The Basic Rov Control System Wiring Manual (Rev. 1)

Written & Designed by Steve Thone
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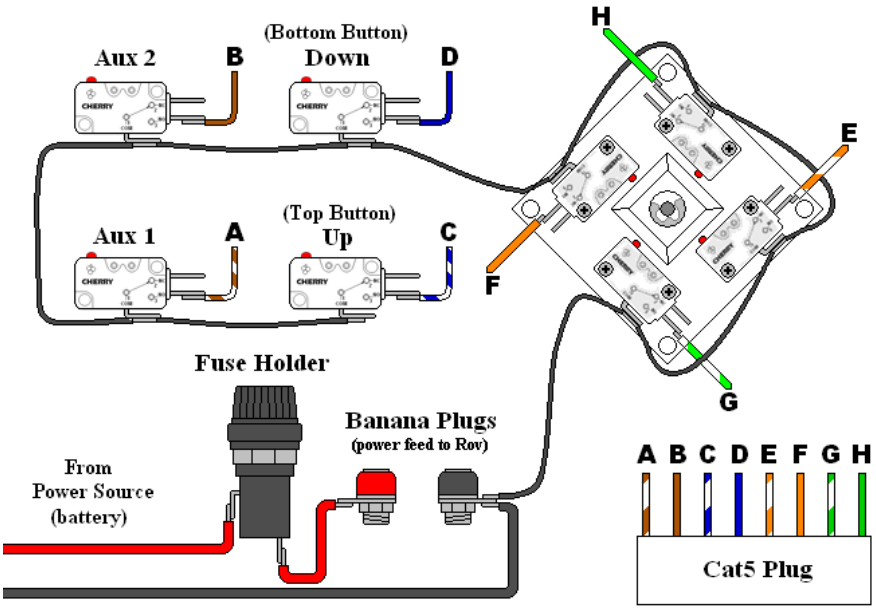


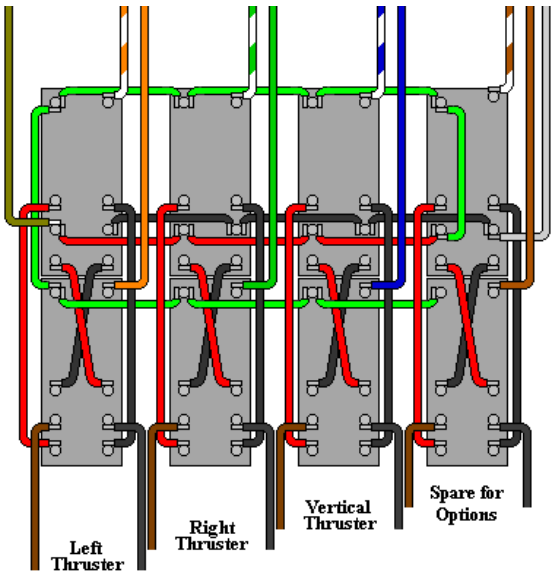


Table Contents

Introduction

Thank you for downloading the Basic Rov Control System Wiring Manual. This is an excerpt from a set of plans for a basic Rov that I have been working on (and off) for quite some time (years even) but I ran into some snags along the way and I have yet to finish them. I thought I would at least release the control system part of the plans so all of the hard work I've already done doesn't go to waste. Most of the control system info in this manual is already on my website (www.homebuiltrovs.com) this manual is just a more detailed "How to" of that same system.

The BRCS is a very simple control system that is meant for a basic observation class Rov with three brushed motor thrusters (typically bilge pump type) that allows for 3 degrees of freedom. (forward/back, left/right, dive/surface) This system only allows for basic on/off control of those three thrusters (no speed control) with the option of one add-on such as an additional thruster (for lateral movement), lights, or an open/close type manipulator. Although none of those are actually covered in this manual.

This manual will provide basic step by step instructions to wiring the control box, a simple joystick, and basic tether construction. There may be different options for certain aspects of construction and allowances must be made for your particular Rov design and the parts that you choose to use. With that in mind please read through the entire manual before starting to get an understanding of what needs to be done or changed along the way.

If you run into trouble along the way you can always email me for help at stevethone@comast.net

Tools & Parts Required

(but not limited to)

Tools Needed

Permanent Marker
Electrical Tape
Razor Blade
Wire Cutters
Tweezers or Needle Nose Pliers
Soldering Iron & Solder
Tape Measure
Drill & Bits (size dependant on wire use)
Phillips & Flathead Screwdrivers
Lighter
Scissors
Small File
Hole Saw
Soup Can & a Coat Hanger
Oven Mitt

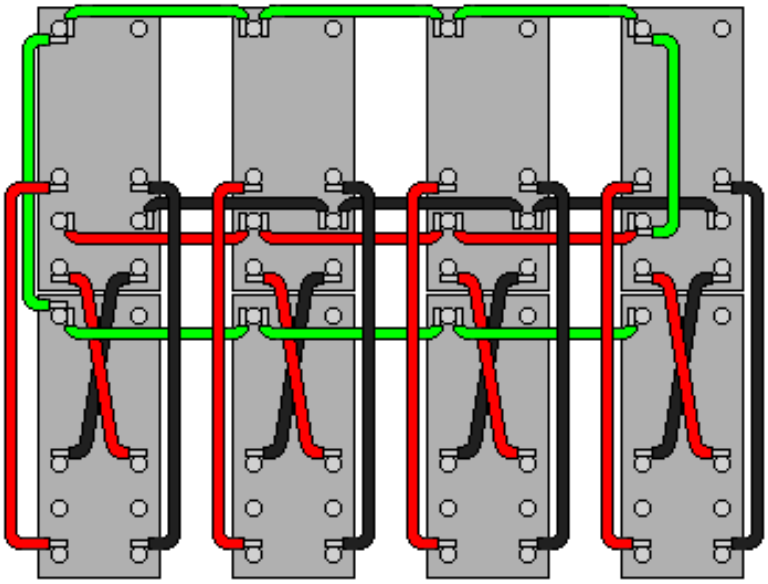
Parts List

6-8 Relays (rated to the thrusters used)
Project Box (sized to fit relays)
Cat5 Cable (Lengths depends on your tether requirement) I used 100' length
16 Gauge Wire (speaker wire works good)
Hookup Wire (20 gauge)
12 Gauge Wire
Cat5Jack
Banana Plugs and Jacks
Fuse & Fuse Holder
8 Way Arcade Joystick
Screws or Bolts (for mounting joystick)
2-4 Switches
Project Box or Enclosure (for controller housing)
Alligator Clips
Clay
Wax
Zip Ties

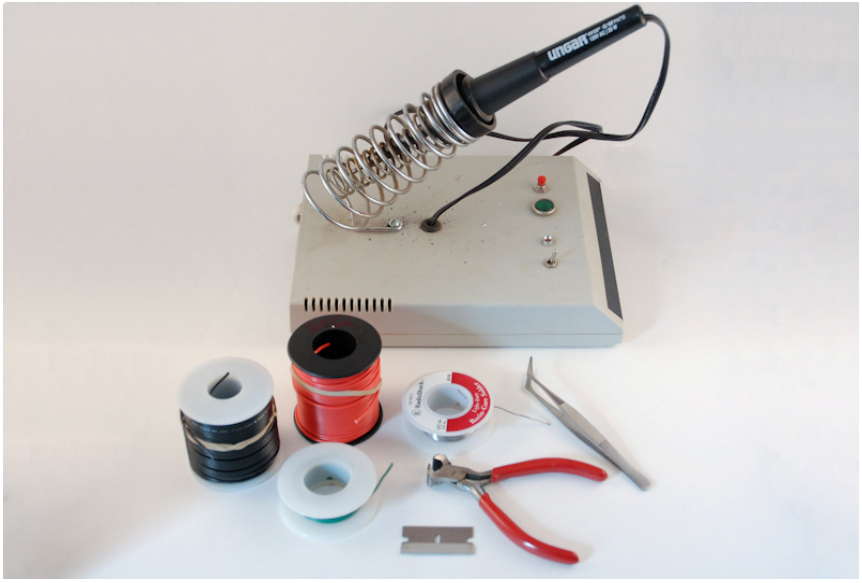
Optional Parts

Camera Cable
Hollow Polypropylene Rope (sized to your wires) I used 100' length of 3/8"

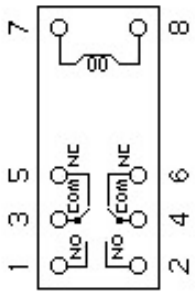
Wiring the Control Box Relays



This manual uses both diagrams and actual pictures to aid you in wiring the control box and joystick. Above is an example of one of these diagrams.



Examples of some of the Tools required – Soldering Iron, Solder, Wire Cutters, Razor Blade, Tweezers, and Hook Up Wire.



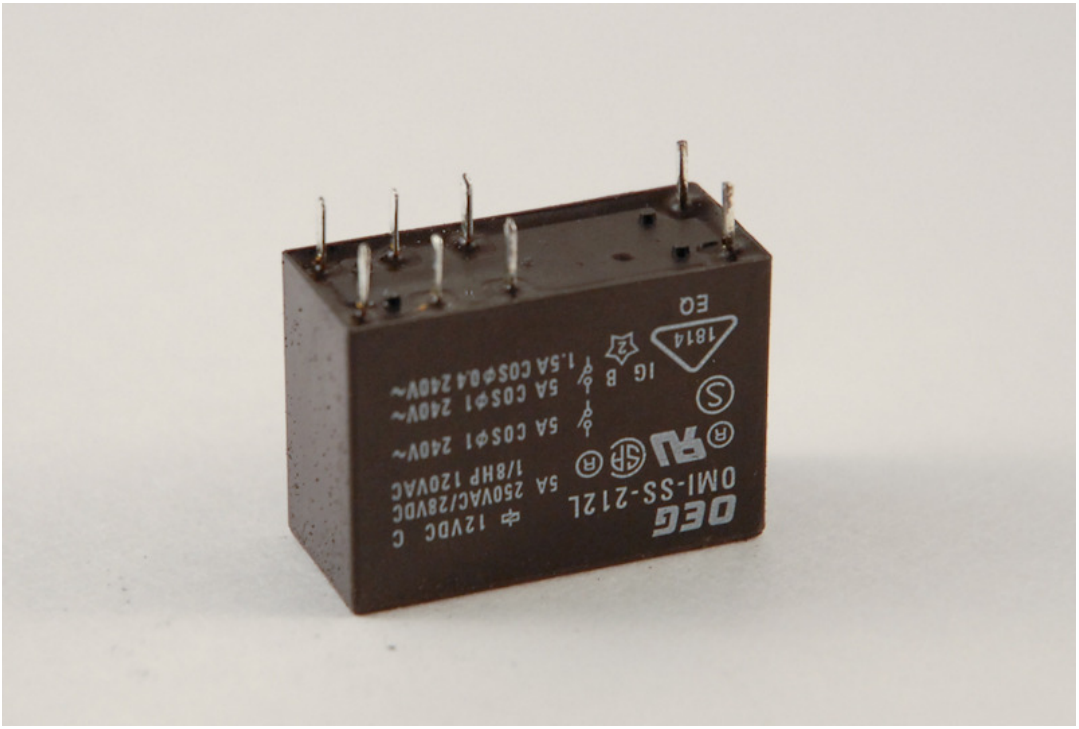
You will need at least (6) Duel Pole Duel Throw (DPDT) Relays to control both forward and reverse of the three thrusters. (two per thruster) It is best to test the maximum amp draw of your thrusters before buying the relays. If you are using bilge pump converted thrusters your relays should be able to handle a minimum of 5 amps.

Note - While a bilge pump thruster running a 50mm prop can draw over 6.5 amps (typically) you will experience a certain voltage drop over the length of your tether. I chose a 5 amp rated relay because I know from testing over a 100' tether my thrusters only draw 4.5 amps at the Rov end. If you go with a shorter tether you may need relays with higher rated contacts.

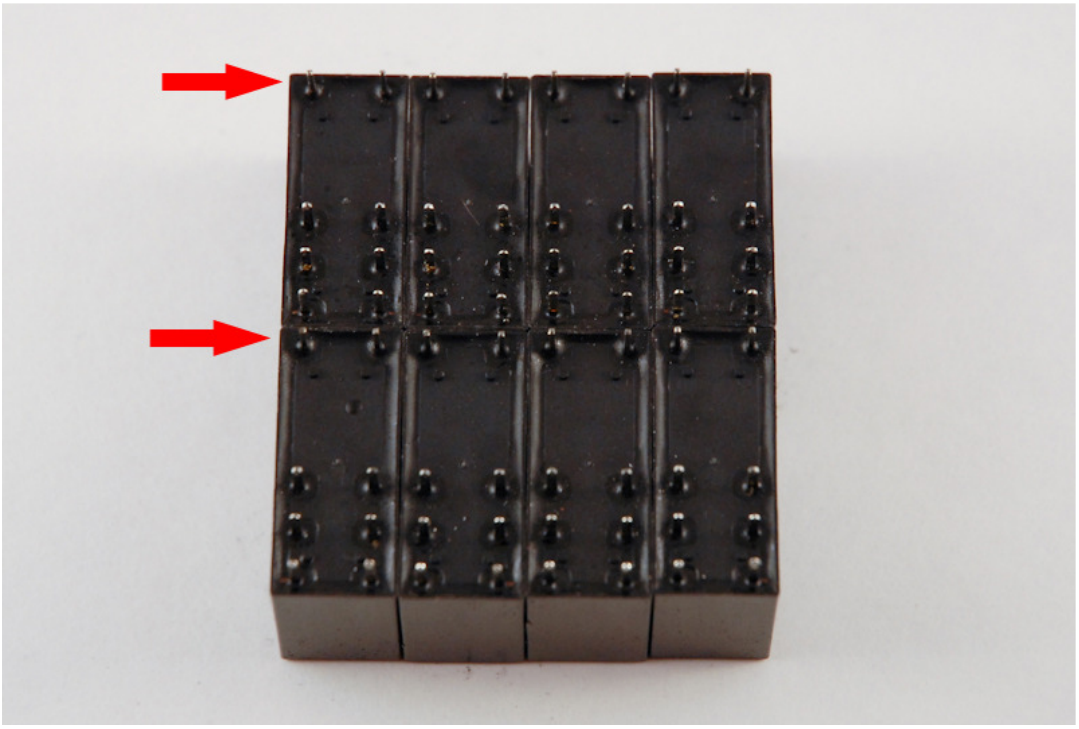
The relays you select **must also be a sealed type relay** because you will be sealing them in the project box with melted wax. (if you choose this method) If they are not a sealed relay the wax may leak into the relays and prevent the relay contacts from functioning. See the steps starting on page 72 for more info on what will be involved.

I will be showing the wiring of the control box using a total of eight relays because the cat5e cable used to control these relays contains 4 pairs (or 8 Wires) so the extra wires and relays can be used to control additional options if you choose to add them on later.

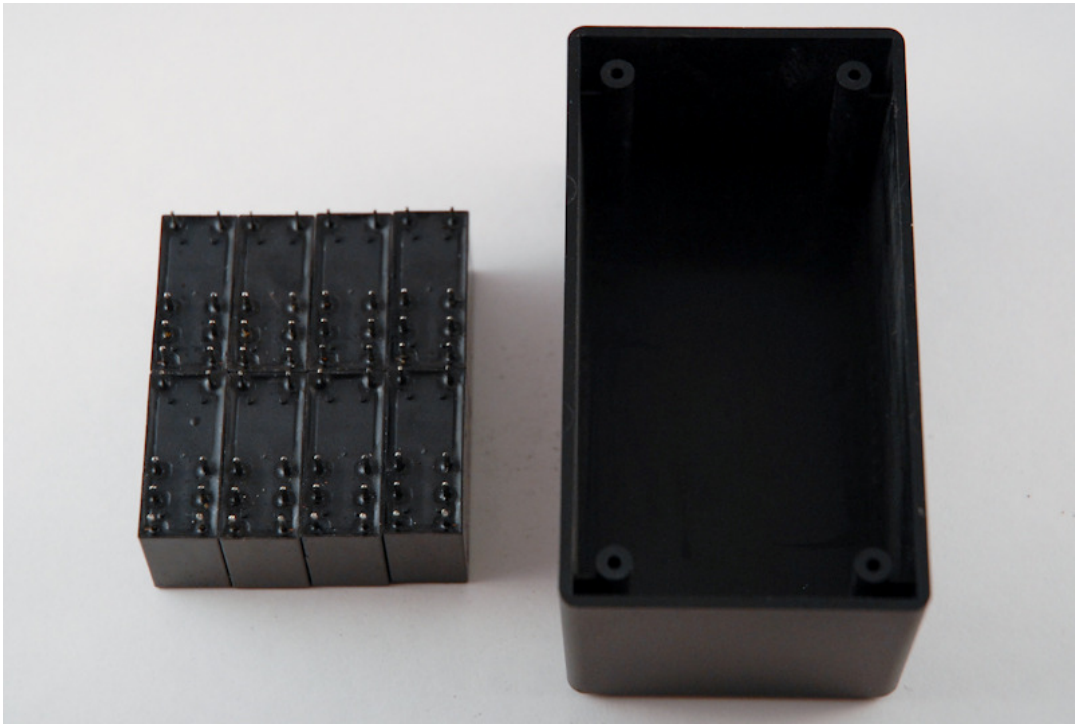
All relays are unique and can have different pin layouts so you will need to make sure you know which pins are which before you start. The DPDT relays I am using have 8 pins as shown above, (looking at the bottom of the relay) 1 and 2 are the Normally Open (NO) pins, 3 and 4 are the Common (COM) pins, 5 and 6 are the Normally Closed (NC) pins, while 7 and 8 are the Coil Pins. Depending on the relays used sometimes the Common pins maybe located where my NO pins (1 and 2) are shown. If you happen to buy relays like this just follow the hook up directions text and don't go by the pictures. (e.g. - Hook the NO pins of the top relay to the NC pins of the bottom relay)



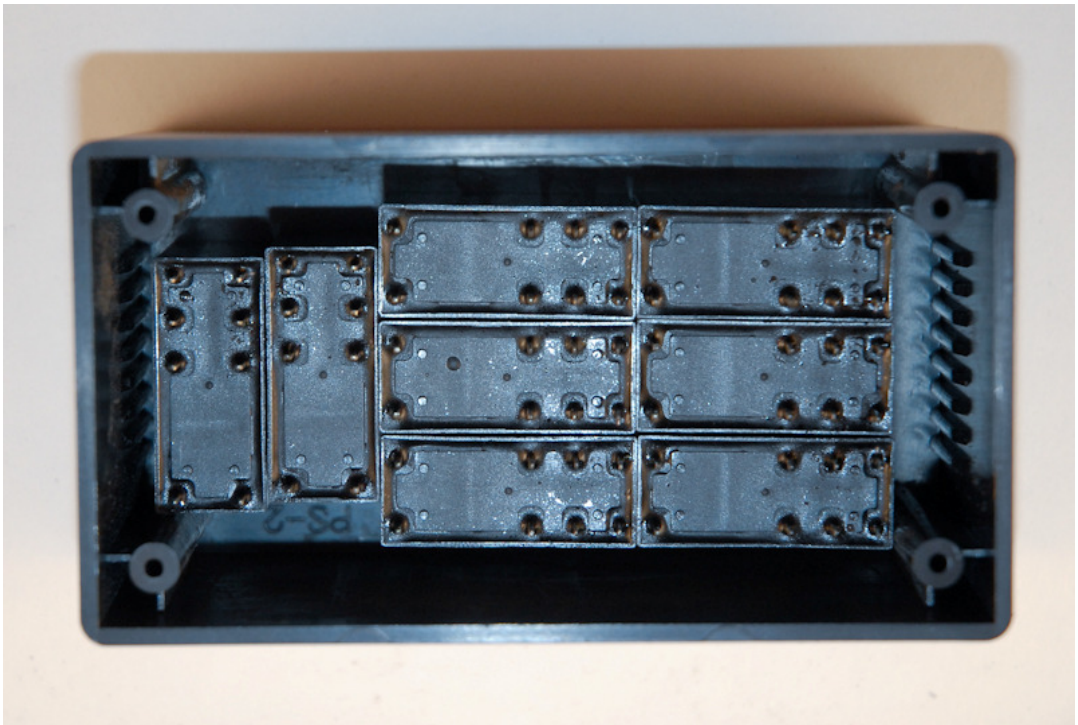
You will be mounting the relays upside down and just wiring the pins together using the hook up wire.



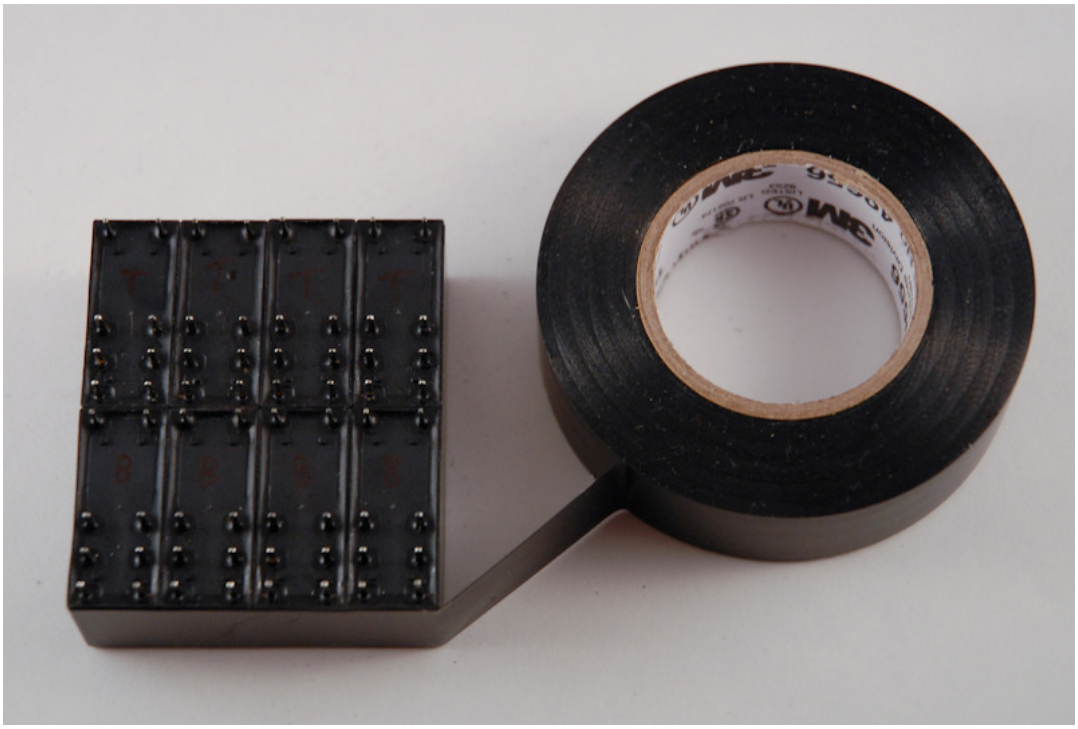
The first step is to arrange your relays as shown with the pins for the relays coils at the top for both the top and bottom relays. As shown by the red arrows.



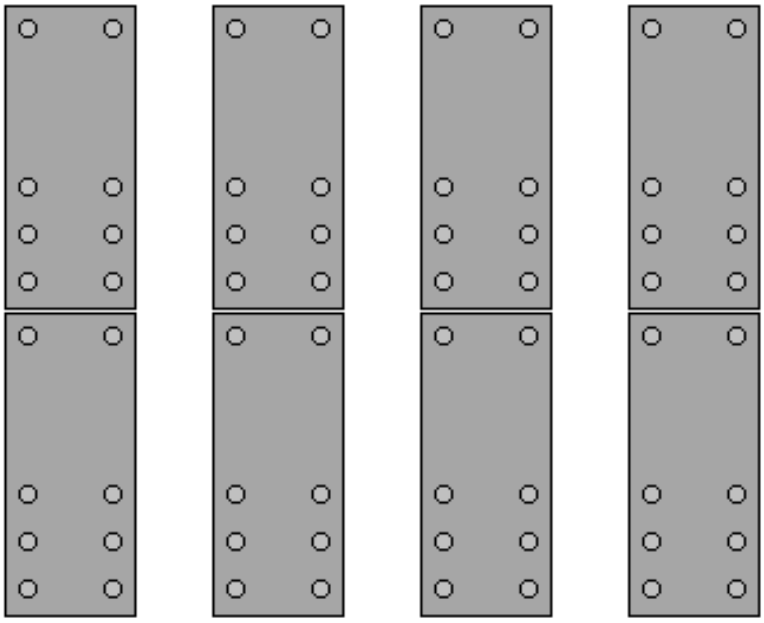
This would be a good time to make sure your relays will fit in the plastic project box. The size of the box will depend on the relays used and the design of your Rov. Make sure you have some room for the wires and wax that will be used later on to waterproof everything.



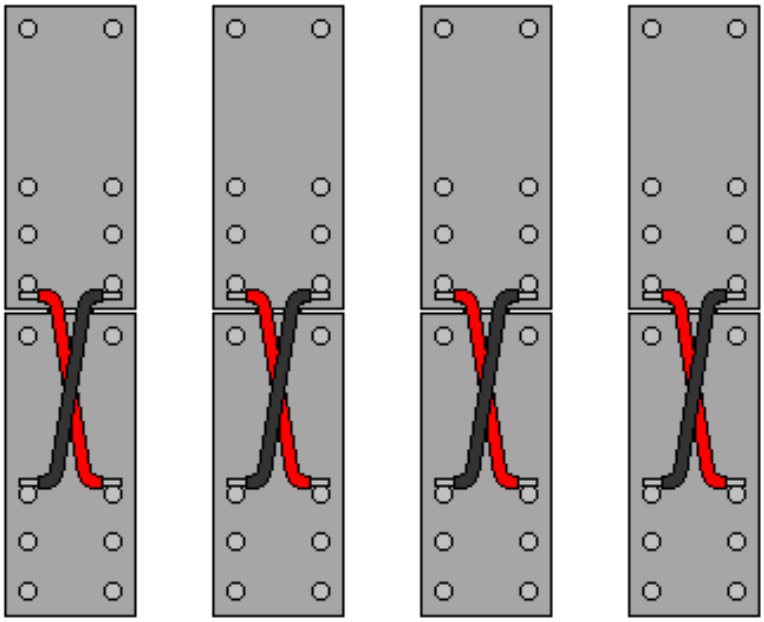
You can change the placement of the relays (such as shown above) to fit the box if you need to but you would just have to follow the text directions for hook up instead of looking at the pictures.



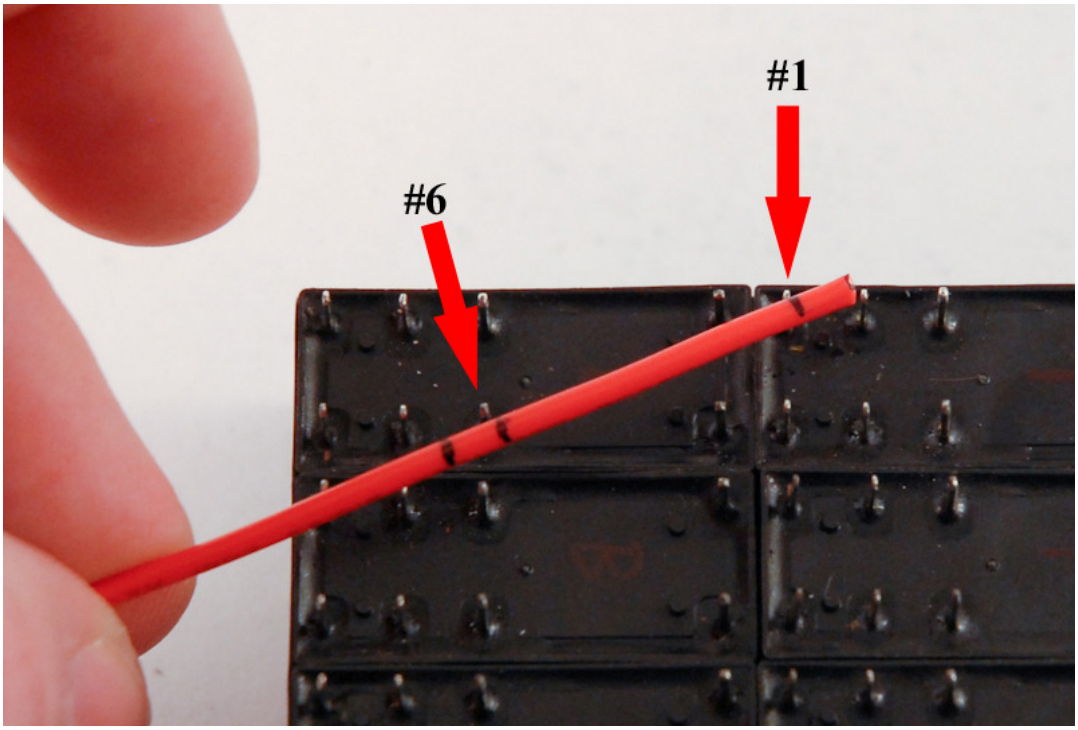
I like to start by taping the relays together with electrical tape to hold them while I solder the connections. I also like to mark them top (T) and bottom (B) so I don't get confused at any point.



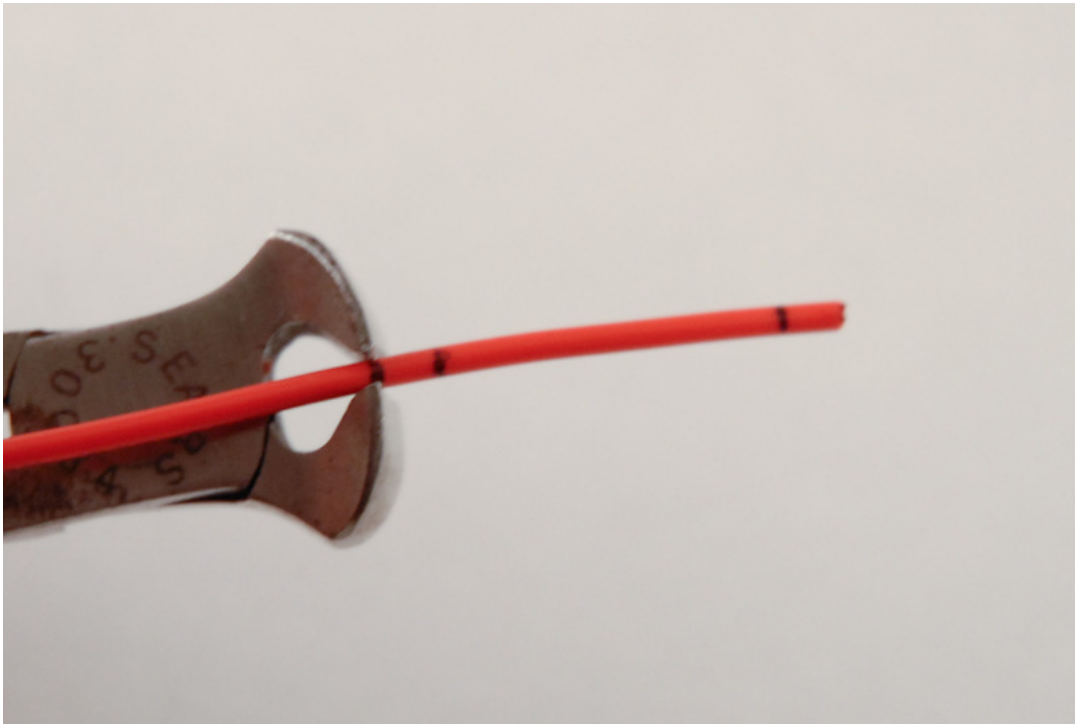
To make my wiring diagrams a little easier to read I show them with the relays spaced out.



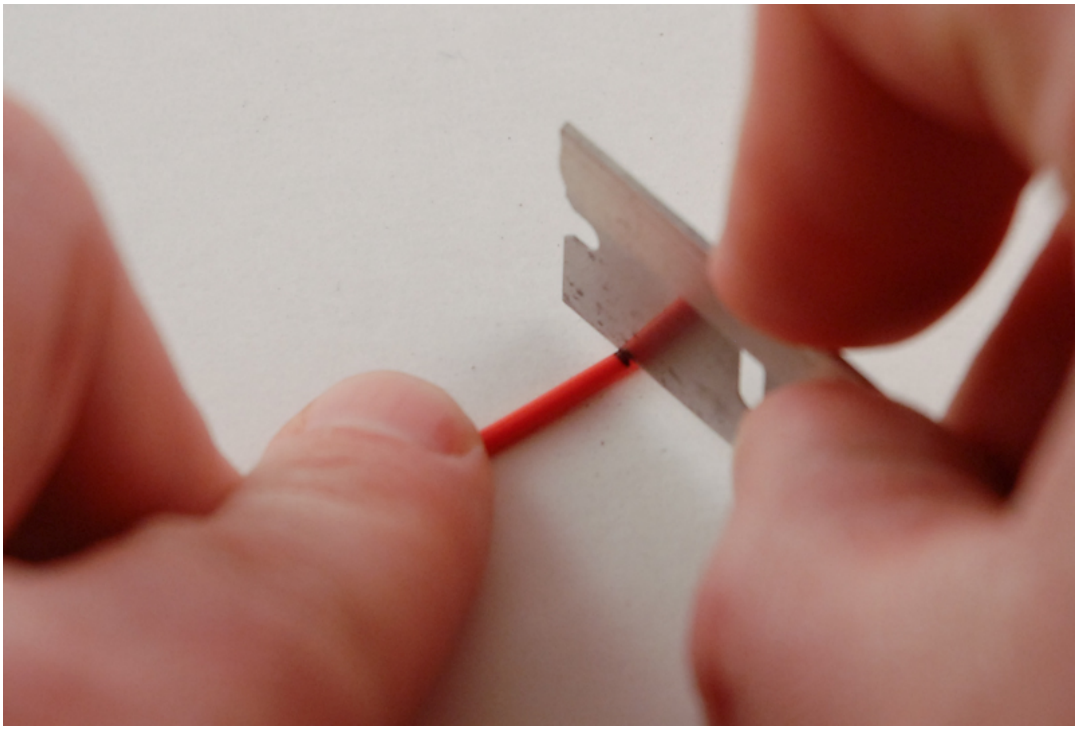
The first step in the hook up will be to form the crossover between the top and bottom of each relay set. You will be connecting the NO pins (1 and 2) from the top relays to the NC pins (5 and 6) of the bottom relays. Using red wire connect pin #1 of the top relay to pin #6 of the bottom relay. Then using black wire connect pin #2 of the top relay to pin #5 of the bottom relay. You will be doing this for each pair of relays as shown above.



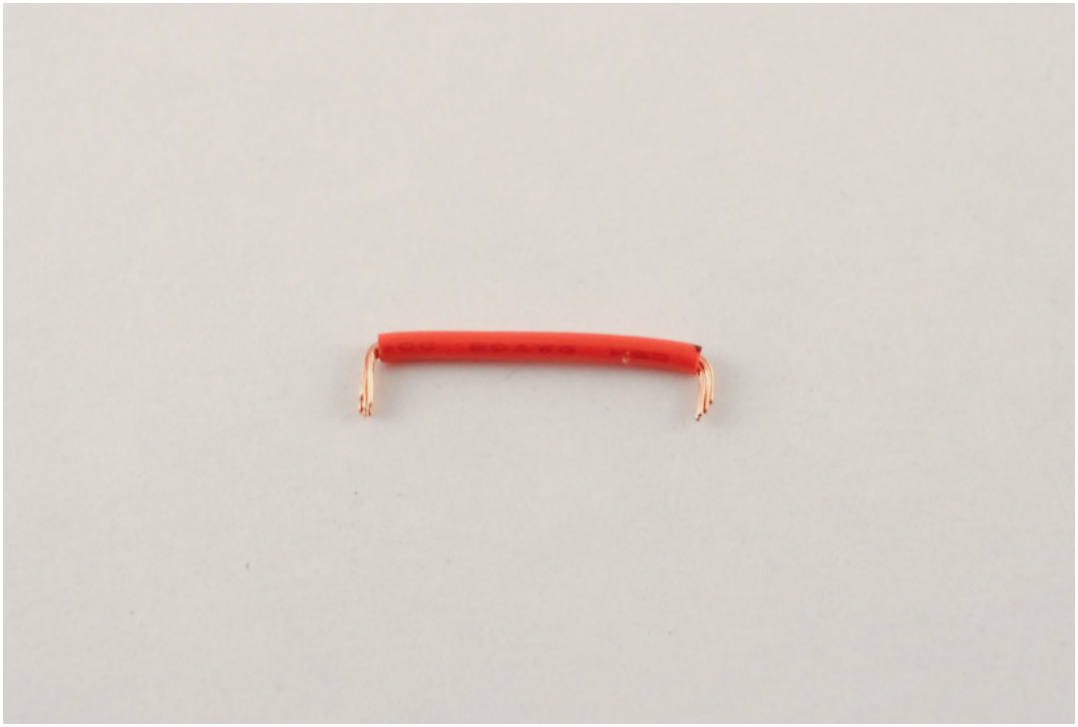
To keep everything as clean as possible so everything will fit into the box I like to make the wires as short as I can. I start by holding the wire up to the pins I need to connect to and mark where I need to strip them. Leave about an 1/8” of wire past the #1 pin of the top relay and mark the location of both pins to be connected and the another 1/8” over hang past the #6 pin on the bottom relay.



Using your wire cutters, cut the wire on the third mark you made.



You can use your wire cutters or wire strippers (if you have them) for this step. I find it hard to hold such small wires firmly enough to strip this way so while holding a razor blade on the mark I made I roll the wire with just enough pressure on the blade to cut the jacket and not the actual copper wire.

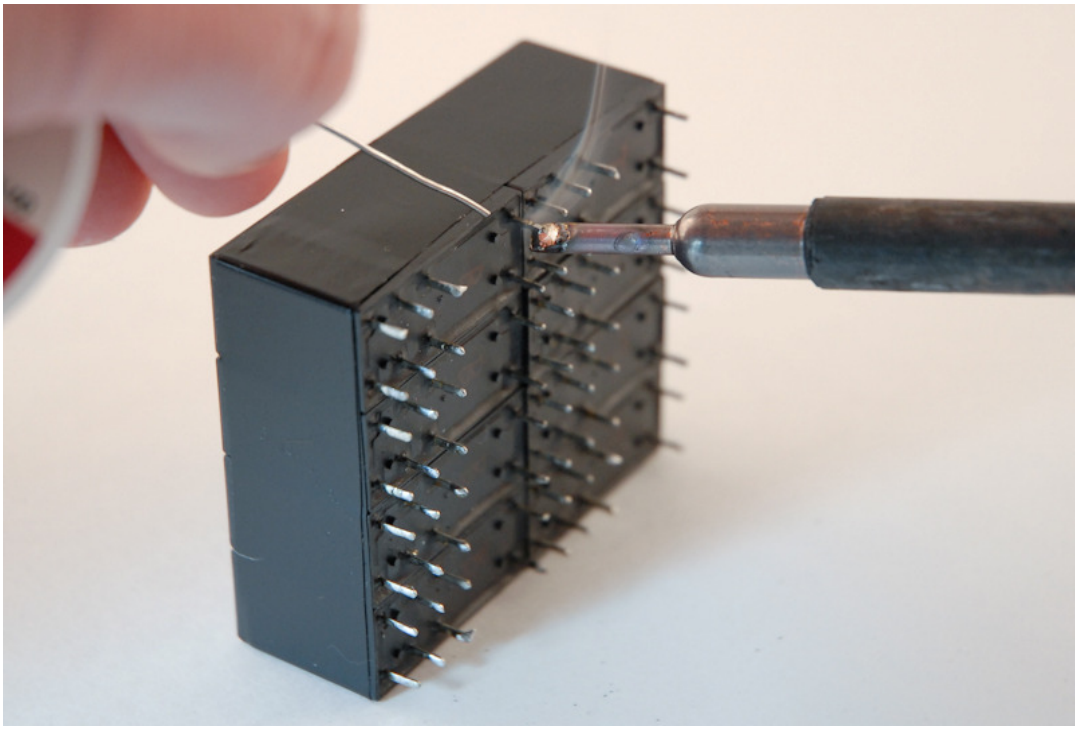


After both of the ends have been stripped just twists the ends a bit and then bend them downward at a 90 degree angle.

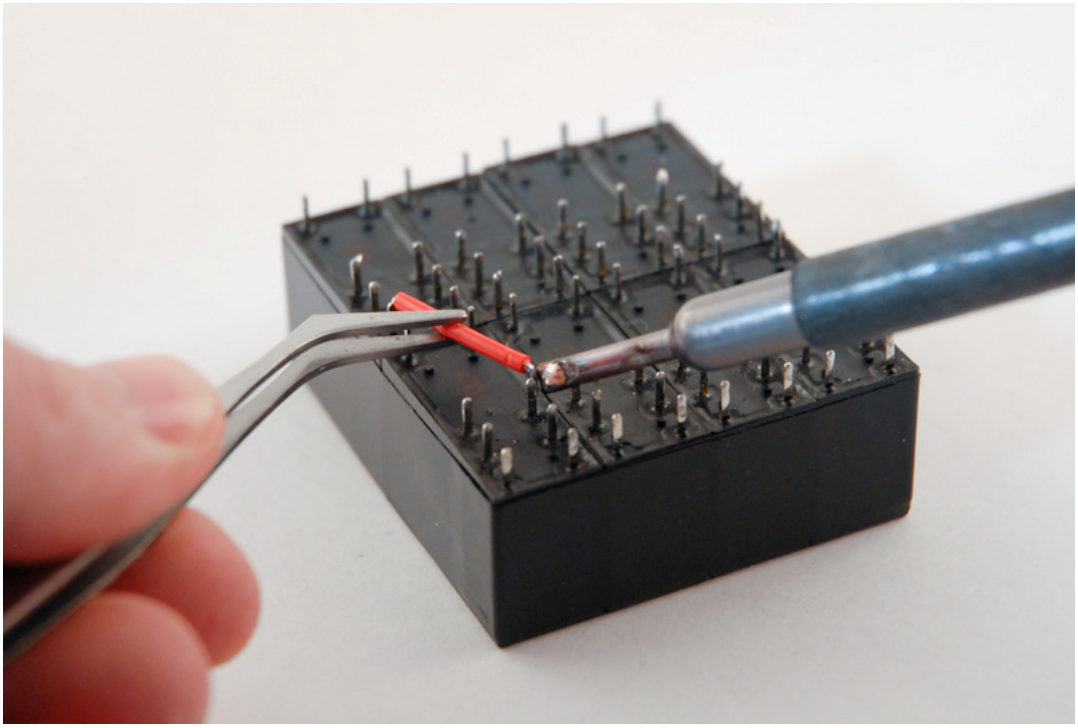
Make four wires for each connection (4 red & 4 black) and using your soldering iron tin each end.

To tin a wire, heat up your iron and start by cleaning the irons tip with a wet sponge or wet paper towel to remove any old oxidation. Apply a bit of solder to the tip of the iron (don't over do it) then hold the tip of your iron to the wire for a bit, next apply the solder to the wire, (not the iron) wait for the solder to flow into the wire coating it, then remove your iron.

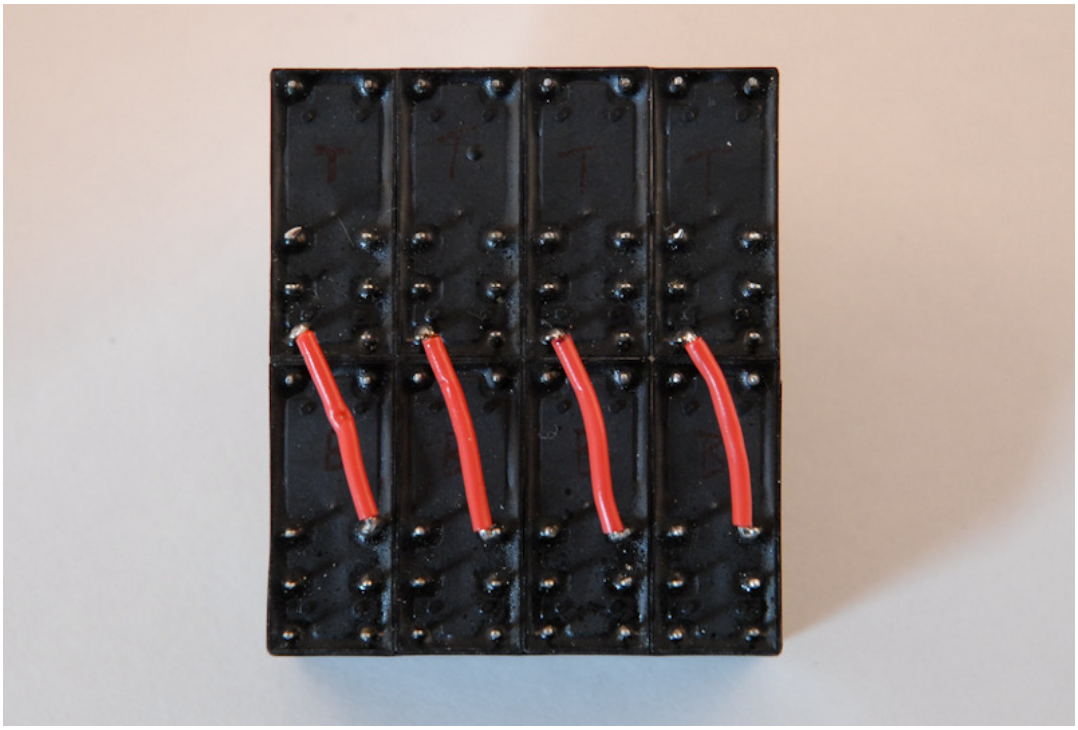
Having a pair of helping hands (as shown above) can help when soldering small wires because they can heat up quick and be too hot to handle.



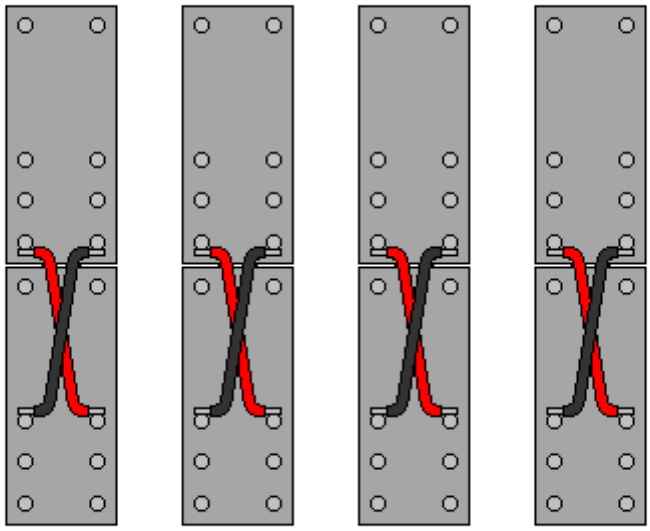
After your wires are tinned, continue by tinning each of the pins on all of the relays. Remember a little solder goes along way here with the pins this close together on the relays you do not want any heat and glob soldering.



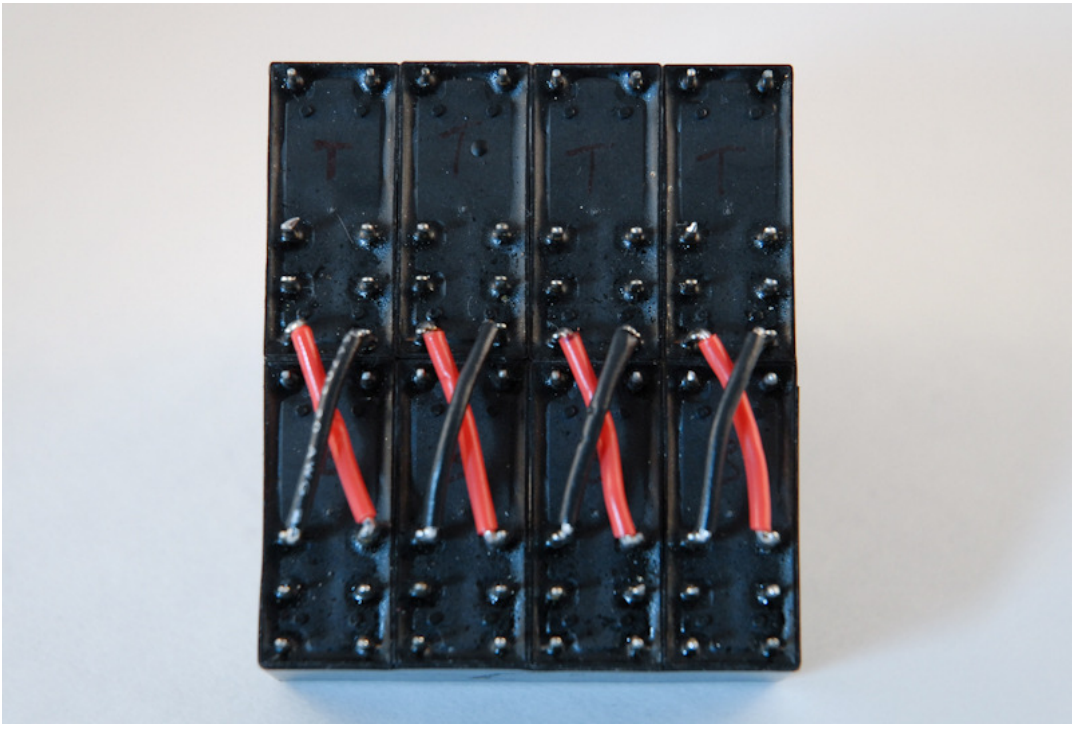
Using a pair of tweezers or needle nose pliers hold the wires to the right pins and apply some heat with the tip of your iron to start the connection for each wire. Remove the iron and hold the wire until the solder cools.



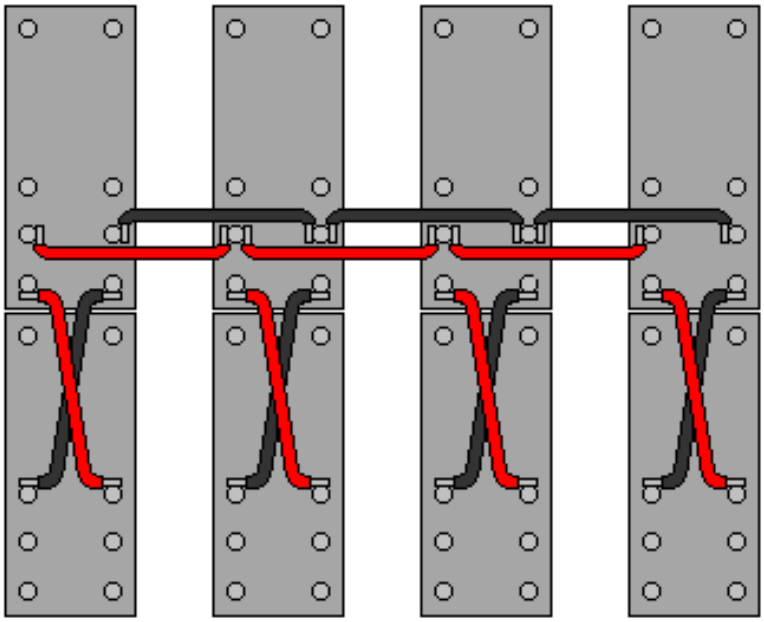
I like to connect one side of the cross over at a time on each set so I don't become confused.



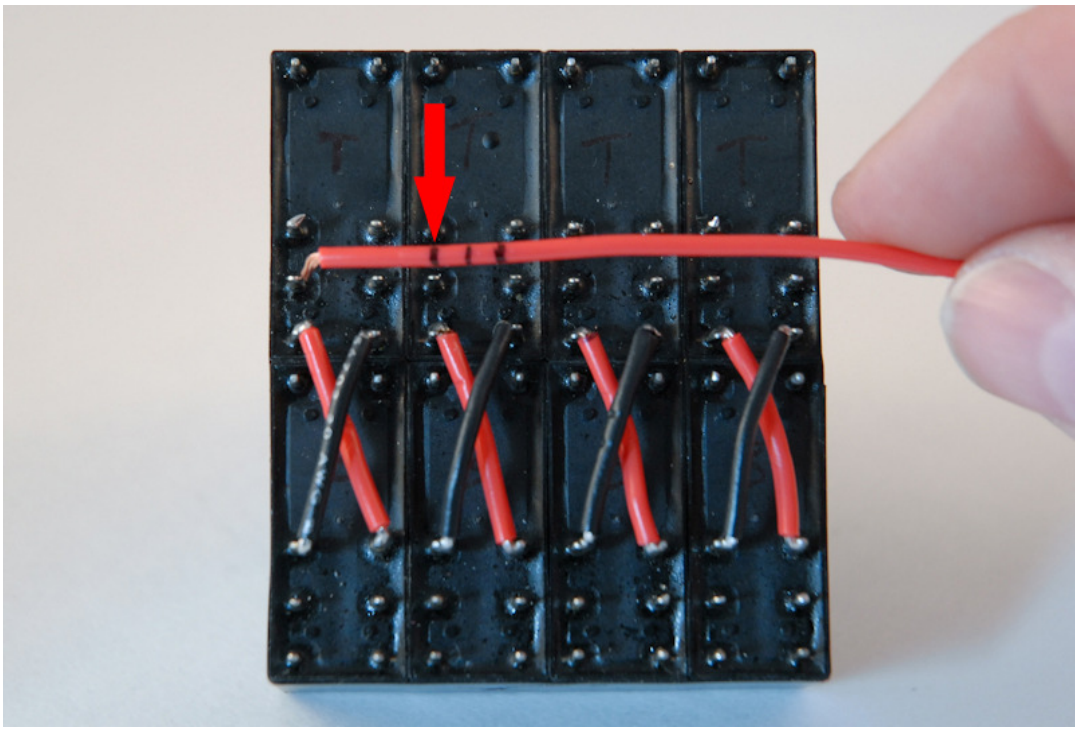
Following the same process continue with the other half of the cross over using the black wires.



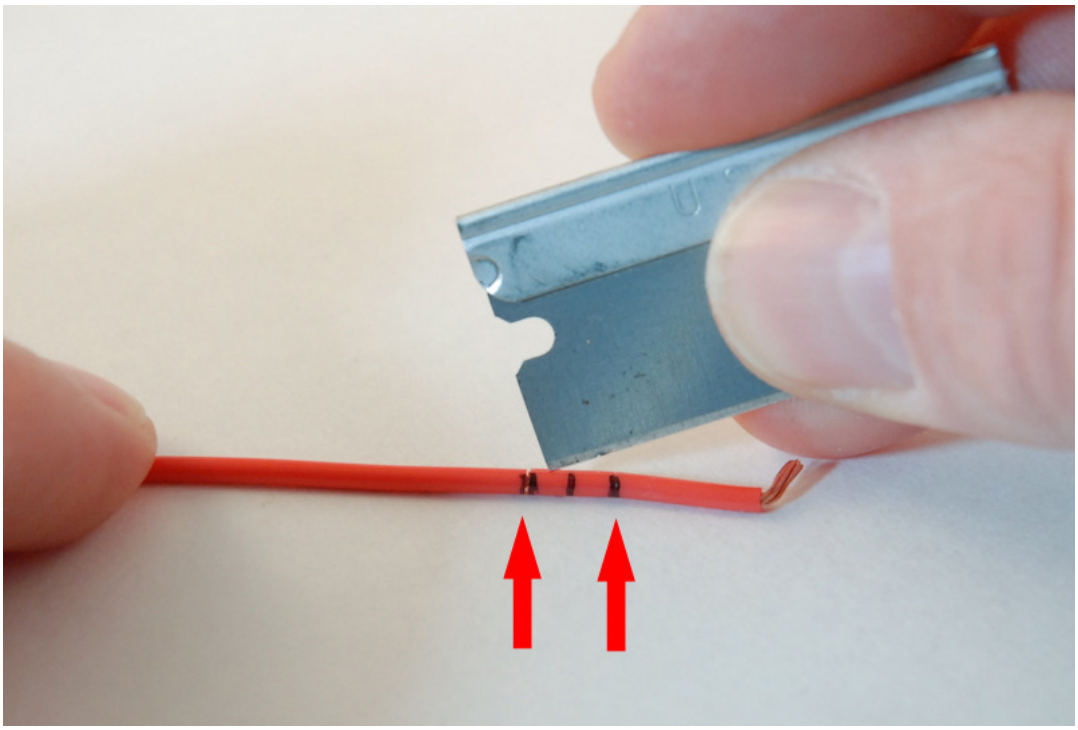
At this point your relays wiring should look just like the picture above.



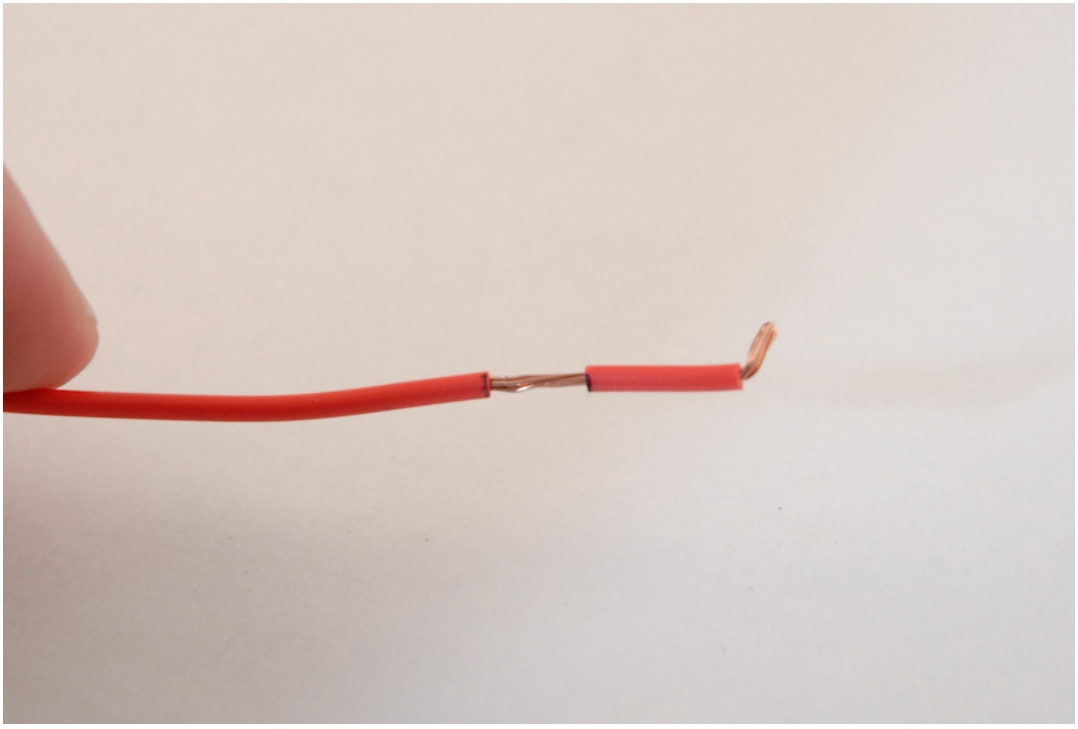
The next step is going to be connecting the common pins of the top relays together. This will be you main power feed to all of the relays. For the positive feed wire (red) you will be connecting together all of the #3 pins and for the negative feed wire (black) all of the #4 pins on each of the top relays only.



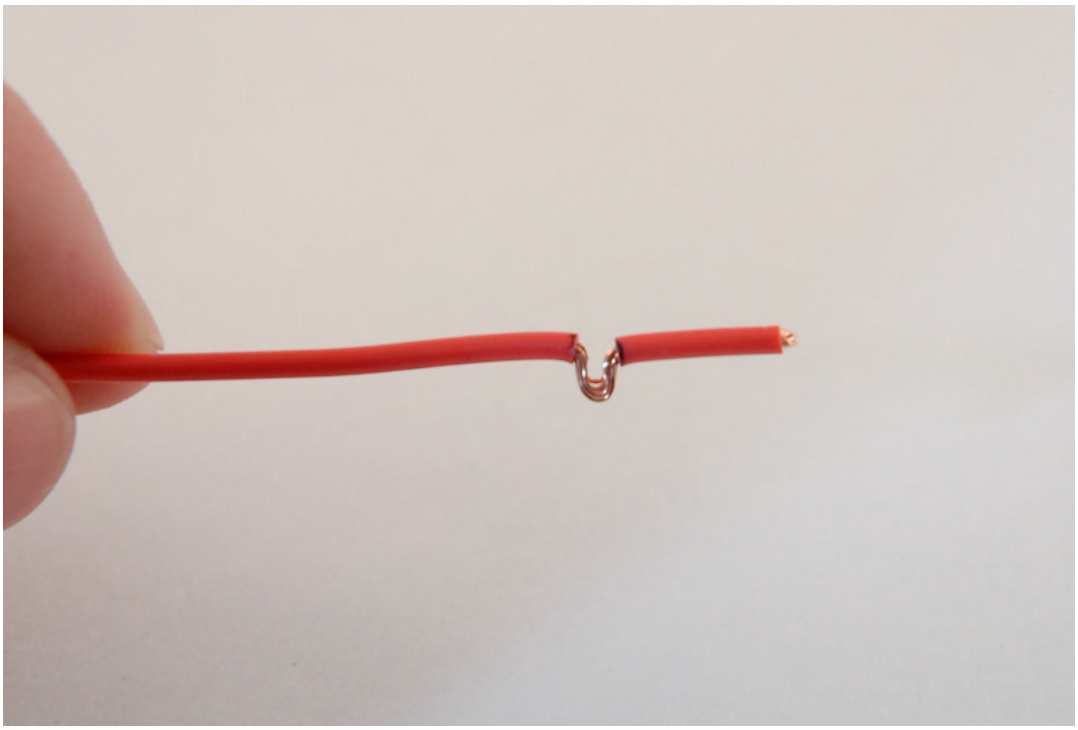
Start by stripping the first 1/8” of a piece of wire and bending it down for the first pin. Then line up that bend with the #3 pin on your first relay, next mark your first line where the #3 pin is on the second relay. Mark two more lines each a 1/8” or so apart. The second line will be the middle of a U bend in the wire and is more for visual reference. I like to make all of these connections using a single wire because it is easier then trying to hold two separate connections from two separate wires to each pin while you try to solder each connection.



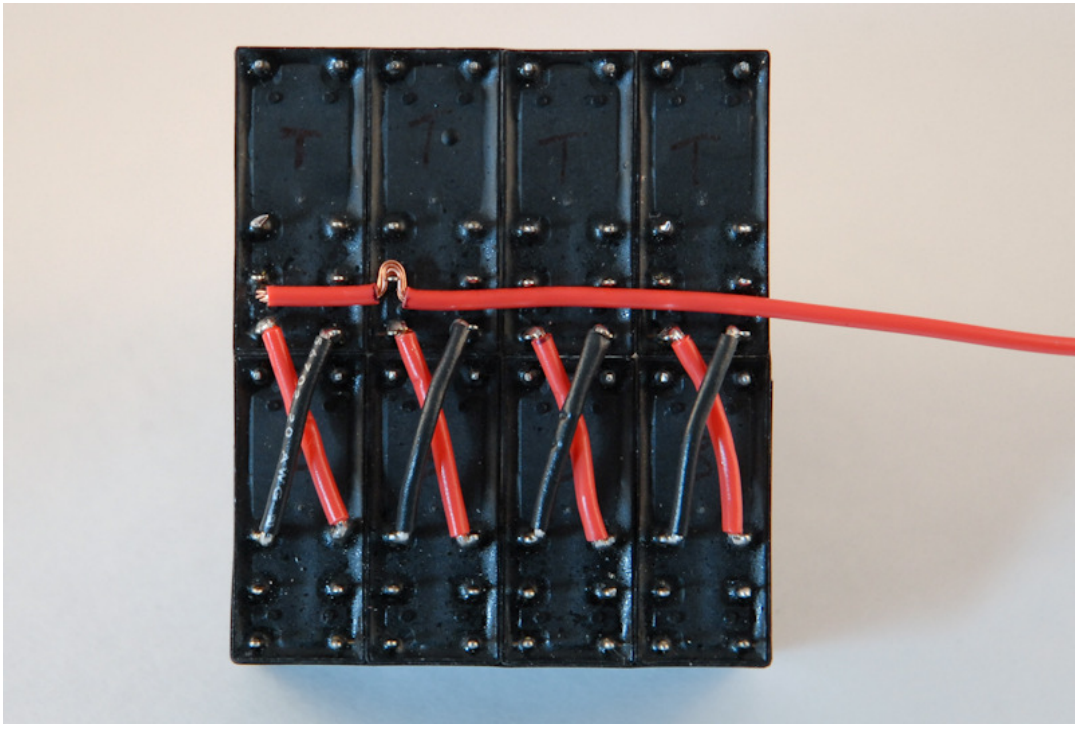
Using your razor blade (and the same cutting rolling method described before) slice through only the jacket on the two lines shown above. Then slice lengthwise between those two lines being careful not to cut yourself.



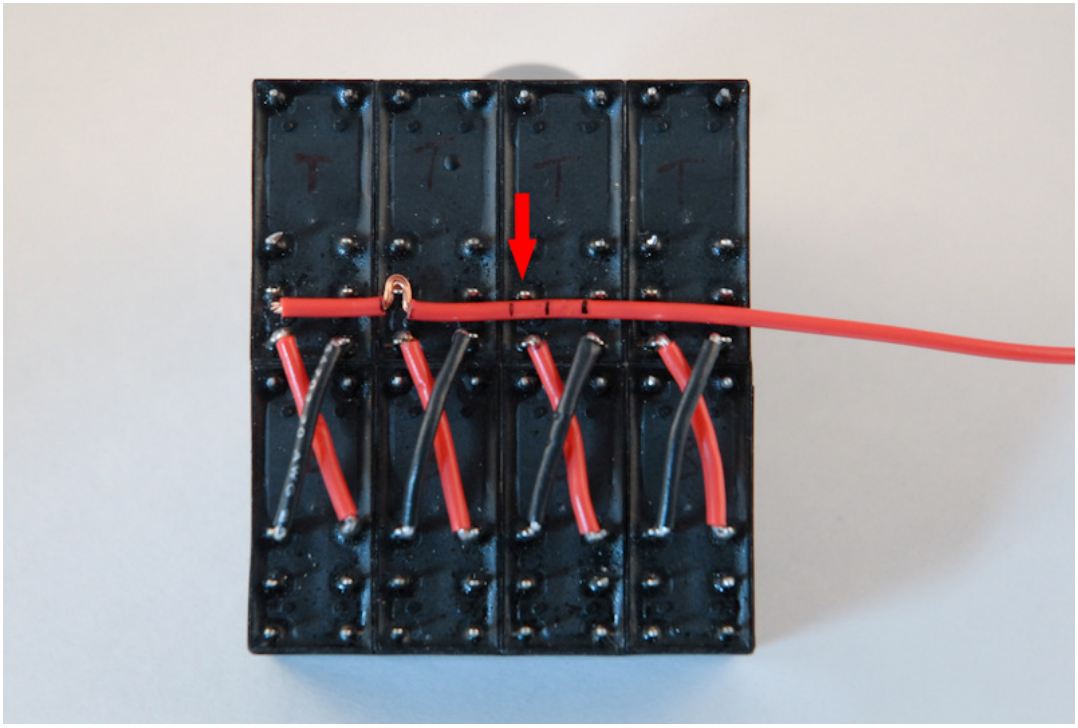
Peel off the jacket between the two lines so your wire looks like the picture shown above.



Now you will be bending a small U shape in the bare part of the wire. Make the U bend 90 degrees to your first bend.

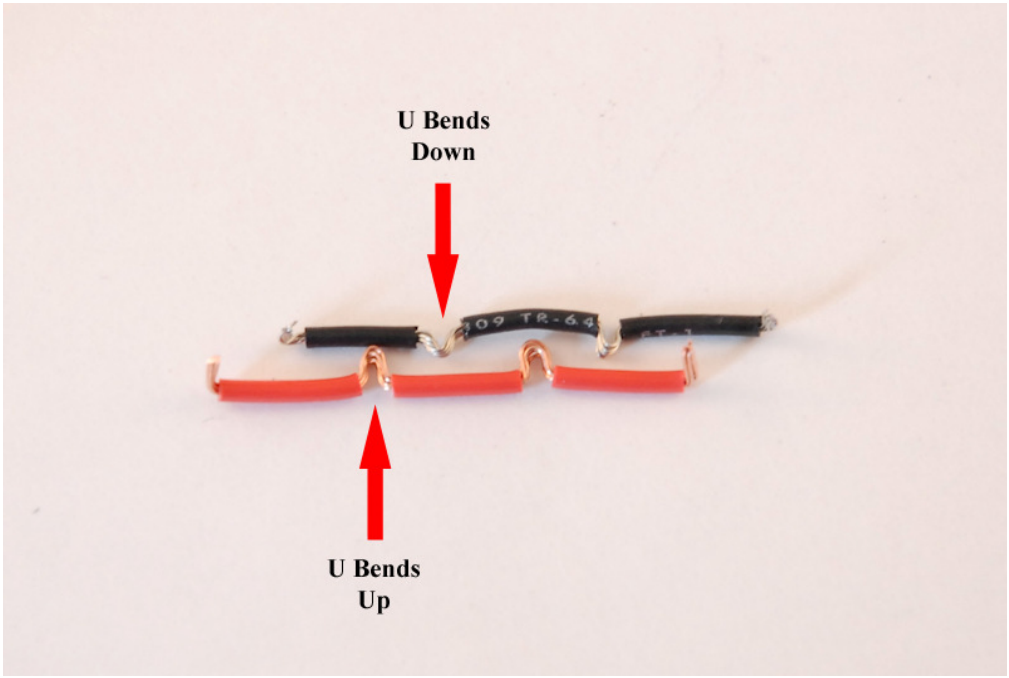


This will allow you to hook the wire on the pin and will make soldering the connection easier.

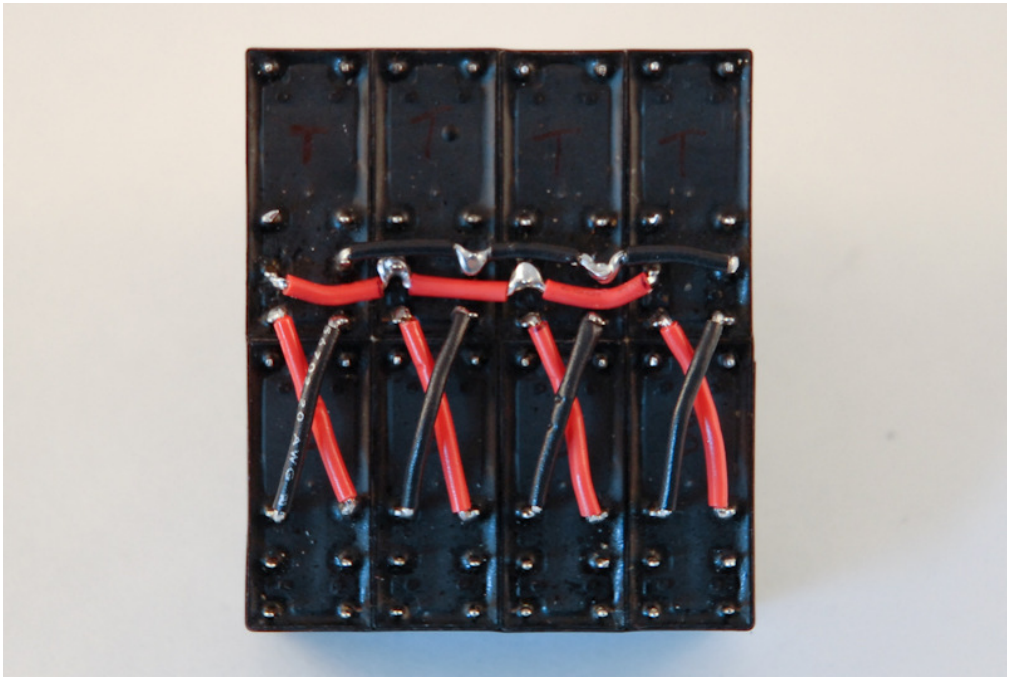


Continue marking, stripping, and bending the wire for the next #3 pin on the third relay in the same manor.

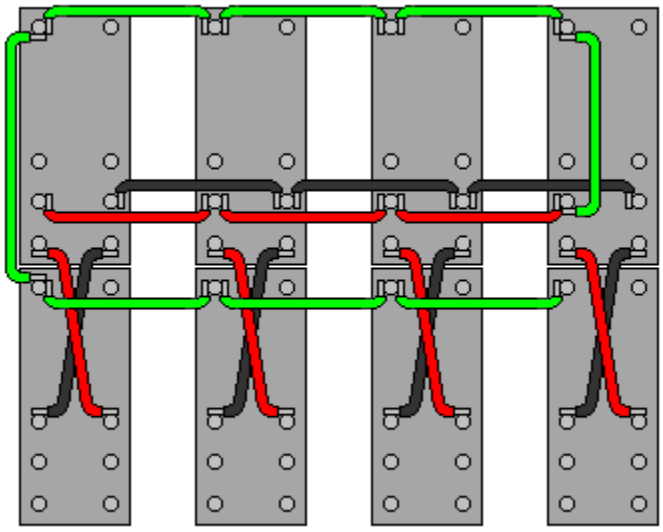
You can now mark the position of the last #3 pin on the fourth relay and cut the wire an 1/8” longer, strip it, and bend the end down to match the other side of the wire. The ends should be 90 degrees to the U bends.



Use the same methods for making the black wire for the #4 pins, but this time make the U bends so that they are in the opposite direction as the red wire. (as shown above) Test fit your wires to the relays first to make sure everything lines up before you attempt to solder them on. You may have to remake a wire if it doesn't come out quite right the first time.

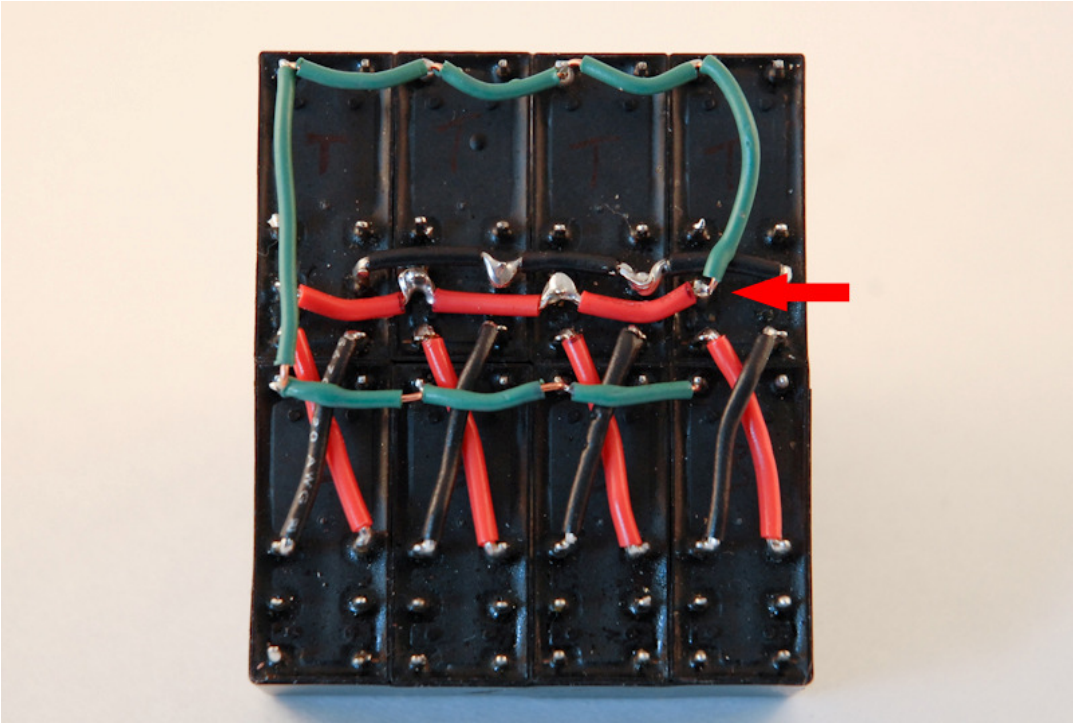


Next tin only the ends of the wires. (Do not tin the U bends) Start by soldering one end of the wire to the #3 pin starting on the first relay. Then press the bends in the wire over the next two #3 pins. You may have to adjust the bends to get everything to fit. Once everything lines up hold the bend against the pin (using your tweezers) and apply solder to the bare wire. Once the wire is coated with solder remove the iron and continue to hold the wire to the pin until the solder is cool. Repeat this method to solder the other connections for each of the wires.

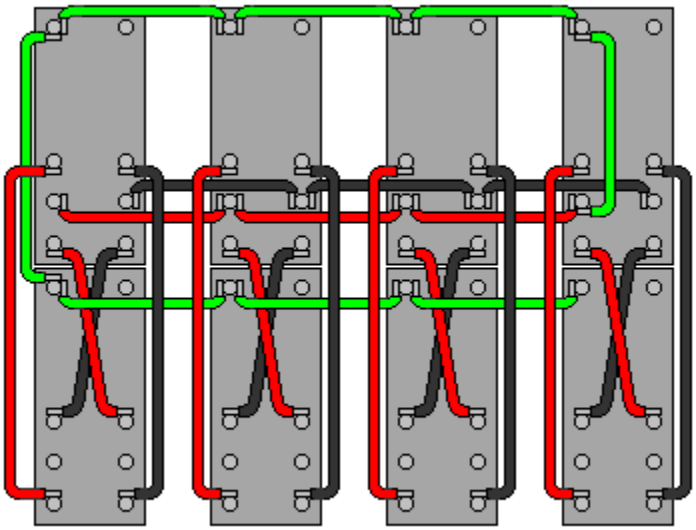


The next step is going to be connecting a common positive wire to the #7 pins of each relay. (I used a thinner green 22 gauge solid cope wire for this step only because I wanted to use a different color wire so it was easier to see for the purpose of this manual and it was the only other wire I had at the time.) You can use the same red hookup wire as it all ties back into the positive main feed anyway.

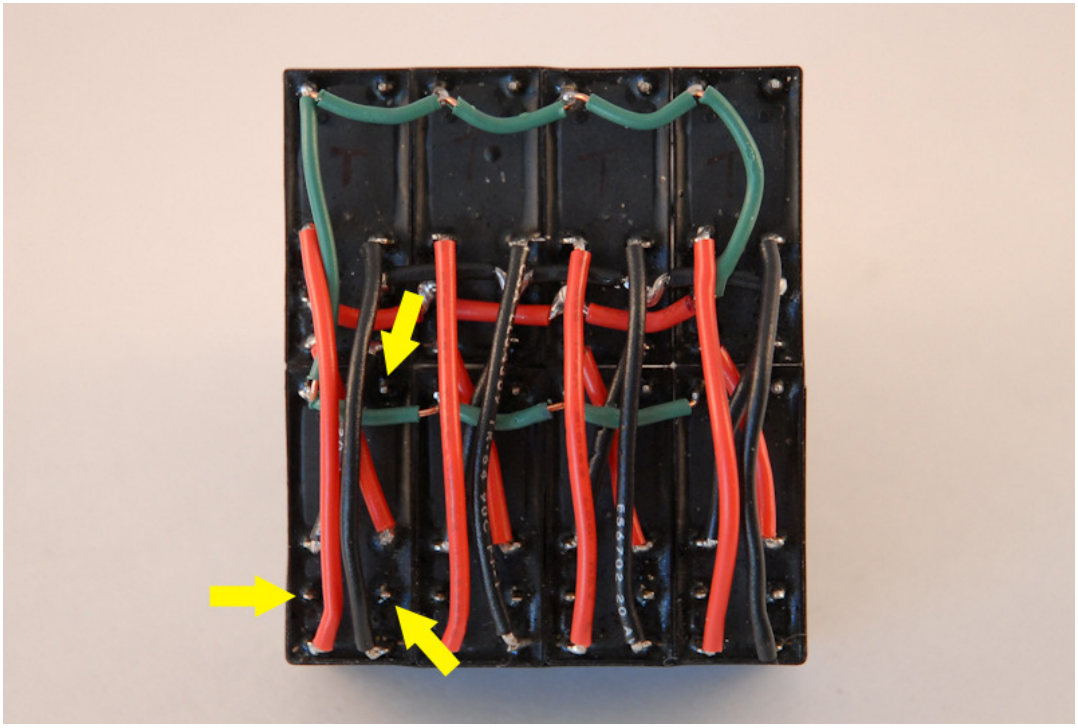
Marking and stripping this wire is the same as before but on this wire you will have more room for soldering on the connections at the pins so you really do not have to worry about a nice U bend, just fold the wire over and bend them all downward as shown above. Tin all of the bends after have you complete the wire. The wire has not yet been tinned in this picture.



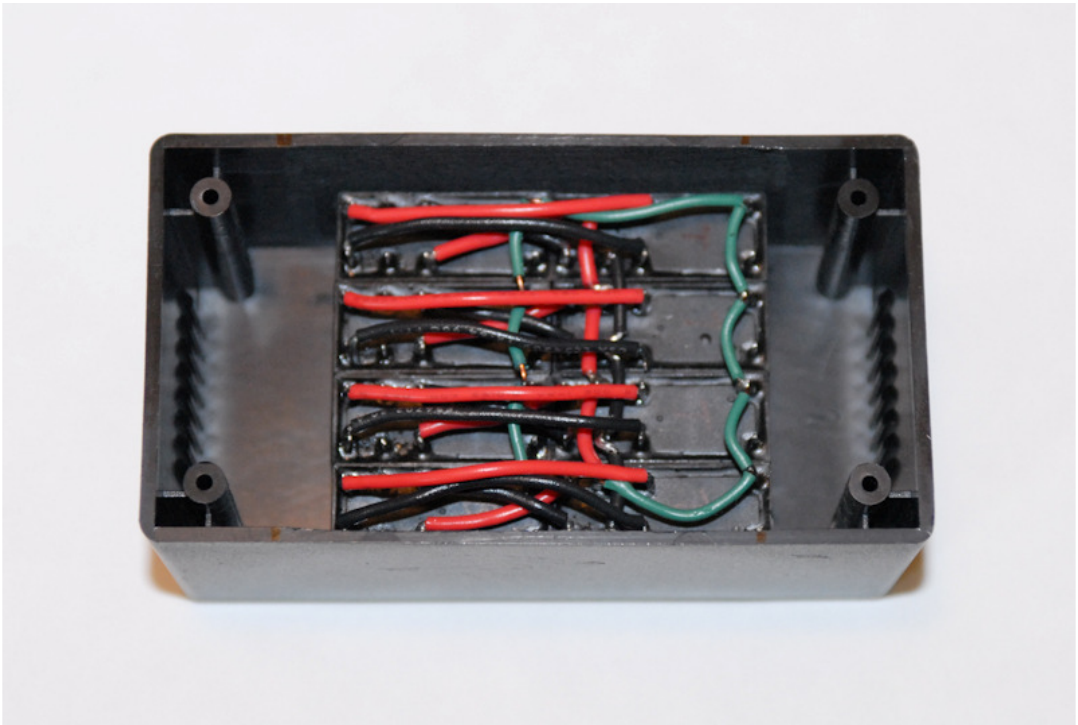
Start your connections of this wire on pin #7 of the bottom 4th relay and continue soldering on your connections to the other #7 pins as you go. The last connection to be made is to tie the wire back into the positive main power feed wire (shown at the red arrow). Make sure the connection from the main power feed doesn't come off when you are soldering on this one. You can use one single wire for this and the red main power feed wire that you started on page 16 but it's easier to mark, bend, and cut them in separate sections.



The next connections to be made are going to be to connect the NC pins (5 and 6) of the top relays to the NO pins (1 and 2) of the bottom relays. Using red wire connect pin #5 of each of the top relays to pin #1 of the bottom relays. Then using Black wire connect pin #6 of the top relays to pin #2 of the bottom relays.

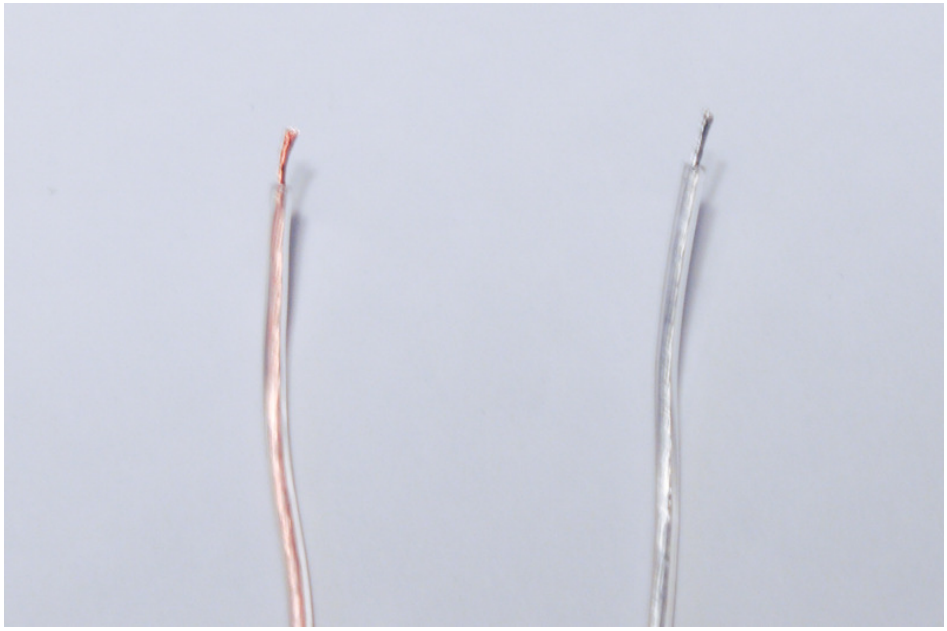


You can actually leap frog these wires over the other wires and connections just try and keep the heights of the finished wires low so they will fit in your project box later on. You will also have to bend the wires so the last 3 pins of each of the bottom relay are accessible. Shown by the yellow arrows.

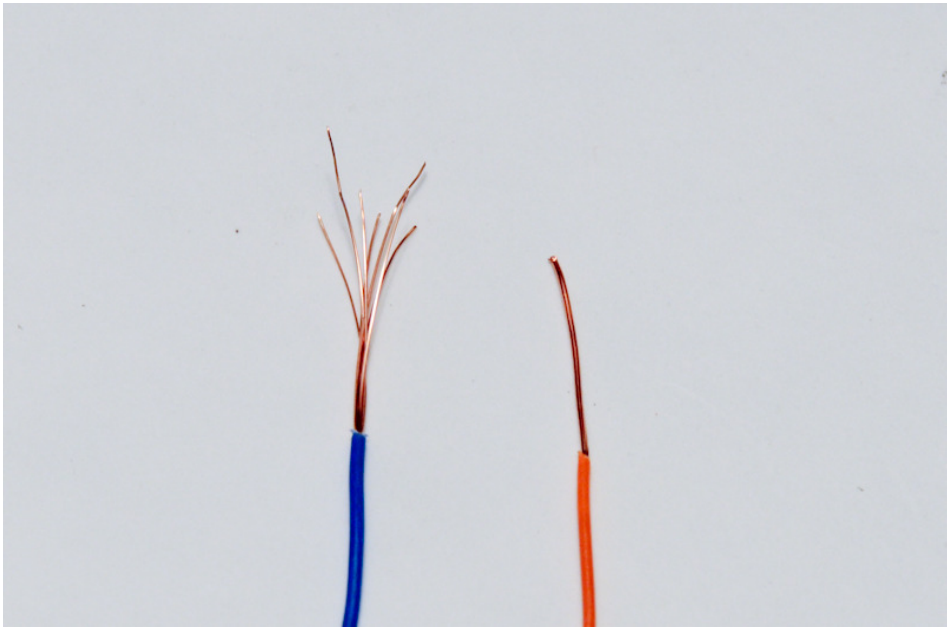


Next fit your relays into the plastic project box. You can actually use a bigger box I was designing a small Rov so I went with as small as a box as I could.

The next step you will need to do before you finishing wiring the control box is to construct your actual tether. Your tether may vary depending on your Rov design but as an example my tether was made up of a pair of 16 gauge power wires, 8 relay control wires (Cat5 cable), a camera cable, and 3/8" hollow polypropylene rope. The only wires required for the purpose of this manual for control are the main power wires and the Cat5 cable for the control wires so some of the following steps may be skipped if your design does not call for them.



For the power wires I normally use speaker wire (shown above) because it is relatively cheap and commonly available, but this time I found a finely braided thin jacketed 16 gauge wire that is super flexible. You can use a thicker wire such as 14 gauge and it will give you more power but it will also weigh more and keep in mind your thrusters have to be able to drag the tether around as well as the Rov. If you do use speaker wire you can usually split the speaker wire into two separate wires by just pulling them apart (as shown) and this is should keep the tether from having a weird twist and it should also be more flexible.



For the relay control wires you will be using Cat5 internet cable. When selecting your Cat5 make sure the conductor is labeled as Stranded and **NOT as Solid.** (e.g. Blue = Stranded, Orange = Solid) The problem with using a solid core conductor wire (besides being stiffer) is they have a tendency to break when bent back and forth a lot. Using solid conductor wire is one of the main causes of tether wiring problems on home made Rovs because the tether is constantly be wound and unwound.

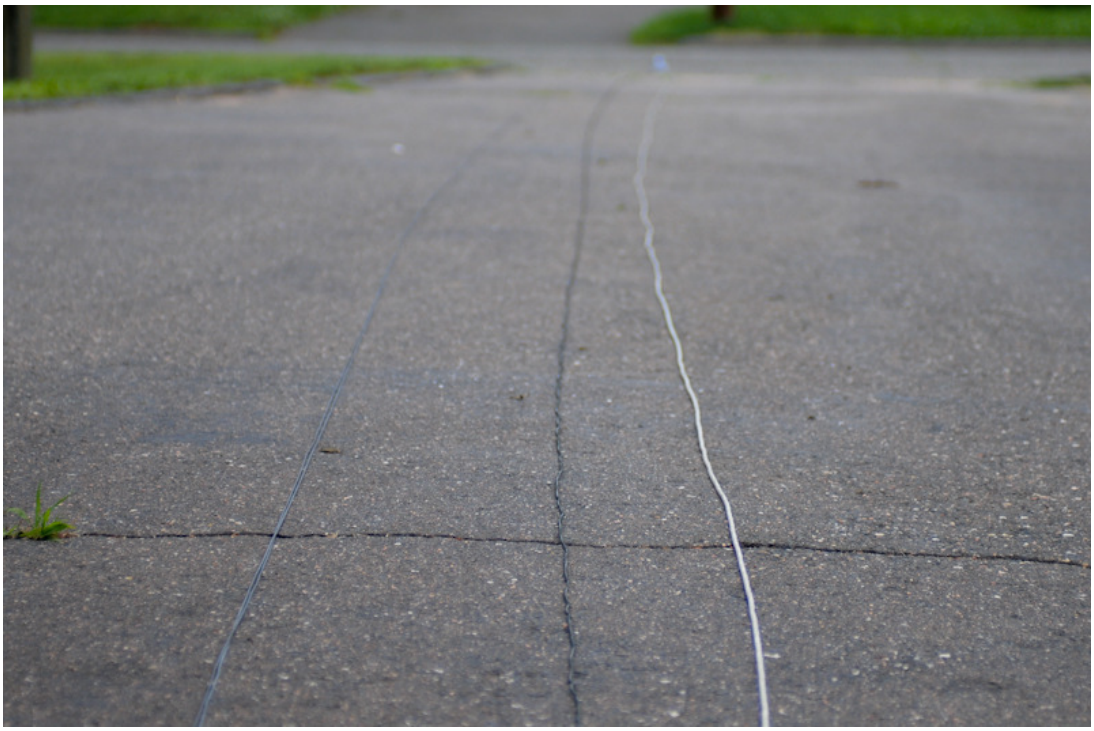
While your Rov tether will need a camera cable it is not required for the controls covered here but I will go over what I did.

The camera cable I used is a Audio Video (AV) cable. I chose an AV cable that has duel plugs. This gives me the option of using a single camera that either has a built in microphone or running duel cameras. The AV cable I selected also has a power feed for the camera too. I like to run a separate power feed to the camera so there is no chance of interference or power drain from the thrusters when they are turned on and off which can lead to on screen flicker.

The poly rope shown here is also optional but you will need to bundle all of your wire together somehow so plan ahead.

For the last part of my tether I use a hollow polypropylene rope. The wires will be feed through the rope to bundle every thing together as well as add some protection and act as a strength member for the tether. Poly rope does float, but it will not make the entire tether buoyant. (buoyancy will have to be added to the tether later although I do not cover that in this manual.) As a covering choice it won't add to the negative buoyancy like other bundling covers can such as spilt loom or spiral wrap. It will add a little weight and drag though so it does have its disadvantages. You can also use a product called Expandable Mesh Sleeving. This is a lot more expensive option but may hold up better over time as poly rope is susceptible to deterioration from the sun.

To feed the wires through the poly rope later on the first thing you need to do is cut off one end of the Cat5 cable. Any plugs on the camera cable will have to be removed also. Depending on your cable these can be reattached later or soldered right to your cameras wires. If the cable has a shield though this might be tricky.

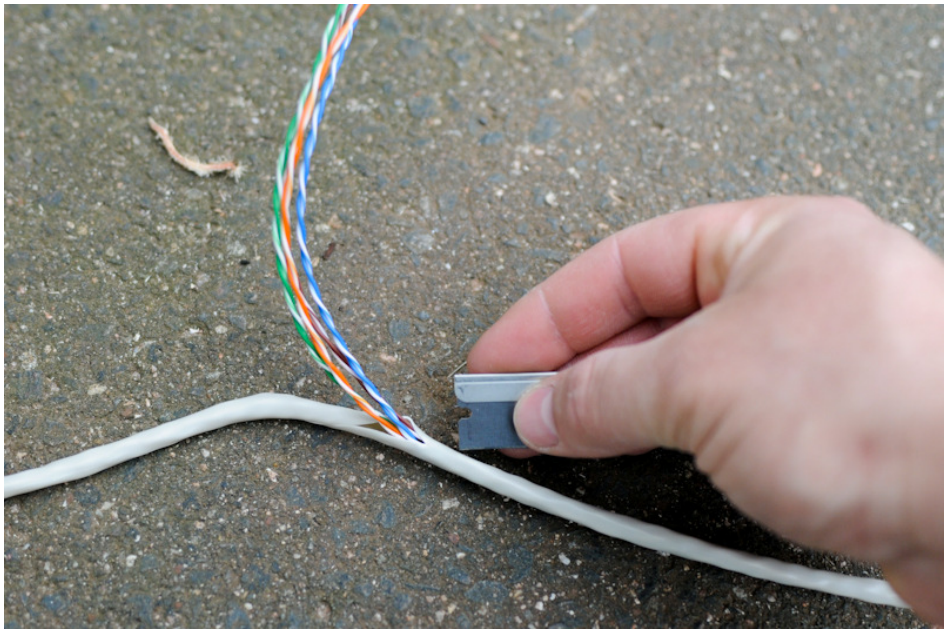


Next lay out the wires and cables (making sure they are not twisted) so they won't become tangled while you are working with them. I was able to stretch them entirely out down the length of my driveway. If you do not have this much room you may need a helper to wind them up while you align the wires and cables.

Then line up the plug ends of the Cat5, AV cable, and power wires and tape them together to hold them. The power wires can be left a little longer as they can be trimmed later.

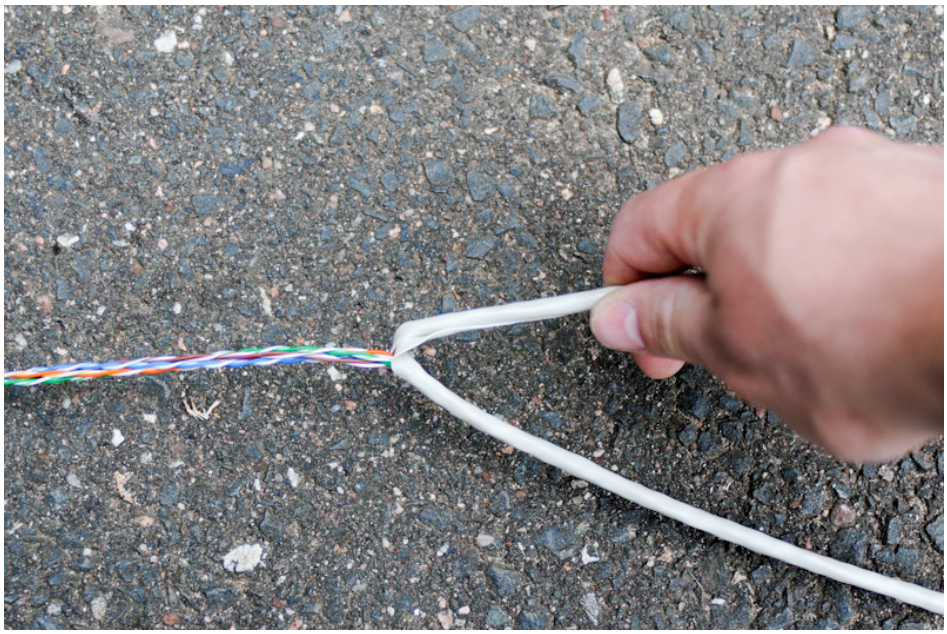
If working alone place a weighted object on the end of the wires and cables to hold them while you continue with the aligning process.

You will want to make sure the wires are all the same length when you get to the other end so play the wires through your grasped fist as you walk the length of the tether. This should even out the wires and cable out as you go. You may have to repeat this a few times. Do not let the wires tangle up behind you though.

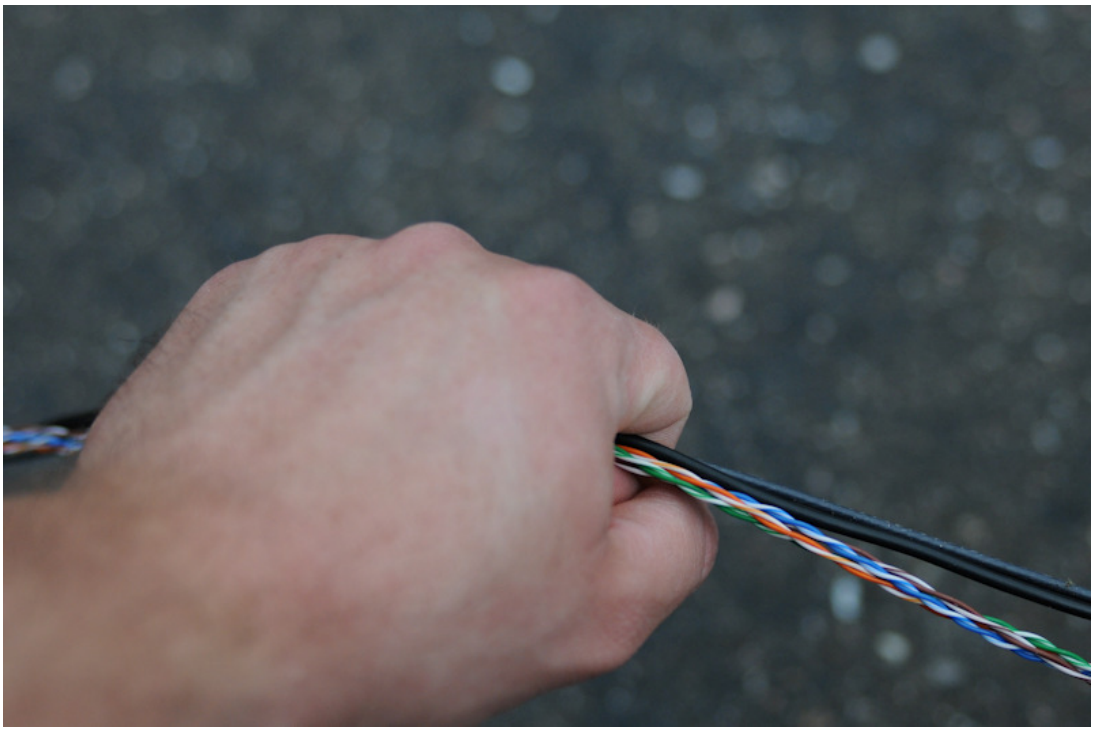


********* These next steps are optional *********

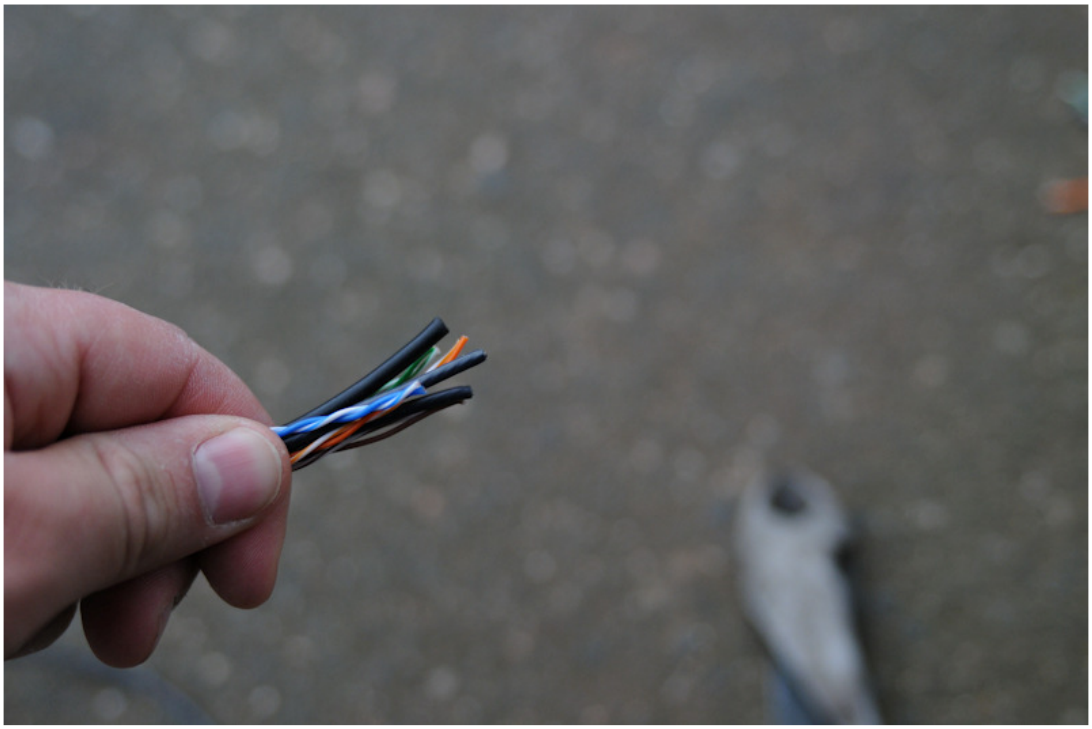
I chose to remove the outer jacket of the Cat5 cable to save some weight and maybe make it a little more flexible. To remove the jacket I start by lightly scoring the jacket with a razor blade. **Just score** the covering, **do not** cut completely through to the wires or you may sever them ruining the entire length of the Cat5. This saved about 13 ounces of weight but you will lose the protection of the jacket so again this option is strictly up to you.



After you have scored the length of the jacket, hold the wires in your left hand and pull the jacket in the other direction to strip the covering away. The jacket should peel off pretty easy along the line you scored with the razor blade, do not over force it though, if it feels to hard to remove rescore the line again. (again do not cut to deep though) I left on the last 5' of jacket because that part will never be in the water anyway and the flexibility there will not matter.



If you chose to remove the jacket you may have to run your hand along the wires again to realign everything. Be careful because the loose wires of the Cat5 will be very easy to tangle now.



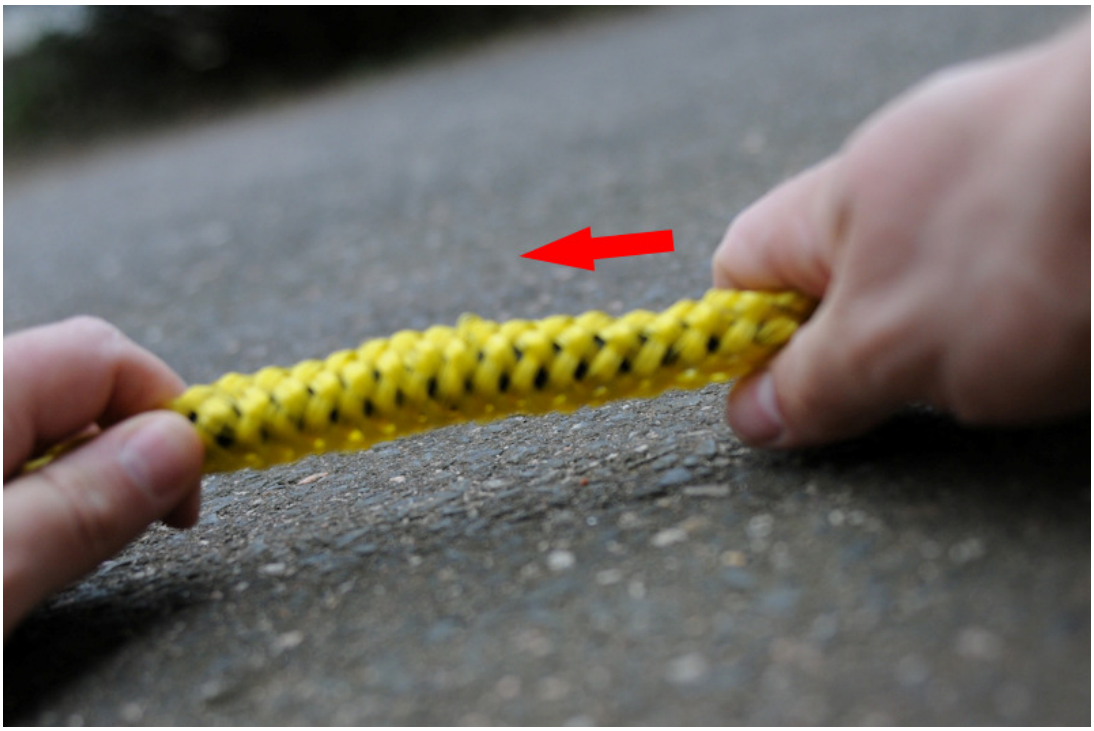
Weather you chose to remove the jacket or not after you have everything aligned your wires may still all be different lengths, using your wire cutters trim the (non plug ends) ends so they are all even.

The next step is to insert the wires and camera cable into the splicing tool that came with the poly rope. This will aid in feeding the wires through the rope. If your rope didn't come with this tool you can make one simply by cutting up a sharpie marker or something similar.

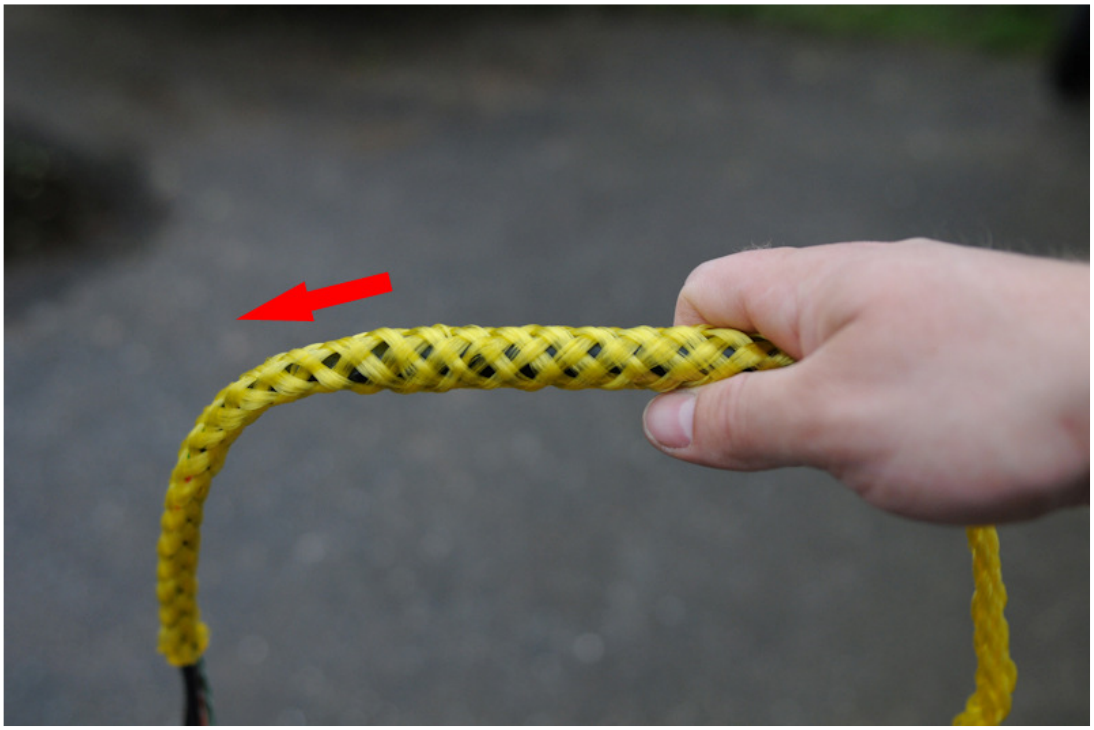
Using electrical tape and starting about an inch or so from the back of the splicing tool (red arrow), wrap the tape toward the wires and continue to wrap the tape around the wires until the wires are secured into the tool.

Next you will be feeding the wires through the entire length of the poly rope. Start by inserting the tool into the center of the rope, making sure the tip stays inside the rope and that it doesn't poke through the weave.

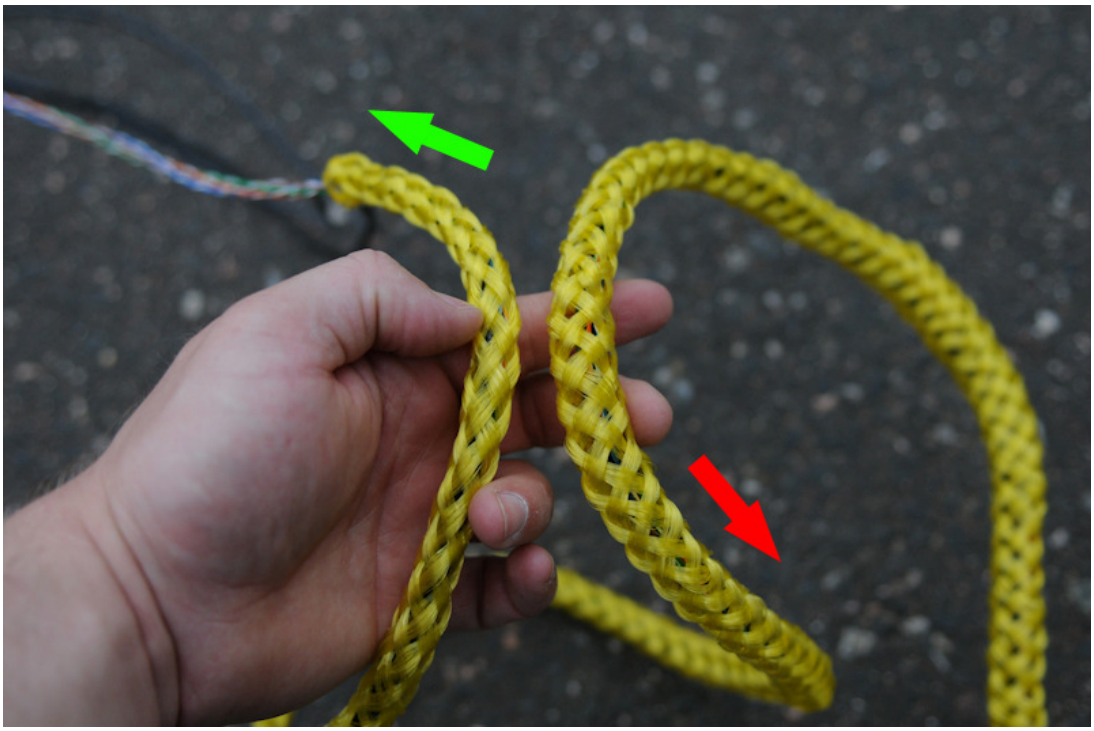
I call this next part "feeding the snake". Start by grasping the rope at the rear part of the tool with your left hand, you will only be able to feed the tool and wires into the rope a little at a time.



Now with your right hand grasp the rope a few inches before the tool and pushing toward your left hand forming a bulge in the rope over the tool.

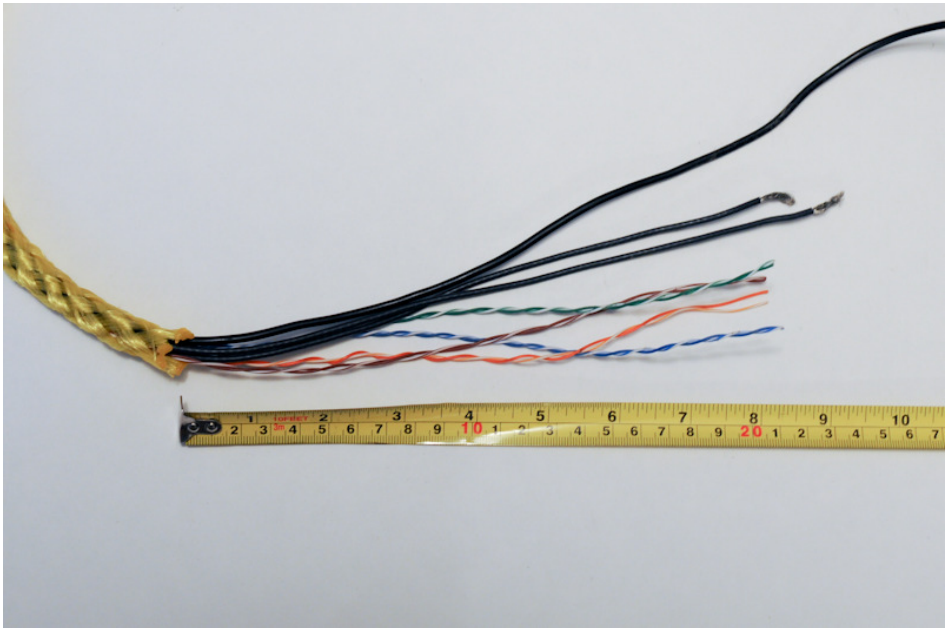


Now just let go of your left hand and work the bulge down along the rest of the wires. The first time you actually do this you'll see why it's called "feeding the snake", that is if you have ever actually seen a snake eat ☺

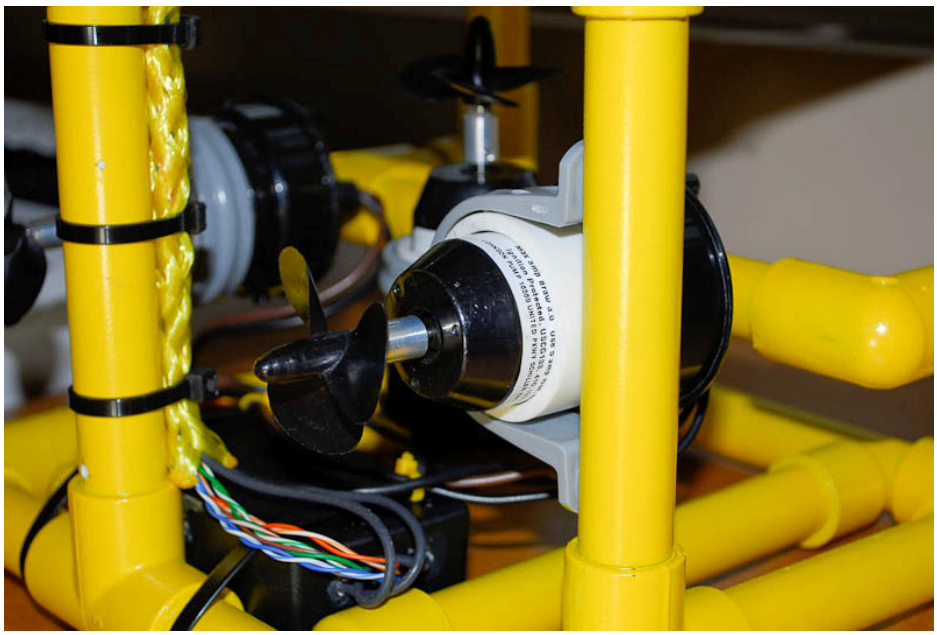


You can get a pretty good size bulge going before working it along the rest of the wire but do not try to over do it. This is a time consuming process, but if you have a helper have one person start the bulge over the tool while the other work the bulge down the line of the tether.

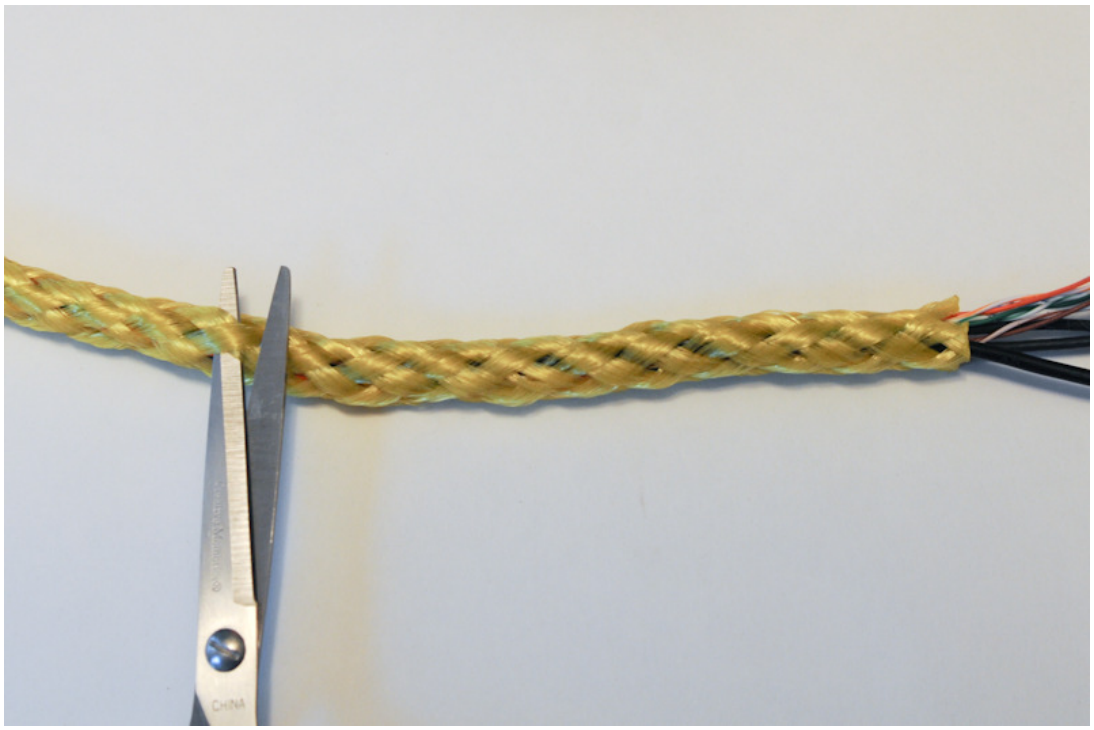
After you're done feeding the snake your tether is finished for now and you can continue on with wiring the relay box. As you can see from the picture the ends of your wires on the plug side may have shifted some, as long as they are not too far off this is not a big deal.



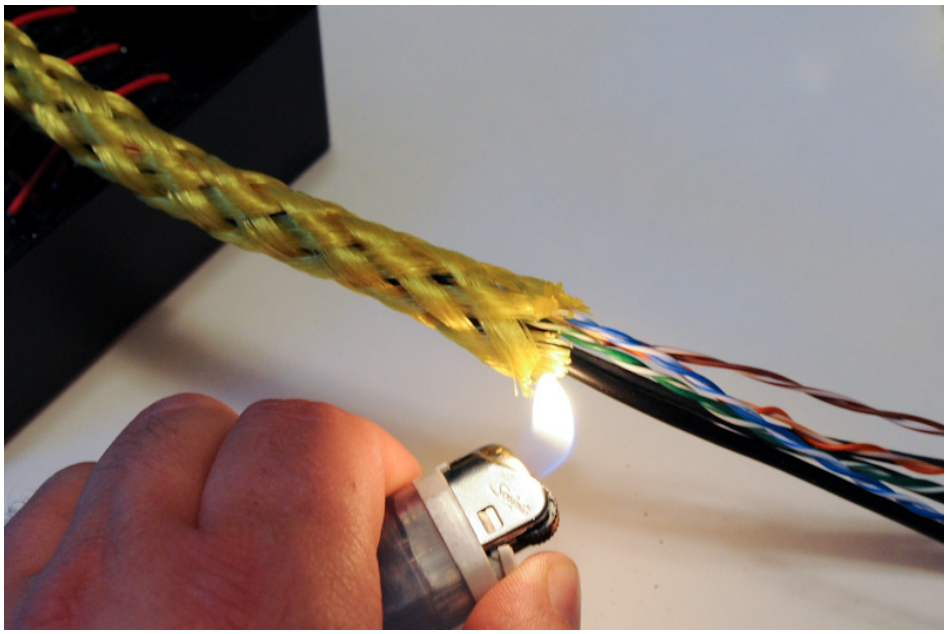
First trim off about 12-14 inches of the Cat5 wires you will use them later for wiring the joystick controller. Next you will have to expose enough of the wires from the end of the rope to work with. You will need to make sure you have enough of your power and control wires to reach where ever your control box will mount to the Rov. You will also need to leave enough room for your camera cable so it can reach to the part of the frame where the camera will be mounted. Using your ruler measure the distances required for all your wires and cable according to your specific design (see note below) and mark the rope where it will need to be trimmed. If you left the jacket on the Cat5 this is fine don't worry about the picture showing the individual wires you will trim back the jacket at a later point.



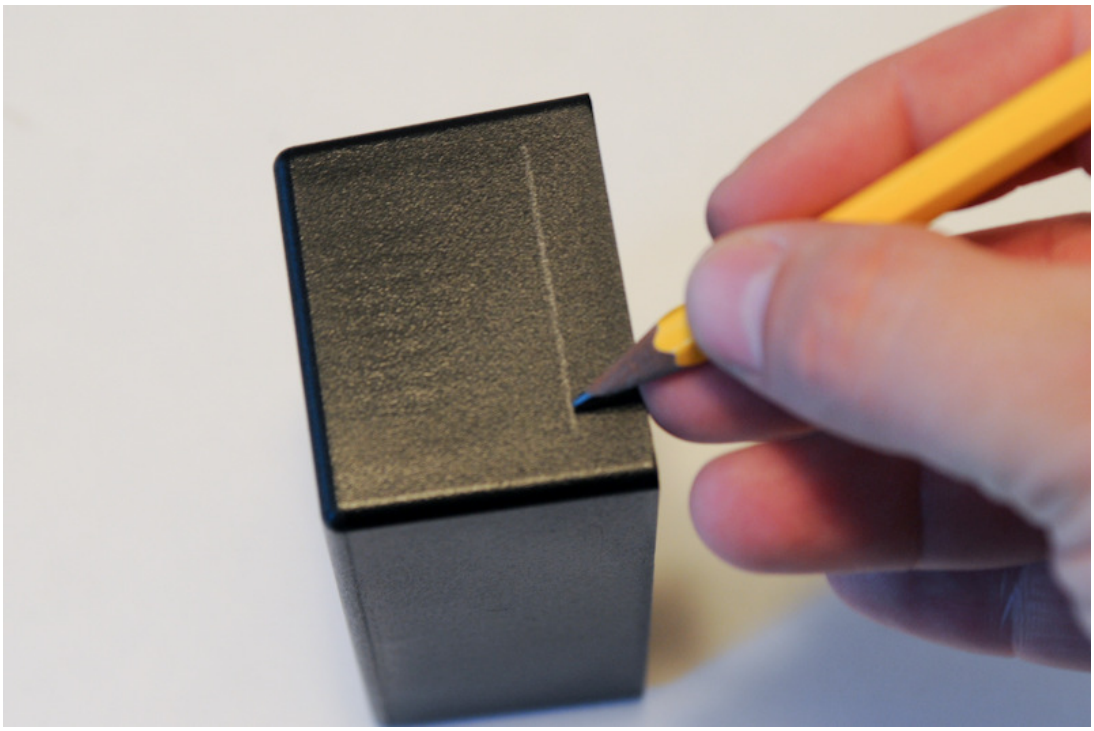
Note – As seen here in this example I usually zip tie the end of the braided rope section of the tether to my frame so if I need to lift or pull the Rov by the tether it will not pull the wires out of the box so measure from the tether attachment point on your Rov to the mounting location of your control box. (I do not use a removable tether with quick connectors for the main reason that if my Rov ever gets stuck underwater on something I can yank it free via the tether.)



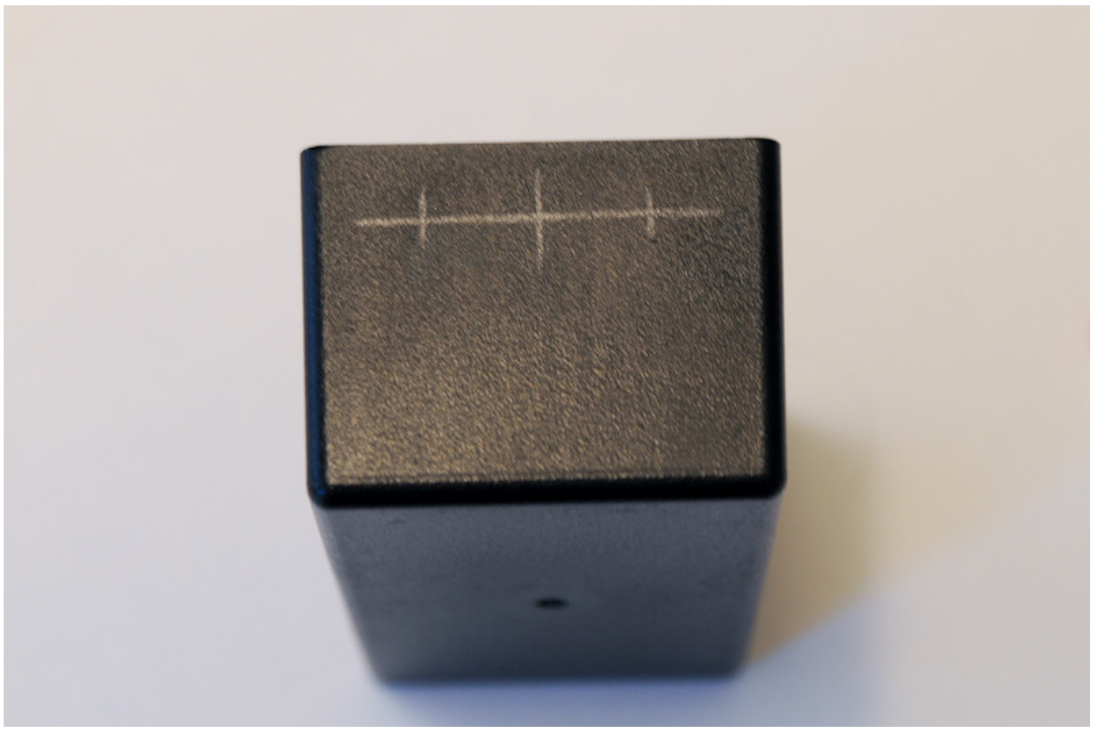
The safest way to cut the rope is to use a pair of scissors. Stick the tip of the scissors through one loop of the rope and cut a single braid/strand at a time. **(being sure not to cut any wires in the process.)** Continue this process until you cut completely around and through the rope.



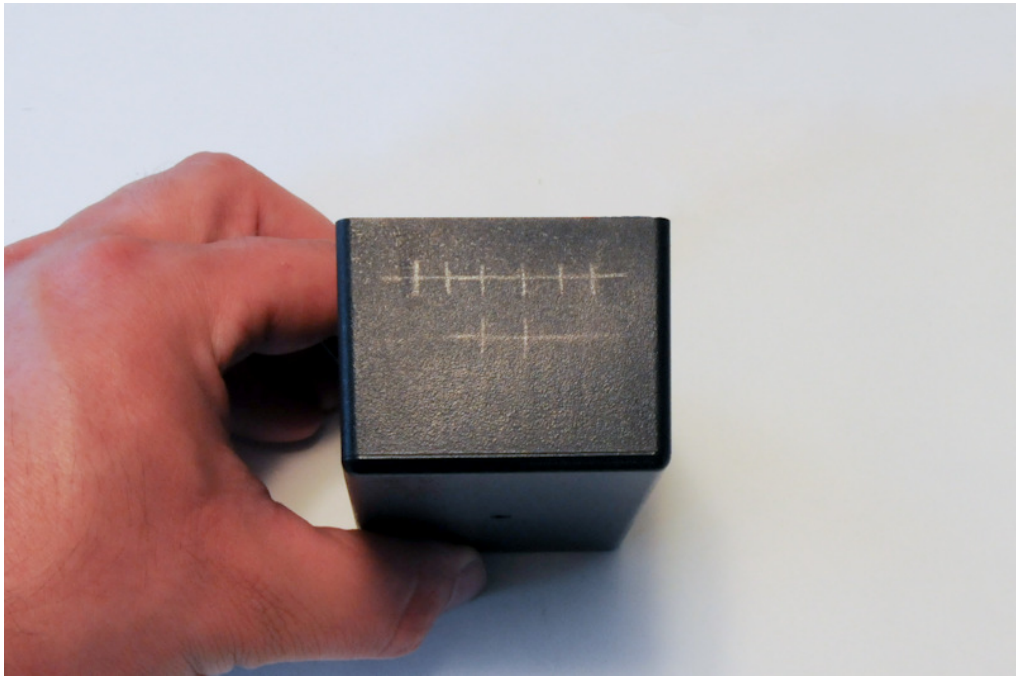
After you cut the rope you will need to keep it from unbraiding or fraying. You can do this buy melting the ends with a lighter. Use a low flame and only use the heat from the flame, do not actually touch the flame to the rope or it will catch on fire and the melting rope can actually start to drip like liquid. Make sure you do not melt any of the wires either. Heat shrink tubing would also work as an alternative to melting the rope.



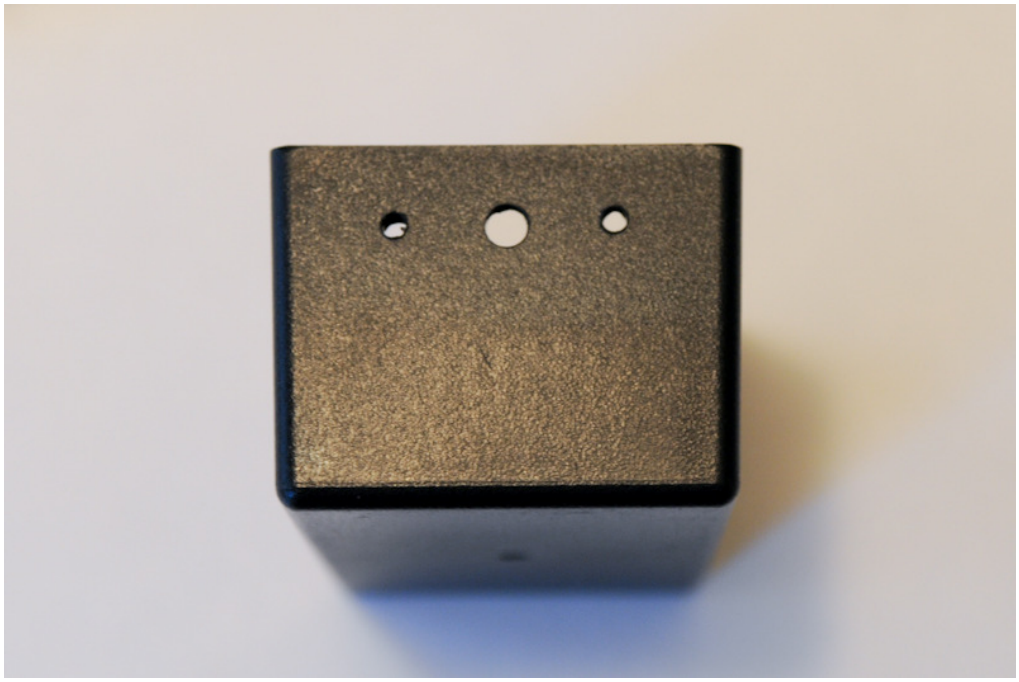
Next you will need to drill some holes in the plastic project box for the wires. On the right side of the project box using your pencil draw a line about 3/8" down from the top of the plastic project box. This height should be sufficient for the wires to clear the top of the relays, but double check against the relays you use. You can use your finger along the top of the box as a guide to draw a straight line.



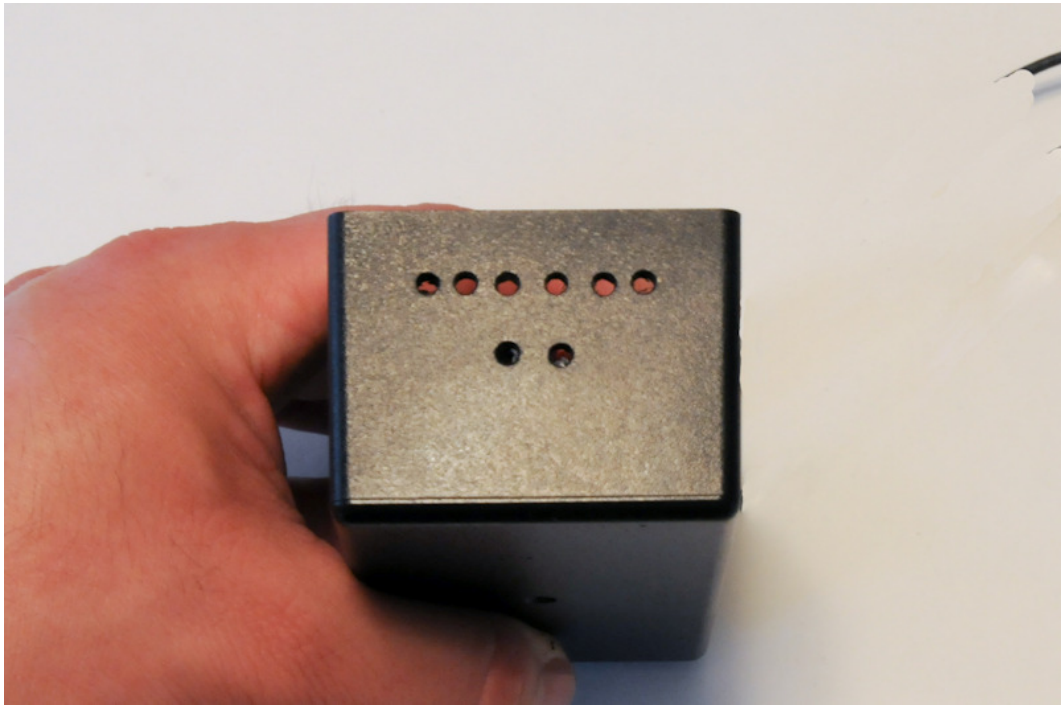
On the right side of the project box you will need three holes for the power and control wires. Mark a line in the center for the control wires and two more lines about a ½" away from the center line.



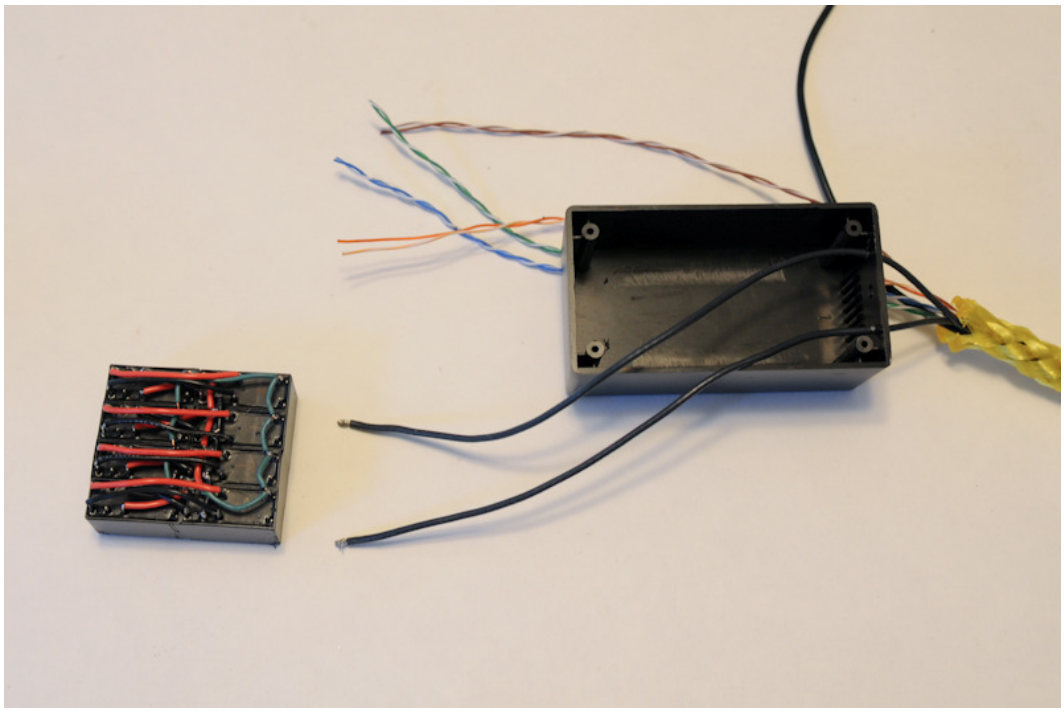
On the left side of the project box you will be marking between six to eight holes. The six top marks will be for the wires from your three thrusters, these marks are about 3/16” apart, just make sure all of the holes will be in between the two post that the cover screws into (not shown) The two lower marks are for the wires that will go to the additional two relays if you choose to add them as an option at the beginning.



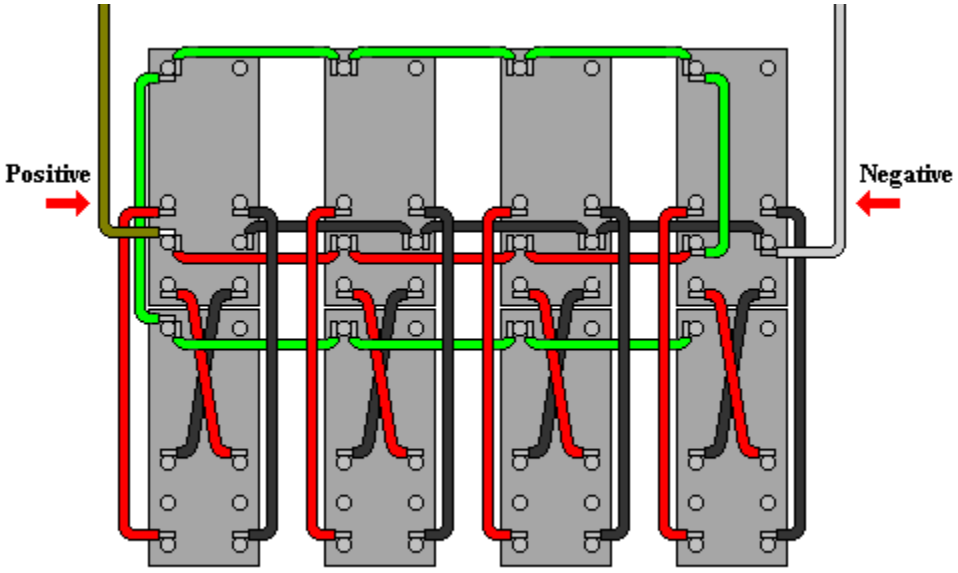
Select a drill bit that closely matches the diameter of the wires you chose to use. The center hole should be larger too accommodate the eight control wires (or the outer jacket of the Cat5 if you did not remove it), while the two outer holes are for one single main power wire each.



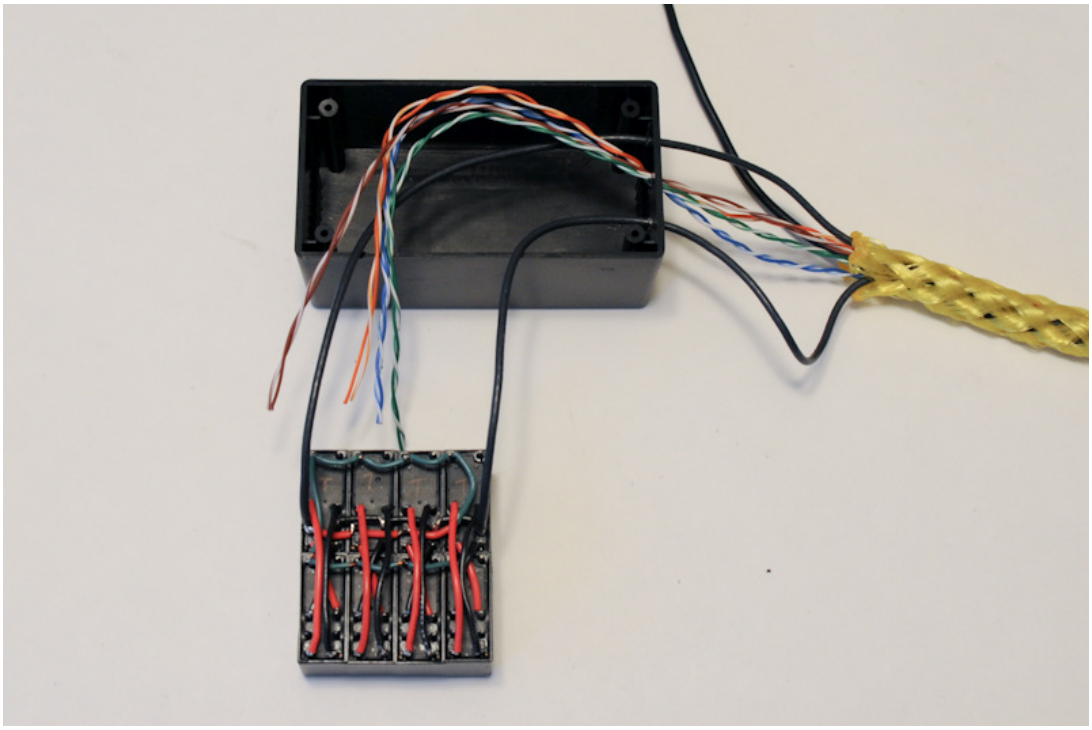
I used a 1/8” drill bit on the left side for the thruster wires which are usually 16 gauge, but double check the wire on the thrusters that you have selected just to be safe before selecting a drill bit size.



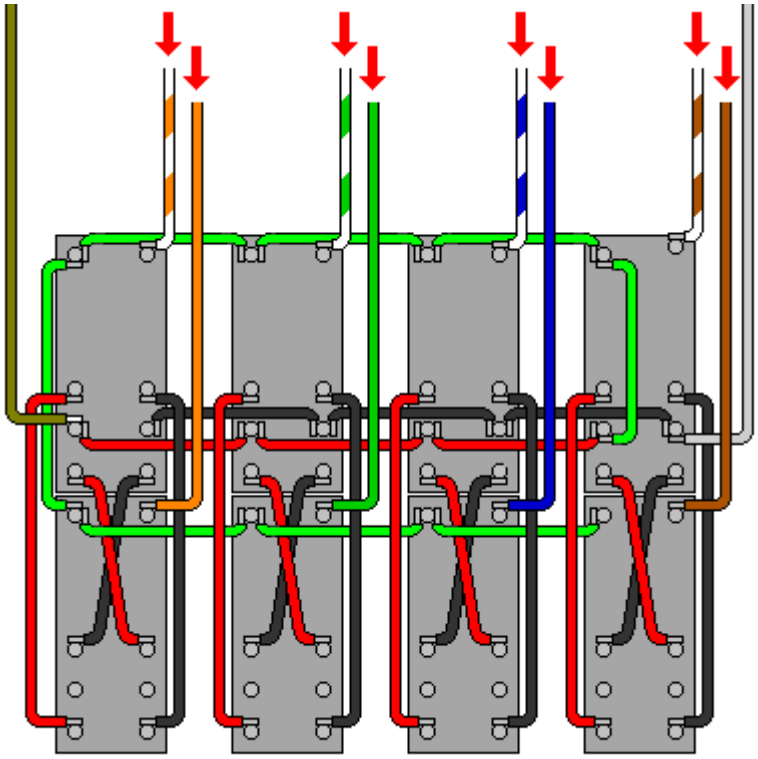
With all of the wires and connections you have all ready made to the relays the next connections to be soldered can be a tight fit. You can actually make these connections outside of the box to give yourself more room. Start by feeding the power wires through the two outer holes you made in the box. The silver wire goes in the left hole while the copper color wire goes in the right one. **Do not forget this step or you will have to undo everything you are about to solder.**



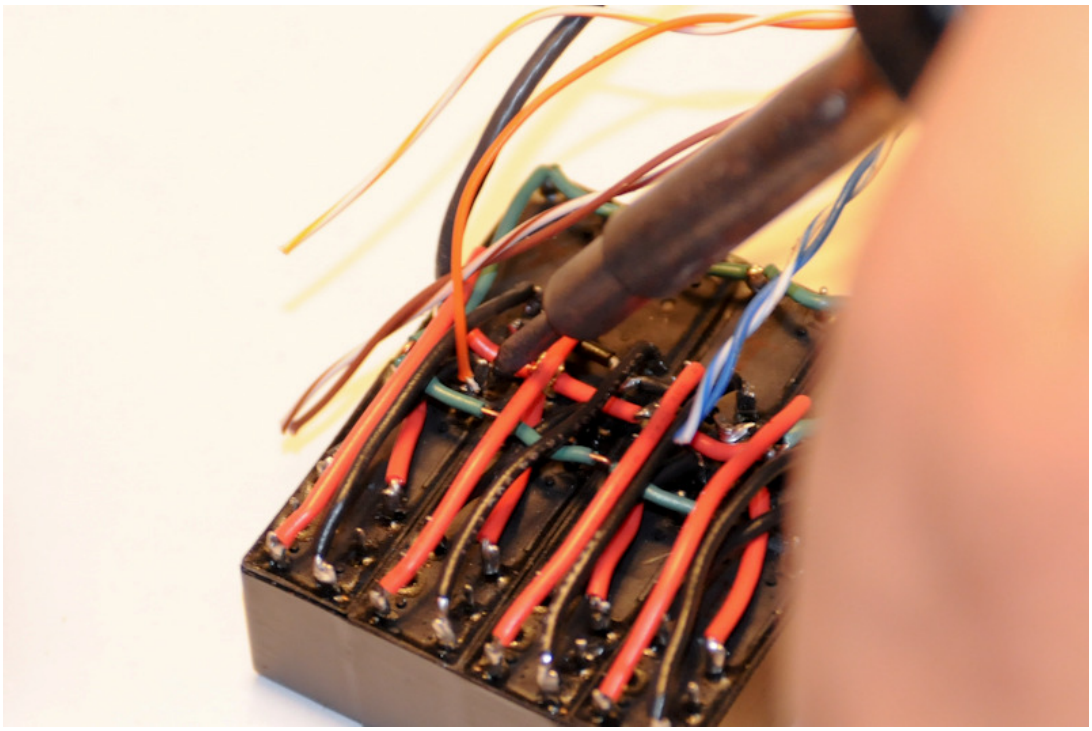
The power wires will be soldered to the main power feed (that you started from page 16) it doesn't matter where you connect into it but I found the 2 outer pins (Pin #3 of the top left relay, and pins #4 of the top right relay) offer the most room to make the connection. I drew the power wires to represent speaker wire (copper and silver in color) but the colors really don't matter, yours may be different depending on the wires you selected.



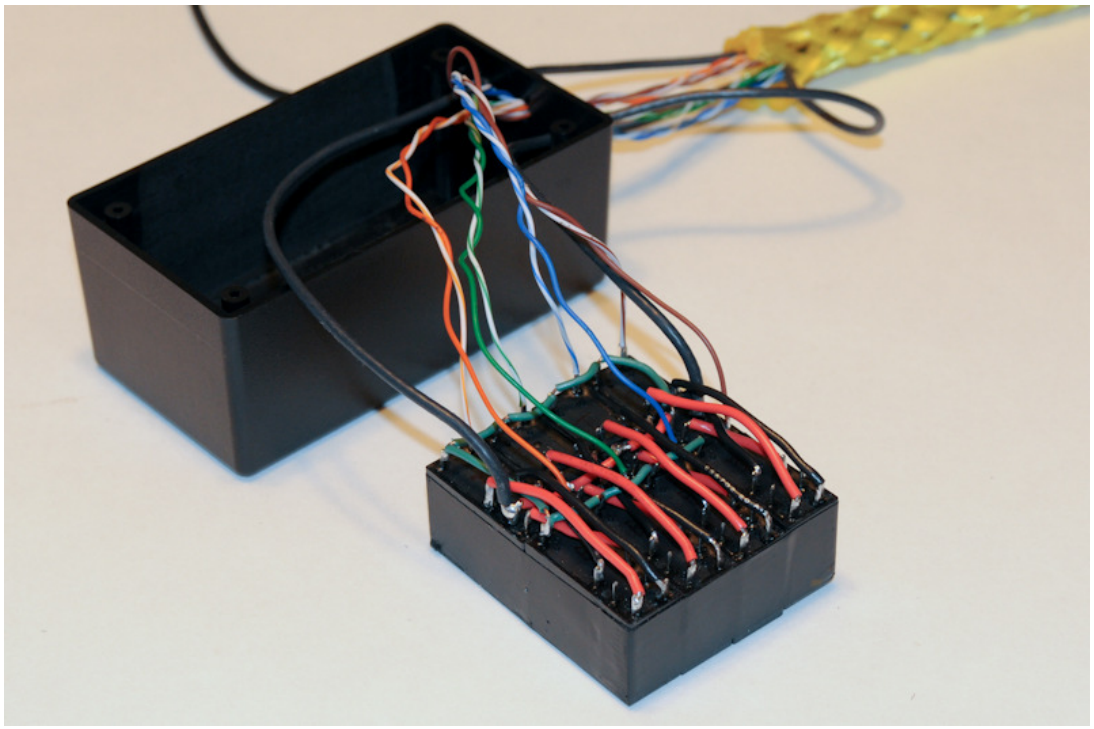
Here the power wires have been connected and the next step is to feed the control wires through the center hole in the project box. If you left the jacket on the Cat5 cable remove just enough of the jacket so you have enough of the individual wires that you can work with. The jacket will get a final trimming when it is time to put the relays in the box. **Again do not forget to feed the control wires through the hole in the box before you solder them to the relays.**



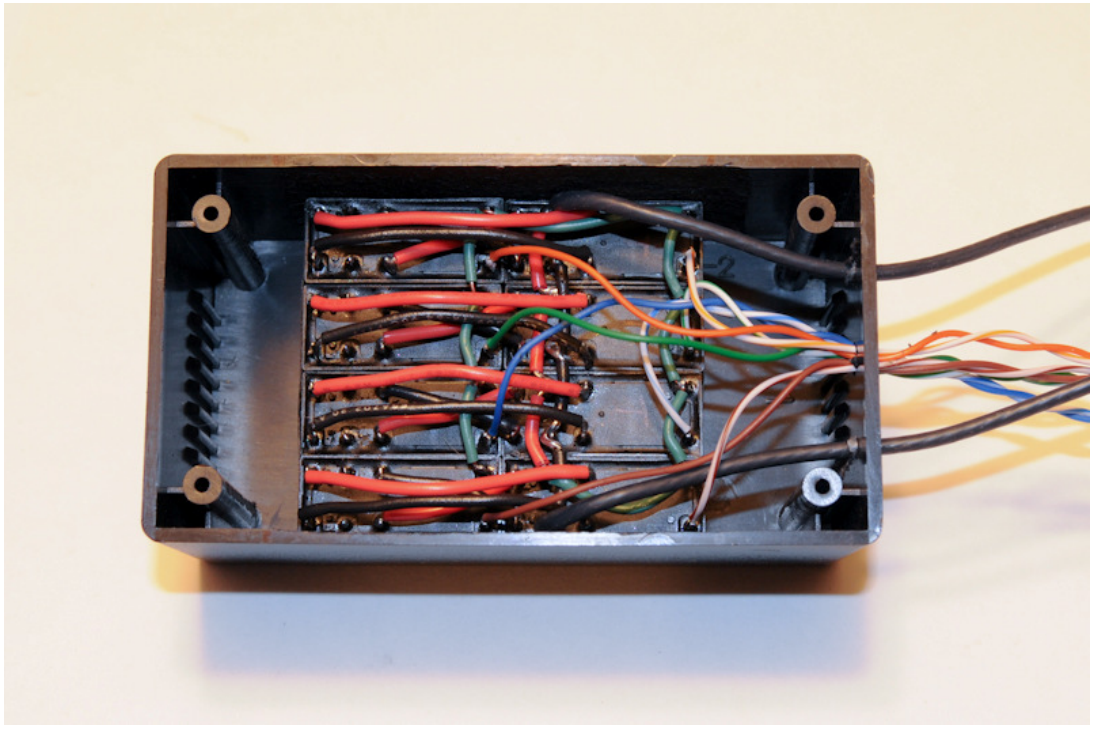
Next you will be making the connections for the control wires. You will be soldering one control wire to pin #8 of each relay. Follow the diagram above for the correct color layout of the control wires. (This will make wiring the joystick much easier later on.) The striped wires will be connected to the top relays and the solid color wires to the bottom relays.



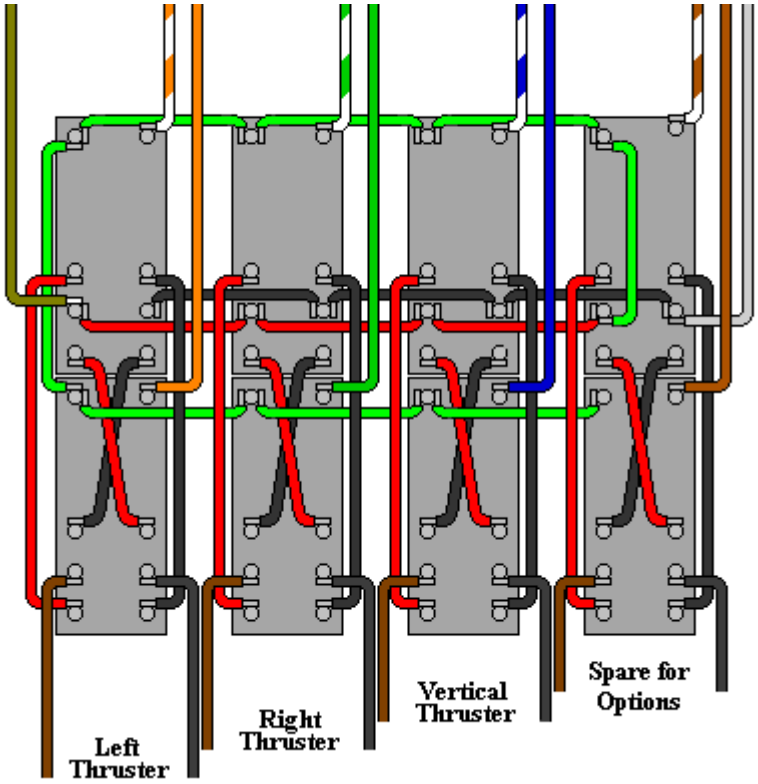
Even though you are doing this outside of the project box everything will still be a tight fit so use care that you do not melt any of the other wires with the soldering iron.



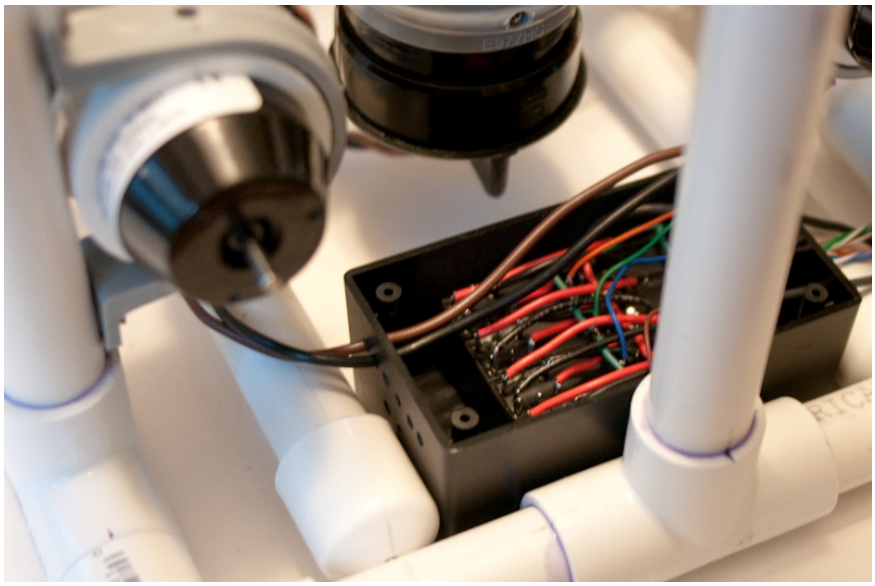
At this point all of your incoming feeds from the tether (with the exception of the camera cable) should be wired into the relays and look similar to the picture above.



Place the relays back in the project box and feed the excess wire back out through the holes so the wires are not all bunched up inside the box. For those of you who left the jacket on the Cat5 cable you can now mark and trim back the jacket until only about a ¼" or so is left inside the box. Be careful though not to cut any wires in the process of trimming the jacket.

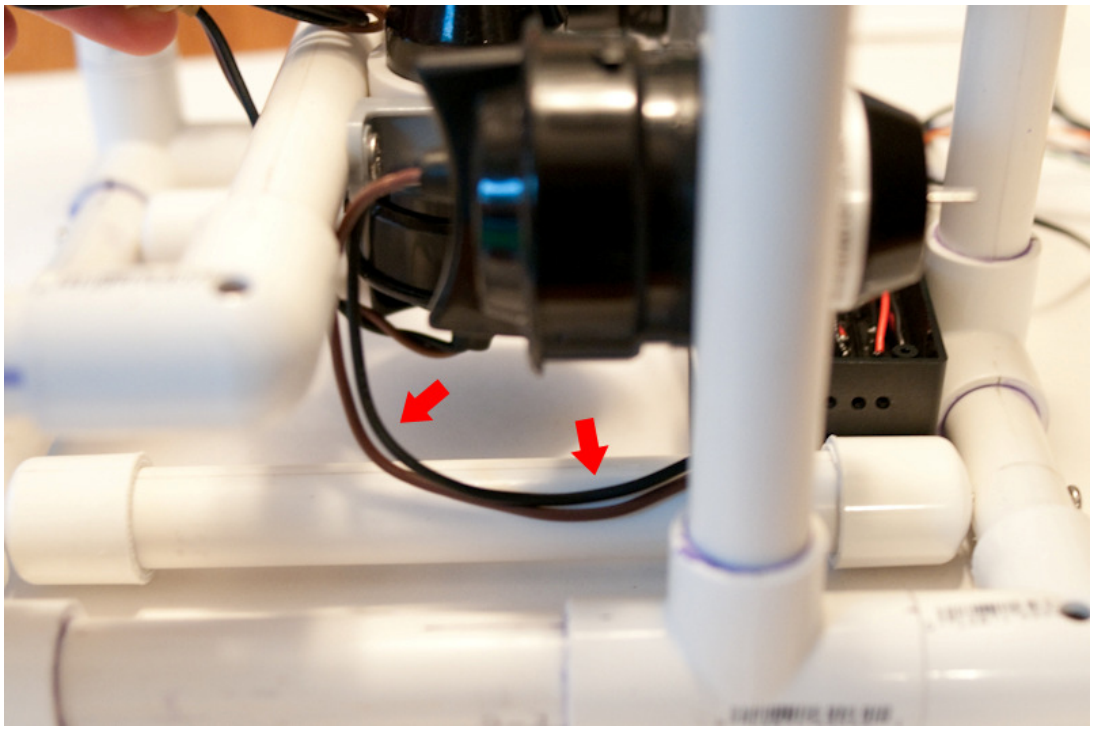


Next you will be wiring in the actual thrusters. The above diagram shows which pair of relays controls the correct thruster.

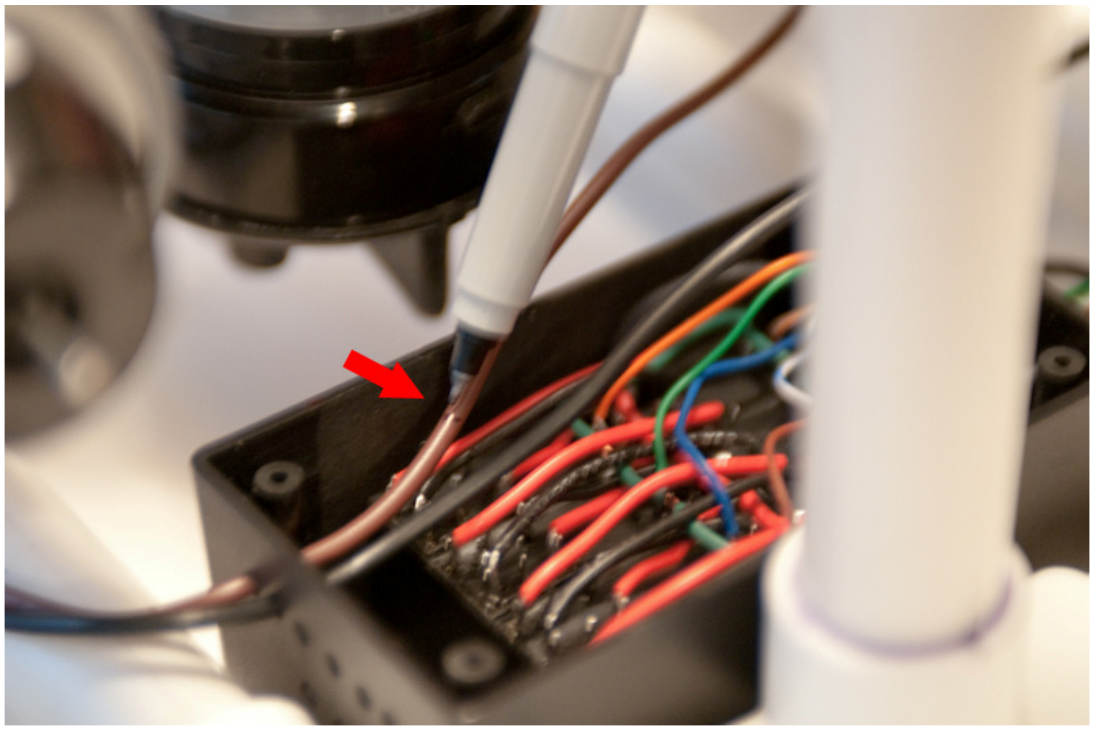


(The following pictures are for example only your thruster placement will be different.)

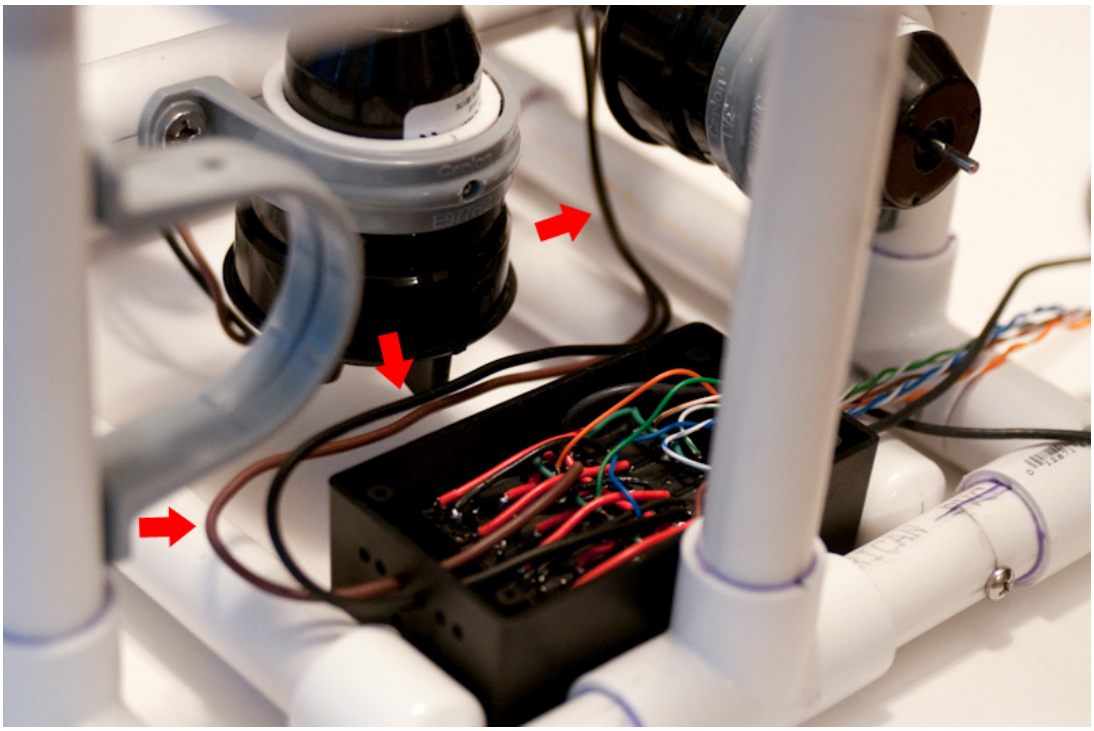
Before you continue you will need to mark and cut the thruster wires to the correct length to prepare them for soldering. Placement is all going to depend on your particular Rov design. Mount the thruster to your frame and place the control box where it will be located. Route the thruster wires to the control box, the positive (brown) wire goes in the left hole and the negative (black) wire in the right hole for each thruster.



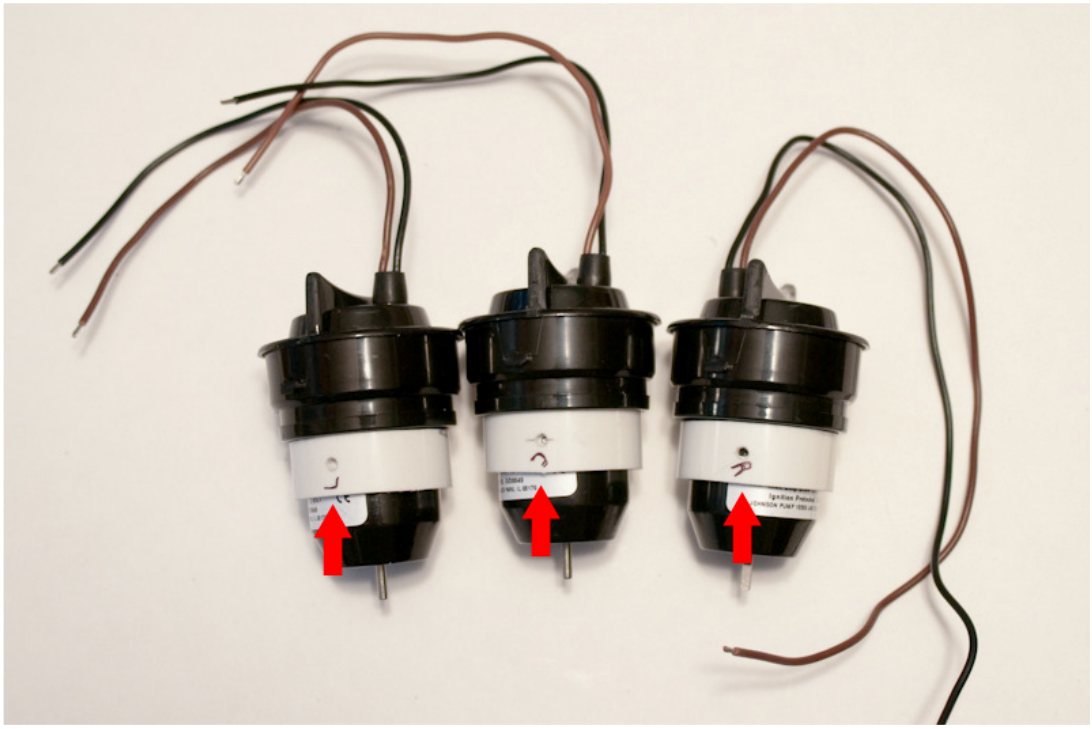
When routing your wires be sure to route the wires away from where the props will be and leave enough slack so they can be zip tied to the frame later on. Do not actually secure any of the wires yet though.



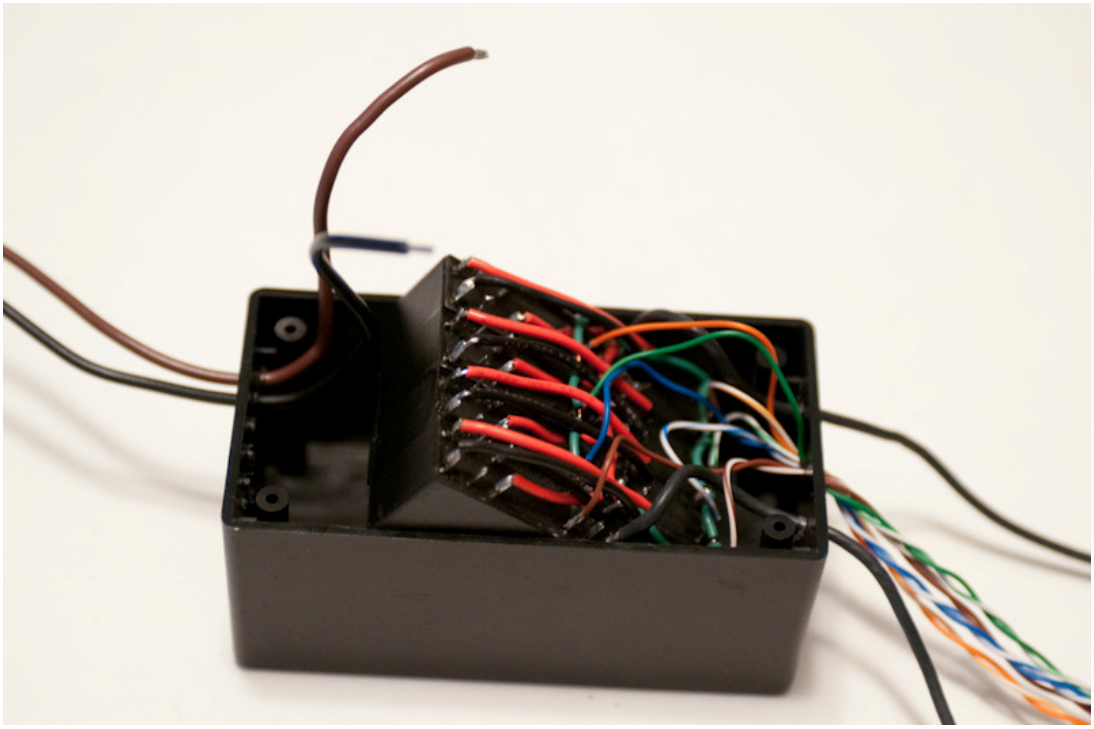
After you have determined the routing of the wires you will need to mark where the wire will need to be cut. Align the wire with the #3 and #4 pins of the correct bottom relay and using your marker make a line about 3/16” past the pins. This will leave enough extra wire after you strip the end of the wire for soldering. Remove the wire and you can now cut and strip the ends.



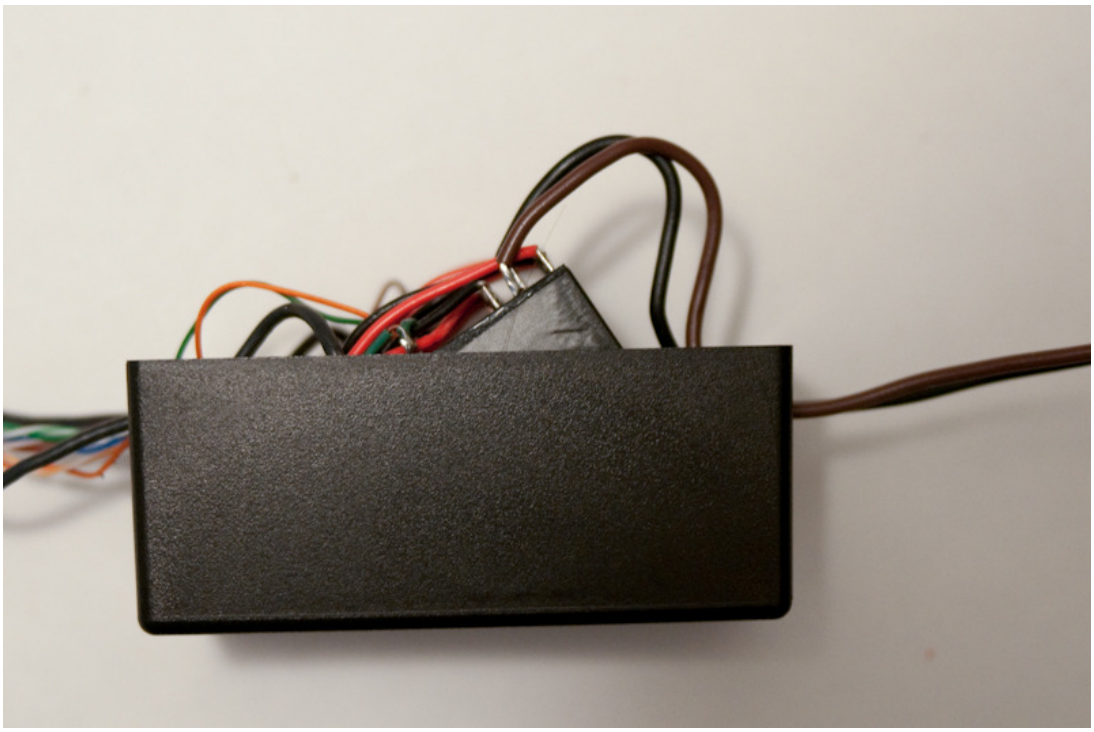
Continue the same process for the other thrusters. Again leave room to zip tie the wires to your frame but do not secure any of the wires yet. Assuming your design allows this, it is much easier to wire the rest of the box by removing everything from the frame first.



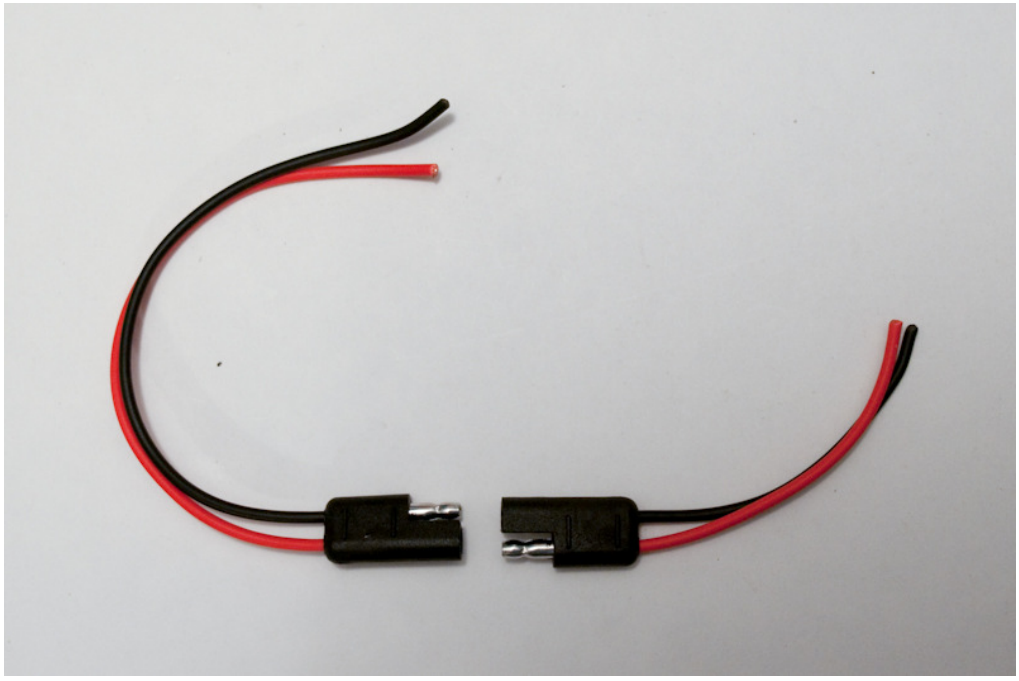
As you remove and cut each thrusters wires be sure and mark the placement of your thrusters (e.g. - left, center, and right) because the wires will all be different lengths and will need to be wired to the correct relays and this will all be done outside the frame.



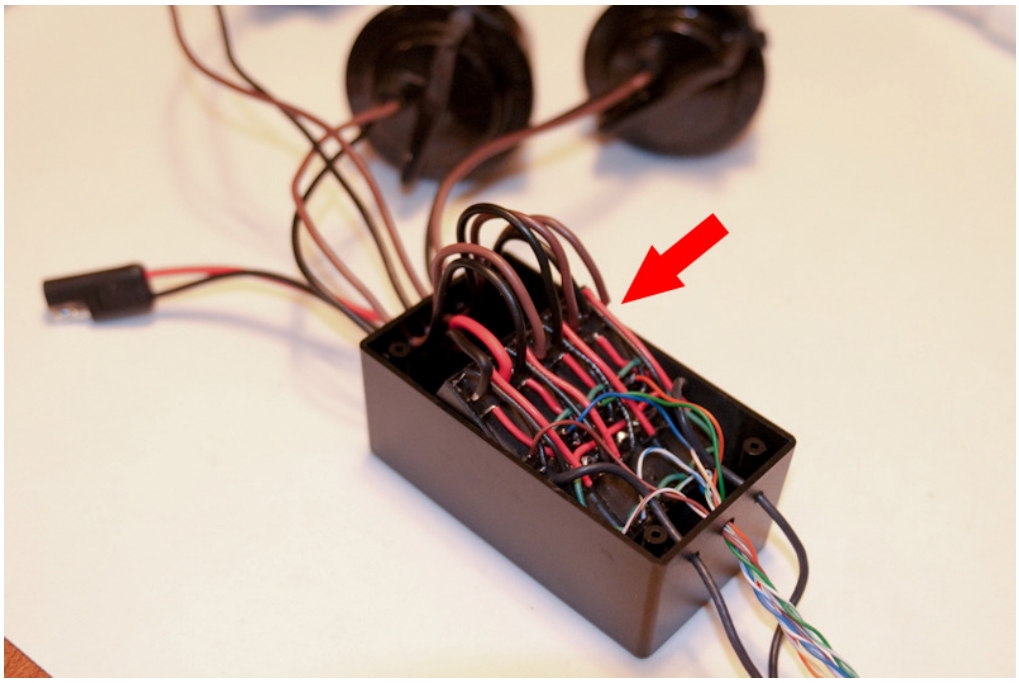
To make soldering on the thruster wires easier you can angle the relays out of the box a little to provide more room to work. Just don't forget to stick the wires through the holes in the box first before soldering them on. Once again the positive (brown) wire goes in the left hole and the negative (black) wire goes through the right hole.



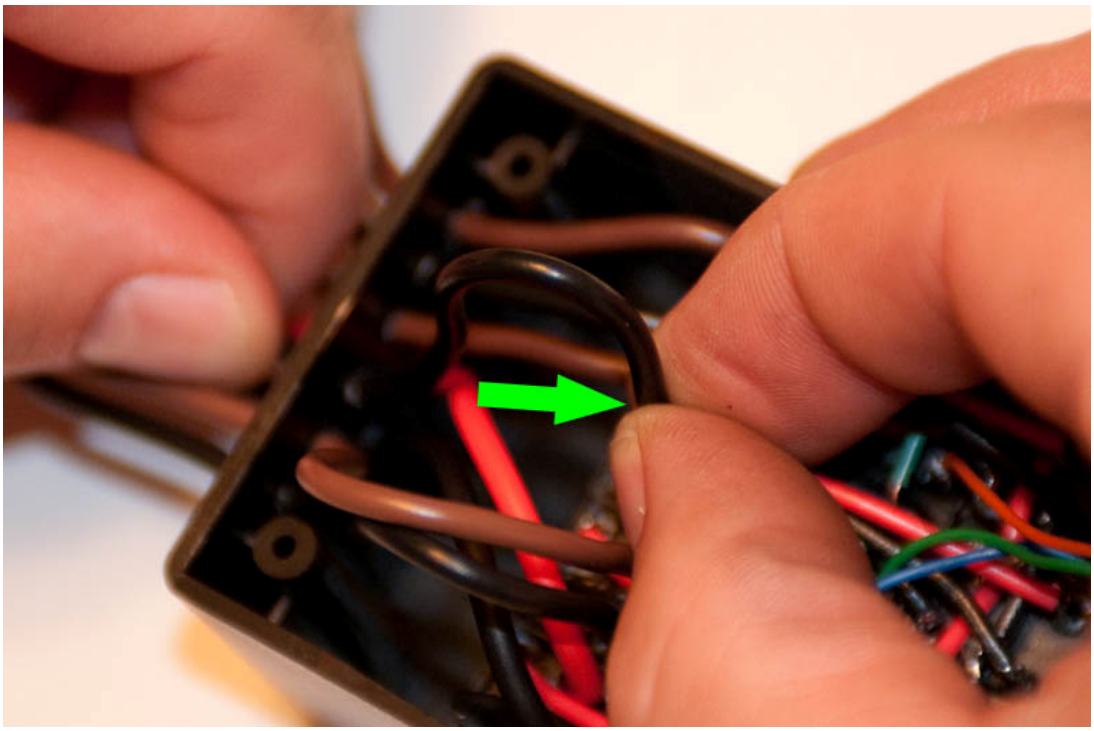
Here you can see the left thruster wires have been connected and how angling the relays out of the box has provided more room to accomplish this task. Continue the same process for wiring the other 2 thrusters.



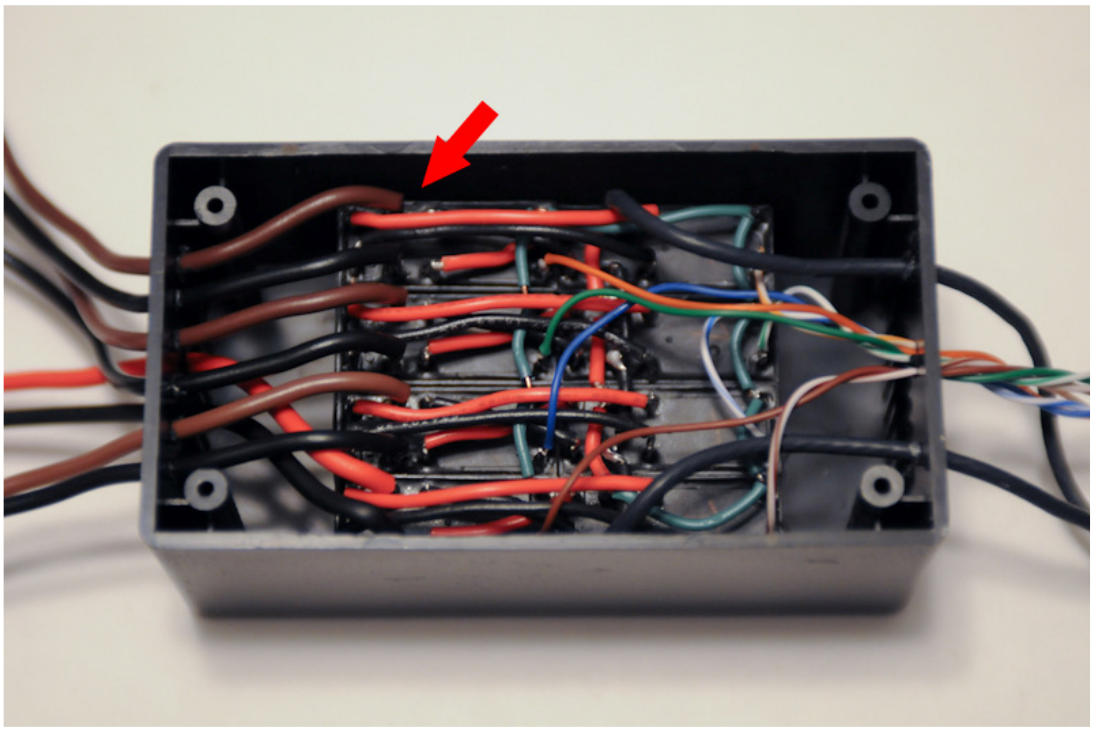
If you chose to add the 4th set of relays (for options) you will need to wire in a spare set of wires to those relays now, the wires are inserted into the bottom two holes and wired to the last set of relays. You can use the excess wire you cut off one of the pumps or add some type of plug (such as the one shown above) to make changing different options easier later on. This is suppose to be a water proof plug, not in the way that the connections are waterproof, but in that water cannot enter the plug and flow through the inside of the jackets of the wires. This system is such low voltage the connections not being waterproof shouldn't hurt anything, and a little dielectric grease should keep the contacts from corroding. Keep in mind all connections for MATE Rov's must all be waterproof and not exposed to water.



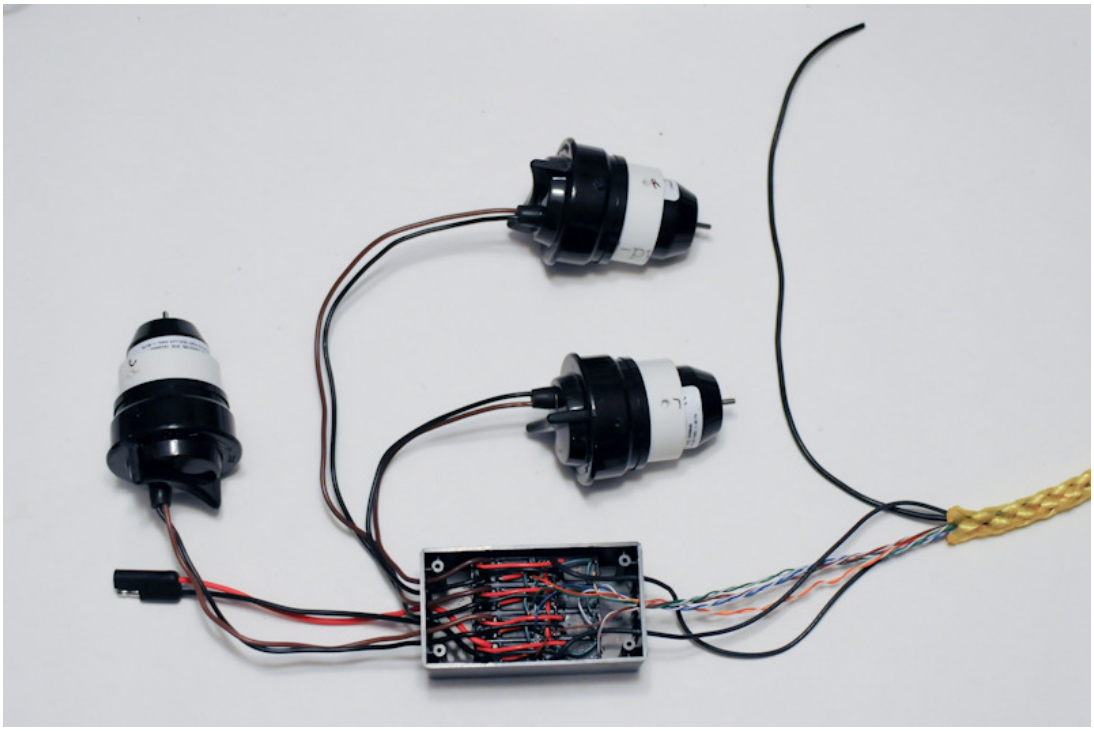
After you have made all your connections press the relays back down into the control box.

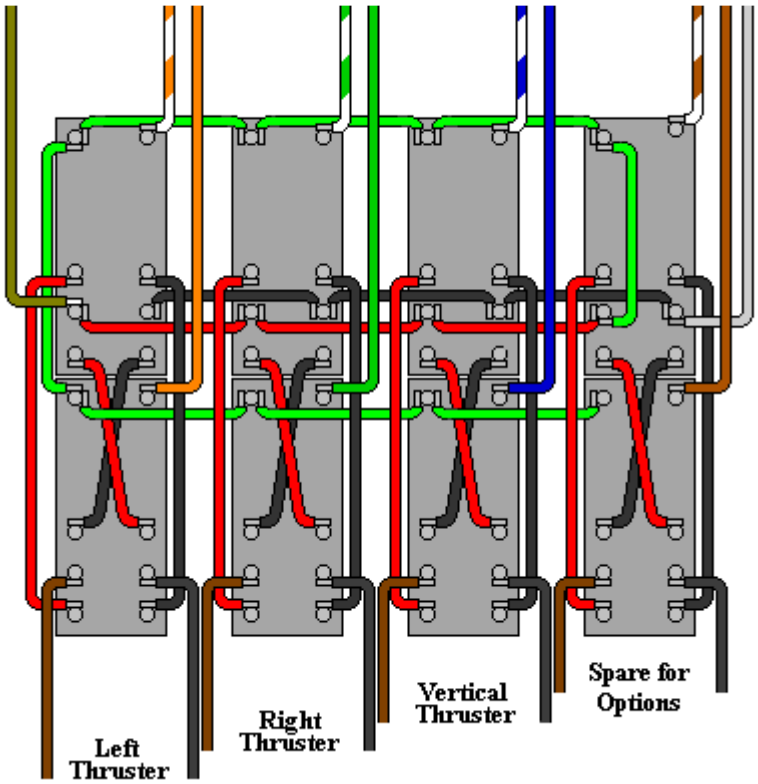


Next you will have to pull the excess wire from each thruster back out of the box. When doing this you have to be careful not to bend or break off the pins from the relays though. Hold the wires where you soldered them to the relay pins (green arrow) with your right hand while you pull the wires out through the holes your left hand, this should take the pressure off the pins.



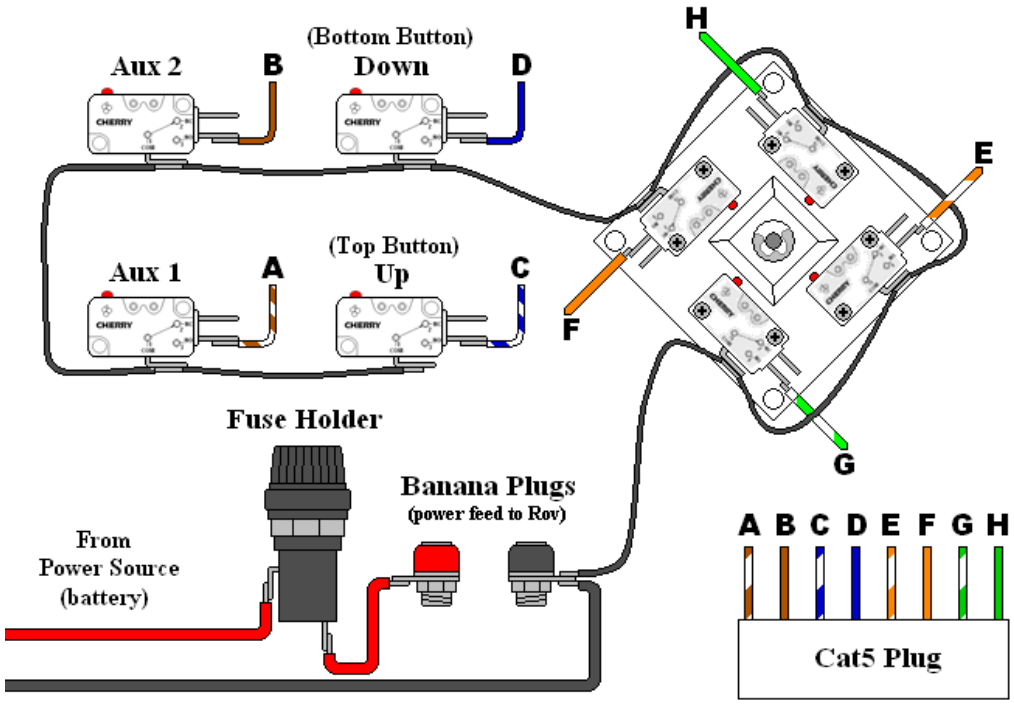
After you have pulled all of the excess wire back out of the box and have enough room to put the cover back on, make sure none of the pins of the relays have bent or any of the solder connections are touching each other.





At this stage of the wiring your control box should be nearly complete, this is a good time to double check that all connections are correct, that none of the soldered pins or wires are touching each other, and to make sure your motors are connected to the right relays. Next you will be wiring the actual controller.

Wiring the Topside Controller



Some of the steps in this next section of the manual for building and wiring your controller may vary because the layout and the components you select maybe slightly different. The layout and location of your joystick and buttons is all a matter of personal preference.

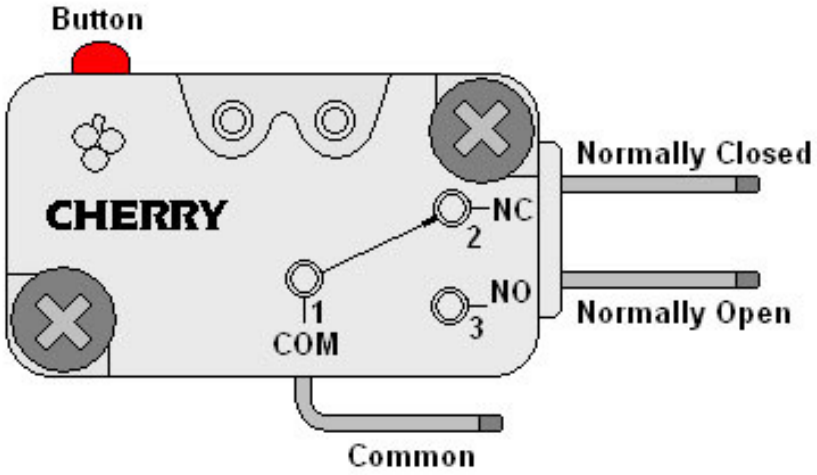
The first thing you're going to have to do is select a box that you can use as your controller housing. You can use anything such as a tool box, storage box, or you can custom build a box out of wood, metal or even Plexiglas. I selected this fishing box to use because it will house all of the need controller components as well as hold a small tractor battery in the bottom for when I need a fully portable setup.

The cool thing about this box is the top section (the part that will actually house the controls) is easily removable. It is little details like these that can make your system more versatile.

The components for the controller include a Cat5 jack, 2-4 buttons (4 if you added the spare relays for options) an arcade joystick, 2 banana plugs & jacks, and a fuse & fuse holder.

When selecting the arcade joystick make sure it is a “8 way” type and not only a 4 way) they both look similar an each one has 4 switches but the control block contacts the switches in different way on the different models. (I prefer to use the 8 Way HAPP Competition Model.)

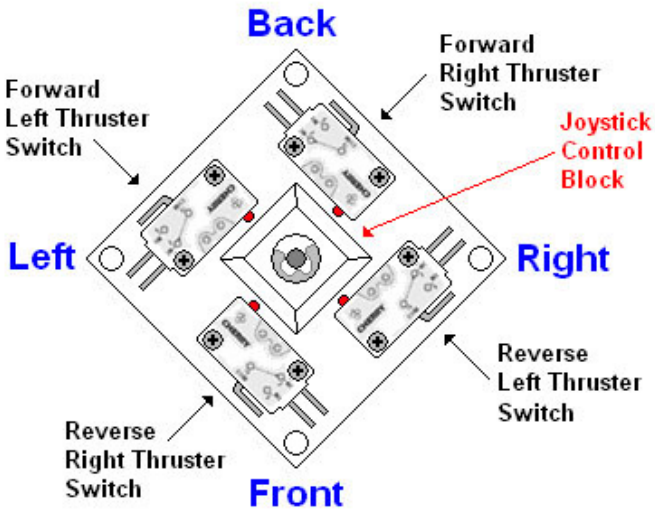
Snap Switch



The arcade joystick consists of 4 snap switches that should look similar to what is shown above. You will only be using the Common (COM) and Normally Open (NO) connections.

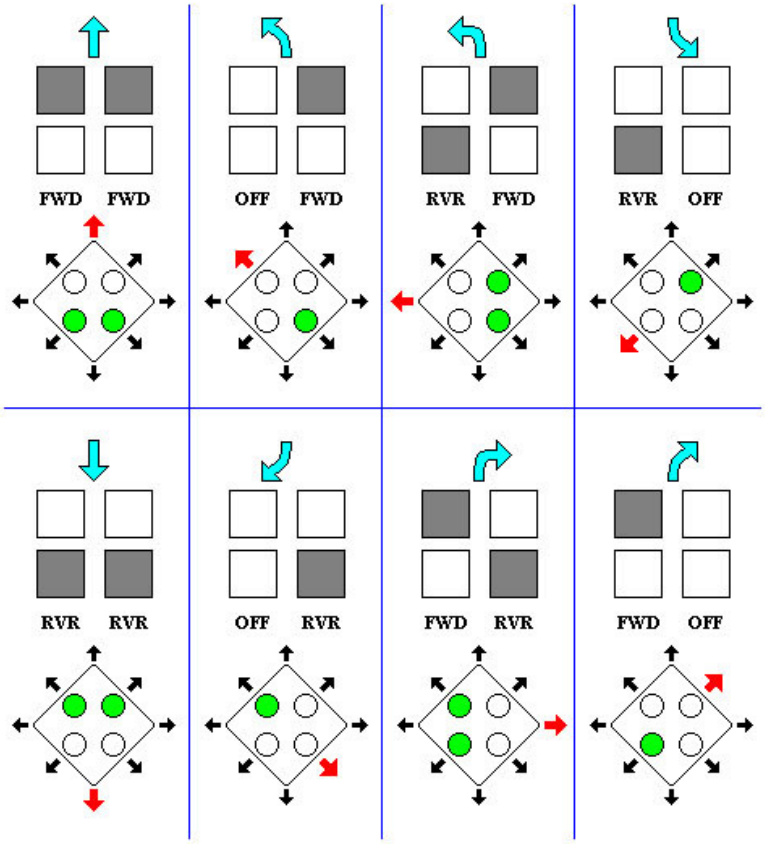
The buttons I am using are also arcade type so they use the same snap type switches as the joystick. You can use standard SPST N.O. (Single-Pole Single Throw Normally-Open) push buttons (as shown above) if you want. Make sure you use a momentary type buttons for the up/down thrusters. The buttons or switches you select if you added the relays for options will depend on what kind of optional device you are adding.

The next thing you need to do is figure out the placement of your controls in your box. The configuration of the controls can be however you would like them to be and is all a matter of personal preference.

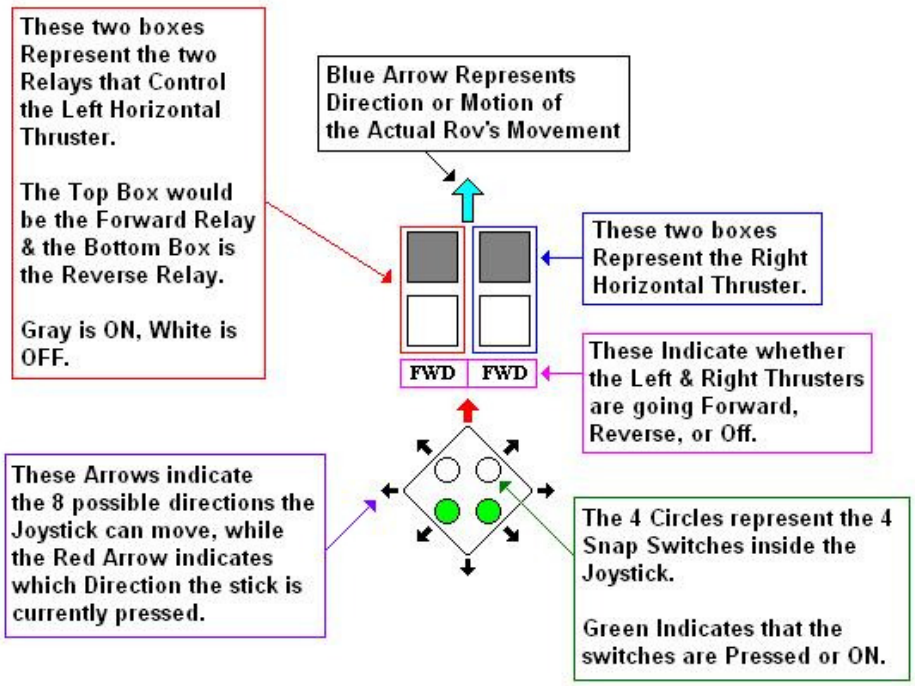


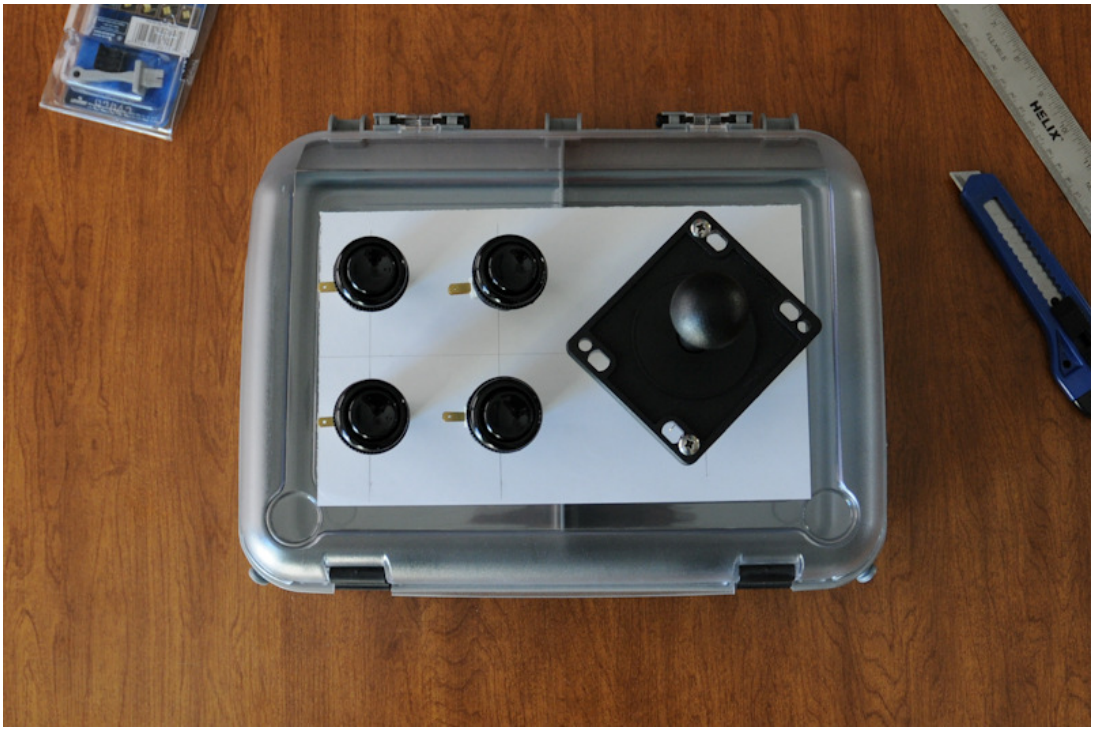
Bottom of Joystick

Keep in mind when laying out your joystick you will be mounting the joystick assembly in your control box diagonally. When you press the stick forward the block actually moves toward the rear switches and will press on two of the switches at the same time. In the diagrams (as show above) you will be looking at the bottom of the joystick. You'll also notice that the left and right reverse switches are labeled backwards, operation is explained in the following tables.



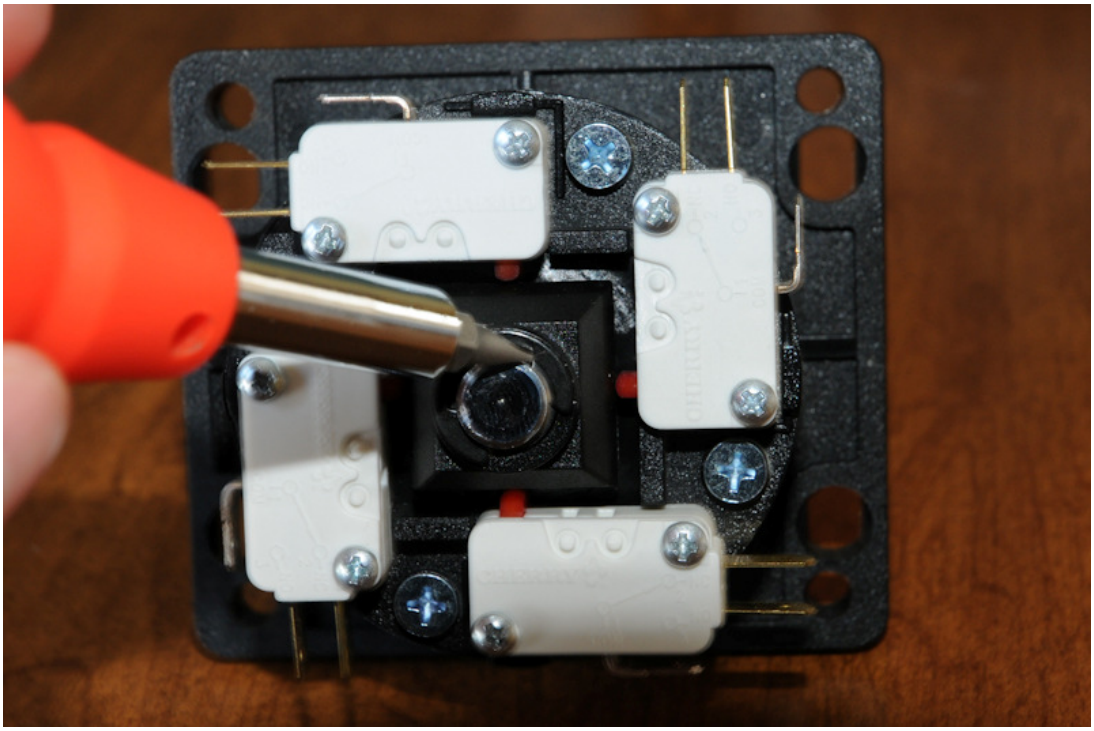
This table should explain which Relays will be ON when the joystick is pressed in a certain direction. (Below is an explanation of what everything means.) Turning sort of has 2 speeds, if you press diagonal into the corners only one thruster is turned on and your Rov should turn relatively slow in that direction. If you press true left or right one thruster goes forward while the opposite thruster goes in reverse which will make your Rov turn faster or spin in place. You can also figure out from this table why the reverse switches are backwards. The joystick diagrams shown here are shown looking from the top of the joystick this time.



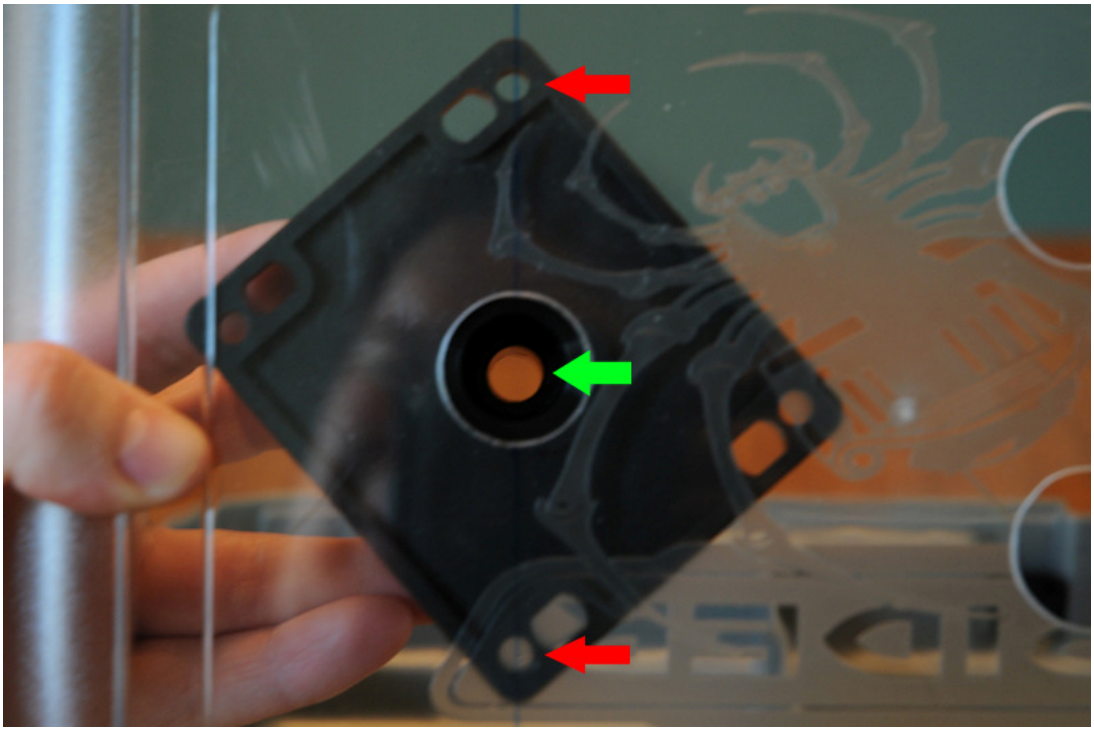


I like to actually do a quick mock up placement of the controls to make sure they are comfortable to me before I actually mount them. You can make a temporary box out of cardboard and mount the controls to it first to make sure everything is comfortable before making your actual controller box. (Not shown)

After transferring the marks to the controller box use a 1" hole saw to drill the holes for the joystick and other buttons. Your buttons may vary in size, use the appropriate size bit for your switches/buttons. Next I draw a center line vertically across the hole for the joystick.

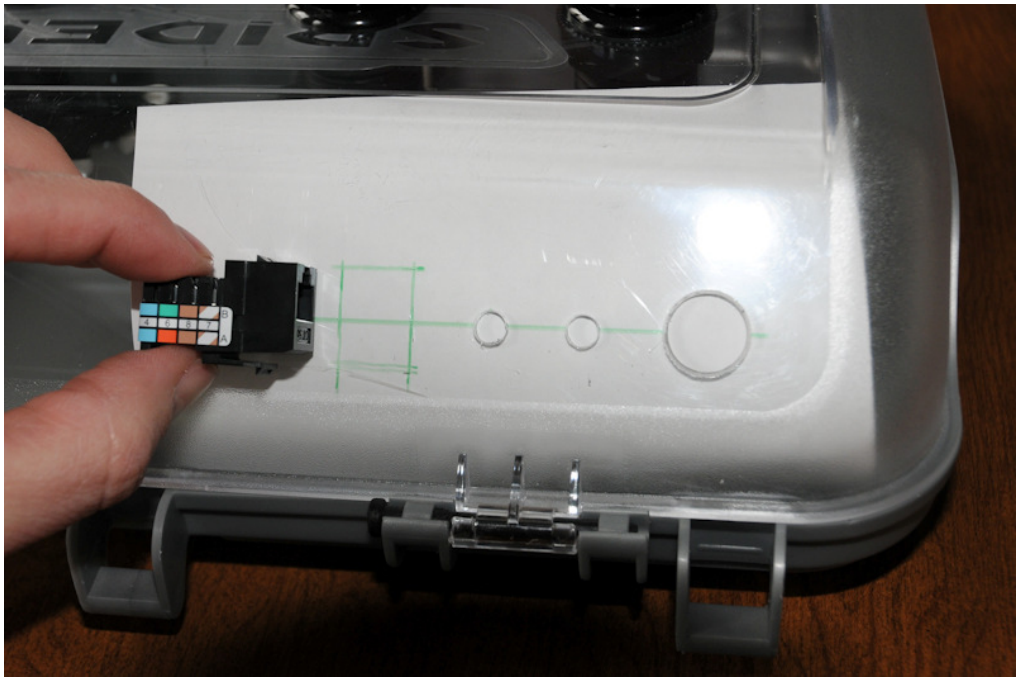


Most of these joysticks are similar. Using a flat blade screw drive remove the clip holding the handle of the joystick in. Be sure to note the position of the control block, any spacers and/or springs that make up your handle so you can put it back together after the joystick assembly is mounted in your controller box.

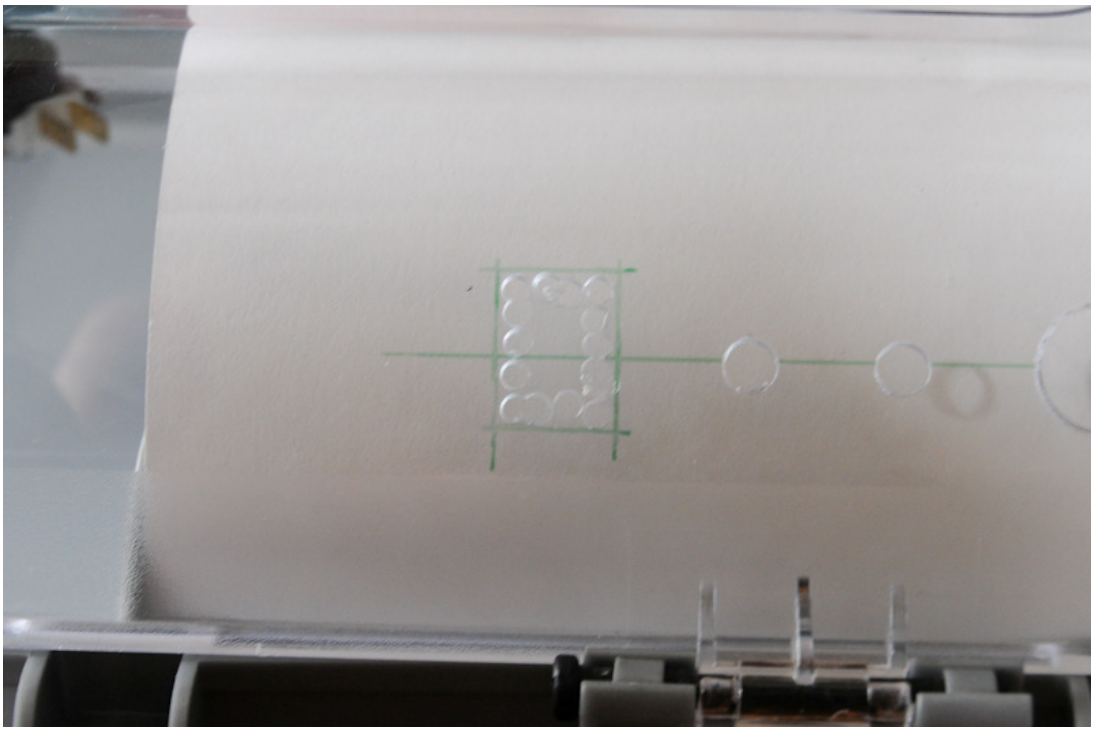


Center the handle hole of the joystick assembly over the hole you drilled in your controller box (green arrow) and after lining up the mounting holes (red arrows) on the center line you drew mark the center of the mounting holes. After selecting the appropriate size mounting screw or bolt (depending on you controller housing) drill the mounting holes and mount your joystick assembly and reassemble the handle in the reverse order that you just took it apart.

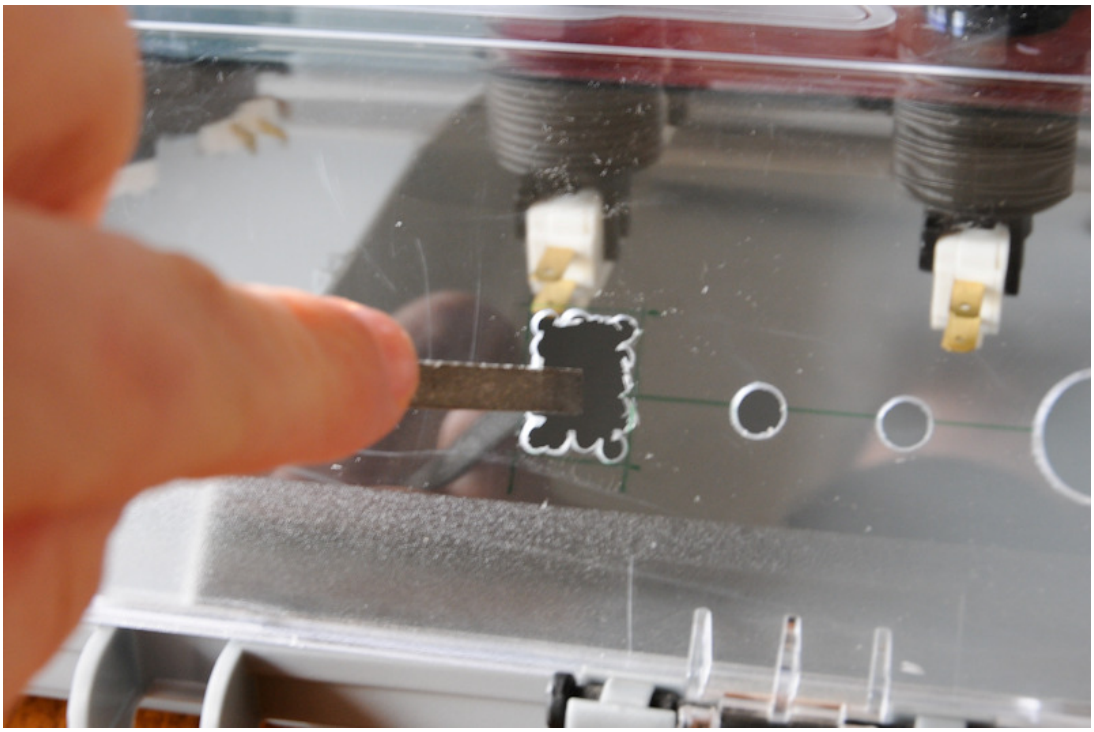
Finish mounting your joystick assembly and the other control buttons and/or switches that you have selected. Next you will be mounting the Cat5 jack, banana plug jacks, and the fuse holder. Again, placement of these components is all a matter of personal preference, but try to plan ahead, this is where the tether will connect to your controller and you will want to wires to exit in a spot where they will not be in the way or inhibit your use of the controls.



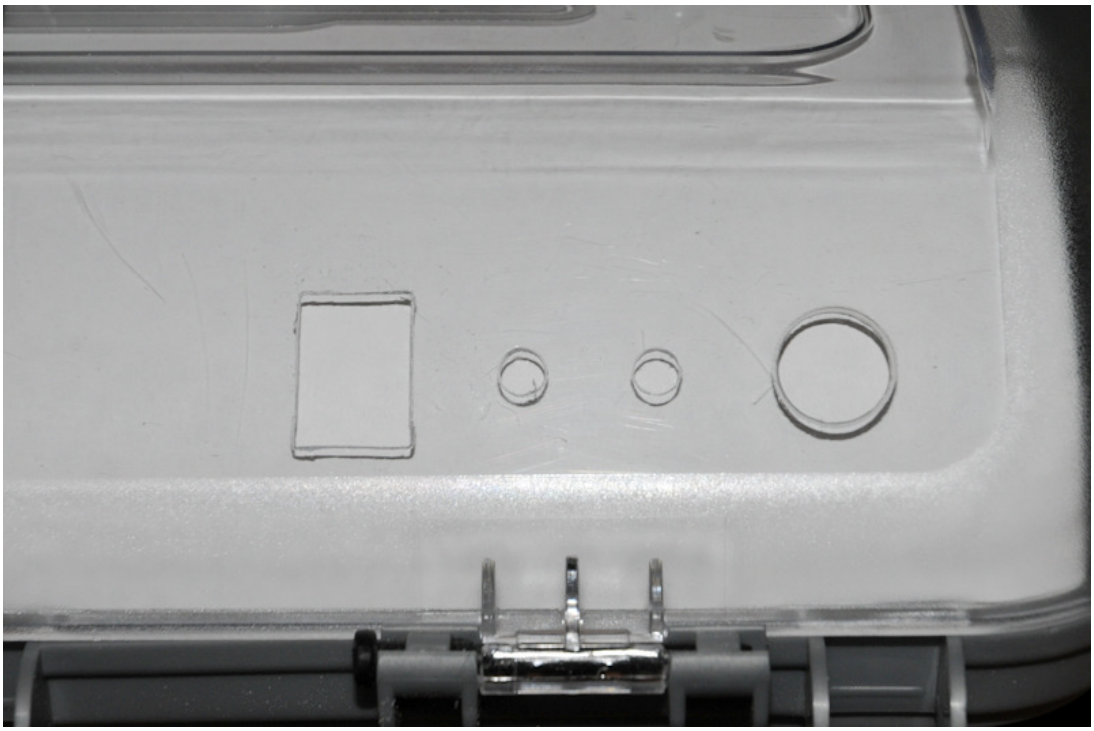
You can normally use standard drill bits to mount the fuse holder and banana jacks, but Cat5 jacks are usually square and snap fit in so you will need to make a square hole. Measure the jack and tab spacing and mark your housing where it is to be mounted.



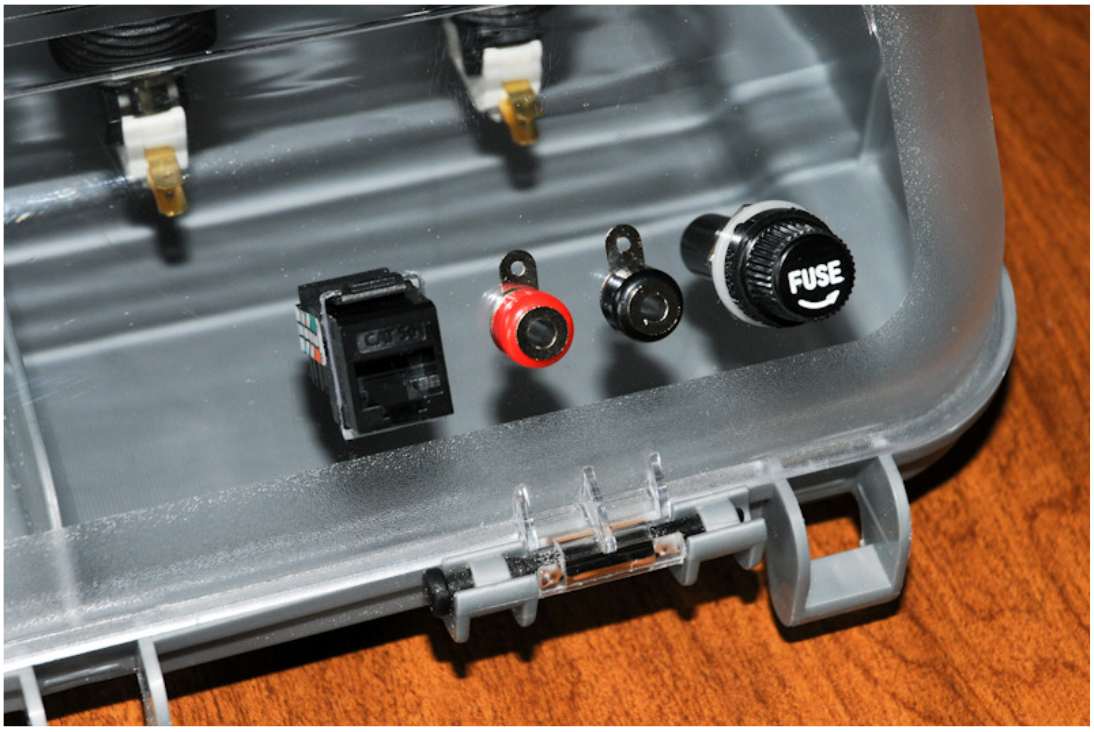
Using a small drill bit, I drill several holes (as close together as I can get them) around the inside perimeter of the marks I made. After they are all drilled I just walk the drill bit (up and down/side to side) from hole to hole to punch this section out. A dermal cutoff wheel might work also, but it can also melt plastic as it cuts so you may not get a clean hole.



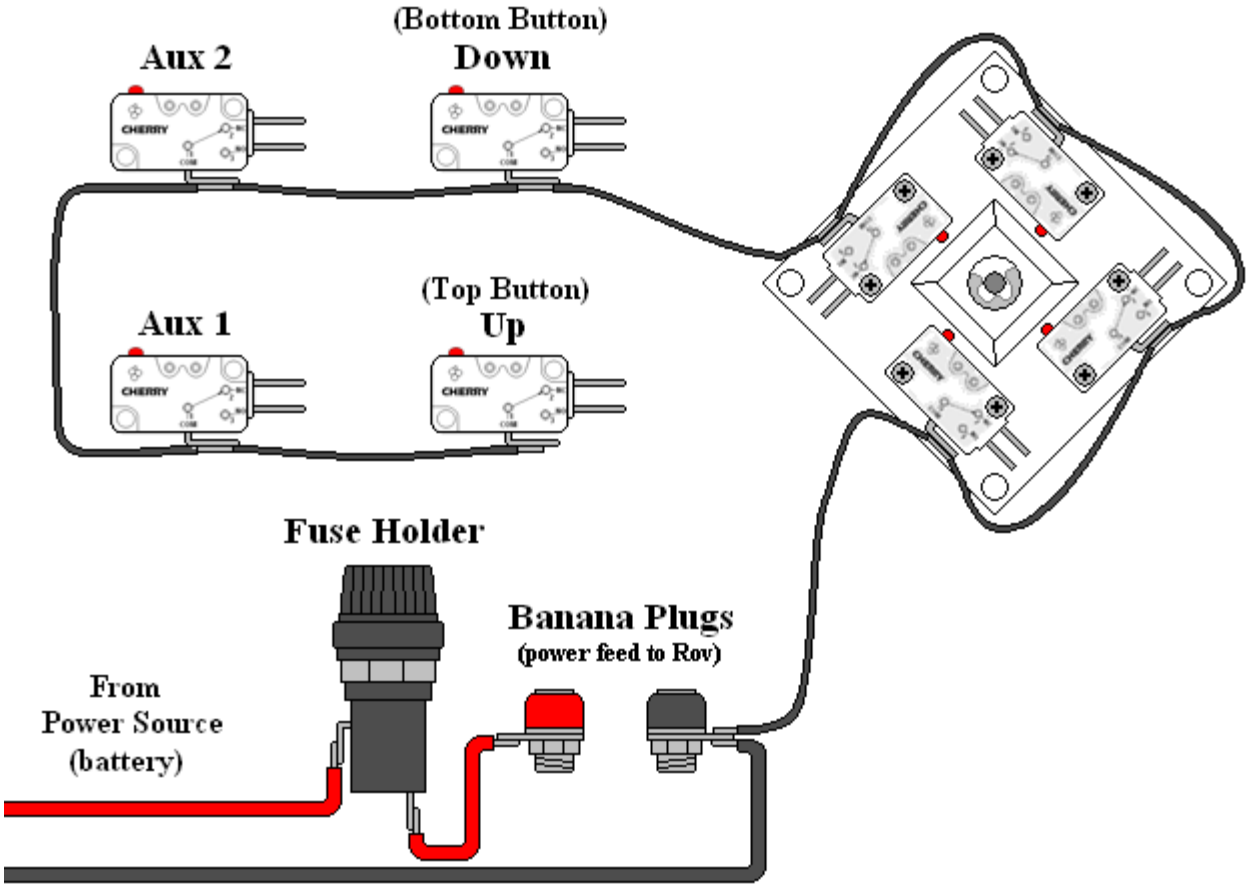
I then use a small file to clean up the hole until my jack fits.



Your finished hole should look something like this.

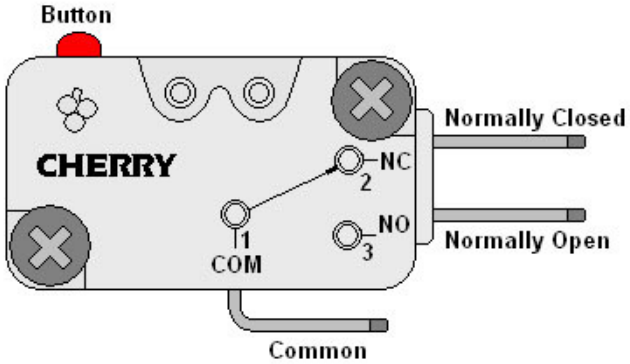


After you can finish mounting your jacks and fuse holder, you are then ready to wire the controller connections.

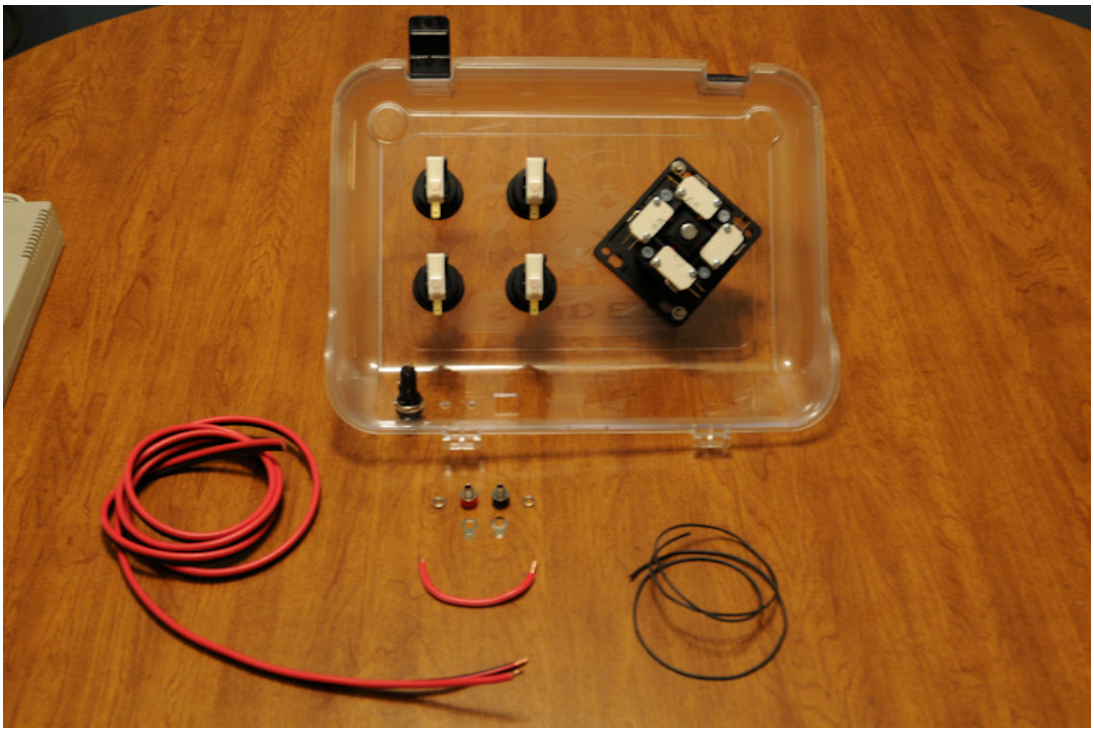


To begin the wiring for the controller you will first be wiring in the main power feeds from your power source (Battery) and then continuing the ground to all of the common (COM) switch connections. Your layout and the connections on your fuse or banana jack may vary slightly but just follow this wiring diagram for the proper connections.

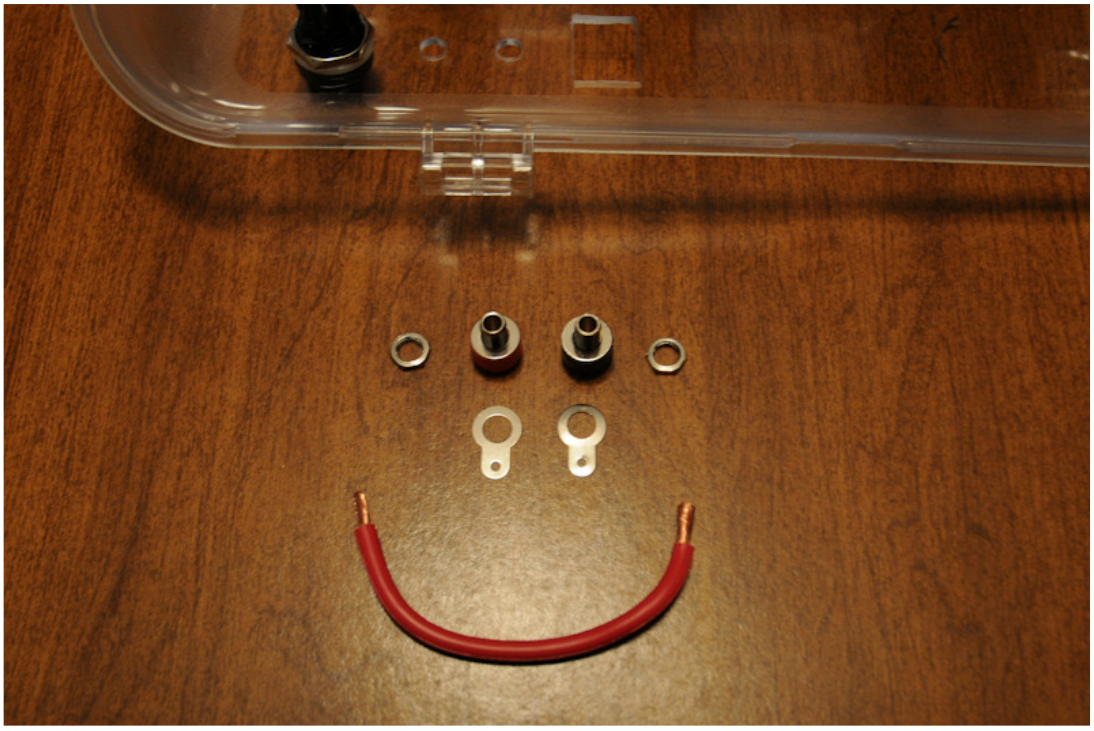
Snap Switch



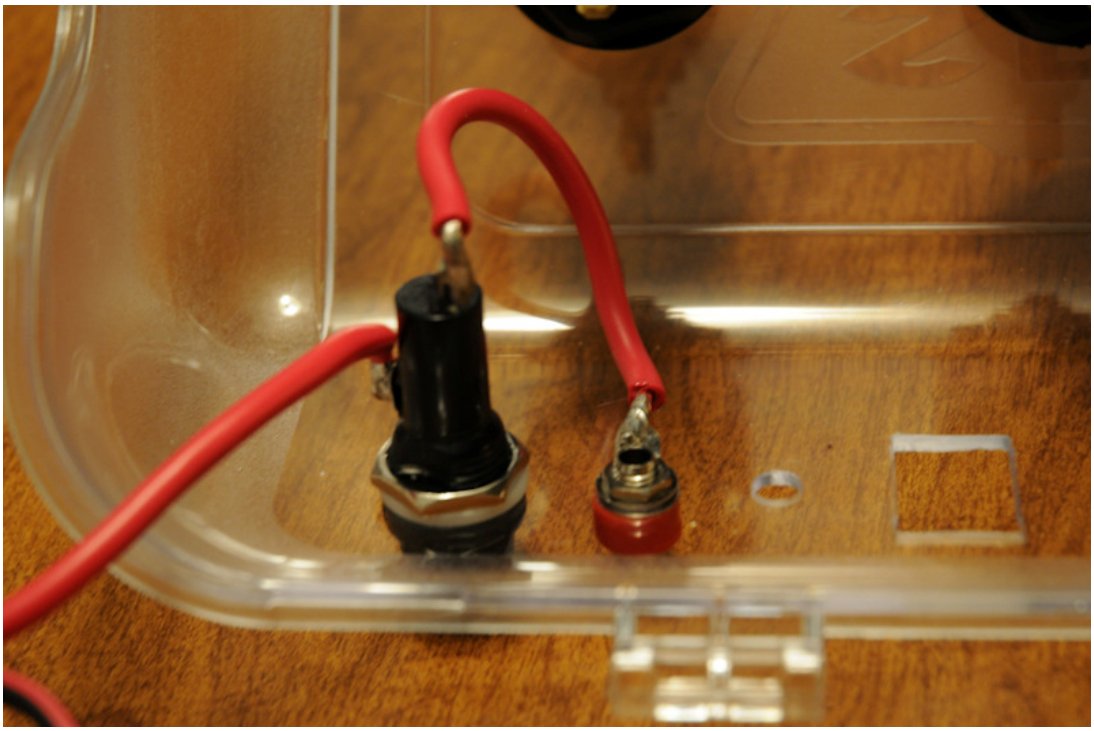
You will only be wiring the common (COM) connections for this step.



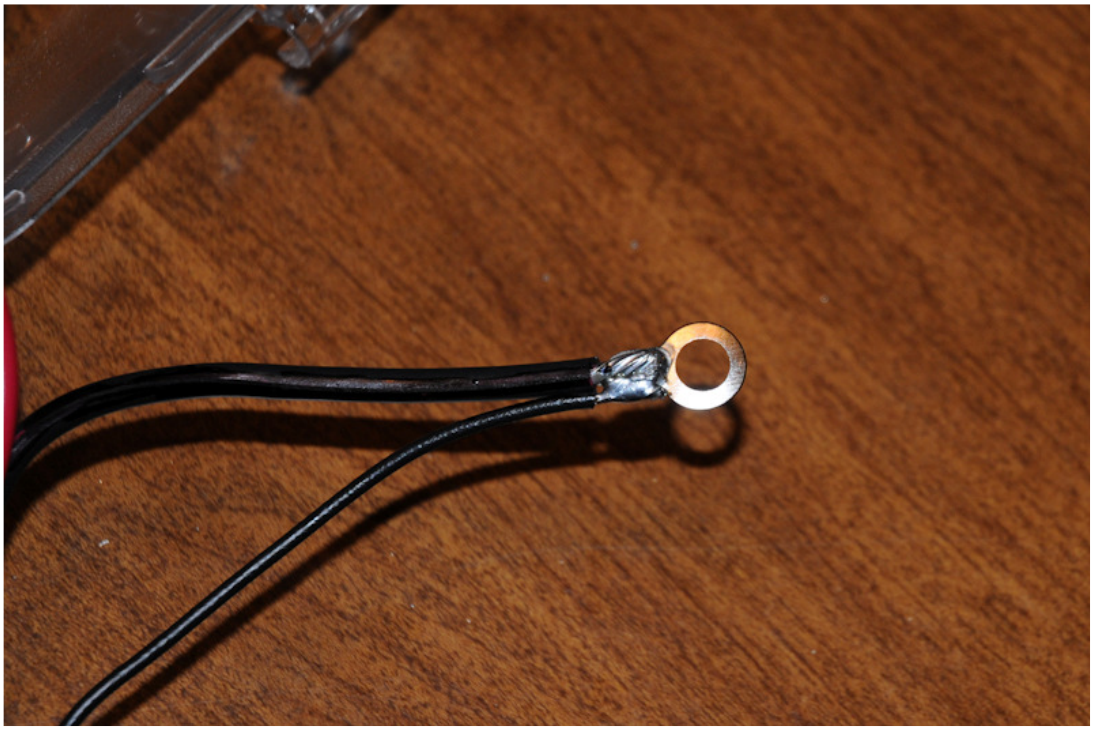
I'm using a piece of 12 gauge wire (red and black) for the main feed from the battery. (You can use the same main power wire you used in the tether though) I like to use color coded (red and black) wire for any connections that will be connected directly to a battery, this way it lessens the chance of hooking it up backwards and damaging anything. You can use the same hook up wire that you used during wiring the relays to continue the common ground to the switches.



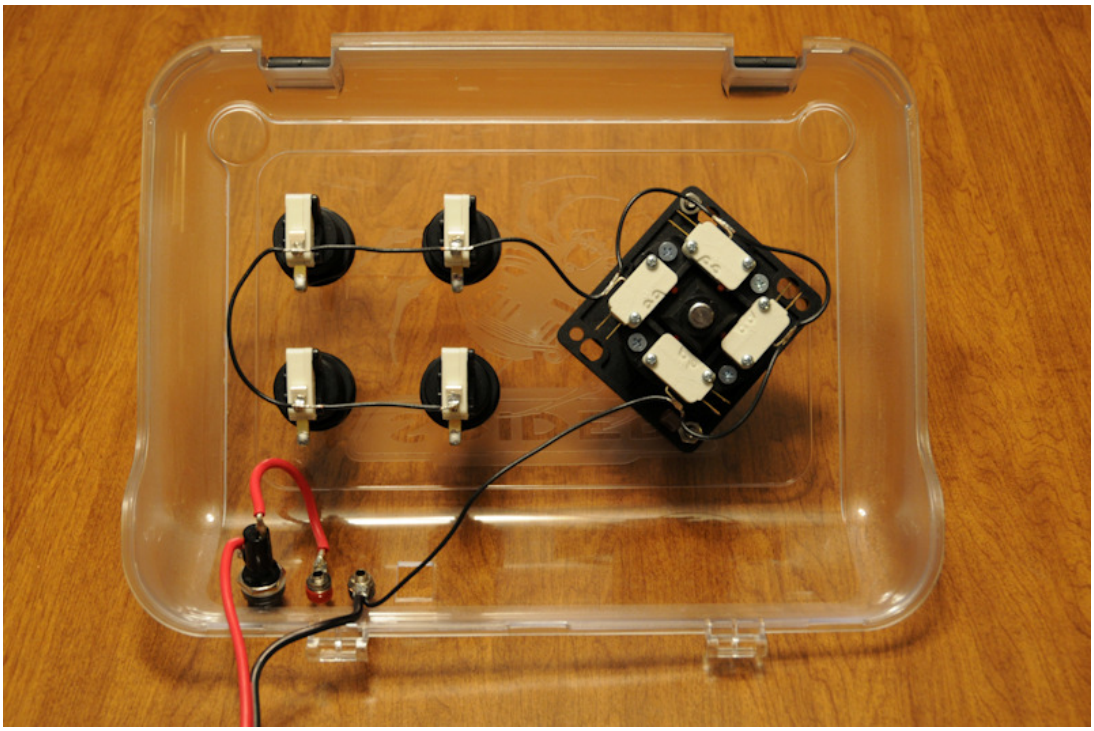
Most banana plugs have removable connections tabs, so you don't melt the plastic jacks while trying to solder the wires on. The short piece of wire shown will be used in the next step.



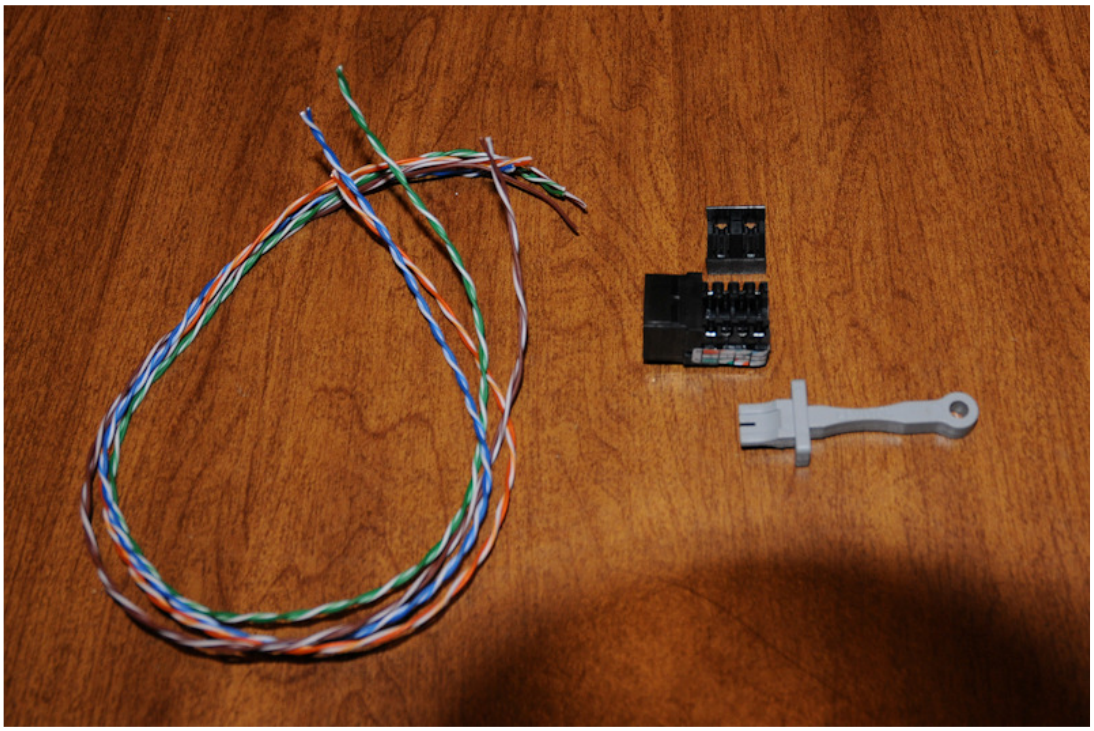
Your main positive power feed (red wire) will be soldered to one connection of the fuse holder you then can continue that feed from the other connection of the fuse holder with a short piece of wire over to the red banana jack.



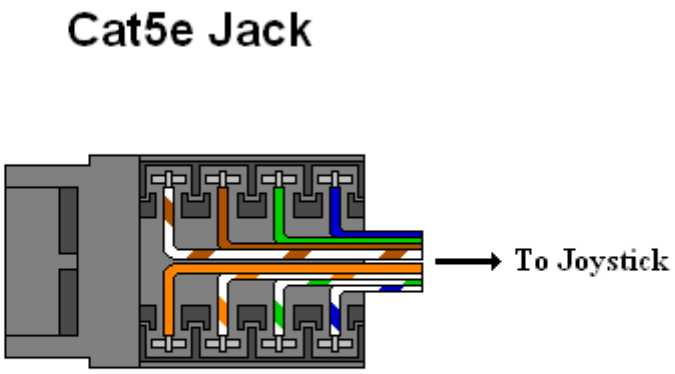
The negative power feed (black wire) will connect directly to the black banana jack and then continue on to the common connections of the switches. The easiest way to do this is to solder the main feed and a piece of hook up wire right to the removable tab of the banana jack if it has them.



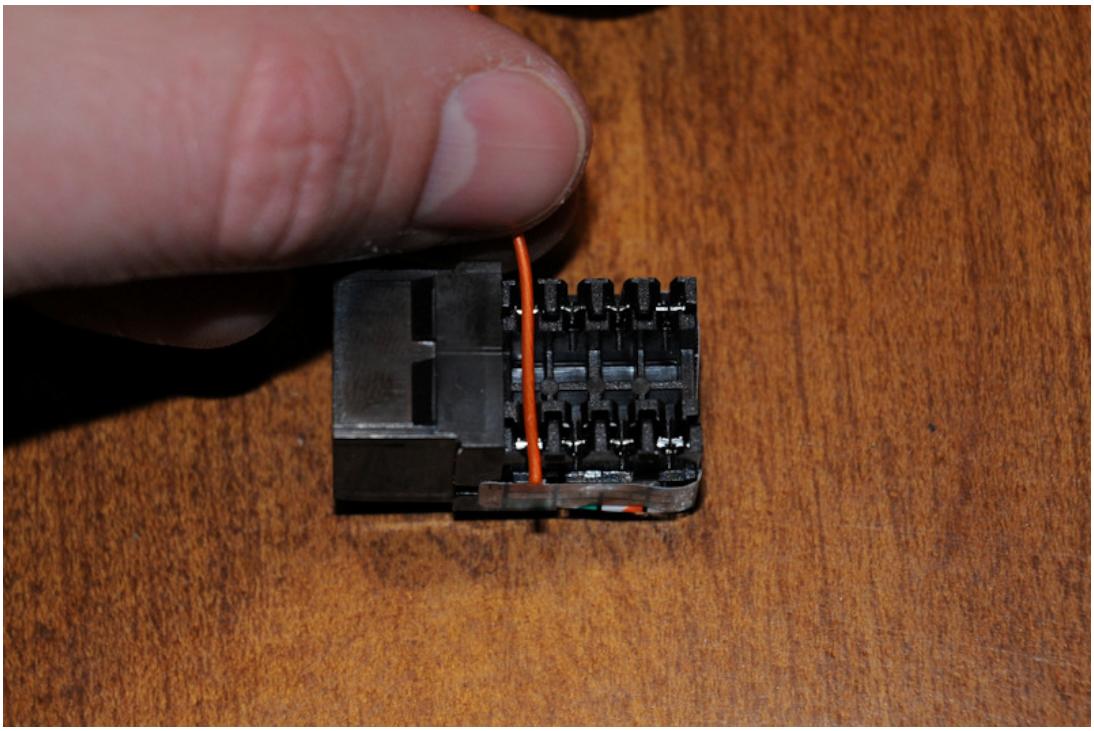
Next following a route similar as shown above use the same method of marking, roll cutting, and tinning the negative power feed wire (as you learned on page 11) to prep the negative power feed. After the wire is prepped tin the switch contacts and wire then solder the negative power feed to all of the common connections on the joystick and switches.



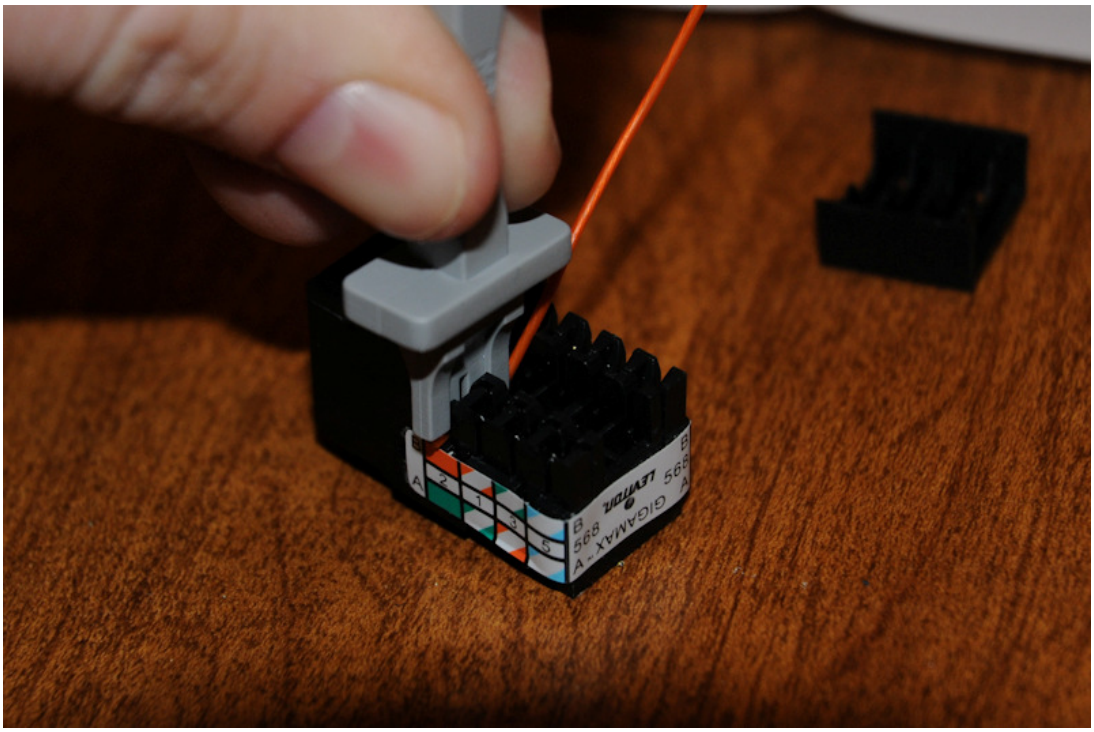
Next you will be wiring the Cat5 plug to the joystick switches. (Hopefully you saved the excess control wires that you trimmed off of the tether. (Page 35) If not, you can use any hook up wire, you will just have to label it so you know what wire goes where.



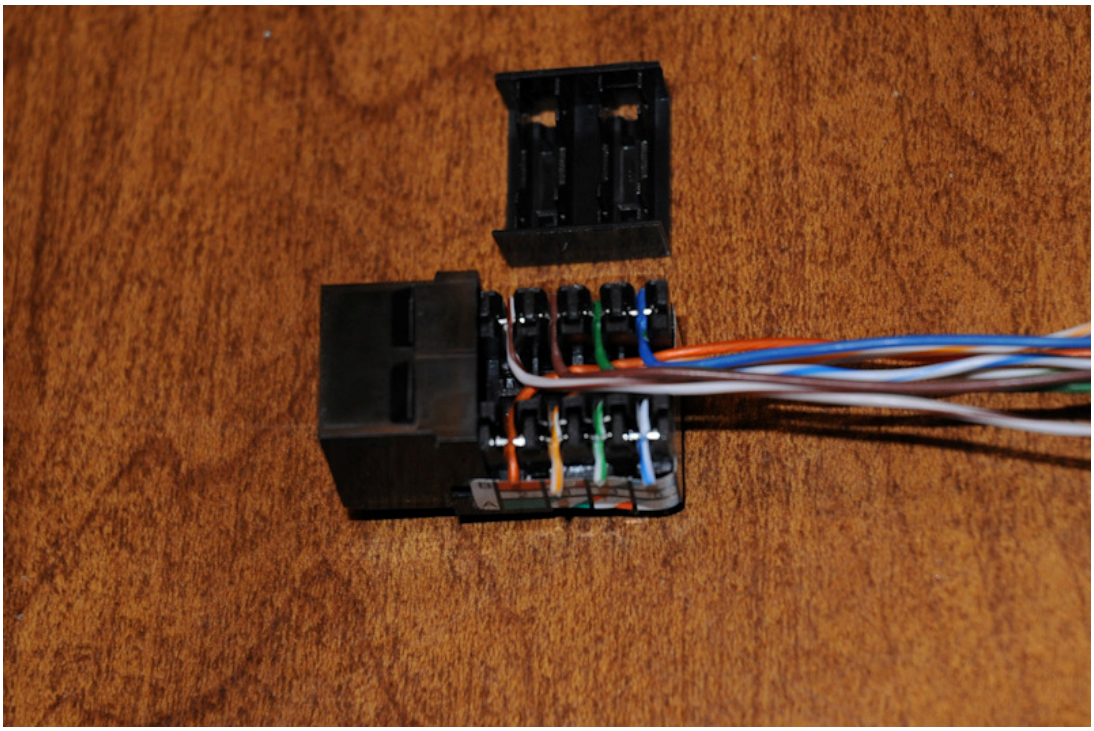
Most Cat5 jacks come with two color coded labels (A & B) that shows the proper way to wire them, I used the T568B standard, follow the directions on the package to wire your jack but it should match the diagram above.



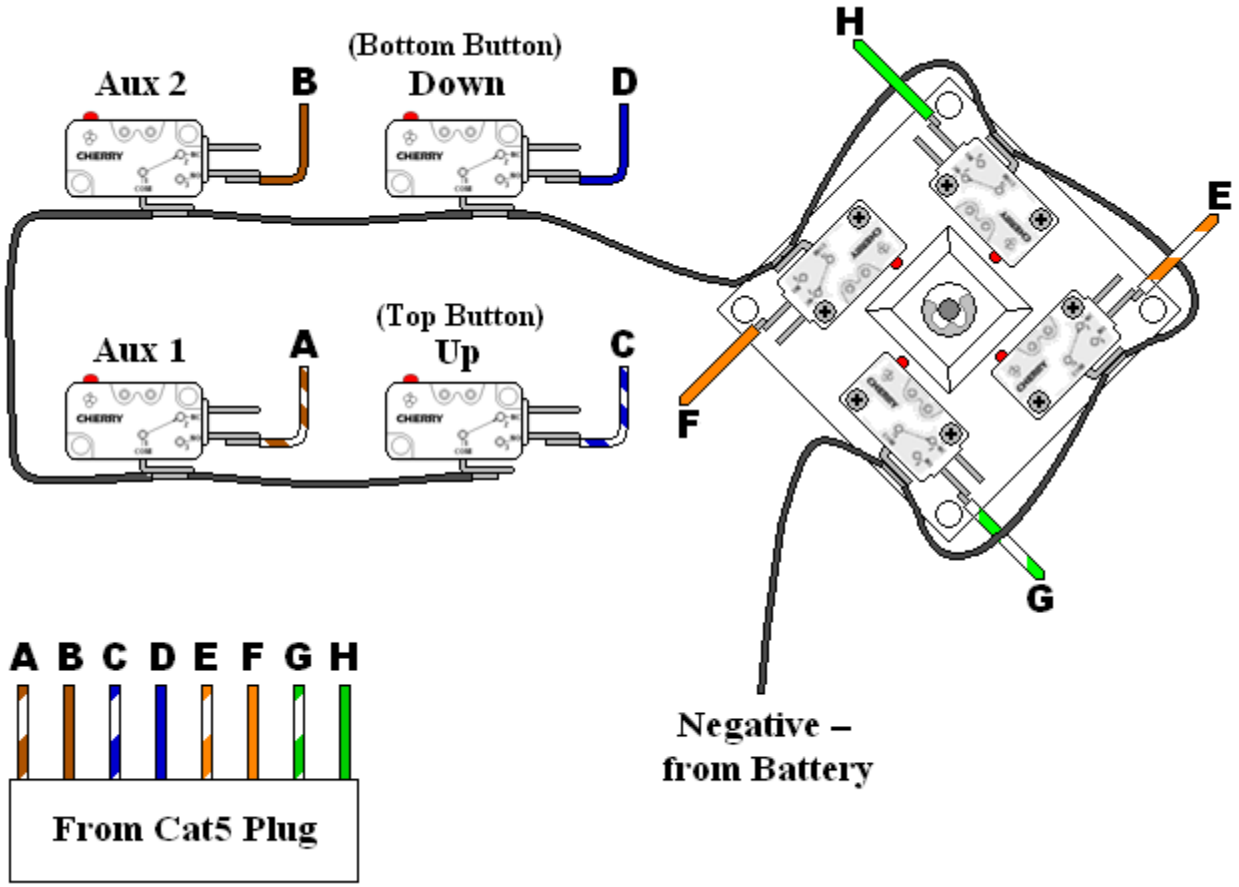
To wire most Cat5 Jacks you don't even have to strip the wires, you just pick the right color wire and match it up to the colored label and place it in the slot….



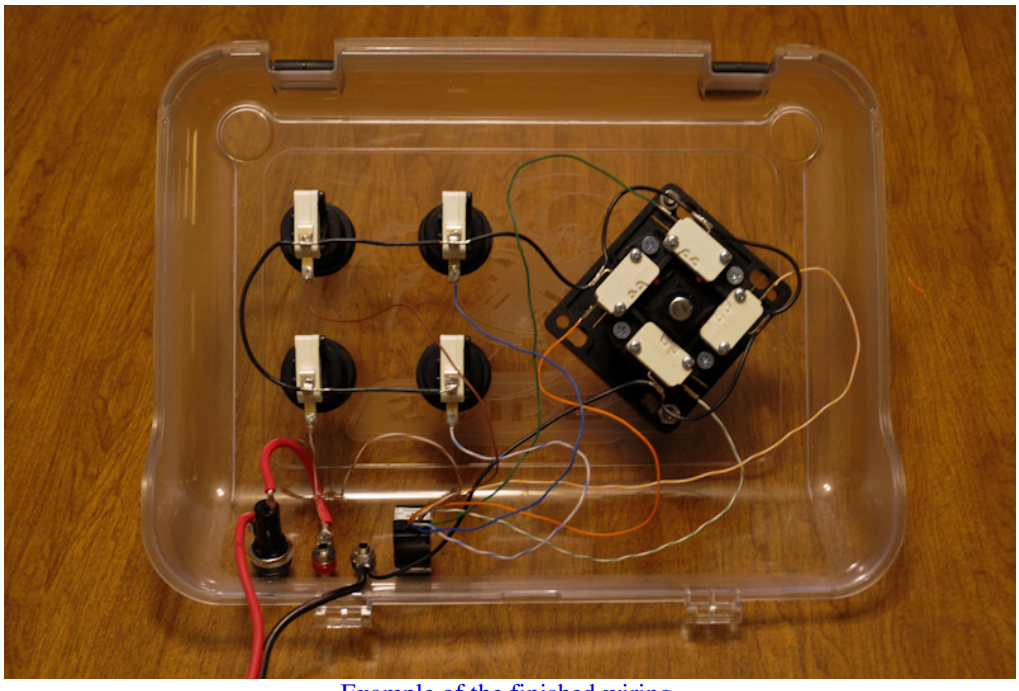
… and using the supplied tool you press the wire down to lock it in.



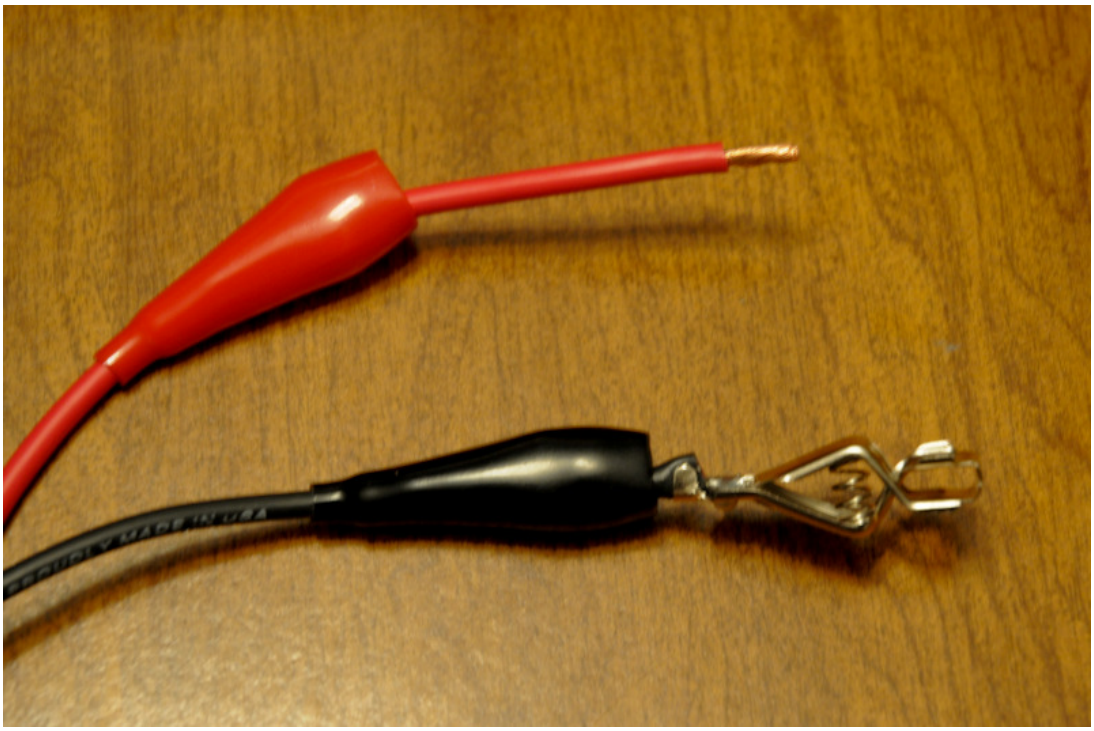
Double check your wiring to the diagram on the pervious page, if everything looks good you can snap on the cover and trim off any excess wire that is sticking out of the sides.



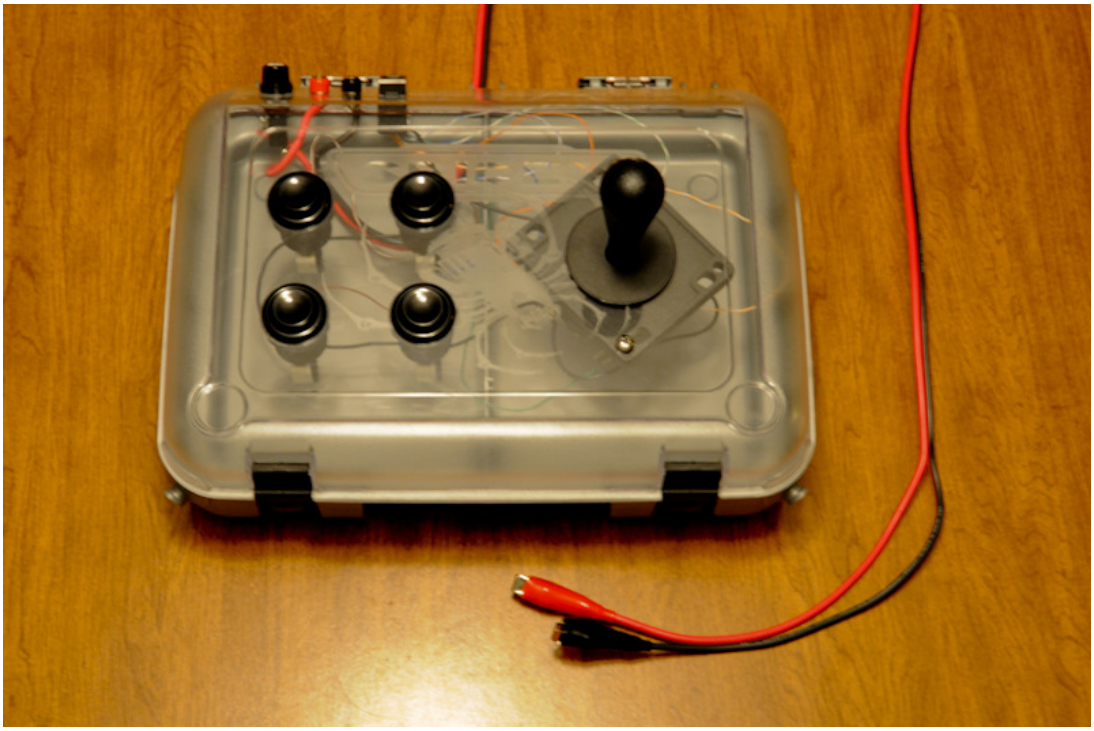
The next step for wiring the controller is to connect the control wires from the Cat5 jack to the joystick and other switches. Use the color coded diagram above to make your connections. The control wires connect to the normally open (N.O.) connections of the switches. (Remember this diagram is looking at the bottom of the joystick.)



Example of the finished wiring.

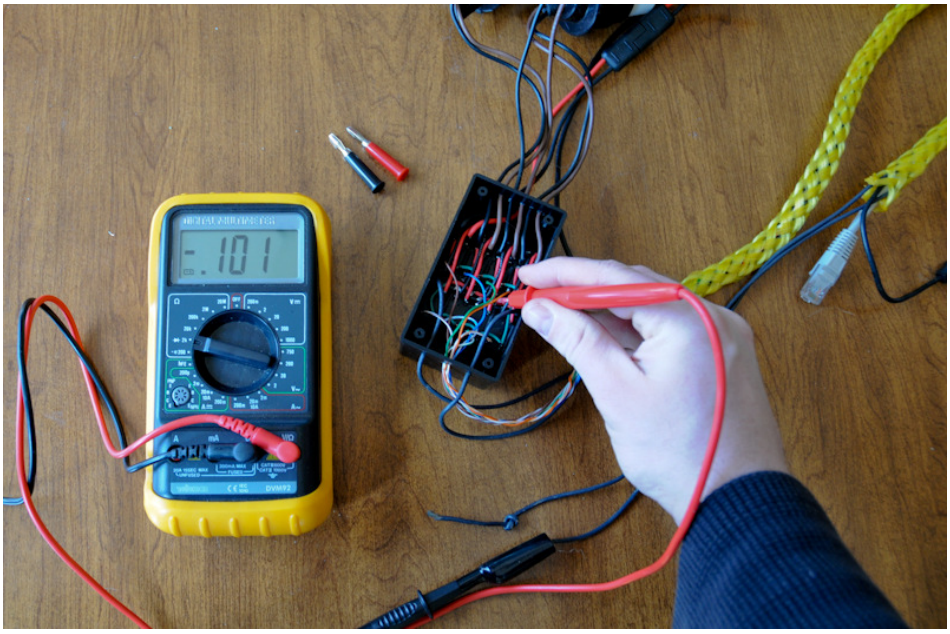


The last step for wiring the controller is to finish off the other end of the main power feed. This is the end that will connect to your power source. (normally a 12 volt battery) There are several options you can use such as large alligator type clips, (as shown above) terminal ends, ect. Once again this is personal preference and/or dependant on your chosen power source.

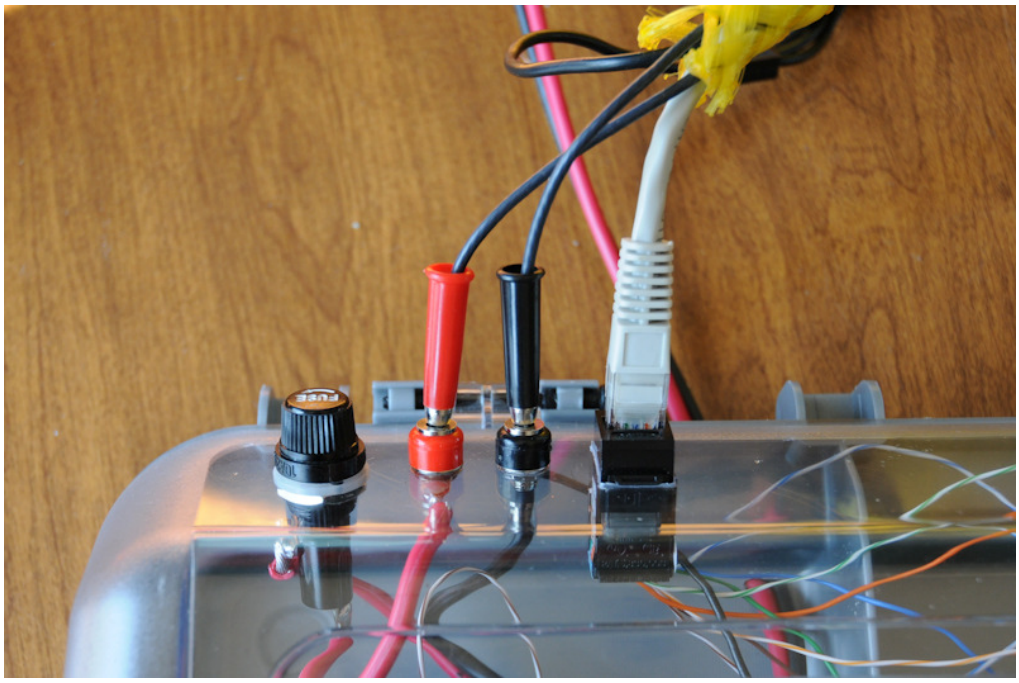


The finished topside controller.

One last step before you test out all of your wiring is to attach the banana plugs to the power wires in the tether.

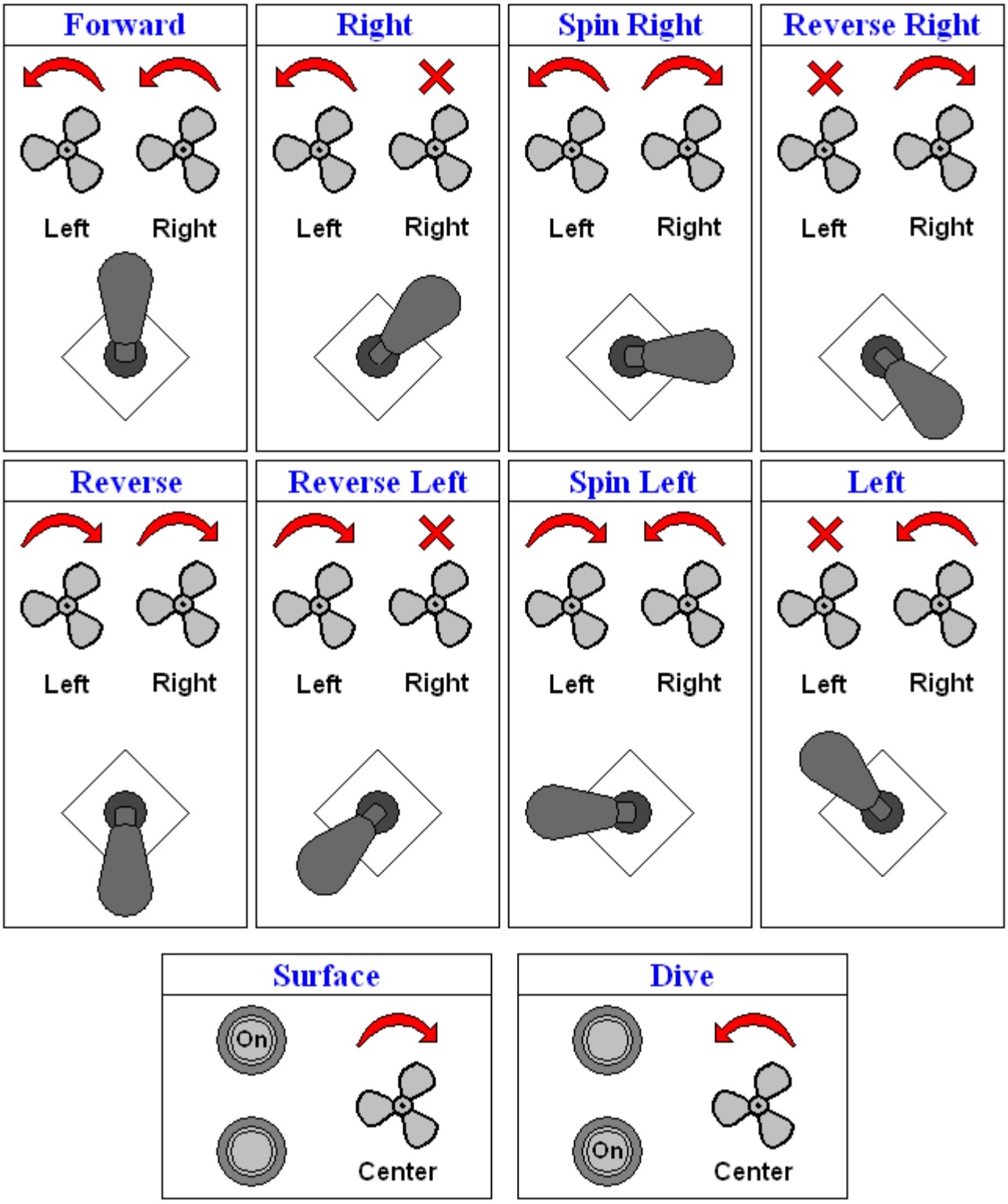


If you used speaker wire (which is normally colored silver and copper) and followed my diagrams you can connect the red plug to the copper wire and black plug to the silver wire. If you used a wire that is the same color for both the positive and negative you may have to use a multimeter to determine which wire is which. Set your meter to measure resistance (Ωohms), clip one lead to either wire and then probe the negative wire where it connects in your control box. (look at the wire diagram on Page 40 if you cant remember which is the Negative) If you get a reading on your meter, that is the negative wire, if you don't get a reading switch the lead to the other wire (tether joystick end) and try again. Once I find the negative wire I like to tie a knot in it so I don't lose it. Now just solder the correct color banana plugs on and you're almost ready to test everything out. Don't forget to slide the colored piece over the wire before soldering on the metal plug.



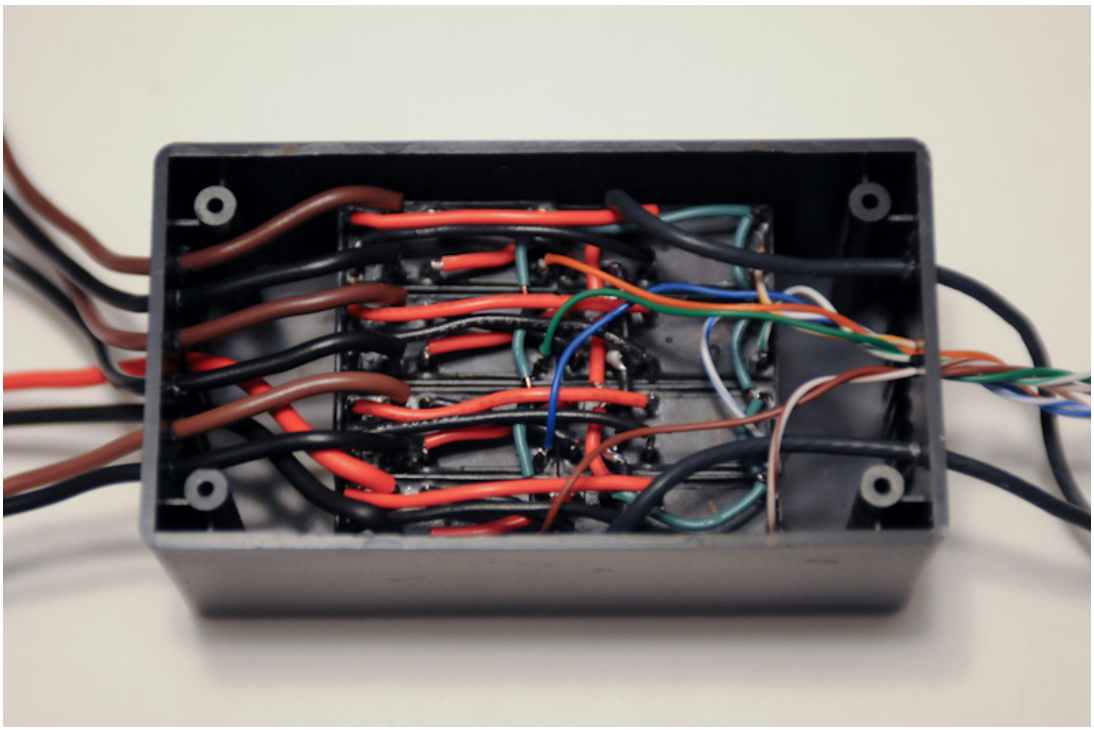
Plug in your tether and hook up your leads to your 12 volt power source (battery) and you are ready to test. Don't forget to install a fuse or you might drive your self crazy trying to figure out why nothing is working don't ask me how I know this.☺ I used a 15 amp fuse which should handle all three thrusters running at once. If you add more options that draw more amps you may need a larger fuse. What ever size you do choose always have extras.

For safety (especially while the thrusters aren't mounted to the Rov) I like to just put tape on the shafts instead of props so I can see which why they are spinning during testing. Use caution still as the thruster still may jump around when power is applied. Use the table on the next page to determine if your thrusters are spinning in the correct directions. If you have added the spare relays to add options later on you can test these with a multimeter or even a small 12 volt light bulb hooked to the spare leads.



This table assumes you are looking at the thrusters from the rear of the Rov. Red Arrows indicate the direction the props will be turning, while the Red X's indicate that thruster is off. Forward Diagonal movements of the stick only turn on one thruster making the Rov turn relatively slowly in the direction of the stick movement. Reverse diagonal movements (e.g. - Reverse Right) indicate the actual Rov will move backwards and to the left while the camera view pans to the right. Left or right stick movements cause one prop to spin in forward while the other spins in reverse. This will turn the Rov faster or cause it to spin in place. Keep in mind different props from different manufactures on different sides of the world can be either Left or Right handed props there is no standard.

Waterproofing the Control Box



The following is the method I use to waterproof my control box you can use any method you see fit.

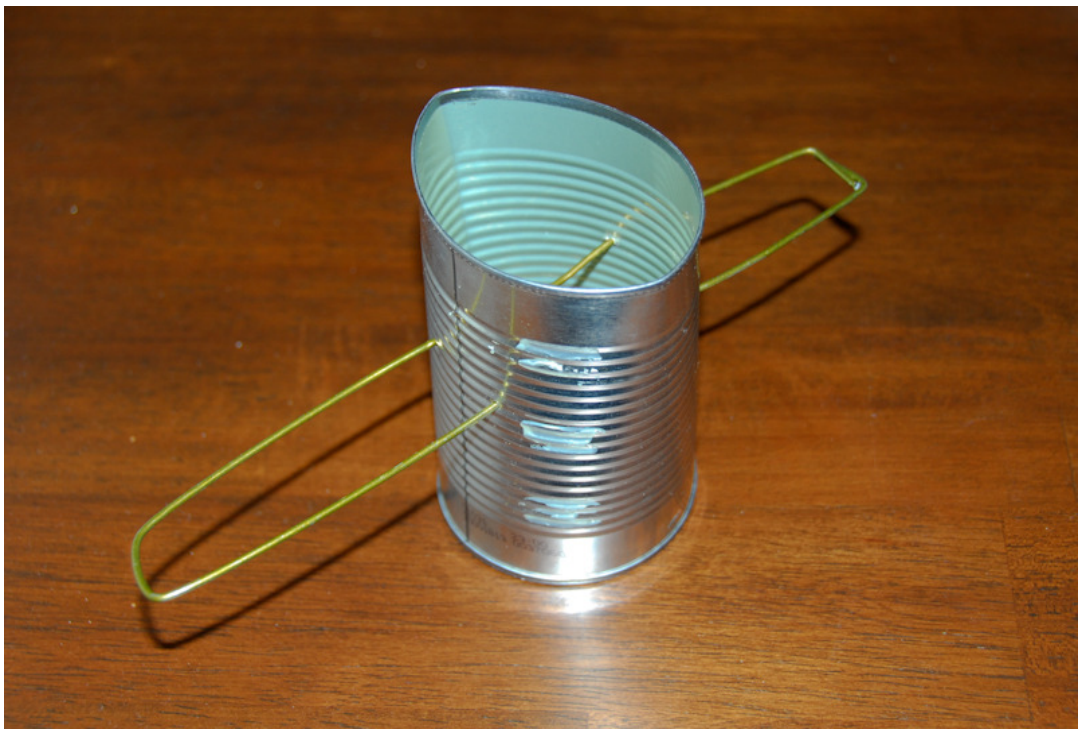
After you have tested out all of the functions and are absolutely sure everything is working correctly and that the motors are all turning in the right directions it is now time to waterproof the control box. **Make sure you read and understand everything in the next few paragraphs before continuing.**

Sealing the wire exits and cover of the plastic project box alone would be pretty hard to do without it leaking at some point so what I do is just to fill the entire box with melted wax to ensuring everything will be completely sealed once the wax has re-solidified. The only downside to this (as stated back on page 6) is that the relays have to be a sealed type relay **(I cannot stress this point enough)** or the wax can leak inside causing them to malfunction because relays are actually a mechanical device and they have moving parts inside them. If that were to happen you would pretty much have to undo all of the wiring you just completed to fix the problem.

If you're not sure about your relays being sealed the best thing would be to buy a few extra's and test them first.

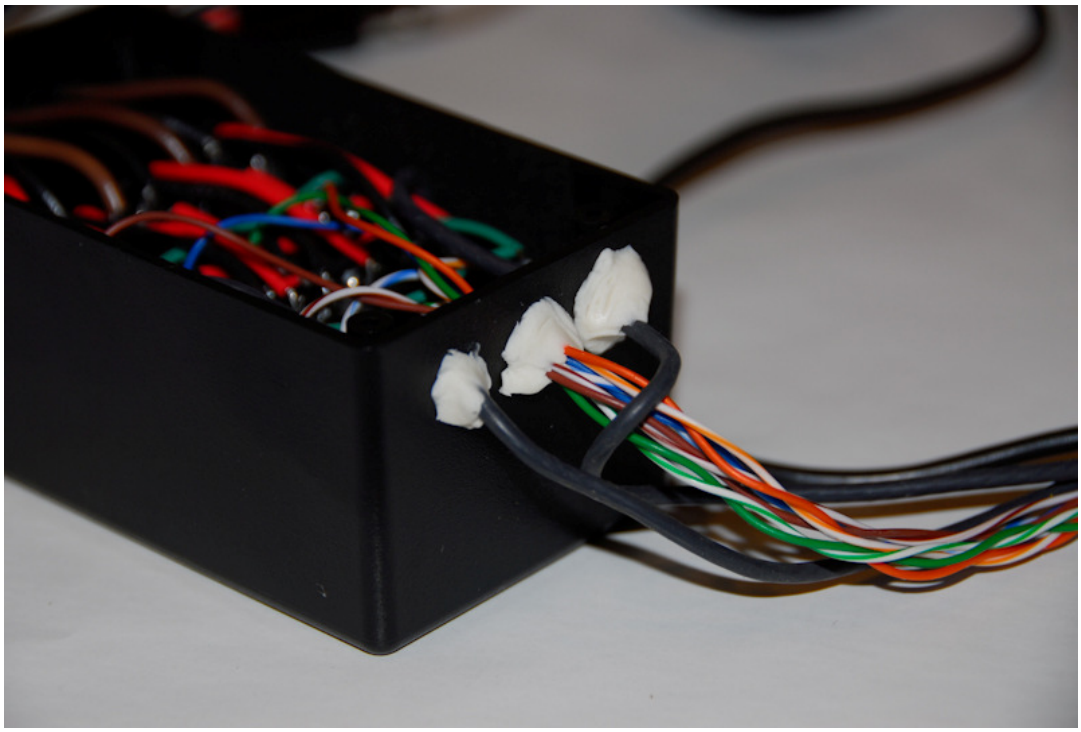
If you're confident that everything is wired and working correctly and your relays are of the sealed variety you can continue on with waterproofing the control box.

First you are going to need some wax (cheap candles work great), some clay, and a pouring pot to melt the wax in.

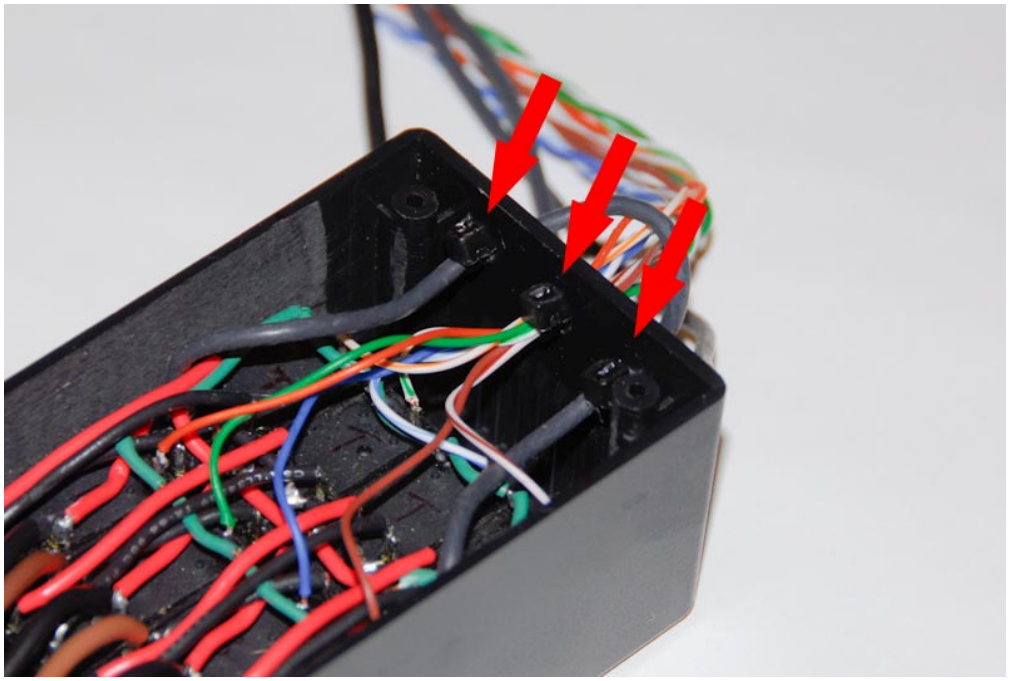


You are going to melt the wax in a double boiler setup. A double boiler is created by boiling a pot of water on a heat source then placing the pouring pot containing the wax within this boiling water. For the pouring pot you will need something to actually put the wax in that you don't care about. I use an old soup can and bend a coat hanger to use as a holder/handle. This in turn will be put in a pot of boiling water so the handle is made to rest on the edge of the pot while keeping the can off the bottom of the pot.

Then modeling clay is used to seal around the wire exits to keep the melted wax from leaking out while it re-solidifies. Any type of clay should work, I've even used squished up bread in a pinch.



Form the clay around the wires on the outside of the project box forming a seal. Do this for each of the wires on both sides of the box.

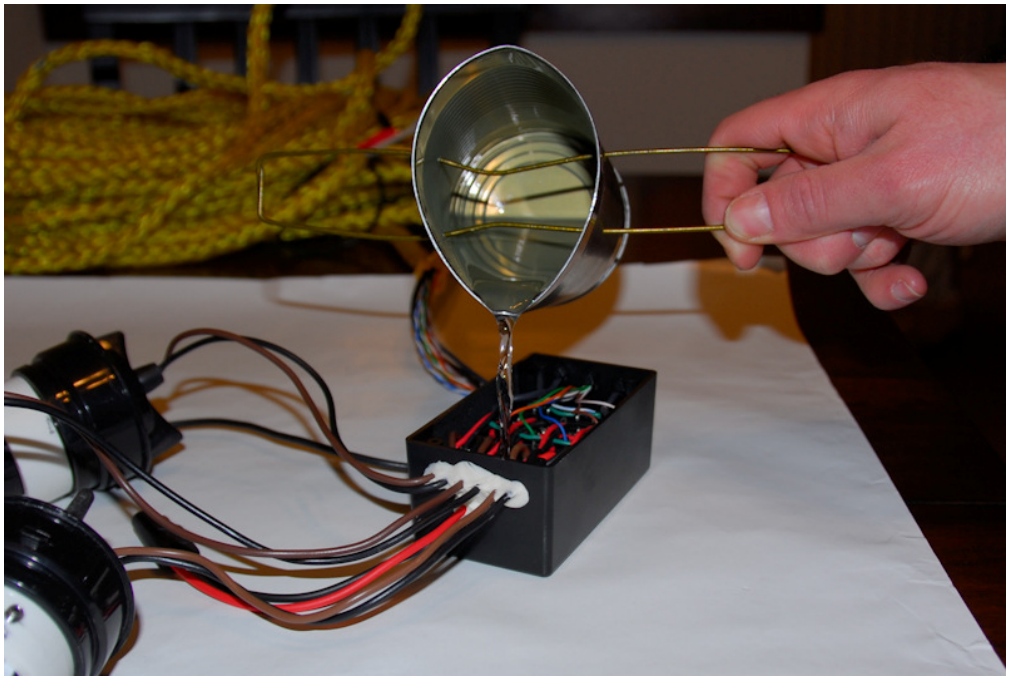


One last thing I like to do before pouring the wax into the box is to put zip ties on the power, control, and thruster wires on the inside of the project box. These will act as a strain relief keeping the wires from pulling out of the box if you lift the box with the wires from the tether before it gets attached to the frame.

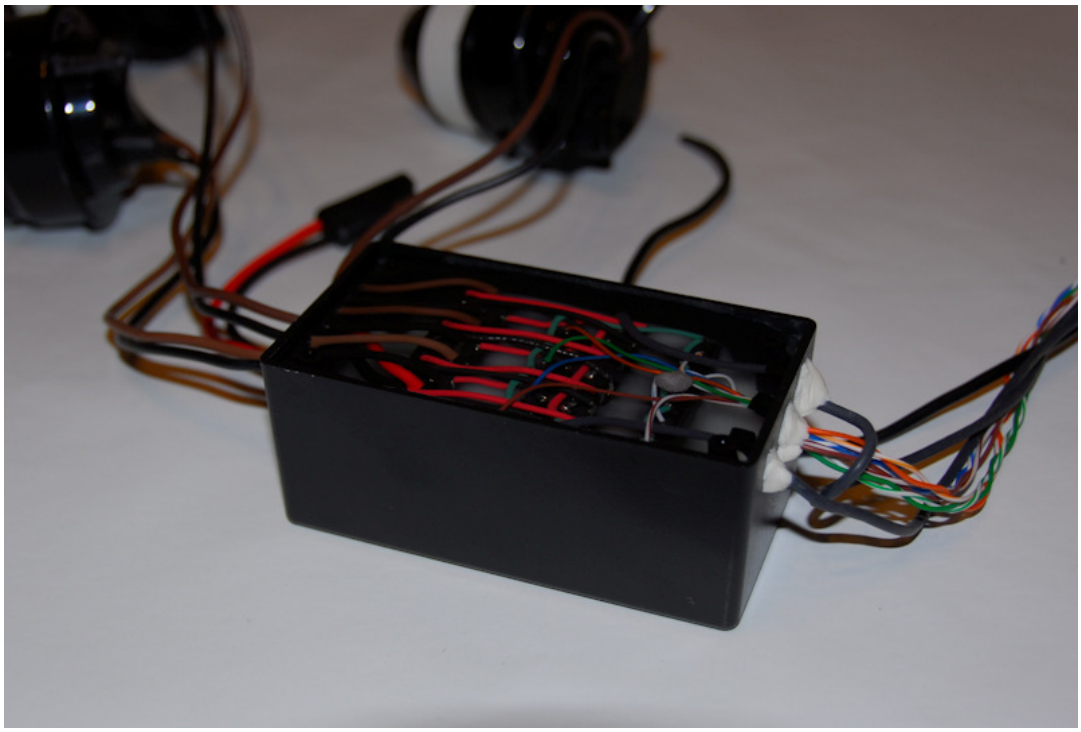
Next cut the wax into small pieces so that they will melt evenly, also remove any wick material. I use a butter knife (because it has a dull edge for safety) and cutting board to break the candles apart. Try and melt enough wax the first time to completely fill the box. Having more is better than not having enough. Before continuing on with melting the wax, make sure the area where you plan on pouring the wax is all setup, I recommend laying down something to protect your surface area just in case you spill any wax during the pour.

After placing the wax pieces in your pouring pot place this setup in a sauce pan full of water and bring it to a boil. The pouring pot setup should not touch the bottom of the sauce pan.

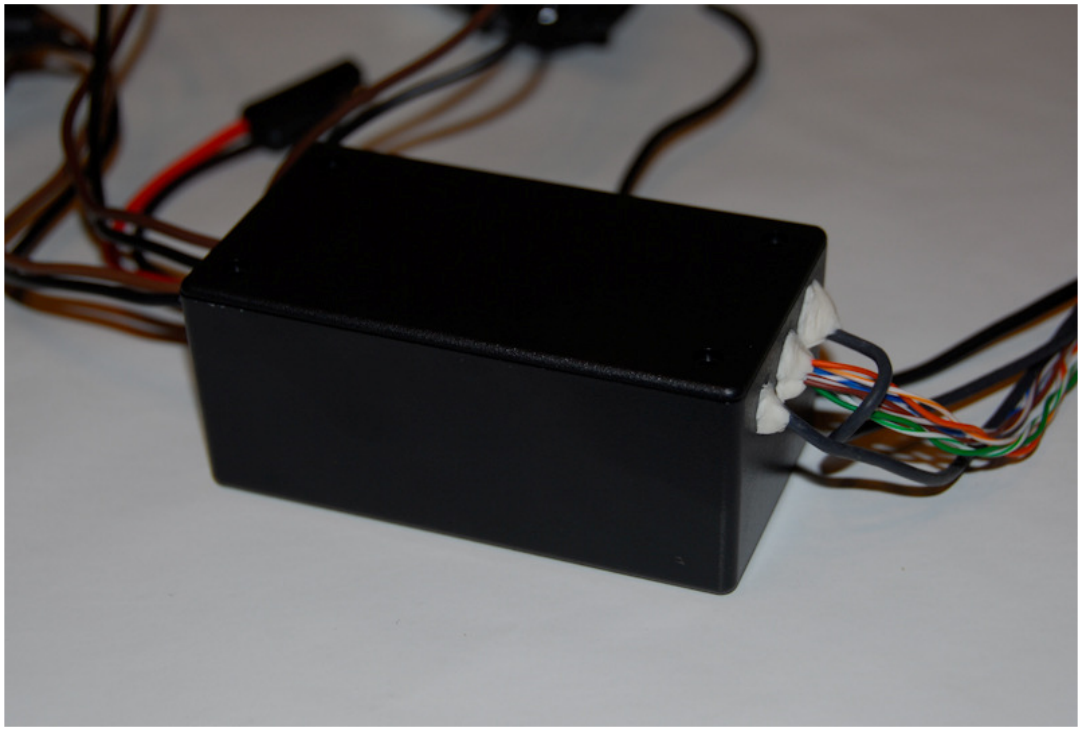
NEVER LEAVE MELTING WAX UNATTENDED. It shouldn't take that long for the wax to start melting, once it has liquefied the temperature can rise sharply, if the wax reaches the Flash Point the vapors produced can be extremely flammable.



You do not want the wax to get to hot, as soon as the wax has all liquefied (stirring may be required) remove the pouring pot from the boiling water (use caution as the handle may be hot, you may need an oven mitt) and begin pouring the wax into your project box. Try not to pour the wax directly onto the relays or wiring, try to pour it into the corner or the side of the box and let it fill up around the relays.



Only fill the project box up to the top of the mounting posts for the lid, if you cover these there is a good chance the lid will not fit.



I like to set the lid on top after I'm done filling to allow the wax to form to the edge of the lid and to keep the mounting post clear if the wax level is too high.

(Do not worry about the screw shown in these pictures it is only applicable to my Rov.)

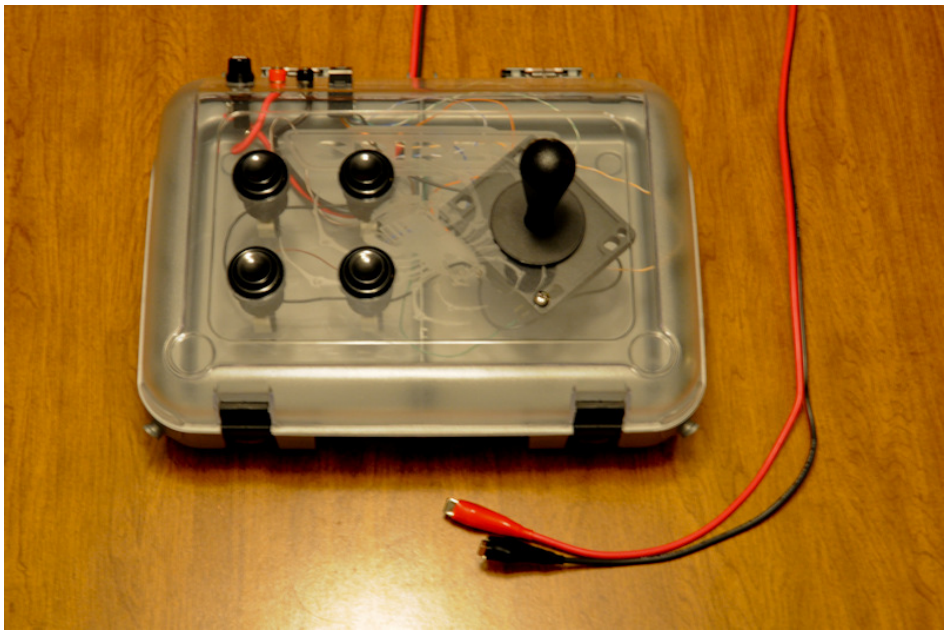
Give the wax plenty of time to harden, (I recommend leaving it at least overnight if not longer) even though it may look dry from the top the insides will take awhile to completely re-solidify. If you press on it to see if it is dry you will make an indent. Do not do this, be patient and let it dry.

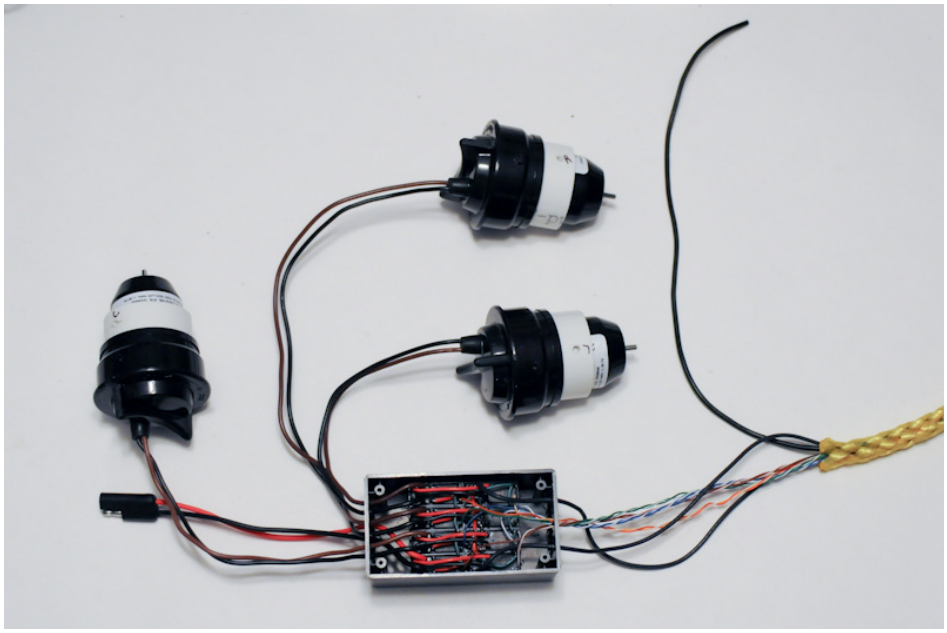
After everything has completely hardened and you remove the cover you may notice some voids have formed in the top layer. Normally this is just from trapped air pockets during the pour and can be filled in by just dripping wax from a lit candle. Filling these in will just keep any air or water from getting trapped in the voids. You can now remove the clay from around the wires.

At this point you are going to want to re-test your control box to make sure no wax has leaked into any of your relays and that all of the functions are still working properly. Reconnect your controller as shown on page 70 and using the table on page 71 double check all of your control functions. If everything is still working correctly you can now screw on the lid.

If for some reason one of your functions (e.g. - one of your thrusters fails to work or spin in only one direction) you will have to determine which relay has been affect and change it out. I haven't had to do this myself but I have been told by others who have used my setup and that have actually had relays fail (after time) that you can use a heat gun (perhaps even a good hairdryer) to re-melt the wax enough to be poured out of the project box to allow access to the bad relay. Do not use to much heat though or you will melt the box.

There are a few ways to tell which relay has failed, most of the time you can tell by listening which relay is not clicking on and off. Other times you will have to use a multimeter and check the output of each relay. (Remember there are two relays per thruster) Most of the time you should have to check at the Normally Open pins of the relays because this (more than likely) is where the wax is not allowing the relay contacts to connect. Unfortunately once you find the bad relay there is no easy fix, because that fact that this setup is enclosed in a project box you will probably have to unsolder a good portion of the wiring to be able to remove the bad relay and to replace it.





(Project box cover not show.)

Your **Basic Rov Control System** should now be complete and ready to install in your Rov. Piloting (or flying) the Rov is going to take a bit of practice with the BRCS because with the lack of any kind of speed control you are going to have to learn to just bump the controls for small precise movements. Be patient though with a little practice you should be exploring the depths in no time.

Thanks again for downloading the BRCS Wiring Manual. If you actually build this system and find it useful send me an email over at www.homebuiltrovs.com and let me know how it worked for you.

"Imagine, Create, Inspire." - Steve Thone