

Introduction to Electroluminescent Wire

revision 0001

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Functional Prototype

Author Note

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Keywords: [Tap here to add keywords.]

Introduction to Electroluminescent Wire

revision 0001

This document is a guide for soldering and fabricating with electroluminescent wire aka “el wire”. El wire requires a basic set of skills in soldering and use of hand tools. If you have never soldered before don't learn with el wire -- it can sometimes be a challenge for people who already know how to solder.

Required Tools and Supplies

You will need the following tools:

- Safety glasses, preferably bifocal glasses that are at least +1. El wire connections involve soldering wires the diameter of human hair and bifocals will act as a magnifying glass. (If you are farsighted and already need bifocals to read, find safety bifocals that are at least 1 diopter over your Rx glasses.)
- Soldering iron, at least 30W. If you're using lead-free solder, a soldering iron that can reach the needed temperatures for your solder.
- Wire cutter / dike. All stripping will done with a razor knife, so no fancy stripping tools are required.
- Hobby razor knife (X-Acto® brand or similar) and blades. You'll need a box of fresh blades to do the delicate cuts needed for stripping el wire and you'll make blades dull by stripping off wire insulation.
- “Third hand” soldering station.

And the following supplies:

- Solder. I prefer lead-free, but leaded solder is acceptable if you maintain clean work habits and do not eat while soldering.
- Heat-shrink tubing. This is used to insulate the wires and connections. Do **not** use electrical tape with el wire, reasons will be explained in the fabrication section.
- Copper tape. 1/4" is a good width to work with for beginners.

El Wire Overview

El wire is a phosphorescent wire that operates similar to neon bulbs under an electric charge. When the phosphor in el wire is excited by an AC current from an el wire “driver” it glows in a narrow color band, the light is filtered through colored PVC sleeves to generate specific colors.

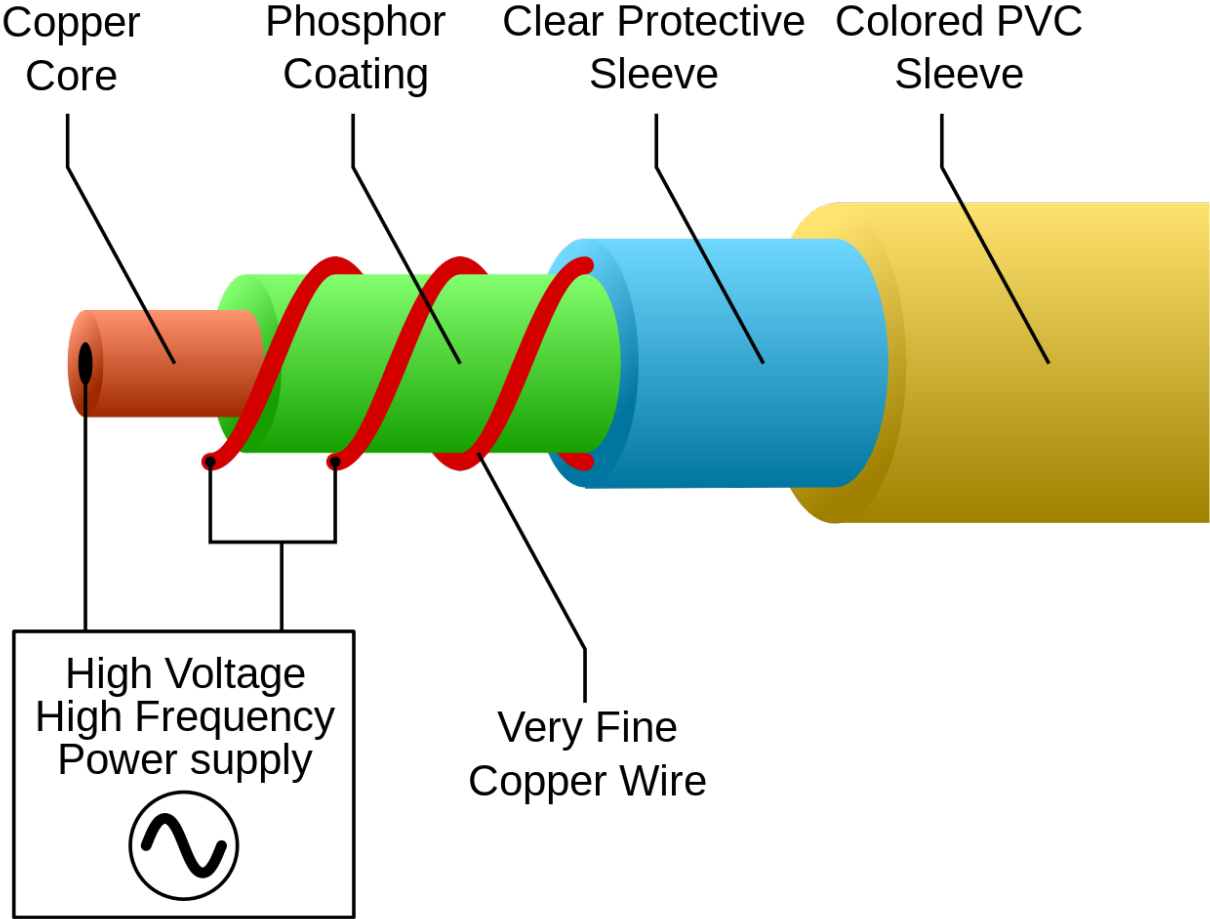


Figure 1 - Electroluminescent Wire Design

Soldering El Wire

There are three types of connections used with el wire:

- El wire to “normal” wires. This is the most important connection, between el wire and the output wires from an el wire controller. Regular wire can also connect two pieces of el wire, this will be elaborated on in Fabrication.
- El wire to el wire union. This is a connection between two strands of el wire. This connection cannot support any weight or be part of a flexible joint.
- El Wire Termination. The end of the el wire segment, opposite from the end connected to the controller, must be terminated in a way that prevents it from shorting out and damaging the controller.

Order of Soldering

When working with el wire it is important to establish a design before you begin soldering. With el wire we usually solder “in reverse”, that is we go from the terminated end of the el wire, through the design, and then to the controller. We work in reverse to know how much el wire we actually need to complete a project and prevent unwanted union joints in the wire. Union joints are non-optical “blank” spaces in el wire.

Trimming El Wire

The most difficult part of working with el wire is learning to remove the protective and clear sleeves without cutting the fine wire under the sleeves. You’ll use a razor knife for this, but do not use it like a carving knife or steak knife, it’s too hard to make a gentle cut in this position.

One good way to do this is to roll the wire along the surface of the knife, applying a slight amount of pressure between the knife and the wire. The safe way to do this is to lay the wire on a table, hold the knife like a pencil, and gently roll the wire with the blade of the knife. Roll the

wire in one or two revolutions, then inspect the cut to see how close you are to the wire. This will take practice, use scrap el wire until you're comfortable making the cut.

I do this trimming the more dangerous way -- by holding the knife in my fingers and rolling the wire across the blade with my thumb.

El Wire Termination

This is the easiest solder connection and a good way to learn your way around el wire. The goal is to separate the core wire and fine wires to keep them from shorting out.

1. Cut the end of the el wire smooth with wire cutters.
2. Slide a 20mm long piece of heat shrink tube on to the el wire, slide it back at least 20mm from the terminated end of the el wire.
3. Use a hobby knife to trim around 10mm of the protective sleeve and color sleeve from the wire, but do not cut the fine wire.
4. Gently pull the fine wire away from the inner wire and fold it back over the outer sleeves.
5. Use a small piece of copper tape to hold the fine wire against the sleeve.
6. Slide the heat shrink tube down so that it extends a couple of mm past the end of the wire.
7. Use a heat gun to seal the heat shrink in to place.

El Wire to El Wire Union

This is the hardest connection to make and there are several different approaches to this connection. The method I use is a combination of the official Lytec guide and techniques developed by people making costumes for Burning Man.

Start by preparing the el wire segments:

1. Trim off 20mm of the outer sleeve. (After some practice you can do this with as little as 10mm of the sleeves trimmed off.)
2. Cut a piece of copper tape long enough to go around the outside sleeve 2 or 3 times.
3. Wrap the copper wire around the outside sleeve 1 time.
4. Fold the fine wires back to the copper tape. You want the wires touching the tape at the same location.
5. “Tap solder” the wires to the copper tape. The easiest way to do this is to get a little solder on the tip of your iron, then tap the tip on the fine wires where they touch the copper tape. El wire insulation melts at relatively low temperatures so the traditional soldering technique of “heat the wires then melt the solder” is difficult to use.
6. Test to see if the fine wires are soldered in to place by gently wiggling them with the tip of your finger.
7. Wrap the copper tape around the solder joint to protect the fine wires.
8. Starting from 1-2mm away from the fine wires, scrape off any inner insulation and the phosphorus from the core wire. Use the razor knife to scrape off the insulation and remove all the phosphorus you can see covering the wire.

Now it's time to solder the two wires together, but first, did you slide the heat shrink on before you stripped the wires? For the core wire connection, arrange them so they are side-by-side (parallel) and touching, then solder them together. Do **not** make “j hooks” or “fish hooks” using the core wires, these joints are impossible to unsolder and disconnect.

The final connection is to solder the two copper pads together using a “jumper” wire. Cut a piece of normal wire long enough to reach from one end of one copper pad to the end of the other. Trim off the insulation off each end of the wire so the wire can be soldered to the

copper tape. Solder the jumper to the tape as quickly as possible, remember the problem of el wire sleeves melting at a low temperature. One technique is to put a blob of solder on the end of the wire, then solder it to the tape by pressing down on top of the wire with the tip of the soldering iron.

Now slide the heat shrink down over the union joint and use a heat gun to seal the tube around the joint.

El Wire to Regular Wires

This connection is similar to the el wire union but simpler to execute.

1. Prep the el wire as in the union connection.
2. For the regular wires, trim one wire so that it's long enough to reach the copper tape on the el wire. Trim the other wire shorter, so that it lays alongside the core wire and does not reach the sleeves.
3. Slide a segment of heat shrink ~10mm longer than the solder joint on the el wire.
4. Solder the shorter regular wire to the core wire similar to the union joint, with the wires side-by-side.
5. Solder the longer wire to the copper tape.
6. Slide the heat shrink down to cover the joint and use a heat gun to seal the heat shrink.

Design and Fabrication

El wire has some constraints that limit its use in costuming and clothing, some of these are environmental and others are physical limitations of el wire. Once you've learned how to navigate around those constraints, designing and fabricating with el wire is a simple matter of labor.

Fundamental El Wire Constraints

There are three primary physical constraints working with el wire:

- It cannot be bent at an angle or in a tight loop.
- It cannot carry physical weight.
- It cannot be used in sunlight.

Bending is the first challenge, if you bend el wire too sharply those pesky fine wires will snap and your el wire won't "el". My rule is that the smallest bend you can make is wrapping it loosely around your thumb. This seems reasonable until you find yourself wanting to make an angle in your design, say the tip of a feather or a corner on the letter "L" if you are making signage. (We'll address this problem in fabrication.)

El wire also has no "load carrying" capability, it cannot be used as a thread or a connector between two pieces of material. I assume that it can't carry its own weight for more than a few inches and loosely secure it to any costume or sign with thread or monofilament line (fishing line).

Finally, it can be used in sunlight, but it will quickly burn out and convert from el wire to "really expensive wire that used to el but does no longer."

Practical El Wire Constraints

Ignoring the cost of el wire, the biggest practical constraint are the controllers used to powering el. Very short lengths of el wire can have a controller the size of a few AA batteries and lengths under a meter can be controlled by a coin-battery sized object. Jen's "big wings" [ATTACH FIGURE] are made of two 75m strands of el wire, one for each wing. The power for each wing is a carrier for 8 AA batteries and a controller of the same size, the batteries last ~2 hours before being completely drained.

Another practical constraint is “what carries the el wire”? In the case of Drue’s Garden Dress [ATTACH FIGURE] the carrier is a prom dress from the surplus store that cost all of \$6. The frame for Jen’s “big wings” is made from aluminum, plastic, and several hundred meters of thread used to attach the el wire to the frame.

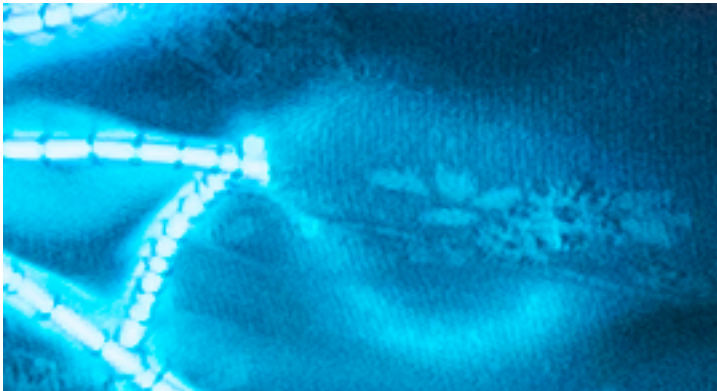
Design Considerations

Where will this el wire creation be used? If you’re making clothing, how long do you plan on wearing it? How long will it take to put on / take off? Do you have control of your surroundings, that is, will you be on stage in a live performance, at a party, at a rave, or at an outdoor event similar to Burning Man or Frostburn?

Design Tricks and Workarounds

There are a number of tricks and workarounds for el wire and it’s constraints.

Corners. The biggest problem with el wire is making corners. There is an easy trick for corners, all it requires is an opaque mounting foundation or opaque heat shrink. Make a loop out of el wire and note where the wire crosses itself – that’s your corner. The trick is hiding the loop. If you’re working in opaque fabric you can simply hide the loop behind the fabric. Here’s an example from Drue’s dress, where an overexposed photo picks up the loop “peeking” through the dress fabric:



If you don't have fabric to work with, you can use heat shrink around the el wire loop. However, you will need to measure and test a few times and also determine how to hold the el wire together at the cross point. This is another use for monofilament – using it to tie el wire to itself.

Fastening El Wire. This is mostly a list of what to do and what to avoid.

Good fastening techniques:

- Direct sewing or lacing. This is one of the most common fastening methods, diagonal whip stitches are easy to do by hand and with the right needle, can be used with leather or plastic.
- Plastic tubes. Plastic tubes are an easy way to show (and hide) el wire attached to static models or clothing where no joints are required. Plastic tubing is also cheap and reusable, so it's good for situations where you need to use cement or glue as a fastener.
- Heat shrink tubes. Similar to plastic tubes in choice of color and dimension, but also a more permanent fixture that can only be removed with a razor knife.
- Zip ties. Cheap, come in many colors (including clear), and useful for things like maintaining a loop or attaching el wire to a flexible surface.

Things to avoid:

- Hot glue. Remember all the steps we took when soldering to not melt the el wire? Pop quiz: how hot is your hot glue gun? Mine runs at 220C which is close to the temperature my 3d printer uses to melt plastic when building a model.
- Electrical tape. This is designed to prevent electrical connections between two pieces of metal and doesn't hold a joint together, it should be called "electrical insulation".

Also, the glue used on electrical tape is hard to remove and collects dust and lint, making it harder to re-use your el wire on a future project.

Controllers. The problem we always think about at the end instead of the beginning. How big is your controller, where will it live, how will you change the batteries, and what environment does it have to survive are all questions to answer. My controllers built for Burning Man start with a waterproof Pelican-brand enclosure. Any holes I make for buttons or power jacks use silicone insulation as “glue” to hold the buttons and power jacks in place. This is a problem best solved in prototyping, not design.

Prototyping

The first step in fabrication is to make a prototype using inexpensive supplies, usually paper and 20g wire. Do not use yarn or string to prototype for el wire, it bends and stretches enough that estimating the amount of el wire you will need is difficult.

While you’re prototyping your costume, do all the things you plan on doing (and don’t plan on doing) while in costume:

- Walk
- Dance
- Get in your car
- Get on the bus
- Go to the bathroom
- Rehearse your act
- Change your batteries
- Sit down because your legs are tired

- Drop the controller or the thing holding your controller
 - Can you pick it up off the ground without help?
- Is your costume dangerous to you or to others? Are there loose wires you can trip over? Something that can poke someone else's eye out?

After going through this exercise, revisit your design. Do this a few times, have a friend or two help you out. They might think of things not on this list – what happens if someone trips and bumps in to you as they fall? Can they get tangled in your el wire and take you down?

Once you have an idea of how much el wire you will need, determine which controllers you will need. You'll also need to decide how to maintain the controller and change batteries. Will it go in your back pack? Be a part of the outfit? How will you change the batteries – can you do it yourself or do you need a grip to do it for you?