The Ultimate FPV System Guide

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Introduction to FPV Systems

FPV (First Person View) is a unique addictive and almost surreal flying experience! After years of dreaming about being able to do this, we can finally fly from a pilot's perspective!

Affordable FPV systems have appeared within the last decade. As an aeromodeller, it opened up a whole new world of flying to me. What was once thought impossible, is now finally a reality and very affordable!

The current technology boom keeps this subject alive and forever interesting! Screens, goggles and glasses continue to evolve. Video transmitters and receivers have improved and become more reliable. Antennas and antenna tracking systems have improved. GPS accuracy has improved. There are heads-up display systems, head tracking capability and return-to-home features. There are apps that work in conjunction with your equipment to view video and GPS information. The list goes on!

Learning to fly an rc aircraft around line-of-sight (LOS) is a key skill, and should be your first stop on the drone adventure, but switching to first person view is incredible fun, and opens up a whole new world of flying and potential for fun.

Having a video feed coming back from your aircraft means you have information flowing both ways – from your radio for the RC control, and back to your goggles or screen for the video. For this to work well, it is important to understand what is going on, the frequencies used, and how to avoid problems. After all, the last thing you want is to lose control of your precious model, either by a loss of radio control (and don't think that GPS will always save you), or by losing your video feed and crashing.

The basic elements of an FPV system setup are the camera, the transmitter, the receiver and the display device.

A few years back, in order to get into FPV, some basic electronics and soldering skills were required. That is still the case for some systems, but fortunately there are now plenty of plug and play options available.

FPV System for the DJI Phantom

The Phantom is by far the most popular quadcopter available today. If someone mentions aerial photography, it wouldn't be unusual to think of the DJI Phantom. There's no denying that DJI have done a great job designing a plug and play system, which requires little understanding of the technology, capable of capturing pictures and videos, and all with minimal training! They are leading the way in making this technology accessible to everybody.

The original Phantom was good, but the new improved Phantom 2 series is even better, with better flying characteristics, significantly longer flight times as well as optional additional camera and FPV features. It's a solid first choice for many.

The latest Phantom 2 basic version comes without a camera and therefore would require a 3 rd party FPV system, such as a system from Fat Shark, but may require a little soldering, etc. Not a big deal, but I appreciate not everybody is comfortable doing this.

Another good option for the non-Vision line is the DJI Lightbridge downlink coupled with a pair of glasses. Zeiss and DJI teamed up provide a bundle option which makes a lot of sense because you will need both the glasses and the downlink to make this setup work. It is kind of pricy a $2,099 but it's more economical than buying the two units separately.

The Phantom 2 Vision is equipped with DJI's own 'High Performance Camera' and the Phantom 2 Vision+ comes with a fantastic 3D gimbal giving silky smooth, stabilized footage. The latest Phantom 2 Vision and Vision+ uses the 5.8Ghz frequency for transmitter control. This means using a 5.8 Fat Shark system for example is a no go.

Both the Vision and Vision+ come with the option of attaching a smartphone via Wi-Fi and being able to fly in FPV mode using your phone as the screen.

Hubsan

Hubsan also offer a few off the shelf, FPV ready to fly options. How about a mini FPV quadcopter for less than 200USD!

The Hubsan H107D FPV X4 Mini is a complete FPV system, coming with a reasonably sized LCD screen built in to the transmitter! A great, inexpensive introduction to quadcopters and FPV.

If a fixed wing aircraft is your thing, than how about the Hubsan SpyHawk?

Than a little bigger, the Hubsan H302F FPV Sky Cruiser.

I'm sure there are other options, but these at least give you some idea of what's now available. With any of the listed models, you can be flying with without the need to build and no soldering skills required. All electronics are pre-installed and usually require little set-up. If you've never flown before, than training from someone who has is highly recommended with any system.

All of the above systems are known to work well. However, they all have their limits. If you don't mind building things and using a soldering iron, I would advise against the above systems and look at the almost infinite and more exciting custom builds!

Goggles, Glasses or Screen?

What do you choose? This one is down to personal preference and application. For me personally, I like to be fully immersed and therefore have always flown with goggles. For some, being fully immersed makes them feel uncomfortable and they would rather have a screen, giving them the ability to be able to switch between 'line of sight' and camera view, quickly. Now there are glasses available, giving you a screen and line of sight, simultaneously which I can see as a great alternative for many. It all depends on your application and comfort level.

Goggles

Goggles have been around for a while. For a long time there have been systems offering 320×240 QVGA & 640×480 VGA resolution. I'll start with the lowest resolution with Fat Shark's Teleporter goggles. These work fine and have a built in 5.8GHz receiver and head tracker, but the low 320×240 QVGA resolution is disappointing by today's standards.

In recent years, goggles have offered an acceptable 640×480 VGA resolution. Fat Shark started with their Base model giving a wide 35º angle field of vision. What this means is that when wearing your goggles, the edge of the screens are at a 35º angle from the center point of your eyes.

These have been around for a while and still not a bad option. People say they offer a good immersive experience despite the quality not being quite as good as some of the more modern models.

One of the most popular start-up kits from Fat Shark is the Predator V2 system. The goggles come with a built in 5.8GHz receiver. You get a 25mW or 250mW transmitter, a camera and is a plug and play system. It's still my current system and it works really well. Still 640×480 VGA resolution but with a narrower 25º field of vision.

For better screen size and field of vision, there is of course the Attitude and Dominator range. Again offering the 640X480 VGA resolution, but using bigger and better quality screens. Both variants of these models are very

popular. There are pros and cons of each model that steer towards personal preference.

Besides Fat Shark, Boscam also produces FPV equipment and goggles of their own. I have briefly used a pair of the GS920 goggles that feature dual receivers capable of working on 2.4 & 5.8Ghz frequency bands but not cross compatible with Fat Shark systems. These offer a 32º field of vision and another alternative 640×480 VGA solution.

Well worth mentioning are the SkyZone SKY-01 goggles. These are actually WVGA offering 854×480 widescreen resolution. I had the chance to try some of these a couple of weeks ago and was quite impressed by them. However, being widescreen, they do stretch the image on most systems, as systems tend to be 4:3 screen ratio and not 16:9. An important feature of these is that the built in receiver is cross compatible with Fat Shark and Boscam systems and also features Diversity antennas, which in short gives better reception with the right antennas. They also have a camera on the front of the goggles so you can see in front of you without taking them off!

High-end goggles like Zeiss Cinemizer 1909-127 OLED will set you back a fair amount of money! This particular model has been out for a while. The OLED screens offer clear 800×600 SVGA resolution. I've yet to get my hands on a pair and try them, but they receive good reviews!

The Zeiss Cinemizer product video:

Fat Shark Dominator HD's are also 800 x 600 SVGA resolution. I planned to get a pair of these myself. Unfortunately, the availability has been scarce to say the least! Fingers crossed that changes soon and I can try a pair. They offer a very wide 45º field of vision, giving an even more immersive experience. They feature an interchangeable receiver module and head tracking option and include a DVR recorder!

It won't be too much longer before we start seeing 720p or 1080p goggles. Oculus is responsible for the Oculus Rift Virtual Reality goggles by Samsung. If you've not heard about Oculus Rift, take a look. These are a possible game changer! If we could use these, it would be amazing! I believe they're eventually aiming for 1080p resolution! We don't yet have the technology to back up that kind of resolution, but like everything else I'm sure it's only a matter of time.

For a true immersive experience, goggles are they way. If like me, immersion is key, this will be your most important investment. It's important you make the right choice and my advice to everyone is to buy the best goggles you can afford.

Glasses for FPV Systems

If immersion isn't important to you and you want to maintain line of sight of your model and see a screen, than combine the two! Glasses such as Epson's Moverio BT-200 overlay streaming video into your field of vision and allow you to maintain line of sight of your model.

It's cool idea that will no doubt appeal to many. Unlike other systems that stream video directly to your glasses, the Moverio glasses use an Android app installed on the glasses to view the video. I have now have personal experience with the Moverio and have to say that I would not recommend it at this point. The video experience is not stunning at all, but could say is decent. At the same time, navigating in apps and manipulating the device via the trackpad is really cumbersome. From a form factor point of view, the trackpad itself has a sort of indented knurled surface which is not pleasant at all to tap around on. I admire Epson's effort trying to create the device and there surely will be an appeal for this approach, but I believe we will have to wait for the next generation to arrive before we can opt for this product. The current price of more than $550 is also discouraging.

Here is the Moverio BT-200 product video:

Flying with a screen can be pretty good, too. Maybe not as immersive as goggles, but to have the ability to look up and see where your model is when flying, is useful. With any of these options, it comes down to personal preference and application.

FPV Transmitters and Receivers

Where do you start? There are now so many options available. The most common you'll come across today are 5.8GHz systems. There are other frequency bands used but it is important to be aware of the legalities when using them. Laws vary from country to country. I'll use the UK as an example for each band.

900 MHz

Offers brilliant range and great penetration. Unfortunately, shares the band used by mobile phones making it illegal in the UK. Being the lowest frequency, wavelength is longest and therefore the antennas can be quite large!

1.2 GHz

Offers great range and good penetration. Band is used by other sources in the UK and therefore illegal.

1.3 GHz

Offers great range and good penetration. In the UK, this is a clear band. Unfortunately still illegal to use.

2.4 GHz

Offers good range and equipment is cheap. Unfortunately, most RC systems now operate on the 2.4Ghz band, along Wi-Fi equipment, Bluetooth, etc.

5.8 GHz

Offers good range if setup correctly. Equipment is cheap and compact. The band is free of other interference but suffers from low penetration.

Please be aware of the systems you choose and consider the legalities. Power limitations apply! I know that in the UK you're limited to only 25mW! Other countries aren't quite so strict.

Cameras for FPV Systems

If you own a GoPro than you already have a seriously good FPV camera. However, for some applications, a GoPro simply isn't practical. It's just too big. Instead you may want to purchase one of the many smaller CMOS or CCD cameras, of which there a many to choose from. Some perform better than others and prices vary.

Types of camera

CCD (Charge-Coupled Device)

When digital cameras first appeared they used CCD sensors. They're made through a special manufacturing process. The process creates a high quality sensor, which can produce excellent images. Thanks to the high quality manufacturing process, they also produce less noise than their CMOS counterparts. The downside to CCD sensors is that require far more power than a CMOS sensor.

CMOS (Complimentary Metal Oxide Semiconductor)

These sensors are less expensive than CCD sensors because they're much cheaper to manufacture. They do have their main advantages is considerably less power consumption.

Much like everything else in your setup, do your research. Buy once and buy right!

NTSC or PAL

NTSC (National Television Systems Committee)

NTSC is the analogue television system used throughout the American continent and parts of Asia. NTSC video is lower resolution than PAL but appears smoother due to the slightly higher frame rate (29.97 vs. 25 frames per second).

PAL (Phase Alternating Line)

Used throughout Europe and many other parts of the world. Higher resolution than NTSC but with a lower frame rate.

Some people prefer the smoothness of NTSC and some prefer the resolution of PAL. Once again, all down to personal preference.

Cameras – dedicated or integrated?

An important decision to make when flying is whether to run off a dedicated camera, or to use the live video out functionality available with many common cameras like the GoPro and Mobius Actioncam.

Debate still rages about this, but it comes down to budget and intent in the end.

When I started out, I used my Hero2's video out to fly FPV for quite some time. All I used to do was hover up high and fly about carefully, so it wasn't ever a problem. The video filled my goggles quite nicely too.

Once I got into mini quads and higher speed, close proximity flight, I tried a dedicated FPV camera, and since then I haven't been able to switch back. The main problem is that there is a noticeable amount of lag (delay) on the video feed from the integrated solutions, because their internal circuitry has to resize and process the digital video from the sensor into an analogue signal.

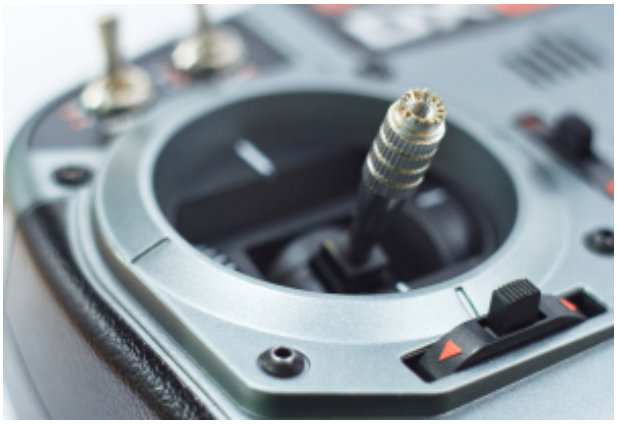
This processing can also introduce problems – the Hero3 suffers from a fairly low frame rate and variable quality in most modes when you use the video output, and the Mobius video has a black border around it, preventing it from filling your vision, as well as severe lag.

Dedicated cameras are generally designed specifically for FPV – so they can compensate for rapid changes in brightness very quickly, which is essential for fast flying in variable light conditions. You can also fly in very dark conditions with them, much moreso than with a GoPro feed.

So basically, if you're on a budget, and don't want to fly fast, you can get away with using your video recorder output, but if you want to race, a dedicated camera is the go.

FPV System Frequencies and Transmitter Compatibility

Obviously you need your transmitter and receiver to match in frequency, but you also need to make sure the two are compatible.



For example, Fatshark and Boscam both support 5.8ghz, but use different frequencies and are generally incompatible (some newer receivers, and goggles like the Skyzones can pick up both types).

The next big thing to note is that you can't use the same frequency bands for RC control and video. RC control is all digital, and can tolerate a lot of interference, but it can't deal with a whopping big analogue video transmitter sitting right

next to the sensitive receiver on the copter itself. Think of a sensitive microphone listening for a gentle bird song far away, sitting right next to a big stereo belting out Iron Maiden. The noise floor is just too high, so you have to choose differing RC and video frequencies.

Why choose one or the other? Well, lower frequencies penetrate solid objects better, but require physically larger antennas, and external receivers (higher frequencies are said to have a slightly sharper picture too, but in reality the difference is often negligible).

If your goal is to trundle around the park, or fly up high within visual range of your craft, 5.8ghz is fine, and will provide the easiest setup.

Lower frequency bands like 900mhz and 1.2ghz are much better for flights where object penetration is important. Your 5.8 system will go through a few trees, but stick a big one in between you and the transmitter, and your video will fuzz out badly. On 1.2ghz you can comfortably cruise around your entire local area, well below the tree line. Think of the difference between AM and FM radio when you drive through a tunnel; the principle is the same.

You might have noticed that I skipped over 2.4ghz. There are a few things to talk about. First of all, the signal penetrates better than 5.8ghz, but not as well as 1.2ghz. This means that your radio control can potentially drop out before your video feed does, and this is Bad. 2.4ghz is also a harmonic of 1.2ghz, and so is more prone to interference. For this reason, many people who use 1.2ghz or 2.4ghz also use UHF control systems for their RC control (typically around 400mhz). As you can see, things get complicated quickly.

The DJI Phantom Vision is a special case. They use 5.8ghz for RC control. Why? Because they wanted to use the 2.4ghz band to send back video from the quad via Wi-fi. So, be very aware of this when flying around people who are using the reverse frequency combination. Always check your frequency bands before flying! Also be aware of the increased lag you'll get with Wi-fi transmission, and the fact that your RC control can drop out suddenly if you fly behind something solid.

Antennas

If you've done any research into FPV, you'll have seen some funny looking antenna designs, with lobes like clover leaves.

Because FPV video is generally sent as an analogue signal, any interference is immediately obvious. Digital RC controls, on the other hand, don't need to worry about interference so much. It's like the difference between digital TV, and the older analogue system that is now a distant (bad) memory for many of us.

Cloverleaf antennas are much better at rejecting certain types of interference, generally caused by the signal reflecting off solid objects (radio waves bounce around just like light does when it hits the right surface).

Because lower frequencies have a physically larger wavelength, antennas designed for 1.2ghz are physically much larger than those tuned for 5.8ghz. This makes them much more fragile, and so if high speed, fast proximity racing is your goal, you're much better off with 5.8ghz, even if you get some interference from the trees.

Receivers

The popular FPV goggles (Fatshark, Boscam and Skyzone) have built in receivers, but if you want the very best reception, or you prefer to use a screen or other goggles, you'll need a standalone receiver. This will require its own battery and cabling to the goggles or screen.

Many people use cheap tripods to mount their ground station gear.

FPV System Installation tips

Some systems, like DJI's Lightbridge, are designed to be plug and play. Others will require basic soldering skills.

A typical installation will always require power for the transmitter. Similarly, dedicated FPV system cameras need

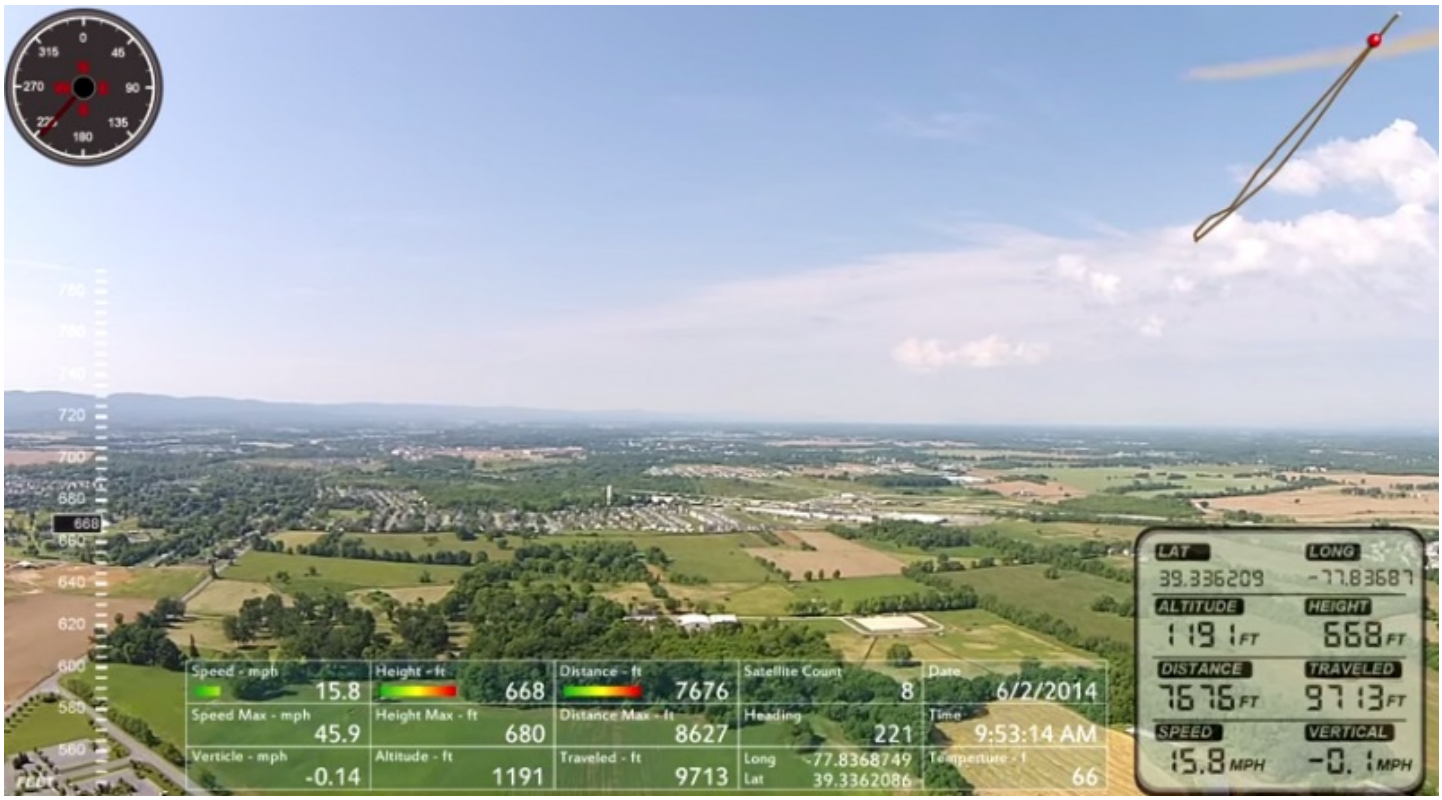
power – and you need to be careful about what voltage you feed them. Some run off of 5v or 12v only, and some can handle a wider range. You may wish to power your FPV subsystem with a secondary, smaller battery as well, to make sure it keeps on tracking if your main battery fails (at least you get to see where you crash).

Standalone cameras like the GoPro can run off their internal power – but make sure they're charged up before flying as the last thing you want is to lose your feed mid-flight.

An obvious Plug and Play type FPV System for DJI Phantom 2 Vision or Vision+ quads would be one that runs it's own android. A good example, and the most obvious choice at this point is the Epson Moverio BT-200. If you would like to keep line of sight with your quad, this is a good option, while some might prefer a fully immersive experience like the Fatshark Predator which unfortunately is not compatible with the Vision product line because of the frequency it uses (as we discussed before).

Installing the Moverio BT-200 is a breeze, as all you have to do is to fire up the built in Android and use DJI Phantom Vision app as you would with your smartphone or table based setup. U can use the trackpad or touchpac that comes in the set to manipulate the app for starting and stopping the recording, tilting the camera and all the other options you have. It is a little something like this:

If you take the time to play around with more optional software solutions, you can set you Moverio Glass based setup to give you a cockpit like view with all the telemetry projected in front of you. You will need additional software and hardware like the Flytrex to record log files and a software called Dashware, but the result is pretty awesome. We will get into more details on this in future posts.



More specific installation instructions are beyond the scope of this article – but tons of help is available from web forums like RC Groups, and often a simple Google image search is all that's required to find a diagram showing how to hook up a given system.

Fly safely

It cannot be stressed enough that we need to fly responsibly, or this hobby will quickly get shut down.

FPV system based flying presents some unique new risks over traditional RC aircraft, because you can fly a long way away very easily.

If there is any chance of people coming into your flying space, having a second person acting as a spotter is a very good idea. This is especially important if you are flying with immersive goggles. Remember that you can't see behind yourself, and the cameras give you severe tunnel vision.

Remember also that many systems have a bit of lag in them. In particular, anything that involves digital processing will be delayed. This can include RC control in the case of tablet-controlled drones. So maintain an appropriate distance at all times!

Hopefully this article has helped clear up some of the basic details of FPV video. As always, there is a lot of information available out there, and I've just skimmed the surface. Do your research, don't rush, and make an informed decision when you pick your gear.