Advanced RC Systems
By Bob Aberle

THIS IS MY 10TH installment in this initial phase of the "From the Ground Up" series. I'll be back next month with some frequently-asked questions and in the April issue the emphasis will shift to fueled models under Frank Granelli's expert tutelage.

Typical RC transmitters (L-R): Hitec Neon three-channel (single control stick); Hitec Laser 6, which has two control-stick assemblies but is basic—not a computer radio; Futaba T6EXA entry-level computer radio; Hitec Eclipse, which is computer driven and has channel synthesizer.

At the beginning of this series I discussed some of the basic Radio Control (RC) systems as an overall introduction to the model-aircraft hobby. To keep it simple and inexpensive, I selected a basic three-channel transmitter with a single control stick. I use several of these systems for my flying, so please don't worry; I didn't recommend that you buy something that would quickly become obsolete.

As the series progressed I described the Hitec Neon three-channel system, then the electric power system, and then the Aero Craft Pogo as a first-time (Almost Ready-to-Fly) training aircraft.

My student Jay Federman had already done a bit of flying on his own, and he owned a four-channel, dual-stick RC transmitter. When we flew the Pogo for the first time, using a trainer cable, Jay had to hold the Neon transmitter since it was the one broadcasting the signal. The master control was my transmitter (a dual-stick-assembly four-channel unit), which I held as the instructor pilot.

Jay got confused because the throttle lever is on the rear of the case (of the three-channel transmitter) and it operates with a side-to-side motion. He had done some flying using a left-side control stick that moved up for high speed and down for idle speeds.

I recognized this problem right away, and many readers wrote in to "scold" me for having suggested a three-channel RC transmitter to a beginner. Admittedly, as you progress to four-channel ("full house," as we call it: elevator, aileron, rudder, and throttle control), the throttle control will be on the left stick and is operated with an up-and-down motion.

I guess some apologies are in order. Just keep in mind that the three-channel RC system will never become obsolete. It is well suited for my RC sailplanes, parking-lot flyers, and indoor RC.

I'm getting into more advanced RC systems at this time because eventually you will want to, and when you do you will quickly appreciate some of the extra features they can offer. You will also be pleased to know that many of these advanced radios are simple to operate and are comparatively inexpensive. So let's get into it.

A basic RC transmitter, be it a three- or four-channel-function unit, will not be what we call a "computer" or microprocessor-type radio. It will not have a Liquid Crystal Display (LCD) screen that allows you to set the special commands or controls.

L-R: Futaba T6EXA computer transmitter is covered in text. Hitec Eclipse transmitter can be set for high or low FM deviation and with Spectra synthesized module can dial up any of 50 RC channels for models. Polk's Tracker II has all Eclipse features, but you don't have to remove module to change channels.

Most basic transmitters have servo reversing, and a few might even offer dual rate control on two-channel functions. Servo direction is usually changed with the flip of a tiny switch (unplugging and rotating a cable on the Hitec Neon). Dual rate control cutback is adjusted by rotating a small potentiometer control (dial). These basic radios have a few switches and potentiometers (dials) but no internal computer circuitry and certainly no memory circuits.

An advanced RC transmitter has an internal computer chip that contains a great deal of stored program information in its memory circuits. It can also store your control inputs, allowing you to operate several models from a single transmitter.

You can tell that it is a computer-driven system because it has an LCD screen on the front of the transmitter case. (One exception is the FMA Direct T-80RF, which is just a small step up from a basic unit). The LCD screen displays a variety of parameters; some are basic and preplanned for you, and others you can call up from a menu system that is programmed into the transmitter.

How you access these menus, make changes, and store the new inputs in the memory is what an advanced RC transmitter is all about. Once learned, you will have many more control features available for your use. You can start with an advanced RC transmitter, but use only basic controls until you gain a certain amount of experience.

Before I get into a computer-driven RC transmitter's inner workings, I must mention several more facts. Most modern RC systems broadcast their signal on frequency modulation (FM). Only a few amplitude modulation (AM) radio systems are still on the market, and they are gradually disappearing.

You can't intermix signals with these systems. An FM RC transmitter can't operate an AM RC receiver. Even within the FM category, there are two types of signals that various manufacturers employ. One is called FM deviation on the "low side." Futaba, Hitec RCD, FMA Direct, and GWS make use of this type of signal. There is also FM deviation on the "high side," as exhibited in radios that JR Remote Control and Airtronics manufacture.

Left: Rear of Hitec Neon three-channel single-stick transmitter. Pointer shows location of throttle-control leve which must be moved side to side to adjust engine/motor speeds. Right: Futaba T6EXA computer transmitter, which has two control-stick assemblies. Throttle control is obtained from left stick and operated in up-and-down movement (for high and low throttle settings).

Keeping all of this in mind, a Futaba FM RC transmitter can operate a Futaba FM RC receiver and FM RC receivers made by Hitec, FMA Direct, and GWS. A JR FM RC transmitter can operate a JR FM receiver and an Airtronics FM receiver.

Utilizing smart programming techniques, several RC transmitters are able to select "high" or "low" FM deviation. This can be a bonus since one transmitter can be used to operate almost any brand of RC FM receiver on the hobby market, provided it is on the same frequency (RC channel). Later I will mention an even more sophisticated RC transmitter that uses a synthesizer which is capable of dialing up any of the 50 RC channels available for model aircraft.

I hate to get complicated early on, but in FM RC equipment there is one other type known as pulse code modulation (PCM). It is a technique in which a special digital code is added to the FM signal. It provides much greater interference rejection than regular FM, but it is usually only offered on the expensive, top-of-the-line radio systems. These PCM systems also provide a fail-safe feature that adjusts the controls to preset positions and reduces the engine throttle if interference is experienced.

You should also know that each manufacturer uses its own dedicated digital code, so you must stay with one brand for the transmitter and receiver; you can't intermix these units.

Types of Advanced RC Systems: You have already been introduced to the basic radio. There are also "first step" computer-driven RC transmitters. These entry-level systems offer many extra control features, are relatively easy to use, and are comparatively inexpensive (full systems range from $180 to $250).

Several manufacturers offer a further step into the computer-radio market with systems ranging from $300 to $500. These offer more features than the first-echelon systems but add a certain amount of complexity. For the all-out expert competition-minded pilot, there are top-of-the line radio systems that cost as much as $1,000 and more. That won't be for you for some time yet!

The JR XP662 distributed by Horizon Hobby is a popular entry-level Radio Control computer transmitter.

The First-Step Computer-Radio System: All of the popular RC manufacturers—including Airtronics, FMA Direct, Futaba (Hobbico), Hitec RCD/Multiplex, and JR (Horizon Hobby)—have these entry-level computer-radio systems. Some of the big mail-order hobby companies also offer "house radios," but they are generally made by the manufacturers I just listed.

The model numbers of these first-step radios are important for identification purposes. For instance, the Airtronics VG6000 has a new, innovative menu system. I expect to review this radio in *Model Aviation* in the near future.

The Futaba T6EXA is simple and affordable (roughly $180!), and this is the one I will explain in depth in a moment. Also popular are the Hitec RCD Flash 5 X and Eclipse models and the JR XP662. I have to admit that at this time I have little experience with the new Hitec/Mulitplex systems from Europe.

You do not need to use any of the special features on these first-level computer radios right away. You can turn off or inhibit the extras while you learn to fly your first few RC models.

New Airtronics VG6000A is popular entry-level computer RC transmitter. It will be featured in an MA product review in the future.

Futaba T6EXA: The heart of any computer-radio system is the transmitter, and that is what I will discuss. Refer to the photos as I proceed. Some photos are of the LCD screen on the T6EXA transmitter, and others are of the illustrations in the Futaba instruction manual (for added clarity).

Most RC-system manufacturers include their instruction manuals on their Web sites. They are posted as PDFs (Portable Document Formats) for viewing, or even printing, purposes. You can access the Futaba T6EXA manual at www.futaba-rc.com/manuals/6exa-manual.pdf.

The six-channel-control-function Futaba T6EXA transmitter offers:

- low-voltage alarm
- digital trims
- six model memory positions
- the ability to reset any memory slot to the factory-default positions
- dual rate control of two channel functions
- exponential rate control of two channels
- endpoint adjustment (EPA) on all channels
- servo reversing on all channels
- trim memory and position
- programmable mixing of any two channel functions
- wing mixing (elevons, flaperons, V-tail)
- throttle cut for glow-engine operation and provision for trainer cable

It's all there in that one transmitter case! Keep in mind that six memory positions means that you can fly as many as six models from this transmitter.

Looking at the T6EXA's front panel, you will see the two dual axis control-stick assemblies. When flying with only three channels, the right stick operates the rudder and elevator and the left stick moves up and down for the throttle control. All control sticks have spring return to the neutral position except the throttle, which has a ratchet device to hold the last position.

When using four-channel control, the right stick usually has the aileron and elevator functions and the left stick assembly provides rudder and throttle. For years this stick configuration has been called Mode 2. A few pilots (mostly in Europe) still fly

what is called Mode 1. I have no intention of getting into that other mode at this time, but the T6EXA is capable of Mode 1 control as explained in the manual if that is your preference.

In addition to the four basic flight controls, a fifth channel is available to operate a retractable landing gear, as a towhook release on a sailplane, or as any other auxiliary function you might think of. It is not a proportional control channel; the servo goes to one side or the other (no neutral position). The fifth channel is operated by the "CH.5 GEAR" switch at the upper left corner of the case.

At the top right corner of the transmitter case is a knob that proportionally operates a sixth channel function; it is identified as "CH.6 FLAPS." This channel is primarily used as a flap or spoiler control, but, again, you could use it for a variety of auxiliary functions.

Futaba T6EXA is roughly $180 from Tower Hobbies. Full system has receiver, four servos, full Ni-Cd battery packs.

There are several more switches on the front panel. At the upper right is one identified as "AIL/ELEV D/R." It simultaneously turns on or off dual rate control for the aileron/elevator (or rudder/elevator for three-channel control). This switch also turns on/off the special exponential rate control to the same two channel functions.

At the top left corner of the case is a momentary contact (spring return) switch to operate the trainer-cable function. The "From the Ground Up" installment in the September 2003 issue (on page 71) has a more detailed discussion about using a trainer cable.

When momentarily pulled forward and released, that trainer-cable switch will act as an engine-kill (stop) switch. This is helpful when your transmitter employs digital trim, as does the T6EXA. By pulling this switch, you don't have to operate the throttle digital trim lever to completely kill your glow-fueled engine. (Frank Granelli will explain this in more depth later in this series.)

We've finally gotten to the computer system. At the lower portion (middle) of the transmitter case is an LCD screen. To the left of the screen are two push-button switches identified as "MODE" and "SELECT." To the right is a data-input switch that moves up (+) and down (-). Next to this switch the six channel controls are listed by number and function, such as "CH1=Aileron," "CH2=Elevator," etc.

When you first turn on the transmitter power, an initial or basic display will appear on the LCD screen. It will have a small number (1 through 6) at the upper right and a larger number, such as 10.0v, at the lower right. The smaller number tells you which computer-memory position is currently in operation.

The larger number is this particular transmitter's battery voltage. At 10.0 volts or slightly higher, the transmitter battery is close to full charge. When the voltage falls to 8.5, an audible alarm will sound and a battery icon will flash on the LCD screen. This is a warning to land your model immediately because you only have several minutes of charge remaining. At that point you recharge the battery or substitute a freshly charged battery pack.

Upper left portion of Futaba T6EXA transmitter case. Switch on front is for "CH.5 GEAR"—a nonproportional auxiliary channel. At top left corner is "TRAINER/THT CUT": a momentary contact switch you pull forward to operate; when you let go, it springs back rearward. It operates trainer cable function or can kill a glow-fueled engine.

To access the various control features, you must get into the T6EXA computer menu. Many of these computer radios have two menus; one is for basic programming and selection of the model memory and the other contains all of the detailed control features. I chose the T6EXA because it only has one menu, which makes it simple.

With the transmitter power on, press the MODE and SELECT switches (keys) and hold them for a second or two. The first thing to show up on the LCD screen is the "MODEL" memory position. A large-size number (1 through 6) will flash on the screen. You change the model number by pressing the data-input (+ or -) switch. This will allow you to scroll up to 6 or down to 1.

On some computer transmitters you can add a model's name to the memory-position number for identification purposes, but that feature isn't available on this unit. As an alternative I pasted a list on the rear of the case indicating each model and the number assigned to it.

You must be especially careful when selecting the correct model-memory position. If you don't select the right number, you may find your controls reversed and a crash could easily result. On the other hand, remember that you can operate as many as six different aircraft from this transmitter.

While still in the MODEL portion of the menu, if you press SELECT you will see a "CL" flash on the LCD screen along with the model memory-position number. Pressing either data-input key (+ or -) for roughly two seconds will erase any inputs stored in that memory position. Controls will then be restored to factory-default settings. This can be helpful when you are setting up controls for a new model.

Moving along the menu, press MODE and you come to "REVERSE." This function will let you reverse any servo's direction. Press SELECT to choose the channel function you want to reverse (1 to 6), and then press + or - to select the "NOR" (normal) or "REV" (reverse) servo direction. Press MODE again, and the "D/R" (Dual Rate) function comes up. The menu keeps going in one direction, as in a loop. If you miss an item, keep pressing MODE until it appears again.

Dual rate control applies only to channels 1 (aileron or rudder when flying with three channels) and 2 (elevator). The LCD screen will show CH 1 or CH 2, which you choose by pressing SELECT. Then you will see 100%, meaning that the control is set for "full," or maximum throw. Use the data-input - switch to reduce the control to something less than full.

Top right corner of transmitter case. "AIL/ELEV D/R" switch turns dual rate, exponential rate control on or off. On top is "CH.6 FLAPS" knob you turn to operate proportional sixth channel function. You can use it to operate flaps, spoilers, or any other auxiliary function.

Now that AIL/ELEV D/R switch at the upper right comes into play. With it in the down position, you want your aileron or rudder and your elevator at full throw, or 100%. Move that switch to the upper position, and the reduced throw that you just set (something less than 100%) will appear. Keep in mind that the AIL/ELEV D/R switch affects the two channels at the same time on this transmitter; you can't separate the aileron and elevator functions.

Dual rate control can be helpful on faster models. At takeoff and landing speeds you have the controls set at full, or 100%. During the flight, you can flip the D/R switch to the up position and the controls will be reduced somewhat, making the airplane easier to fly at high speeds.

When pressing the SELECT switch while in this same D/R function, after D/R you will come to an added feature called exponential rate control. When you get to this function you will see a plus and minus sign and 0% on the LCD screen. If you then

press the minus switch, you will see a negative number such as 5, 8, 10, 15, etc. These negative numbers make the initial servo movement less than normal.

What happens is that the control response is slower or "softer" around the neutral position. By selecting that negative number, you can tailor the feel to suit you and your model. I realize that this sounds slightly complicated at first, but you will learn as you gain experience with the system. Keep in mind that with the T6EXA you can have dual rate and exponential rate together or you can have dual rate or exponential rate separately.

The next menu item (press MODE) is EPA. This is available on all six channels. It is especially nice to have EPA on the throttle channel when using a fueled engine; it makes high and low carburetor adjustments so easy.

Lower front part of Futaba T6EXA has LCD screen, control necessary to operate built-in computer system. To left of screen are "MODE," "SELECT" switches. At right is "DATA INPUT" switch; it rocks up or down for + or - control inputs. Each channel function (six total) is listed next to DATA INPUT switch.

With EPA you can set the servo control throw to the exact amount of control required. You can even set the elevator for more up than down or more right aileron than left. This is probably the best feature in a computer-radio system. It is the control function you will use the most.

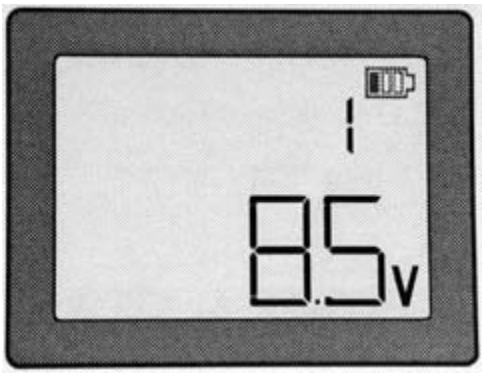
As you go through the menu and make control adjustments, your inputs are saved automatically in the computer each time you move on to the next menu item or if you turn the power off. Afterward, any time you call up that particular model memory position, the control inputs you made will be right there for you (stored in the computer memory).

The next menu item is important because it involves the trim function. Each of the four main channels has a separate trim switch. On this transmitter the trim is the more modern digital variety. The purpose of trim is to allow you to set your model for straight and level flight with your hands off of the control sticks. You "rocker" the trim switches left or right or up and down to achieve level flight characteristics.

Once you have a model adjusted for level flight, you can call up the "TRIM" menu item. It will allow you to select any one of the four channels that provide trim (aileron, elevator, rudder, or throttle). For each function the LCD screen will provide a numerical trim position. This is strictly for reference purposes. Remember that

whatever trim you use on a particular model to achieve level flight will be stored in the computer and will remain until you make changes.

On this particular transmitter, the fifth and sixth channel functions do not have trim. Also, on the CH 3 throttle function the trim only operates when the control stick is down close to minimum throttle. This is so you can set your fueled engine carburetor for the lowest possible idle speed yet not stall the engine. Frank Granelli will go into this feature.



When you initially turn on transmitter, basic screen display will appear. Small "1" in upper right corner is current model-memory position. Larger "8.5v" is transmitter battery voltage. At 8.5 volts, audible alarm will sound and battery icon on screen with flash, telling you to stop flying and recharge battery.

The remaining menu items cover certain mixing functions. There is a programmable mixing ("P.MIX") circuit that will let you combine any two control functions. I like to use this for coupled aileron and rudder on some models. When you apply ailerons to bank the model, the rudder will respond to that single command.

Several wing-mix ("W.MIX") functions can provide such things as elevon control ("EL") that will mix aileron and elevator for flying wings or delta-wing models. The flaperon ("FP") function makes both ailerons drop down for flap-type control. A V-tail ("V") mixing function provides a rudder and elevator effect, as on a Scale Beechcraft Bonanza. I won't get into these mixer functions in any detail because you probably won't be using them right away.

Quite a few computer-driven RC transmitters include multimodel-type programming; they offer menus specifically for fixed-wing aircraft, for helicopters, and in some cases for sailplanes. This makes for some difficult menu searching. Also, the switches are marked three ways, making identification difficult. I chose the T6EXA radio because it has one menu and is intended exclusively for fixed-wing aircraft.

Many of these computer RC transmitters draw upward of 200 mA of current. It is still common to see 600 mAh-capacity Ni-Cd batteries supplied with these systems, but in today's hobby market we are seeing NiMH batteries in the same AA size with capacities up to 1100 mAh and more.

Batteries such as these are available from suppliers such as Batteries America and SR Batteries. They even provide the mating connectors for your particular brand of

transmitter. If you want more capacity with which to operate your transmitter for longer periods of time, these higher-capacity replacement packs are the way to go.

Just remember from my "Battery Basics" article (in the October 2003 *Model Aviation*) that you must charge these batteries at the rate of C/10 (capacity divided by 10). An 1100 mAh battery would have to be charged overnight at 110 mA. To obtain that kind of current you will need a variable output charger, such as the Ace R/C Digital Dual Variable Charger.

A number of computer transmitters currently on the market employ a synthesizer: a circuit that allows you to dial up any one of the 50 channels available for flying model aircraft. You can purchase the Hitec Eclipse transmitter with Hitec's Spectra synthesized module. This module plugs into the rear of the transmitter case. To change channels, you unplug the module and rotate two tiny dials to obtain any channel from 11 to 60.

The Eclipse is also one of the transmitters that lets you select high or low FM deviation. That means you can operate any FM RC receiver on the market with this transmitter (regardless of the deviation or the channel number).

Polk's Modelcraft Hobbies has gone one better with its Tracker II computer-driven transmitter, which accommodates more than 90 memory positions. A synthesizer lets you select any one of the 50 RC aircraft channels using the LCD screen so you don't have to remove a module and twist any dials. You can also enter the channel number for each model into the memory along with the proper deviation.

When you first turn on the Tracker, a built-in scanning receiver (right inside the transmitter) scans the operating channel before allowing it to go on the air. The Polk's Seeker companion receiver can listen for an FM signal and then set itself to that channel. With this concept you could switch channels every flight and never have to wait for an available channel.

The fact that these computer-driven transmitters can store control data for many models means that you will need many more receivers (one for each model) but only one transmitter. Generally, the RC manufacturers would like to sell you an entire system: transmitter, receiver, and servos. Through the years, many of these manufacturers have priced airborne packs (receiver and servos) at practically what it costs for a full system.

More recently, companies have come out expressly with aftermarket receivers and servos that will work from almost any computer-driven transmitter. FMA Direct has a complete line of receivers and servos. It even has a micro-size dual-conversion receiver (the M5) that weighs 0.35 ounce! Using aftermarket microreceivers and microservos is commonplace today, especially with parking-lot and indoor RC flyers.

When mixing and matching computer transmitters, receivers, and servos, you will have to contend, to a degree, with connector polarity. Connectors used on receivers, switch harnesses, and servos now follow the same convention.

On three-pin servo connectors, one outside pin is battery negative, the center pin is battery positive, and the other outside pin is the signal. Plug it in one way, and the

servo works. Reverse the connector (some have keys that prevent this possibility), and the servo does not work.

One thing is for sure: you cannot blow out that servo with this type of polarity convention. Years ago this was much more of a problem. The only connector that is still different is the charger plug on the JR transmitters; the center pin and outside connection are different on this plug than on all others in the RC hobby industry.

For the More Advanced RC Pilot: Most of us fly on one of the 50 RC channels that the Federal Communications Commission (FCC) has made available expressly for the control of model aircraft. With 50 channels to choose from and added features such as synthesizers with dial-up channel-selection capabilities, you never have to wait very long to make a flight.

However, you may see certain concentrations of channels at local flying fields. One possibility to avoid a "channel traffic jam" is to obtain an FCC ham radio license and then operate on the Amateur Radio Service 6-meter band (50 MHz). Many RC manufacturers offer systems on 10 channels near 50 MHz.

If you are interested in what it takes to become a ham and practically be able to fly on your own channel, contact the national organization (which is like our AMA). It is the American Radio Relay League, 225 Main St., Newington CT 06111; Tel.: (880) 594-0200; Web site: www.arrl.org.

My articles in this series began with the March 2003 *Model Aviation*. Look for Frank Granelli and the glow-fueled-model input for months to come. I expect to do several "guest spots" on subjects such as parking-lot/backyard flying, indoor RC, Lithium-Polymer batteries and their application, and some FAQs (frequently-asked questions), which will be published next month.

Keep in mind that this series is posted on the *Model Aviation* portion of the AMA's Web site, at http://modelaircraft.org/mag/index.htm. ***MA***