Radio Control System Operation

All modelers should have a basic understanding of how the radio control (R/C) system works. This knowledge can help to determine when there are apparent radio problems and possibly the cause.

There are four (4) basic components of an R/C system:

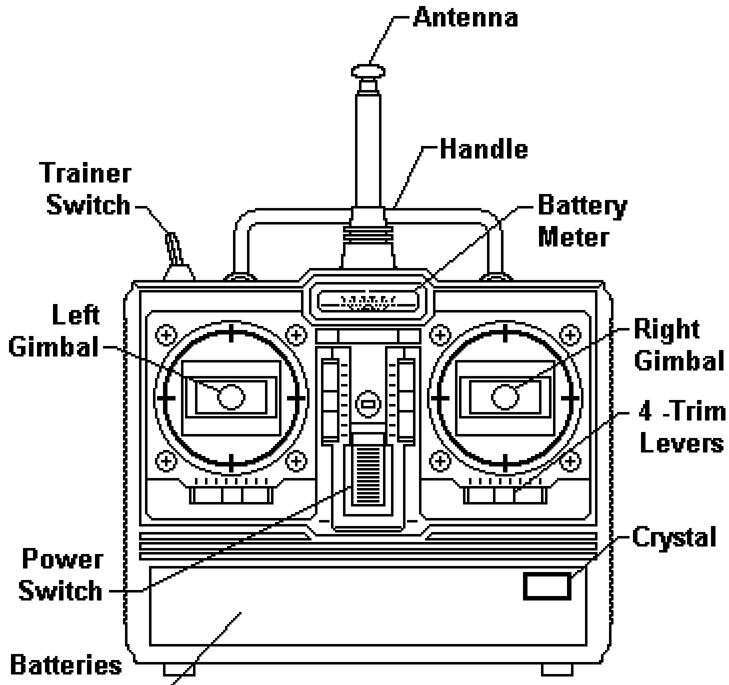
Transmitter	-	The unit which takes the input from the user through the gimbals or sticks, encodes it, and sends it to the aircraft
Receiver	-	The unit that receives the signal, decodes it, and routes it to the appropriate servo
Servos	-	The device that converts the decoded signal to mechanical force to operate a control surface
Batteries	-	The device that provides power for the other devices to operate

There are specific frequencies assigned by the Federal Communications Commission (FCC) for use with airborne R/C models. A modeler must ensure that the system that he chooses is operating on one of these frequencies. Most radio system manufacturers place a sticker on the outside of the carton that says, "For airborne use only". There is frequency reference chart available that lists the purposes of all of the frequencies that are assigned for R/C use. The AMA has assigned channel number to all of the frequencies that have been allocated for R/C use.

The radio that is chosen must meet the 1991 specifications for narrow band transmitters and receivers. The modeler need not know the actual requirements of these specifications because the systems are required to be certified to this standard. The owner's manual for the system will note that the requirements are met and many of the transmitters and receivers will have a gold sticker to signify this fact, although the sticker is no longer required by the AMA.

The radio system may transmit and receive on either AM or FM. FM radios seem to be less prone to interference than the AM although those using AM radios seldom have problems with interference. Some radio systems use one of two types of modulation systems to help to nullify interference. These are called pulse position modulation (PPM) and pulse code modulation (PCM). Each has its advantages and limitations.

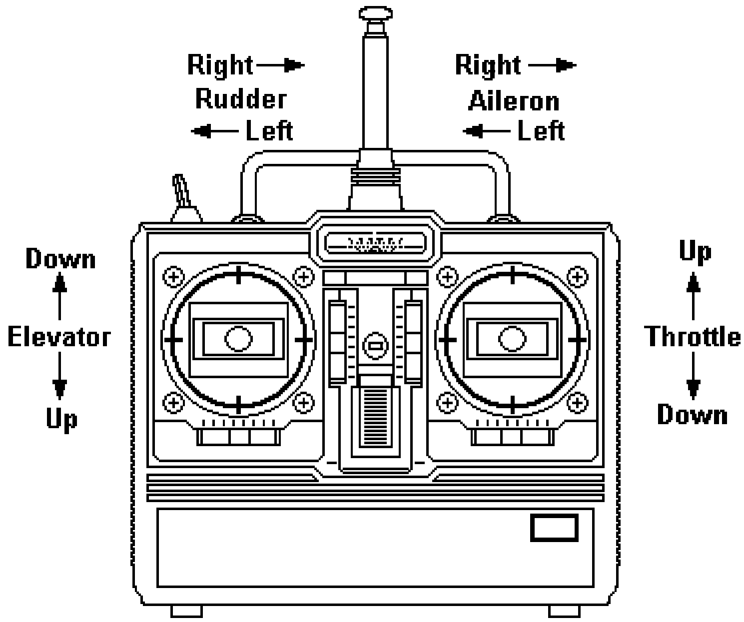
Regardless of the brand of system, the number of channels, or the price, all transmitters have the same basic components. Transmitters may have additional switches, slides, and displays depending on the functions they perform but the basic components remain the same.



Typical Transmitter

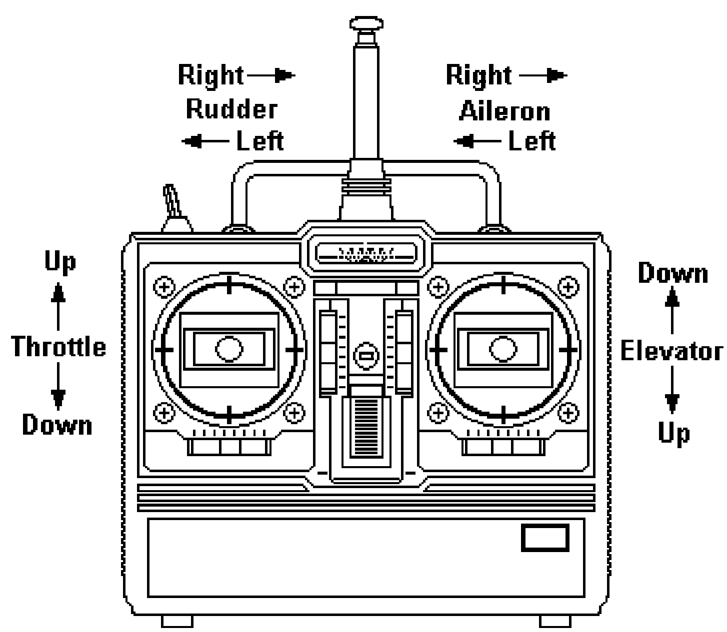
Antenna	-	The telescoping tube that transmits the signal
Batteries	-	The device that provides power to the transmitter
Battery Meter	-	The device used to monitor the strength of the transmitter batteries
Crystal	-	The device that sets the radio frequency of the transmission
Gimbal (or Stick)	-	The device that allows the user to input desired control movements into the transmitter
Handle	-	The device for carrying the transmitter
Power Switch	-	The switch used to apply battery power to the internal components of the transmitter
Trainer Switch	-	The switch used to allow an instructor to give control of a model to the student
Trim Lever	-	Slide controls used to adjust control surfaces during flight

There are two (2) primary modes of operation, meaning the way the gimbals are set up for operation. There are unsettled debates as to which mode is the easiest to use and best for modelers. The modes of operation have become switched between the United States and most European countries. Mode I is primarily used in Europe while Mode II is primarily used in the United States.



Mode I

Mode I started in the days of reed actuated proportional systems. The transmitters were uniformly set up in this manner. The thought was that the elevator and rudder or ailerons were the primary controls and each should be operated by an opposite hand for precision control. Later this carried over into the more modern proportional systems since this was the mode used by most modelers.



Mode II

In later years, the thinking changed to the Mode II configuration. More modelers believed that it was easier to control the primary surfaces effectively with the same hand. Mode II grew in popularity and is used almost exclusively by aircraft modelers in the USA. A beginner does not have to be concerned about which mode he should select since most manufacturers install the gimbals according the most widely used mode for the nation to which the radio system is being shipped. However, most R/C radio manufacturers will supply the choice of modes on special order.

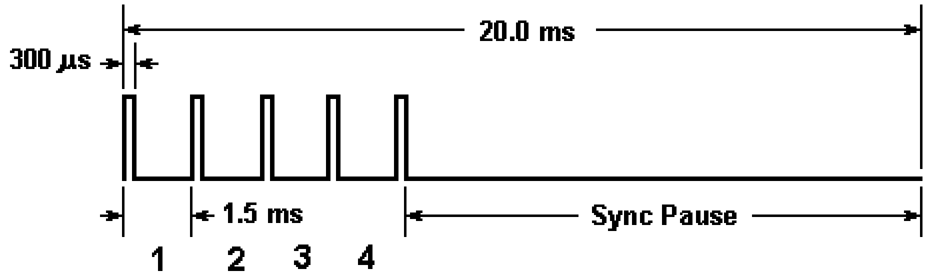
Any number of channels may be used to control a model from a single channel to control the rudder to eight (8) channels which might control ailerons, rudder, elevator, throttle, flaps, landing gear, bomb bay doors, and canopy. Although a radio system may feature six (6) or more channels, they do not all have to be used. Many modelers buy six (6) channel systems in order to get the added features of dual rate and exponential control while only four (4) of the channels are used for controls.

In order for a model to be controlled in flight, the modeler must be able to input control movements which are sent to the model and translated into control surface movements. This is the sole purpose of the radio control system. The radio transmitter consists of an input device, an encoder, a radio frequency (RF) section, and an antenna. Each part serves a specific purpose and each is required for the total operation of the system.

An input device may be a gimble, a knob, a switch, or a slide control. Basically, each of these devices set a particular resistance value that represents a particular type of movement or input. This is the method that the modeler uses to relay needed control movements to the model. The actuation of an input device is emulated in some way at the model depending on the installation.

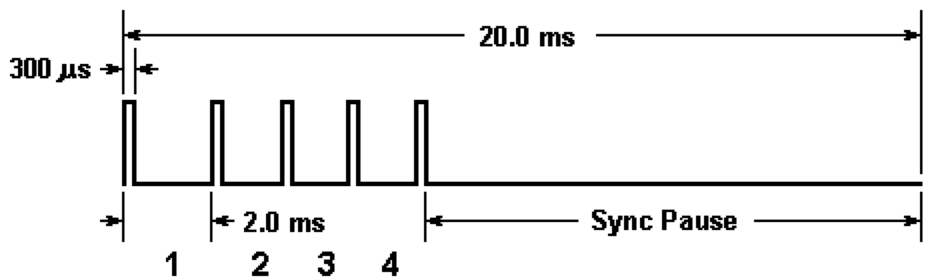
The input devices are connected to potentiometers, which convert the positions into voltages. A dedicated IC called an encoder reads these voltages and produces a stream of pulses that is then sent to the RF section. The pulses are set to specific values as determined by the value of the input device and placed in a stream called a pulse train.

The pulse train is a series of square wave pulses that are about 300 microseconds in width. For a standard 4-channel transmitter, there will be five positive going pulses. With all surface controls in neutral and the throttle control at midpoint, all of the pulses will be spaced approximately 1.5 milliseconds apart which is measured from the leading edge of the first pulse to the leading edge of the next and on down the line to the last pulse. Assume the base line is 0 volts and the positive going pulses are at about 5 volts. When the trailing edge of the last pulse in the train drops down to zero volts, the output of the encoder stays at 0 volts for a period of time that is called "sync pause". After the output has been at 0 volts for a period of time, another set of pulses called a "frame" of information or data is generated. The purpose of the sync pause is to reset the decoder IC in the receiver to start receiving another set of pulses. Most PPM/FM transmitters have a frame period of about 20 milliseconds.



Neutral Controls

As a command is given, the distance changes between the pulses. If Channel 1 is moved to the full upper extreme, the pulse width will be approximately 2.0 milliseconds wide as shown in the Channel 1 Control detail. The length of time can vary from 1.0 to 2.0 milliseconds depending on the stick position. If a switch is a 2 - position type, these pulses are 1.0 millisecond in length when the switch is in the off position and 2.0 milliseconds in length with the switch in the on position. If a switch is a 3 - position type, these pulses are 1.0 milliseconds in length when the switch is in the first position, 1.5 milliseconds in length with the switch in the next position and 2.0 milliseconds in length with the switch in the last position.



Channel 1 Control

The sync pause will vary in length so the frame width will stay the same. The sync pause is long enough so with all controls in an 8-channel system at 2.0 milliseconds, there is still have enough time left in the sync pause to reset the decoder in the receiver.

The RF section is the part of the transmitter that actually generates the radio signal. The pulse train is interpreted by the RF section and a particular amplitude or frequency variation is generated to represent the pulse train. The radio signal is sent to the antenna and radiated from the transmitter.

The receiver consists of a radio receiver, a decoder, and a servo buss. Each component is precision made and each is required for proper interpretation of the radio signal.

The radio receiver section receives the radio signal. All RF is stripped from the signal. The signal is then demodulated into a pulse train. The decoder generates a large positive going pulse for each receiver channel. The decoder then directs the pulse to a particular port or connector on the servo buss.

The servo is the device that actually does the work in the system. It is basically nothing more than a bi-directional motor that receives the pulse from the port in which it is plugged. It has a circuit that directs the rotation of the motor to a particular position based on the pulse signal. This position determines the current position of the corresponding control surface.

As might be expected, this description of the operation of a radio control system is over-simplified strictly for the understanding by the average person. There are many books on the market that go into great depth in electronic and radio theory to explain the operation of the system. These are recommended for those who have a desire or need for more knowledge on the subject.

I *would like to offer special thanks to Jack R. Albrecht for supplying most the information for this article and for his patience in helping me to understand how a radio works so I could write the article.*