Components for Creating an Unmanned Aerial Vehicle

Application note

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This application note will explore the considerations which should be taken in to account while selecting which components will be used to create a first UAV (Unmanned Aerial Vehicle).

Background

UAV is a very broad term because this can range from anything from a toy helicopter to a military grade vehicle. UAV's are gaining popularity among companies and hobbyists alike due to their many uses. In this application note we will focus on more of the Quadcopter modeling instead of airplane framed models.

Types of UAV

Before it is decided on what kind of UAV is the best suited for one's project, the choice is dependent on how much one would like to learn about the field. Building a custom UAV can provide to be a challenging and involved project. If your purpose is just to get the UAV and fly it or design it down to the last rotor there are choices out there.

There are the Toy UAV's that are smaller preassembled models that you can purchase. These models aren't necessarily easier to fly but they are more resistant to crashes. This would be great for younger hobbyists to peak interest in the field.

There is the RTF "Ready to Fly" model kit that is an all-inclusive kit. The UAV comes pre-assembled and pre-wired and comes with the battery charger and the transmitter. This is more for people who just want to get a UAV and want to fly it immediately.

The ARF "Almost Ready to Fly" is a kit that comes with all the core parts assembled like the motor and the flight controller. This kit usually needs a transmitter/receiver and sometimes requires a battery. Generally this is a good place to start if one wants to get into building their own UAV. It lets the hobbyist get some input into the final design while knowing that most of the UAV already works.

The Basic UAV kit usually includes everything the ARF model kit does except the flight controller. That would mean the hobbyist would have to calibrate the model and make sure that the components work with the components from the kit. But every kit is different so it would be a good idea to see what components come with the kit before you buy it.

Then there is the Custom build. This is where the hobbyist builds the UAV from its bare essentials. This approach requires that you understand all of the components of a UAV and how to make them compatible with one another in order to create the UAV. This is not recommended to start due to the complexity of UAV's in general. It would be better to gain experience using an ARF or a Kit in order to figure out how the model works before committing to the custom build.

Toy UAV

RC Transmitter

Although it is possible for the flight contoller to control the UAV autonomously it is generally a good idea to have a RC transmitter so that you can control the UAV if something goes wrong or just use the RC transmitter instead so you can fly manually. In order to choose the best fit for a transmitter depends on how complex the UAV is. Most of the time a handheld transmitter is adaquate enough but for larger areal vheicles it is better to have a base station to help with all of the controls.

Handheld Transmitter

Transmitters are judged based on how many channels they have. The number of channels a Transmitter has relates to the number of separate signals the transmitter can send. The more complex you make your UAV the more channels you are going to need for the transmitter. Usually a 7 channel radio is adequate enough to operate most beginning UAV's. Also when looking for transmitters for a UAV it is a good idea to check and see if the radio includes a 3 position switch or variable knob. This is requred by most autopilots to switch between various flight modes.

A reciever usually comes with the transmitter and will have to be binded or synced to the transiver. This is usually a very easy process that can be achieved as easy as pressing a button on both of them at the same time.

Base Station

Multi Rotor Frame

The frame is an important part of the aircraft because it needs to be light enough for the UAV to take off but still strong enough to provide support and not break in a minor crash. Building personal frames are not recommended. UAV's have their own flight dynamics and structural integrity that needs to be met and for first time designers it is difficult to understand what exactly is needed. There are many frames out there for purchase and are highly recommended and tested.

There are many different frames to choose from and each one has different purposes. The most common frame used is the Quadcopter but for heavier loads we also have the Hexacopter and Octocopter and for a different look we also have the Tricopter.

The Tricopter is the UAV with three arms usually with 120 degree angle between the arms. This is in theory the lowest costing model because it needs fewer motors. Since this UAV is not symmetric the rear motor is more complex than the other two in order to maintain a stable flight. It should also be noted that not all autopilots support this configuration.

Tricopter

The Quadcopter is a UAV with four arms, and is the most popular design. The quatcopter is the easiest to constuct and is also quite versitile. All the flight controllers work with this design. But if one of the motors fail then the UAV will most likely crash.

Quadcopter

A Hexacopter is a UAV with six arms but can also be used on a Tricopter frame by dubling the moters. If it is designed that way it is refered to as a Y6 configuration. If one of the motors on the Hexaxopter go out usually the other motors can make up for it and make it to ground more safely than a quadcopter. Using more motors creates more uplift allowing the drone to lift heavier payloads but as a drawback these models are usually more expensive.

Hexacopter

Y6 Hexacopter

The Octocopter has the same advantages and disavanages as the Hexacopter. Since it has more motors it can lift heavier payloads and recover better from a failing motor than a Hexacopter. This also means that the Octocopter is more expensive model. It is also possible to add the extra sets of motors on a quadcopter to create another version of an Octocoter calles an X8 this the same advangages and disadvantages as an avarage Octocopter.

Octocopter

X8 Octocopter

Motors/ Speed Controller

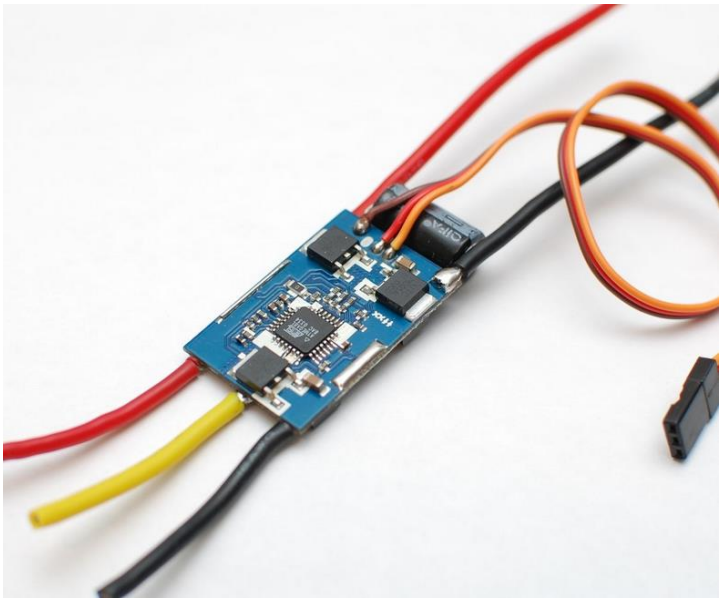
The motors chosen will have a huge impact on the flight time and how heavy of a load the UAV can carry. It is highly recommended that the same type of motor be used for all of the rotors so that they all do the same amount of work for the UAV. Even though the motors are the same make and model their speeds may still vary which is the purpose of the flight controller that will be mentioned later.

There are multiple motors to choose from most of the UAV motors are DC motors because gasoline motors are too heavy for the UAV and a battery pack provides a DC current to make the DC motors the ideal choice. The key factor when looking for your motor is the KV rating. The KV rating of a motor relates how fast it will rotate for a given voltage. Most multirotor UAV's a low KV is desired for stability like somewhere around 500 – 1000 KV[2].

If it is available it would be important to overserve the thrust rating that some manufacturers provide. Usually they will provide it with a given propeller options because depending on the propellers you get it will affect the total thrust you can achieve. This thrust is essential to your design because if your thrust is only 2.5 Kg and your UAV weighs 2.5 Kg then it will have difficultly taking off and staying up. Choose the propellers and motors so that you can get the maximum thrust.

Pancake DC motor a typical model UAV motor

The ESC (Electronic Speed Controller) is what helps the flight controller to be able to control each of the motors separately. Using this device the flight controller can provide the correct amount of voltage at a time so that the entire UAV can stay stabilized.



Picture of an ESC

Flight Controller

Flight controllers are the brains of your UAV, they help stabilize your motors and synchronize them so that even if the motors give a different output of thrust the UAV can steady itself. Depending

on the flight controller that the user purchased they can even be programmed to take off and fly to waypoints.

Flight controllers are a huge part of the UAV design since it connects all of the pieces together. Because of this flight controllers can range from user programmed Arduino to over $3000 autopilot systems. It is important that to know what the purpose of the UAV is in order to give it the right amount of processing power.

For most flight controllers they tell you what they can do. A recommended one is the APM autopilot these are what it specifically offers according to their website:

- Point-and-click programming/configuration to get you up and operating without hassle
- Multiple command modes: Acro, Stabilize, Loiter, Alt-hold, Return To Launchpoint, Land, Simple, Guided, Position, Circle, Follow Me, GeoFence, and Auto (which runs fully scripted missions using GPS waypoints)
- Failsafe programming options bring peace of mind in the event of lost control signal or low battery conditions
- Three Axis camera control and stabilization, shutter control, live video link with programmable on-screen-display
- Data transceivers allow real-time telemetry and control between your ground station computer and APM, including joystick control options
- Full data logging provides comprehensive post mission analysis, with graphing and Google Earth mapping tools
- No dead ends — Advanced users will find endless options for customization and expanded mission capabilities
- As part of the 3DR Robotics Open UAV Platform, it's easy to customize APM or develop new applications on top of it. Many compatible third-party applications, such as mobile apps and image processing tools, already exist.[3]

APM autopilot

This is an example of one flight controller but it is used to give an idea of how it can run the UAV for the user. There are many other flight controlers that do significantly more and you can even create your own software on computer on a chip to create your own flight controller. The possibilites are endless.

Battery

Most of the Batteries today are lithium based batteries because of how lightweight they are and has a higher charge density than typical Lead Acid and Nickel based batteries. Unfortunately these batteries are a little more expensive and in a few cases have dangerous side-effects but for the most part these batteries are more readily used.

The battery should be based on the chosen motors for the UAV. The battery pack's capacity is measured in amp-hours(Ah) meaning that gives us how long we can last on the battery. But keep in mind the higher the capacity the heavier the battery will be. The average flight time of a model UAV is around 10 – 20 minutes on a 2-3Ah battery.

Batteries are the heaviest item on a UAV so they are usually mounted on the dead center of the drone to subject the motors to the same load. Since batteries don't have their own mounting unit because screws that punctures the battery could cause a fire. Attaching the battery using Velcro has become popular because of its accessibility.

Conclusion

Building and working on UAV's can be challenging and rewarding. And with many industries using drones for practical uses such as Amazon delivering packages or utility companies inspecting power lines it shows that UAV's can be fun and useful. For more in-depth information about building your own UAV there is a very well detailed tutorial at the website provided in the second reference citation.

References

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