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# Introduction and what you should know

Have you ever dreamed of having the ability to fly like an eagle? While you might not be able to literally fly and feel the wind blow on your face, your visual senses can actually experience the surreal feeling of flying soaring heights. For many of us, FPV is the biggest reason for getting a drone.

Imagine being able to see what your drone sees as it flies, in real time! With improved video transmission, receivers and quality camera capabilities of today, you can now experience a whole new world of flying.

In this guide, you will learn everything you need to know to get started in FPV and how to have your own FPV setup.

## STICK TO A BRAND

With FPV, it is important to pick a brand a stick to it. Stay consistent with the different components of your FPV setup. We are not going to endorse any particular brand here, but the best way to pick a brand is to ask around what others are using in your local community of flyers. That way, you can get advice and support whenever you want. If you do not fly with others, go online and read reviews, pick a brand based on what is good and what is easily available where you live.

## GET AN ALL-INCLUSIVE KIT

If you are just starting with FPV, it is recommended that you get an FPV kit that comes with everything you need including camera, transmitter, receiver, antenna and wires. Optimization can come when you are more experienced and are confident picking and assembling the components separately and building your own wire harness based on different voltage requirements.

Make sure to read the manual and plug in the wire connectors correctly if you are going this route. Another important thing to note with kits is that they usually do not come with a battery. Make sure you purchase an additional LiPo battery or you will not be able to power the system!

## FIXED WING OR MULTIROTOR

The FPV system you setup would be dependent on what kind of craft you will be flying. Flying a fixed wing aircraft is a completely different experience in relation to a multicopter. With fixed wing, the focus would be on flying long distances, very fast. With multicopters, your goal would be to maneuver through tight spaces. This will ultimately lead to what kind of camera your setup will have, for example. Some cameras are wide angled and give you better peripheral vision which is needed more on multicopter flight than on fixed wing crafts.

A Multicopter IS the way to go, if your primary purpose is to take photography and video. Most multicopters released today offers excellent photography and videography features which are simply hard, if not impossible to find in fixed wing crafts

Relative to other types of flying machines, a fixed wing crafts offers much less maneuverability. If you want your machine to perform acrobatics and want to have the flexibility of flying acrobatically within short range distances including but not limited to moves involving backward, side to side flight, flips and other 3D moves, you might want to go for a multicopter.

## START SMALL

Just like our advice on starting small when beginning to fly drones, it is recommended that you start small with your FPV equipment. It is recommended that you steer clear of getting the best FPV gear possible in the beginning. Get a cheaper camera, transmitter, receiver, antenna and goggles (or monitor). FPV setup can get every expensive when you are building your own drone. If you are a beginner, learn to setup and fly with cheaper FPV gear so you not only know if you really need/want FPV, but also get used to flying with the gear on, so you don't wreck your expensive FPV gear.

## SETUP YOUR CRAFT WELL

Whether or not you are building your own drone or trying to integrate a new FPV setup onto a ready to fly drone, you need to know if your craft is setup well. Flying FPV is VERY different from flying line of sight and you need to make sure that your craft does not have any weak links.

# Some safety guidelines to keep in mind before you start FPV

- Always have someone to spot you.
- Fly the craft without FPV to check if everything is OK first.
- Start slow.
- Fly in an open field without danger.
- Make sure you are within FPV range and that the video is clear.
- Ideally, be seated so you avoid problems like vertigo. FPV can be disorienting if you are not used to it.
- Make sure that fail safe functions like RTH are enabled..
- Now that we have covered the important points, we'll take a look at the different components that make up an FPV system and how you should pick those components based on your needs.

# The viewing gear

## MONITORS



You may not get full immersion with monitors, but goggles are not always the go to FPV viewing gear. Monitors are extremely useful in a variety of situations where goggles fall short. For example, if you want to frame a shot for aerial photography, you need to know where your drone is and have situational awareness. Unless you have a spotter, this is impossible with goggles as they completely handicap you in terms of situational awareness.

Monitors come in a variety of sizes and configurations. You can get a dedicated monitor for your FPV or rely on your phone or tablet. If you are get a dedicated monitor, you of course get more flexibility and a better FPV experience. Here are specifications you need to keep in mind while buying an FPV monitor:

- Screen size and resolution
- Viewing angle: Wider the better
- Make sure it is non-blue screen
- Antenna bay: Ideally, the monitor should have the capability to mount two different antennas at the same time. As we shall see in the subsequent sections, different types of antennas have different strengths and weaknesses. You need to be able to harness the strength of both types.
- DVR capability: DVR capability is the ability to record the flight. This allows for a “backup footage” of your flight. It is especially useful if you have crashed your craft somewhere. The backup footage is then for example,

immensely valuable in finding out where it crashed, making it easier to recover your craft.

- Storage capacity : Higher the better
- Sun protection capabilities are a BIG bonus.

## GOGGLES



- **Display**
- For the display, the following considerations are to be kept in mind:

- **Resolution:** Higher the resolution, the better. Keep in mind that the camera should also be high resolution for this effect to be noticed.
- **Field of view (FOV):** Larger the field of view, the more immersive experience you get. If you look inside an FPV goggle that has a large field of view, you'll find the screen closer to the eye. Higher end models like the Fatshark Dominator HDV2 has an FOV spec of 50 degrees, giving a really immersive experience.
- **Screen aspect ratio:** Some FPV goggles like the Fatshark Dominator V3 comes with an aspect ratio of 16:9 (which is great if you are an aerial photographer piloting something like the DJI Phantom) while other goggles come with a 4:3 aspect ratio. It is important that it matches with the camera or else everything in the video will look shrunken down. Most board cameras support 4:3 aspect ratio, so if you are planning to get a Dominator V3, best match it with a camera that supports a 16:9.
- **IPD (Inter pupillary distance):** This factor is really important so do not overlook this, especially if you are getting a cheaper FPV goggle that doesn't have an adjustable IPD. We all have eyes that are spaced differently so there is no one size fits all. With an adjustable IPD, you can adjust the FPV goggle to fit the spacing of your eyes. Especially if you are considering a goggle that doesn't come with this feature, it is important to try it out before purchasing it.

- **DVR:** DVR capability is the ability to record the flight in the goggles in a Micro SD card that is placed inside the goggle. This allows for a “backup footage” of your flight. It is especially useful if you have crashed your craft somewhere. The backup footage is then immensely valuable in finding out where it crashed, making it easier to recover your craft.
- **Head tracking:** Head tracking is a feature that’ll increase your immersion experience. It ‘tracks’ the motion of your head and make the camera on-board to move accordingly. Talk about “being one” with your craft!

- **FPV antenna, modularity and range:** Yet another consideration to keep in mind is the type of the FPV receiver antenna and whether or not the goggle has a modular receiver bay. Some goggles like the Fatshark Dominator V3 and HDV2 do not come with a receiver but it has a modular receiver bay, meaning you can attach a variety of different (supported) antennas to the goggles while others may not come with this feature. The type of the antenna should also be kept in mind. Linear antennas sends out signals that are only good for long distances and are extremely prone to multi-path interference (especially in places with lots of objects) while 'Clover' (circular) antennas are much more interference friendly at close ranges, which is why most higher end goggles are either modular or come with clover antennas.
- **Design:** Vent fan - whether or not the goggle comes with a vent fan, which is important to counter-act 'fogging' during summer and winter, HDMI Port and the overall quality of the build

# FPV cameras



Obviously, any FPV system needs a camera. This is what captures what your drone sees, which is then transmitted to your viewing device (monitor or goggles) via a transmitter. There are a variety of different options here but we'll classify the cameras into two

main types - Dedicated FPV cameras and other cameras (like GoPro).

## DEDICATED FPV CAMERAS

Also called “board cameras”, these are specifically designed for FPV. Compared to GoPro and other types of cameras these cameras have poor resolution and quality. However, where they lack in quality, they make up for in latency and the overall effectiveness in working with the FPV system as a whole to give you a smooth, lag-free experience. If your goal is to do FPV racing and do aerobatics, pick up a dedicated FPV camera.

Video transmitters and receivers are the ones that ultimately decide the upper limits of your FPV video quality, no matter what quality camera you have. For example, you could buy a 1000 TVL camera and still be limited to the specifications provided by the transmitter and receiver of your FPV setup. Same goes for resolution.

Here are some of the considerations you must keep in mind while picking a dedicated FPV camera:

**Cmos vs CCD:** Cmosc cameras are cheaper, but offer less in terms of quality. If you want the best quality in light, go for a CCD camera. One experiment you can do to check the difference is to let both cameras point slightly to a bright enough sky. With CCD cameras, you’ll notice that the vision of the ground remains intact. With the CMOS however, the ground tends to go black.

**Light handling:** Most cameras work well when the sun is up and the sky is clear. However, different cameras have different light handling capabilities in low light conditions (think cloudy days) and high light conditions. CCD cameras outperform CMOS in terms of light handling.

You should do your due diligence and research what cameras have the best light handling capabilities for your particular purpose. Make sure that the camera you get also has IR block (infra red blocking) capabilities so it also functions in high light conditions optimally, if that is what you want. If you want better performance in low light conditions, get a camera without IR blocks. CMOS cameras perform well in low light conditions.

**Consider getting wide angle lens:** For a few extra bucks, you could get a wide angle lens for the camera you purchase and have a whole difference experience flying. If you are flying multirotor drones then this is going to be really important.

**Voltage :** Make sure that the battery you use matches the voltage limits on your camera. Failing to do so can be disastrous (speaking from experience!). If you absolutely need to use a battery with higher voltage rating, use a regulator and step it down.

## GOPRO, MOBIUS AND OTHER CAMERAS



If your goal is to save the video that you are recording, then the board camera will not cut out. You ought to get your hands on a GoPro or mobius. Like we already covered, the quality of your FPV video transmission will be limited by the video transmitters and receivers.

As far as the quality of the FPV video transmission goes, using a GoPro, mobius may not give you a significant boost. This, in addition to the fact these cameras have higher latency FPV video, makes it poor choice for FPV only in relation to dedicated FPV cameras.

If you want to fly slowly and record footage, then a little bit of latency might not be a problem. Most drone photographers and videographers do this anyway. If want to do aerobatics and record a clear footage however, the ideal setup would be to include both an onboard camera (for FPV purposes) and a GoPro or mobius (for recording).

Do note that to setup GoPro or mobius to your FPV system via a transmitter, you need to buy separate video-out cables, unlike board cameras dedicated for FPV.

# Antennas

FPV antennas come in different shapes and sizes. Here, we'll look at the two main types of antennas and the benefits of using each.

## LINEAR ANTENNAS



Linear polarized antennas shoot out information in a straight path. These are ideal for sending signals over really long distances. However, if your craft is flying through objects, the signal that the antenna sends is going to bounce back. Linear antennas are poor equipped to handle these bounces causing “multi-path interference”.

If you use linear antennas other than for long distances in really open areas, you are going to get messed up, disturbed double-images on your video.

## CIRCULAR POLARIZED ANTENNAS



With circular polarized antennas, there is no multi-path interference. The signal is sent in concentric circles (either clockwise or anti-clockwise) and when it hits any object and returns, it comes back in circles that rotate in the other direction cancelling it out with the signals that are sent by the antenna.

This is why you see circular polarized antennas being used in FPV racing and obstacle course flight. They are ideal for short distance, clear image unhindered by objects.

### **Left and right hand**

With circular polarized antennas, you get two versions - right handed circular polarized and left handed. If you use right handed antenna on your transmitter, use a right handed antenna on your receiver as well. If you are flying with a friend and he or she is going to fly his/her craft near you, then it would be best if they used the version that you are not using to minimize interference.

# Video transmitters



**Note of caution:** Never power up your video transmitter without having the antenna plugged in. The exception to this is if the transmitter comes with the ability to toggle transmission on or off.

## Video link bands

## Legality

Before you decide on what band you want to set your video to, you need to know if it is legal in your country. Check your local laws for what frequencies you are allowed to use. You might also need a radio license for tapping into certain bands, depending on where you are.

### **The different frequencies, power and penetrating power**

There are four different frequency bands used for FPV - 900 Mhz, 1.2 or 1.3 Ghz, 2.4 and 5.8 Ghz. 900Mhz setup will have the best penetrating power, meaning objects around you will not cause that much interference. Also, it will enable you to go longer distance with less power consumption.

That means that if you buy a 900 Mhz transmitter with a lot of power, it will give you the best results. However, you have to be careful with high power transmitters if you are flying with others because there will be interference. "Video bleed" is highly unideal and is the reason why high power transmitters are banned from FPV racing events. Many transmitters come with the option of switching power.

The higher you go up in terms of frequency, the less penetrating power it will have and the more power it will need to consume to enable long distance FPV. However, the drawback with lower frequency setup is that the antennas tend to be very large. There is also a potential for interference with your transmitter with the 1.2 Ghz and 1.3 Ghz setup, but this can be solved with using a filter.

With many RTF drones, you get the 5.8 Ghz FPV out of the box. This is because most government laws recommend the use of this band. Moreover, the 5.8Ghz will cause little to no interference with your transmitter. Also, users do not have to get a radio license. The 2.4 Ghz is used the least because this is the frequency that your drone transmitter taps into. If the video link uses the same frequency, there will be interference.

## SMA vs RPSMA

The connector on the video transmitter (the one that you connect antenna to) comes in two different version - SMA or RPSMA where RP stands for reverse polarization. Most transmitters come in the SMA version, but you have to nevertheless make sure that the connector on your transmitter complements the antenna. With SMA, the transmitter will have the female end while with RPSMA, it will have the male end.

Also note that if your transmitter comes with an extended SMA/RPSMA connector, then it is going to be better for durability. Otherwise, you may have to build an extension on your own

## Audio

Some video transmitters come with a built-in microphone while others do not. If you want to record everything downlink and use only a dedicated FPV camera without a built-in microphone, then this feature might come in handy.

Other types of video transmitters come with the ability to connect the audio transmission to the camera (which will have the built-in microphone) via a wire.

## Bands

The more bands your video transmitter is capable of tapping into, the better. If the transmitter comes with a “race” band, then it is a bigger bonus because the frequencies are more spread out. This is a huge plus if you are going to fly with your friends.

# How to increase the range?



First, you might want to know how far your drones can actually fly. To measure the maximum distance a controlled drone can go, we must not limit our thinking to the maximum range. This is because the furthest distance traveled regardless of the transmitter or controller range will be limited by the speed and flight time (battery or fuel life) of the craft.

This is obvious from the basic formula **Distance traveled = Speed x Time.**

When we talk about the type of drone, one thing to think about is if the craft is with rotors or if is fixed wing. A consumer grade quadcopter (or multicopter) has an average flight time of 15 minutes.

Fixed wing planes on the other hand, running on a gasoline engine or even large batteries (10000 mAh or more) typically have far greater capacities for long range flight than the average consumer grade multicopter. Multicopters simply aren't aerodynamically suited for long flight times.

Some fixed wing beasts can fly at more than 200 mph and have long flight times giving them a capacity to travel large distances.

Several new technologies are being tested and proposed to extend drone flight times. [Hydrogen powered systems](#) are one example. This technology could extend the average multicopter flight time to over 4 hours! And then there are other examples of [solar powered drones](#) that have a continuous flight time of over 20 hours!

## Video and transmitter modifications

Out of the box transmitter/receiver pair you would get with consumer grade drones (running on 2.4 Ghz) can have a maximum range of about 1 mile, depending on the noise and obstacles.

But then again, that would be going out of the line of sight and hence, installing an FPV (first person view) camera system is necessary to achieve control during such distances.

One must be vary however, because in many countries flying beyond line of sight can be [heavily fined](#) . Hopefully, new regulations forthcoming in the near future will change this.

You must be now wondering if it is possible to extend control beyond this stock 1 mile range. The answer is - most definitely! How? With modifications.

There are several modifications options for your radio gear for achieving long range FPV flights. The most common way is by replacing stock antennas with high gain antennas that run with more power.

So if your stock antenna has is a 2 dB, you might want to upgrade to a 4 or 5 dB antenna. This will increase your power draw to about double. Say it was 60mW, with this setup, you could be

hitting 200mW! This can increase your range anywhere from 30 - 50%.

Another way long ranges are achieved is by using power boosters. Such power boosters can boost the output of your transmitter to 2W! With appropriate setup, ranges as far as 30 miles are not unheard of. Do take into account the potential noise output, from using such high power setup.

Yet another way is by using an UHF system like DragonLink. This gives you the flexibility to pick lower frequency radio within the [UHF](#) range. (Well below the standard 2.4 GHz to about 400 Mhz).

As you may or may not know already, lower frequency radio waves travel longer distances before getting attenuated than their higher frequency counterparts. Lower frequency radio waves also tend to travel through objects better.

Not only this, you get to lower the frequency for your video transmitters and receivers as well without having it interfere with the transmitter radio. This means, longer range for your video signals as well.

Be wary though, lower frequency waves like the 400 MHz are littered with interference! You might have to get your hands on a spectrum analyzer to see how much noise output a particular

spectrum has. Also, you need to know whether or not tapping into a particular band is legal in your country. You may need a radio license.