RC 'What's What' for Newbies

Have you just gotten started with radio-controlled models, or perhaps getting ready to do so? If so, and if you are a bit confused, I'm sure you are not alone. I would like to help clear the fog.

Related to the confusion is the number of different brands and types of radio control systems. If you have joined a club, then it's quite likely that you simply decide to use what the one who is training you is using. That makes good sense. And if you don't care about comparing with other options, don't bother reading this. But if you would like to know enough to understand what others are talking about, or if you are still deciding what system to use, read on!

Radio Transmitter Brands

In the past, you simply selected a brand and stuck with it. Transmitters of one brand would not 'talk' to receivers of another brand, etc. Each one had their own protocol for sending the radio signal that they had developed on their own. That has to do with what sort of radio signal they send, and how they use multiple frequencies to make sure it gets through.

Today it's still true that several manufacturers have their own protocol, but there are also manufacturers who have 'reverse engineered' the proprietary systems to either create a module that can send a signal that works with those, or receivers that can receive them. In addition, there is open-source software development taking place that any manufacturer can utilise to provide a good outcome at a low cost.

Radio Transmitter Function

It's often not even thought about, but there are two functions that any transmitter needs to perform. One has to do with computing. Control switches and sticks are indicating what the pilot wants the plane to do (or car, boat, etc.), but that often needs to be altered somewhat. For example, you may want finer control when the stick is near the middle, to make movements less abrupt when you are landing or making small adjustments. But you still want full control travel for extreme movements. That is what we call "expo" or "exponential." It's applying an exponential curve to the control output. When you set up your plane, the instructions will recommend how far the control surfaces should move for full stick travel. That's what we call the rate. And you might want to use a low rate for taking off and landing, to help keep from 'over controlling,' making it easier. And, once you are up in the air, you might want a higher rate to do quick rolls and loops. Working those things out is part of the 'computing' function of the radio. And there is a lot that can be done.

Once the computing part of the radio has worked out what a given control needs to do, that information needs to get sent to the receiver, so it can send a signal to the control servo, or whatever else is being controlled. Translating that information into a radio signal that the receiver can understand is what the transmitter module needs to do. That's done according to a set protocol that both understand.

Often a manufacturer will develop more advanced systems for the computing and/or signal transmission protocol. That might be a higher end model, or simply a new model replacing an older one. Commonly the new or higher end transmitter will work with the lower end receivers by using the old or lower end system with them. But sometimes they are so different that they only work with the receivers designed for the higher end system.

For example, a Futaba T16IZ transmitter works with their high end FASST protocol, or with the lower end FHSS system. Whereas their lower cost T10J transmitter only works with FHSS. With FlySky, they have three different ranges of transmitters. The receiver that you get with the lowest cost transmitter will work with the middle range transmitter, but not with their 'flagship' top end transmitter. Receivers that work with the top end model will work with any of their transmitters.

In recent years, 4 in 1 modules have been created to enable some radios with a module bay to work with any of four major receiver protocols, covering dozens of brands. The module is rather small and simply clips into a pocket in the back of the transmitter. Frsky, Jumper and Radiomaster transmitters are ones that will do that, and you can even get some with an internal 4 in 1 module, without having to use the bay on the back.

Line of Sight or FPV?

When selecting a radio system, you need to think about what you are going to use it for. Traditional radio control flying is line of sight, and that's the way a lot of us continue to do it. You watch the plane as you fly it. With that type of flying a dependable range of 1 km free of obstacles is fine, which all the systems should be able to deliver (clear of obstructions, antennas placed properly).

FPV, or "First Person View," involves a video camera in the aircraft with its signal being transmitted back to the pilot. Viewing that with goggles or on a screen, the pilot flies as if he or she was right in the plane or drone. With that, the control signal needs to be reliable for a longer distance, and able to penetrate objects that might be in the way of the line of sight.

In the past, to get the extra range you would need to go to a lower frequency transmission signal, and that would result in a lag in response. We refer to that lag as latency. That is not likely to cause the aircraft to crash, unless you are travelling fast and dodging trees or other objects. But it would be less precise. Today, that lower frequency would be 900 MHz.

2.4 GHz is the frequency generally used by line-of-sight flyers currently. It is fast, and it has a wider frequency range in its band. That means that it is less likely to have interference problems when a lot of flyers are in one place with everyone using it.

Until recently, that was the choice. But, with the development of ELRS ("Express Long Range System") you can get the best of both. "Express" indicates that it is fast: low latency. "Long Range" is self-explanatory. It can be used on either 900 MHz or 2.4 GHz. But, even on 2.4 GHz, 30 km plus range is achievable, and that's with a set of control signals getting sent to the model 250 times per second! ("Frame Rate").

Before we go any further, be aware that ELRS is a system for the transmission of the radio signal from the transmitter to the model. It's not the computing part of the transmitter that we told you

about earlier. So, a transmitter that is using ELRS to control a model might have Open TX or Edge TX as the system that is doing the computing. More about those later.

One more thing to add. Earlier we mentioned how you can clip special modules onto the back of your transmitter. That can enable you to have a more traditional and common system in the transmitter, and the ELRS in the external module – or the other way around! That allows you to select which system you want to use for a given aircraft.

We might mention that there are things that will reduce the range of a radio signal. Components in a plane can partially block the signal. Having a person's body between the transmitter and receiver will also reduce the power of the signal received. Orientation of the antenna(s) in the plane can do the same. Antennas perform the best when transmitter and receiver antennas are parallel to each other, and perpendicular to a line of sight between them. Effective signal strength reduces as you rotate them relative to each other to where they are crossways to each other. The worst-case scenario would be where the two antennas are pointed directly at each other. That could result in a total loss of control at a relatively short distance. Each of these issues can be mitigated against by having multiple antennas on the receiver and/or transmitter. Placing them at a right angle to each other eliminates the possibility of only having two antennas pointed at each other. Adding a satellite receiver can help reduce the possibility of a component in the plane blocking the signal. Those connect to the main receiver and basically add additional antennas at a distance. The receiver will use the signal from the antenna that has the highest signal strength. And, of course, how you position the transmitter antenna will make a difference. Don't position the transmitter antenna such that is pointed directly at the plane!

A Simple Decision? Not!

You might now think that it's an easy answer. But there are valid reasons for a bunch of different choices. Take Spektrum, for example. That's a very popular, highly respected, innovative and dependable brand. They have all their own 'stuff.' Whether it's the software or hardware, they stick to their own. They put a lot of money and effort into making things straightforward and easy. Their "Smart Technology" allows a lot of information to flow back through the system. It's all oriented to line of sight flying, but if that is what you do, that's not a problem! Spektrum has everything from entry level radios to top professional gear, and as you move up, what you already have in your planes still works.

So, why wouldn't you want Spektrum? The main issue is the cost. And just because they are good, that doesn't mean you will not have problems along the way. My limited experience tells me that any manufacturer's radio will have issues some time or another.

One remaining thought. Most of us flyers are in a community. We are a part of a club, and we encourage new guys to come along. When they do, they will need training, and that means that what radio they use will need to be compatible with something that we have, so that we can set up a buddy box. Spektrum is popular, common, and they have a good, easy to use system for setting up a wireless buddy box for training.

Short Answers – What's What?

TX and RX – short for "transmitter" and "receiver"

Packet – a radio signal containing a set of information on the desired position of a given set of channels covered by the radio.

Frame – a group of packets, usually two, that between them cover all the channels covered by the radio.

Fade – a frame didn't get through on one of the antennas.

Frame loss – a complete frame didn't get through on any antenna.

Hold – 45 consecutive frames not received on any antenna. Basically, a loss of signal for one second.

DSMX and DSM2 – protocol developed by Spektrum for the radio signal going from the transmitter to the receiver. DSM2 was developed first, and it did the amazing thing of jumping back and forth between two frequencies to make sure the signal got through. But today that is nowhere good enough. DSMX was developed to rectify that. It jumps from one frequency to another every 22 milliseconds (ms). As it does that it is jumping through 23 different frequencies out of 80 that are available. The selection of which ones, and the order that they are used is made random by using the unique identifying number of the transmitter. Furthermore, as one frame is sent every 22 ms, that contains two packets, and each of those packets usually has the primary four channels included, with the remaining channels split between the two. So, the primary channels are updated every 11 ms. That's about 91 times per second.

Note that each of the major manufacturers has their own way of doing something similar.

With the popularity of Spektrum, many manufacturers have reverse engineered DSMX and are offering third-party transmitter modules or receivers that are compatible with that system. Examples include transmitter modules built by Radiomaster and Jumper, and receivers built by Lemon RX. Of course, there are others as well.

LBT vs FCC – A radio that conforms to LBT is required in the European Union for radio gear. It limits the level of power that can be used. That's not an issue for line-of-sight systems, but it could be for some long-range systems. FCC is the American standard, which is used by pretty much the rest of the world.

Hall Gimble – The gimbal is what gets moved by the control sticks. A standard one uses potentiometers, which essentially have a metal finger moving back and forth across a coil of wires. They can wear out. A Hall gimble utilises the "Hall effect" which has to do with an electromagnetic field moving in relation to sensors. There isn't anything to wear out in the electronic circuit. Note that as you go to higher priced gimbals they will be more precise. The difference that I have noticed is when you get to the limit of travel of the control stick. With a standard gimbal, if you add pressure to the stick when it gets to the limit, it will increase the level of the signal by about 1-2%. A top-quality gimbal will not do that. Practically that will not make a difference for most of us. But, if you are flying many times every week, after several years you might have some issues with a standard gimbal. By then it's probably time to replace the transmitter anyhow!

FrSky – Pronounced “free sky.” A manufacturer of radio systems for long range FPV, using the 900 MHz band. They have their own protocols for the radio signal. The older one is “ACCST.” It only has a range of 1-2 km, and there can be difficulties in working out what version of firmware (software) to use with it. That has been superseded by “Access.” It still has about the same range, but some of the firmware difficulties have been eliminated. Note that the “Taranis” is a model of radio transmitter made by FrSky.

Radiomaster and Jumper – manufacturers of radios that use open-source software. For the computing side of the transmitter, that would generally be Open TX, Edge TX or Crossfire. Open TX and Edge TX are very similar, with Edge TX being the newest and with the most features. On the radio signal side, you can either have a four in one module, covering many of the line-of-sight protocols, or for long range applications, ELRS or Crossfire (see next item). Using open-source software means that the costs are held down, and it’s amazing how much support and information is provided by the community. Check out https://www.expresslrs.org/. Some manufacturers use rebadged Radiomaster gear.

Crossfire – An older radio signal protocol that is well established for long range use. It uses the 900 MHz band with the long range, high penetration advantages and the high latency disadvantages. Tried and proven, and still commonly used. More expensive than ELRS, less active development.

Points of difference – transmitters

- Cost
    - FlySky has super low-cost transmitters and receivers. The downside includes not enough 3 position switches on the entry level transmitter (but see our video on how you can rectify that: https://youtu.be/fJsJBKB-G9A) and the lack of third-party receivers or add on equipment. Product support is very limited, especially for those of us who don’t write or speak Mandarin.
    - Spektrum has great features, but everything they sell is expensive.
    - Radiomaster has a cost between those two, but has great functionality, including the ability to use both name brand receivers as well as ELRS or other long-range receivers. It’s more oriented towards technically minded users, and has some advantages over Spektrum. But, there are also things that Spektrum Smart Technology does that are better.
    - Lemon RX has low-cost receivers that work with either Spektrum or Radiomaster 4 in 1 transmitters. Those receivers include stabilized receivers with telemetry.
    - As far as we have experienced (and we have used them all), each of the above are quite reliable for the purposes they were made for, but not bulletproof. We have documented a couple of radio failures during flights.
- The number of channels. At least one channel is used for each function. So, with a single engine plane you would have one channel for the throttle. For the ailerons you would normally have one channel, but if you have a separate servo for each side, you may want to use two channels to give you more options on how they are adjusted and

operate. Additional channels for the rudder and elevator cover the basics. But then you have the possibility of stabilization mode, stabilization gain, landing gear, flaps and whatever else you may want.

- Mechanical construction – how sturdy the case is, what is used for bearings in the gimbals
- How comfortable is it to hold?
- Length of the control sticks. Many can be lengthened or shortened to suit an individual's preference.
- How strong the self-centering is on the control sticks. Radiomaster provides a softer set of springs with their transmitters in case you don't like the stronger ones.
- Number of dials or sliders. Note, a slider is like a dial in being able to adjust the signal over a continuous range, and hold it in one spot, but it gets pushed lengthwise instead of being turned. That can be handy to do with minimal movement of the hands.
- Number of switches – 2 position or three position. My older FlySky ST-8 only had one three position switch, and it was on the right-hand side. But I have changed out a two position switch on the left side with a three-position switch. See our YouTube video: Flysky FS-ST8 RC Transmitter Switch Replacement. That radio also didn't have any dials or sliders, but I understand that the new ones do have two sliders on the back.
- Different length of levers on switches next to each other. If there are two side by side, you would like the one closest to the edge to be shorter so that you can move the inside one without also engaging the outside one. In general you should also be able to feel where all the controls are without looking at the transmitter. When you are flying it's good to keep your eyes on the plane!
- Standard vs. hall effect gimbals
- Standard vs. precision machined gimbals
- Does it have a bay on the back for accessories? Is it JR compatible or Nano? What modules are available that will work in that bay?
- Whether it is designed to be simple, doing as much as possible for you, or intended for someone who is happy for something that is more complex but gives more options and capabilities – such as Spektrum vs. Radiomaster.
- How telemetry and other data can be recorded in a flight log. Is it put in a single file for all flights (Spektrum), or is a separate file generated for each flight (Radiomaster)? How hard is it to set that up, and how hard is it to retrieve?
- Whether it has the capability to work with different transmission protocols.
- Whether it has one or two antennas. If your planes all have receivers with two antennas, then it isn't much of an issue, given that you are not pointing the transmitter antenna at the airplane. Otherwise, it is better to have a transmitter with two antennas. This is because of polarization. When the transmitter and receiver antennas are parallel, you get the best signal. If an antenna is pointed directly at the other, it delivers the weakest signal.
- Whether it has an internal receiver to be used as the master transmitter with a wireless buddy box setup (Spektrum). For an example, see our YouTube video: Spektrum NX and DX Buddy Box Instructions - updated

Further thoughts

You want many more control switches, dials, etc. than the number of channels. That's partly because you will want certain types of switches, etc. for different functions, and you may run out of one type. You may want certain switches just to change how something is done with one or more channels, rather than being the primary input for that channel. So, you might have a switch to change between flight modes, one to turn stabilization on, off or safe, a dial to change the amount of stabilization being used when it is turned on, etc. You might also have dials assigned to change screen brightness or adjust speaker volume.

Points of difference – receivers

- Number of channels
- Physical size
- Number of antennas – generally one or two
- Length of lead on the antennas. Only the last 31.2 mm of the antenna functions as an antenna. The rest of it is shielded, but the extra length allows you to get the antennas away from other gear, away from each other and have them perpendicular to each other.
- Whether or not they have stabilization capability
- Limitations on how they can be oriented if being used for stabilization
- Setup procedure for stabilization can be quite different
- Telemetry – what information can be sent back to the transmitter, and do you need to add accessories to do that?
- With telemetry is it flyby range or powerful enough to be continuous?
- Is a binding plug required for binding, or can it be done with a button?
- Does it have the option to add a satellite receiver? That's a secondary receiver that has its own antennas. The main receiver will use the strongest signal coming from any antenna on either the main receiver or the satellite receiver.

Final thoughts

There is still more to learn, but this should give you a good start. To learn more, check out our YouTube playlist on Radios and Electronics.

