

## Radio Control System Operations

By Bob Aberle



*In foreground is model mock-up with all RC-system components in place. In back is RC transmitter with antenna mast almost fully collapsed into case.*

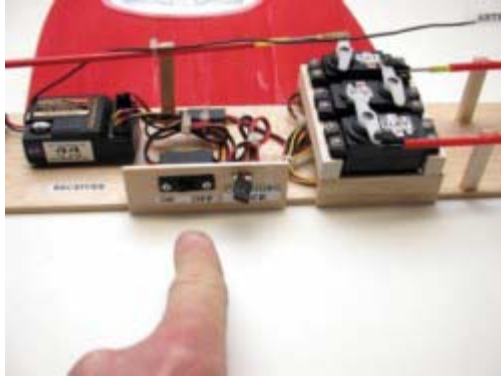
IN THE PREVIOUS installments—the second and third, in the April and May issues—I discussed the basic Radio Control (RC) system, the selection process, and basic installation in a model aircraft. This month I'll get into the operation of an RC system. More detailed information using a basic training model will be provided in following months, including the assembly and flying aspects.

For the purpose of this presentation, let's assume we have that RC model-aircraft mock-up (containing the RC airborne components) from the previous article sitting in front of us on our workbench. The RC transmitter is nearby. To get familiar with your new RC system you are encouraged to operate it at home, try the various controls, and even pretend you are flying the model! Allow yourself to get the feel of it.



*Hitec Laser 6 is typical four-channel-function-control RC transmitter. Antenna mast is collapsed to short section, to which channel-number flag is attached. Shortening antenna greatly reduces transmitted power, making transmitter safer to operate for tests in shop and permitting convenient range check outdoors. If you can get receiver to operate to roughly 50-100 feet from transmitter while antenna is retracted, you will have out-of-sight range once model is in air and antenna is fully extended.*

Before turning on that transmitter, think for a moment about your location. If you are operating from your home shop or garage, the important thing to consider is whether there might be an RC flying field in the immediate area. You would be wise to check this out before turning on your transmitter for the first time. Keep in mind that two identical RC channels can easily interfere with one another.



*Failure to turn on receiver power for your model only after you have turned on transmitter power could lead to jammed control rods and broken servo gears.*

As a precaution, you can operate your RC transmitter for relatively short periods with the antenna fully collapsed. By doing this you are able to operate your RC system for checkout purposes, but the transmitted signal will be greatly reduced. Extended use of the transmitter with the antenna collapsed might cause overheating and damage to the output stages.

A cardinal rule of RC operations is to turn on your transmitter, then turn on the receiver (airborne pack). Use the reverse order when shutting down the system; turn the receiver off first and the transmitter off last. (The transmitter goes on first and off last.)



*Finger points to transmitter power switch. Always turn on transmitter power first and turn receiver on second.*

If you turn the receiver on first, without any signal being broadcast from the transmitter, it is possible for the servos to jitter (dither) or even drive to an extreme control position and stall out the servo motor. In this condition you would have excess battery drain and might even damage a servo motor or gear.

Make sure your transmitter and receiver battery packs have been charged properly. The supplied dual-output battery charger should always be employed prior to operating the system. The amount of charge placed on these batteries by an RC system dual-output charger is at a low enough level that they can't be overcharged.



*Charge transmitter and receiver battery packs using supplied system dual-output charger overnight—at least 10 hours. More time won't hurt. Do not try to put back in the battery what you think you took out. In this simulated photo, wall-plug transformer was not plugged into 115VAC outlet.*

The general rule is to charge transmitter and receiver battery packs overnight, or at least for 10 hours. The only problem you might experience is if you charge for less than 10 hours. As I have already stated, never attempt to just put back into a battery what you think you took out. Several charging sessions for only an hour or two can quickly lead to a battery that has little, if any, charge remaining. That is an invitation to potential control problems in flight.

Most RC transmitters will have a meter, an LCD (Liquid Crystal Display) voltmeter, or color indicator lights that inform you of your batteries' charge status, and some even provide an audible alarm when the battery needs to be recharged. The airborne battery needs extra monitoring while at the flying field; we will get into that in the installment about flying.

Now that we have the batteries charged and we know the sequence for turning on the power, one of the first steps on a new RC airborne installation is to determine that all controls operate from the proper control sticks on the transmitter. The order in which each servo cable plugs into the RC receiver makes the difference. For our initial training purposes we will employ only three channel functions, such as rudder, elevator, and engine/motor (throttle) control. That will involve three servos for a fuel-powered model or two servos and an Electronic Speed Control (ESC) for electric power.



*The three servos operating rudder, elevator, engine throttle are plugged into receiver connectors 1, 2, 3 respectively. If transmitter rudder stick operated elevator servo, you would unplug one of three connectors and try another location until rudder responded properly. At other end of connector block is power input plug from switch harness.*

With the transmitter and receiver powered up, move the rudder control stick, which will be on the right side (or right control-stick assembly) on a three- or four-channel-function transmitter. Rock this stick side to side (left to right) and observe the rudder on the model (or mock-up in this case).

The rudder should move when you operate the control stick. If, say, the elevator moves when you move the rudder stick on the transmitter, you have to change the servo plug at the receiver.



*Finger holds rudder-control stick over on transmitter, and rudder is hard over at aircraft (mock-up) end. It means rudder is moving in correct direction; applying right rudder at transmitter results in right rudder at aircraft.*

I wish I could simply tell you that connector position one at the receiver is always rudder, two is elevator, etc. Unfortunately no two RC manufacturers use the same convention or order. The rudder and elevator functions will generally be on the first and second position, with the throttle on the third.

So if your rudder stick is operating the elevator, swap those first two connectors at the receiver terminal block. Try the rudder stick again; the rudder will most likely operate properly. Try the elevator control stick in an up-and-down motion, and the elevator will probably respond. If it doesn't, you must try other connector positions on your receiver until the control-stick command operates the correct control function.

Try the throttle control on the transmitter. This will be located on the left-side control-stick assembly (on a four-channel transmitter) or on the rear of the transmitter case for a three-channel transmitter.



*Rear of Hitec three-channel transmitter showing throttle channel lever located away from case edge, which would be the idle position.*

For a glow-fueled model you will be using a third servo to operate the engine carburetor (throttle device). In this instance, it will be obvious when you move the transmitter throttle stick that the throttle servo is responding. It won't be as obvious when using electric power because the ESC is substituted for a servo, but we will get more into that next month.

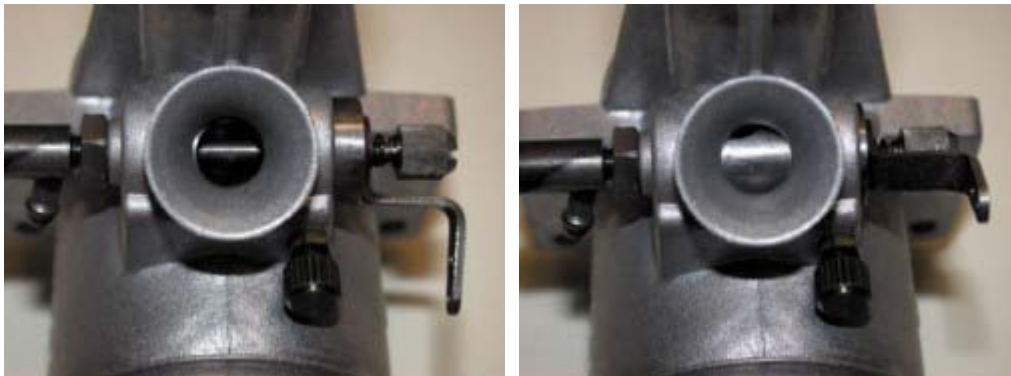
Now we have the control surfaces and throttle operating from the correct control sticks on the transmitter. The next important thing to check is the direction of the servo movement. We are going one step further in our basic checkout procedure.

Move the transmitter rudder-control stick fully to the right side while observing the rudder's position on the mock-up (simulated aircraft in this case!). The rudder should be deflected to the right, which would produce a right turn in the aircraft. As you move the control stick from the neutral position to the extreme position (such as full right), the rudder operates in direct proportion to your stick deflection. This proportional control allows you to impart any amount of rudder control to the aircraft, depending on how far you deflect the control stick.

Let's say that the rudder moved to the left when you applied right rudder stick at the transmitter; that means it is hooked up backward, which could easily crash your model on its first flight. Almost all modern RC transmitters have a servo-reversing switch for each control function. In this case, flip the rudder-reversing switch to the opposite position.

Now move the control stick to the right, and the rudder should move to the right. Follow this same procedure, and check to make sure that the elevator moves up when you are pulling back on the elevator control stick.

Check the engine throttle control. With the throttle-control stick in the uppermost position, the engine carburetor should be set for full open, which will provide full, or maximum, power. At the bottom throttle-control-stick location, the carburetor should be almost fully closed, which will provide a low idle speed. On a three-channel transmitter, with the throttle-control lever located on the rear of the case, convention usually dictates that moving the lever to the outside of the case is high throttle and moving the lever toward the inside (pulling it toward you) is the idle position.



*Looking inside typical glow-fueled model engine's carburetor with throttle barrel at full open for full, or maximum, power (left) and almost completely closed off (right) to produce low or idle speeds.*

On some of the lesser-function RC transmitters (such as the three-channel variety), it is possible to see servo-reversing switches on the first two channels but not on the throttle channel. If this is your problem, it will require special attention. On a glow-fueled model, you simply move the throttle control-rod location from one side of the servo output arm to the other. That will reverse the direction of the control. It gets more complicated in the case of electric power; let's leave that for next month.

The next item to concern ourselves with is the position of the trim levers for each channel function. On most RC transmitters there are levers adjacent to the control stick (for rudder, elevator, and throttle) that when moved can impart a certain small amount of control adjustment for trimming purposes while the aircraft is in flight. These levers usually have a ratchet-type device that produces a clicking sound when moved; this is done to prevent unwanted movement of the trim levers.



*Each primary channel function (rudder, elevator, throttle on three-channel radio; aileron, rudder, elevator, throttle on four-channel radio) has own trim-lever adjustment. Shown is rudder trim lever set in middle position; rudder itself is exactly at neutral.*

The full movement of a trim lever will usually impart approximately 15% of the full control throw. Digital trim is being employed on some of the more sophisticated RC transmitters, in which case the traditional lever is replaced by a push-button switch. There will be more about that when we get into the advanced radio systems, at a much later date.

For each new model you are advised to turn on the transmitter and receiver, then position the rudder and elevator trim levers for the middle or center position. With the throttle control stick in the high or full-power position, move the throttle trim lever to the uppermost position.

At this point you might observe, with your hands off the transmitter control sticks, that your rudder and/or elevator are/is not exactly at the neutral control position(s). If that is the case you must adjust your control rods, which presumably have adjustable clevises on at least one end. By screwing the clevis in or out, you are changing the length of the control rods, hence the position of the control surface (rudder or elevator).



*Adjustable clevis attached to top hole of elevator control horn. Spring device is slid up over clevis and acts as safety "keeper." It will prevent clevis from opening. If you detach clevis, you can rotate it on its threaded rod, which will allow you to adjust elevator position. Which hole you select on control horn will provide different amounts of control throw.*

With the throttle stick at full power and the throttle trim at the uppermost position, your engine carburetor should be full open. Again, adjusting the clevis will make this happen. Moving the throttle control stick all the way down should make the carburetor opening almost fully closed. This will provide a low idle speed. At this point, if you move the throttle trim lever to the lower position, the carburetor, if mechanically set properly, will completely close and the engine will stop running.

Mechanically adjusting the carburetor control linkage can take extra patience. More advanced RC transmitters have electronic-type dial-up adjustments that make carburetor settings easy, but I want to keep everything simple for the moment.

If you were dealing with a real model with a glow-fueled engine, at this point it would be appropriate to take it outside and run up the engine a few times. This would allow you to fine-tune the carburetor settings for the various throttle control stick and trim-lever positions.

A guest author will write an article about fueled engine operation and the necessary support equipment (fuel type, fuel pump, starter battery, starter motor, propeller size, tank size, fuel lines, muffler, etc.) within the next few months.

How much control throw or control excursion do you need for your first few flights? Model-aircraft manufacturers and model designers who publish plans in magazines usually provide guidelines for your initial flights. They may suggest one-inch rudder throw or travel on either side of the neutral position and half-inch elevator control on either side of neutral.

If you don't get a recommendation, ask a friend who has more experience than you do or use the one-inch rudder and half-inch elevator for starters. It is probably better to have a little more than less control for that first flight. Once you get past that point, your instructor (hopefully you will have one!) will correct the control throws as necessary to make life easier for you as you learn to fly and solo.

Making adjustments to increase or decrease control throws (control-surface movements) is generally handled by the selection of the hole position on the servo output arm and the control horn on the control surface. Moving the clevis attach point from the outside control-horn holes to the inside will cause increased throw. The same can be done (if more convenient) at the servo output arm. Moving from the outside hole closer in to the servo-output-arm hub will prompt a decrease in control throw.



*Pointer shows black plastic keeper that prevents control-rod wire end from falling off servo output arm. Output arm screw is securely in place. Without this screw, servo output arm might fall off. Which hole you select on servo output arm affects amount of control throw obtained.*

Never forget to make safety checks on your model. Do this before your first flight and on a regular basis thereafter. One of the most common problems is failing to properly attach the control-surface hinges. Hinge choices and their installation will be the subject of a future article.

For now, no matter what type of hinge you use, physically pull on the control surface to make sure it is secured properly.

Throughout the years, I can't tell you how many rudders or elevators I've pulled off of beginners' models before a first flight. You can have the best radio system and the best model in the world, but if a rudder or elevator falls off in flight you will have no model at all!

In the same regard, make sure that all of your control-rod clevises, or whatever connectors you employ, are locked in place. Small keepers can be purchased to slip over the clevis so it can't separate. Other types of "keepers" prevent a Z-bend wire end from dropping off of a servo output arm.

Also make sure you have that single screw in place holding the output arm to the servo hub. I've seen many output arms fall off in flight, only to result in major crashes. The radio and aircraft worked fine, but those pilots were beaten by a single missing screw (known as single-point failure).

Most trainer-type models' wings are held to the fuselage with a few rubber bands. You shouldn't be too casual with what looks like a simple task; don't use a couple of leftover rubber bands. Most average to larger models should use the standard No. 64 rubber bands. The smaller models, such as park flyers, can use lighter-weight No. 33 size. You can find these rubber bands in quantity (bags or boxes) at the larger stationery stores (such as Staples and Office Max).

Each model should employ approximately six rubber bands to hold down a wing. Use a cross pattern, such as front left dowel to right rear dowel (three and three). Although seemingly wasteful, use new rubber bands each time you go to the flying field; it's cheap insurance.

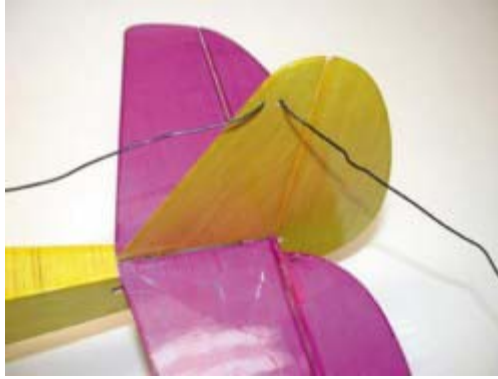


*To hold medium to large model's wing to fuselage, use at least six No. 64 rubber bands—three on each side, crisscrossed.*

Every RC receiver will have an antenna wire, which is usually roughly 40 inches long, exiting its case. On larger models you will have plenty of room to "hang" or stretch out this length of wire. On the smaller models you may end up with a considerable excess length that has to trail off the rear of the model. Don't cut any of this antenna wire off! Your receiver is tuned for that specific length. Making the antenna shorter can have a serious effect on your RC performance. Most important, the range of radio operation might be reduced.

As you get into the hobby, you will learn that special shortened antenna rods can be substituted for the full length of wire. A primary source for these antennas is Eclectic Electric Necessities, or E-Cubed R/C ([www.ecubedrc.com](http://www.ecubedrc.com)). Several models are available, down to as short as 11/2 inches in length. Radio reception is said to only be reduced by 15%. However, you will be required to cut off the existing antenna close to the receiver case, then solder the wire from the new rod to the remaining wire stub. For now I'd prefer that you stick with the supplied, full-length antenna.

Antenna routing, or locating in the fuselage then out to the tail, is most important. If you get too close to such noise generators as a servo (the motor inside) or an ESC, you might see interference in the form of jittery controls or reduced radio range.



*Simple receiver antenna attachment on top of fixed vertical fin. Pass wire through one hole, out the other. Leave remainder of antenna wire hanging off rear of aircraft. Don't cut off any antenna wire!*

The best idea is to get the antenna wire outside the fuselage as soon as possible, then route the long wire up to the top of the fixed vertical fin or out to the tip of the stabilizer. I generally drill two holes in the stabilizer tip or top of the vertical fin, and pass the antenna wire in one hole and out the other. I don't like to place any real tension on the antenna wire because it might eventually break. Nor do I favor attaching the antenna wire to any moving surface, such as the elevator or rudder; the constant flexing motion could eventually break the wire.

With every new airplane and new radio-system installation, you must run a prescribed range check to make sure you have adequate control when the aircraft gets hundreds of feet away from you in the air.

The best way to do that is to collapse the transmitter antenna as much as it will go. If it retracts all the way into the case, leave a few inches sticking up above the top of the case. By doing this, you will greatly reduce your transmitter's transmitting power, which will allow a simulated range check, but at a much shorter distance.



*Airtronics Radiant transmitter (L) and trainer cable used to connect two RC transmitters. Student holds one transmitter and instructor holds other. Instructor can hit switch and take primary control of model at any time.*

Turn on the transmitter then the receiver. Operate all of the control functions. Have a friend hold the aircraft and walk away from you. You will be holding the transmitter and moving, say, the rudder control stick hard every few seconds. At the aircraft end you should see the rudder move positively to your exact commands.

A point will be reached where the control surface will start to get nervous or jittery. A little beyond that point the radio may even stop working (the control surface locks or simply doesn't move). The exact point at which that happens can vary between 50 and 100 feet. The exact distance can be determined from your RC-system operation manual or by contacting the manufacturer directly.

If you only get 10 feet or so, you have a problem. It might be in the radio itself, the batteries might not be charged, or the antenna-wire routing might be too close to a servo. No matter what the problem, it must be resolved before you attempt a first flight.

It's a good idea to run such a check at your local flying field. Get a club member or a local flier to coach you through this process the first time around. Remember to obtain the frequency-control pin for your channel number before you turn on your transmitter!

Since fueled engine vibration and electrical noise generated by electric motors can have an effect on radio range, run the same transmitter-antenna-collapsed range check while running your fueled engine or electric motor. If everything is okay, you should be able to obtain the same range regardless of whether the engine/motor is running or not.

On most four-channel RC transmitters with dual control-stick assemblies, there is a hook and eye located in roughly the center of the front panel. This bracket accepts a neck strap that many RC manufacturers supply with their systems. You put the strap around your neck and attach it to the hook and eye on the transmitter case. The strap helps support the case, leaving your fingers free to grip or operate both control-stick assemblies.



*Transmitter neck strap attached to hook and eye on Airtronics Radiant transmitter. Strap goes around pilot's neck and supports transmitter case, leaving both hands free to grip and operate transmitter control sticks.*

Complete transmitter support trays are also available. Their use is quite common with the RC pilots throughout Europe. The tray is supported by a neck strap, then the RC transmitter is placed into the tray. Longer-length control sticks are usually substituted. The pilot can grip them, making it feel more like flying a full-scale aircraft. I encourage you, as a new flier, to keep it simple and resort to these support devices later, as you gain experience.

I almost forgot to mention that most RC transmitters provide certain adjustment for control-stick length and spring tension. You can read about how to do this in your operating manual. It is strictly a matter of preference; I rarely change a factory control-stick setting on any of my transmitters.

There are several items you should be aware of as you begin your flight training. They will be the subject of articles in the near future, as you absorb all of the details of this wonderful hobby.

One such item is a "trainer cable." Many RC transmitters have trainer jacks or connectors and trainer-operated switches. You can purchase the cable as an accessory item from your RC-system manufacturer. You must have the same brand of RC system, and it is helpful, though not imperative, that you have the same model of RC transmitter.

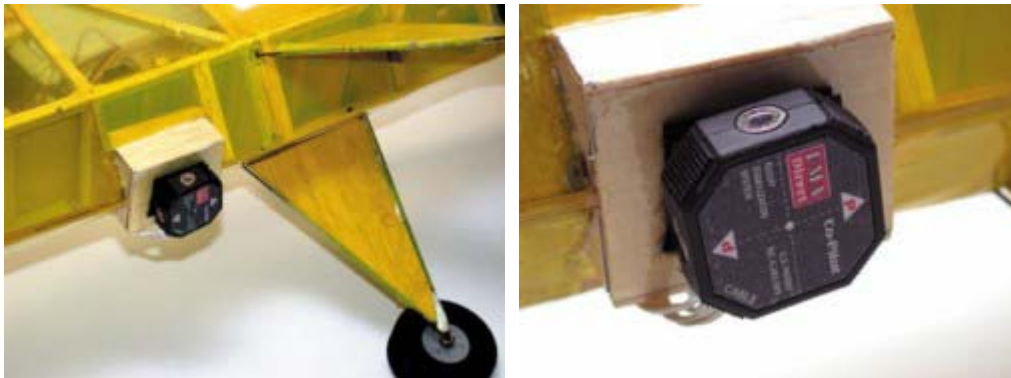


*Rear of Radiant; trainer cable is plugged into special jack. Same goes for other transmitter, which gets other end of cable.*

The idea is to plug this 6- to 10-foot cable between the two transmitters. Only one transmitter will actually send the signals or control commands to the aircraft. Your instructor holds one transmitter and you hold the other. You will be in control of your aircraft, but if you get into a situation that might prompt a crash, the instructor holds onto a long-handled switch and instantly takes over control of the model. This is considered a better technique than having the instructor grab the transmitter from you each time you get into trouble.

We have recently seen several self-stabilizing devices come onto the hobby market. The one that comes to mind is the FMA Direct Co-Pilot, which I reviewed in the August 2002 Model Aviation (pages 77-79). This device uses an infrared sensor, located on the bottom of the fuselage, to sense and maintain level flight.

Let's say you make a turn and the aircraft starts to spiral and descend. Just take your fingers off the control sticks, and the Co-Pilot will almost instantly return your model to level flight. This is where the term "self-stabilizing" comes from.



*FMA Co-Pilot sensor on bottom of aircraft fuselage. This self-stabilizing device will return model to level altitude when you take your hand off control sticks.*

Simulators are an extension of video games. They operate from a personal computer (PC) and use a transmitter case and control sticks instead of the traditional mouse. You view the aircraft's flight on the PC monitor and input controls via the transmitter box. These simulators have become quite refined in recent years and offer considerable realism, making it easier to learn some of the basic control maneuvers. The use of simulators will be the subject of a separate Model Aviation article in the near future.

After all of this, you are ready to go out to the flying field and make your first flight. Well, almost ready. We haven't discussed a specific first-time model. It is important to learn how to assemble it

(in the case of an Almost Ready-to-Fly, or ARF, type of model) and install the necessary RC equipment, and then you can head out to the field for that first flight.

Next month I'll introduce you to electric-powered flight. It's my specialty, and I have used it exclusively for many years. I've had considerable success training new RC pilots using this form of power.

My intention in succeeding articles in this series is to select an electric-powered ARF, assemble it, show how to operate it, then get you out for that first flight. After that I have a simple-to-construct, original-design electric-powered sailplane to include. The idea will be to teach you "scratch building" from magazine plans in its simplest form. All of the radio and electric power equipment from your ARF will be transferred to the scratch-built model. You will also receive the all-important flying instructions.

I recognize that not everyone in our hobby likes or wants electric power, so guest authors/experts will write articles for this series to include such topics as assembling and flying glow-fueled ARFs and basic building techniques and covering skills that everyone needs to know, regardless of what power source you choose. We hope to get into model kit building as well.

Other types of models will be explored that do not employ RC, yet can be equally enjoyable to fly (such as Control Line, Free Flight, rubber power, and Hand-Launched Gliders). That's what this series is all about.

Please write in with your questions and suggestions to "From the Ground Up" in care of Bob Hunt, Box 68, Stockertown PA 18083; E-mail: bobhunt@mapisp.com. That is most important to us.

→