How-To

Connect a Conventional Receiver to High-Voltage Servos ... and eliminate “Y” connectors.

Why discard a perfectly good conventional receiver, to use HV servos? This article will show the advanced modeler how to have more control of your airplane electronics system. To do this, I will discuss some basics, and then present a break-out board solution that will not only eliminate “Y” connectors but also give you the ability to use one, two, or even three batteries to power servos, receivers, and gear. As a plus, you now have a convenient way of injecting power from a Lipo battery into your receiver, instead of having to make adapter cables. The board is highly versatile, and can be adapted for use in many situations.

To show how to separate receiver power from servo power, let's use a simple example of adding a single HV servo to a conventional receiver like the ubiquitous Futaba R617FS. To demonstrate, we are going to use a “Y” cable. The positive power pin that connects to the receiver is removed (this prevents “conflict” of the “low” voltage to the receiver, and the high-voltage to the HV servo). Power is injected to the HV servo via a separate (LiFe) battery on one of the pigtail leads, and the servo connected to the other pigtail. Since the servo has a source of its own power, all it requires from the receiver is a negative “common” wire, and a control “signal” wire. In this case, the black and white wires. Note that the receiver is powered with a separate Ni-Cd receiver pack (4.8 volts). It’s really that easy!

When you connect a battery to a conventional receiver, the power delivered is also distributed on a bus inside the receiver that allows you to conveniently connect servos to each channel without having to worry about providing a separate way to power the servos. This is good, but if you want to connect high-voltage (HV) servos to the same receiver, using high-voltage, you now have a problem: how do you separate the receiver power from the HV servos you want to add?
One kind of break-out board can be made from Vector board. This board has pads and traces connected together to form multiple contact points for (in our case, a bus) negative power, positive power, and a signal wire. To make breaks in the circuit, you physically cut the traces with a knife. This method is especially good for eliminating “Y”s, due to the common bus, but still is a little clumsy in handling the power injection function. This method may not be pretty, but it can work well, is easy to prototype, and is inexpensive. The downside is that it is time consuming to make these kinds of boards, and larger wire sizes tend to come close to other bus traces.

The image below shows a conceptual summary of the way to power the receiver with a "low" voltage battery and feed high voltage to HV servos. It is simplified to reveal what is "under" the rat's nest of wiring that results from making so many connections:

Board "A" serves as a tie-in point for the receiver battery. The battery could be connected directly to the receiver, but this "part" of the board allows you a place to anchor wires.

Board "B" serves as the connection point for the high voltage Lipo battery, and as a place to connect servos (here not shown, for clarity).

The Ground wire is common to all. The positive low voltage wire only feeds power to the receiver. The positive high voltage wire feeds power to the servos. The signal wires are feed from the receiver directly to the servos.

Black is the negative bus. Red is positive power, and the signal is shown as white.

The deluxe treatment would be to make a custom Printed Circuit (PC) board. Because of cost, we want a board that is as versatile and suitable to as many common applications as possible. The easiest way to make a PC board is to use a PC board creation service like Sunstone Circuits to make the PC boards for you. No masking, drilling, cutting, or etching, is required. You can order as many PC boards as you need. This is a tremendous time saver, but it is a little pricey, especially for quantities below 10 pieces of the same board. If you are in a club, sharing the cost with other members is a great solution.
Servo Receiver Power "Y" Interface Breakout Board (SRPYIB)

Let's look at a board that I designed and see if you can use some of my ideas in your project. You can use my board design as is, or as a starting point for your own ideas, and customize the board to your needs. My cost for 30 boards was $10.83 each board, with a promo code, and free delivery.

As a service to our members, you can download the design file of this board free of charge (see the address on RCGroups under “Sources”); once you have the file, you can download the PCB123 software from Sunstone to edit or order boards.

This SRPYIB board has many advantages:

- Expand receiver outputs with clean power, and eliminate "Y" connector cables.
- Use conventional receivers with high-voltage servos, without the worry of damaging your receiver.
- Provide a convenient way to power electric retracts with a single or separate battery.
- Monitor voltage of your servo and retract batteries.
- Heavy-duty PC (Printed Circuit) board will handle high-current digital servos.
- Versatile – many easy to hook-up configurations. All low voltage, all high voltage, or a mixture of the two.
- Provide an interface to connect a Lipo battery to the system (power injection).

Printed Circuit Board Design Considerations

Board thickness can be standard 0.0625 inch or thin 0.032 inch. Unless you have special needs, use the standard board.

Use standard 0.1 inch pitch for headers, and electronic components. To prevent that “crammed in” connector look often seen in receivers, space connector housings so that they have some room to prevent them from being jammed up against each other. My design has spacing between header housings of 0.110 inch instead of the more commonly found 0.100 inch pitch.

Double-sided board will give you greater current carrying ability. Use the same pattern on the top of the board as on the bottom of the board.
Standard copper weight is 1 ounce per square inch. 2.5 ounce per square inch adds cost without any real benefit for our needs.

Consider how you will distribute power and signal routing, whether you will use headers to connect external devices or wiring, and what features you want the board to have, like LED indicators, etc.

Place components in efficient locations to minimize routing and try to avoid having to use “jumper” wires to make connections.

The size of the board will have a direct relation to cost. The smaller the board, the better, in terms of weight and cost. You want to be able to utilize the board in as many scenarios as possible to give you maximum versatility.

How are you going to mount the board? Thru holes, guides, stand-offs, bottom mount with Velcro?

Solder pads will vary in size, but most will be 0.075 inches with 0.038 holes. Traces can be 0.060 inches.

You must also specify drill hole sizes in the board. Sunstone can produce any finished size hole from 0.010 inch to about 0.250 inch. My board uses standard number gauge drill bit sizes. I would recommend that you keep the number of different sizes to a minimum. See chart for recommendations:

**Drill Chart:**

<table>
<thead>
<tr>
<th>Size (inches)</th>
<th>Quantity</th>
<th>Drill Bit</th>
<th>Pad Size</th>
<th>Comment</th>
</tr>
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<tbody>
<tr>
<td>0.025</td>
<td>20</td>
<td>#72</td>
<td>0.075</td>
<td>LED's, Caps, Resistors, TO-92 Regulator</td>
</tr>
<tr>
<td>0.038</td>
<td>104</td>
<td>#62</td>
<td>0.075</td>
<td>Header Terminals and 22AWG</td>
</tr>
<tr>
<td>0.0465</td>
<td>4</td>
<td>#56</td>
<td>0.100</td>
<td>20 AWG wire</td>
</tr>
<tr>
<td>0.0785</td>
<td>8</td>
<td>#47</td>
<td>0.150</td>
<td>16 AWG wire</td>
</tr>
<tr>
<td>0.089</td>
<td>8</td>
<td>#43</td>
<td>--</td>
<td>For board mounting, passes #2 screw</td>
</tr>
</tbody>
</table>
Batteries - 6 volt sources and 8.4 volt sources.
For the purpose of this article, and to avoid confusion, I want to refer to (and group) Ni-Cd, NiMh, LiFe, A123, and LiFePo4 batteries used as a source of power, as simply "6 volt" batteries. While Ni-Cd and NiMh can be 4.8 volts, let's just refer to their 6 volt versions in this article. Can you use this board with 4.8 volt batteries? Yes; in fact, you are not limited to any kind of power supply (or type, such as a BEC); limits are imposed by the allowable voltages of the receiver, servos, and other devices you may connect. Limits are also imposed when the voltages of the receiver, servos, and other devices are different.

Can you use a Battery Eliminator Circuit (BEC) or the BEC in the Electronic Speed Control (ESC) instead of a battery? Short answer: yes.

Conventional fully charged 2-cell (2S) LiPo batteries will be referred to as “8.4 volt” batteries (not 7.4 volts as their nominal voltage is often referred to).

We can use a 6 volt source on a conventional receiver, but we cannot use an 8.4 volt source on a conventional receiver unless we use a voltage regulator. We need to be especially careful when we want to mix 6 volt servos with HV (8.4v) servos. The board I designed can give you many signal and power options, but you need an understanding of each components voltage requirements and limitations. I will try to illustrate as many practical examples as possible, but I cannot cover here every possible connection combination, or every caution.

Servos
Conventional servos operate on 4.8 to 6 volts. The newer high-voltage (HV) servos operate directly on 6 to 8.4 volts. One of the major advantages of the HV servo is the higher torque and performance from operating on 8.4 volts. One servo from Hitec, for example, has an amazing torque rating of 611 oz.-in. (38 lbs.) on high voltage. There are some specialty servos that operate on voltages are great as 4S (16.8v), and this break-out method can be made to work for them as well.

Receivers
Conventional receivers use 4.8 to 6 volt batteries. The newer high-voltage (HV) receivers can use an 8.4 volt LiPo battery directly.

Electric Retracts
Most electric retracts are designed to operate between 6 and 8.4 volts. Most manufacturer's recommend that a separate battery be used for operation apart from the receiver battery. The reason is that most electric retracts when operated, have a large power surge when first starting up or when coming to a stop. This voltage surge can damage receivers. 2 cell Lipo or LiFe batteries are recommended due to their ability to provide large current inrushes and handle surges. Even though it is an “extra” battery, that brings along with it some weight, a small 20C, 1000mAh Lipo, for example, will operate even very large electric retracts for a very long period of time, before recharging.

SRPY1B Details:
This circuit board has four sections:
(1) Yellow - provides a "breakout box" to eliminate "Y" connectors and to inject power.
(2) Blue - provides an independent source of battery power and connections for electric retracts.
(3) Orange - provides clean 5 volt regulated power for receivers (optional).
(4) Red - lets you plug-in external voltage monitoring devices (optional).
In my design, battery power connections are “V-Servo” and “V-Gear”. Negative polarity is common to all. The large holes in the board for the battery are designed for 16 gauge wire with two sets of holes for 20 gauge wire. If you wish, you can use one battery and connect each of the positive rails together, or you can use the board with two separate batteries utilizing the “V-Servo” and “V-Gear” terminals. Another option is a third battery that could be used to power the receiver directly, instead of using V-Servo power or the regulator.

Optional LED battery indicators are placed at the positions marked “LED”. The positive terminal is marked “A” for anode. A ¼ watt resistor is placed in holes marked “R”.

The figure shows the main routing of power and signal. Black is the negative bus. Red is the positive bus, and the signal bus is shown as white. Blue is other routing.

**Break-out Box – (Section 1)**

The board has eight break-out “Y” boxes to connect to your receiver. You can use header terminal pins or wire (up to 22 gauge). This section is powered by the battery connected to the “V-Servo” terminals. Since the PC board I used is two-sided, it can carry a lot of current for those power-hungry digital servos. Another advantage of the two-sided board is that you can mount headers on the top or the bottom of the board. I like to have the “Y” on the top, and the wire or header to the receiver on the bottom, so that I can mount the receiver directly below the SRPYIB, to have a nice clean finished look. If you don't like the designations of the silkscreen I used for each channel on my board, just cover them with your own label.

**Retract Break-out - (Section 2)**

The board has one break-out 3-position “W” box to connect to your receiver. You can use header terminal pins or wire (up to 22 gauge). There is a header for left and right main gear, and one for nose-gear. This section is powered by the battery connected to the “V-Gear” terminals. There is no reason why you can't re-purpose this for other uses such as LED lights or other control needs. You can even use it with digital serial data communication systems like Futaba's S.Bus or JR America's XBus.

**Voltage regulator - (Section 3)**

This section is OPTIONAL and only needed if you are using a conventional receiver with HV servos powered by a 8.4 volt source (and you are NOT using a 6 volt battery connected directly to the receiver or a 6 volt source on “V-Servo”).
This section is used for plugging in your favorite voltage monitor. There are terminals to monitor the battery voltage on the V-servo bus and the V-Gear bus.

**Application:**
Specify the components that will be in your project:

- Chose what batteries you want to power the project with: Ni-Cd, NiMh, LiFe, or Lipo. You can use one battery to power everything, or two batteries to power the servos, gear, and receiver. You can even use three batteries to provide independent power to each set of servos, gear, and receiver. It is also possible to use a BEC.
- Choose the receiver: conventional or HV, decide how it will be powered.
- Choose your servos: conventional or HV, decide how they will be powered.
- Electric Retracts: decide how they will be powered.

Once you have the components sorted out, you can make decisions on how you are going to configure the board for the voltages you want to use. You also need to make decisions on how connections will be made from the board to the receiver.

**Rule #1:** In ALL cases, a common wire (negative power) MUST exist between the board and receiver.

**Rule #2:** If the voltage is NOT the SAME between the interface board and the receiver, DO NOT use the positive power wire from the board to the receiver (*).

**Rule #3:** V-Gear section should have signal and negative wires to receiver. Do NOT use the positive wire.

(*) An exception exists when using the optional on-board voltage regulator.

One of the most common applications will be using a 6 volt battery to power a conventional receiver with a separate Lipo for the Gear, and a separate Lipo for the HV Servos.
Application showing how to use a BEC set to 5 or 6 volts for a conventional receiver with a separate Lipo for the Gear, and separate Lipo for the Servos

Another common application will be using a HV receiver with a Lipo for the Gear, and a Lipo for the HV receiver and servos.

Expanding an output channel: typically on multi-motor electric aircraft you need up to 4 throttle outputs from the receiver. A jumper between the signal connections can provide this. Shown here, as an example, the headers on “THRO” and “AUX1” labeled “1”, “2”, “3”, and “4”, would connect to the ESC’s.

Decide on how the board is to be powered. If by battery, then disable the positive wire of each BEC, and make your controller connections to each throttle header. Consult manufacturer’s instructions for connecting ESC if using BEC power.
Parts List:

You will need standard gold-plated 0.1 inch Header Strips. Typically these are sold in a 40 pin configuration that you can cut apart into 3 pin sets. Each 40 pin strip yields 13 three-pin headers. If you fill the board completely with 3-pin headers, you will need at least three 40 pin headers. You can obtain these headers though Hansen Hobbies or other electronics dealers.

You should install $C_{\text{IN}}$ in two locations. This ceramic capacitor can be 0.01µF to 0.1µF at 25 volts minimum. I suggest Digi-Key # 490-8814-ND (0.1µF cap). The purpose of this capacitor is to filter noise from the wires to the board.

LED indicators are optional, and not critical, and almost any device can be used. I suggest: 3mm, Green, Diffused, Digi-Key # 754-1723-ND. LED's require a dropping resistor. For 8.4 volt sources, use a 560 ohm, ¼ watt resistor; Digi-Key # S560CACT-ND. For 6 volt sources, use a 390 ohm, ¼ watt resistor; Digi-Key # S390CACT-ND.

In addition, you will need male servo-type connector pigtail leads or male-to-male servo connectors to make connections from the board to the receiver. I like to use black wire for negative power, red wire for positive power, and white wire for the signal lead. Other colors are fine, as long as you know which wire is negative, positive, and signal.

Servo type connectors should be prepared with a signal and negative wire (remove positive wire) when the voltages between the receiver and board are DIFFERENT. This is IMPORTANT; there CANNOT be a POSITIVE wire connecting the receiver and board when the VOLTAGES ARE DIFFERENT!

Assembly:

Use a low power (10-20 watt) soldering iron with a fine tip for soldering the components on to the board. Use a quality, fine diameter (0.031”), rosin core 60/40 (Sn60Pb40) electronics solder; I like the Kester brand.

A note on the installation of the headers on the board: Headers can be more easily placed by building a jig. This jig is made by placing the board on a piece of hardwood on the opposite side that you want the headers to be soldered to, and by drilling holes with a #62 numbered drill bit. Strips of wood hold the board in position with alignment marks. Cut your headers into 3 pin segments and place them long pin in, into the jig. Then fit the PC board over the pins, aligning them, and seating them, so that you can then solder the headers to the board. This results in a professional looking board with absolutely straight headers. Also note that in my design, the thru-holes for headers are “square shaped” outlines on the board, and positions for wires are “round”. This helps distinguish location on the board.

The mounting holes on the board are designed for #2 screws. Make sure when you mount the board, there is nothing that can touch the board to prevent shorts. A piece of clear heat-shrink tubing can be placed around the battery end of the board (with cut-outs for the terminals, if necessary).
**Board Testing:**

Check your work; be especially aware of REVERSED polarity. IF YOU ARE UNSURE of anything, before you connect electrical power, please have an experienced electronics person check over your work, or design.

Make sure that before you connect your receivers or servos or any other electronics, that you use a voltage tester and protected power supply to determine if the right voltages are in the right places on the board. This is especially important if you plan to use more than one battery.

For example, if you have a conventional receiver that will be powered by a 6 volt battery connected directly to the receiver, and you will be powering your HV servos and retracts with a single 8.4 volt battery on the board: [make sure receiver, servos, and gear are not connected, and V-Servo and V-Gear positive terminals are connected together] Connect a short-circuit protected voltage source to the board. Use a voltage tester to determine if the correct voltage is present on the board at various points. Check pigtail leads (header leads) to receiver, there should be NO voltage present on them. Check to see if there is voltage on any signal wires, indicating incorrectly wired or crossed-connections. If all tests pass, then you are clear to connect your electronics.

**Other thoughts:**

I like having two power leads from the board to the receiver, if possible. This gives you power redundancy in case one of the power wires fails due to a bad contact crimp or other damage. Once you have the two sets in place, you can leave out the red power wire for the rest of the channels or ports on the breakout board; you can even just run a short signal wire from each channel to the board without the positive and negative wires since these are already connected elsewhere.

If you are using the board only as a “Y” break-out box, you can save some weight by cutting away the unwanted section of the PC board.

Servo leads that have had the positive power wire removed should have a “filler” contact inserted into the housing. 3 terminals have more “grip” than 2 terminals.

**Accessories:**

To complete your airplane installation, you may need connectors to allow you to disconnect the wings when you transport the plane. ElectroDynamics and TailDragger RC, among others, sell harnesses that are perfectly suited to this task. The harnesses connect directly to the break-out headers on the board and make connection and disconnection of your wing wiring easy.

I like to make my own wing connector ends using housings and a PC board Servo Y-harness from Hansen Hobbies. You can buy them still attached to each other so that you can “break-away” what you need. I used two of the harnesses that were still attached to each other to make one half of the wing receptacle shown. The cable is about a foot long. The other end of the cable is soldered directly into the SRPYIB board.

I hope you found the information presented in this article useful.

— Nick Gaynor
Here is a complete test system. Conventional receiver, with HV servos. Note the wing harnesses: I used three Hansen Hobbies harnesses and a 90 degree, 9-pin header to make a custom wiring harness for aileron, flap, and retract. On the Interface board, instead of using headers, I used leads soldered directly to the board. In the model, the cable from the wing harness to the SRPYIB board would be about one foot.

Shown here, free of clutter for clarity, is the on-board 5 volt voltage regulator and connectors to the receiver. There are seven connectors, two of which feed power from the board to the receiver. Note that the signal (white) wires are connected to the break-out section. The receiver has 7 channels and this wiring lets you use all the channel slots without having to take up a slot just for power. Note also, the orientation of the Texas Instruments LP2950 regulator.
Sources

RCGroups (location of this blog article and design file) http://www.rcgroups.com/forums/showthread.php?t=2499623
Sunstone Circuits, Printed Circuit Manufacturer http://www.sunstone.com/
You can use their free drafting software (PCB123) to create your own PC boards. Sunstone Circuits prices are moderate in quantity.
Digi-Key Electronics http://www.digikey.com

Hansen Hobbies http://www.hansenhobbies.com
Kester Solder http://www.kester.com
TailDragger RC has 20 AWG Dual Servo Multiplex Extension Harness's http://www.taildragerrc.com/servo-wiring-accessories/
LED Calculator: http://led.linear1.org/led.wiz

Additional Info for the optional Voltage Regulator in Section 3:

Power applied to the “V-Servo” terminal is filtered and regulated down to 5 volts by a 3-terminal electronic regulator such as the Texas Instruments LP2950. The LP2950 is designed for battery circuits and typically has a very low dropout voltage of less than 380 mV. The device has a very wide input supply-voltage range of up to 30 V, and it has a rated output current of 100mA. You may think that 5 volts at 100mA is not enough power. Keep in mind, that we are NOT powering servos and a receiver, we are ONLY powering the receiver. The Futaba R617FS receiver, for example, only consumes 38mA! The 8.4v battery connected to “V-Servo” is powering the servos directly.

Other low dropout voltage regulators like the Microchip Technology MCP1702, or Linear Technology LT1121 may be used. If you need a low dropout voltage regulator in the 1 amp (1000 mA) range, you can use the STMicroelectronics L4941. I do NOT recommend that you use the 78L05 or 7805 series of regulators as the dropout voltage on these devices is typically about 2 volts, and they cost about as much as the LP2950 anyway. If you select your own regulators, always consult the manufacture's data sheet before using the device.

If using the LP2950, 100mA voltage regulator, or other low-current regulators, you must NEVER connect a servo or servos, or anything else, like LED lights, to the receiver bus. You will exceed the power capacity of the regulator, and it WILL shut down, and so will your airplane!

Some tantalum and aluminum electrolytic capacitors are polarized. Observe polarity. There are markings on the device that indicate polarity. The negative lead is always inserted into the outer most hole in the board. Capacitors are available in 0.1 inch or 0.2 inch pitch, the board accommodates both.

LED: long lead is the anode and is positive. Case may have a flat on it, this indicates the cathode or negative lead.
Here are four different regulator and capacitor set ups that could be used:

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<th>DEVICE</th>
<th>CIN</th>
<th>COUNT</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP2950 5v Regulator</td>
<td>22µF 25v Alum Electrolytic</td>
<td>22µF 16v Tantalum</td>
<td>Note polarity of 22µF caps.</td>
</tr>
<tr>
<td></td>
<td>Digi-Key # 296-20933-1-ND</td>
<td>Digi-Key # P15802CT-ND</td>
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<td></td>
<td>Digi-Key # MCP1702-5002E/TO-ND</td>
<td>Digi-Key # 445-8614-ND</td>
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<tr>
<td>LT1121 5v Regulator</td>
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<td>Note polarity of 22µF cap.</td>
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<tr>
<td></td>
<td>Digi-Key # LT1121CZ-5#PBF-ND</td>
<td>Digi-Key # 445-8614-ND</td>
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<td>L4941 1A 5v Regulator</td>
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<td>Note polarity of 22µF cap.</td>
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<tr>
<td></td>
<td>Digi-Key # 497-6695-5-ND</td>
<td>Digi-Key # 490-8814-ND</td>
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DISCLAIMER: Electrical and other Safety:

Your safety and the safety of others is your own responsibility; including proper use of equipment and safety gear, and determining whether you have adequate skill and experience.

Use of this article with its instructions and suggestions is at your own risk. The author disclaims all responsibility and liability for any resulting damage (including aircraft), expense, injury, or death.

This project uses electrical power and the use of high-power batteries. These power sources have cautions and warnings that must be followed for safe use. The most prominent danger is from accidental electrical shorts and sparks, leading to possible fire, burns, and explosion.