID loop frequency you choose, as slower DShot speeds cannot send updates fast enough to fully utilize higher PID loop frequencies. Because of this, it is recommended to use 8K with DShot600, 4K with DShot300, and 2K with DShot150. Other options like Oneshot125 are only needed for very old ESCs like the original BLHELI, newer BLHeli S, BLHeli 32, BlueJay, or AM32 ESCs should use DShot

MOTOR STOP - Prevents the motors from spinning at idle when arming. Not usually required, it is considered safer to spin the motors so that bystanders can see that your quadcopter is in ARM mode.

ESC_SENSOR – Allows receiving telemetry data from the UART connection to the ESC, as configured in the Ports tab.

Bidirectional DShot - Required for RPM filtering. Instead of sending DShot commands to the ESC only on the motor output connectors, the FC will also listen for feedback from the ESC on the same wire. Motor Poles - The number of permanent magnets installed in the motor bellhousing

INFORMATION Larger motors such as the 2207 or 2306 have 14 magnets, while the 1103 and smaller motors have 12 magnets. The number of magnets typically changes from 12 to 14 in 14xx/15xx size motors.

Motor idle (% static) - sets the minimum value of engine power to ensure smooth acceleration of the engine from idle without lag and without loss of control.

3D ESC/Motor features - 3D allows the motors to operate in both directions, allowing for inverted flight. Zero throttle is now at 50% stick position, and the lowest stick position now gives the maximum negative throttle position, while the maximum positive throttle position is at the highest stick position.

ENGINE TEST MODE

DANGER Be careful when bench testing motors, be sure to remove the propellers. Be careful when using LIPO batteries. The blade fingers are sausages!!!

Please be careful!

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PRONOV | CHSTROYSTE

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

ENGINE TEST MODE

Visualization of the current motor rotation. The propellers must be removed before testing the motors. After connecting the battery and turning on the

ESC, the motors can be rotated using the sliders. If the motors do not rotate correctly

(correct rotation of motors is in the image), you need to use Motor direction. The image shows an example of the numbering order

engines Here is the correct order of the engines and their rotation:

engine 1 rear right engine 2 front right engine 3 rear left engine 4 front left

The only thing you need to change is the ESC/Motor Protocol. If you are using BLHeli S or BLHeli 32 ESCs, it is recommended to use the Dshot protocol.

As a rule of thumb, choose: DShot600 for 8KHz looptime DShot300 for 3.2KHz/4KHz DShot150 for 1.6KHz/2KHz

It is recommended to keep the "IMOTOR STOP" option disabled, otherwise you will not be able to determine whether your quadcopter is powered on the arm. The rest of the parameters can simply be left at default. Click Save and Reboot, then go back to the Motor tab again.

DIRECTION OF ENGINES IN BETA FLIGHT Why change the direction of motors/propellers in a quadcopter? In this article, we will discuss some of the advantages of the outward propellers (reverse motor rotation) option for an FPV drone compared to the inward propellers configuration, which is the default.

Aerodynamic advantages By default, Betaflight is set up for quadcopters to use "props in", which is the default direction for the motors to spin. If you want to reverse the rotation of all motors (we call this "props out"), you must enable the "Motor direction is reversed" option in the Configuration tab. You will also need to change the ESC settings, which will be covered shortly.

Let's try to explain why you might want to change the default settings and use "outward propellers".

One of the main benefits of reverse rotating engine and propeller will be aerodynamics.

Center of traction When the propeller is spinning while the drone is stationary, the center of thrust is right in the middle (i.e. on the propeller hub). But when the quadcopter starts flying forward, the propeller experiences air resistance forces that shift the center of thrust to the advancing blade (red circles in the main illustration of the article). This means that the advancing blade will create more thrust and pull in more air than the returning blade.

The front two propellers have their center of thrust on the outside, while the rear propellers have their center of thrust on the inside. The faster the drone flies, the further the center of thrust is from the hub. This means that the drone's

rear propellers will operate less efficiently than the front ones, according to the principle of moments.

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BACKGROUND | EMERGENCIES

CONCEPT OF UAP (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

ENGINE TEST MODE

Air disturbance Furthermore, air turbulence from the front propellers can cause the rear propellers to operate even less efficiently. (This is precisely the problem the Stretch X frame was designed to solve, with the front motors located significantly away from the rear motors.)

With the engines spinning backwards, the thrust center of the front propellers is now inward and the rear propellers are outward, which compensates for the damage we get from the violent air disturbance from the front propellers.

Improved yaw maneuverability With inverted rotation, the rear motors are less likely to stall on tight yaw turns. The effect is especially noticeable on smaller quadcopters like the Tiny Whoop and other micro drones.

However ...

These advantages will not be of much importance when hovering or performing aerobatics, where the propellers can rotate in both directions.

Other advantages One of these reasons may be enough to make you try the "propellers out" option on your machine.

Since the front propellers rotate outward rather than toward the FPV camera, the camera lens will not pick up dirt, grass, or water from the fans. However, the flight controller unit will take care of all of that.

But if you use the turtle mode, the reverse propeller configuration can play a negative role. When trying to return the inverted drone to the correct position, the propellers will rotate inward and are more likely to smudge your lens.

When spinning in reverse, you are also less likely to get caught on gates or branches, as the propellers will simply bounce off the obstacles when they collide.

Another positive thing about changing the propeller rotation is that many of us have often encountered situations where we don't have any clockwise (CW) propellers, but we have a lot of counterclockwise (CCW) propellers, or vice versa. The reason is that we are left-handed or right-handed, and therefore

tend to instinctively make more turns in one particular direction. Now we can simply change the rotation and continue flying.

How to reverse the rotation of the motors?

Here's how to set up ”propellers out” for a quadcopter in Betaflight. Important! For safety reasons, remove all propellers before continuing!

In the Betaflight configurator, activate the option ”Motor Direction is Reversed”. Then install the propellers in reverse order: CW propellers instead of CCW and vice versa. But do not install them upside down.

It's a good idea to double check the motor reverse setting in Betaflight after you've flashed or updated your FC firmware, as sometimes the settings reset after flashing.

Is it possible to recommend the ”propellers out” configuration? Yes and no.

Large quadcopters (3 inches and larger) are better to fly

with default rotation setting (”propellers inward”),

since the advantage of reverse rotation is almost not noticeable. In addition, every time after updating the firmware, you will have to reconfigure the drone.

However, for micro drones (less than 3 inches) such as Tiny Whoop and toothpick drones, it is better to use reverse rotation (propellers outward). Your efforts will be rewarded with improved flight characteristics.

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DY DRONES | DEVICES

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

ON-SCREEN MENU INSERT Now go to the OSD tab on the left panel. If you are using DJI/Avatar/HDZero FPV systems, make sure to switch to HD video format, this will give the correct font and screen size, it will look much better. For analog systems, just select Auto (or PAL/NTSC if you know what type of camera you have).

By customizing the OSD, you can display important flight data such as voltage and timer on the screen.

You can enter standard OSD data into the command line: set osd vbat pos = 2467 set osd *link_quality* pos = 2114 set osd rssi dbm pos = 2082 set osd tim 2 pos = 2486 set osd throttle pos = 2104 set osd current pos = 2135 set osd mah

drawn pos = 2403 set osd_warnings_pos = 14633 set osd avg cell voltage pos = 2435 save

VIDEO TRANSMITTER INSTALLATION

If you are using an analog video transmitter and want to change the channel and power in the OSD, you need to set up a VTX table. This does not apply to digital FPV systems (DJI/HDZero/Avatar). There are 3 ways to load VTX tables:

- select the VTX Table preset in the Presets tab
- . upload the JSON file in the Video Transmitter tab
- paste the code snippet into the CLI (my preferred way)

Usually you can find a JSON file or CLI snippet of the VTX table for your specific VTX on the corresponding product page, if not you can just google it.

Firmware Be sure to save the factory settings in text format via the command line, write “dump” in the command line and save the information that appears in a text document.

Instructions for reflashing: At the time of writing the instructions, the main firmware that is installed on all drones is 4.4.0. This firmware version limits the work with the Betaflight configurator program (in particular, interaction with the ”Servos” tab). To eliminate these limitations, you need to flash the drone to version 4.4.2.

- To do this, connect the chimera to the computer; 1.
- b. Enable Betaflight configurator;
- Before starting work, you need to save all the settings. To do this, go to the ”Command 3. line” section and enter the ”dump” command;

Click the “Save to file” button in the lower right corner and name it so that in the future it will be 4. clear what it is;

5. In the first menu, before pressing the “Connect” button, on the left side of the screen, press the “Programmer” button;

In the screen that opens, in the “Select flight controller” field, select the name of the drone’s flight 6. controller;

Automatically, depending on the flight controller, the most current firmware is selected, if this does not happen, you can select it manually;

8. It is necessary to mark the position “Full chip erase”;

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1D DRONES | DEVICE | WITH

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

ON-SCREEN MENU INSERT

Instructions for reflashing:

- i. Finally, the filled fields should look like this (Fig. 1) 10. Scroll down and in the “Radio protocol” section, set CRSF; 11. In the “Other Options” section, add the “Servo” position;
- l. ”Telemetry protocol” should be set to ”None”;
- m. «Motor Protocol» - DSHOT;

Core Only	Build Configuration	
Radio Protocol		Telemetry Protocol
CRSF.GHST.SBUS	0	[None]
Other Options		Motor Protocol
· GPS	* LED Strip	= OSD (5D)

- n. xv. At the bottom of the screen, click the button “Download firmware (online)”
- for this you will need an internet connection;
- p. If the firmware has loaded correctly, the following message will appear in the lower left corner:

Loaded Online Firmware: betaflight_4.4.2_STM32F7X2_IFLIGHT_BLITZ_F722_7f5062a8.h

- q. Now the “Flash firmware” button is available for pressing, click on it;
- r. If you see this message in the lower left corner, you need to put your flight controller into bootloader mode; Please upload the firmware file
- s. To do this, you will need a special program that forcibly switches the flight controller to bootloader mode;
- t. To get this program, you need to go to the initial
- page in the ”Welcome” tab and click as indicated here in the section
- “Driver Fix” click on the inscription “ImpulseRC Driver Fix”;
- Turn off Betaflight configurator, physically disconnect the drone from the PC, 21.
- run the program you just installed;
- v. The program searches for the controller, after this line is displayed, connect the drone to the PC. If everything went correctly, then after the inscription ”Installing DFU drivers” the program will close and in the Betaflight configurator in the upper right corner there will be an inscription as in the image;

23. Repeat steps 6-15. First, all information from the flight controller will be erased, then a new one will be installed, and at the end this message should appear;

To check the correct operation, connect to 24.

Now you need to restore all settings. To do this 26.

Configurator: 10 9 0 (6970 flight controller (the "Connect" button in the upper right corner, Fig. 2): If the firmware is 4.4.2 (at the time of writing 25. instructions). then everything went correctly: Fig. 2

go to the command line again and load the file that you created in step 4 (via the "Load from file" button, at the end don't forget to write "Save").

Programmer		Figure 1
Show release candidates		
IFLIGHT_BLITZ_F722 4.4.2 [01-Jun-2023]		
	0	
No reboot	0	
Complete chip erase	0	
Manual bitrate	256000 ×	

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DY DRONES | DEVICE |

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

ON-SCREEN MENU INSERT

Expert mode By turning on Expert mode at the top of the window, you'll have access to additional tabs on the left panel and advanced settings. However, for your first flight, you typically won't need to touch any of these settings.

Command line console (CLI) in Betaflight

What is Betaflight CLI? CLI stands for command line interface, it is a configuration mode that gives you direct access to all the firmware parameters. CLI is a very powerful tool, but it can be intimidating for less technical users. In this guide, we will explain how and why to use the Betaflight console

Why do you need a console (CLI)?

The console (or command line) appeared back in the days of Beseflight, and still exists in CleanFlight, Betaflight, iNav. Butterflight, etc.

Due to the large number of parameters in these firmwares, it is very difficult to make a simple GUI for all of them. So it makes sense to display only

the most frequently used ones, and the rest can be changed through the console.

Another advantage of the command line is that it allows you to make a backup easily and simply.

a copy of all settings in a regular text file, more details about this will be written below.

Commands can be entered in the text box (at the very bottom of the screen) and pressing the Enter key executes them,

After you have changed the parameters, you need to type the command ”save” to save the settings. If you exit the console without executing this command, all changes made may be lost.

To exit the console, simply type ”exit” and press ”Enter”, or click on another tab, or disconnect the flight controller and reconnect it.

How to check the settings in the console?

The first commands to remember are ”dump” and ”diff”. The ”dump” command will simply output all the parameters and their values. How

You would think the list would be impressive.

If you want to see only those parameters that have changed (current values are not equal to default values), then enter ”diff”. This list is much easier to read, especially if you want to check previously made changes.

Backup and restore Betaflight settings via CLI

It's a good habit to make a backup of your Betaflight settings every time before making changes, so that if something goes wrong you can roll back everything.

To make a backup, type ”diff all” and copy the result into a text file. To restore, simply paste the file contents into the console and press ”Enter”. Don't forget to save your changes before closing the console.

CLI Command Line Interface Commands Capital letters or small letters, the command will be executed the same way!

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DRONE ZIDES | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | SETTING UP BETAFLIGHT

COMMAND CLI COMMAND LINE INTERFACE

Capital letters or small letters, the command will be executed the same way!

TEAM	DESCRIPTION
bl (unu boot loader)	put your flight controller into DFU mode
QUX	set aix settings
dump	full backup of PC settings as a text file saves settings that are different from the default ones.
!	Also saves only the current PID profile saves settings that are different from the default ones.
diffall will display what additional features you have enabled, for example	Also saves all PID profiles
feature	”Enabled: RX_SERIAL TELEMETRY OSD ANTI_GRAVITY DYNAMIC_FILTER”
help	show all commands
map	will show the channel table, for example, AETRI234
mixer	Shows the type of your quadcopter
motor	will show which channels the motors are linked to (for remapping, for example)
sow	save settings and reboot
status	show system status
version	show version
servo	servo settings
sd_info	sd card information
tasks	show statistics
save to file	Save to file

TEAM	DESCRIPTION
board_name ..	The target name is the flight controller configuration description file.

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Y DRONOV | CHSTROYSTE

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | BATTERIES + CHARGING STATION

BATTERIES + CHARGING STATION

UNDERSTANDING THE BASICS OF LIPO BATTERIES

Lithium Polymer batteries, or LiPo batteries, have an exceptional power-to-weight ratio, making them an ideal choice for FPV drones.

LiPo battery voltage LiPo batteries are made up of individual cells, each rated at 3.7V, as indicated on the battery label.

A LiPo battery is designed to operate safely within a specific voltage range, typically 3.0V to 4.2V. Overcharging a LiPo battery above 4.2V is dangerous and may cause a fire. Discharging below 3V may cause permanent performance degradation or damage to the battery. This minimum voltage is also called the cut-off voltage. It is generally recommended to stop discharging when the battery voltage reaches 3.5V per cell to extend its life.

Number of elements LiPo batteries can contain multiple cells. The 'S' rating on the battery refers to the number of cells it contains. So, a 6S battery has six cells, a 4S battery has four, and so on. Since each cell has a nominal voltage of 3.7V, a 4S battery has a nominal voltage of 4 x *3.7V = 14.8V, while a 6S battery has a nominal voltage of 6* x 3.7V = 22.2V.

Battery voltage directly affects motor speed, so using a battery with more cells can increase the power of your drone (assuming

The drone supports higher voltages). However, adding more cells also makes the battery heavier and more expensive.

In the hobby, batteries are usually named by the number of elements or the "S" designation: 1S = 1 element = 3.7 B

2S = 2 elements = 7.4 B

3S = 3 elements = 11.1 B

4S = 4 elements = 14.8 B

5S = 5 elements = 18.5 B

6S = 6 elements = 22.2 B

For example, a 14.8V battery is called a ”4-cell” or simply ”4S” battery.

Connecting two identical batteries in series doubles the voltage but does not change the capacity (e.g. two 2S 1000mAh batteries connected in series

turn into a 4S 1000mAh battery). Connecting in parallel doubles the capacity while maintaining the same voltage (e.g. 2S 2000mAh battery).

LiPos may also use the ”P” notation for voltage, with the ”P” indicating the number of parallel cells, 2S1P meaning ”2 cells

”in series and 1 cell in parallel”. If a battery has no ”P” it is assumed to be ”1P”, so 2S1P and 2S are the same thing.

3S2P means ”3 cells in series and 2 cells in parallel”. This battery has a total of 6 cells, with 2 parallel cell groups, each containing 3 cells in series.

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I DRONES | DEVICE

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | BATTERIES + CHARGING STATION

UNDERSTANDING THE BASICS OF WORKING WITH CRO BATTERIES

Capacity The capacity of a LiPo battery, measured in mAh (milliampere hours), tells you how much current you can draw from the battery continuously for an hour before it runs out. Note that 1000 mAh is equal to 1 Ah. For example, it would take an hour to completely discharge a 1300 mAh (or 1.3 Ah) battery if you draw a constant 1.3 A from it. If the current doubles to 2.6 A, the duration will be halved (1.3 / 2.6 = 0.5). If you draw 39 A of current non-stop, the pack will only last 2 minutes (1.3 / 39 = 1/30 hour). Increasing the battery capacity can increase flight time, but the trade-off is a heavier, larger battery. Weight significantly affects the flight time of an aircraft, so it is important to choose a battery with the optimal balance between capacity and weight for maximum efficiency. Larger capacity batteries can also provide higher discharge currents.

Denomination C The C rating is a measure of the maximum current you can safely draw from a LiPo battery without causing harm.

Theoretically, this can be calculated using:

Maximum current consumption = capacity x Rated C

It is not recommended to use a current higher than the C rating, as this may cause the battery to overheat, increase internal resistance over time, shorten the battery life, or even cause overheating (fire) in extreme cases.

Batteries with higher C ratings tend to be heavier and larger, even if the capacity is the same. For example, these two 650mAh 4S batteries shown in the image are different weights and sizes due to differences in C ratings.

A battery with a higher C rating will provide better performance, especially for power-hungry drones, but it's not always the best choice. On a low-power cruiser, the extra power from a higher-rated battery may not be needed, while the extra weight can be counterproductive and lead to shorter flight times. It's all about using the right tool for the job.

While the C rating could be a useful tool, it has become more of a marketing tool in recent years, so take it seriously. Brands can inflate the C rating, making comparisons between brands meaningless. However, it can still be useful when choosing a battery from the same brand, as long as they meet the same standard. As long as you choose batteries according to our recommendations, the C rating should not be a major concern.

Over-discharging and over-charging Over-stressing a battery by discharging at a higher current than it is rated for over a long period of time will cause it to overheat. Also, completely discharging will cause the battery to become inoperable. The biggest factor affecting the maximum rate of discharge of a battery is its internal resistance. High levels of IR radiation will cause the voltage to drop more noticeably as the throttle is increased, a phenomenon known as "voltage droop." As the voltage drops, the motors will lose power and the drone will feel less powerful and responsive.

Internal resistance All electrical components, including batteries, have resistance. The resistance inside a battery is called the internal resistance (JR), which is how much the battery resists current flow. The internal resistance can be used to measure the performance of a LiPo battery. A lower JR means the battery can power your FPV drone more efficiently.

Monitoring IR emissions over time is also useful for determining when to use a LiPo battery. LiPo cells' IR emissions slowly increase over time and use, which is an inevitable and irreversible process.

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PRONOV | CONSTRUCTION

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS
ADDITIONAL INFORMATION | BATTERIES + CHARGING STATION

UNDERSTANDING THE BASICS OF WORKING WITH CRO BATTERIES The following incorrect actions can accelerate battery aging:

Charging connector All LiPo batteries come with two sets of wires/connectors:

charging connector (main terminal) and balancing connector (balance terminal). However, 1S batteries only have a discharge connector since balancing is not required for 1 cell.

The charging cable usually consists of two thicker red and black wires used to power the FPV drone.

Another set of smaller wires connects to the white element in the battery.

The most common discharge connector is the XT60, mainly used in 5-inch FPV drones or larger. For smaller drones, it is often

sip connector

HTZO is used, a smaller version of HT60. They have similar shapes, but differ in size and rated current.

Balancing connector LiPo batteries with more than one cell will always have a balance port, which is designed to monitor and balance the cell voltages. The official name for the balance port is JST-XH.

You will need to connect the balance lead to the charger while charging. This allows the charger to check and balance the voltage of each cell while charging. Important, always connect the balance lead before charging! The number of wires in the balance lead starts at 3 for 2S LiPo, and this number increases by 1 for each increase in the number of cells: 2S - 3 wires 3S - 4 wires 4S - 5 wires 5S - 6 wires 6S - 7 wires It is not uncommon for the balance lead to be damaged by the spinning propellers during flight.

BATTERY TYPES

LiPo LiPo stands for lithium polymer, and is the standard battery chemistry used for racing and freestyle FPV drones. The full charge voltage of a LiPo is 4.2V, and the full charge voltage of a battery is 3.85V. LiHV

LiHV is a special type of LiPo battery, HV stands for ”high voltage”. They are more energy-dense than traditional LiPo batteries and can be charged up to 4.35V per cell (as opposed to the standard 4.20V). However, there are mixed reviews regarding the longevity of LiHV batteries, as they can experience a decline in performance sooner than regular LiPos. In our post, we compared

LiHV batteries to LiPos in terms of performance. Despite these concerns, Li-ion batteries have become a popular choice for 1S Tiny Whoops, as the impact of the higher voltage is significant.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | BATTERIES + CHARGING STATION

UNDERSTANDING THE BASICS OF WORKING WITH CRO BATTERIES

Lithium-ion Li-Ion stands for lithium-mono, and typically has a much higher capacity than a LiPo of the same weight. Because of their higher capacity per unit weight, Li-ion batteries are great for long-range flights. However, they have a much lower discharge efficiency, making them unsuitable for aggressive flying.

CHARGER

Charger modes

Charge balancing: While charging the battery, the charger monitors the voltage of each cell and keeps them balanced. This is the safest and most recommended way to charge a LiPo battery. Bulk Charge:

The charger supplies each cell with a storage voltage (which is between 3.80 V and 3.85 V, depending on the charger).

Discharge: The charger is attempting to discharge the LiPo battery (this process can be extremely slow, depending on the charger's discharge rate).

Always connect the balance cable before charging,

Each cell in the battery has a slight difference, and after the flight you may find that the voltage across the cells is different. Charging a battery with unbalanced cell voltage without using a balance cable can cause some cells to drop below 4.2V and others to exceed 4.2V, which is dangerous.

It is recommended to charge LiPo batteries at a current of 1C or lower, as this puts the least load on the battery. This means that the charging current should be 1 time greater than the battery capacity. For example, for a LiPo with a capacity of 1500 mAh, charging at 1C means setting the charging current to 1.5 A (1C x 1500 mA), and for a battery with a capacity of 900 mAh - 0.9 A, and so on.

Choose a safe place to charge It is very important to charge batteries in a place where there are no flammable objects or materials. If you charge batteries indoors, try to do it near a window or tree so that in case of fire you can quickly throw away the battery.

Improper handling of LiPo batteries may result in fire.

Please read these safety guidelines before handling or charging batteries:

Handle LiPo batteries by the body, not by the wires, which can be torn from fragile solder joints. Allow batteries to cool completely after flight before charging them.

Never use or charge damaged or swollen batteries.

Before charging, make sure the battery quantity and type are set correctly on the charger.

Avoid overcharging. Although smart chargers can usually take care of this for you, it is a good idea to check the voltage of your cells regularly.

Store batteries away from direct sunlight.

Before charging, always remove the battery from the device it is powered by and place it in a safe place.

Do not short-circuit the battery terminals under any circumstances.

How to Use LiPo Batteries Safely How long can you leave LiPo batteries fully charged?

You can charge the batteries the day before you fly. However, if you are not flying for the next couple of days, you will need to return the batteries to their storage voltage (e.g. 3.8V per cell).

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION | BATTERIES + CHARGING STATION

CHARGER Don't leave them fully charged or discharged for long periods of time. Batteries that are not in storage voltage will degrade faster over time. Generally, most people find it acceptable to leave batteries fully charged or discharged for a few days. However, if you don't plan to fly for more than a couple of weeks, it's best to put your batteries in STORAGE mode. Most modern chargers can handle this easily, but the discharge may be slow.

Operating temperature LiPo batteries for FPV drones work best at temperatures between 30 and 60 °C. Cold weather has a negative effect on LiPo batteries, causing voltage drops and shorter flight times. Keep batteries warm before flying (for example, by putting them in your pocket).

LiPo batteries also suffer from excessive heat: they can run or even catch fire. Do not leave them in direct sunlight in the summer!

When to Land a Drone The drone should be landed when the battery voltage reaches 3.5-3.6 V.

While you can continue flying at a lower voltage, this puts extra stress on the battery and can shorten its life. Every cell in a battery is different, and during hard throttling the battery will sag, with some cells sagging more than others. This can cause the voltage in the cells to drop below a safe limit and cause damage. Landing at around 3.5 volts reduces the risk of this happening. Another reason to land early is that the voltage drops below 3.5 volts much faster. Continued

flight may cause the battery to over-discharge before you can land safely. Over-discharging can cause permanent damage and shorten the life of the battery.

How to Store LiPo Batteries As mentioned earlier, if you do not plan to use your LiPo battery for a long time (for example, longer than a few weeks), you should:

- Charge it to 3.8-3.85V
- Store it in a fireproof place (LiPo bags, ammo box, etc.)
- Store at room temperature; too cold or hot conditions may affect battery life and safety.

When the voltage of a LiPo cell is around 3.8-3.85V, it is approximately 40-50% charged. This is the most stable state for a LiPo battery, which is why new batteries from stores usually come half charged.

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

The Radiomaster Boxer is a great balance between ergonomics, size, functionality and ease of use. It features full-size knobs, a large number of switches, a built-in 1W ELRS module, a large battery compartment and a removable antenna.

The Boxer comes with the following accessories:

- 1 x Carrying Case
- 1 x Antenna
- 1 x USB-C Cable

- 1 x 1.5mm Allen key
- 2 x Screws M4*4 (spare)
- 4 x Low tension springs (spare)
- 1 x Stickers
- 1 x Manual

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DRONE TYPES | DEVICE | O

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS The kit also includes a plastic injection molded gimbal protector, but I didn't receive it with my review unit so I can't show you. But here's a photo of the gimbal protector you get when you buy the Boxer. It also protects the switches, keeping the radio safe during transport. Note that batteries are not included. An alternative is to get a 2S 6200mAh LiPo battery (from Radiomaster, from GetFPV) which has twice the capacity of two regular 18650s, so in theory you should get twice the runtime.

FIRST OF ALL, you need to copy the MicroSD data, the flash drives included in the kit are not known for their reliability.

Specifications and Features The Radiomaster Boxer radio comes with EdqeTX V2.8.0 pre-installed and the internal ELRS RF Module is V3.0.1. Both programs represent cutting-edge software in the field of radio technology.

Technical specifications:

- Powerful STM32F407VGT6 processor with 1MB of RAM
- Operating frequency: 2.400 Ghz-2.480 Ghz
- Indoor RF versions: CC2500 / 4-in-1 Multiprotocol / ELRS
- Maximum transmit power for CC2500 and 4IN1: 20 dBm (100 mW)
- Max transmit power for ExpressLRS: 30dBm (1W, or for FPV pilots it's 1000mW :- 0)
- Built-in cooling fan for ELRS RF indoor module
- Up to 16 channels (depending on receiver)
- Input voltage range: 6.6V 8.4V DC
- Supported batteries: 2S LiPo or dual 18650 Li-ion cells (batteries not included)
- Supports QC3.0 fast charging with charging current up to 2A at 5V
- Monochrome LCD display 128*64
- Hall sensor imbals with front tension adjustment

- Possibility of installing an external module compartment compatible with JR/FrSKY/Crossfire modules
- Size: 235 *178* 77 mm
- Weight: 532.5 g
- 529 g without battery
- 638g with dual 18650.
- 727g with 2S 6200mAh LiPo

Stick tension adjustment is very convenient for Voxeg, you can do it from the front, no need to disassemble the remote. Before using, you need to calibrate the sticks, it is also worth doing after flashing EdgeTX/OpenTX. Go to Radio Setup page again, then press "PAGE" button several times to go to "HARDWARE" page, select "Calibration" option to calibrate the sticks and sliders. Just follow the instructions, it is quite simple.

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DRONE TYPES | DEVICE | S

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS Make sure you only move the sticks as shown in the following image. For best results, do not move the sticks in a circle. Press the sticks as gently as possible so that the radio can read the end points correctly.

Use a left / right / up / down pattern when calibrating the sticks for the most accurate calibration.

Do not make a circular motion when calibrating sticks.

Switches and Menu Buttons There are four switches on the front panel, one two-position and one three-position on each side. Two rotating dials in the center. The power button is located in the center between the two imbals, below it is a colored LED indicator.

There are two more low-profile switches in the upper corners - a latching (SE) switch in the upper left corner and a momentary (SF) switch in the upper right corner.

At the bottom of the radio, between the imbals and the screen, there are 6 buttons that control the flight modes. You can also assign other functions to these buttons in the "Special Functions" section, such as playing music/sound/telemetry or taking screenshots.

The layout of the menu buttons and scroll wheel is pretty standard, like other Radiomaster radios, very easy and intuitive to use. The scroll wheel is made of metal and feels solid and well made.

The screen is a monochrome LCD, slightly smaller than the Radiomaster Zorro but with the same 128x64 resolution. It has a bright backlight and is easily visible in direct sunlight. The detachable T-shaped antenna can be angled for optimal reception. This is the same antenna that comes with the Radiomaster Ranger Micro/Nano modules. It is a relatively low gain (3.43 dBi) antenna that provides a uniform signal around the pilot's perimeter.

The Boxer has an RP-SMA connector, you can remove the antenna for transport or replace it with a higher gain antenna.

If you need a higher gain antenna for longer range, here is a good option:

(5.98dBi) Theoretically this will give you up to 38% increase in maximum range at the cost of reduced above/below range.

On the top of the radio you'll also find a Trainer port, a USB data port for connecting SD cards and playing simulators, and a headphone jack.

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In GUSTROIS

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

Explanations for the warning about a possible launch To turn on the remote, hold the power button for 3 seconds.

A brand new remote shouldn't give you any warnings when you first turn it on, but in case it does, here's a list of possible warnings and what they mean.

Throttle Position Warning - When the radio is turned on, the throttle is not at the lowest position. Simply move the throttle (left) all the way down and you will get rid of this warning.

Switch warning (also known as control warning) - some switches are not in their default positions. To clear this warning, simply move all switches to the UP position (push away from you).

SD Card Warning - The SD card content version does not match the firmware version.

Model profile The Boxer comes with several model profiles pre-built for you out of the box. You can use one of them depending on what type of model you want to fly. To see what model profiles are available, you can navigate there

by holding the MDL button. For FPV drones, you can simply use the ”Boxer” profile, which already has the internal RF module (ExpressLRS) enabled and all the controls and switches assigned to the appropriate channels in the MIXES.

Creating a profile for FPV simulators If you plan to play FPV simulators with this controller, it is recommended to create a special model profile with the internal and external RF module disabled.

To do this, simply collide the Vohegi profile and create a duplicate of the profile. Then set the model settings to ”Off” for both internal and external RF.

Energy consumption Power consumption of Boxer at 7.4V, it consumes about 0.48A with an output power of 1W (ELRS version, without screen backlight):

2S 6200mAh LiPo batteries can give you more than 12 hours! If you use the output power of 25mW (0.3A at 7.4V), you can get up to 20 hours of battery life.

You can charge both the Li-ion and Li-ion batteries inside the radio via the USB-C port on the bottom of the radio. Battery charging supports the QC3.0 standard. In my tests, the radio was able to output up to 9.6 Bm (about 1.9 A at 5 V) using a QC-enabled power adapter. A 2S 6200mAh LiPo will take at least 6 hours. If you’re in a hurry, it’s probably quicker to remove the batteries from the radio and charge them on a proper LiPo charger (for example, a 1C charge will only take an hour).

The Radiomaster's design is clever - there are a couple of slots in the battery compartment cover through which you can pass the XT30's power cable to connect it to the external module (if you use one).

Boxer supports the older JR module, which is compatible with modules such as Crossfire, other ExpressLRS modules, Ghost, Tracer, etc.

The Radiomaster Boxer has an SD card slot inside the battery compartment, a 256MB micro SD card is included with the Boxer.

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DRONE TYPES | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

Output Power Testing Output power (in mW) and current consumption at 7.4 V (internal RF module only) at different power levels

Power Levels	25mW	50mW	100mW	250mW	500mW	1000mW
Boxer Internal Module	24 (0.22A)	53 (0.24A)	97 (0.26A)	212 (0.28A)	435 (0.32A)	932 (0.4A)

Operating principles Communication channels. The number of channels is the number of aircraft functions that can be controlled at all. Each function: gas, direction of movement, pitch and roll angle requires a separate interaction channel. For comfortable control of the copter, a minimum of 4 channels are required

Receiver - a device designed for radio reception, i.e. for isolating signals from radio emission. The receiver is installed on the copter, receives a signal from the remote control and transmits it to the flight controller. Antennas are required for its operation.

Bind

Let's look at two options for transmitter (TX)/receiver (RX) binding in the ExpressLRS system: ExpressLRS BINDING PROCESS ExpressLRS and TBS Crossfire

Pairing by binding phrase (BINDING PHRASE). The transmitter and receiver communicate with one phrase (password) - preferable in terms of security (the copter will not be stolen). Manual - bind without a bind phrase.

ExpressLRS BINDING PROCESS ExpressLRS and TBS Crossfire

First, we determine the RX/TX firmware version

Check the firmware versions of the receiver on the copter and the transmitter on the equipment. The firmware is version 3.2.4

- 3 major, completely rewritten with significant changes that do not support previous versions.
- 2 not changed, but added features, minor changes.

4 - bug fixes.

Within one upper firmware (major version) 3 - can be bound, if different values - no. For example, version 3.2.4 can be bound with version 3.1.5, but it will not be possible to bind with version 2.3.4. or 5.3.1

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RONOV | CHSTROYS

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

First, we determine the RX/TX firmware version How to check the transmitter version (TX) on the equipment:

Press SYS (system settings button) - TOOLS menu - select ExpressLRS, scroll to the end - there will be a firmware version

If ExpressLRS shows the status “Loading”, it means that the transmitter on the device is not turned on (external or internal (turn on Internal CRSF).

How to check the receiver version (RX) on the copter:

Connect the battery!!! It is advisable, especially on digital video transmitters, to blow (cold hair dryer, fan) on the video transmitter or turn it off, because it can burn out from overheating (it has only passive cooling)

- Wait 60 seconds, the receiver will switch to WI-Fi mode (fast blinking)
- Connect to ExpressLRS RX access point (password expresslrs always and everywhere)
- Go to https://10.0.0.1/ and you will get to the ExpressLRS update page - the top line will display the name of the device (Receiver module), the line below - the firmware version (Firmware Rev.)

BINDING - option 1 (with binding phrase) We set the binding phrase on the receiver (RX):

- Connect to ExpressLRS RX Access Point
- In the ”options” tab, find the BINDING PHRASE section and enter the binding phrase there.
- Save

We set the binding phrase on the transmitter (TX):

Enable Wi-Fi point on the equipment (suitable for both internal and external transmitter) Go to the system settings menu - Press SYS (system settings button) - TOOLS menu - select ExpressLRS (run LUA ELRS script) - WI-Fi Connectivity Enable Wi-Fi- (Wi-Fi Ranning...) - connected

- We search for a point from a smartphone or computer, the network will now be called ExpressLRS TX

- . Connect to it in the same way, in the options tab set the same binding phrase as in the receiver
- . Save

BINDING - option 2 (manual, without binding phrases)

!!! Binding - the phrase should not be installed before this!!!

- The equipment is turned off.
  Switch the receiver (RX) to manual binding mode (should blink in cycles of two blinks) hold down the bind button (small button) for 5 seconds - the first state is Wi-Fi mode, hold it down again for 5 seconds
- manual binding mode
- Or supply power (connect and disconnect the battery) to the receiver (RX) 3 times
- ** On small copters, bind only through the Betaflight configurator in the Receiver tab.
  Enable the equipment: go to the system settings menu - SYS (system settings button), TOOLS menu - select ExpressLRS (run the LUA ExpressLRS script), then in the menu you need to select the [BIND] menu. (the binding ... window will appear) - binding has started

The result is the same for both options:

- On the equipment, a “C” (connect) icon and signal level divisions will appear in the corner of the screen.
- The signal level (LQI/RSSI) will also appear in the glasses in the OSD
- Receiver (RX) is constantly on

Firmware Remote Internal, External ExpressLRS

FIRST OF ALL, FAMILIARIZE YOURSELF WITH THE ASSEMBLY PARAMETERS

Build parameters A brief description of what we need to set in the firmware build parameters in the ExpressLRS configurator.

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In NSTROYS

CONCEPT OF UPUA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS Some of these options are common to both the receiver and the transmitter.

Necessary and sufficient transmitter settings: Regulatory Domain (Region)¶ Regulatory_Domain_AU 915 Regulatory_Domain_EU_868 Regulatory_Domain_IN_866 Regulatory_Domain_FCC_915 Regulatory_Domain_ISM_2400 Regulatory_Domain EU_CE_2400

For 2.4 GHz we always select ISM 2400. For 868/900 we select FCC 915 for 915 MHz and IN 868 for 868 MHz.

Binding Phrase We enter our unique password for the bind, it is entered both on the receiver and on the transmitter. The receiver will find the transmitter using this phrase. No additional procedures are required for the bind, everything is automatic. Please do not enter 123456, etc., judging by the ELRS chat there are a lot of such people, and someday such lazy people will cross paths on flights and will bind to each other.

Home WiFi settings: HOME WIFI SSID HOME WIFI PASSWORD

Here you can set up your home WiFi network, do this only if you understand why you need it. I recommend not connecting the receiver/transmitter to your home network until you understand how it works, to avoid further misunderstandings.

ATTENTION After you connect your TX/RX module to your home WiFi network, it will always connect to your router. It will not create a regular WiFi point while it sees your home WiFi. If you cannot find the device in the local network, turn off the router and connect using the first method, then remove the home WiFi network.

Additional options: UNLOCK HIGHER POWER

Some transmitters have an optional high power checkbox, make sure your transmitter has enough cooling, sometimes you will need to modify the transmitter and install a cooler/radiator.

UART INVERTED

Almost all devices require the UART INVERTED checkbox to be set. The only exception is devices on DeviationTX.

Options for the receiver Necessary and sufficient receiver settings

NOTE The receiver and transmitter options in the region part and the bind phrases must match for them to successfully communicate with each other.

Inverting the TX pin on the receiver: RCVR INVERT TX

O Standard mode 0	Manual mode		
Regulatory domains > REGULATORY DOMAIN ISM 2400		0	Performance options E LOCK_ON_FIRST_CONNECTION	2
D REGULATORY_DOMAIN_EU_CE_2400		0	Network
Binding phrase setup > BINDING PHRASE		0	D AUTO_WIFI_ON_INTERVAL Value 40	0
Custom binding phrase		0	HOME WIFI_SSID	0
Compatibility options			1 HOME WIFI_PASSWORD	0
D RCVR UART BAUD		0		
RCVR INVERT_TX		0		

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DRONE TYPES | DEVICE | S

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS If you are in a situation where your flight controller has a free UART with only Sbus/iRx/RXI (inverted RX) pin, then this option is for you. It will set the inversion on the TX pin of the receiver, and you will be able to solder it to the Sbus/iRX pin, in this case the protocol will not become SBUS, on the flight controller side you need to set the CRSF protocol: USE R9MM R9MINI SBUS

Similar setup for R9MM/R9Mini receivers, from the SBUS pin of the receiver you can receive an inverted signal and feed it to the SBUS of the flight controller (the protocol still remains CRSF)

Do I need these checkboxes? LOCK_ON_FIRST_CONNECTION The receiver will remember the packet rate with which it connected to the device after switching on. With FailSafe, the receiver will not try to sort through other hertz in search of a transmitter, but will always remain at the packet rate with which it was initially connected. You can turn it on to quickly exit failsafe, you can turn it off so that in case of loss of connection you can lower the packet rate in the device to 50 Hz and try to catch the receiver at increased sensitivity.

Now you know what boxes you need to check here and you can proceed to the firmware.

FIRMWARE

Internal transmitters Before flashing, make sure you have the latest version of EdgeTX.

Also make sure that you have the ExpressLRS version of the hardware, not the Multi module. Check that on the 6th page of the settings in the hardware (Hardware), in the Serial Port item, the USB-VCP parameter is equal to CLI

In the Model settings on the hardware, select Internal RF = CRSF

Turn on the equipment and connect the USB cable to the desired port (for Radiomaster equipment, this is the upper one). Select the USB Serial (Debug) or USB Serial (VCP) option in the window that appears on the equipment.

IMPORTANT Please read this step carefully, as frequent problems with flashing using this method are related to it.

If your PC is on Windows, make sure that in the Device Manager the hardware is identified as STMicroelectronics Virtual COM Port.

If not, and you see a yellow exclamation mark on the logo next to the device name, then you need to install drivers (clickable). Unzip the archive and run VCP V1.5.0 Setup W7 x64 64bits.

In the ExpressLRS configurator, select the version you need and the correct device type, as well as the EdgeTXPassthrough firmware method.

Flashing Method EdgeTxPassthrough 2

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DRONES | DEVICE | S

CONCEPT OF UPUA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

Firmware via EdgeTX B ExpressLRS Configurator, after selecting the correct target and Build Parameters, click Build and Flash and flash the transmitter. Wait for the end, if the flashing is successful, the message "Success" will appear.

Disconnect the USB cable and run LUA Script, check the functionality and firmware version.

Method via browser Once you have selected the correct target and Build Options, press the Build button to build your firmware via ExpressLRS Configurator.

After the lines in the configurator window are successfully run, the explorer will open, where there will be a file Name _TX-<version>.bin. Do not close this window, but save this file to a convenient place for subsequent loading, for example, drop it into Telegram saves.

The next step will require the ELRS Lua script (right-click, save as *.lua). Download and put it on the device's flash drive, in the /Scripts/Tools folder. To open the script on the hardware, hold down the SYS button and select ExpressLRS.

If the script does not open and hangs on Loading ... , check that Internal CRSF is set in the model

B System, select Wifi Connectivity in the script, and then click Enable Wifi. Click OK again to enable WiFI on the transmitter. Connect to the ExpressLRS TX network with the password expresslrs.

Open your browser and go to http://10.0.0.1/ , a nice site will open where you will need the Choose File button, select the file Name TX-<version>.bin obtained earlier from the configurator and click Update.

After the file is loaded, a green confirmation window will appear, indicating that everything is fine, or an error. If it complains about the target, make sure it is correct and click

Flash Anyway. Check that the version at the bottom of the script or on the WiFi page has changed to the one you flashed.

			Here you can update module firmware, be careful to upload the correct file othernise a bed flash may occur. If this happens you will need to reflash via USB/Serial
Useful Links and Sup			
			Chaose File No file chosen Update
GitHub Repository Discord Chat	Update Succeeded		
	Update complicte, please wall 12 secords before powering of the Natuk		
Firmware Update:			
	OK		
Fleits you can update module firtravers, be VOG WILL INNERS In Pethards with USE/Serial.		a had fiest may pocar. If this heppen	

Suitable for all external ELRS transmitters on 2.4Ghz/900Mhz, which are installed in the external slot of the equipment

Firmware via WiFi:

Device Category:

Selecting the brand of your transmitter

Device: Select your transmitter model, for example HM ES24TX Pro Series

2400 TX - for HappyModel PRO

Flashing Method

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DRONE ZIDES | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

Firmware via WiFi

NOTE The flashing methods described below only work if your modules are already on 2.x firmware. For modules on ancient 1.x firmware, you will have to update it via USB.

Method via browser After selecting the correct target and Build Parameters, build your firmware via the ExpressLRS Configurator using the Build button

After the lines in the configurator window have successfully run, the explorer will open, where there will be a file Name TX-<version>.bin. Do not close this window, but save this file to a convenient place for subsequent loading, for example, drop it into Telegram saves.

The next step will require the ELRS Lua script (right-click, save as *.lua). Download and put it on the app's flash drive, in the /Scripts/Tools folder. To open the script on the hardware, hold down the SYS button and select ExpressLRS.

If the script does not open and hangs on Loading..., check that External CRSF is set in the model.

Select Wifi Connectivity in the script, then click Enable Wifi. Click OK again to enable WiFi on the transmitter. Connect to the ExpressLRS TX network with the password expressIrs.

Open your browser and go to http://10.0.0.1/ , a beautiful site will open where you will need the Choose File button, select the file Name TX-”version”.bin received earlier from the configurator and click Update.

After the file is loaded, a green window will appear confirming that everything is fine, or an error. If it complains about the target, make sure it is correct and click Flash Anyway

Check that the version at the bottom of the script or on the WiFi page has changed to the one you flashed.

Below you can see the information on the sample images:

ITAL TELEMETRY RADIO SYSTEM	MENI		
Setup PAGE EXIT SYS TOOLS	ENT MDL 01 Betaflight setup	TARANIS 9 Nov	01:49
02 Crossfire configure	03 ELRS	04 ExpressLRS	
05 Spectrum (INT) HiFi]	06 Spectrum (EXT)		

DIY2400 E28		07500
Packet Rate Telem Ratio Switch Mode Model Match > TX Power > VTX Administrator > WiFi Connectivity [BLE Joystick] [Bind] master Firmware Update: Here you can update module firmware, be careful to upload the correct file otherwise a bad flash may occur. If this happens you will need to reflash via USB/Serial Choose File	1:64 Wide Off 942c40 No file chosen	Ulodate

Connected					
St.	ExpressLRS TX	Secured	Enter the network security key		
expressirs The	Next	Cancel			
116 10	0				
Network & Internet settings	Change	settings, such as making a connection metered			
(c) 12	m	Mobile	hotspot	Wi-Fi	Airplane
(D)	09:57	C			
Useful Links and Sup	GitHub Repository				
Update Succeeded	Discord Chat	Undate complete, please wait 10			
seconds before powering of the 00	module	Firmware Update:			

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HOME KE

DRONE ZIDES | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

Firmware via USB/UART

- Device Category:

- Selecting the brand of your transmitter

Device: Select the model of your transmitter, for example NM ES24TX Pro Series 2400 TX - for HappyModel PRO

Flashing Method

Flashing via UART If you have a module from HappyModel/BetaFPV, before flashing via USB, you need to make sure that the jumpers or dipswitches are in the correct mode for flashing the transmitter Tx Module Flashing:

transmitter. Wait for the end, if the firmware is successful, the message ”Success” will appear

the inscription ”Success”			Software (11) Software · 11	
				v11.0.0 inf files(advanced) 11/18/2021
BUILD	BUILD & FLASH		CP210x VCP Mac OSX Driver Update Succeeded	v6.0.2 10/27/2021 v6.7
			CP210x VCP Windows	9/4/2020
			CP210x Windows Drivers installer wizard(easy)	v6.7.6 9/4/2020
			CP210x Windows Drivers with Serial Enumerato	v6.7.6 9/4/2020
IPOEKT	«HDXH	- I>	t.me/projectArchangel	project-archangel.rf

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DRONES | DEVICE | ASSEMBLY

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

Firmware for TX Receiver Setting up the flight controller

After soldering the receiver, configure the ports and protocol in the flight manual. If you soldered on TX(x) RX(x), then select the UART(x) port in the ports tab and check the Serial RX box opposite it, DO NOT ENABLE ANY OTHER CHECKS OR OPTIONS ON THIS PORT.

In the receiver tab, set the CRSF protocol

If you are upgrading to 3.x.x firmware version from 2.x.x, first update your receiver to version 2.5.2, otherwise the firmware will not install via WiFi. The error will show the message ”Not Enough Space”.

Firmware via Wifi

Device Category: Selecting the company of your receiver

Device:

Select the model of your receiver, for example HappyModel EP 2400 RX for HappyModel EP1/2

If you are upgrading to 3.x.x firmware version from 2.x.x, first update your receiver to version 2.5.2, otherwise the firmware will not install via WiFi. The error will show the message ”Not Enough Space”.

Firmware via Wifi Device Category:

Selecting the company of your receiver

Device:

Select the model of your receiver, for example HappyModel EP 2400 RX for HappyModel EP1/2

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DRONE TYPES | DEVICE | ASSEMBLY

CONCEPT OF UPUA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

Firmware via WiFi

Method via browser (The easiest and least labor-intensive method, recommended to everyone) Before starting, make sure that you have correctly soldered the receiver and configured the flight controller.

Once you have selected the correct target and Build Options, press the Build button to build your firmware via ExpressLRS Configurator.

After the lines in the configurator window have been successfully run, the explorer will open,

where the file Name RX-<version>.bin will be. Do not close this window, but save this file to a convenient place

place for subsequent download. for example, drop it into Telegram saves.

Apply power to the flight controller. This can be done either via USB or by plugging the battery into the drone. The diode on the receiver will start blinking slowly. After 20-30 seconds, the diode on the receiver will start blinking quickly, which means it has started distributing WiFi.

Connect to the ExpressLRS RX network with the password expressIrs.

Open your browser and go to http://10.0.0.1/ , a nice site will open where you will need the Choose File button, select the file Name RX-"version".bin received earlier from the configurator and click Update. After the file is loaded, a green confirmation window will appear that everything is fine, or an error. If it complains about the target, make sure it is correct and click Flash Anyway. If the firmware is successful, you will see a green confirmation window. Wait until the receiver reboots and starts blinking slowly again. After that, re-apply power to the flight controller, the receiver is flashed.

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DRONES | DEVICE

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

Firmware via USB via flight controller Device Category:

Selecting the company of your receiver

Device:

Select the model of your receiver, for example HappyModel EP 2400 RX for HappyModel EP1/2

Firmware via flight controller Make sure the receiver is soldered correctly and the BetaFlight/iNav settings are correct EP1 RX connection diagram EP2 RX connection diagram

Disconnect from Betaflight Configurator and close it.

Connect the flight controller via USB, if the receiver does not light up, also connect the battery. Select the correct COM port, the same one that is used in Betaflight to connect to the flight controller. Click Build & Flash and wait for the firmware to complete successfully.

Error during firmware If an error occurs during the firmware, reconnect the USB to the flight controller and press the firmware button again. If the receiver manages to raise WiFi before the firmware starts with the configurator, it will not be flashed.

(BINDING) TBS CROSSFIRE

TBS Crossfire BINDING - option 1 (EdgeTX (OperTX) equipment with an external TBS crossfire transmitter and binding with a TBS Crossfire receiver

On equipment with a TBS Crossfire transmitter (TX):

Connect the TBS crossfire transmitter to the equipment and turn it on.

On the equipment in the working model or in a new, previously created one - in the settings select an external receiver - external TX

Press the system settings button (SYS), TOOLS menu - select the TBS agent light script - select

TBS transmitter (should be displayed) - select bind .

On the TBS Crossfire receiver (RX):

Press and hold the bind button (between the LED and the antenna output).

Determine the status from the receiver indication (see below)

BINDING - option 2 (TBS Crossfire equipment and receiver) On equipment with a TBS Crossfire transmitter (TX) and a TBS Crossfire receiver (RX):

In the equipment - go to the menu, select TBS agent light, select the built-in module (should be

will be displayed) The LED on the equipment will start to pulse

On the receiver - press the bind button (between the LED and the antenna output) The LED on the receiver will start to slowly blink green at regular intervals

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DRONES | CONSTRUCTION

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

(BINDING) TBS CROSSFIRE

On the TBS Crossfire receiver (RX):

- In the hardware, press bind
- The equipment will display ”bind ok” The LED on the equipment will start pulsating
- The receiver will light up green continuously.

The result is the same for both options: On the equipment, the “C” (connect) icon and signal level divisions will appear in the corner of the screen, the LED will be constantly green.

- The signal level (LQI/RSSI) will also appear in the glasses in the OSD.
- Receiver (RX) is constantly green

| VIDEO TRANSMITTER + VIDEO RECEIVER (GLASSES) + ANTENNAS

ANTENNAS

FPV Antennas: How to Choose and Use Them in FPV Drones FPV antennas are a critical factor in determining the range and signal strength of your FPV setup. There are so many different types of antennas on the market that choosing the right one for your specific setup can be a daunting task. In this article, we’ll cover the basics of antenna design, the different types of antennas available, and give you tips on how to choose the right model. Whether you’re a

beginner or an experienced FPV pilot, this guide will provide you with valuable information about FPV antennas.

What is FPV Antenna The FPV antenna is responsible for transmitting a real-time video feed from the drone's camera to the FPV goggles or monitor, allowing the pilot to see what the drone sees while flying. The quality, performance, and configuration of your FPV antenna will significantly impact the range, clarity, and reliability of your video transmission.

What is a drone FPV antenna made of? An antenna is a piece or several pieces of wire that convert an electrical signal into electromagnetic waves and vice versa. Regardless of its design and external form, each antenna consists of the same components.

- Element. A conductive material that transmits and receives electromagnetic waves.
  Ground plane. Associated with the electrical ground of the device and also made of a conductive metal. A properly adjusted ground plane amplifies the radio signal emitted or received by the antenna element.

Coaxial cable. A special type of shielded wire that carries the signal between the connector and the antenna element without radiating radio signals. It is used to extend the length of the antenna and is usually made of a rigid material. Coaxial cable is not needed if the connector is directly connected to the element.

Connector - This is where the antenna is physically connected to the video transmitter/receiver.

FPV antenna components are made of fragile copper wires and are usually housed in a protective plastic casing. These casings do not weaken the signal and provide protection for the antenna in the event of falls or collisions.

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Antenna Directivity When choosing an antenna, the most important factor is its directionality. There are two options: directional and non-directional (omnidirectional) antennas.

Omnidirectional antennas radiate radio waves equally in all directions, while directional antennas focus radio waves in

one direction. A classic analogy would be to compare a light bulb to a flashlight. The light bulb would be like an omnidirectional antenna, while

flashlight - to directional. If both light sources are operating at the same power, a flashlight can achieve more because it focuses the light in one direction, but at the expense of a narrower beam width.

Omnidirectional antennas are great for everyday flying and provide good signal coverage around the pilot.

Directional antennas are often used in diversity receivers, where they can be combined with omnidirectional or multidirectional antennas to cover all required angles.

Note. A diversity receiver can receive two signals from two antennas and display the stronger signal.

Antenna polarization The term ”polarization” is used to classify FPV antennas. There are two types of polarization:

- linearly polarized antennas (LP Linear Polarization) 1.
- Circular Polarization (CP) antennas 2.

Antennas with circular polarization are in turn subdivided into:

- Left-Handed Circular Polarized (LHCP) Antennas
- Right-handed circularly polarized (RHCP) antennas

Linear polarization Linear polarization is used in many common antennas, such as

standard dipole antennas that come with your video transmitter (VTX) and video receiver (VRX), or even in your home Wi-Fi router

With linear polarization, the signal oscillates in one plane as it propagates, either horizontally or

vertically.

Circular polarization Helical, cloverleaf, and tilt-plane antennas are examples of common circularly polarized antennas.

Circular polarization involves transmitting signals in both the horizontal and vertical planes with a 90 degree phase shift, which looks like a spinning corkscrew.

However, there is one important point about circular polarization:

the direction of the radio waves "twists". There are only two directions here: right-hand circular polarization (RHCP) and left-hand circular polarization (LHCP). If you transmit a radio wave with one antenna, you need to receive that wave with an antenna with the same rotation. Therefore, you should only use RHCP antennas on your receiver if your transmitter also has an RHCP antenna. The same is true for LHCP

Failure to comply with this requirement will result in significant signal loss.

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What antenna polarization is best for FPV drone? It is generally believed that circularly polarized antennas are better suited for FPV doons for the following reasons: Linearly polarized antennas are much more susceptible to multipath interference compared to 1. circularly polarized antennas.

The range of a linearly polarized antenna is greatly affected by the orientation of the antenna, but 2 it is almost impossible to constantly maintain good antenna orientation on a quadcopter, since it rotates around all axes all the time.

Linear polarized antennas have become widespread due to their simplicity of design. They are typically smaller, lighter, cheaper, and easier to manufacture. In general, linear polarization is a good choice for long ranges because all the energy is concentrated in one plane. However, the range advantage is rarely fully realized due to multipath interference.

To achieve the best reception, both the transmitting and receiving sides should use linearly polarized antennas, which should be aligned with each other to ensure maximum overlap. FPV drones are constantly rotating around all three axes, making it nearly impossible to maintain perfect alignment. For example, when the transmitter and receiver antennas are at 90 degrees to each other, they will have the least signal overlap, resulting in a signal strength loss of more than 20 dB (a range reduction of more than 90%), which is called cross-polarization. Linearly polarized antennas are more suitable for RC airplanes, cars, boats, etc. On the other hand, circularly polarized signals always overlap regardless of the orientation or angle of your FPV drone relative to the receiving antenna (there is no signal loss regardless of the antenna orientation). For this reason, circularly polarized antennas are the standard for FPV drones.

Another advantage of circularly polarized antennas is their ability to suppress multipath interference. Multipath interference is a form of noise in an analog video stream that often appears as random color changes, static or scrambled images, and signal dropouts. It occurs when the signal bounces off objects (such as walls and the ground), becomes distorted due to phase delay, and interferes with the main signal.

For normal FPV drone flying, circular polarized antennas are recommended. However, some pilots may prefer to use specially designed

manufactured antennas with linear polarization because they can be made smaller, lighter, and more durable, despite inferior RF performance.

When to use circular polarized antennas:

When you fly close to large objects such as trees and buildings, or in enclosed areas such as parking lots and stadiums where there is a significant amount of multipath interference.

During aerobatic flights, when the orientation and angle of the drone are constantly changing. During low altitude (close range) flights.

When to use linear polarized antennas:

During steady flight in a straight line without significant deviations in roll and pitch. When the size, weight and durability of the antenna are extremely important factors.

Is it possible to use linear and circular polarized antennas together? (LP+CP) In your FPV setup, you can mix and match linear and circular polarized antennas, but the price is some signal loss. Some racers sometimes mount a dipolar antenna on the drone for durability and weight savings, and use a circular polarized antenna on the VCR. You'll get about a 3dB (30%) signal loss, but that's not too bad for short-range flying like racing. RHCP/LHCP doesn't matter here. But it's preferable to the worst-case scenario of using only linearly polarized antennas at both ends, where the maximum signal loss is 97% (30dB). It's a tradeoff between performance and durability.

For casual FPV pilots, we recommend using only circularly polarized antennas.

Differences between left-handed and right-handed circularly polarized antennas

Circularly polarized antennas are either left-handed (LHCP) or right-handed (RHCP). The transmitter and receiver must have matching antennas, otherwise significant signal loss may occur.

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ANTENNAS Therefore, you must use the same type of antenna on both the receiver and the transmitter. If you mix LHCP and RHCP, you will suffer from significant signal loss.

Pilots flying in a group are best served with both LHCP and RHCP antennas for greater flexibility. If you're just flying solo most of the time, it doesn't really matter: both LHCP and RHCP have similar performance. RHCP antennas are more common among analog FPV systems, while LHCPs are more common among digital systems like DJI and Avatar.

Antenna performance When considering the features of an FPV antenna, there are several performance metrics to consider, including:

- Gain factor.
- Radiation pattern.
- Axial ratio.
- KCBH (VSWR).
- Frequency and range.
- Impedance.

When choosing an antenna, we recommend focusing on the first four factors. But if you're buying a reputable brand, you shouldn't worry too much about these details. After all, we're not building rockets for NASA, so don't overload your brain.

If you want to learn more about these parameters, you can find a lot of useful and detailed information on the web, for example, on the Wikipedia page "Antenna". And in the following sections, we will give a brief explanation of what each term means.

Gain factor The gain is an indicator of the range and coverage angle of a directional antenna. It shows how much more power an antenna can radiate in a particular direction compared to an isotropic radiator (a theoretical reference antenna that radiates equally in all directions).

Gain is expressed in decibels or dB.

Higher gain usually means longer range, but with a narrower beam width.

The antenna gain can change the radiation pattern, which can be seen in the antenna datasheet. For the video transmitter, it is better to use lower gain omnidirectional antennas to provide better coverage in all directions around the drone. For the video receiver, a combination of a low gain omnidirectional

antenna and a medium/high gain directional antenna should be used to get the benefits of both systems. If you are not flying long distances, you can simply use low gain omnidirectional antennas on the video receiver.

When dealing with decibels, it's helpful to remember that every 3 dB of gain you get from your antenna is equivalent to doubling the power of your transmitter. For example, if you can get a 6 dB gain by replacing a new antenna on a 200 mW video transmitter, that's the equivalent of upgrading to an 800 mW video transmitter, and that can give you double the range!

Radiation pattern The radiation pattern of the signal emitted by your antenna is represented by two diagrams. One shows the signal when looking at the antenna from above, and the other when looking from the side. These graphs will tell you where the weak points are.

Here is an example of an antenna with 0 dB gain. As you can see, it is truly omnidirectional and has a nearly perfect spherical radiation pattern.

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This demonstrates an important point when flying a drone at high altitude - do not fly directly above yourself! The top of the radiation pattern indicates the area where the gain is lowest and signal loss is most likely.

Here are the radiation patterns for an 8 dBi gain patch antenna. Note the narrow beam width in both the vertical and horizontal planes.

A low dB gain may seem less attractive in terms of range, but it can provide more reliable performance due to a more spherical radiation pattern. You can get

a fairly strong signal, even with the antenna pointed directly at the receiver.

Axial ratio In fact, there is no such thing as a perfect circularly polarized antenna. For example, an RHCP antenna might output 90% of the RHCP signal and 10% of the LHCP signal. So there might still be interference even if you

do everything perfectly. And the axial ratio is used to measure this property of the antenna.

In terms of FPV, this is a measure of how susceptible the antenna is to multipath interference. Antennas with better multipath rejection capabilities make it easier to fly in areas with a lot of concrete and metal. An ideal circularly polarized antenna will have an axis ratio of 1, with antennas with an axis ratio close to 1 having better multipath rejection capabilities.

Frequency and bandwidth Antennas are tuned to a specific frequency. For example, the length of a dipole antenna determines the frequency it is tuned to. The antenna can provide better performance when transmitting and receiving a signal at that frequency.

If you transmit or receive a signal at a slightly lower or higher frequency, the antenna provides acceptable performance, and this "acceptable range" is called the passband. Outside the passband, the signal strength is greatly weakened or even suppressed.

You need to know what frequency your antenna is tuned to and what the bandwidth is. This is necessary to select the most effective channel/frequency to use. Otherwise, you will have a higher chance of getting interference and losing the picture.

This can even lead to overheating and damage to the video transmitter, since feeding power to a mismatched antenna can reflect the energy back, where it can accumulate as heat. In any case, most FPV antennas rated for 5.8 Gigahertz should be suitable for all channels in the A, B, E, F, and R bands, unless otherwise stated in the product specifications.

KCBH (VSWR)

VSWR stands for Voltage Standing Wave Ratio. It measures the efficiency of an antenna by showing how much energy is radiated after

how you feed the power to the antenna. When designing an antenna, you want the value to be as close to 1 as possible. A VSWR of 1 means we can transmit 100% of the power into the antenna and output 100% to the air. A value between 1 and 2 is considered acceptable. If the VSWR exceeds 2, the performance will be poor.

Please note that the coefficient changes depending on the frequency. When setting up the antenna, you should aim for the frequency with the lowest VSWR. Special devices can be used to measure VSWR. An affordable amateur model is produced, for example, by OwIRC

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Antenna types Now that we've covered almost all the basics of an FPV antenna, let's talk about the different types of antennas commonly used in FPV.

	TEAM	DESCRIPTION
Linear polarization	Unipolar, dipole ”Cloverleaf”, ”Inclined-plane	Patch antennas
Circular polarization	”Wheel”, ”Pagoda”	Helical, cross, patch antennas

Single-pole (non-symmetrical) antenna Type: Omnidirectional, Linear.

Application area: Radio control systems and radio receivers.

A monopole antenna is the simplest form of antenna. It consists of

unshielded single-core wire that serves as an antenna element. This type

It is widely used in radio receivers due to its low cost and ease of repair.

However, these antennas are not as effective as dipole antennas. The length of the bare wire has

is of crucial importance because it determines the resonant frequency at which the wire can receive signals,

Dipole antenna Type: Omnidirectional, Linear.

Application area: Radio control systems, radio receivers and video transmitters.

Often radio and video equipment comes with dipole antennas. They are lightweight and durable enough to survive more than one accident.

The dipole antenna has a simple design. It consists of two elements of equal length that are positioned perpendicular to each other, usually in a straight line. One element is the radiating element, while the other serves as a ground plane. The dipole antenna has a higher gain than

single-pole antenna, due to the decrease in efficiency in the vertical position.

Cloverleaf Antenna

Type: Omnidirectional, Circular Application area: Video transmitters and video receivers.

The ”tilt wheel” and ”clover leaf” are the most popular

antennas for mini FPV quadcopters. The Cloverleaf has three petals, and the Tilt-Plane Wheel has four.

These antennas, like dipole ones, are omnidirectional. Circular polarization

delivers fantastic performance regardless of the antennas' relative positions. They're also less susceptible to multipath interference, so you can fly around walls and trees without losing video quality.

However, they are relatively fragile, so they are often equipped with protective covers. They are sometimes called mushroom antennas because of the shape of the protective case.

Pagoda type antenna Type: Omnidirectional, Circular.

Application area: Video transmitters and video receivers.

The Pagoda is a relatively new antenna design on the FPV scene, appearing in 2016.

It is an omnidirectional antenna with circular polarization and is often used in

video transmitters. The unique design and use of special materials provide increased strength. By the way, this type of antenna is easy to manufacture, so

It is very popular among DIY enthusiasts.

They are cheaper to make because they can be printed on circuit boards, and the quality will be about the same. However, they are less efficient because they use fiberglass as a dielectric instead of air, so you may get less signal power than antennas with identical characteristics that use wires.

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Helical antenna Type: Directional, Circular. Application: Video receivers.

Helical antennas are circularly polarized directional antennas in the form of a spring. The antenna gain depends on the number of turns of the coil. Helical antennas with only one or two turns have characteristics comparable to a standard patch antenna. And adding more than six turns can increase the antenna's range by an order of magnitude.

Patch antenna Type: Directional, Linear or Circular.

Application area: Radio control systems and video receivers.

Patch antennas are also directional and can use either linear or circular polarization.

They are relatively inexpensive to produce since they can be printed on printed circuit boards, but their efficiency is inherently lower than other types of antennas that use air as a dielectric, such as helical antennas.

Patch antennas are generally less directive than helical antennas and have a smaller coverage area.

How to Choose Antennas for FPV Systems: Recommendations For beginners, it is best to start with omnidirectional circularly polarized antennas such as the Cloverleaf or Pagoda.

Antenna performance depends heavily on the quality of the material and precision, so good antennas will cost more. Some top-notch antennas can cost 2-3 times more than cheaper ones, but they can only provide a 5-10% increase in range.

Axial ratio is another important factor to consider. It is usually not mentioned by the manufacturer itself, but you can find information on specialized online resources. Ultimately, choosing the best antenna for you will depend on your budget and your level of knowledge.

Once you've invested in a diversity receiver setup, you can purchase directional antennas to improve signal quality and increase range.

Antennas for receiver and transmitter Antennas are made to receive a signal, transmit a signal, or both. It is important to choose the right antenna for each purpose.

For acceptable performance, you should use an omnidirectional antenna on your video transmitter. The reason is that the quadcopter is constantly moving and rotating, making it impossible to keep a directional antenna pointed at the pilot's video receiver at all times. You can use a narrow beam antenna on your video receiver, as you can point the antenna in a specific direction. If your FPV goggles have a diversity receiver, you can combine a directional and omnidirectional antenna to get the benefits of both systems.

Antenna connector types The connectors commonly used for FPV antennas are SMA and RP-SMA. They differ in design and are not compatible with each other, so make sure you buy the right one.

option. If you are new to this hobby, try to use only SMA connectors for your equipment to avoid confusion in the future. There is no difference in performance.

The SMA connector has two variants: SMA and RP-SMA. They may look similar, but they are not compatible with each other. There is no difference in performance between them.

SMA Male

SMA Female

RP-SMA MaleRP-SMA Female

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MMCX is a new type of connector used in video transmitters and antennas. It is the perfect balance between SMA and UFL connectors in terms of weight and size. It is much stronger than UFL and has many more mating/disconnecting cycles. We currently recommend this type of connector, which can survive more severe accidents than UFL, but takes up less space than SMA.

Durability When choosing an FPV antenna, the user must consider its durability. The antenna is mounted externally and is therefore susceptible to damage. It will likely survive many crashes during its service life. Therefore, it is important to choose an antenna that can withstand adverse external influences, especially if you often crash. Before purchasing, carefully examine how reliable and durable the antenna is and choose one that has a durable protective housing.

Bec People usually pay little attention to such a thing as antenna weight. But when it comes to mini drones, which are becoming lighter and lighter, antenna weight becomes an important factor. After all, every gram saved can improve the performance of the quadcopter.

Antenna size and weight are often overlooked, but they are becoming increasingly important as FPV drones themselves become lighter. If you can shave

a few grams off the weight, you can improve performance and increase your flight time. So when choosing an antenna for your mini quad, it is important to consider its weight.

UFL connectors have gained popularity in recent years due to their light weight and compact size. However, they are quite fragile and have a limited number of mating/disconnecting cycles.

Combined use of linear and circular polarized antennas Despite all the advantages of circularly polarized antennas, are they always the best choice? Even the smallest circularly polarized antenna will be larger than a dipole and will generally be less robust.

Nowadays it is quite common to use a dipole on the copter and an antenna with circular polarization (it doesn't matter whether it's right or left) on the receiver.

In this case we get some advantages of each type of antenna. Of course, we lose about 30% of the signal (3dB) due to different polarizations, but the quality will always be better than with the worst mutual arrangement of two antennas with linear polarization, where about 97% of the power (30dB) is lost.

How to install an antenna for a video transmitter (VTX)? When installing an antenna for a video transmitter, the most important thing is to place it away from any conductive materials. This is because such materials can block or absorb radio waves, which will weaken the signal.

It is also necessary to use a rigid, fixed antenna, as a long antenna can create vibrations during flight, which makes it difficult to tune the drone and increases the level of interference.

The best placement for the VTX antenna depends on your flying style. If you spend most of your time flying in cruise mode, your quadcopter may be tilted 20-30 degrees. Mounting the antenna tilted backwards will ensure that it stays vertical during flight, which is the most optimal antenna placement.

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How to install an antenna for a video receiver? When installing the video receiver antenna, you need to consider the type of your system. For a single antenna receiver, it is recommended to use an omnidirectional circular polarized antenna, while for diversity systems, it is better to use a directional and omnidirectional antenna to improve overall performance.

When flying long distances, it is common practice to place the video receiver module on a ground station to prevent unexpected changes in antenna orientation due to the pilot's own movements. A partner observer can also help adjust the patch antenna and point it in the right direction. If your FPV goggles have a patch antenna, you can try turning your head to point the antenna at the drone when the signal gets weak.

Using SMA adapters You can use adapters to make it compatible with different connectors (RP-SMA, SMA, MMCX, UFL, etc.). These adapters even come in 45 or 90 degree angles if you want to point the antenna at a specific angle. However, when using these adapters or coaxial extension cables, there is some signal attenuation. Typically, the power loss is a few percent, depending on the quality and design of the adapter (extender).

But sometimes the benefits of using an adapter or extender outweigh a small signal loss. For example, you can use a coaxial extension cable to increase the distance between the video transmitter antenna and the radio receiver or other sources of interference. Or you can use a 45-degree adapter to achieve optimal orientation of the video receiver antenna.

SOLDERING (SAFETY PRECAUTIONS WHEN SOLDERING)

Soldering is a fundamental skill in the world of FPV drone building and repair. It involves using molten solder to join two metal components together. While it may seem simple, it takes a lot of practice to master. Before you dive into the soldering process, it's important to keep a few things in mind. It's essential to use a quality soldering iron with a replaceable tip so that

ensure smooth and precise soldering. The best solder joints are made quickly, but not in a hurry. Always be careful not to burn yourself!

Soldering tools Having quality equipment is just as important as good soldering skills.

Preparation before soldering Solder can spit when heated, sending tiny molten balls of solder flying in random directions. These droplets can cause short circuits between electrical contacts or components when power is applied to the device. Therefore, it is a good idea to cover the areas of the controller

where soldering is not taking place with masking tape, electrical tape, or Kapton tape.

Next, make sure your soldering iron is heated to the right temperature. For small connections, you should heat the tip to about 390°C, and for larger connections, you should heat it to 450°C. Cheaper tips usually cannot provide enough heat, so it is important to make sure your tip can reach the required temperature.

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The tip of your soldering iron can accumulate a dull gray or brown coating that affects its ability to transfer heat to the part. To clean the tip, simply wipe it with a damp sponge or brass wool, then add a little solder to it. This will help

improve heat transfer to the soldered joint.

To extend the life of your soldering iron tip, add a decent amount of solder to it before turning it off. This will create a protective layer and help prevent oxidation.

Hold the PCB or component securely in place with a soldering iron. Duct tape can help you quickly secure wires and PCBs to your workbench.

Tinning of contacts Always tin the contacts and wires before attempting to solder them together, this will make them much easier to connect.

Tinning basically means coating the wires and solder pads with the appropriate amount of solder before joining. Tinning will allow you to solder faster since you have already saturated the pads and wires with solder,

To solder the pads, apply a small amount of solder to the tip and touch it to the pad. Do not use too much solder as this may cause the solder to bleed over the edge of the pad and create a mess. If you are not using a rosin-cored solder or if the solder is not

If the solder sticks to the pad, first apply a little soldering flux to the pad.

For wires, strip them to expose enough wire (about the length of the pad) to solder, then twist them together and tin them. When heating the wire, be sure to use the soldering iron to heat the wire, not the solder itself. When the wire is hot enough, the solder will melt and bond to the wire. Again, if the solder is not sticking to the wire, apply a little soldering flux to the wire before soldering.

The most common soldering task is to solder a wire to a pad on a flight controller.

To get started, make sure the wire and pad are tinned and the soldering iron is heated to the desired temperature. Then melt the solder ball on the pad, apply flux and bring the wire to the pad, put the soldering iron on the wire and under the influence of the tip temperature the tin will melt and the wire will sink into it. Carefully remove the soldering iron and hold the wire in place for a few seconds so that the solder cools completely and hardens. Since the wire can fall off or micro cracks will appear in the connection, which can fail due to vibrations and falls. Do not press hard on the wire with the soldering iron, the temperature is enough.

Don't be afraid to use a little more solder. If you don't have enough solder, the joint can easily come apart. If there isn't enough solder in a soldered joint, it will look uneven and the wire strands will be visible. Using more solder will ensure a stronger, more secure connection.

The finished joints should look round, shiny, strong and fully covered with solder. Here is an example of what a properly soldered joint should look like.

Soldering a large wire to the pad When soldering larger wires, such as the XT60 pigtail to the ESC, it is important to set the soldering iron temperature accordingly and use a larger soldering tip. This will ensure that the thicker wire gets sufficiently hot.

When tinning large wires and pads, use as much solder as the pad can handle, but not so much that a solder bridge is formed.

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It is also recommended to apply a decent amount of soldering flux to the pad before connecting the wires.

The solder on the battery wire solder joints will take longer to melt due to the larger piece of metal. Be careful not to press too hard with the soldering iron when melting.

solder on a large wire, as this can cause the wire strands to unravel. A good solder joint for large wires should be round, shiny, and completely cover the strands.

Soldering the header pin to the through hole Insert the pin into the hole, holding it at the right angle with your fingers or tweezers. Heat both the pin and the ring on the through hole for a couple of seconds. Apply solder to the joint, and it should be strong, shiny, and look like

volcano.

Wire to through hole

There are two options here: you can treat the through hole as a solder pad (lay the wire on the hole and solder from above) or you can treat it as if you were soldering a header pin (slide the wire through the hole and then solder from below). This is

depends on which side of the board is easier for you to access. Here's how to solder a wire directly over a through-hole:

Here's how to insert the wire into the hole and solder it from the bottom like on the header pin.

Connecting two wires When you need to connect two wires, it is very useful to have a "mpemyu hand" or blu-tack putty. If you plan to use heat shrink, do not forget

put it on the wires before soldering. For small wires and quick jobs, you can solder one wire directly next to the other. It is also useful to twist them together before soldering to increase the mechanical strength of the joint.

When joining two larger gauge multi-strand wires, straighten the strands and press them together, then twist them together to keep them together. Apply a little soldering flux and solder the wires together.

This method maximizes the contact area between the metals, resulting in a smaller, stronger solder joint. In any case, if the joint is strong, it will work just fine.

Paws on the court In this work there is no need to tin either the paws or the soldering pad.

Bring the paws to the platform and fix it with the "Third Hand"

Heat the contact and pad for a few seconds and apply solder to the joint. Remove the soldering iron and allow it to cool.

When soldering multiple tab contacts, make sure the first contact is straight. The entire job will be easier if the first tab is securely fastened in the right place.

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Xt60 connector Clamp the XT60 connector in your hand or in a bench clamp to keep it stable while soldering. Use a small amount of solder to very lightly tin the inside of the XT60 connector. Too much solder can make it difficult to insert the wire into the holes. Tin the electrical wire by heating it with a soldering iron and applying solder until it is evenly coated.

Insert the tinned wire into the hole on the XT60 connector and heat the soldering iron over the wire and connector. Bring the solder to the joint and let it run down the wire until it is completely covered and recessed in solder. Be careful not to apply too much solder as this can cause unwanted bridges between the connections. Once the joint is complete, remove the soldering iron and let the joint cool for at least 10 seconds before handling it.

Tip: Connect the connector before soldering - this will prevent the plastic from deforming under the influence of heat.

Cleaning soldered joints

After soldering, you may find solder residue around the solder joints - this is burnt flux or simply flux residue. Some fluxes are more conductive than others, depending on the type, so it is best to clean them off.

You can use a cotton swab soaked in isopropyl alcohol to wipe off any remaining flux. You can also use a brush, but make sure it is a soft-bristled brush so as not to scratch the components.

Common Soldering Mistakes and How to Fix Them Soldering is a necessary skill for building and repairing FPV drones,

Overheat LIPC

When soldering, it is very important to avoid overheating the small soldering pads. Leaving the tip on the pad for too long can cause the copper layer to peel off from the fiberglass PCB, leading to costly repairs or even failure of the entire component.

Cold seam If the solder has not melted completely, or if you have not used enough solder. A cold solder joint looks grainy and dull, is considered a poor

contact between components, and is often unreliable. To fix this, you need to reheat the joint and apply more solder until it becomes shiny.

Another problem that can occur is that solder sticks to the tip when you remove it from the joint. This is a sign that the flux has burned out and it is time to add some more soldering flux or use fresh solder.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS CONTROL RECEIVER + CONTROL TRANSMITTER + ANTENNAS

SOLDERING (SAFETY PRECAUTIONS WHEN SOLDERING)

Solder bridges A solder bridge occurs when two adjacent pads are accidentally connected by solder, creating a short circuit. The solution is to remove the excess solder with a solder tip.

Dirty soldering iron A dirty or oxidized tip can prevent proper heat transfer and result in cold solder joints. Regular cleaning with a damp sponge or brass wool can solve this problem.

Soldering temperature Leaving the tip on the soldering pad for too long can cause overheating, which can damage components or cause the copper pad to fall off (possible fix). Therefore, it is important to quickly install and remove the tip.

For this, it is recommended to use a slightly higher temperature, which will melt the solder faster. But be careful not to use too high a temperature, as this can also cause damage.

300 ° - for particularly delicate work

390C° - for soldering signal wires on the flight controller or ESC

450 ° - for large connectors, ESC power supply and Xt60 pigtail

Electronic warfare (SAR and EW)

INTRODUCTION One of the serious problems faced by platoon-company level units, as well as assault unit fighters during a special military operation, was the lack of means of detecting and suppressing small UAVs, in particular, products of the company D . Attempts at suppression by small arms fire, in accordance with the recommendations of the Russian Ministry of Defense, have led and continue to lead to senseless deaths or injuries of personnel, and standard electronic warfare means have practically no effect on commercial unmanned aircraft.

GENERAL INFORMATION Let us consider the technology of detecting commercial-type UAVs, namely DJ products (Mavik, Matrix family) and their analogues (Autel, Fimi), geo-positioning of which is carried out at frequencies of 1100-1600 MHz, transmission of telemetry, audio and video signals at frequencies of 2400 MHz and 5800 MHz.

TECHNICAL PART To organize the work of the tactical group, the following software and hardware systems are used:

PAK "Masterok-3", which includes:

1. Antenna KRM12-2400/5000 (Operating frequency range, MHz 2400-2500, 5150-5900) or KR-15-750/2900 (wideband 2G\3G\4G antenna 15 dB)
2. Measuring antenna KM-6-600/6000
3. Spectrum analyzer ArinstSSA-TGR2, Chinese "analogue" of SA6, or another with similar functionality *for operation it is necessary to install software Additionally, for the convenience of the operator of the complex, it is possible to use mobile devices (smartphone or tablet (Android OS), PC (WIN)) connected to the analyzer via Bluetooth protocol.

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TYPES OF DRONES | DEVICE | ASSEMBLY

CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROL BODIES, ELECTRONIC WAR (REM AND EW) SETTINGS

Electronic warfare (SAR and EW)

1. Antenna KR-15-750/2900 (wideband 2G\3G\4G antenna 15 dB) KRM12-2400/5000 (Operating frequency range, MHz 2400-2500, 5150-5900)

- b. Measuring antenna KM-6-600/6000

3. Spectrum analyzer ArinstSSA-TGR2, Chinese "analogue" of SA6, or another with similar functionality

*software must be installed to work

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CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROL BODIES, ELECTRONIC WAR (REM AND EW) SETTINGS

Electronic warfare (SAR and EW)

Spectrum Analyzer. A must-have device in the SVO zone. When used correctly, it can hit the enemy with a surge of suicidal sentiments for lost birds.

So: A directional frequency spectrum analyzer scans a square of several kilometers for the presence of a peak in the spectrum of various frequencies by which it can be determined what kind of UAV is in the air.

- 1.1, 1.2 kamikaze, Baba Yaga
- 2.4 reconnaissance drone (Mavic)
- 5.8 kamikaze

Spectrum analyzers, some modifications, come with a screen that can be connected to the drones' FPV camera, and the anti-drone monitors the signal from the enemy drone's camera and can even see where it flies. Makes work easier for electronic warfare systems, anti-drone guns, since you already know what frequency, what model of copter and what type is moving in your square.

Essential before:

- take off your UAV to see if there is a bird on duty. 1.
- landing your UAV to make sure you don't bring the tail with you (we often do this by jumping on the 2. tail of an enemy bird and destroying the UAV crew)
- c. when rotating for observation

The thing is inexpensive, but I advise you not to skimp, it will save your life and help you remain invisible.

PAK Drone Detection and Suppression System LPD-820 The complex includes a drone detection module, which allows detecting signals at frequencies of 2400 Meu and 5800 MHz, as well as at an additional customizable user frequency from 100 MHz to 6000 MHz, as well as an LPD-801 drone suppressor.

Indication of drone detection is carried out using a light and sound signal, it is also possible to use any type of headphones (including active ones)

ENEMY UAV DETECTION Considering that the signal transmission from the copter to the operator's console is on the W/Fi frequency, the frequency analysis method is used to detect the UAV

At present, the Masterok-3 PAK uses the KRM12-2400/5000 antennas (Operating frequency range, MHz 2400-2500, 5150-5900) or KR-15-750/2900 (wideband

2G\3G\4G antenna 15 dB) and the KM-6-600/6000 measuring antenna manufactured by KROKS. The advantage of the former is greater accuracy and measurement range due to stronger signal amplification, while the advantage of the latter is a wider observation range.

It is recommended to use both antennas together. From the antenna, the signal is fed to the ArinstSSA-TGR2 spectrum analyzer by connecting the SMAmale-famale and coaxial cable. When assembling the PAC, according to the factory requirements of the manufacturers of microwave coaxial connectors with a threaded type of connection, when connecting, it is NOT ALLOWED to allow the central contact entering the collet that receives it to rotate. To do this, it is necessary to hold the axial base of the screwed half of the connector, allowing only the nut itself to rotate, and not the entire screwed structure. This significantly reduces scratching and other mechanical wear of the mating surfaces, ensuring better contact and extending the number of switching cycles.

For ease of use with LAC, as well as the ability to remotely receive and analyze information by the PAC operator, it is possible to pair the complex with a device based on Android OS via a Bluetooth connection.

The Arnist software is available for download in the Google market and does not require licensing. In the software itself, the operator of the Masterok-3 PAK can set the frequency range he needs for observation, which allows him to search for enemy UAVs in all necessary ranges. The frequencies are set by opening the menu in the Arnist program by clicking on the menu icon in the upper left corner of the program. In the menu, select the sub-item "Range" (Amplitude), in which the data for the beginning and end of the spectrum are set.

It is recommended to set the range to 100 MHz with a scale step of 10 MHz.

Example:

Start: 2400 MHz, End: 2500 MHz, Step: 10 MHz

It is also possible to save the most frequently used settings.

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CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROL BODIES, ELECTRONIC WAR (REM AND EW) SETTINGS

Electronic warfare (SAR and EW)

The assembled complex is installed on a tripod with manual or mechanical rotation of the antenna, after which the PAK "Masterok-3" is ready for operation.

The effective detection range of the Mavic-3 copter is up to 1500 meters. It is possible to increase the range by replacing the antenna with products with higher gain.

At the moment of target detection at frequencies from 2400 to 2500 MHz or from 5800 to 5900 MHz, a sharp and characteristic increase in the signal is recorded, which is wave-like by 10-15 decibels (up to the third line in the Arnist program), which increases in amplitude as it approaches the operator's post. The bearing on the signal is the bearing on the enemy UAV.

The Masterok-3 PAK is also capable of detecting enemy electronic warfare. In this case, an increase in the radio signal power is observed across the entire observation spectrum.

The complex is powered by portable batteries (power banks) via a USB connection. To optimize work with spectrum analyzers, it is possible to use the Android application DroneAlert (in TG @DroneAlert). The DroneAlert application is designed to monitor and signal the detection of radio signals, including signals from unmanned aerial vehicles (drones).

What it gives:

- saving man-hours because the operator does not need to constantly look at the spectrum analyzer screen - saving on equipment: the program works with cheap civilian spectrum analyzers on a regular smartphone.

Main functions:

- signal detection
- classification of drone/not drone signals (currently in test mode)
- the ability to scan several frequency ranges at once
- Sound or vibration alarm when signals are detected.
- scanning with the screen off is supported: you can hide the phone + analyzer in a backpack/vehicle with the program running and have a notification tool on the go

System requirements: The application works on mobile devices (smartphones, tablets) running Android 6+, connected to the spectrum analyzer via an OTG USB cable.

The following spectrum analyzer models are supported:

- Arinst SSA-TG
- Arinst SSA-TG-WA
- Arinst SSA-TG-LC .
- Arinst SSA-TG-R2
- Arinst SSA-TG-LC-R2
- Asinst SSA-R2
- . Sa6

The program contains the following user interface elements:

- The ”Settings” menu contains saved application presets: settings for algorithms and starting 1. frequencies displayed at the bottom of the screen
- b. Name of the connected spectrum analyzer
- c. Alarm level: disabled / any signal / drone (UAV only)
- d. Sound settings
- Step bandwidth. Corresponds to one point on the scan graph. 5.
- Scanning frequencies. Manual adding/removing/editing or selecting known frequencies is possible 6. UAV see menu Settings → Frequencies
- g. Scan start button. When pressed, you are taken to the scanning screen with the selected settings.
- h. Selecting files to view radio data records

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CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROL BODIES, ELECTRONIC WAR (REM AND EW) SETTINGS

Electronic warfare (SAR and EW)

1. Instructions for drone operators with the ”1001” firmware version for Mavic3 from Russian hackers. The drone has the ”1001” firmware version. This allows you to use the drone bypassing some of the restrictions built into it by the manufacturer.

Changes in firmware:

- DRONE ID is disabled;
- NFZ disabled;
- added the ”Antispoofing, quick takeoff without GPS” mode;
- FCC is activated on the drone itself (additionally, the 5.8 GHz frequency and higher data transmission power are used - the communication range with the drone increases);
- Removed all restrictions (range, altitude, etc.) if you are not logged into the DJI FLY app; the range limit is set to ”unlimited” and the default max altitude is 10 km
- independence from the location on the map (even in areas with height restrictions); . the Airsense system is turned off;
- . added the ability to descend when the lower sonar is obscured;
- the possibility of reflashing to the factory version is blocked.

Some of these changes can be ”turned on” or ”turned off” by entering a command in the ”Name” field in the ”Information” window of the DJI FLY app settings.

The drone can fly “without GPS” and “with GPS”.

In the firmware ”1001” the ability to fly with complete disregard for data from the GPS module (”Antispoofing, fast takeoff without GPS”) was added, with forcibly set coordinates (0; 0). In this mode, a white ZERO is displayed in the satellite number icon.

2. Switching between the modes ”without GPS” and ”with GPS” can be done either by the central switch ”CINE”/”NORMAL” or the commands ”gps off,”/”gps on.”

No GPS mode ”Antispoofing, quick takeoff without GPS” (switch position ”CINE” or command ”gps off”) - allows you to quickly take off and fly without GPS signals from satellites, flying only visually using the camera. In this mode, everything that is based on GPS is unavailable: the drone's location coordinates are static (0; 0) throughout the flight, the track is not drawn on the map, the distance is not displayed, the return to the Home Point and the flight by points specified on the map do not work. In this mode, the drone becomes immune to GPS spoofing attacks (coordinate substitution, i.e. ”hijacking”)

If electronic warfare fakes a signal from GPS satellites:

- moves to the airport; .
- . changes the current location;
- . changes the altitude or speed of movement, the drone does not react to this in any way - it does not see real data from GPS.

In this mode, the drone positions and stabilizes itself only using the lower sensors, without using GPS, so the higher the flight altitude, the worse it will hold itself and be blown away by the wind.

Often at altitudes over 200 meters it will switch to ATT/ mode - depends on the surface below. Also, while in this mode, you can fly in SPORT mode, for this you need to enter the command ”cine sport”, This will allow you to fly at higher speeds, angles of inclination and ignoring obstacles.

To switch to normal flight mode (but still without satellites), enter the command ”cine normal,” Also available from this mode are the commands ”tof off(on)”, ”leds off(on)”, ”up1000”, ”up9999”.

Mode ”with GPS” ”Factory mode with GPS positioning” (switch position ”NORMAL”, ”SPORT” or command ”dps op”) - standard flight using GPS coordinates of the satellites. The correct coordinates and flight track of the drone are displayed (only not in ATTI mode), the return to the Home Point works.

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PRONOV | CHSTROYS

CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROL BODIES, ELECTRONIC WAR (REM AND EW) SETTINGS

Electronic warfare (SAR and EW)

In this mode, the drone may be vulnerable to GPS spoofing (coordinate substitution), i.e. it can be "hijacked". Unlike the factory one, in "1001" the altitude is firmly nailed to the barometer, i.e. the drone is immune to altitude spoofing. Also, while in this mode, you can fly in SPORT mode, for this you need to move the central switch to "SPORT". This will allow you to fly at higher speeds, tilt angles

3. Ignoring obstacles. To switch to normal flight mode with satellites, you need to return the switch to the "NORMAL" position. The following commands are also available from this mode: "gps off", "cine normal(sport)", "tof off(on)", "leds off(on)", "up1000". "up9999".

During the flight, you can switch between "with GPS" and "without GPS" modes.

In the "with GPS" mode, if there are satellites, the home point will be updated (or you can update it manually) and returning home will be available.

In fact, the "Antispoofing, quick takeoff without GPS" mode is a software analogue of the board that is installed in unprogrammed drones.

In all modes, the maximum radsus and flight altitude set on the remote control are ignored and the drone behaves as if the remote control is set to "no limits".

The default flight altitude limit is set to 10 km (you can set 1 km with the command "up1000"). The position of the central switch in the "CME" is redefined - in fact, it turns on the NORMAL + "qps off" mode. If you need SPORT + "qps off", then you must additionally enter the command "cine sport",

The "without GPS" / "with GPS" mode depends on the position of the central switch on the remote control when turning on or switching during operation.

NOTES Each command ends with a "comma", do not forget about it when entering;

- a. To avoid confusion, it is recommended to perform the entire flight in one mode: either "without GPS",
- b. or "with GPS";
- c. If the flight started in "no GPS" mode, then switching to "with GPS" mode makes the drone vulnerable to GPS spoofing again;
- d. If the drone starts behaving strangely during a GPS flight, it is better to immediately switch to the "Antispoofing, quick takeoff without GPS" mode (switch position "CINE" or command "gps off");

- e. If during the flight in the ”Antispoofing, quick takeoff without GPS” (” №E” or ”qps off”) mode there was also the ATT mode, then when switching to ”GPS” (”NORMAL” or ”gps on”) you can see ”flight controller error”. This error does not interfere with the flight;
- f. To exit ATT/mode, it is recommended to reduce altitude in order to ”aim” the ground again with the lower cameras;
- g. The mode must be switched when the drone and remote control are turned on. If, when the remote control and drone are turned on, the switch value does not correspond to the mode displayed on the screen in the DJI FLY app, then you need to switch to another mode on the remote control and after a couple of seconds return the switch back to the desired position:
- h. With a drone flashed with ”1001” you can use any version of DJI FLY. Firmware testing was carried out using versions 1.5.10, 1.9.9, 1.10.1, on more recent versions - changes in behavior are possible;
- i. In the latest versions of DJI FLY (for example 1.10.6) there is no button for selecting a dual-band radio channel in the ”Transmission” tab. When turning on the drone with the ”1001” firmware, radio communication is carried out in two ranges, if buttons 2,4 and 5,8 are not pressed. But if you select at least one of these ranges with the button, then you will not be able to return to the dual-band mode without rebooting;
- If the drone already has a 2.4 GHz amplifier (booster), then each time the drone is turned on, you need to 10. forcibly select the 2.4 GHz frequency. Otherwise, the drone will operate in two frequencies, and when switching to 5.8 GHz, the radio path will operate without an amplifier;
- After rebooting the drone, the values of the commands “leds off(on)” and “cine normal(sport)” are remembered, but the states of the 11. other entered commands are not saved;
- You can visually determine that the drone is flashed with the ”1001” firmware: unlike the factory firmware, the flashed ”1001” 12. when turning on the power, the icon with the number of satellites counts: 99,88,77,66,55,44,33,22,11.

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PRONOV GUSTROIS

CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROL BODIES, ELECTRONIC WAR (REM AND EW) SETTINGS

Electronic warfare (SAR and EW) A brief description of the commands and changes is given in the ”Memo for the operator of the Mavic3 drone reflashed to version ”1001”"

Memo for the operator of the Mavic3 drone reflashed to version ”1001” The drone has firmware version ”1001” from Russian hackers with the following

changes: Command in the drone remote control interface in the ”Drone name” field Description Enable Disable The drone is not visible on the aeroscope (DRONE ID is disabled) - The drone does not send information about itself to the aeroscope: not its location, nor the home point, nor the operator's coordinates.

You can use any version of DJI FLY and Iphone.

NFZ Disabled - Drone will not react when entering NFZ (NoFly-Zone). The phone will show that the drone is in NFZ and will land, but this does not affect the flight of the drone itself, you need to calmly ignore these messages.

- Added flight mode ”without GPS”: 1.
- b. Anti-spoofing GPS, fast takeoff without GPS - gps off, gps on,
- c. The ”gps off” command activates the ”no GPS” mode. In this case, the received information from the GPS module is completely ignored, with the eternal deception that the signal from zero satellites is strong, and the coordinates are always (0; 0). This allows you to immediately after turning on the drone NOT wait for satellites, as if it immediately caught them, set the Home Point at coordinates (0; 0) and removed all restrictions on takeoff.
- In this case, the satellite icon with the number ZERO turns white (on the Android version of the application). 4
- e. This mode is also activated by the switch on the remote control in the “CINE” position.
- f. Flight in this mode is carried out visually - by camera.
- The command ”gps op” allows the drone to fly using GPS. This mode is also enabled by the 7. switch on the remote control in the ”NORMAL” position. In this mode, the drone is vulnerable to GPS spoofing (coordinate substitution), i.e. it can be ”hijacked” by electronic warfare.
- h. Switching to SPORT mode with the option ”gps off”, ”cine sport”, ”cine normal”, When switching the switch on the remote control to the ”CINE” position (gps off.), by default the drone flies in NORMAL mode.
- i. If you need to fly faster in SPORT+ ”gps off”, you must additionally enter the command ”cine sport”,
- Maximum flight altitude 10 km ir1000, up999, 10.
- The maximum flight altitude of the drone is 9999 m (10 km) by default (or set by command 11. ”ir999,”), and the command ”cr1000,” sets the factory limit to 1000 m (1 km). All other altitude restrictions are removed.
- l. FCC activation on the drone - Additionally, the 5.8 GHz frequency and high data transmission power are used - the communication range with the drone increases. The 5.8 GHz range is available on any remote control, this is activated on the drone itself.
- Removed all restrictions (range, altitude) if not logged into DJI FLY app

13.

- Removed altitude/range restrictions of 30/50 meters from launch site if NOT LOGGED into DJI FLY app account 14.
- o. Automatic shutdown of the AirSense system
- AirSense is a system that allows the drone to receive signals sent by airplanes or helicopters (using the ADS-B protocol) and warns the user about the presence of a manned airplane or helicopter nearby. In case of critical proximity, it blocks control.
- q. Turning off the lower sonar in case the drone will not descend because it is blocked by a gimbal or load tof on, tof off, If the lower sonar (not the camera) is blocked by a gimbal or load, the drone does not fly down: neither by sticks, nor by the ”landing” command. In this case, the ”tof off” command will forcibly turn it off and allow the drone to fly down.

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BY DRONES | DEVICES

CONCEPT OF BPPA (DRONE), STRUCTURE, CONTROL BODIES, ELECTRONIC WAR (REM AND EW) SETTINGS

Electronic warfare (SAR and EW) In this mode, you need to land manually - the standard system does not see obstacles below. 18.

Turning off the onboard lights leds on, leds off, The LEDs on the drone beams are turned on with the command ”leds on” and 19. turned off with the command ”leds off”.

Impossibility of reflashing

- It is not possible to reflash the factory firmware version over 1001, thereby deleting the changes made to it.

Electronic warfare continuation FPV operators are few and their training requires complex efforts. FPV is not ”wings”, operators are always close to the front line. The enemy is aware of this and actively tries to locate the operators and destroy them.

The accuracy of determining the location using electronic intelligence (SAR) depends on the distance between the enemy's direction finders and the front line. Usually, these direction finders are not closer than 10 kilometers from stationary complexes or 3 kilometers from mobile ones. As a result, the accuracy of determining the location at a distance of 5 kilometers from the front line will be no more than 200 by 200 meters, and at 10 kilometers - 400 by 400 meters. The pilots of enemy unmanned aerial vehicles are busy with other important tasks, so their numbers are small.

- Controlling a drone from the ground, This option is common, since it does not require a long time to 1. reach the target. In this case, it is difficult to detect the SIGINT control panel on the ground. However, the higher the drone is in the air, the higher the probability of its detection by SIGINT. Therefore, we fly at the lowest level. When taking off, do not rise sharply upward, but move away from yourself at a low altitude, then smoothly increase the altitude, changing the route in the direction of the enemy.
- b. Flying at high altitude. In this case, there is also a risk of detection of the remote control. My recommendation is to use directional antennas with a narrow opening angle, for example, an antenna with a large number of elements in the wave channel. If possible, cover the antenna on the sides with something metal at a distance of at least 1.5 meters so that the radiation does not spread by side lobes. For example, you can fly inside a building through a window opening, being a meter away from it.
- c. Flights using a repeater. In this case, the situation is more favorable. A repeater in the air is visible at a distance of 40 kilometers. The enemy is well acquainted with the CrossFire and LRS signals used by repeaters. Therefore, try to fly with a repeater as far to the side as possible. As already mentioned, the accuracy of SIGINT is insufficient for accurately directing artillery fire at the pilot. The enemy understands that the error of artillery fire and determining the pilot's location make this task impossible, so for accurate reconnaissance, he will send a winged unmanned vehicle. It will try to detect you in the specified square visually. Therefore, it is important to ensure the camouflage of your transport and position. Do not forget about the repeater, which can also attract the attention of the enemy.

Analog and unencrypted video transmission via FPV allows the enemy to easily see its content. The video stream often displays information about the flight range. By watching the picture, you can roughly determine the departure point if the pilot was flying in a straight line. Many units also display their identifier on the picture to confirm the completion of tasks. The enemy, having intercepted such a video signal, will decide how important it is to destroy this particular group of experienced pilots.

Remember that you yourself may attract unwanted attention.

So, a quick summary:

- Determining the location using electronic warfare is not enough to successfully destroy the pilots, but common squares can be detected;
- General camouflage is important, the enemy will definitely be there
- conduct a visual search in your direction;
- Use directional antennas with a narrow opening angle; FPV flight should be carried out at the lowest possible altitude;
- The repeater is visible from a long distance and should be placed to the

side;
- Consider what information to display on the drone's video feed.

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GDRONOV GASTROS

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, SAFETY TECHNIQUES

SAFETY PRECAUTIONS

Safety when working with UAVs According to safety regulations, any aircraft must undergo a pre-flight inspection to determine the serviceability of all systems. Ideally, the UAV should be ready to fly at half the throttle. It is also worth checking the serviceability of all parts. It is necessary to ensure that the cable is not connected to the board before the drone is ready to fly. If you use a GPS module, in order for piloting to be controlled, it is necessary for the device to determine the required number of GPS satellites. Only then can you unlock the propellers. Another parameter that requires checking is the return point. If the return point is not set, you must reboot the device and update the GPS satellites and the coordinates of the return point. A failure in navigation can cause loss of control of the copter, which in turn can have tragic consequences. The safest models are those that do not use carbon and fiberglass, since these materials can cause serious injury to people and damage to property. Piloting a drone requires some skills, which are more profitable to acquire on an inexpensive and lightweight model. Besides, in this case, a breakdown due to pilot error will cost much less in all respects. After purchasing, do not immediately proceed to flying. First of all, you need to carefully study the instructions. Simple modes are best suited for starting operation. Having mastered them, you can use more complex ones.

Safety when preparing for flight:

- Before using the quadcopter, it is necessary to visually check it for integrity and reliability of the units, as well as for the correct installation of the screws and motors!
- Tightness of frame mounting nuts
- Tightening of nuts (caps) of screws
- Make sure there is no damage to the main components of the quadcopter
- Check the reliability of the wire fastening, if necessary, tighten protruding and dangling wires with ties
- Check the integrity of the protection
- Make sure the batteries are charged
- Make sure the remote control is set up and charged. 4. It is imperative to designate the piloting area in advance.

Pre-flight safety:

- It is necessary to place the spectators behind the pilot.
- Do not allow spectators to enter the hemisphere in front of the pilot (into the UAV piloting area).
- Connect the battery only before takeoff and disconnect it immediately after landing.
- Stand at least 3 m away from the quadcopter (when piloting in an open area),
- It is possible to be closer only if the UAV is in a special zone limited by a net. Take off from the ground from a flat area.
- If you hear any strange sounds when turning on the propellers (ARM), turn it off immediately (DISARM). Wires or a cable may have gotten into the propellers. It is necessary to check the drone again for any malfunctions. The drone pilot must always remember how long the batteries of the device are designed for. Do not fly longer than indicated in the instructions. Failure to follow any of the manufacturer's recommendations threatens at least damage to the drone. In the event of a decrease in thrust, destabilization and an accident of the drone may occur, which in turn threatens injuries and damage. Many countries have already introduced laws that regulate the use of copters and prohibit their launch near people. The reason for this restriction is the accidents that have occurred in recent years. Maintaining a safe distance is necessary each time the device is launched and is the first safety rule. Even the lightest drone can cause serious injury and even kill a person. For safety reasons, you should not let the drone out of sight and monitor the movement of people around it.

Safety during flight:

- Follow all instructions of the flight instructor.
- When learning to fly indoors, fly at a level below your chest.
- Fly close to you at a distance where you can see the orientation of the copter in space.
- When controlling, all movements with the sticks must be done carefully and smoothly. Avoid sudden movements. Otherwise, the copter may suddenly gain flight speed and there is a high probability of it crashing.

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SAFETY PRECAUTIONS Safety during flight:

- You should fly carefully and perform only those elements that you have no doubt about. It is forbidden to perform aerobatic maneuvers whose success is in doubt and maneuvers associated with risk.

- Observe the speed limit. Keep the copter's flight speed within the speed of a walking person.
- Return the copter to the landing site by the calculated time, do not allow the battery to completely discharge during the flight.
- Landing should only be carried out on a flat, open area, away from obstacles.
- In case of impact with the ground or hard landing, perform the following actions:
  - Stop the flight. Land the copter on the ground. 1.
  - ii. Disarm (turn off engines)
  - Disconnect the battery on the copter. 3.
  - iv. Turn off the remote control
  - Inspect the copter and (if necessary) repair. 5.
    - After the planned landing, perform the following steps:
      - a. Disarm (turn off the engine).
      - Disconnect the battery on the copter. 2.
      - Turn off the remote control 3.

ACCIDENT !!! No matter how experienced you are, if you have a drone, you need to understand that accidents can happen. Sometimes it's your fault, sometimes it's due to reasons beyond your control. So what do you do if it does crash? First of all, find it. Check it for damage. Write down what damage it has sustained. You'll use this note in case you need to contact the manufacturer. Turn off the drone and remove the battery and propellers. Clean off dirt, sand, and other debris with sterile wipes. While the drone is upside down, turn the propellers to dislodge sand and dirt, then blow into each one (or use compressed air) to remove any remaining dirt.

ACCIDENT !!! Check the battery for damage to the frame. Remove all propellers. Make sure they are not deformed or cracked. If there is a problem, replace the propeller. Check all parts of the stabilizer and fall protection device to make sure they are securely fastened and not damaged. Check the frame for cracks, including the struts. Check each motor, how it is fastened, each screw. After completing a thorough cleaning, reinsert the battery. Restart the UAV on a level surface and fly it again. Start the motors without the propellers, check if they vibrate. Turn off the motors. Attach the propellers. Restart the motors and check again if the device vibrates.

ACCIDENT !!! Fly the drone low to check for any strange movements or swaying. Do one long-range flight. Keep it low speed and low to the ground (avoid water) to make sure everything is working. Drones are very complex devices that rely on several different systems to fly properly. You can't influence the software or hardware, but if you are aware of the issues you can control and the mistakes you can avoid, you can minimize the chances of crashing or even losing your drone. Most accidents can be prevented by simply being vigilant

and careful when preparing for and flying.

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DRONES | DEVICES

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, MAPPING

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Orientation Positioning in space is carried out using GPS (NAVSTAR GPS).

This monitoring system was created and implemented

US Department of Defense. It began operating in 1994 with 24 satellites (in 2019, there were 31 satellites in orbit at an altitude of 20,200 km).

Each GPS satellite continuously transmits a radio signal, which consists of two carriers, three or four codes and a navigation message.

GPS uses the code division multiple access (CDMA) principle.

GPS was originally developed as a military system, but was also available to civilians. However, to maintain a military advantage, the US Department of Defense provides two levels of GPS positioning:

- for military use Precision Positioning Service (PPS);
- for general use Standard Positioning Service (SPS).

The GPS system has two codes (and two carriers):

- The first code is a coarse code (C/A code) and refers to the Standard Positioning Service (SPS), available for civilian use by all users.
- The second code is the Precision Code (P/Y code), which is modulated on both carriers, and is for the Precision Positioning Service (PPS), intended for US military users.

PPS accuracy is twice as good as SPS (PPS accuracy = 1.5-15m 95% of the time vs. SPS accuracy = 3-30m).

The pilot must have the skills to operate the drone in conditions of navigation system failure after being exposed to electronic warfare, compass failure, or when using the drone indoors.

Navigation In the general sense, navigation is the process of managing a certain object (including an informational one) that has its own methods of movement in a certain space.

In navigation, the following two components can be distinguished: theoretical justification and practical application of methods for managing a routing object (its type is routing in information networks), choosing the optimal path for an

object to pass through space. In information technologies, information systems, navigation is considered:

- in WWW;
- on the Web page, on the Website.

On every Wikipedia page, at the top of the left column, there is a group of links called "navigation".

Aeronautical navigation (air navigation) is the science of methods of flying aircraft along a given course and altitude while maintaining a specified flight time.

The methods used to navigate in the air depend on the flight rule used by the pilot:

- according to visual flight rules (VFR);
- instrument flight rules (IFR).

In the second case, the pilot will navigate exclusively with

using flight instruments and radio navigation aids such as

radio beacons, or follow the radar control instructions issued by the system

air traffic control.

In the case of VFR, he will navigate to a large extent by means of "coordinate calculation" techniques in combination with visual observations (pilotage) with reference to appropriate charts. This may be supplemented by radio navigation aids.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, MAPPING

CARTOGRAPHY

Main types of air navigation:

- terrain flying;
- compass navigation;
- radio navigation;
- astronavigation.

Radio navigation means radio engineering methods and means of obtaining information about the position and movement, as well as control of moving objects for information support of the precise movement of a moving object along a certain trajectory and its precise output to a specified point at a designated time in a way that is optimal for the given conditions. When solving navigation problems, the movement of an object must

be carried out along a certain trajectory. The projection of the flight path onto the earth's surface is called the path line. The trajectory consists of a set of points at which the object must be located in succession. The point at which the moving object is located is called its location.

Orientation on the ground Orientation is the ability to determine one's location relative to the cardinal directions.

Cardinal directions:

- main north, south, west and east;
- intermediate northeast, southeast, southeast and northwest.

You can determine the cardinal directions using natural objects:

- Anthills are almost always located on the south side of a tree, stump or bush.
- The bark of solitary trees on the north side is thicker, often covered with moss.
- On a clear day, you can navigate by the Sun. At noon, at 12 o'clock, the Sun is in the south. Therefore, the shadow from objects will be directed to the north. The north-south shadow line is called the midday line. You can navigate by the North Star, which always indicates the direction to the north with an accuracy of 1°.

How to remember: To determine the cardinal directions in the north direction, you need to face north and spread your arms to the sides. East will be on the right, west on the left, and south behind.

Algorithm for orientation using the North Star:

- Find the constellation Ursa Major in the form of a “bucket” of seven bright stars.
- . Draw an imaginary line through the two outer stars of the “bucket”.
- Put off on the line five times the distance equal to the distance between the two outer stars.

Orientation by compass: Most often, the direction relative to the cardinal points is determined using a compass. Its magnetized needle always points north with one end and south with the other. The magnetic compass was invented in Kumae. The compass appeared in the Mediterranean region around the 12th century.

Sequence of actions for orientation by compass:

- Place the compass on a horizontal surface.
- Release the magnetized arrow using a special lever.

- Wait until the arrow settles down.
- Turn the compass housing until the N (North) mark coincides with the direction indicated by the dark end of the arrow.

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CARTOGRAPHY

Azimuth Azimuth is the horizontal angle between the north direction and the direction to the selected object. The angle is measured only clockwise. The azimuth value can vary from 0° to 360°.

Rhumb is the angle between the direction to an object and the nearest end of the meridian.

Meridians indicate the north-south direction.

Algorithm for determining azimuth according to plan:

- Orient the plan using a compass. To do this, you need to turn the plan so that its north direction coincides with the direction indicated by the compass.
- Place the compass at the point on the plan from which you need to determine the azimuth of a particular object.
- Orient the compass to the cardinal directions.
- Determine the azimuth on the compass scale by turning the ring until an imaginary line connects the slot, the front sight and the image of the object to which the azimuth is determined.

Representation of the unevenness of the earth's surface on a plan and map Relief is all the unevenness of the earth's surface. On a plan and map, relief is conveyed using contours or layered coloring.

Contour (isohypse) - a line on a plan or map connecting points of the terrain with the same absolute height relative to the level of the World Ocean.

Contours on the map are drawn at certain intervals in height, for example, 5, 10 or 20 meters.

Bergstriches are short lines that indicate with their free end the direction of slope descent.

If the contours are close together, the slope is steep; if the distance is increased, it is gentle.

There are two types of altitude: absolute and relative.

Absolute height Absolute height is the height of the terrain determined from the level of the Baltic Sea (on Earth, the level of the Baltic Sea (Kronstadt tide gauge) is taken as the starting point for measuring heights).

The absolute height of points located above sea level is positive, and below - negative. Thus, above are the mountains of the land, below - individual lowlands.

For example: The absolute positive height of the highest mountains in the world, the Himalayas, is 8848 m above sea level, and the absolute negative height is the level of the Dead Sea (-395 m).

On plans and topographic maps, absolute height is determined by contour lines. Absolute heights of hilltops or mountain peaks are shown on plans and maps by a number with a dot. On the ground, absolute height can be determined by a benchmark - a geodetic sign indicating the height above sea level of a given point on the earth's surface. On a plan or topographic map, it is determined as the difference in absolute heights of two points.

Relative height Relative height is the elevation of one point on the earth's surface over another.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, MAPPING

CARTOGRAPHY

Methods of depicting the Earth. Land on a plan and map Aerial photographs can be plan (taken perpendicular to the surface) or perspective (the shooting axis is tilted at a certain angle). The terrain shown on them is taken from a low altitude, so the image is quite detailed.

A space image is a photograph of a section of the Earth or another celestial body taken from a spacecraft (satellite, ISS, etc.).

Scale Scale is a fractional value that shows how many times the image of the terrain on a map, plan or globe is reduced compared to its actual size on Earth. That is, the scale shows how many centimeters on the ground are contained in one centimeter on the map.

The scale can be:

- numerical (1:1,000,000);
- named (in 1 cm 10 km); .
- linear (in the form of a ruler).

For example: The map scale is 1:300 000. This means that 1 cm on this medium-scale map contains 3 km of distance on the ground.

The smaller the number of times the terrain is reduced when depicted on paper, the larger the scale of the image, and vice versa. Thus, a scale of 1:25,000 will be larger than a scale of 1:1,000,000, because in the first case 1 cm is 250 m, and in the second, 1 cm is 10 km. It is clear that on a larger scale the terrain will be depicted in more detail. Therefore, the larger the number in the scale after one, the smaller it is.

Linear scale is used to avoid calculations. On the map, the distance between the required points is measured with a compass, and then the compass is applied to the scale and the required distance is determined on the ground. However, it is not always possible to measure the distance in whole centimeters on the map. For a more accurate determination of distances, one of the segments of the linear scale (the leftmost one) is divided into smaller divisions of 1-2 MM.

Kapma A map is a reduced, generalized image on a plane of a large area of the earth's surface, made using conventional symbols in a specific projection and scale.

The map must include a grid of lines that are oriented along the cardinal directions.

Example:

- The vertical lines are meridians, indicating the north-south direction.
- The horizontal lines are parallels indicating the west-east direction.

Classification of cards:

- By scale: 1.
  - large-scale (from 1:5,000 to 1:200,000). General geographic maps of this scale are topographic;
  - medium-scale (from 1:200,000 to 1:1,000,000). General geographic maps of this scale are called survey-topographic maps;
  - small-scale (from 1:1,000,000 and less). General geographic maps of this scale are called overview maps.
- b. By purpose:
  - educational;
  - tourist;
  - synoptic;
  - meteorological;
  - navigation;
  - communication routes;

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, MAPPING

CARTOGRAPHY When making a map, there are bound to be distortions of length, angle, area, and shape that result from transferring the spherical shape of the Earth onto a plane. There are various projections that minimize specific types of distortion.

Ukraine is located in temperate latitudes, where the line of minimal distortion of the conical projection passes.

Conventional signs Conventional symbols on maps are divided into scale, non-scale, linear, and explanatory.

- Scale symbols convey the actual dimensions of objects, expressed in terms of the map scale.
- Scale symbols consist of an outline.

For example, the outline of a forest or swamp and its filling, which is indicated by color or shading.

Off-scale symbols are used for objects that are not expressed in the map scale. These can be geometric figures, letter symbols, schematic drawings. Such symbols on the map indicate populated areas, mineral deposits, power plants and other objects. Linear symbols on maps convey linear objects: rivers, roads, borders, communication lines.

For example, they also include isolines - lines with the same values of absolute heights (isohypses), temperature (isotherms), magnetic declinations (isogons), atmospheric pressure (isobars), sea depths (isobaths), precipitation (isohyets), and salinity (isohalines).

All these conventional signs are to scale in their length and configuration, but not to scale in their width.

Explanatory symbols are, for example, arrows indicating the direction of the river flow, wind, etc.

Plan A plan is a drawing of a small area of the Earth at a certain scale, made using conventional symbols (without using a projection, since a projection is used to depict large areas of terrain due to curvature).

The scale of the plan is from 1:5000 and larger. The plans are always oriented to the cardinal points of the horizon. The main directions north-south are indicated by an arrow. An upward arrow points to the north, a downward arrow to the south. Accordingly, the east will be on the right, and the west to the left.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, MAPPING

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COMPARISON OF PPAN AND MAP

PLAN	MAP
There are no parallels or meridians	There are parallels and meridians
The direction of the horizon is indicated by an arrow.	The north-south direction is shown by meridians, west-east by parallels
VARIOUS SYMBOLS	
The relief is depicted using contour lines.	The relief is depicted using contour lines and layered coloring.
More detailed image	The largest and most important objects are depicted

The main forms of relief of the Earth Relief is a set of forms of the earth's surface, different in outline, size, origin, history of development and formed under the influence of internal and external processes.

The largest (planetary) forms of the earth's surface include continents and ocean basins.

The main relief forms are plains and mountains. Small relief forms are river valleys, ravines, canyons, dunes, sand dunes, etc.

Plains Plains are relatively flat areas of the earth's surface with differences in relative heights of no more than 200 meters.

The plains in the tectonic structure correspond to platforms.

According to altitude, plains are divided into:

- lowlands (from 0 to 200 m above sea level);
- elevations (from 200 to 500 m above sea level);
- plateaus (500-700 m above sea level).

Among the elevated plains, the following are distinguished:

- plateaus are elevated plains separated from the surrounding lowlands by steep ledges.

- ridges are the remains of destroyed hills, for example, the Donetsk ridge.

Primary plains are those that were once the seabed, but over time the earth's crust rose, the sea retreated, and its bottom became dry land (West Siberian Plain, Black Sea Lowland).

Secondary plains are formed as a result of the destruction of mountains, for example, in Africa and the East Siberian plateau. Or as a result of river sediments. In Ukraine, the Dnieper and Polesie lowlands are largely formed by river sediments from the Dnieper.

According to their shape, plains are divided into:

- flat (West Siberian Plain);
- hilly (Volyn Upland, Dnieper Upland).

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, MAPPING

CARTOGRAPHY

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Mountains Mountains are vast, highly elevated areas of the earth's crust above the adjacent plains with highly dissected relief.

- Mountainous country is a large territory with mountainous reliefs and sharp peaks.
- A mountain range is a linearly elongated relief form, limited by slopes diverging in opposite directions.
- A ridge is the highest part of a mountain range.
- Passes are low-lying areas of mountain ranges that connect valleys located on both sides of the range.
- Mountains in the tectonic structure correspond to areas of folding.

According to height, mountains are divided into:

- low (up to 1,000 m): Urals, Crimean Mountains;
- . medium (1,000-2,000 m): Carpathians, Scandinavian Mountains;
- high (over 2,000 m): Himalayas, Andes.

The height of the mountains depends on the type of rocks that make them up and the rate of rise (mountain growth). Thus, mountains composed of unstable rocks (sandstone, limestone, etc.) are quickly destroyed and, despite their "young age", have separate peaks and are relatively low. For example, the Karlatas are young mountains of alpine folding, but they are of average height.

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CARTOGRAPHY According to age, mountains are divided into:

- young (the mountain-building process is not yet complete, younger than 60 million years): Alps, Pamir;
- old (age of formation exceeds 60 million years): Urals, Scandinavian Mountains.

The reason for the diversity of the mountains of the Earth is also their origin.

Highest points:

- Carpathian Mountains: Gerlachovsky peak (2655), in Ukraine Hoverla (2061);
- . Crimean mountains: Roman-Kosh (1545), Ai-Petri (1234).

Hydrosphere The hydrosphere is the water shell of the Earth. The waters of the hydrosphere cover about 70.8% of the Earth's surface.

Components of the hydrosphere:

- World ocean (oceans, seas, bays, straits);
- Continental surface waters, glaciers and groundwater (rivers, lakes, swamps, artificial reservoirs, permafrost);
- . Atmospheric waters (water vapor, clouds, precipitation).

On Earth, the large and small water cycles occur simultaneously.

The process of water movement on the globe is the great (global) water cycle in nature: ocean - atmosphere land - ocean

First, water evaporates from oceans, seas, rivers, and the like. As it rises, the water vapor cools and turns back into liquid. This liquid then falls to the ground as rain, hail, and in winter, snow. Any precipitation flows down the earth's surface, for example, into rivers, lakes, and some of it seeps into the ground. Over time, the water returns to the ocean again.

It happens that water that evaporates from the surface of the ocean returns as precipitation directly into the same ocean.

This is a small water cycle in nature: ocean - atmosphere - ocean

World Ocean The area of the World Ocean is 361 million km2 (71% of the entire earth's surface; 3/4 of the Earth's territory, and only 1/4 of its surface is land).

The World Ocean contains 96.5% of all the Earth's water resources, so it is considered the main part of the hydrosphere. The surface of the World Ocean is called the water area.

Sea A sea is a part of the ocean that goes deep into the sea or is separated from the ocean by islands and peninsulas. There are marginal, internal and interisland seas.

Marginal seas are located along the outskirts of continents and do not extend much into the land.

Internal (Mediterranean and poly-enclosed) seas are located inside a continent or between continents and are connected to the ocean by one or more straits. For example, the Black, Mediterranean and Azov Seas with the Atlantic Ocean.

Interisland seas are located between islands.

Bay A bay is a part of an ocean or sea that extends deeply into the sea but has a loose connection with the ocean. In some cases, the name bay has historically been assigned to such parts.

Strait A strait is a relatively narrow part of a body of water that connects two adjacent bodies of water and separates areas of land.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS

CARTOGRAPHY

CARTOGRAPHY

Parts of Sushi Continents are the largest parts of land, surrounded on all sides by oceans and seas: Eurasia, Africa, North America, South America, Antarctica, Australia.

A peninsula is a piece of land surrounded by water on three sides and connected to a land mass on the fourth. For example, the Crimean Peninsula.

An island is a relatively small piece of land surrounded on all sides by the waters of the ocean or sea. For example, Snake Island.

Continental surface waters Continental surface waters are the waters of rivers, lakes, swamps, glaciers, artificial reservoirs, and canals.

River A river is a natural stream of water moving in a depression created by its movement.

A river system is a main river with its tributaries. A river valley is a lowland from its source to its mouth along which the river flows.

If you stand facing the river flow, the right tributary will be on the right, and the left one will be on the opposite side.

Parts of the river:

- Source is the beginning of a river (can be a spring, a swamp, a glacier, etc.).
- Mouth is the end of a river where it flows into another river, lake, sea, etc.
- A riverbed is a depression in a river valley through which the waters of a river constantly flow.
- A floodplain is a part of a river valley that is flooded during a flood.
- Terraces are stepped ledges on the banks of a river that were floodplains.

- The delta is a lowland plain formed by sediments and cut by channels.
- A threshold is a shallow rocky area in a river bed.
- A waterfall is a steep drop of water from a steep ledge into a river bed.
- A river basin is an area in which a river and its tributaries collect surface and groundwater.
- A watershed is a boundary between the basins of adjacent rivers.

Legend:

- a. source:
- meander (bend, bend): 2.
- c. delta;
- d. mouth.

River regime is the change in water level in a river during the year. A flood is a long-term periodic rise in the water level in a river. A freshet is a short-term rise in the water level in a river. A low water period is the lowest water level in a river. Freeze-up is the time when a river is covered with ice. Ice drift is the descent of ice from a river.

Water supply of a river is a constant replenishment of the river with water. It can be:

- snowy;
- rain;
- glacial;
- underground;
- mixed.

Most land rivers are fed by a mixed type with one of the sources of feeding predominating. Rivers with a predominance of glacial feeding have floods in summer, and snow feeding - in spring (rivers of moderate latitudes).

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, MAPPING

CARTOGRAPHY According to the nature of the river flow, there are:

- mountain (straight channel, narrow valley and fast current);
- flat (channel with bends, wide valley and smooth flow).

The destructive work of a river is called erosion. Meanders are smooth circular bends of the river bed. The river flows faster along the concave bank, washing it away. Therefore, the bends constantly increase until they break through. Then part of the former river bed remains on the side, gradually silts up and forms an oxbow lake.

Lake A lake is a closed natural depression filled with water. A lake differs from a sea by its lack of connection with the ocean.

By origin:

- tectonic, formed in faults and subsidence of the earth's crust (Baikal, Tanganyka);
- volcanic, formed in the craters of extinct volcanoes (lakes of Kamchatka, Iceland);
- glacial, formed in basins that arose under the pressure of a glacier (Bolshoye Solenoye, Bolshoye Medvezhye, Ladozhskoye);
- residual remains of ancient sea basins that separated during the period of coastal uplift (Caspian and Aral Seas - lakes, Chad);
- karst located in cavities formed after the dissolution of rocks by water (Shatsky Lakes);
- estuary located on sea coasts, at the mouths of ancient rivers (Maracaibo, Dniester estuary). Open estuaries are fresh, closed ones are salty, dammed ones - the basin was formed as a result of the blocking of the river valley by landslides, avalanches (Sinevir, Tana);
- oxbow lakes are sections of the old river bed in the valleys of lowland rivers.

By mode:

- wastewater from which the river flows. Freshwater, for example, Lake Baikal is the deepest lake in the world (1602 m), contains the world's fresh water reserves (flows
- Angara River).
- Endorheic salty. For example, Lake Balkhash, which is half fresh and half salty. The western part of the lake is shallow with fresh water, a large river flows into it (80% of the total inflow of water). The eastern part is deep and highly saline.

Swamp A swamp is an excessively moist area of land with distinctive vegetation and a peat layer of at least 30 cm. Swamps occupy 5% of the land's territory. A lot of precipitation is needed for their formation. The location of groundwater is close, the relief is flat, and the impermeable layer of rocks is close.

According to power supply conditions: lowland - fed by groundwater; upland - fed by atmospheric precipitation; transitional - have mixed nutrition, that is, both groundwater and atmospheric precipitation.

Role in nature:

- humidify the air of the surrounding area;

- soften the climate.

Habitat of many animal species and valuable plant species. Place of accumulation of peat, used as fertilizer, fuel and chemical raw materials.

After drainage they have high fertility. They regulate the flow of surface water.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS, MAPPING

CARTOGRAPHY

Artificial reservoirs Artificial reservoirs are reservoirs created by man.

Reservoirs are large artificial bodies of water created to accumulate and store water. People use this water to generate electricity, irrigate, meet drinking needs, etc. Canals are artificial rivers. They are created for shipping, drainage and irrigation of lands.

Ponds are created in ravines or special depressions and are used for irrigating gardens, vegetable gardens, caring for animals, and breeding fish and birds.

Landforms: ravine and gulch Landforms are also formed by temporary water flows.

Ravines are deep, wide and fairly long steep-sided V-shaped valleys that arise as a result of the erosion of loose rocks by temporary rainfall water flows during heavy precipitation, melting snow, ice or glaciers.

A ravine is a dry valley or one with a temporary water flow with a flat bottom; the final stage of gully development.

Weather

Atmospheric pressure belts on Earth Atmospheric pressure is the force with which air presses on the earth's surface.

Units of measurement of atmospheric pressure are millimeters of mercury (mm Hg), Pascals (Pa). Normal pressure is considered to be the pressure of a mercury column 760 mm high at a latitude of 45° above sea level at a temperature of 0°C.

Pressure is measured using a barometer. The air presses on different parts of the earth's surface differently. This can be explained by the uneven heating of the earth's surface, which in turn heats the air. So, atmospheric

pressure depends on air temperature. When the temperature rises, the pressure decreases, and when it decreases, the opposite happens. When heated, the air expands, rises, and presses less on the surface.

When cooling, on the contrary, it contracts and sinks down.

An important factor is also the altitude above sea level. As you rise, the thickness of the upper layers of the atmosphere decreases, as does the air density, so in the troposphere the pressure decreases for every 1 km of elevation by 100 mm of mercury.

There are three low-pressure and four high-pressure zones on Earth. Their formation is associated with the uneven distribution of solar heat on the planet and the property of air to change volume and weight depending on temperature.

Isobars are lines on a map that connect points of equal pressure on the earth's surface.

Wind, constant and variable winds Wind is the movement of air from a zone of high atmospheric pressure to a zone of low atmospheric pressure in a horizontal or nearly horizontal direction. Wind is characterized by

speed, force and direction.

Wind speed is measured in meters per second (m/s) or kilometers per hour (KM/4).

Wind force is determined by the pressure of moving air on objects. It is measured in kilograms per square meter (km/m2). The greater the difference in atmospheric pressure values, the greater the speed and force of the wind.

The wind direction is determined by the position of the side of the horizon from which it blows. The absence of any signs of wind is called calm. A weather vane is a device for determining the direction and, sometimes, the speed of the wind.

An anemometer is a device for measuring wind speed. A wind rose is a diagram that shows the directions of the prevailing winds in a particular area.

The length of its rays is proportional to the frequency of winds of a given

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, WEATHER SETTINGS

WEATHER Westerly winds are constant winds that blow in temperate latitudes.

Local winds (breeze, foehn, bora) - blow over a relatively small area and significantly influence the weather in a given area:

- foehn is a warm, dry wind blowing from the mountains into the valleys;
- bora is a strong, cold, gusty wind blowing from the mountain slopes to the warm sea.
- breeze is a variable wind that blows with daily periodicity on the coast of seas, large lakes and some large rivers. It changes its direction twice a day.
  - The daytime, or sea breeze, moves from the water surface to the land, and the nighttime, or coastal, breeze moves from the cooled coast of the land to the body of water.

Legend:

- and the daytime breeze;
- b night breeze.

Air humidity Evaporation is the transition of water from a liquid to a gaseous state.

Evaporation over a given area of the earth's surface will continue until the air reaches a state of saturation with water vapor. This process depends on the temperature: the higher it is, the more water vapor each cubic meter of air can hold.

Air humidity is a measure of the amount of water vapor in the air.

Absolute humidity is the amount of water vapor contained in the air at a given time and temperature.

Relative humidity is the degree of saturation of air with water vapor.

Clouds and fog When the air becomes oversaturated, water vapor passes into a liquid or solid state. Due to the thickening of water vapor in the ground layers of the atmosphere, fogs are formed, and at a certain height from the Earth's surface - clouds. Fog is formed when the earth's surface and the lower, adjacent layer of air cool at night. The water vapor contained in it thickens. Such ground fogs are formed both above the earth's surface and above the water surface. Clouds are formed when water vapor passes into a liquid or solid aggregate state at a significant height above the Earth. The main components of clouds are water droplets and ice crystals. Depending on the predominance of one or another, clouds are water, ice and mixed. Cloudiness is the degree of coverage of the sky with clouds.

Cirrus clouds Cirrus clouds look like white stripes. They are light and transparent, consist mainly of ice crystals, are located at an altitude of more than 6000 m, and therefore precipitation does not fall from them to the Earth.

Stratus clouds Stratus and nimbostratus clouds are low, thick, often gray or dark in color and resemble fog. These clouds are mixed and consist of both

water droplets and ice crystals. They produce prolonged rain, fog, and snow.

Cumulus clouds

Cumulus and cumulonimbus clouds appear in summer. They are white clouds that gradually grow upward, darken and can discharge into a shower.

Air masses, cyclones and anticyclones Air masses are significant volumes of air in the troposphere with uniform properties: temperature (warm and cold), humidity (dry) (continental) and humid (marine)), pressure, transparency.

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In GUSTROIS

CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, WEATHER SETTINGS

WEATHER Main types of air masses:

- equatorial (warm, humid);
- tropical (warm, mostly dry);
- moderate (temperature varies with seasons, mostly humid);
- arctic and antarctic (cold, dry, transparent).

Between air masses with different properties, narrow transition zones with the greatest difference in temperature, pressure and wind speed arise - atmospheric fronts.

Atmospheric fronts can be warm or cold. A warm front is formed when warm air advances and cold air retreats before it. The warm air, moving faster than the cold air, slowly rises and cools. As it does, water vapor condenses, forming clouds that then produce long-lasting precipitation.

A cold front is formed when cold air moves toward a warm air mass. As it moves forward, the cold and heavy air flows under the warm air and displaces it upward. This front is associated with cooling, the formation of cumulonimbus clouds, thunderstorms, and showers.

Cyclones are a region of the surface layer of the atmosphere with low atmospheric pressure, where winds blow from the periphery to the center. Due to the force of the Earth's rotation, the air in cyclones in the Northern Hemisphere moves counterclockwise, and in the Southern Hemisphere - clockwise. In the center of the cyclone, ascending air movement predominates, which leads to a decrease in pressure. The rise of air contributes to the thickening of water vapor, the formation of clouds and precipitation.

In summer, a cyclone brings cool, rainy or cloudy weather, and in winter - an increase in temperature, thaw, and precipitation.

Anticyclones are areas of high atmospheric pressure where air flows from the center to the periphery. In the center of an anticyclone, downward air movement prevails, which causes pressure to increase and temperature to rise. Due to heating, the air gradually becomes dry, which does not contribute to the formation of clouds and precipitation.

In summer, the antishiklon brings hot, clear weather, and in winter, cold, clear weather.

Types of precipitation and patterns of their distribution Atmospheric precipitation is moisture that falls from clouds or is released from the air onto the Earth's surface in solid or liquid form.

Isohyets are lines on a geographic map that connect points with the same amount of precipitation. The amount of precipitation is measured (in millimeters or centimeters) by the water column using precipitation gauges of various designs and a pluviograph, which continuously records changes in the intensity of rain.

The main factors in the formation of precipitation:

- ascending air movement:
- the presence of sufficient water vapor in the air to form precipitation;
- formation of an atmospheric front:
- . increasing the relief.

The main supplier of water to the atmosphere is the World Ocean, so in general there is more precipitation over it than over land. The greatest amount of precipitation falls at the equator (from 2000 to 3000 mm per year), since there is a zone of low atmospheric pressure there.

The ascending movement of air predominates. When warm air saturated with water vapor rises, it cools, condenses, and the mechanism of formation of rain clouds occurs.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, WEATHER SETTINGS

WEATHER In tropical latitudes, the amount of precipitation decreases significantly, since atmospheric pressure is higher there. In deserts, less than 250 mm falls. Descending movements prevail. As the air descends, it heats up and its relative humidity decreases, clouds do not form.

As one approaches temperate latitudes, the amount of precipitation increases, since in this zone the atmospheric pressure is low, ascending air masses are well developed, and atmospheric fronts and cyclones operate.

Thus, in most of Europe, precipitation ranges from 600 to 1000 mm.

The amount of precipitation decreases from temperate to polar latitudes. This is due to a decrease in temperature and moisture content in the air and the prevalence of descending air currents.

In the polar latitudes of the Northern Hemisphere there is a zone of high atmospheric pressure, the amount of precipitation fluctuates between 150-300 mm per year. Cold air is heavy, concentrated on the surface of the Earth; low temperatures do not allow the air to "collect" much water vapor.

The Southern Hemisphere generally receives more precipitation than the Northern Hemisphere, as it is dominated by water bodies. However, the general patterns of precipitation distribution are the same as in the Northern Hemisphere.

The latitudinal distribution of precipitation on the globe is disrupted by the influence of individual winds, ocean currents and relief. Thus, a lot of precipitation falls in the monsoon zone. However, the greatest amount of precipitation on Earth is observed on the southern slopes of the Himalayas. Here in the town of Cherrapunji, an average of 11,000 mm of precipitation falls per year. The main reason for this is the rise of moist air caused by the presence of mountain slopes. The summer monsoon from the Indian Ocean increases the formation of precipitation in this area.

Rain Rain is water that falls from clouds and reaches the ground in the form of droplets.

Formed by condensation of water vapor when the size of a cloud drop of water exceeds 0.5 mm. A distinction is made between light, moderate and heavy (rainfall) rains.

Snow Snow is solid atmospheric precipitation that falls from clouds in the form of ice crystals. It is formed from snow clouds at temperatures below 0°C. Ice crystals are formed when water vapor quickly cools and passes from a gaseous state to a solid, bypassing the liquid state (sublimation).

Hail Hail is atmospheric precipitation in the form of heavy, irregularly shaped ice particles that form from cumulonimbus clouds at temperatures below 0°C. The ice floes do not have time to melt and fall from the clouds at considerable speed.

Fog Timan is a type of precipitation in the form of accumulation of water vapor condensation products (water droplets) on the Earth's surface. It is formed

directly from atmospheric air when air cools from the Earth's surface or when warm water evaporates into cold air. Visibility is poor during fog.

Dew, frost and hoarfrost Dew is water droplets that form on the surface of soil and plants when the Earth's surface and ground layers of air cool rapidly at night and water vapor condenses.

Hoarfrost is a thin layer of ice crystals on the earth's surface. It forms in the same way as dew, only at temperatures below 0°C. Hoarfrost is often confused with hoarfrost.

Hoarfrost is a loose white accumulation of ice crystals that sticks to tree branches, wires and other objects during severe frosts and fogs.

Weather, its elements, types, changes over time Weather is the state of the lower layer of the atmosphere in a given area at a certain moment (or period) in time.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, WEATHER SETTINGS

WEATHER The main characteristics of the weather are:

- air temperature;
- atmospheric pressure;
- wind;
- humidity;
- clouds and cloudiness;
- precipitation, thunderstorms, etc.

The main feature of the weather is its variability. Factors that determine weather variability:

- changes in the angle of incidence of sunlight during the day, month, year, which affects the temperature conditions of each territory;
- . heterogeneity of the relief and movement of air masses;
- formation of cyclones and anticyclones.

A distinction is made between periodic and non-periodic weather changes. Periodic weather changes are associated with the Earth's movement around its axis and around the Sun. These include, in particular, daily and seasonal changes in air temperature and humidity, wind direction. Non-periodic weather changes are caused by the movement of air masses, atmospheric fronts, cyclones

and anticyclones.

Weather type is a general characteristic of the weather, including its main elements. According to temperature conditions, weather is divided into three types:

- frost-free;
- with the temperature transition through 0°C;
- . frosty.

Frost-free weather prevails throughout the year mainly in equatorial and tropical latitudes.

Weather with temperatures falling below 0°C is typical for transitional seasons - spring and autumn - and occurs only in temperate latitudes.

Frosty weather is observed in temperate and polar latitudes.

Meteorology is the science of the Earth's atmosphere, the phenomena and processes that occur in it. The object of study of meteorology is meteorological elements.

Weather forecast - information about the weather conditions in the future. Weather can be predicted using synoptic methods or local signs.

Synoptic methods - continuous scientific observations of the weather conditions using various instruments, including space ones; compilation of synoptic maps, on which the results of simultaneous weather observations at a network of meteorological stations are plotted using conventional symbols.

Synoptic map According to local signs - the use of folk observations of harbingers of weather changes, folk signs.

Pressure When rising 1 km, the air temperature decreases by 6°C, and the atmospheric pressure by 100 mm Hg. With deepening, the soil temperature increases by 3°C for every 100 meters. Normal pressure (0 m above sea level) = 760 mm Hg.

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

WEATHER Reference:

- 1 ha = 10,000 m2
- Distance 1o along any meridian = 111.1 km, approximately 111 km.
- Distance 1o of the equatorial arc (0o latitude) = 111.3 km, approximately 111 km.

- Equator = approximately 40 thousand km.

ADDITIONAL INFORMATION

Advantages of Reverse Motor/Propeller Rotation on Quadcopters

Advantage in aerodynamics One of the most important benefits of changing the direction of the propellers is improved aerodynamics.

Center of traction application When the propeller rotates as a separate stationary object, the point of application of the thrust force is directly on the axis of rotation of the propeller. When the copter flies forward, the air affects not only the copter, but also the propeller, i.e. shifts this point towards the blade that moves against the movement of the copter (red circle in the picture). This means that the blade that moves forward gives more thrust and drives the air stronger than the blade that moves backward. On the front propellers, the point where the force is applied shifts outward, and on the rear ones

- inward. The faster the copter moves, the more this point shifts. Because of the smaller leverage, the rear propellers will work less efficiently than the front ones.

Turbulence Moreover, the turbulence caused by the front propellers reduces the efficiency of the rear ones (one of the reasons why the stretched cross frame is more efficient in this regard is that the front propellers are farther away from the rear ones). By changing the direction of rotation of the propellers, the point of application of the thrust of the front propellers is shifted inward, and that of the rear ones is shifted outward, thus compensating for the loss of efficiency due to turbulence from the front propellers.

Better yaw control When the propellers rotate in reverse, during sharp turns, the rotation speed of the propellers (due to the rotation of the quartermaster) does not decrease.

All these advantages will not give anything in normal hanging and 3D acrobatics.

Other benefits These advantages will be enough to decide to use the reverse direction of rotation. Due to the fact that the front propellers will rotate not "inward" but "outward", the FPV camera will collect less dust and dirt.

Also, using reverse rotation means there is (theoretically) less chance of getting tangled in the cloth gate.

Another plus is that most of us often break CW or SSI propellers and have a small reserve of one type of propeller. This happens because we are left-handed or right-handed, and instinctively perform left and right turns differently. Now we can change the direction of rotation and continue flying.

We remove the screws Changing the direction of rotation in the controllers via Betaflight Go to the Betaflight CLI console and write: set yaw motor direction = -1

save Update (thanks FEI): In BF 3.2. the command format has changed: set YAW MOTOR REVERSED=ON save

We put the screws in the reverse order, CW instead of CCW and vice versa. No need to turn the screws over!

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

ADDITIONAL INFORMATION

Capacitors for filtering noise in mini-copters Capacitors will help make your video signal cleaner and your copter fly better. In this guide, we'll cover the different types of low-ESR capacitors, explain why low-ESR is important, and show you where to put them.

Soldered to the Xt60 connector:

- 1000uF 35V (4S, 5S)
- 1000uF 50V (6S) .
- 640uF 35V

Soldered to speed controllers:

- 470 uF 35 V
- 330uF 35V
- 330uF 50V (6S) .

Noise (or interference) is caused by surges in voltage, current, and frequency in various electronic devices, even smoothly rotating motors can cause such surges.

If you think about the modes in which the motors in a copter operate, it becomes clear that the electrical environment in which the electronics of the copter are located can be described as ”hostile”. In order for your flight controller, video transmitter, camera and other peripherals to work stably, they need a stable environment, and they are essentially operating among enemies.

As technology advances, motors and controllers become more and more powerful, so the problem of electrical noise/interference only gets worse.

The problem with interference is very serious, if there is no interference, then we can get a great copter for FPV flights; but with them - something terrible, which is impossible to fly.

Why are Low-ESR capacitors so important for mini-copters?

- Adding a capacitor can help clean up the power supply, giving you the following benefits:
- Reduced interference on video from the course camera
- .reduce electrical interference that can damage the motor, controller and radio signal
- improving flight performance by ”cleaning” the gyroscope power supply

you can even save electronics from damage caused by voltage surges caused by active braking (Damped Light)

We prefer Low-ESR capacitors. ESR stands for Equivalent Series Resistance. Capacitors with lower ESR filter electrical noise better.

LC filters are also often used in FPV equipment to combat interference, but they protect systems after the interference has already occurred. Adding a capacitor near the power/interference source, on the contrary, protects the entire system from noise.

Do I need a capacitor in my quadcopter? Capacitors are not required, but are still recommended. If you notice vibrations (copter oscillations, difficulty in setting up PID) or there is noise in the video, the first thing I would do is install a capacitor.

This is how you can determine that the copter is too noisy and you need to install a capacitor:

- Listen to the motors and see if there are any oscillations that you cannot eliminate by adjusting the PID coefficients.
- The engines will be hot
- Noisy video signal from the course camera is a symptom of interference in the power line

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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

ADDITIONAL INFORMATION In rare cases, you may notice a desynchronization of the regulators/motors and a ”death roll” - an unexpected roll that causes you to crash into the ground. The interference may also affect the control signal of the regulators.

Even if these symptoms are not present, it is still better to install a capacitor. Bent and dented propellers will also add noise to your copter.

Where to put capacitors in minicopters? First of all, remember that the capacitors we need have polarity. If you mix up the polarity, the capacitor will at least not work, at most - explode, so be careful! In the picture, the shorter leg is "minus", on the capacitor body it is marked with the corresponding sign.

To get the maximum effect from the capacitor, you need to connect it to one of the three "correct" places in the copter. Note that you need to put it in only one place!

- On the PDB, where the power wire is soldered. 1.
- Where the power wires for the regulators are soldered to PDB 2.
- Or where power is supplied to each of the regulators (IMHO this is the best option). 3.

The closer the capacitor is to the source of interference, the more efficiently it works. The ideal place is the contacts on the regulators where the power is supplied (option 3). However, in this case, you need to install 4 capacitors, one per regulator; but you can install small capacitors, about 330 F.

If the capacitors at the regulators take up too much space, then solder 1 or 2 more capacious ones to the RDV (1000 µF or 2 x 470 µF). Perhaps this is a less effective solution, since we are moving the capacitors away from the source of interference, but I have done this many times, and it works.

To reduce resistance, the capacitor legs should be as short as possible; thin wires are not suitable for high currents.

If there is not enough space for the capacitor near the board, then the legs can be extended with a thick wire, for example, 20AWG, such a wire will not greatly affect the resistance.

Adding a small capacitor to the gyroscopes If adding capacitors near the XT60 connector does not help to get rid of the copter oscillations, then it makes sense to think about a small capacitor on the gyro power bus. This way we can reduce the interference getting to the gyros through the stabilizer.

This solution is only suitable for experienced users. Find a place where

soldering a capacitor is a very difficult task, and you also need to be able to solder well.

Add a capacitor to the 3.3 volt bus The gyros in the flight controllers are powered by a 3.3 volt linear voltage regulator (LDO), so the capacitor can be soldered to the power pin of the gyro chip or to the power output from the LDO. The other pin is soldered to ground.

An excellent option is a tantalum capacitor 4 V 220 - 400 F. {104}--
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CONCEPT OF UPPA (DRONE), STRUCTURE, CONTROLS, SETTINGS ADDITIONAL INFORMATION

ADDITIONAL INFORMATION To get the best result - the capacitor should be located as close to the gyroscopes as possible. Only very few LCs have one power bus for gyroscopes and receivers, but it is in them that you can put a capacitor on the contact pad for the connector. In my opinion, it is not very good to use one stabilizer to power both gyroscopes and peripherals, but adding a capacitor is very easy.

Add a capacitor to the 5 volt power rail The 3.3V LDO for the gyros is powered by the 5V line, so some users put a capacitor on the 5V supply, which also helps reduce the impact of noise on the gyros. This doesn't always work, but it's worth a try.

Tantalum capacitors of 6 volts 220 - 400 F are suitable here. Is it really necessary to add capacitors to the gyroscope power bus?

If there are no problems with the copter vibrations, then there is no need to think about capacitors. If there are vibrations, then first try simpler ways to reduce noise.

In any case, I would like flight controller manufacturers to think about improving the filtering of the gyro power line. It's good that many modern LCs already have capacitors near the gyros. So in the future, you may not have to solder anything.

GUIDELINES: Types of drones, drone structure, drone assembly + additional materials. PILOT RELEASE: EDITION 1.0.1