Flight Simulator Controller

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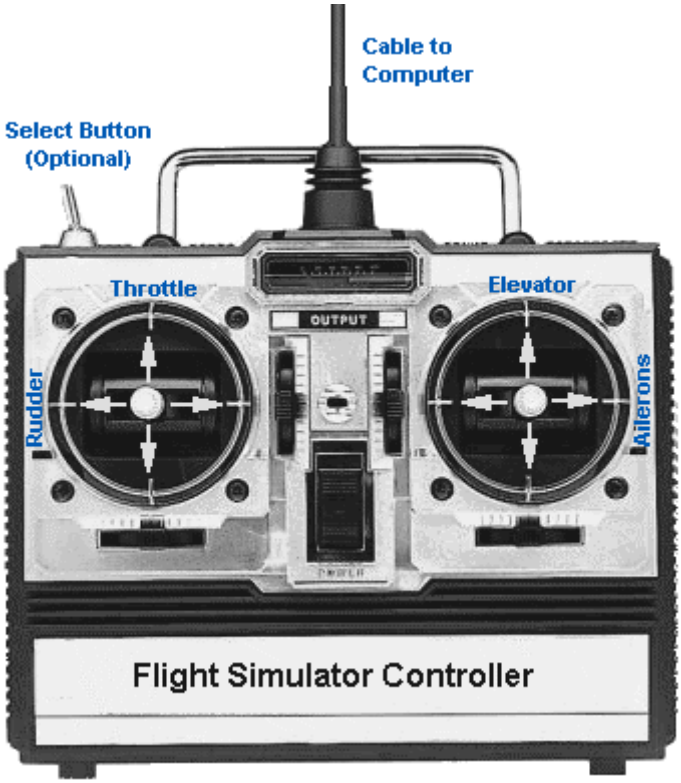

How to Modify a Futaba R/C Transmitter for Use as a PC compatible Controller

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This article explains how to convert a Futaba Conquest 4NBF or a 4NBL Attack transmitter into a PC compatible controller with aileron, elevator, rudder, throttle and trim. FSC will work with any flight simulator that uses a joystick and if properly setup, should calibrate correctly using the standard calibration in the game. The FSC uses 500 K Ohm or 1 meg-ohm pots, allowing nearly the same resistance range as a standard joystick's pots, because of the smaller angle of throw in an R/C transmitter's gimbles. The FSC works with any software that supports a standard PC compatible joystick. No special provisions are necessary.

Hobby suppliers sell the 4NBF case without a crystal, battery or antenna for use as a buddy box. Many people have old transmitters that can be used. Realize before deciding to make the conversion that this is a *permanent* modification. This conversion will probably work with other transmitters but it has not been proven. Some experimentation may be required to get the system to perform properly. Some transmitters, such as the Futaba FG series, use separate potentiometers for the stick axis and trim. In this case, the transmitter may be made to work but trim will not be available.

The computer on which the simulator is run must have a game port that has provisions

for two sticks on one port connector. Some older cards have two separate jacks, one for each stick. Some of the multi-function cards and game ports on sound cards support only one stick period. The recommendation is for a speed adjustable game port like the CH Products Game Port III as it will work more precisely and will allow setting the port for the speed of the computer.

Getting Started

The first step that should be taken is to *read this article through in its entirety* before doing any work. Although this project is not especially difficult, some mechanical and electrical experience is required such as knowing how to solder wires and using basic power and hand tools. It is not beyond the abilities of the average modeler. Both the chassis ground for the computer and the +5 volt power supply run through the controller cable. *The ground and +5 volt lines must never touch each other while this controller is plugged into the computer with the power on.* Care must be taken to connect everything properly so as not to damage the computer's power supply or the game card. Although the instructions and diagrams included in this article have been checked, mistakes do happen. All wiring should be double checked before connecting anything. *Any risk taken in the use of this design is the responsibility of the user.*

What's Required

A clean, uncluttered work surface is required so that parts will not be misplaced. Tools required are a volt-ohm meter (VOM) or continuity tester, a soldering iron or very low power soldering gun, a Dremel tool with a cutting wheel, and some fine grit sand paper. A hacksaw and a metal file may be used rather than a Dremel tool but much more effort will be required to accomplish the same results. Parts required are four 500 K Ohm (500,000 Ohms) linear taper potentiometers (pots), a can of contact or tuner cleaner spray (*not* WD-40 or any other lubricant), heat shrink tubing or a roll of electrical tape and some light grease. Linear taper pots are required for this application since audio taper pots will not work. For ease of assembly, the best pots to use are 5/8" diameter carbon pots that are available from many electronics supply stores. Radio Shack pots (part number 271-211) are most readily available but these are 1 Meg-Ohm pots and require some modification of the case. It may be advisable to get five or six pots in case of errors in cutting the shafts. Finally, an 8 conductor cable and a 15 pin male connector will be required. A momentary contact switch will be required if the joystick is to be used with a flight simulator or game that uses a "Fire" button. If the controller is to be used with Microsoft Flight, 500 K Ohm pots *must* be used.

Disassembling the Transmitter

All the electronics must be removed from the transmitter except for the trainer switch if one is installed. The antenna, battery, trainer jack, main circuit board, etc. are not required and should be removed to reduce the chance of shorting the +5 volt and

ground. The wires for the four gimbles' pots are cut from the small circuit boards to which they are attached. The two gimble assemblies are removed by removing the four screws holding each one in place. The gimble are different and must go back in the same location from which they were taken. If the new pots are more than 3/4" diameter, the meter and power switch must be removed to provide the necessary clearance. The components that are removed can be saved for spare parts for another transmitter.

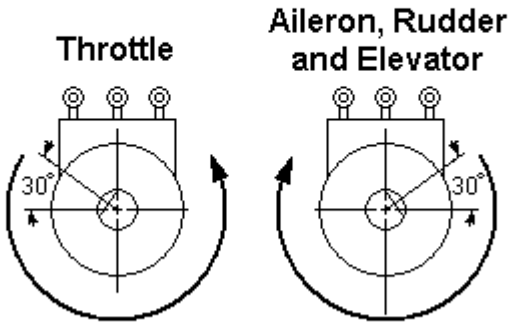
The pots in the radio must be replaced to increase the resistance range to match the average joystick. Examination of the gimble assemblies shows that they are not as complicated as they might seem. The throttle gimble is by far the simpler one. *Only one pot assembly should be disassembled at a time so that the other can be used for comparison for reassembly if needed.* The thin spring steel strip that provides the friction for the throttle stick is removed at this time. The pots are attached to the assembly by a brass bushing but are free to turn within it to allow the pot to rotate slightly in either direction for trim adjustment. The two oblong cams attach the pot to the trim tab so that when the trim is adjusted, all that is occurring is that the entire pot is turning resulting in a change in the center position. The screws that hold the side of the gimble in place are removed and the side will come free with the pot and the trim cams attached. The pot's shaft is attached to the gimble assembly with a snug fit. It can be removed by prying with a small screwdriver if necessary but excessive force should not be used. There is another cam on the inside connected to a spring and a tension adjustment screw. This cam allows the stick to spring back to center (the throttle does not have one). The tension screw is loosened first to avoid loosing the spring when it is removed. The spring, cam, and tension screw/block are removed. All of these parts should be placed in a plastic bag so they will not be lost. To remove the pot, pliers are used to carefully loosen the brass bushing from the inside face of the assembly. Care must be taken to avoid damage to the bushing. When it is loose, it can be unscrewed by hand. The pot will come off along with the two oblong cams. The parts should be examined as to how they go together before disassembly.

Modifying the New Pots

The shaft of the pot is semi-circular with a flat notch on one side and is shorter than the that of the replacement pot. The shafts of the replacement pots must be ground or cut to match those the old pots. First, the shaft on the new pot is cut to the same length as the old one. The shaft is measured from the point that it exits the threaded sleeve, not from the body of the pot. It is better for it to be too long after cutting and to grind it down later if necessary.

The next step is the most critical step in the process as far as functionality of the controller. All cuts must be conservative. The shafts should be trimmed a little and tested for fit. The angle of the flat is fairly critical. Examine the diagram below carefully before proceeding. Ideally, the resistance extremes of the modified pots will be 5 Ohms and 100 K Ohms. If the box that is being used is other than a Futaba 4NBF or 4NBL, experimentation will required to determine the correct position and the method of attachment of the shaft.

NOTES:
1. View is from shaft end.
2. To find the proper alignment for the flat, turn the shaft fully in the direction of the arrow. Cut the flat as shown.
3. The finished shaft must be a snug fit in the gimble component the same as the original shaft.



Shaft Cutting Detail

Note that all the pots are cut the same except the one for the throttle. The throttle pot is mounted and wired backwards, so the orientation of the flat notch on it is opposite that of the others. The correct angle for the flat is determined by turning the shaft all the way against the stop in the direction indicated above and matching the shaft to the shaft of the pot that was removed from the transmitter. A pencil or marker is used to mark where the flat should be cut. The angle of the flat is fairly critical but this method will yield satisfactory results if care is taken in locating the flat. The method used to produce the flat is dependent on the equipment used. Regardless of the method, the face must be as flat as possible and as near the correct angle as possible. Care must be taken to keep the metal filings from getting inside the pots. Work should progress slowly. The new shaft must be a snug fit in the cam the same way the original shaft was. The fit of the shaft should be tested frequently as the flat nears completion. After the flat is cut, fine sandpaper is used to remove any burrs from the cut end.

When the shaft modification is complete, the shaft should press snugly into the plastic part in the same way that the original shaft fitted. The completed pot should be sprayed liberally with contact cleaner to remove any metal dust that may have gotten in it. The pot can now be reassembled using a little lubricant between the cams and the case and on the spring. The alignment pin on the case of the new pot may not line up with the hole for the older one. It can be removed it gets in the way. The electrical connections on the new pot must face in the same direction that the old ones faced. The pot case and the cams must be aligned and centered with the assembly with the trim in the center. Since only one assembly is being modified at a time, the other assembly can be used as a guide for reassembly. All parts should be aligned in the same way as the original. When you the brass bushing is tightened, it must be loose enough for the trims to move easily and tight enough to keep the pot body from turning when the stick is moved. This procedure is repeated for the other axis and the gimble assembly is reassembled. If the pot shaft is too long, it should be carefully ground or filed to fit The screws that hold the gimble assembly together must not be over-tightened. The tension adjustment for each axis is tightened when the spring is replaced. The new pots may require more tension than the originals. Ensure that the stick moves freely and centers when released. If it sticks or binds, more grease may be required or a screw may be tightened too much. With the new pots, the stick may not spring back as positively as before but that

is okay as long as it returns to center when released. After both sticks have been modified, they are remounted in the case.

Wiring

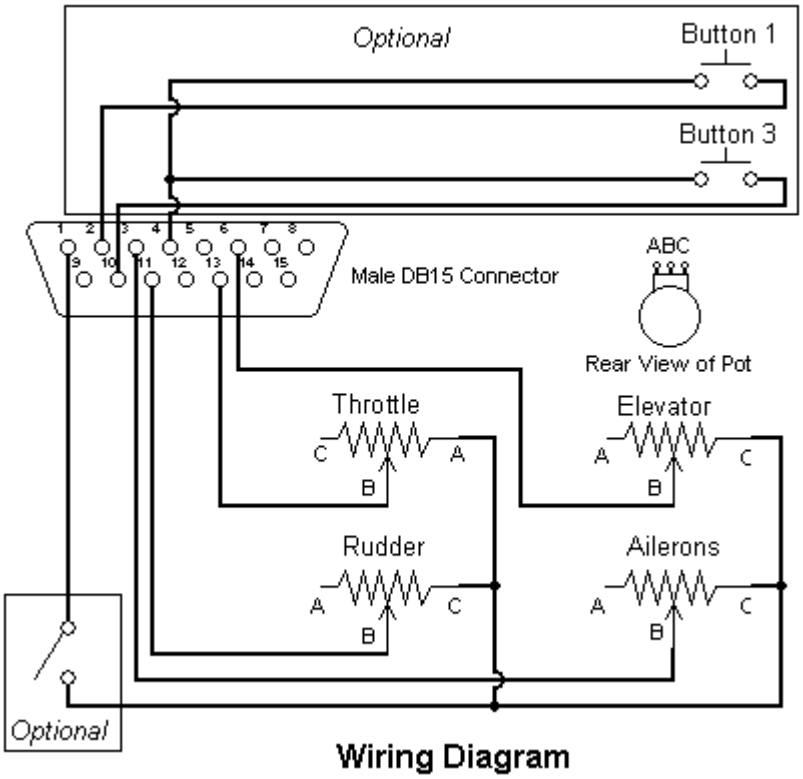
At this point, the hard work is finished but the same care taken in making the mechanical modifications must be carried over in the wiring. A mistake at this point can result in damage to the computer power supply or the game card. The controller cable must have a 15-pin male connector on one end and bare wire ends on the other. A male plug is one with a hollow indentation filled with small pins. The outer jacket of the cable must be stripped sufficiently so that the wires can reach across the required span. A VOM or continuity checker is used to trace the wires out to the corresponding pin of the connector. The wires are color coded so one probe of the VOM is connected to a wire and the other is touched to a pin until continuity is achieved. The following list should be printed and the wire color noted in the appropriate column as it is found. The plug should have very small numbers imprinted adjacent to each pin. If it does not, the diagram below can be used to determine the pin number.

PIN ASSIGNMENT ON CONTROLLER CONNECTOR

(Only the pins shown in boldface italics are required in this project)

PIN #	DESCRIPTION	WIRE COLOR
1	***+5 Volts>***	
2	Button 1	
3	***X-Axis, Stick 1 (Ailerons)***	
4	Ground	
5	Ground	
6	***Y-Axis, Stick 1 (Elevator)***	
7	Button 2	
8	+5 Volts	
9	+5 Volts	
10	Button 3	
11	***X-Axis, Stick 2 (Rudder)***	
12	Ground	
13	***Y-Axis, Stick 2 (Throttle)***	
14	Button 4	
15	+5 Volts	

After the correct wires are determined, wiring can begin. The first thing that must be done is to isolate the unused ground (pin 5) and +5 volt wires (pins 8, 9 and 15). If the wires can be exposed at the male connector end, they can be cut off at the connector. Otherwise, any method possible must be used to isolate the ends of the wires to ensure that a ground and +5 volt wire can contact each other and short. *Shorting ground to +5 volts can destroy the computer power supply.* The wire end of the cable can be routed through the antenna hole or any other point the seems convenient. The +5 volt wire from pin one can be routed through the master switch to allow the power to be turned off to the controller while it is not in use. The use of the trainer switch as a select or fire button is optional. There are three wires on the trainer switch. The VOM is used to find the two wires that have continuity when the trainer switch is pressed and the other wire is removed. The ground (pin 4) is connected to one of the remaining wires of the trainer switch and the wire from pin 2 on the plug is connected to the other. These connections should be taped to avoid having them touch a +5 volt wire. The +5 volt line will be connected the pots so efforts must be taken to assure that no ground wire can make contact with a pot. Referring to the diagram below, the +5 volts will be connected to contact C on each pot except the throttle, which has it connected to contact A. Then each axis wire is connected to contact B of the appropriate pot. Pin 3 on the plug goes to contact B on the ailerons pot, etc. When this step is completed, there will be wires left for other functions. A momentary contact switch can be connected to these to add functionality to the controller. Any wires that are not used must be removed or isolated.



Wiring Diagram

If the major diameter of the pots is greater than 5/8", the case must be trimmed to allow clearance around the pots in order for the rear case half to fit properly. There are two (2) recesses in the rear of the battery compartment. These recesses must be cut out to a depth of about 1/4". Additional trimming may be required depending on the pot that is used. All wires should be double checked to ensure that no wires are touching and that

everything is connected properly. After these steps are complete, the case can be closed.

Trying it Out

***D**o not connect the controller to the computer yet.*Turn the computer on and let it boot to DOS. Cautiously, connect the controller to the game port while watching the monitor. *If the screen goes blank, disconnect the controller immediately.* This is an indication that there is a short circuit. Somewhere in the box, there is a ground wire touching a +5 volt wire. A brief short should not damage anything and the computer should reboot. Open the case and check everything again. This condition must be corrected before the controller is connected again.

If everything seems normal when the controller is plugged in, it's time to test it. The controller should be tested first with the JOYTEST program. This program will confirm that the pots and buttons are wired properly and that the required resistance values can be achieved. When the sticks are moved in any direction, the corresponding indicator must move in the same direction and when the sticks are moved to the limits, the indicators must move to the limits. As each button is pressed, an icon will change appearance to indicate that it was pressed. If a stick indicator moves in the opposite direction, then the pot is wired to the wrong solder post. The pot must be rewired before proceeding to the calibration step.

If a speed adjustable game port card is installed, use the utility program to set the card to a speed that gives the most throw with a good center trim. If there is a joystick calibration utility with the game port card, use it to determine if the controller works properly. If the computer is running Windows 95, use the Joystick Calibration icon in the control panel. If none of these are available, the controller can be calibrated from within a game that shows the stick positions after calibrating, such as Flight Unlimited or FS5. Follow the utility's directions to set the trims for proper center, and confirm that there is a smooth response in each direction of each stick's axis. If there is one direction of an axis that has better resolution than another, try turning the trim control for that axis in the bad direction and recalibrate. If flats of the shafts are too far out of position, it may be necessary to open the case and turn the whole pot. It may take some experimenting but a trim position can be found which will give a smooth response in both directions. The controller should be recalibrated after a change in trim since this changes the center position. If the pot must be turned very far in order for it to work, then the flat of the shaft is probably cut incorrectly or the throttle pot may have been swapped for one of the others. Ensure that the sticks return to center and that there is no "slop" in the center, which would indicate a bad fit between the pot's shaft and the gimble assembly.

Ready to use

The original design of this controller came from *Robert Osorio*. Although it is primarily intended for use with flight simulators, it works well with other games that benefit from precise control. It has been tested with the Dave Brown R/C Flight Simulator, Flights

Unlimited, Microsoft Flight Simulator, Doom, Hexen, and several other games. If this project proves to be beneficial, it would be a good idea thank Robert for his contribution.

Note: If the controller is being used with Flight Unlimited from Looking Glass Software, it is recommend that the update patch be installed. The original version of FU has a bug that does not properly calibrate the controller on some machines. The update patch fixes this as well as several other problems.

The information contained on this page is available for download as a Microsoft Word document (101K bytes). The document has all of the text, tables, diagrams, and illustrations that make up this page but no references to web links.

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