LiFe Charging

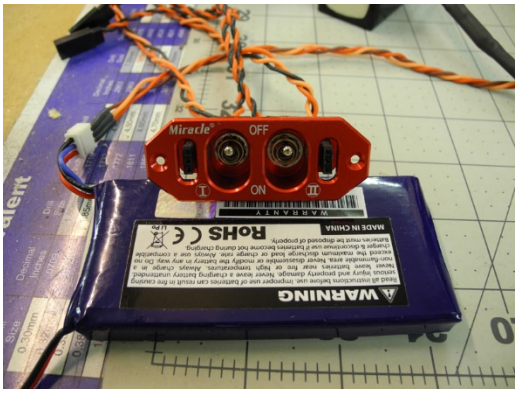
By Randy Oswald

Over the last year or so I have converted my air wing to lithium iron phosphate or "LiFe" receiver batteries.

LiFe batteries offer significant weight and capacity improvement over traditional NiCd's. LiFe's have a nice, flat discharge curve, hold their charge must longer than NiCd's, and are safer than lithium polymer or "LiPo"s. I do not worry about recharging LiFe batteries inside a fuselage.

The only downside to LiFe's is the need to balance the cells from time to time. Ideally, one would balance with every charge, but this requires adding a second charge jack or removing the battery from the fuselage.

Fortunately, there is an alternative. It is possible, with some simple modifications, to balance-charge a 2S1P LiFe battery through a standard, 3-pin charge jack or charge switch like the Miracle Switch shown below.



There are two potential downsides to this, but I don't find either to be a problem.

1. You will be charging and may be powering your receiver through the battery's balance leads. These are not usually as heavy-duty as the power leads. As such, they are not suitable for high-amperage quick charging or high-current servo loads.

I never charge my receiver batteries at more than 1C so this is not an issue. It is possible to drive the receiver and servos via the battery's normal power leads, but that is the subject for another tutorial.

2. You can't bind through the charge jack or a switch's charge port. I plug a "Y" connector into the battery port on the receiver. I plug the switch's power-out lead into one leg and leave the other one free for binding. It means I have to open the fuse to bind or re-bind, but I don't do it often enough to be an issue.

We'll get into the tutorial in a moment. But first, a warning.

WARNING

Do not try this if you are not completely comfortable working with electricity. If done incorrectly these actions can lead to **SERIOUS PERSONAL INJURY**, fried receivers, ruined batteries, destroyed aircraft, or **SERIOUS PERSONAL INJURY**.

Undertake these modifications *at your own risk*!

The author assumes no responsibility for the accuracy or safety of these instructions or for the applicability to any specific aircraft, radio, battery, or charger.

WARNING

I really am serious about the warning, bad things can happen - fast. That said, the mod's needed are individually quite simple, but you do need to understand what you are doing, work carefully, and check your work often. Mistakes are costly and immediate, and the results are irreversible.

For those who might be put off by the warning, there is an alternative. Electrodynamics (http://www.electrodynam.com/store/CCords.html) sells pre-built charge cords and modified charge switches, but what's the fun in that?

Please read the tutorial from end to end before starting, and ensure that you understand what is being done at each step, and why.

To begin with, we'll take a look at how a typical 2S1P LiFe receiver battery is wired. As you can see in diagram 1, the wiring is pretty simple. You'll notice right away that two of the three balance conductors go to exactly the same place as the primary power leads. This is what allows us to do all of our charging through the balance connector. The third balance conductor (light blue in the diagram) allows a balance-charger to access each cell individually. We'll call it the center-tap. The center-tap is schizophrenic, for cell 1 the it is the negative (-) lead; for cell 2 it is positive (+).

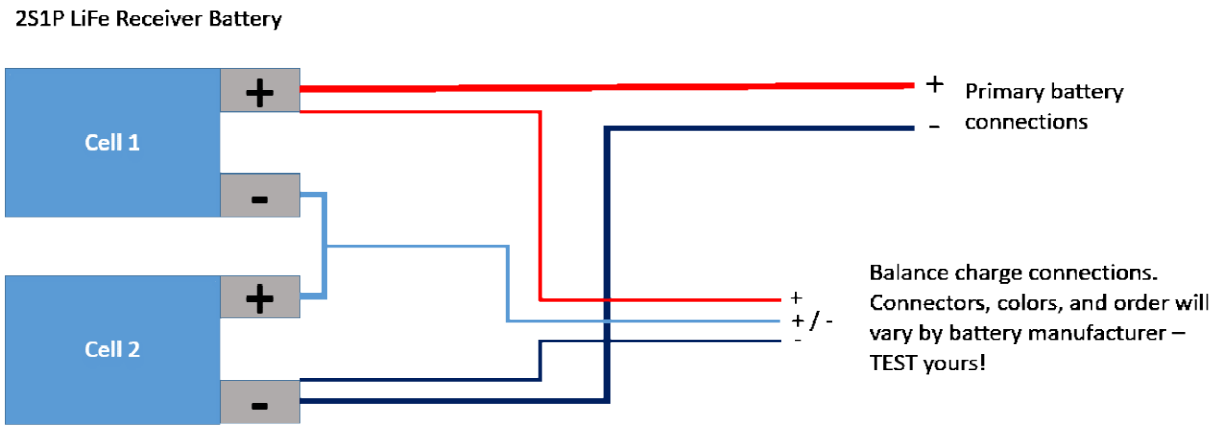


Diagram 1

A note about balance charge wiring:

> All 2S1P batteries with balance connections are wired this way, **BUT** there is no standard for which type of connector is used or for the order (pin-out) or color coding of the balance leads. You will need figure out what type of connectors your battery uses, and you'll need to test to find which wire is which.

Now that we know what our batteries look like under the heat-shrink, let's discuss what we are going to do from a conceptual perspective. To balance charge any multi-cell LiPo or LeFe battery we need 1 more conductor (wire) than we have cells. So, two-cell battery – 3 charge wires, 3-cell battery – 4 charge wires, and so on. Since we want to charge a 2-cell Rx battery we'll need three wires. And, what do you know – standard radio system wires and connectors all have 3 wires.

The problem is that our radio system wiring has a positive and a negative conductor to transmit power, and a signal conductor to tell our servos what to do. We will use the positive and negative wires for their intended purpose, but we are going to hijack the signal wire and use it for charging too. We'll talk about that more in a minute.

So, we are going to use standard servo wires and connectors for most of what we'll be doing, and with two exceptions – all servo wire connections will be wired according to the standard for your radio system. This means they will look exactly the same as any other servo connection. They will also function the same. If you find that a battery lead is too short to reach your receiver you can pop in a standard servo extension and it will work just fine.

As I mentioned, we are going to hijack the signal wire and use it for charging. This is potentially dangerous because the receiver must not see battery voltage on a signal pin. It is easy to prevent, and we'll discuss how later in the tutorial.

Lastly, while we are going to keep most of the wiring "standard" there are two exceptions where we probably cannot. The order of the wires on the balance plug of your battery and the balance port of your charger will probably not be the order we want. We will have to do something to make them line up. We'll look at the details later, but I want you to be clear on the concept here – we will do any and all "adapting" required at these two connections - only. That way everything else will be "standard" for your radio system.

By way of example, I have pretty much standardized on Turnigy Nano-tech batteries from HobbyKing. They use a 3-pin JST XH connector with red, blue, and black balance leads, in that order in the connector, with these functions:

- Red: pack positive
- Blue: center-tap
- Black: pack negative

I fly Spektrum radio gear that uses JR standard wiring with Orange, Red, and Brown wires laid out like this:

- Orange: signal
- Red: positive
- Brown: negative

I'll have to cross the battery's red and blue connectors to get them to line up correctly. We'll do this later in the tutorial.

You will need to understand how your radio and batteries are laid out. Radio documentation is available online. You will probably have to test your batteries yourself.

To determine your battery's configuration, place a voltmeter's probes across each pair of wires as shown in Diagram 2. (+) means connect the red test lead from your voltmeter here, (-) use the black test lead. The numbers in the diagram are what I see for my Turnigy batteries.

- Between Red(+) and Blue(-) : approximately 3.3 - 3.6 Volts
- Between Blue(+) and Black(-) : approximately 3.3 - 3.6 Volts
- Between Red(+) and Black(-) : approximately 6.6 - 7.2 Volts

Start testing various combinations until you get a voltage reading over +6.6 volts. You have now found pack-positive and pack-negative. The other connecter is the center-tap. You should get a reading of 3.3 to 3.6 volts when you probe it and either one of the other pins. If you see a negative voltage, reverse the test leads. Write down your findings!

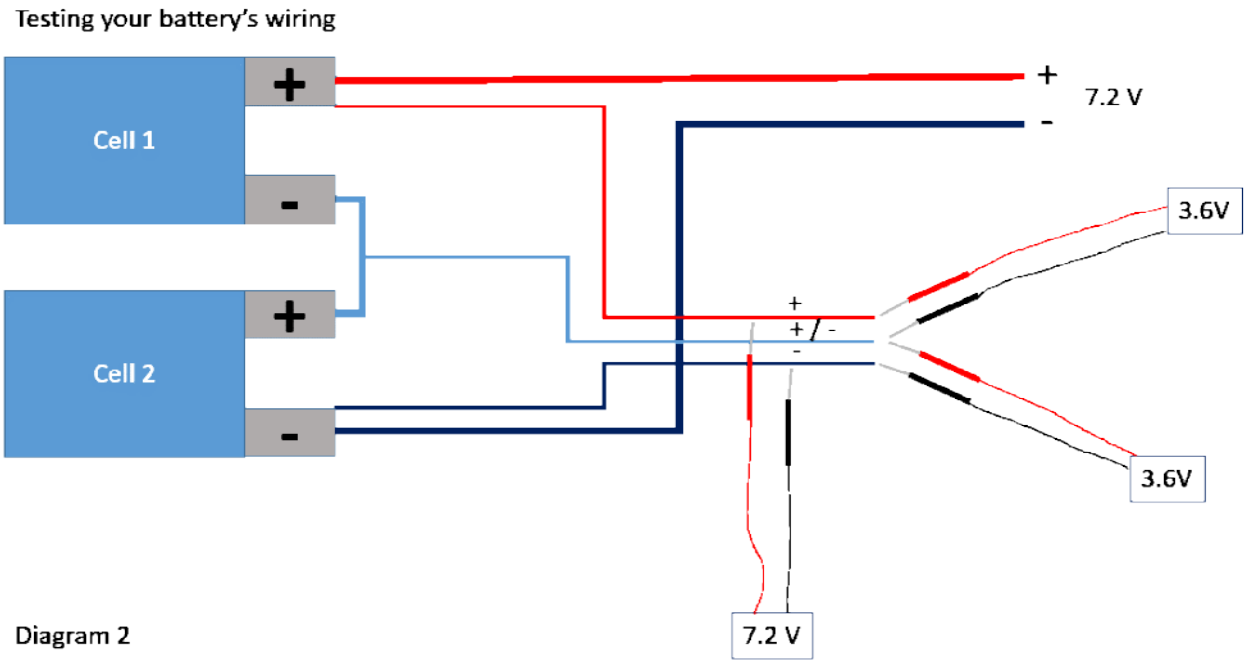
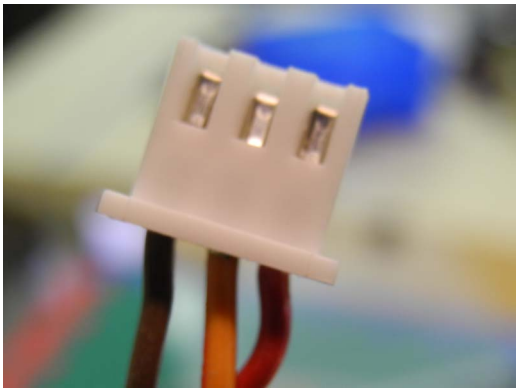


Diagram 2

A note about the orientation of crimp connector housings! One side is usually "blank" while you can see release tabs for the internal crimp pins on the other. I call the blank side the bottom and the side with the release tabs the top. I always work from the "top".



Now that you understand your battery, what are we going to do?

1. Gather tools and materials. We'll need a bunch of bits and pieces.
2. Build and test a custom charge cable.
3. Create a way to attach a standard servo connector to the battery.
4. Modify your charge switches to support single-cable charging.
5. Go fly!

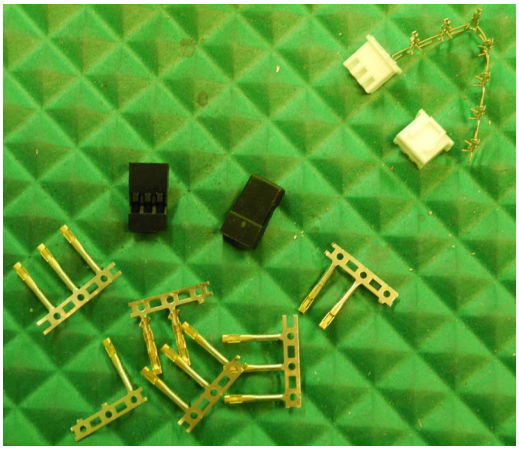
We'll need a bunch of tools and supplies. There is quite an investment required, but the same stuff will also let you build your own servo extensions. This will save you a bundle in the long run! I'll put suppliers and part numbers for everything I use at

the end of the tutorial.

1. A good balancing charger. You must have one that will test for reverse polarity and count cells in the battery being charged.

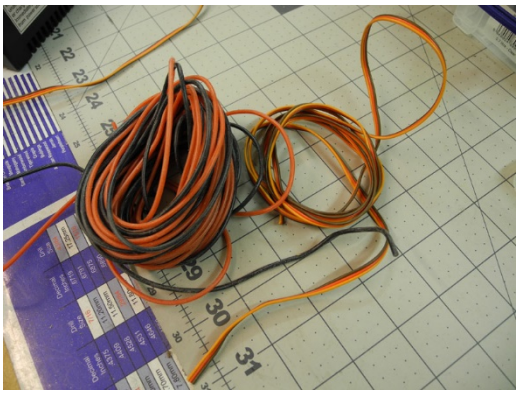
2. Voltmeter. But then you already knew that. I have a really cheap Radio Shack digital multimeter.

3. Appropriate connectors for your battery, charger, and radio. I'm not going to discuss making basic crimp-connections. There is good information about that on the web.
    a. 3-pin housings and female crimp pins matching the battery's balance port (JST XH for my batteries and chargers)
    b. Servo connector housings and male & female crimp pins (JR/Spektrum in my case)
    c. 2mm bullet connectors
    d. Black and red banana plugs



4. Soldering iron – anything over 25 watts should be fine

5. Wire
    a. 22 or 24 gauge red and black silicone insulated
    b. 22 or 24 gauge three-conductor servo wire in colors to match your radio system (orange, red, brown for JR/Spektrum)



6. Pliers
    a. Side cutters
    b. Small-diameter wire stripper
    c. Crimping tool for the connectors

7. Shrink tubing: 3/16^{ths} and 3/8^{ths}
8. Tiny little screwdriver for manipulating crimp connector retainers

Building the Charge Cord

Everything collected? Let's make a charge cable. I'll assume you have a standard balance-charger with banana jacks for charging and a separate board or built-in ports for balancing. Diagram 3 shows a schematic view of what we are trying to accomplish.

The completed charge cable

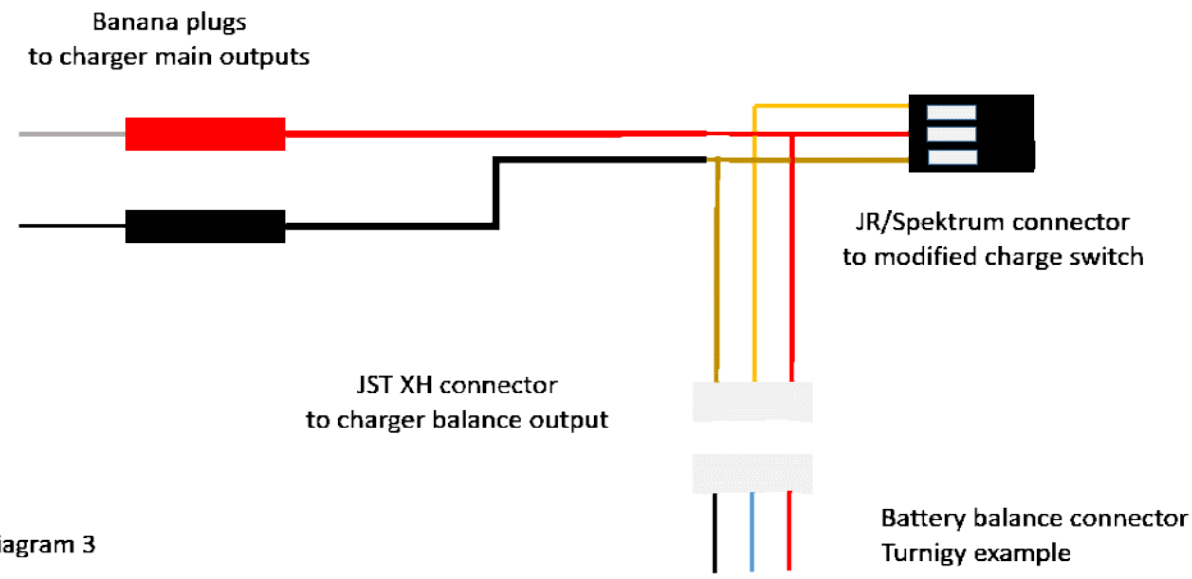


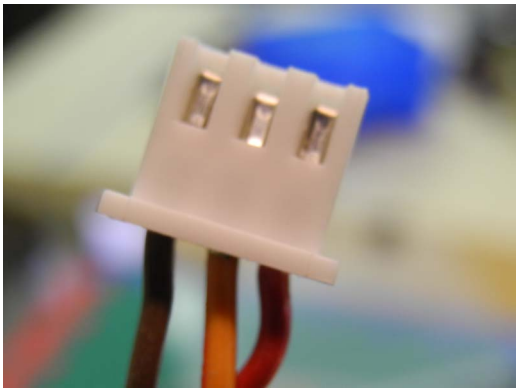
Diagram 3

It really doesn't matter where you start, so let's start at the charger end.

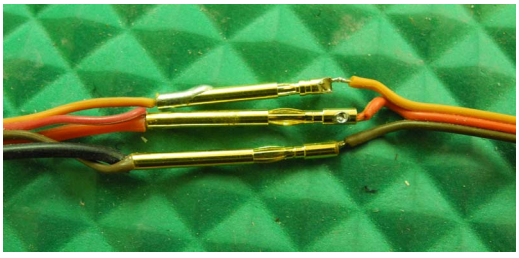
1. Cut two lengths of the silicone wire; one red, one black. Six inches is usually about right, but you can make them longer if you want. Strip both ends and tin one end of each.
2. Solder a banana jack to the tinned end of each wire. It is best if the banana jack color matches the wire color. ☺
3. Cut a similar length of three-conductor servo wire to about the same length as you cut the silicone wires. The total length of the silicone and servo wires must span the distance between the charge and balance ports on your charger.
4. Separate the conductors on each end of the servo wire - about one inch. Strip each conductor and tin each conductor on one end only.
5. Crimp an appropriate female JST XH crimp-pin to each servo-wire conductor on the un-tinned end.
6. Insert the crimped connectors into a balance jack **housing** ***in the proper order for your battery***. Double, then triple-check that the order is correct before seating them fully! For my batteries the order is [BROWN | ORANGE | RED].

   Brown connects charger negative to the servo-wire negative conductor
   Orange connects charger center-tap to the servo-wire signal conductor
   Red connects charger positive to the servo wire positive conductor.

   Once you are sure everything is OK fully seat the crimp connectors in the housing.

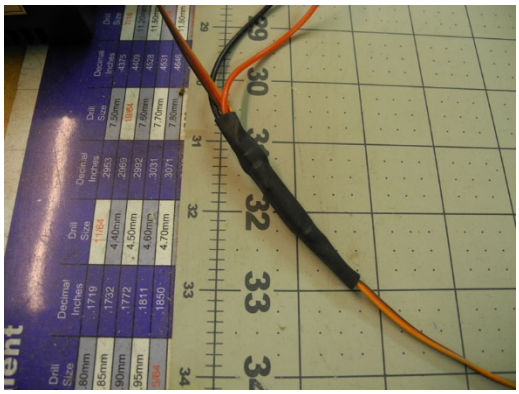


7. Twist the un-tinned ends of the red servo and red silicone wires together tightly. Solder them together. Trim the solder joint to 1/8th - 3/16th an inch.
8. Repeat the process joining the black silicone and brown servo wires.
9. Tin the end of the orange servo wire and trim it as well.
10. Solder the two wire pairs and single orange wire into the female ends of three 2mm bullet connectors.
11. Cut a length of 3-conductor servo wire to whatever length you like. I find an overall cord length of 18 inches is about right, so I cut about 12 inches of servo wire in this step.
12. Separate, strip, and tin one end. Then solder each tinned conductor into the male end of each 2mm bullet connector.
13. Cut three lengths of 3/16^{ths} shrink-tubing long enough to cover the bullet connectors and any bare wire on either end.
14. Cut one length of 3/8^{ths} shrink connector 3 inches long. Slide it over the long bit of servo wire.
15. Slide a piece of the 3/16^{ths} shrink tubing over one half of a bullet connector pair, insert the corresponding half, and seat it fully. Repeat for all three bullet connectors.



16. Center the three bits of shrink tubing over each bullet connector and shrink with a heat gun.

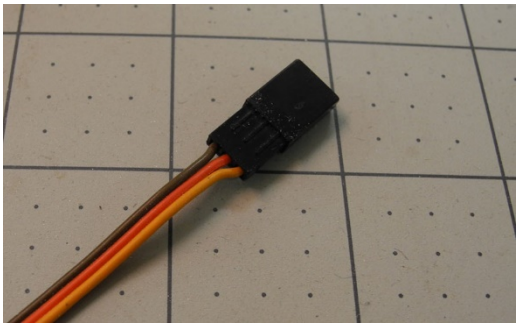
17. Center the long piece of 3/8^{ths} shrink tube over the now covered bullet connectors and shrink it in place.



NOTE: you can skip the bullet connectors and solder all of the wires directly together. I just find the bullet connectors make thinks much easier and neater.

18. Crimp a male servo connector pin to the other end of each connector on the servo wire and insert them into a servo connector housing. Again, be very, very careful about the orientation. ***On this end you must match your radio's standard layout*** in this end. For my Spektrum radio systems the order is ORANGE (+/-) | RED (+) | BROWN (-). Slide and seat the outer housing that covers the exposed pin-ends.

    Note: the connector in the picture is "upside down" the crimp-connector release tab opening are on the bottom. Hence, the conductor order appears reversed. It isn't.



The charge cord is now done. Take a moment and admire your handiwork.

Connecting to a Battery

The next step in the process is to figure out how you want to mate your radio's charge/power lead to the balance plug on the battery. You can make an adapter cord or you can replace the balance plug with a standard servo plug.

My preferred method (diagram 4) is to replace the battery's balance connector with a standard servo connector. This isn't always practical as some manufacturers like to make the balance pigtail really short. But, if it's 1.5" or more you can swap out the connector with a little careful work.

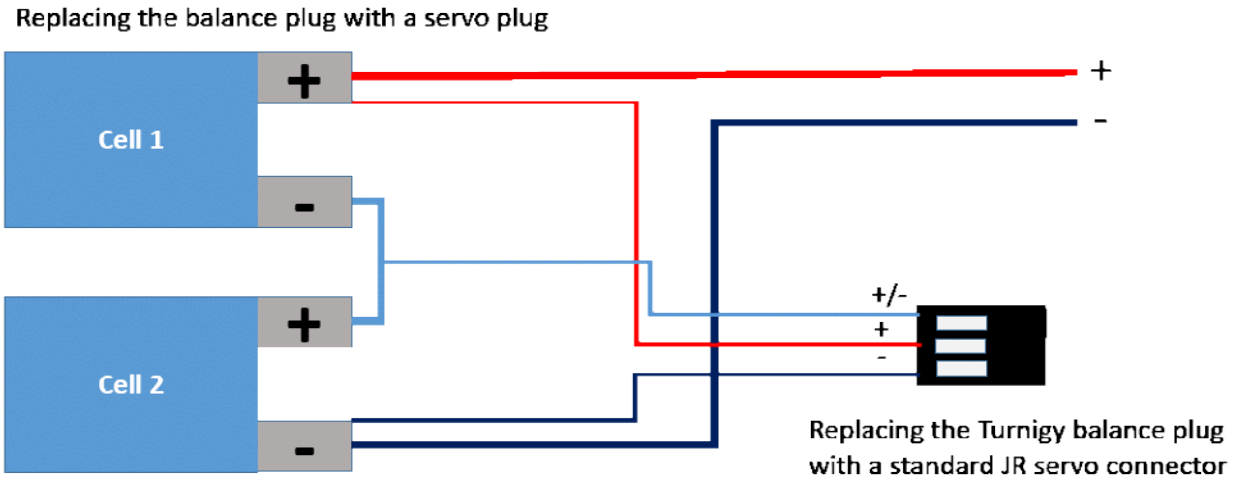


Diagram 4

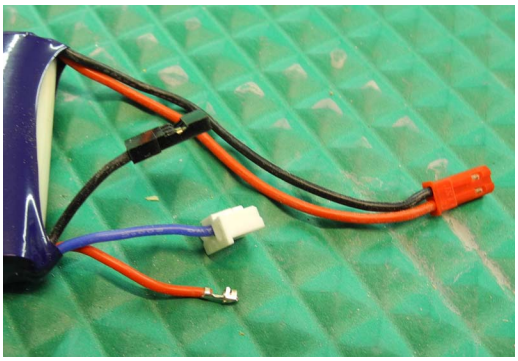
Warning

Remove and change wires from the balance connector one at time. Never have more than one wire "loose". Failure to do this will almost certainly cause a short that can ruin the battery (best case), start a fire (worse case), or cause personal injury (worst case)

Warning

1. Remove one connector from the balance plug. This usually requires simultaneously pushing down on a teeny-tiny little tab at the rear of the crimped-on pin, pulling on the attached wire, all while holding onto the balance plug. Three hands and a goodly supply of bad words are helpful. I have noticed that the JST XH pins require quite a bit of force on the tab.

   Notice in the picture, I have converted the black wire and it's safe in the new servo-connector housing. I am working on the red wire. The blue wire is safely out of the way in the white housing we are working to get rid of.



2. Cut off the crimped-on connecter and strip the wire.
3. Crimp on a new female servo connector pin.
4. Insert the pin into a female servo housing. Once again, pay attention to the location! The wire locations must match their counterparts in your new charge cable and will almost certainly be different from where they were located in the balance plug.
5. Repeat for the other two balance leads
6. Double and triple check everything

The other way to make the transition from the battery's charge plug to standard 3-conductor radio system wiring is to make a short adapter cable as shown in diagram 5.

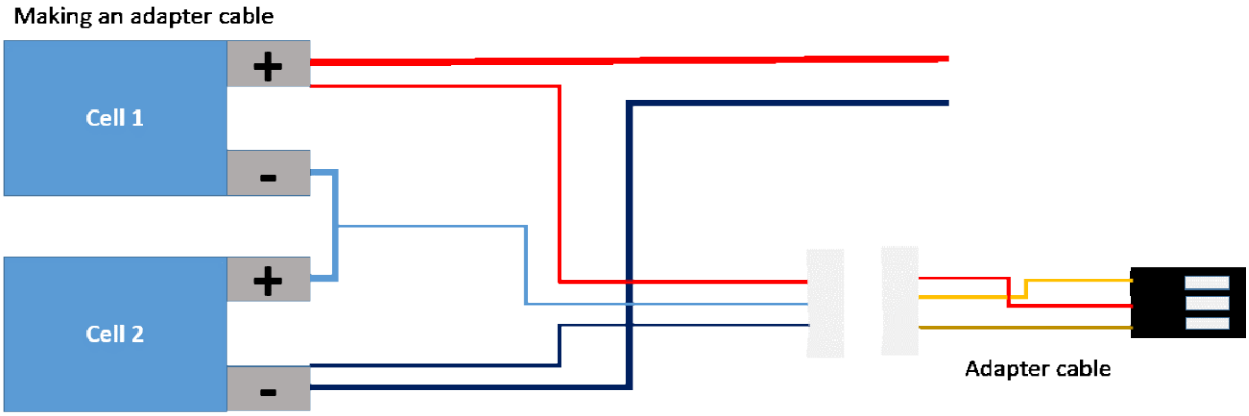
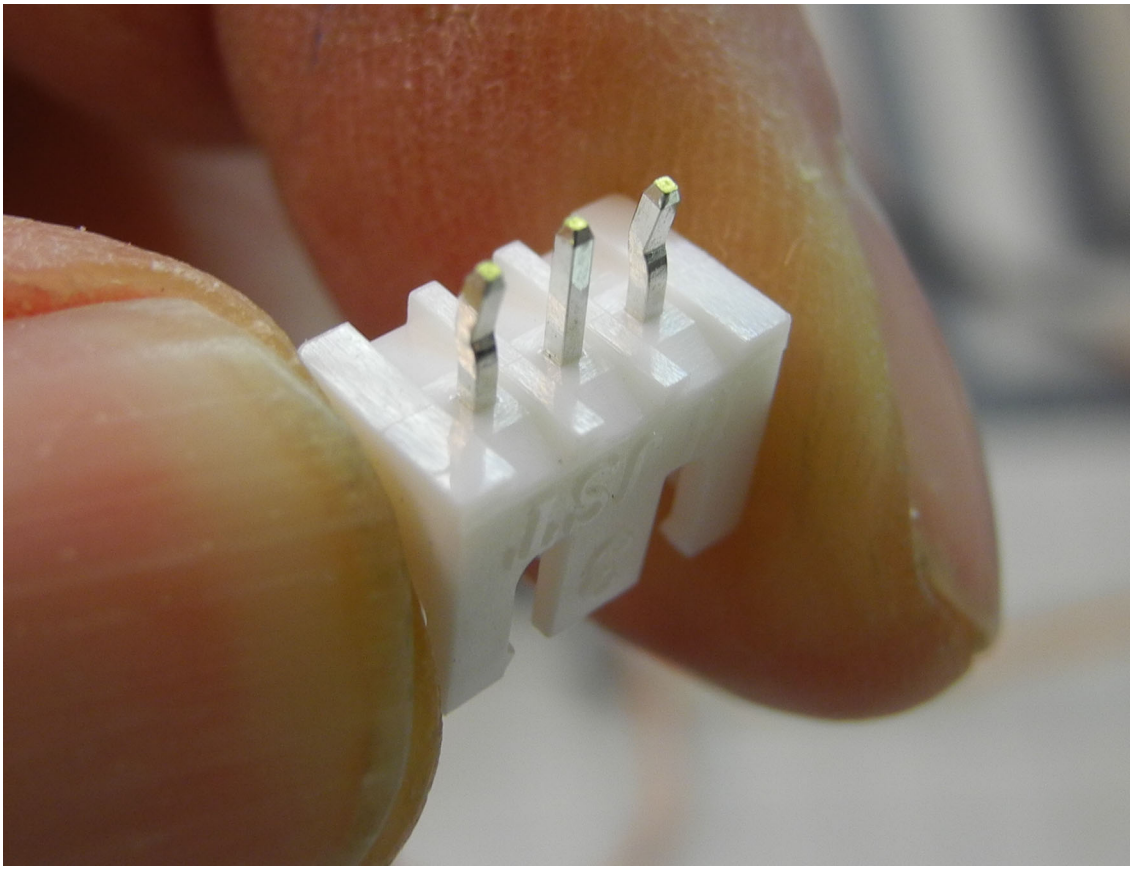


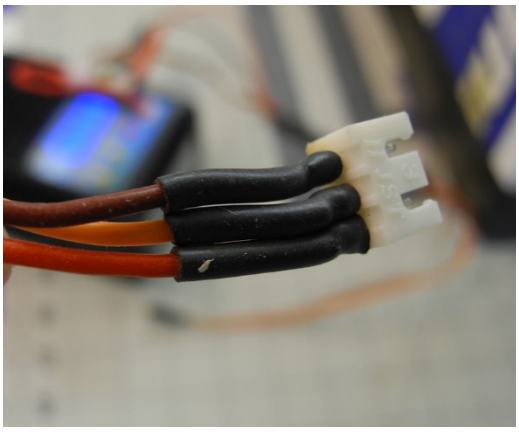
Diagram 5

Making an adapter cable is pretty simple, but has two minor drawbacks in my opinion. The first is that it adds another failure point in the power-path to the receiver. The second is that the male JST XH connectors aren't available with crimp-connectors. They are solder only, and I have a heckuva hard time soldering them without melting and deforming them.



Anyway, the process is thus:

1. Cut an appropriate length of three conductor servo wire. Separate and strip each conductor at both ends. Tin the three conductors at one end.
2. Crimp female servo pins to each of the un-tinned conductors and insert them into a female servo plug matching the standard order for your radio system. For mine that is [ORANGE | RED | BLACK]. It should line up exactly with your new charge cord.
   Slip a short piece of 1/8th shrink tubing over each tinned conductor end.
3. Solder the tinned ends to the male balance connector. Pay attention and get them lined up properly. Again, they will probably not be "straight through". Something will cross somewhere. For me, the proper order is [BROWN | ORANGE | RED].
4. Slide the shrink tube over the solder joints and shrink with a heat gun.



You can now test your setup. Plug your new cable into a smart balance-charger and set the charger for a LiFe charge cycle. In this photo I am charging a 2100 mAh battery. Plug the battery into your new cable. If you have done everything correctly the charger will report seeing a 2-cell battery at somewhere above 6.6 volts (assuming a good battery).

If the charger reports only one cell you have wires out of order somewhere (or an over-discharged battery). If the charger smokes and smells really bad it probably wasn't as smart as it should have been…

Assuming that the charger properly reports 2 cells and a reasonable voltage, press the start button and keep an eye on things for a while. It should charge normally.

Safely connecting to a Receiver

This is well and good and will let you bench charge your batteries with a single cable. To charge through a charge-switch we need to make one more, ***vital***, change.

Understand, this will only work with three-wire charge-switches. Most better charge switches, and any that support binding through the charge port, will be three wire. Others, like Miracle switches, are two-wire, but can be upgraded to support single-port charging.

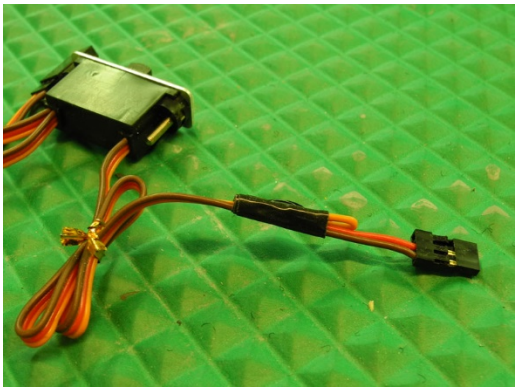
So what is the change? We must ensure that the receiver ***never, ever, ever*** sees battery voltage on the signal input pin. To prevent this, we are going to pull the signal wire from the battery-out connector of the switch. (the one that plugs into the receiver)

Warning
Failure to do this step correctly ***will*** result in the immediate and irreversible destruction of your receiver and potential damage to any connected servos, telemetry devices, etc.
Warning

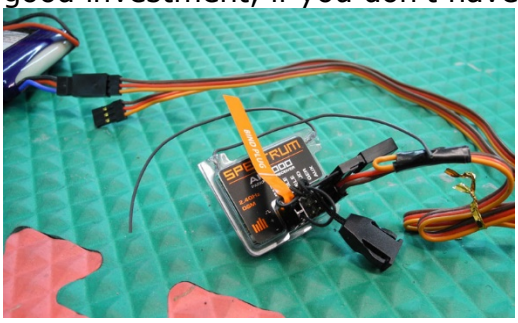
The charge-switch will have three sets of wires coming out of it:

1. Male – power out (to receiver)
2. Male – charge
3. Female – power in (from battery)

2 and 3 will usually be located on the same side of the switch. The power-out lead will be on the other. Test your switch to verify and label what is what. Then, locate the signal wire on the power-out lead. (Orange for me). Gently lift the plastic retaining tab that keeps the crimp connector in the housing and pull out the signal wire. You can cut it off, but prefer to simply fold it back and give it a couple of neat wraps of electrical tape. Voila… receiver protected.

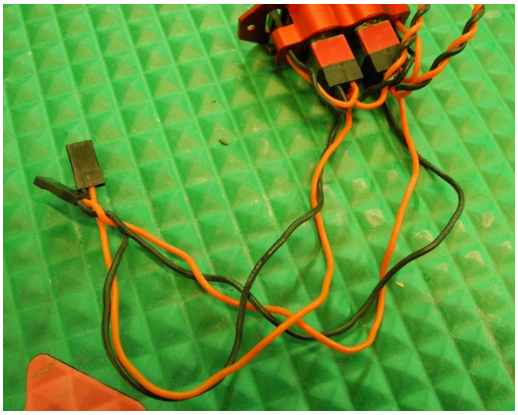


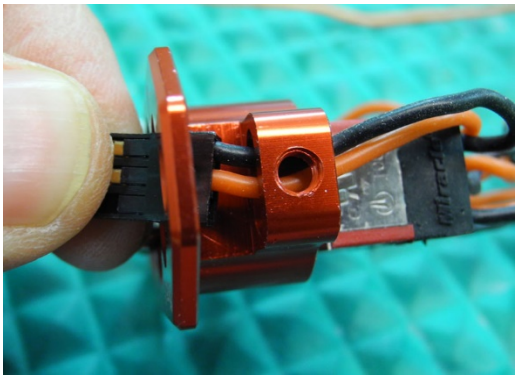
Because of the potential for expensive disaster I always test things on an old DSM park-flyer receiver that I don't use anymore. (A cheap "orange" receiver would be a good investment, if you don't have an expendable receiver lying about)

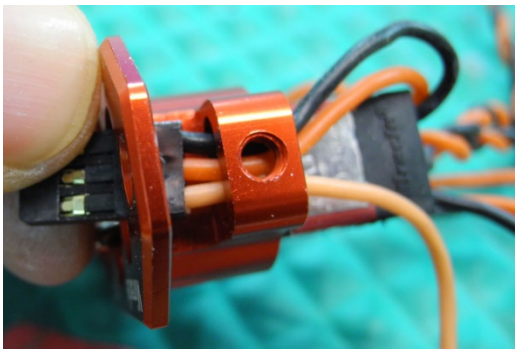


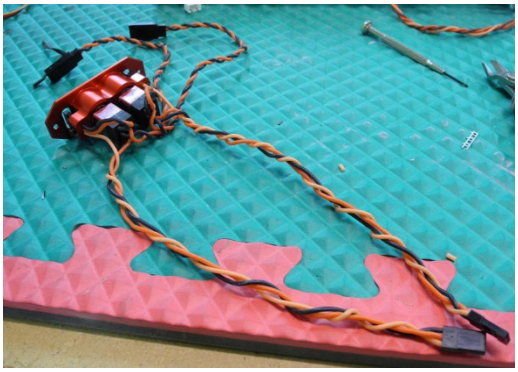
I put in a bind plug, then connect the charge switch and battery. If I get a blinking, orange LED everything is good. If I get smoke, not so much. So far, I've not destroyed anything. Knock on wood.

Some two wire charge switches, like Miracle switches can be upgraded to allow single-plug charging. You just have to add a third wire to the battery connector as shown in the following photos. Since this switch only sends two wires to the receiver no changes are needed on that end. This is a double Miracle charge-switch. I'll add a third conductor to the battery connection on each side. The next few pictures should be pretty self-explanatory.









I hope you find this, rather lengthy, tutorial useful. Please shoot me a PM with questions, comments, or if you find errors! Do be careful if you choose to try single-cable charging. It isn't hard to do, but requires attention to detail.

Regards,

Randy

Sources

A lot of the stuff you will need will be available at your local hobby shop. For those things that aren't, I've had good luck with the following. There are other options as well, but these are folks I've done business with and been pleased with the results.

Description	Source	Part Number
JST XH 3 pin Crimp Housings	www.digikey.com	455-2219-ND
JST XH Female Crimp Terminal	www.digikey.com	455-1135-1-ND
JST XH 3 Pin Solder Header	www.digikey.com	455-2248-ND
JR Connector Pack, Female	www.pololu.com	1924
Futaba Connector Pack, Female	www.pololu.com	1926
Crimping Tool	www.pololu.com	1928
Servo Wire 22 AWG - JR	www.hansenhobbies.com	none
Servo Wire 22 AWG – Futaba	www.hansenhobbies.com	none
Silicone Wire 22 AWG – Red	www.hobbyking.com	R24A80-06
Silicone Wire 22 AWG – Black	www.hobbyking.com	B24A80-06
2mm Bullet Connectors	www.hobbyking.com	AM1002A