How the Draganflyer Flies

Rotory Magazine ••• Nick Sacco

When I first saw the Draganflyer, I knew that this little electric, four-motor helicopter was pure fun. Even though I've flown conventional fuel-type helicopters for years, the idea of a four-motor, four-rotor helicopter was just too good to be true.

Although the Draganflyer is constantly undergoing engineering changes to make it more commercially desirable, its basic premise is that it is a stable hovering platform that climbs and turns by manipulation of the motor-rotor speed only! The Draganflyer uses some fairly sophisticated electronic wizardry to maintain its stable hovering characteristics, but all this is totally transparent (and should be) to the user. After all, do we want to enjoy it or constantly be tweaking and tuning it?

The daily "non-maintenance" is where the similarities to conventional model helicopters stop. As an avid helicopter hobbyist, I enjoy the tuning and tweaking that is a normal part of helicopter life. But I get a vacation from it with the Draganflyer. The Draganflyer is designed to be nearly maintenance free, have a long service life and provide the owner with valuable flying time anytime it is required!

The kit is nearly assembled when received. Wiring consists of plugging a couple of connectors together and the assembly steps are essentially tightening a few screws. Set-up for flight readiness is just as easy also: Charge the batteries, align the motors and go have fun! Quite a contrast to conventional helicopters whose complex pitch mechanisms demand hours of tuning and specialized radio gear.

When you purchase the Draganflyer, you don't have those tasks and all the necessary radio gear is included. Actually the Draganflyer is a complete flying package. All that's missing is YOU.

So how does it work?

The Draganflyer, as I alluded to earlier is designed as an integrated flight package. The circuit board that lives in the center of the machine is the magic (and truly the heart) of the Draganflyer. That means that the remote control system, the stabilization system, and the power system are built into it. There's nothing else to purchase. Let's break down these three main components of the Draganflyer and see just what makes it go…

The Remote Control

The remote control system consists of a 4-channel conventional FM system common in the remote control hobby industry. The Draganflyer uses a standard Futaba® radio transmitter, but in living up to its integrated design, the radio receiver is literally built into the Draganflyer's electronic "brain". Viewing the circuit board from the side, the radio receiver would be the top portion to which are mounted the LED's (light emitting diodes) that serve as the Draganflyer's "ready" indicator and eerie-looking "eyes." The remote control system is a 4-channel receiver having the decoder circuit, the oscillator and RF crystal (which determines on which radio frequency it is operating).

Also located on this particular circuit board is a long square component called a piezo gyro. I'll come back to that when I discuss the **Stabilization Section**.

The Power System

This set of components is located on the horizontal circuit board and is essentially a set of 4 speed controllers – one for each of the 4 motors. The most obvious components are the large square devices located near the rear of the circuit board called FET transistors. FET means Field Effect Transistors. These devices may be thought of as an electronic valve. There are 3 wires on each FET. Two of the wires supply voltage to its motor, while the third wire (the trigger) is how the "valve" is opened. Apply a small voltage, the valve opens a little and the motors start to turn. Apply a little more voltage, and the motor turns faster still. Now just imagine that the FET is responding to your raising and lowering of the throttle stick on the transmitter (via the radio receiver) and you now have a grasp of just how the speed control works.

The wizardry in my opinion is how, by applying certain aspects of physics, the Draganflyer is controlled. Let me give you an example. When something turns, in this case a propeller a force is generated by the motor called "Torque" The propeller wants to turn one way and the motor, the other way. I am referring to Newton's law that states that a force in one direction will produce the same force in the opposite direction. Another force caused by uneven thrust of the propellers at differing attitudes, is known as "P factor.

Conventional helicopters overcome these forces by using a tail rotor. As the main rotor blades are turning via the engine, the opposite force is trying to turn the helicopter's body in the opposite direction. The tail rotor has a variable pitch mechanism that simply pushes more (or less as the case may be) air and produces more linear thrust that offsets the effect of torque and "P factor." Without a tail rotor, a conventional helicopter's body would spin out of control. To actually *cause* the helicopter's body to turn (or pirouette) the pilot either increases tail rotor pitch or decreases tail rotor pitch depending upon which way the turn is to be initiated.

In the case of the Draganflyer, the exact same forces apply. The speed controller is designed to match the front and back, left and right motor-rotor speeds to be exactly the same. But the Draganflyer rotates the left and right motor-rotors in the opposite direction from the front and back motor-rotors. This, in effect neutralizes the torque and "P factor" allowing the Draganflyer to hover without spinning out of control.

So what happens when you push the right transmitter stick to the right or left as you would in a turn? Simple, this is called **Roll**. The Draganflyer's electronic brain receives the signal through the remote control receiver. The signal received tells the motor controller to send more power to the left motor-rotor and simultaneously reduce the power to the right motor-rotor by the same amount. This causes the Draganflyer to maintain altitude (total thrust has not changed) but to tilt up on the left side and thus begin a right turn. The exact same thing happens, albeit in the opposite direction when the transmitter stick is pushed to the left.

When the right transmitter stick is pushed forward or backward for a **Pitch** control (either nose up or nose down) a similar series of commands are given to the front and rear motor-rotors.

Lastly, when the left transmitter stick is pushed to the right or to the left, simulating “rudder” on a conventional helicopter, the Draganflyer’s electronic circuit responds by increasing (or decreasing) the front and back motor-rotors opposite from the left and right motor-rotors. This in effect upsets the torque and “P factor” *balance* of the aircraft and the machine begins to pirouette in response to whichever direction the left transmitter stick is pushed.

Kept in either left or right pirouette, the little machine can get a wicked pirouette going that will make **your** head spin just watching it!

The Draganflyer has this speed logic built into the circuit board’s “chips” and the ratio of motor-rotor speed is a design consideration of the machine.

The Stabilization System

Up to now, You’ve hopefully gotten a pretty good picture of just how the Draganflyer stays in the air and remains under control. What you may not appreciate, is that without the Stabilization System, no one could fly it! The Draganflyer’s motor-rotors and propellers are designed to turn at a pre-determined RPM. Since nothing in this world is perfect, each motor is going to react to the same voltage differently and each FET is going to react to the “trigger” voltage differently. While these differences may be subtle, they are enough to make the Draganflyer nearly impossible to fly. So to create a usable machine, a stabilization system is employed. This same principle applies to many of the high-tech military aircraft such as the Stealth fighter.

In the case of the Draganflyer, the Stabilization System consists of some logic circuits and 3 of those long cylindrical devices called piezo gyros. As I said before, one is mounted vertically on the vertical circuit board, while the other two are mounted on the horizontal circuit board.

Of the two mounted on the horizontal circuit board, the left one is oriented in a front to back position, while the right one has a left to right orientation.

If you haven’t guessed by now, they are mounted that way because of the 3-dimensional space that flight itself occupies. These piezo gyros are used to detect movement in 3-dimensional space. That is: **Vertical** and **Horizontal** or Up and Down flight as the receiver-mounted unit detects. **Pitch** (Pointing nose down or up) as the left horizontal-mounted gyro detects, and **Roll** as the right horizontal-mounted gyro detects.

Basically the piezo gyros are there to sense movement in any or all of 3-dimensional space and provide correctional motor control. Think of this as “dampening” the machine’s controls. Without this dampening as I said previously, the machine would be nearly impossible to fly. This is simply due to the speed at which the machine’s electronics are responding to the transmitter controls. Essentially, when we give a command to the Draganflyer, as in a turn for example, to the right the Piezo gyro circuit controls the speed at which the FET trigger responds and gives the motor-rotor speed changes. What we end up with is a well-behaved machine that is ***possible*** to fly!

Generally speaking, the piezo gyros are configured to produce the *opposite effect* to what they've sensed. That means that if the gyro senses the right side of the Draganflyer for example dropping, it *increases* power to the right motor and *decreases* power to the left to compensate. All this is programmed to happen for you. Of course to perform a right turn, the electronic brain understands that the stick commands from the transmitter override the built-in logic.

So how do the piezo gyros work? Piezo gyros actually harness 2 theories of Physics. One is the piezoelectric effect and the other is the Coriolis effect.

How many of use have used the familiar outdoor gas grill? If yours has that little red push-button that makes a snapping sound to produce a spark to ignite the gas, you've seen one example of the piezoelectric effect.

Pierre Curie discovered the piezoelectric effect in 1883. He noted that certain materials, such as quartz crystals, produce a voltage when they are mechanically stressed. Conversely, those materials' shapes are deformed when a voltage is applied to them. Piezo may be made of a several substances, but the most common are quartz, Rochelle Salt and barium titanate. Piezo derives its name from Greek. P*iezein*, to press tight, squeeze.

Essentially, when a force is applied (i.e., a hammer such as our gas grill example) a voltage is generated. Additionally, when a voltage is applied to piezo, it responds by bending. How much bend is determined by voltage and the structure itself.

How does this make a Draganflyer more stable? Again, we turn to the other basic theory of Physics I mentioned - The Coriolis Effect. Some people have heard of this while watching the weather channel. The Coriolis Effect was named for Gaspard-Gustave de Coriolis was born in June 1792 to Jean-Baptiste-Elzéar Coriolis and his mother Marie-Sophie de Maillet. Coriolis is best remembered for naming and demonstrating that the laws of motion could be used in a rotating frame of reference if an extra force called the Coriolis acceleration is added to the equations of motion.

What does that mean? The best example is perhaps the earth. As we know, the earth rotates to the East. Given that the earth is round, it makes sense that the speed of the earth at the equator (the widest part) must move faster than at the poles. It must, since a person at the equator reaches the same point in space as the person at the pole.

That means that if an object were to be launched from a point on the equator North toward a target perhaps in Greenland, the object would miss its target unless it was corrected for Coriolis Effect. In other words, the object, when launched would be traveling at the same speed as the equator. As the object neared Greenland, it would encounter that part of the earth traveling much slower than at the equator. The net effect is that the object would appear to be moving to the East at a rapid rate when it is truly traveling in a straight line. The faster the object travels to Greenland, the more pronounced the effect.

Now imagine a tiny cylinder – a piezo element. On that cylinder are mounted electrodes. Some electrodes are used to apply electrical current and some are used to measure electrical current.

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When electrical current is applied, the piezo element bends to a predetermined shape. Now a frequency is applied to that current and the element begins to vibrate. Along the axis of this cylinder are the electrodes used to measure current. When the piezo is rotated about the longitudinal axis, there will be a secondary vibration caused by the Coriolis Effect. The electrodes receive this secondary vibration and translate that to mean rotational movement.

The reason that the piezo element vibrates is to create the speed necessary to produce the Coriolis Effect. Its vibrating motion is similar to the earth's rotation. The rotation of the vibrating piezo element causes the vibrations to go out of sync and these out of sync vibrations are what the gyro's electronics utilize to sense motion.

Hopefully this bit of explanation helps you understand and appreciate the electronics of your Draganflyer even more. Imagine all this is going on while you're out just having a good time with your Draganflyer!