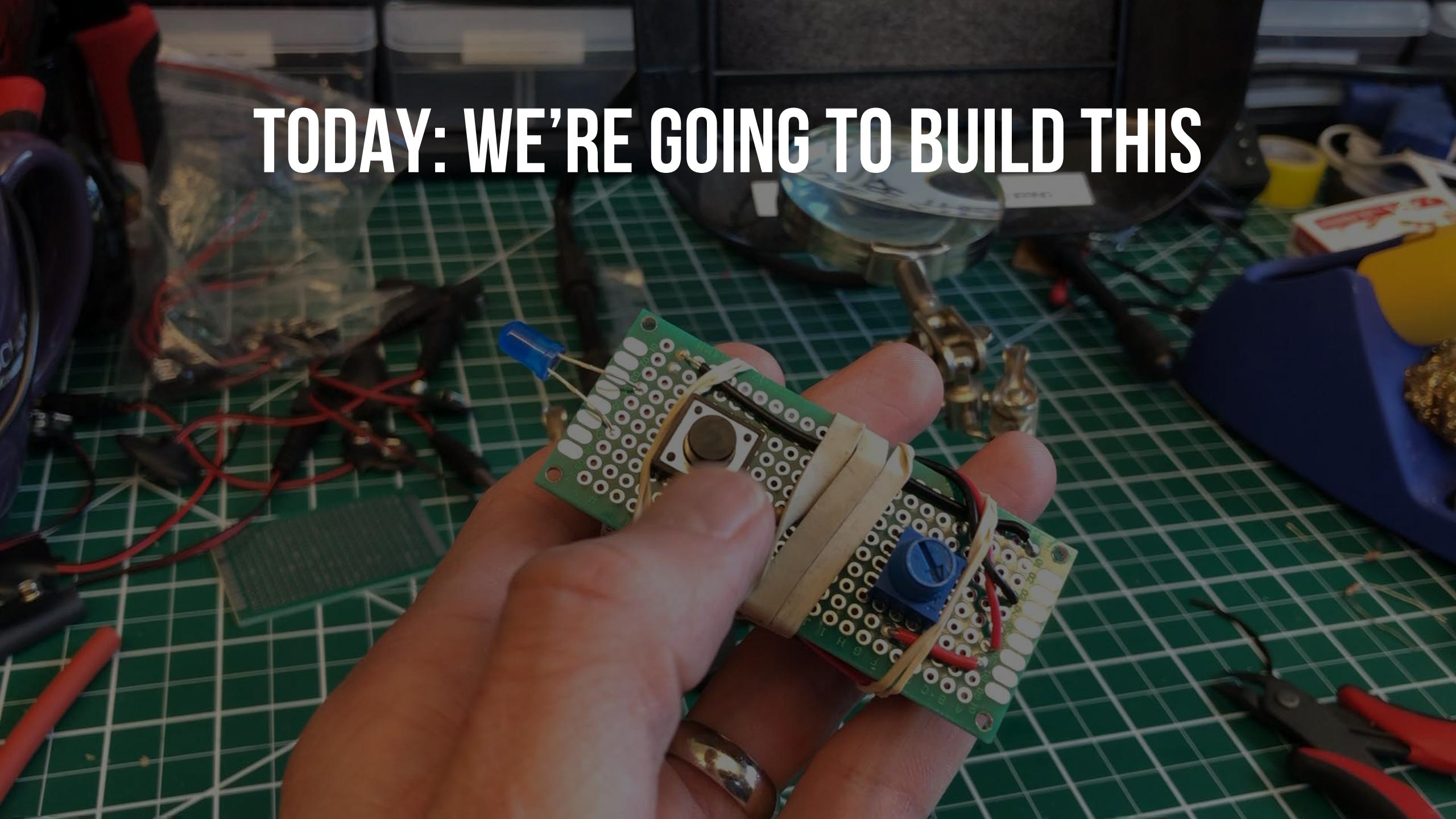


PROTOTYPING FORM 3: WIRE TOOLS/SOLDERING

CSE 599 Prototyping Interactive Systems | Lecture 9 | April 29

Jon Froehlich • Jasper Tran O'Leary (TA)

TODAY: WE'RE GOING TO BUILD THIS



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Add 4.0 Grade Scale

A2: Fabrication: 3D-Printed Interactive Night Light

Published**Edit**

⋮



HOW IS A2 GOING?

Image caption: The Tangible Interactive Computing Top Maker Award from [CMSC838f, Spring 2015](#) designed by Jon Froehlich based on the [Holocron Nightlight](#) by CMSC838f student Philip Dasler.

Overview

This assignment will illustrate and fabricate 3D-printed interactive and light-based products.

Related Items[SpeedGrader™](#)

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A1: Physical Computing: Interactive Night Light

Published**Edit**

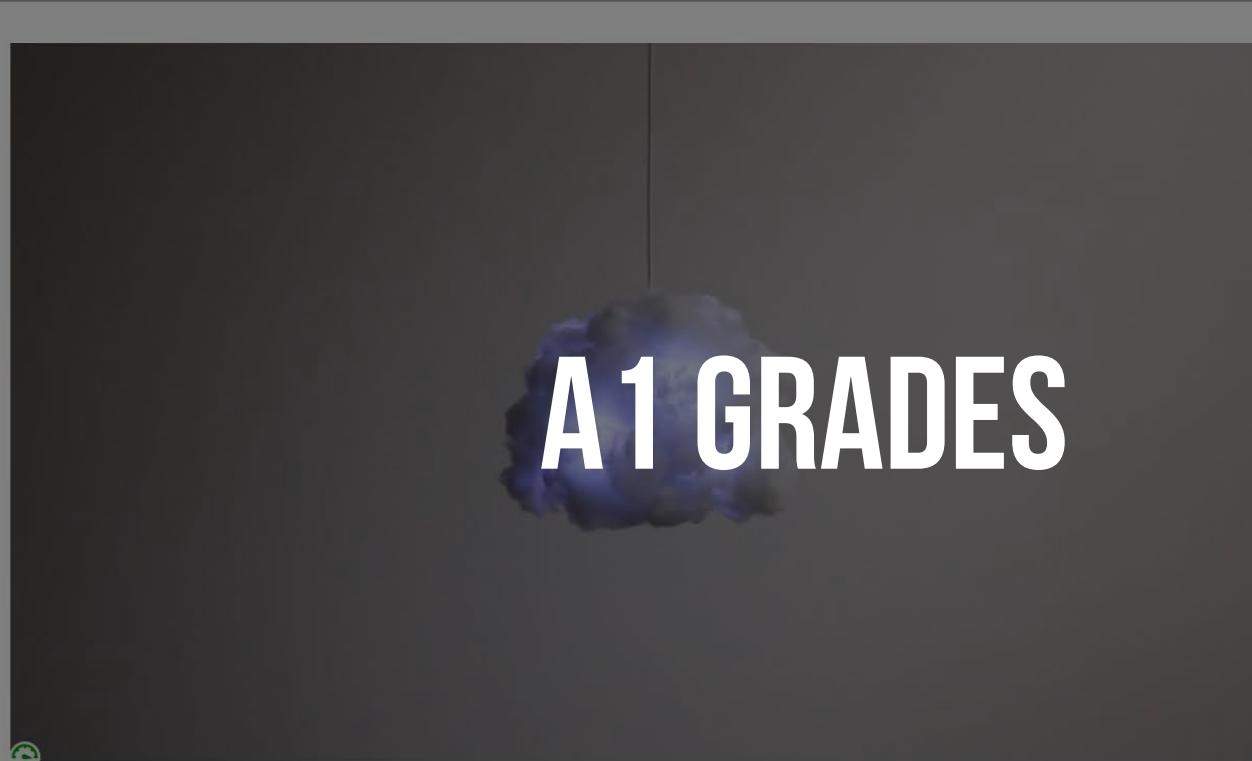
⋮

Related Items

SpeedGrader™

Download Submissions

11 out of 11 Submissions Graded

Image Source: [Richard Clarkson, Clouds](#)

You are working for a design consultancy hired to rethink and redesign interactive ambient light's for the 21st century. You have been asked to rapidly prototype some designs that are responsive to the user and the environment.

Learning Goals

- Introduce and learn basics of electronic circuits, including voltage, current, and resistance
- Introduce and learn basic circuit design concepts, including voltage dividers, pull-up and pull-down resistors

ASSIGNMENT DELIVERABLES

SLIDE DECKS

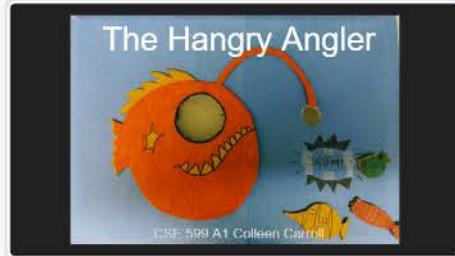
Provide more details on **design process**

Reflect more on **key challenges** and **what you learned**

Make sure to **explain your design** and **how it works**

ASSIGNMENT DELIVERABLES

POSITIVE EXAMPLE: EXPLAINING DESIGN PROCESS



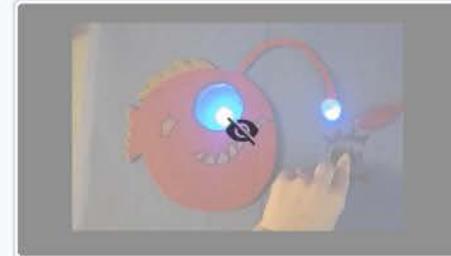
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2



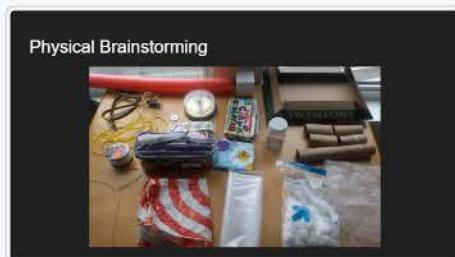
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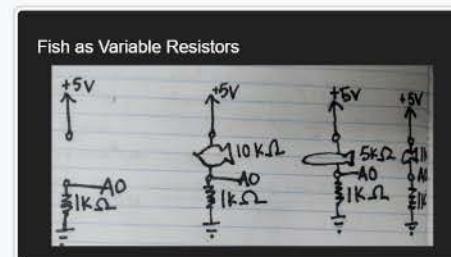
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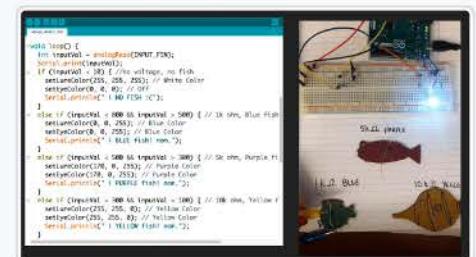
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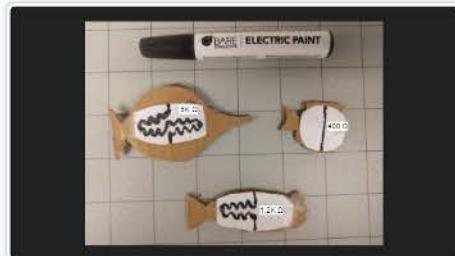
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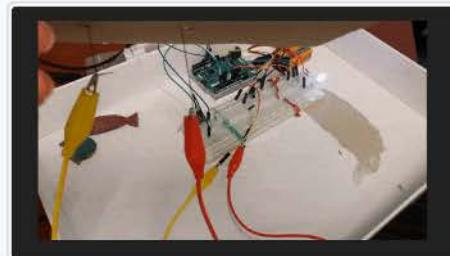
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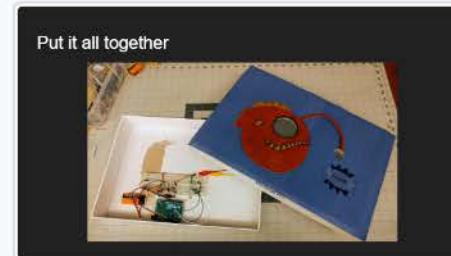
11



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Project Pitches

✓ PublishedEdit⋮

Please read the [Final Project assignment](#) first then loop back to read the project pitch assignment.

While this assignment is individual, you have the choice to work on your course project individually or with a partner.

DEADLINE SHIFTED TO MAY 3, 11:59PM

For your pitches, you must submit:

- **A brainstorm sheet or sheets** (can be scanned from paper or born digitally) enumerating at least 10 different project ideas (at least a sentence or two per idea of explanation)
- You will also **downselect** to your top **two favorite ideas**. For those two ideas, we would like you to write 1-2 paragraphs explaining the idea (with sketches, if you'd like), why its interesting, how it fulfills the design prompt, and feasibility for completion in five weeks. Unlike the brainstorm sheet, we would like these paragraphs written digitally

Jasper and I will review all of the downselected ideas and help you reflect on possible pursuits. We will also spend in-class time to share ideas and form teams (as necessary).

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A3: Signal Processing + Machine Learning 1: Offline Gesture Recognizer

Published**Edit**

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Related Items**SpeedGrader™**

Overview

Imagine working for a new hardware startup designing new input controllers. You've been asked to prototype a new, custom input device with gesture recognition (using an accelerometer)--for example, to use the input controller as a paddle in tennis, as a ball in bowling, or to recognize the "overhand throwing motion" in baseball. In this assignment you will build your own gesture recognizer to automatically recognize these gestures.

A3 POSTED

While in the "real world" you would ultimately need to create a real-time gesture recognizer, for this assignment you will make an *offline* version in [Jupyter Notebook](#) ↗ (we strongly recommend the Anaconda Distribution). Specifically, you will make two recognizers:

- (i) a *shape-matching* recognizer such as via a Euclidean distance metric or Dynamic Time Warping and
- (ii) a *feature-based* (or *model-based*) recognizer using a [support-vector machine \(SVM\)](#) ↗ (recommended) or an alternative supervised learning approach of your choosing (e.g., an HMM).

Within Jupyter Notebook, we will use Python 3 and these amazing libraries [numpy](#) ↗, [scipy](#) ↗, [matplotlib](#) ↗, and [scikit-learn](#) ↗. Numpy and scipy provide numeric array handling and signal processing, matplotlib provides visualization, and scikit-learn is the de facto machine learning library in Python. You are welcome to use other libraries as well (e.g., [this DTW library](#) ↗).

For your deliverables, you will turn in your Jupyter Notebook, your recorded gestures, and a slide deck

LEARNING GOALS

PROTOTYPING FORM 3: WIRE TOOLS + SOLDERING

Intro to **wires**

Intro to basic **electronic hand tools**

How to **solder**

How to use a **perfboard**

Design activity: **build an LED flashlight** with a perfboard

(If time) **Solder header pins** on ADXL335 accelerometer

Ken Yasuhara from Engineering Teaching and Learning Center

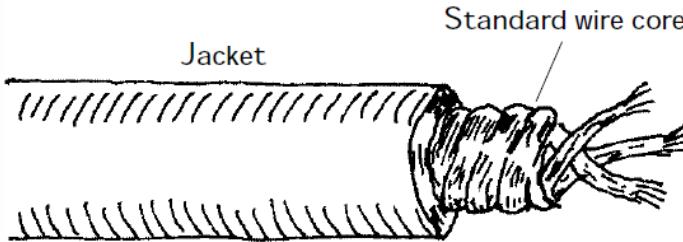
COMMON WIRE TYPES

Solid Core



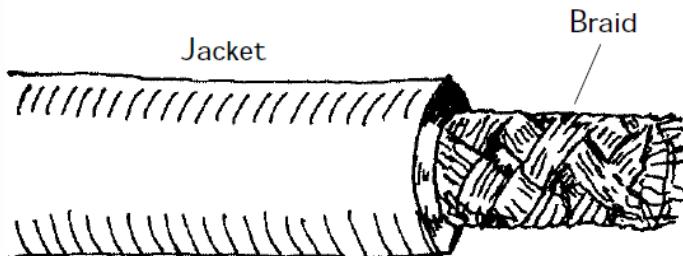
This wire is useful for **wiring breadboards**; the solid-core ends slip easily into breadboard sockets and will not fray in the process. However, these wires have the **tendency to snap** after a number of flexes

Stranded Wire



Comprised of a number of **individual strands of copper**. Better conductor than solid-core wire because the individual wires together comprise a greater surface area. Also, stranded wire will **not break easily when flexed**.

Braided Wire



Made up of a number of **individual strands of wire braided** together. Like stranded wires, better conductors than solid-core wires, and will not break easily when flexed. Often used as an **electromagnetic shield** in noise reduction Cables.



0 items

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Products (375 found)



Hook-up Wire - Black
● PRT-08022
\$2.50



Hook-up Wire - Red
● PRT-08023
\$2.50



Hook-up Wire - White
● PRT-08026
\$2.50



Hook-up Wire - Yellow
● PRT-08024
\$2.50



Hook-up Wire - Brown
● PRT-08027
\$2.95



Hook-up Wire - Gray
● PRT-08025
\$2.95



Jumper Wires Standard 7" M/M Pack of 30
● PRT-11026
\$4.95



Jumper Wires Premium 6" F/F Pack of 10
● PRT-08430
\$3.95



Jumper Wires Premium 6" M/M Pack of 10
● PRT-08431
\$3.95



Wire Wrap Wire - Green
▲ PRT-08186
\$8.95



Hook-up Stranded Wire - White
● PRT-08866
\$2.95



JST Jumper 3 Wire Assembly
● PRT-09915
\$1.50



JST Jumper 2 Wire Assembly
● PRT-09914
\$0.95



Wire Wrap Wire - Yellow
● PRT-08029
\$8.95



Wire Strippers 30AWG
● TOL-08696
\$4.95



Wire Wrap Wire - Black
▲ PRT-08031
\$8.95



Wire Wrap Wire - Red
▲ PRT-08030
\$8.95



Wire Wrap Wire - Blue
● PRT-08187
\$8.95

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Enclosures

General

Hook-up Wire - Red

PRT-08023 RoHS✓

Description: Standard 22 AWG solid Red hook up wire. Use this with your bread board or any project in which you need sturdy wire. Comes in small spools of 25'.

22 AWG solid core wire

**\$2.50****Add to Cart**

1 quantity

121 in stock

\$2.50 1+ units

\$2.25 10+ units

\$2.00 100+ units

Add to Wish List ▾

– Comments

9 comments [Login](#) or [register](#) to post comments.
 Jeremy1998 | about 3 years ago ★ 3

We want blue!

 SlyVixsky | about 9 months ago ★ 1

any plans to carry this and other solid hook-up wires in larger rolls? I usually get 100 ft rolls so they last a while, but Radioshack keeps bumping the price every few months.

 Member #433250 | about 10 months ago ★ 1

Is this wire copper?



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Hook-up Wire - Red

PRT-08023 RoHS✓

Description: Standard 22 AWG solid Red hook up wire. Use this with your bread board or any project in which you need sturdy wire. Comes in small spools of 25'.

\$2.50**Add to Cart**

1 quantity

121 in stock

\$2.50 1+ units

125 10+ units

\$2.00 100+ units

Wish List ▾

9 comments

American wire gauge (AWG) is a standardized wire gauge system used since 1857 predominantly in the United States and Canada for the diameters of round, solid, nonferrous, electrically conducting wire. The cross-sectional area of each gauge is an important factor for determining its current-carrying capacity.

– Comments

Jeremy1998 | about 3 years ago ★ 3

We want blue!



SlyVixsky | about 9 months ago ★ 1



any plans to carry this and other solid hook-up wires in larger rolls? I usually get 100 ft rolls so they last a while, but Radioshack keeps bumping the price every few months.



Member #433250 | about 10 months ago ★ 1

Is this wire copper?

Prototyping

Batteries

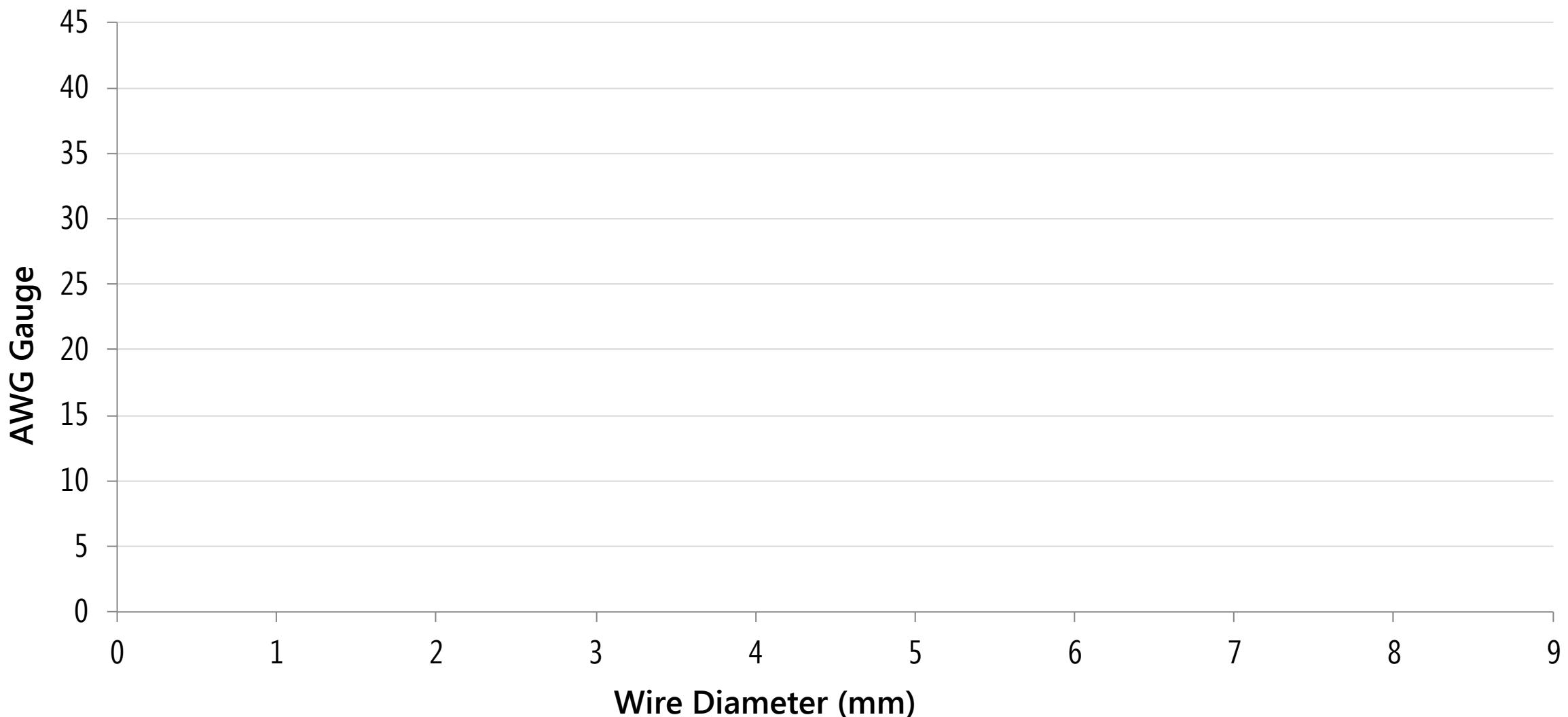
Boards

Connectors

Enclosures

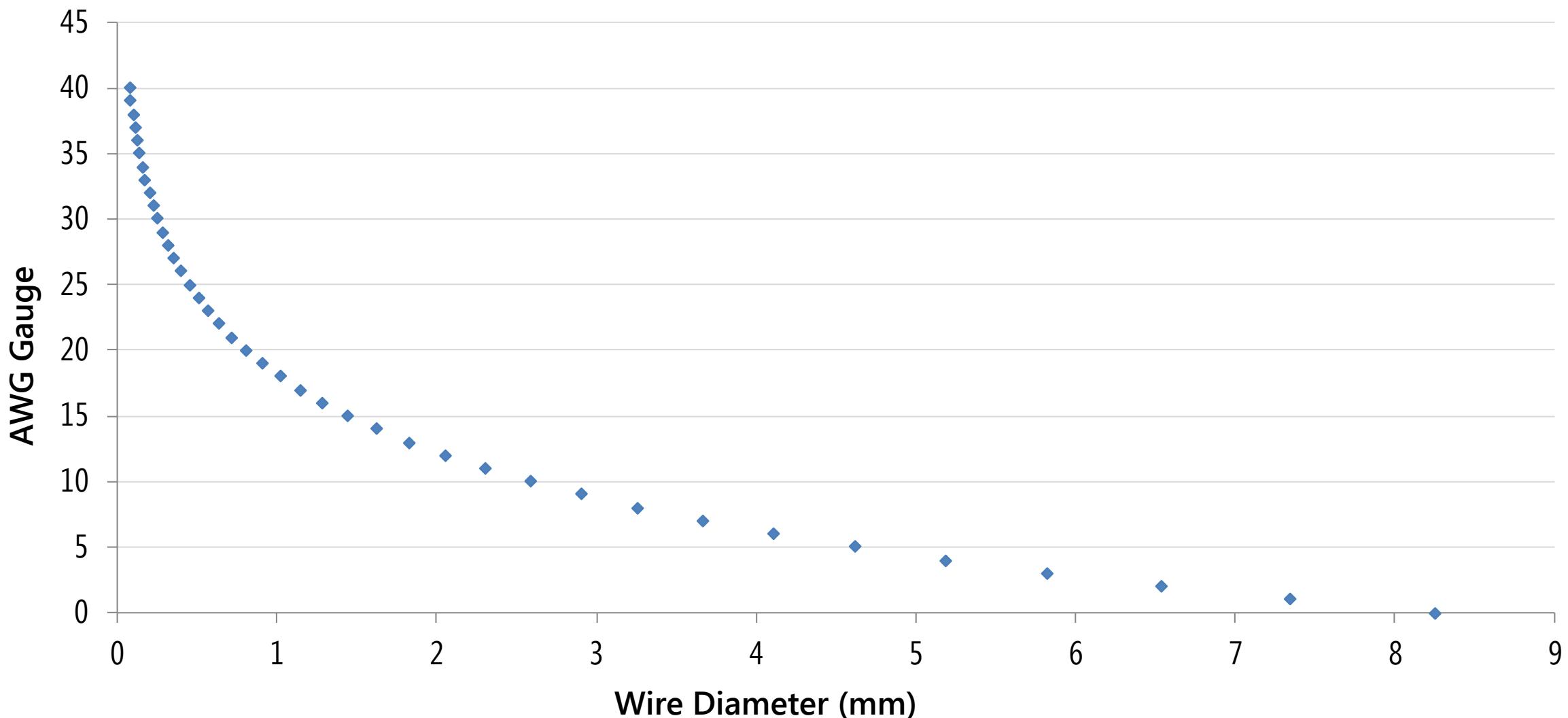
General

AWG GAUGE VS. WIRE DIAMETER (MM)



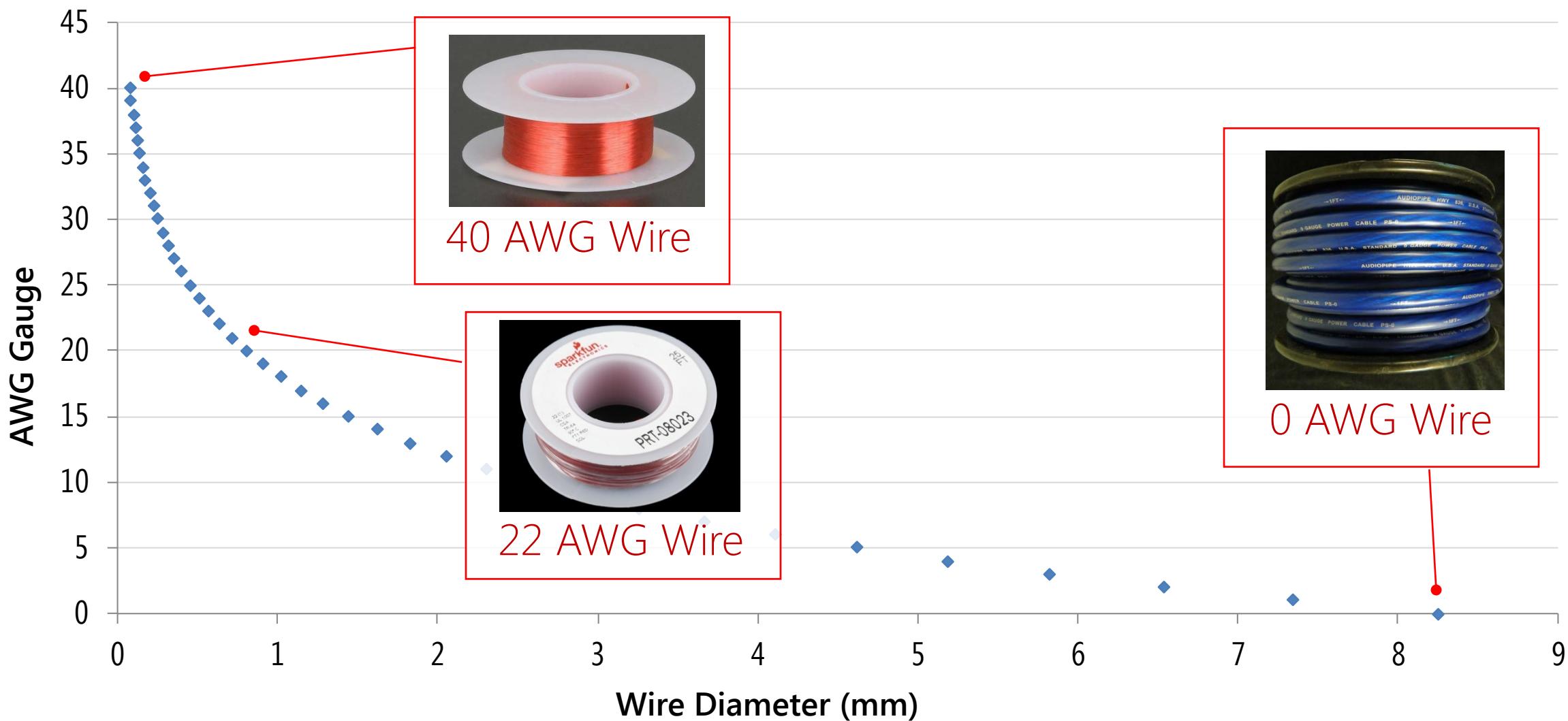
WIRES

AWG GAUGE VS. WIRE DIAMETER (MM)



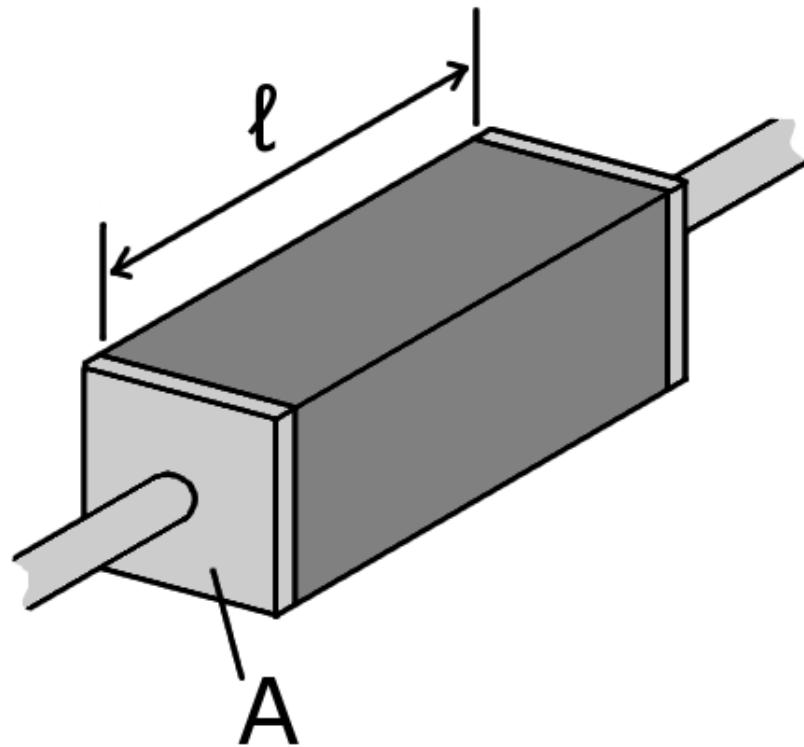
WIRES

AWG GAUGE VS. WIRE DIAMETER (MM)



WIRES AND RESISTANCE R

Recall that all conductive materials also have a resistance. Resistance is the opposition to the flow of current.



A piece of resistive material with electrical contacts on both ends.

Resistance:

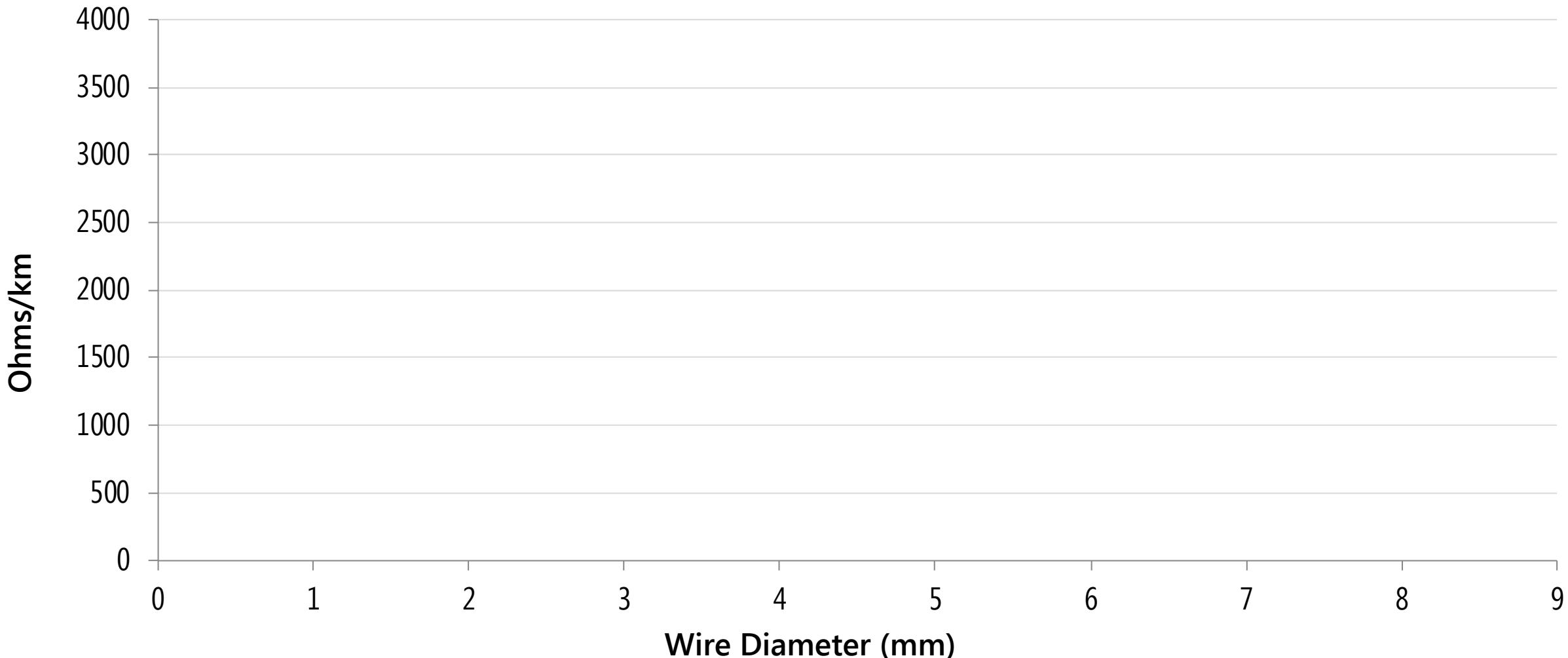
$$R = \rho \frac{\ell}{A}$$

ρ is the electrical resistivity of the material measured in ohms-meters

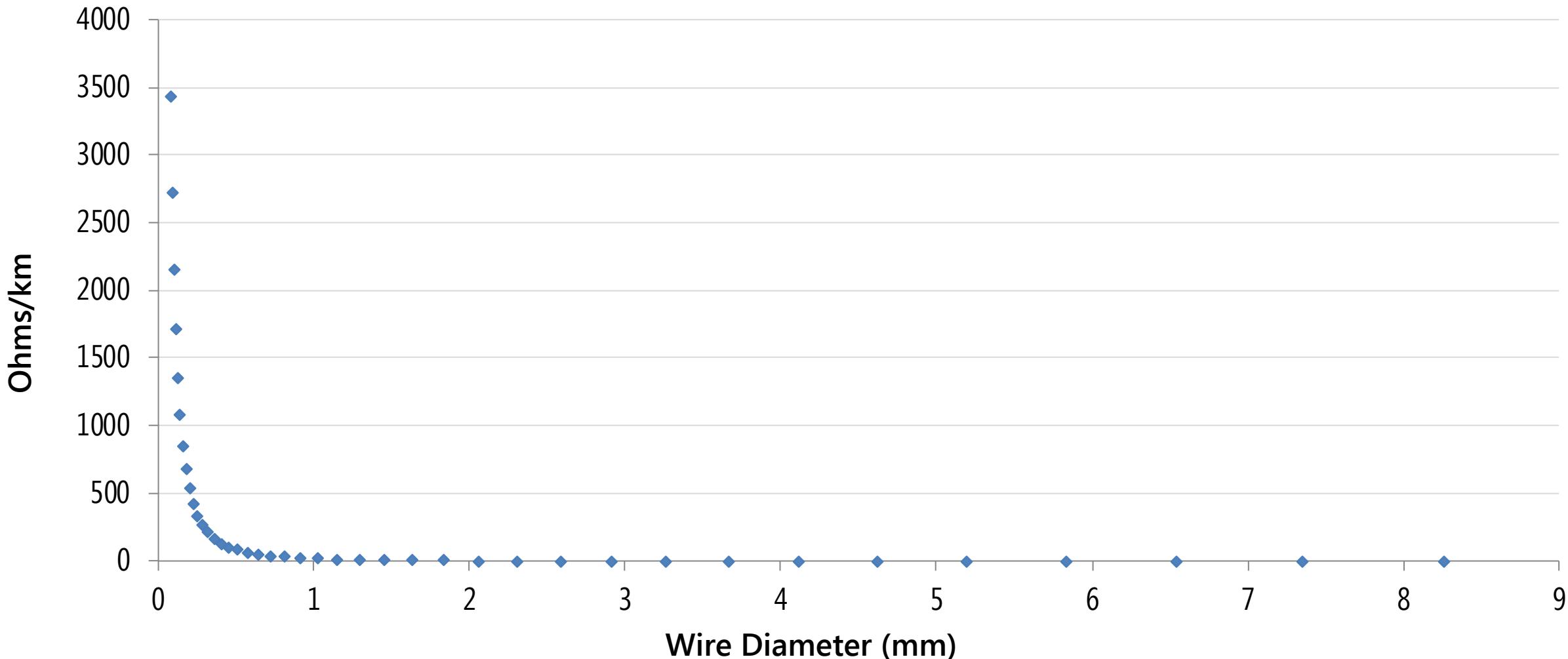
ℓ is the length of the piece of material (measured in meters, m)

A is the cross-sectional area of the material (measured in square meters, m²).

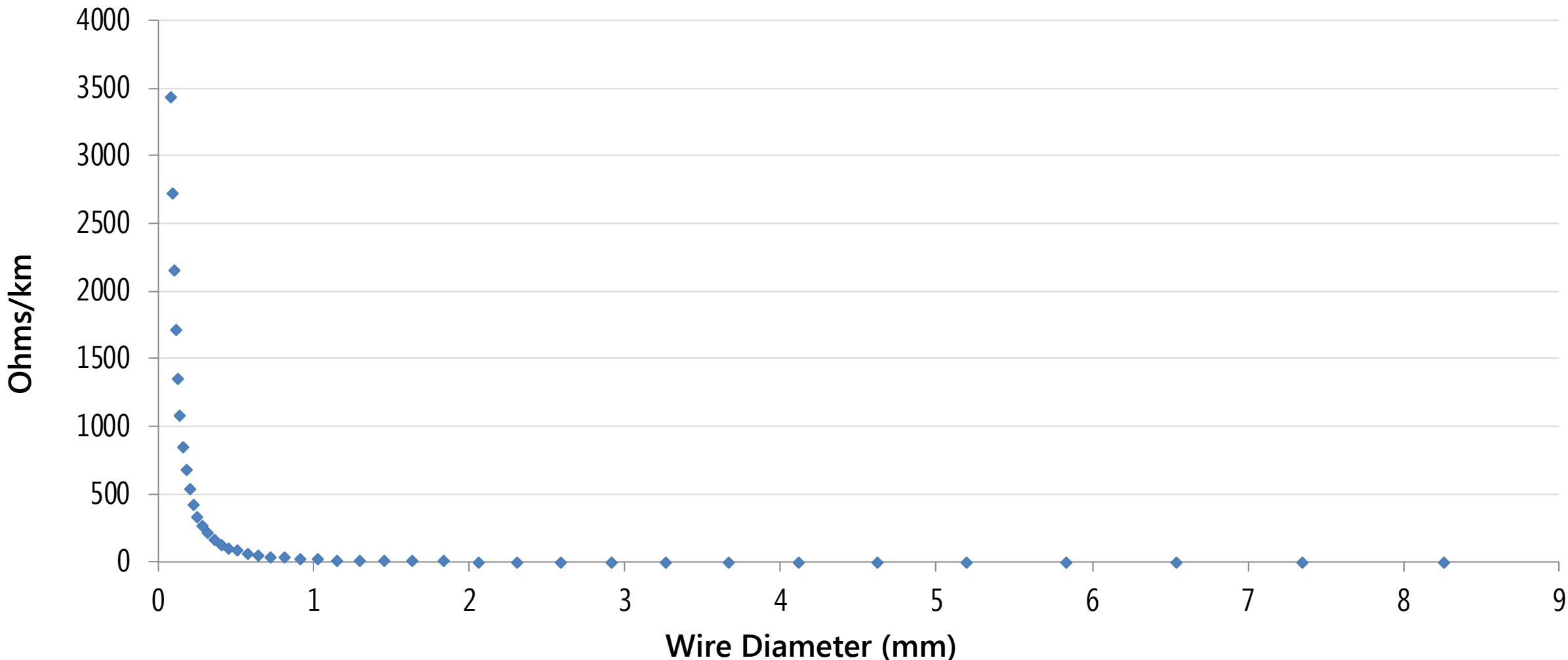
RESISTANCE AS A FUNCTION OF WIRE DIAMETER



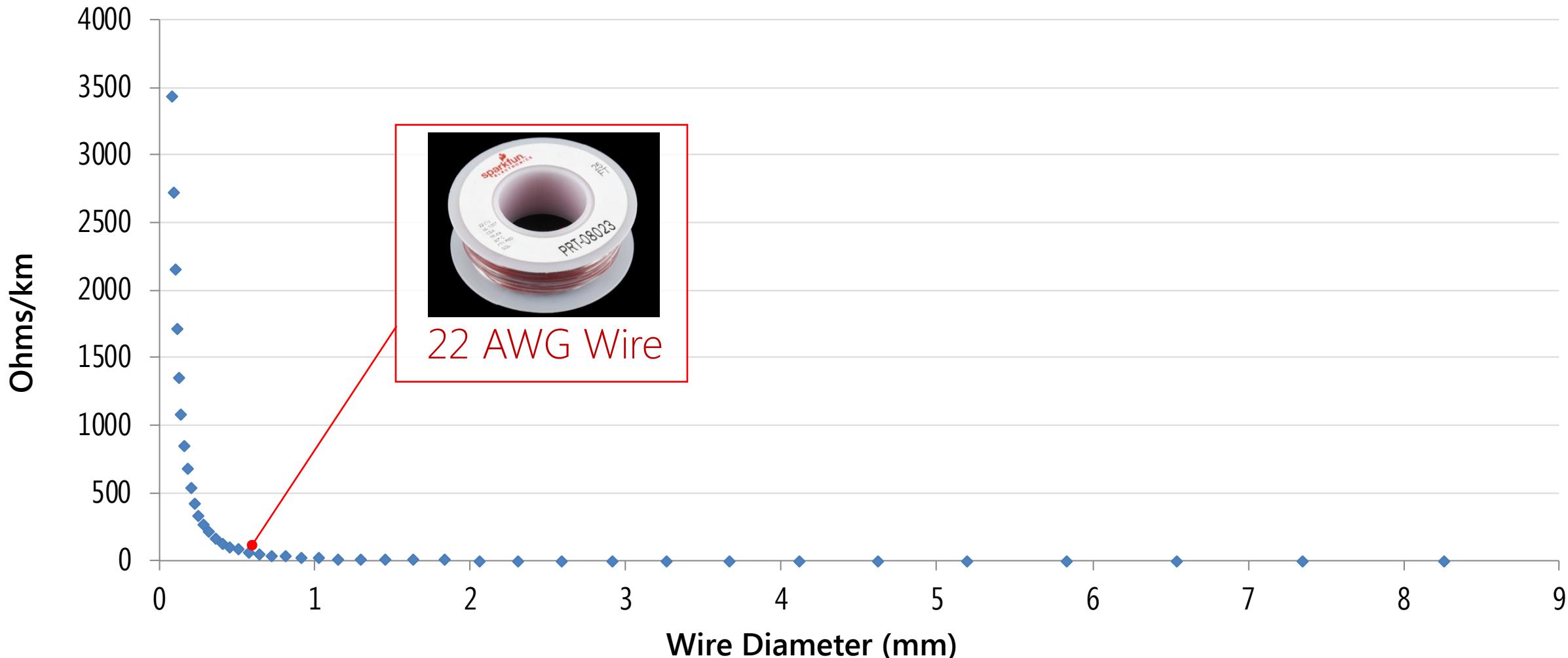
RESISTANCE AS A FUNCTION OF WIRE DIAMETER



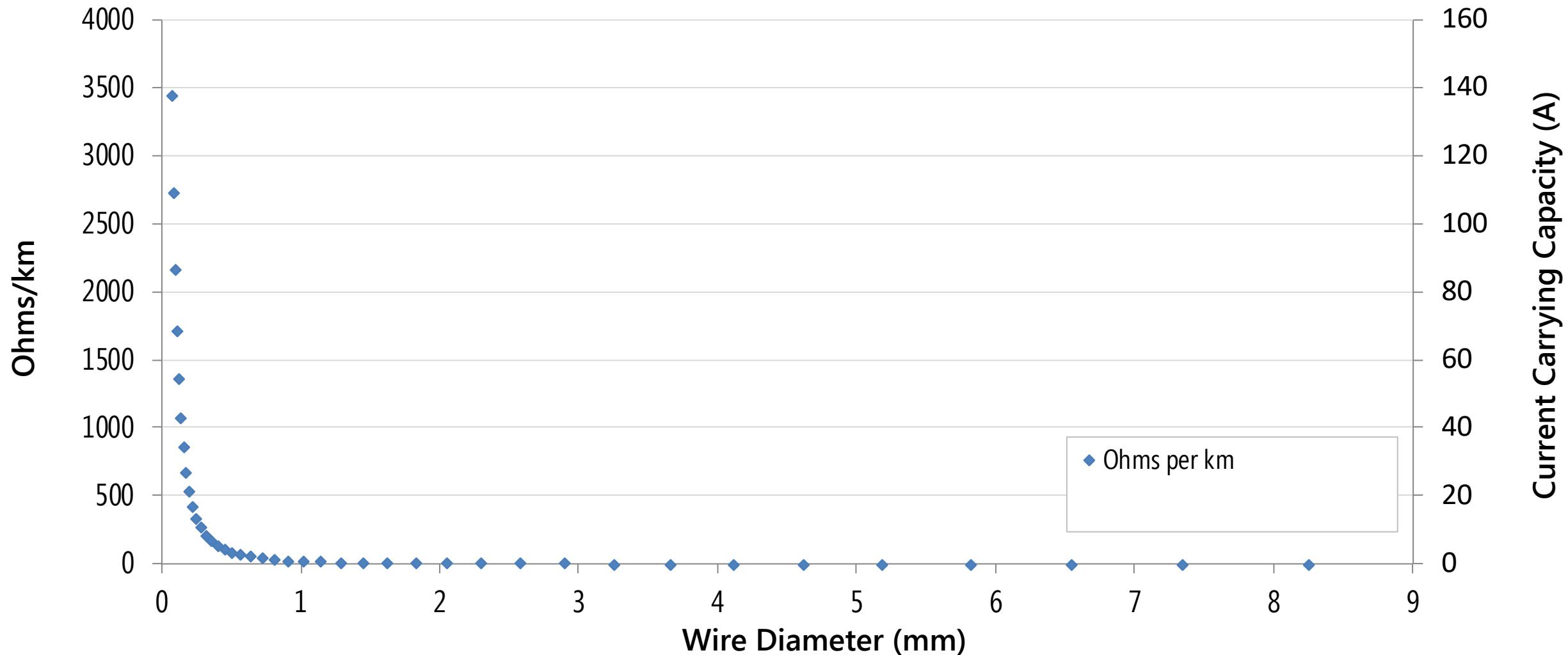
RESISTANCE AS A FUNCTION OF WIRE DIAMETER



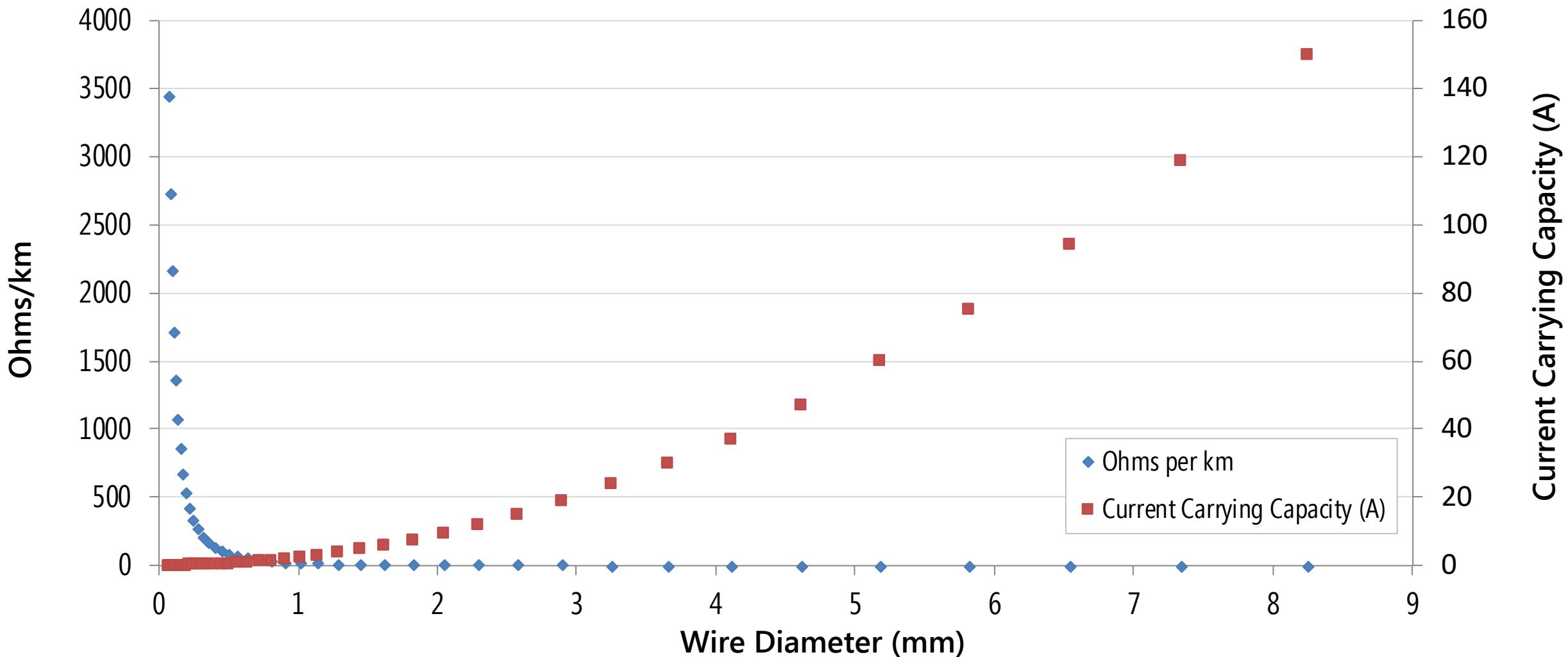
RESISTANCE AS A FUNCTION OF WIRE DIAMETER



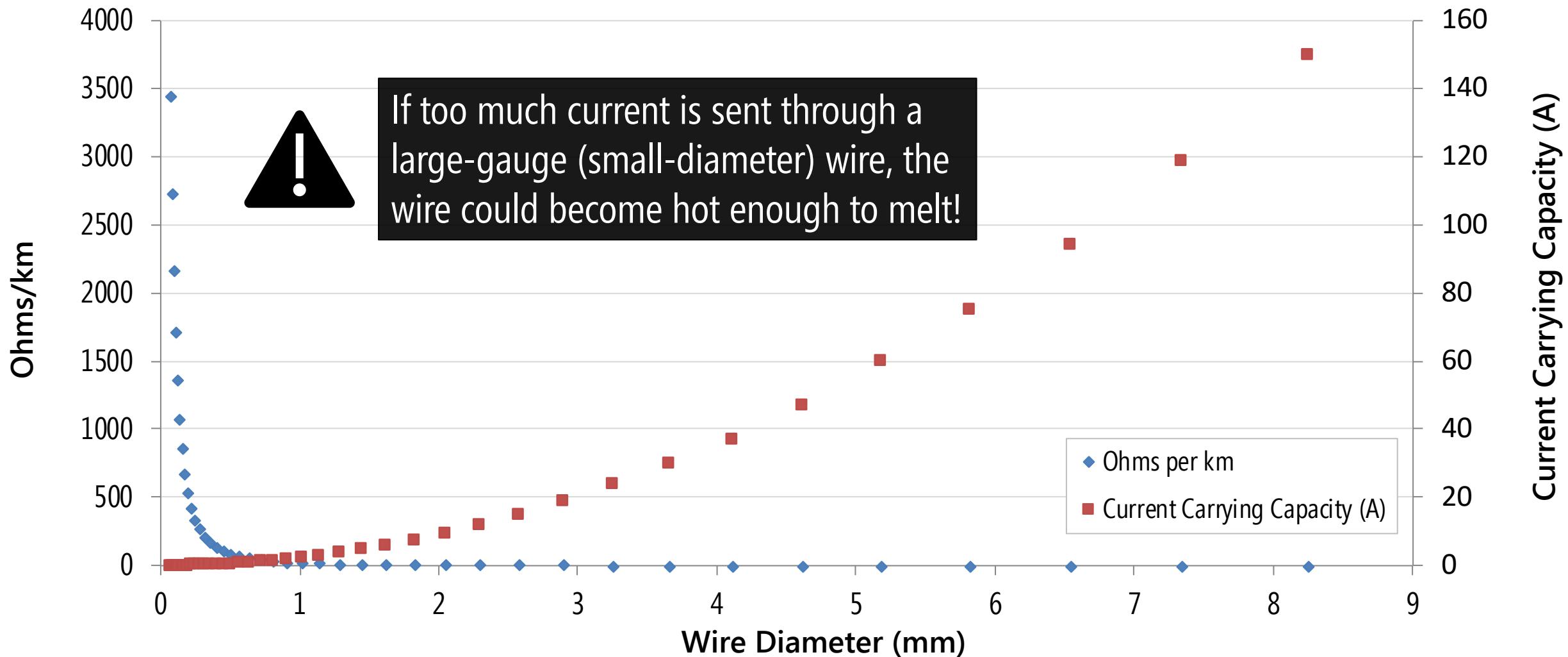
CURRENT CARRYING CAPACITY & RESISTANCE



CURRENT CARRYING CAPACITY & RESISTANCE



CURRENT CARRYING CAPACITY & RESISTANCE



CURRENT CAPACITY AS A FUNCTION OF SIZE

WIRE SIZE (AWG)	DIAMETER (MILS)*	AREA (CM) [†]	FEET PER POUND BARE	OHMS PER 1000 FT, 25°C	CURRENT CAPACITY (AMPS)
4	204.3	41738.49	7.918	0.2485	59.626
8	128.5	16512.25	25.24	0.7925	18.696
10	101.9	10383.61	31.82	0.9987	14.834
12	80.8	6528.64	50.61	1.5880	9.327
14	64.1	4108.81	80.39	2.5240	5.870
18	40.3	1624.09	203.5	6.3860	2.320
20	32	1024.00	222.7	10.1280	1.463
22	25.3	640.09	516.3	16.2000	0.914
24	20.1	404.01	817.7	25.6700	0.577
28	12.6	158.76	2081	65.3100	0.227
32	8.0	64.00	5163	162.0000	0.091
40	3.1	9.61	34364	1079.0000	0.014

* 1 mil = 0.001 in or 0.0254 mm.

[†]A circular mil (CM) is a unit of area equal to that of a 1-mil-diameter circle. The CM area of a wire is the square of the mil diameter.

Diameters of wires in [Fig. 2.26](#) are relative and not to scale.

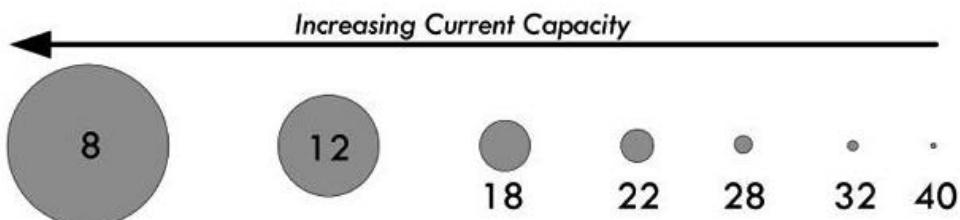


FIGURE 2.26

WIRES

USB CABLE CROSS SECTION



7-strand copper conductor

Colored PVC insulation

Ground (negative)

USB data (D-)

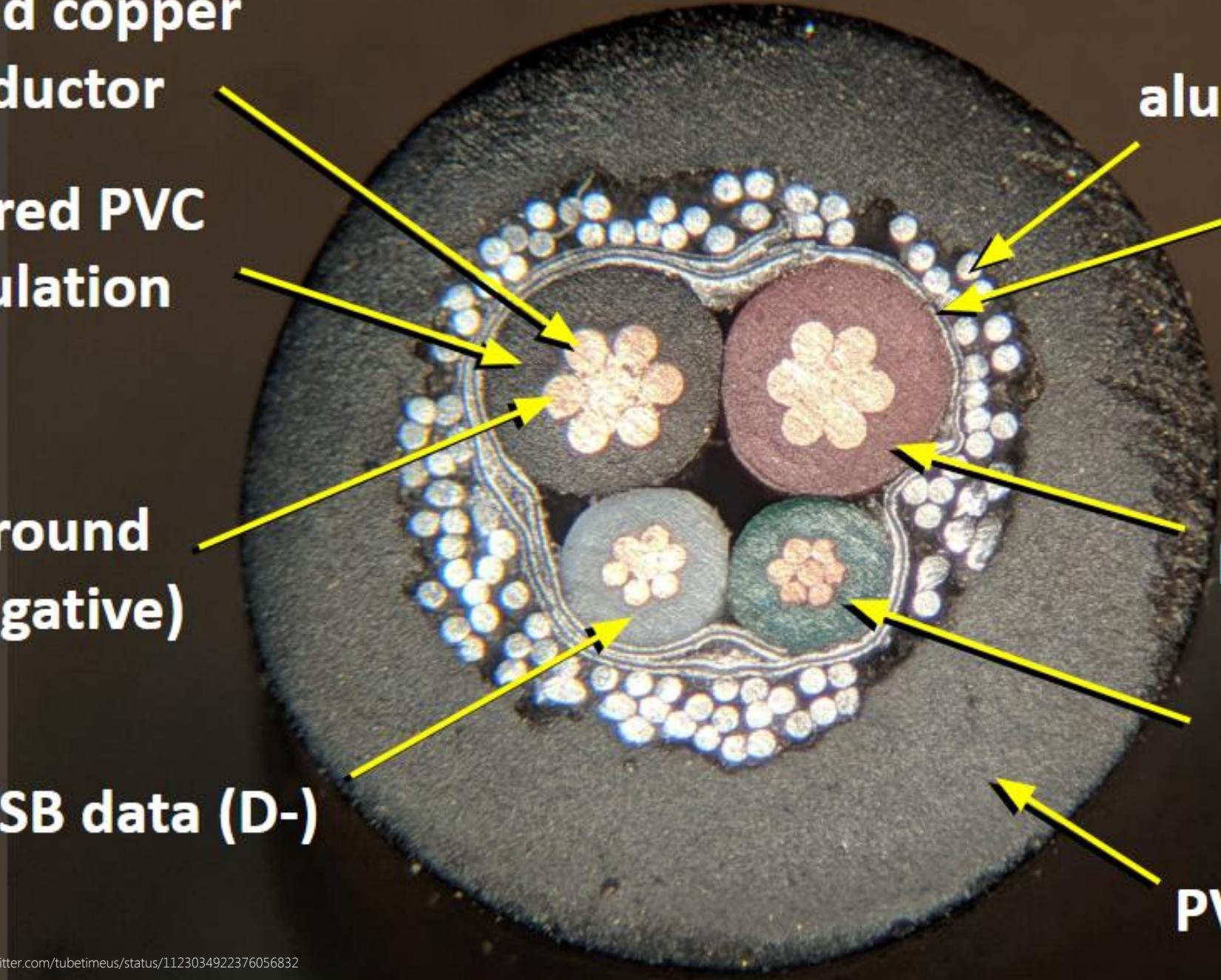
Braided aluminum shield

Foil shield

Positive 5 volts

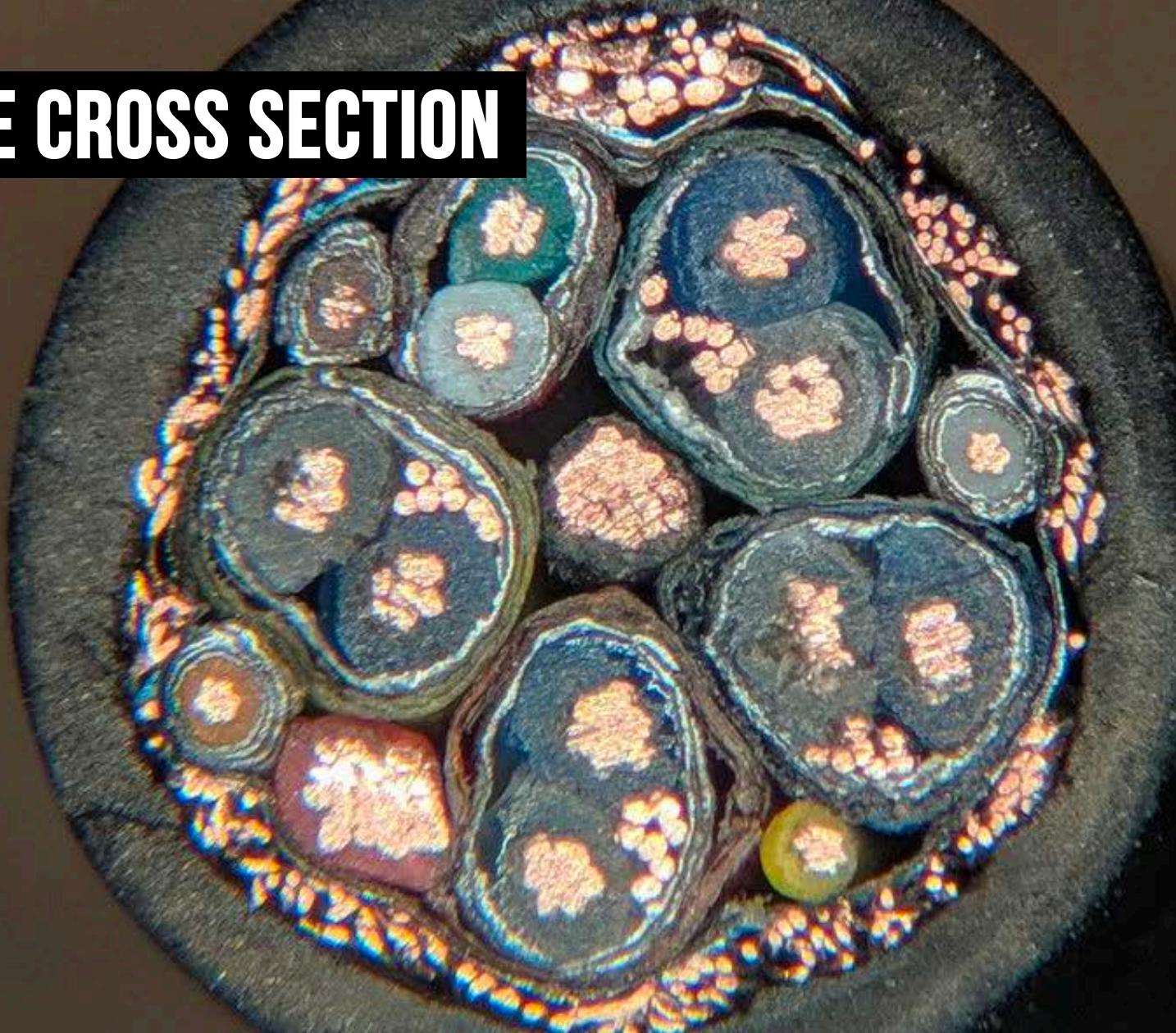
USB data (D+)

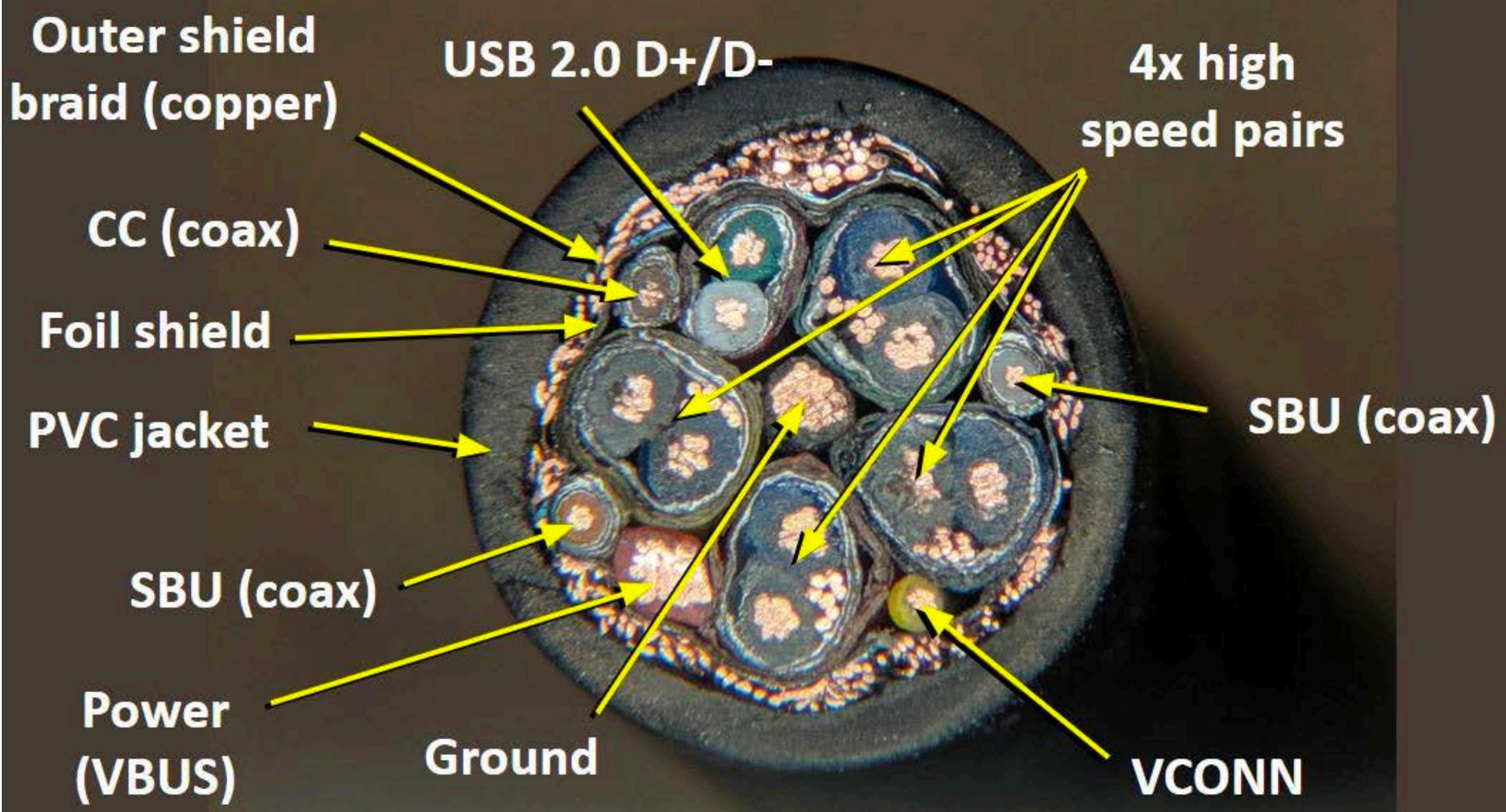
PVC outer jacket



WIRES

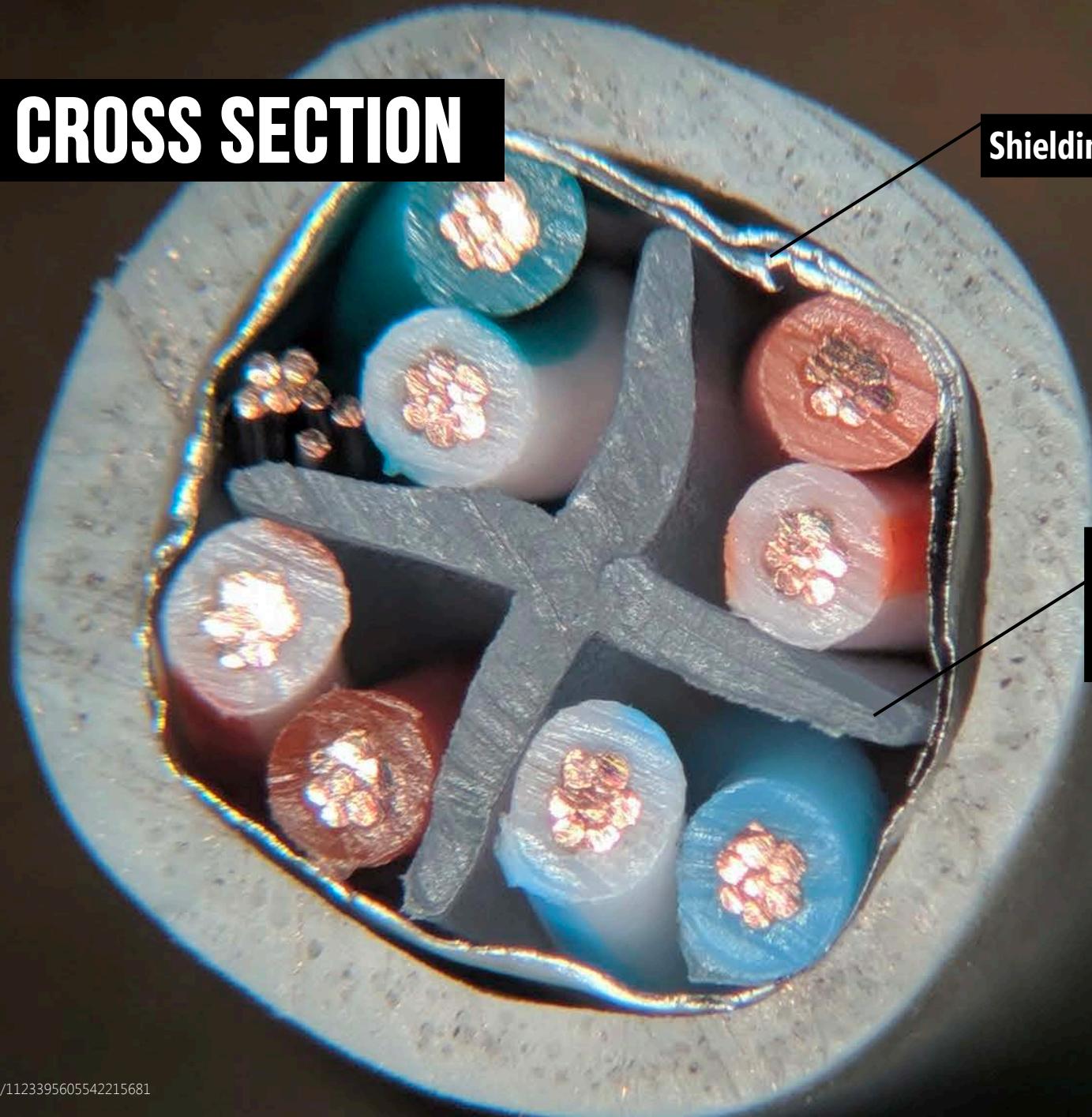
USB-C CABLE CROSS SECTION





WIRES

CAT6 CABLE CROSS SECTION



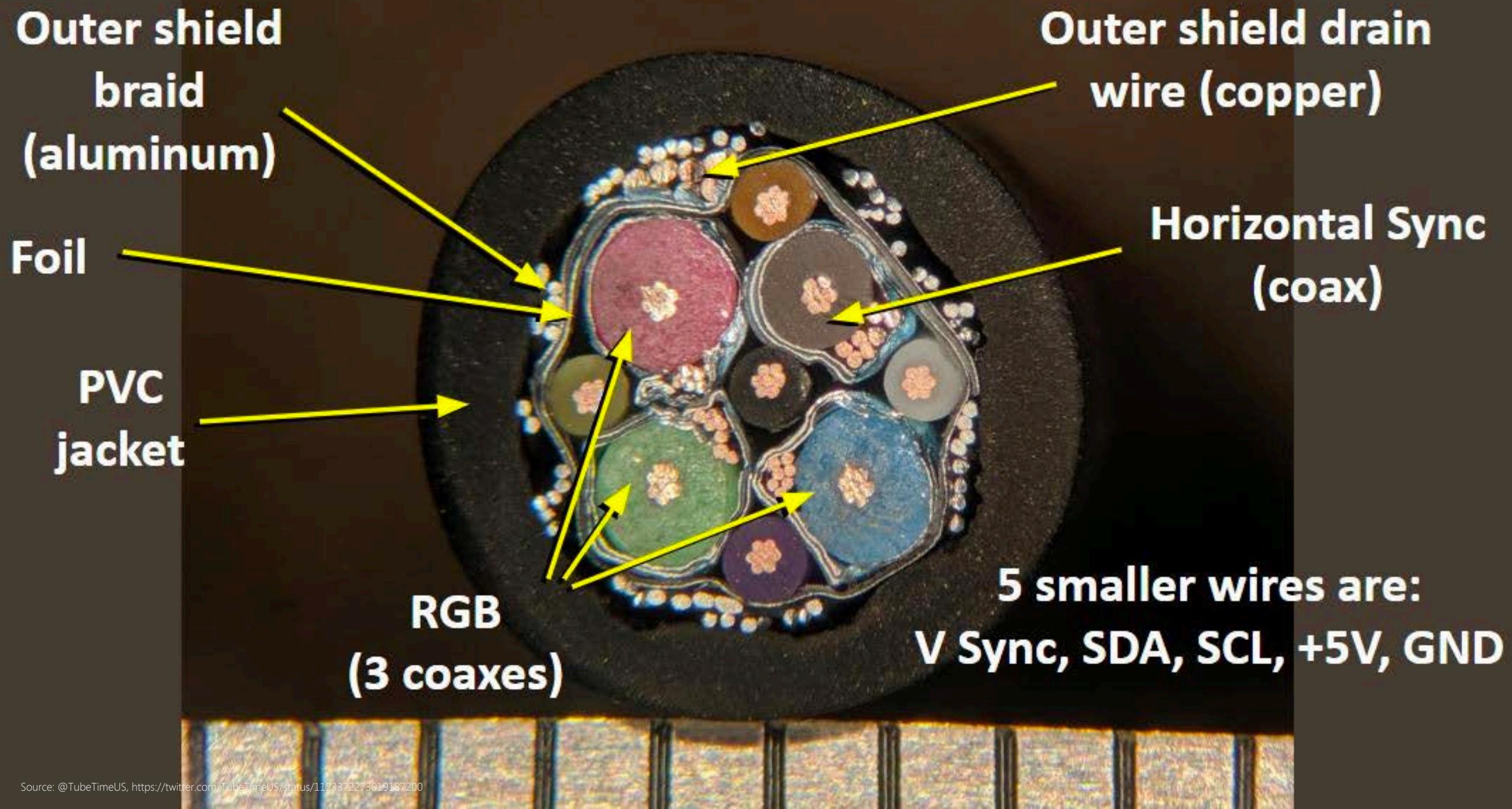
Shielding to reduce noise

Plastic "+" separator
to reduce crosstalk
between wire pairs

WIRES

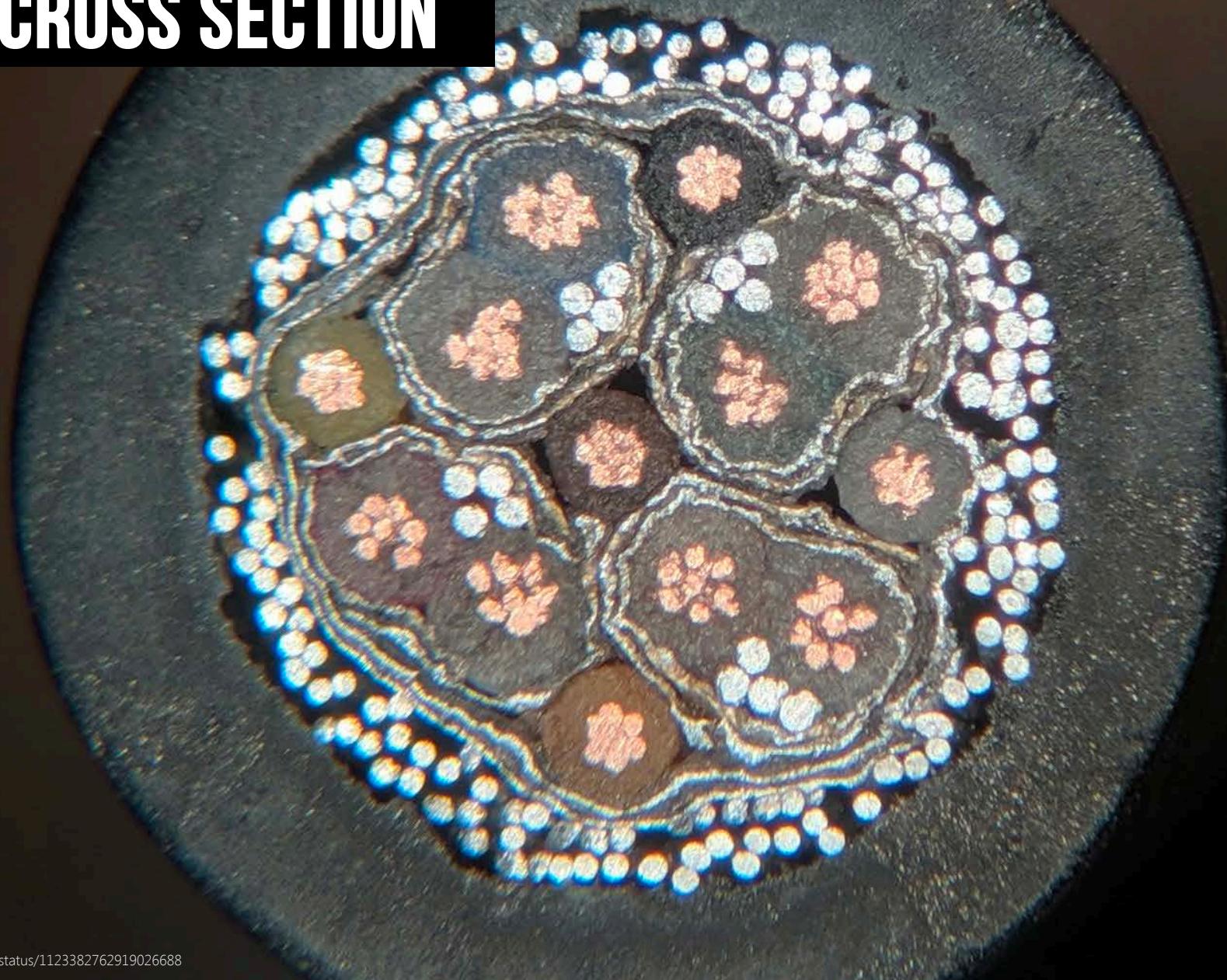
VGA CABLE CROSS SECTION





WIRES

DVI CABLE CROSS SECTION



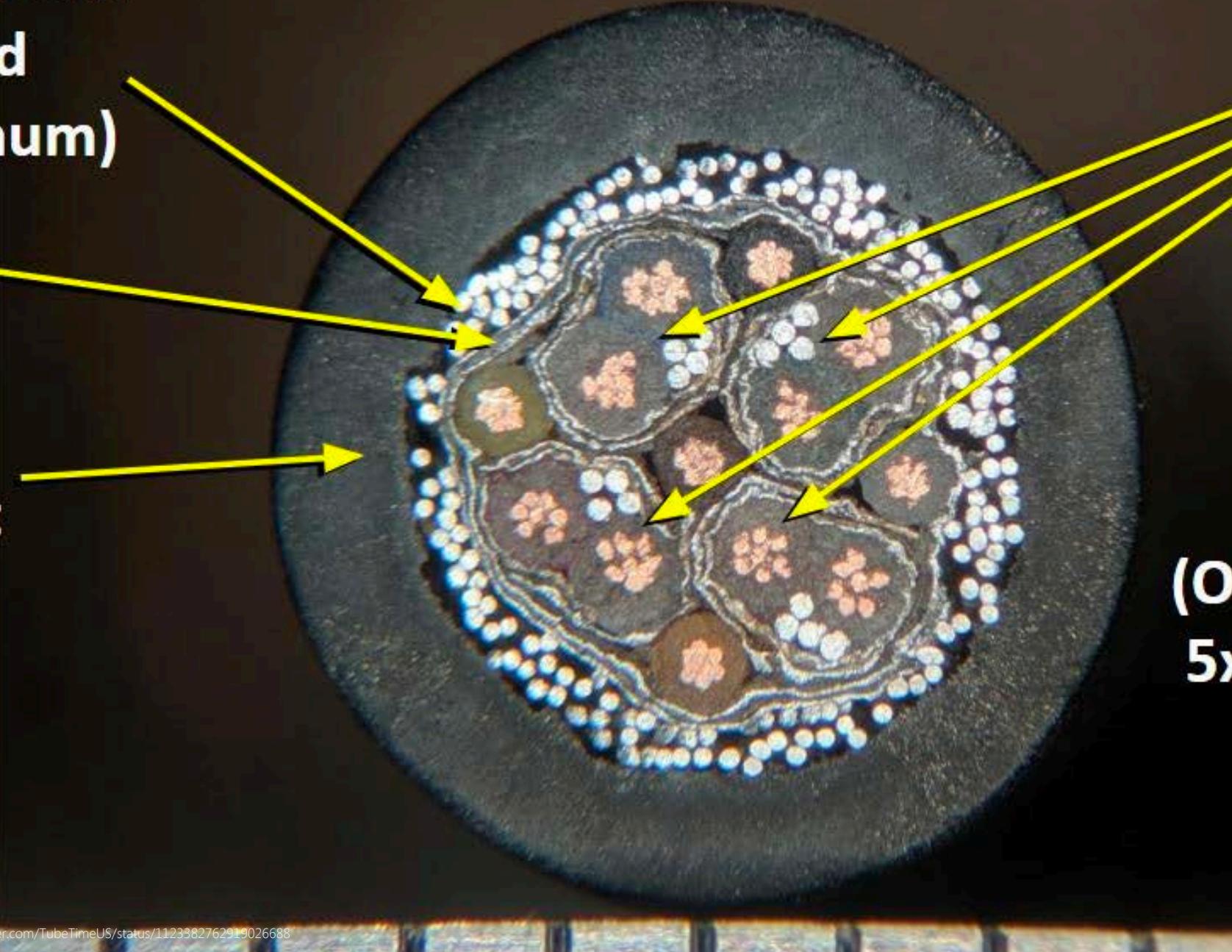
Outer shield
braid
(aluminum)

Foil

PVC
jacket

3x TMDS +
clock pair

(Other wires are
5x DDC signals)



Outer shield
braid
(aluminum)

Foil

PVC
jacket

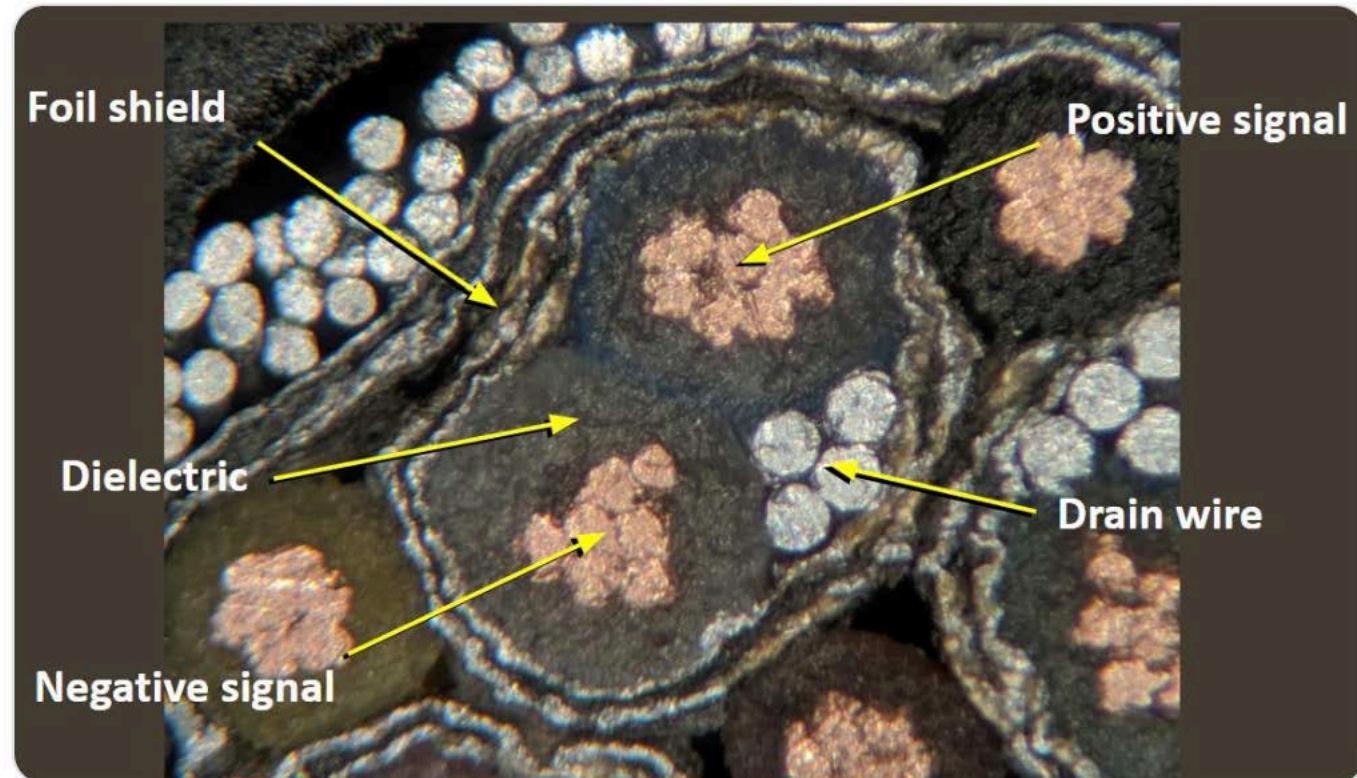
3x TMDS +
clock pair

other wires are
DDC signals)



Tube Time @TubeTimeUS · 12h

closeup of a single differential pair inside the DVI-D single link cable. the geometry has to be tightly controlled to maintain a constant impedance!



1



7



42



Show this thread



PROTOTYPING FORM

ELECTRONIC HAND TOOLS





Panavise Jr. used for holding components when soldering (esp good for holding PCBs)

Third hand used for holding components when soldering

Tweezers for picking up small components

Ratchet Crimper used to crimp connectors onto a wire

Pliers for holding, compressing, and/or bending wires & components

Wire cutter used to cut wire and component leads

Wire stripper used to strip wire at supported gauges. Typically, also has a built-in wire cutter and pliers end.

Auto-wire stripper for fast wire stripping (also called a 'self-adjusting wire stripper').



STRIPPING WIRES



Panavise Jr. used for holding components when soldering (esp good for holding PCBs)

Third hand used for holding components when soldering

Tweezers for picking up small components

Ratchet Crimper used to crimp connectors onto a wire

Pliers for holding, compressing, and/or bending wires & components

Wire cutter used to cut wire and component leads

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Auto-wire stripper for fast wire stripping (also called a 'self-adjusting wire stripper').



Wire stripper used to strip wire at supported gauges. Typically, also has a built-in wire cutter and pliers end.

Auto-wire stripper for fast wire stripping (also called a 'self-adjusting wire stripper').

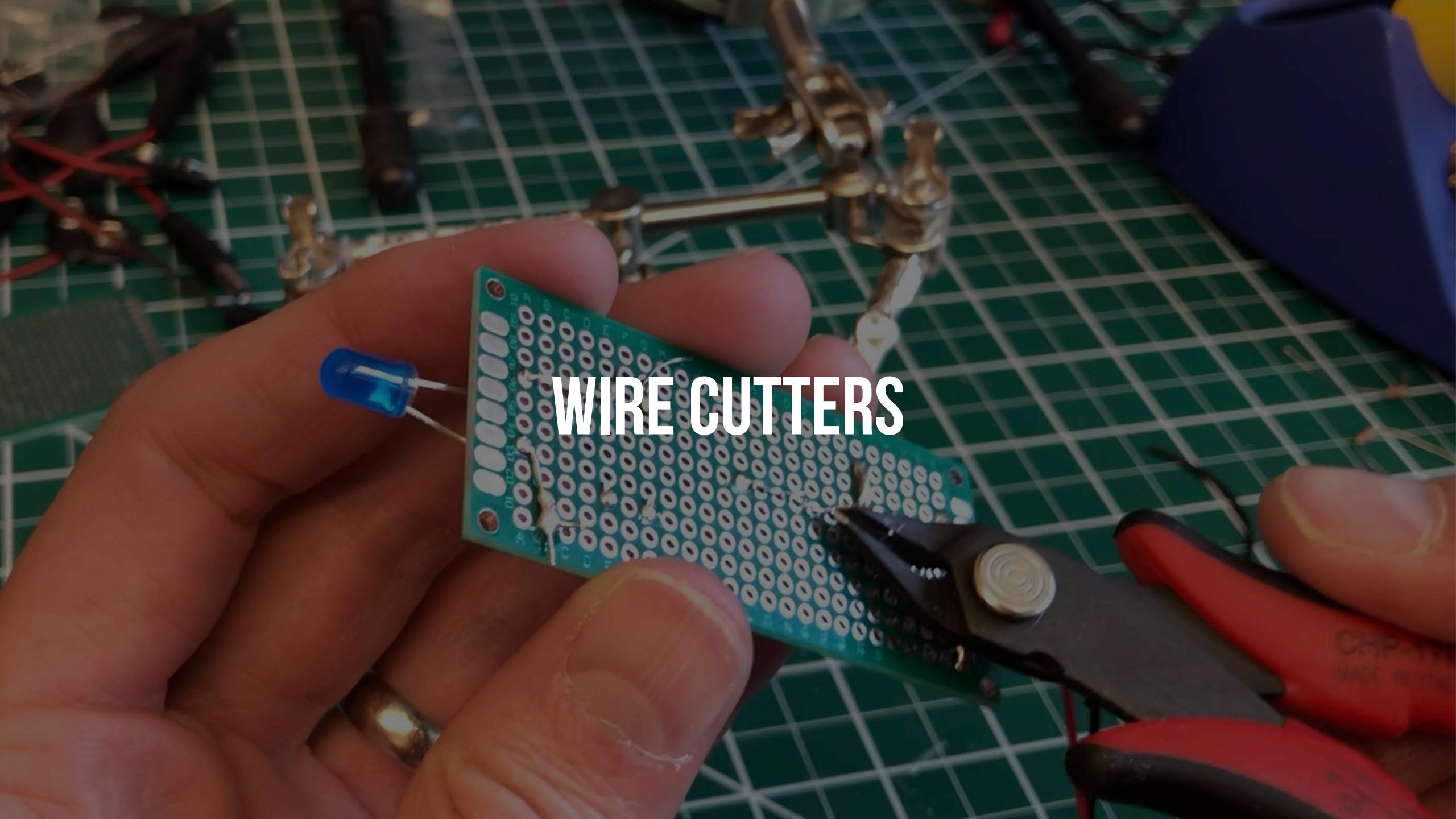


ELECTRONIC HAND TOOLS

WIRE STRIPPERS



Source: Adafruit, Hand Tools, https://youtu.be/J-1phA_vKDg



WIRE CUTTERS



Ratchet Crimper used to crimp connectors onto a wire

Panavise Jr. used for holding components when soldering (esp good for holding PCBs)

Third hand used for holding components when soldering

Tweezers for picking up small components

Wire cutter used to cut wire and component leads

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Pliers for holding, compressing, and/or bending wires & components

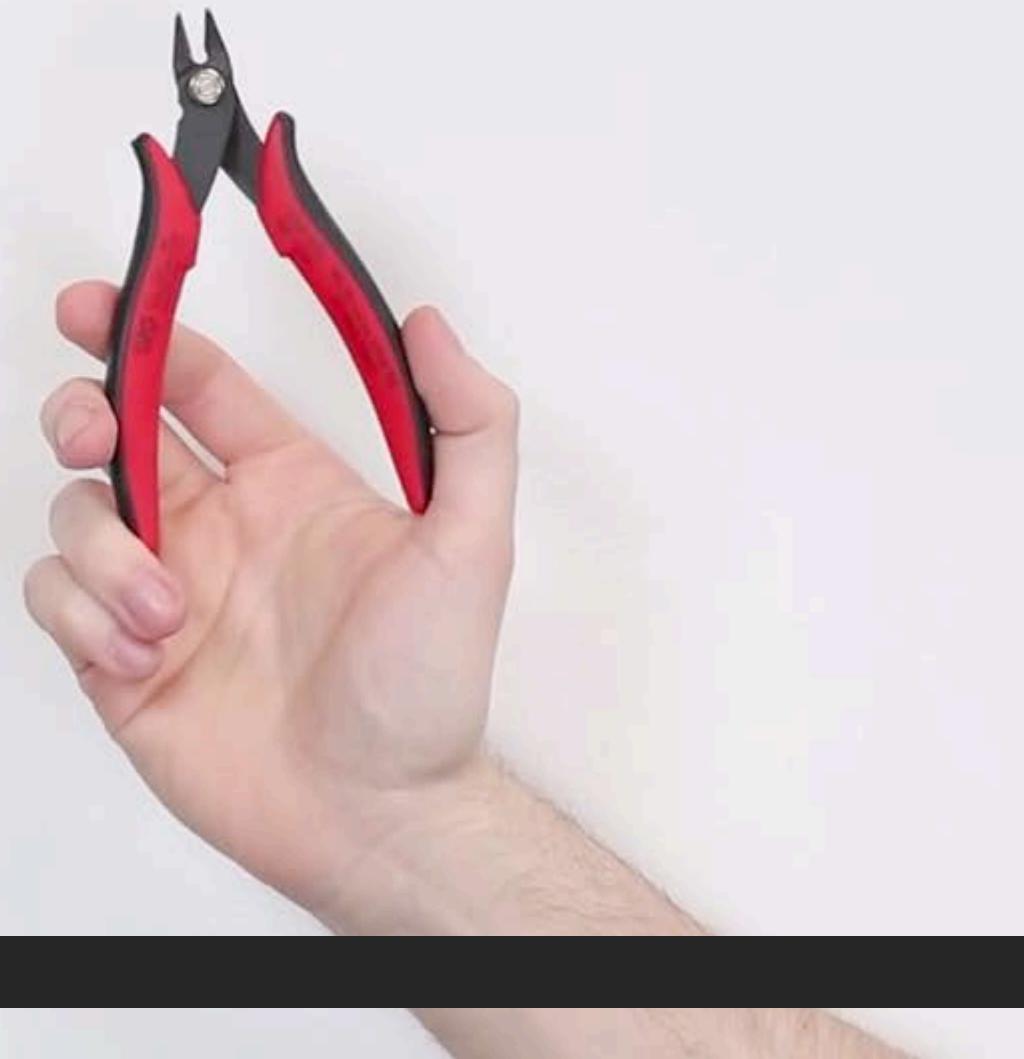
Auto-wire stripper for fast wire stripping (also called a 'self-adjusting wire stripper').

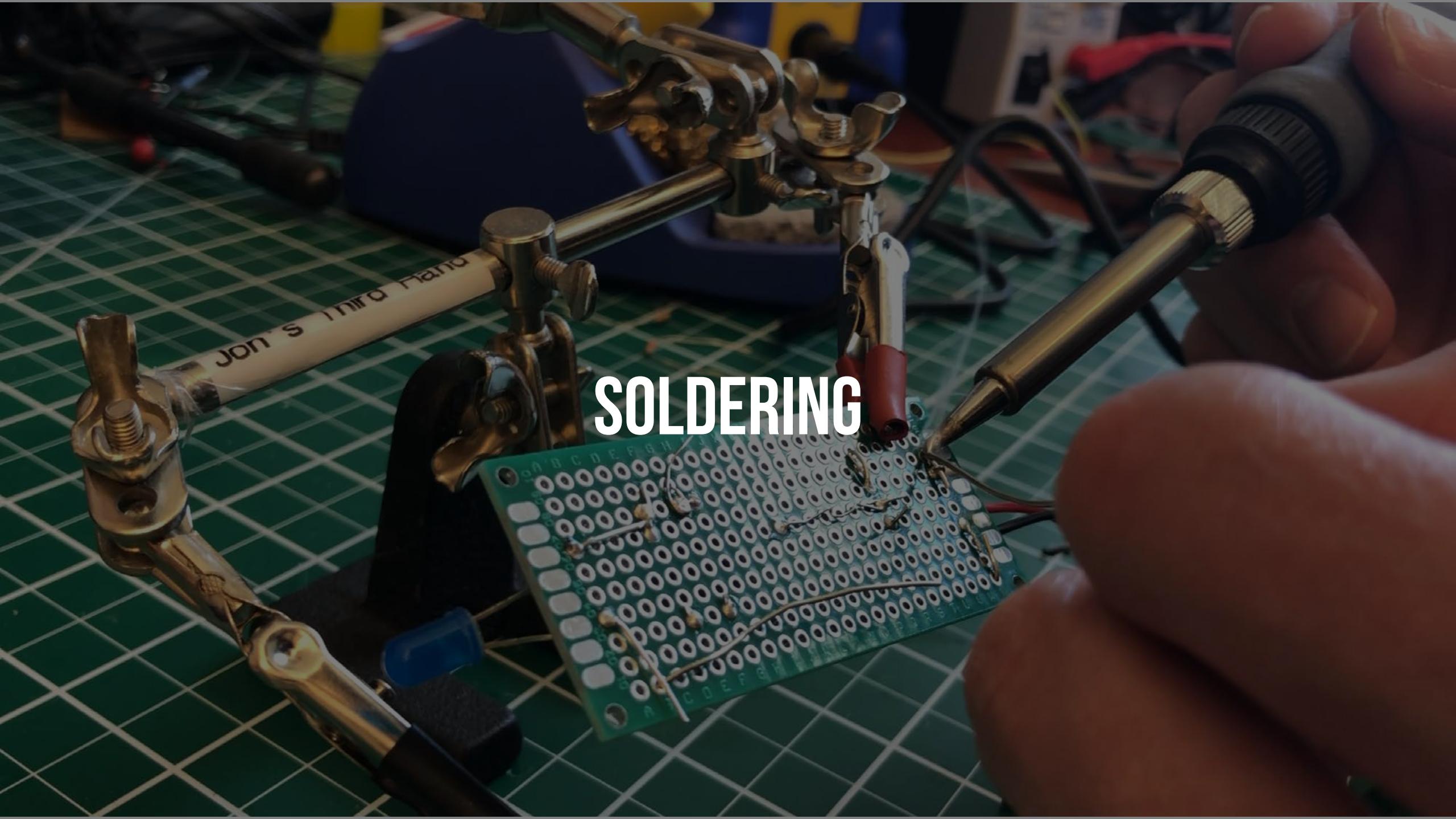


ELECTRONIC HAND TOOLS

WIRE CUTTERS

CUTTERS

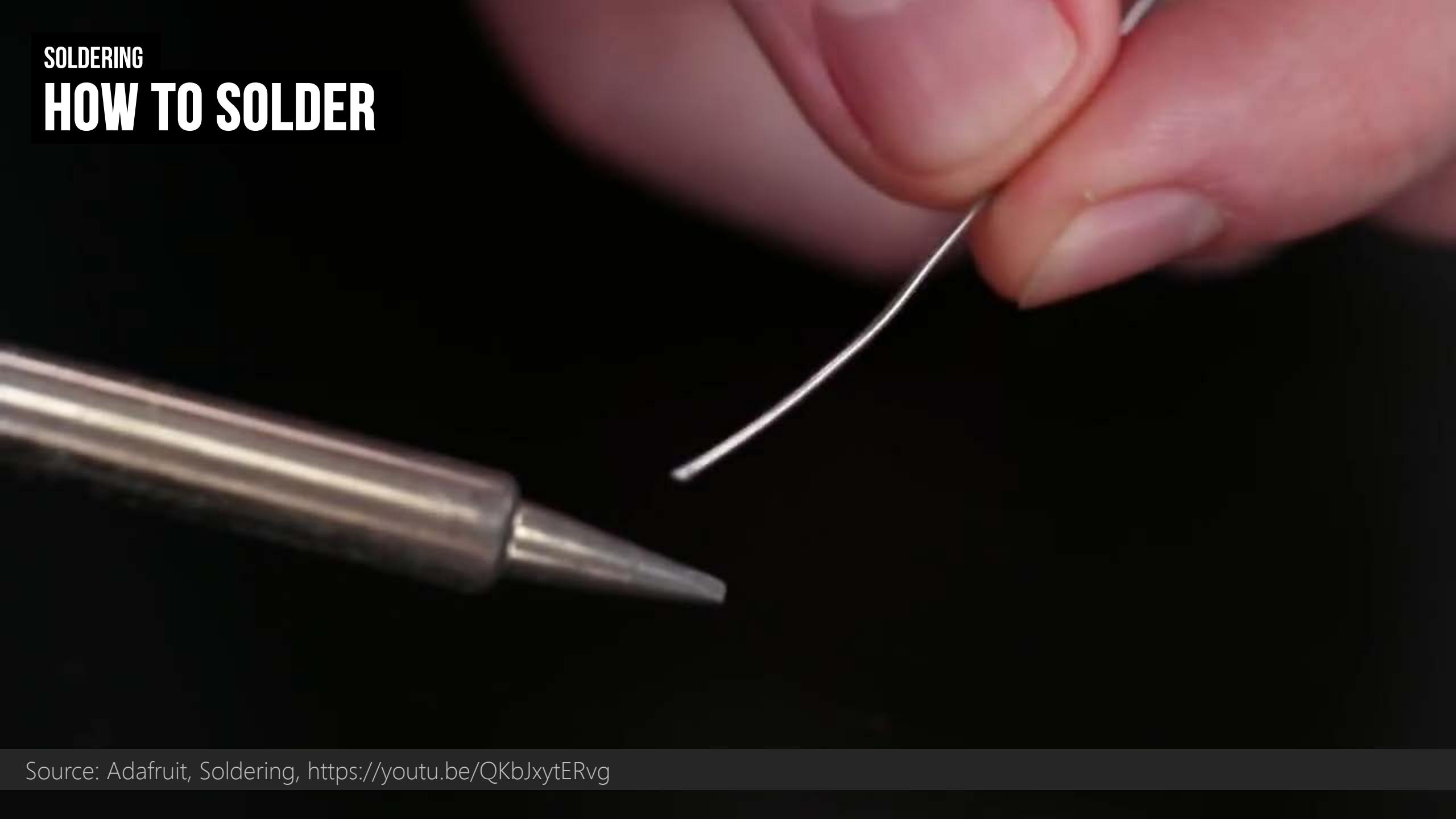




SOLDERING

SOLDERING

HOW TO SOLDER

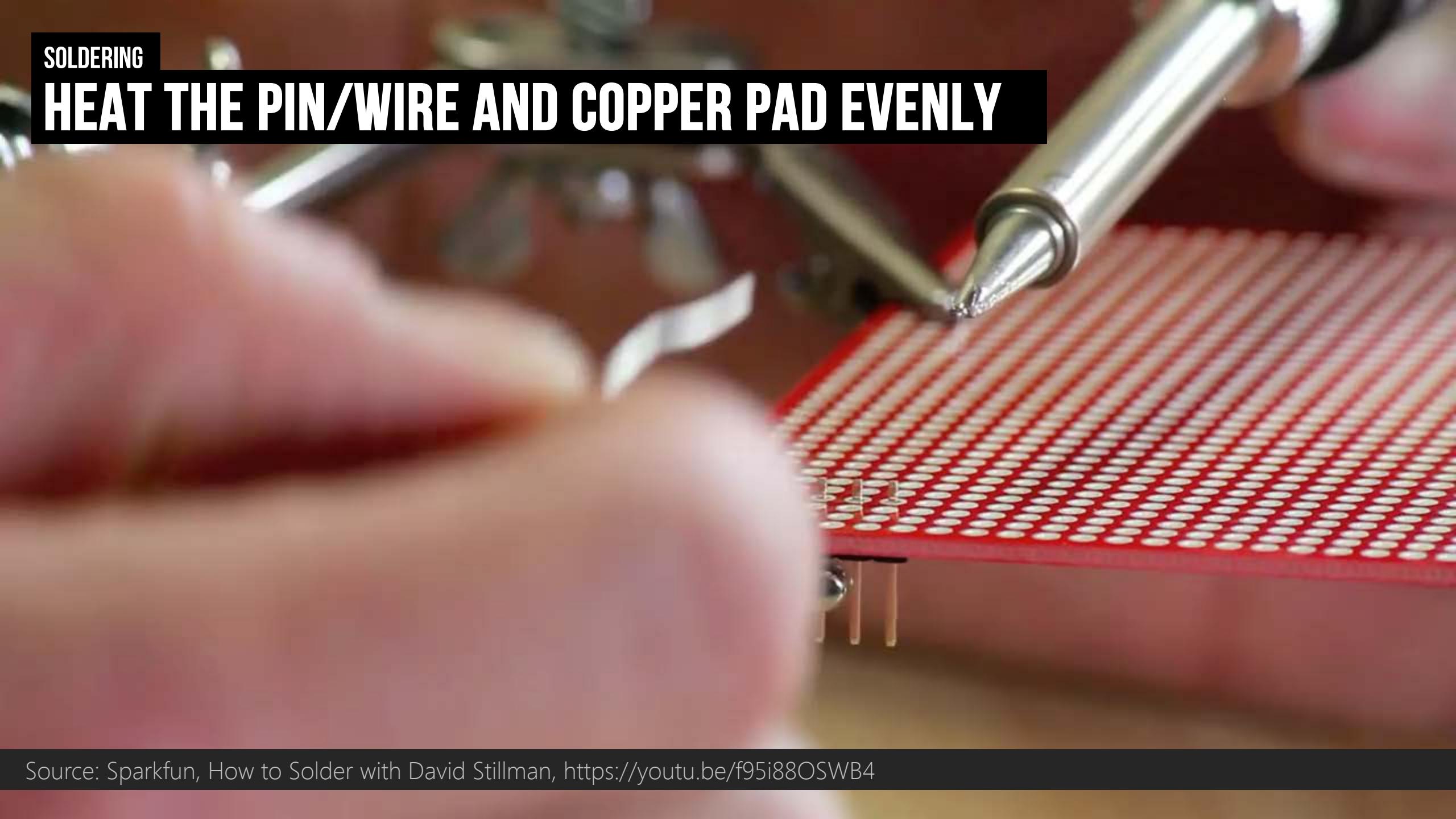


Source: Adafruit, Soldering, <https://youtu.be/QKbJxytERvg>

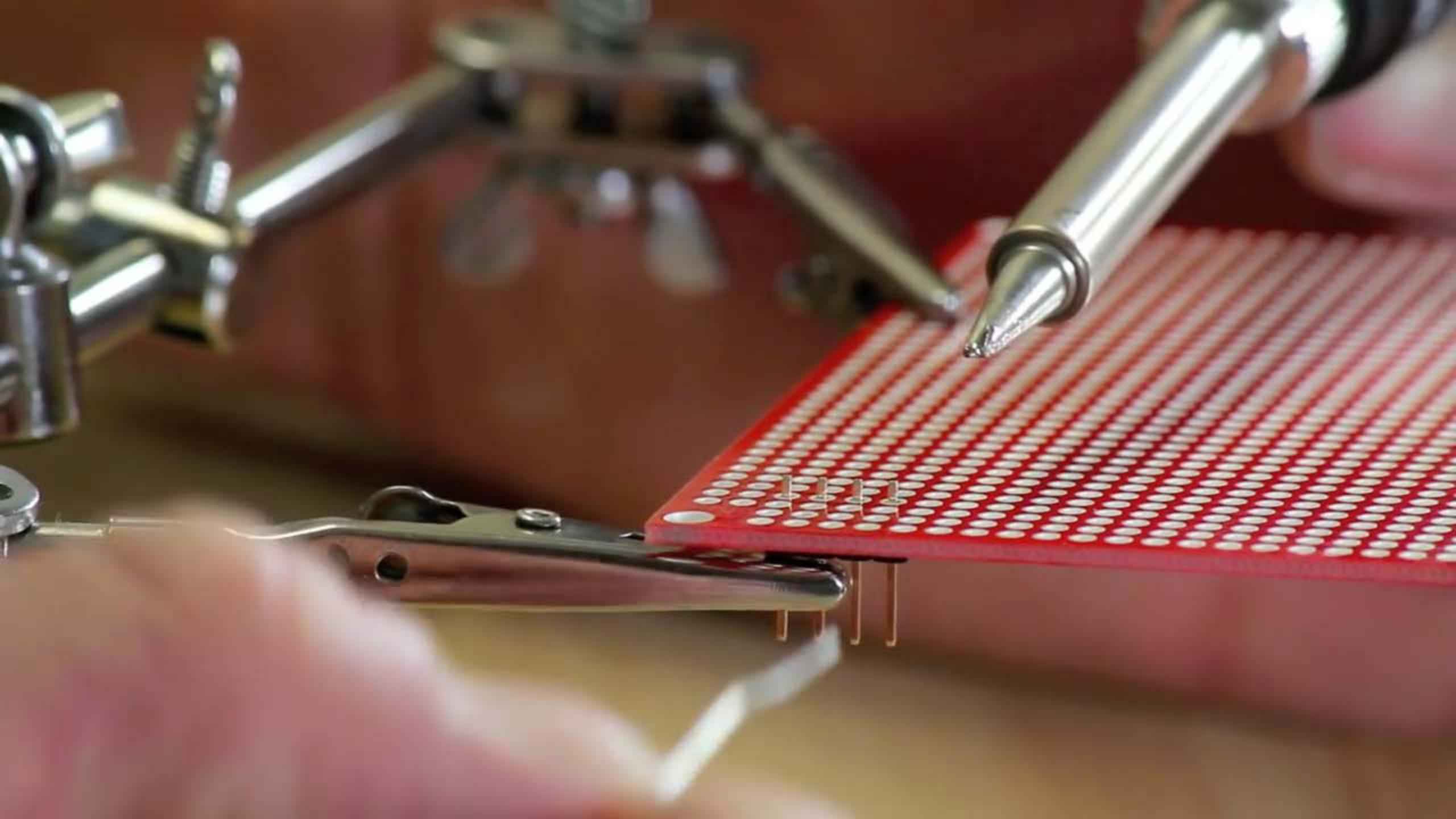


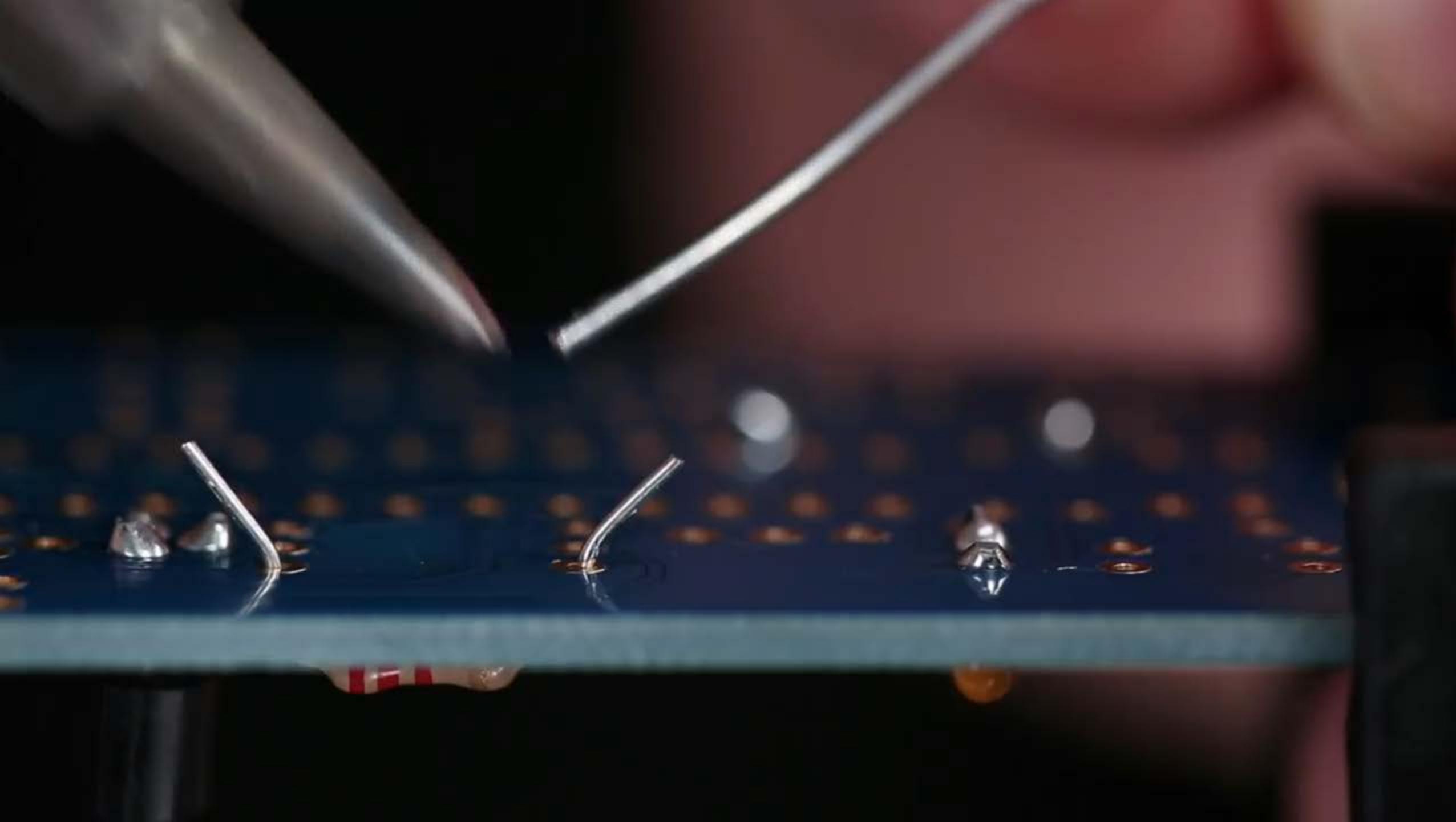
SOLDERING

HEAT THE PIN/WIRE AND COPPER PAD EVENLY



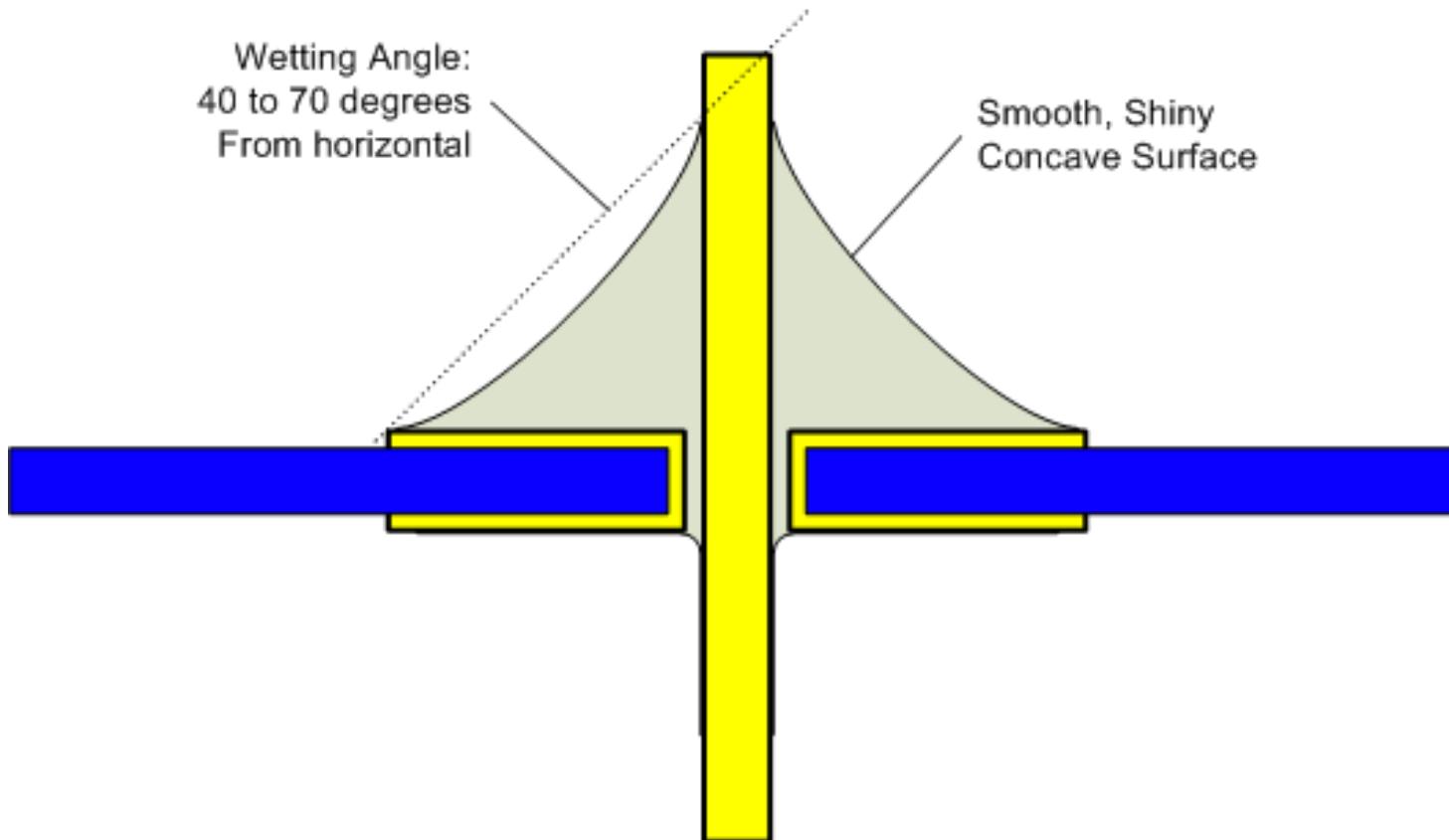
Source: Sparkfun, How to Solder with David Stillman, <https://youtu.be/f95i88OSWB4>





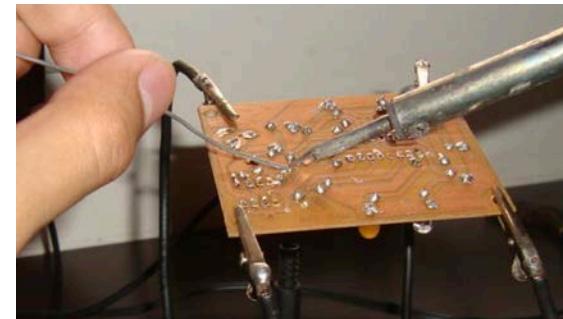
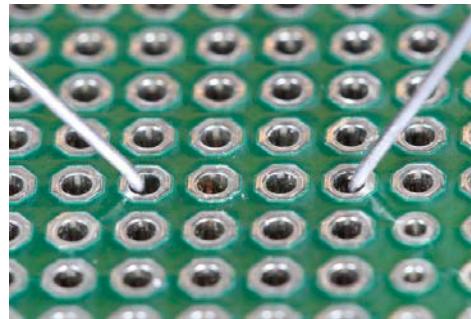
IDEAL SOLDER JOINT

The ideal solder joint for through-hole components



SOLDERING

PREPARING TO SOLDER



1. Turn on Belkin auto-shutoff switch by pressing the momentary switch.

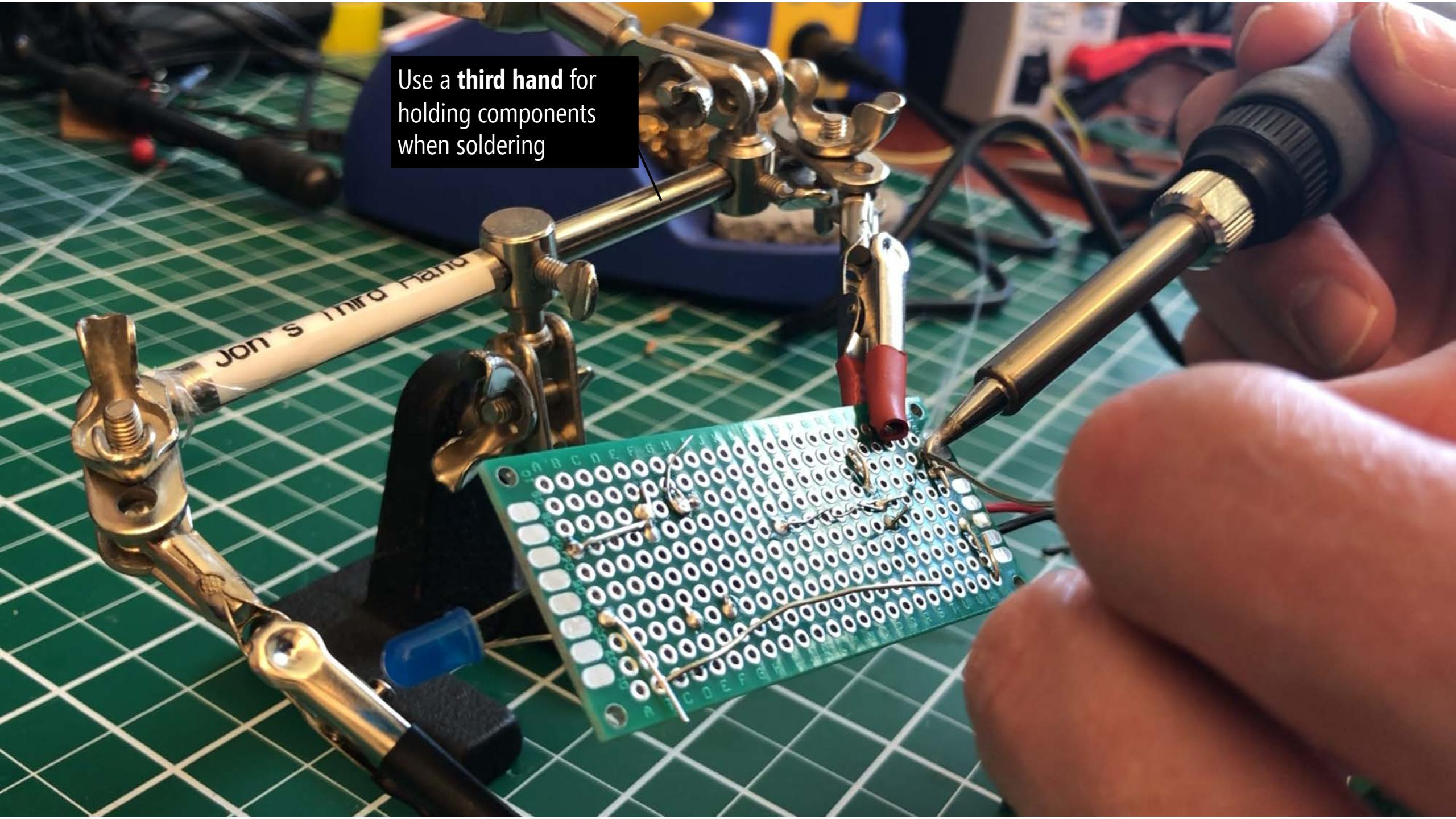
We added these to every outlet connected to the soldering iron for safety and to maintain the health of the soldering iron.

2. Turn on soldering iron. For lead-free solder, set iron to 700-720F. For leaded-solder, set iron to 750F. You can set the temperature by holding down the 'Enter' button until the LED output flashes and using the 'Up' button to select the temperature

3. Tin soldering tip. Apply a small amount of solder to the tip and wipe again to tin the tip. You should have a thin, shiny layer of molten solder on the tip of your iron.

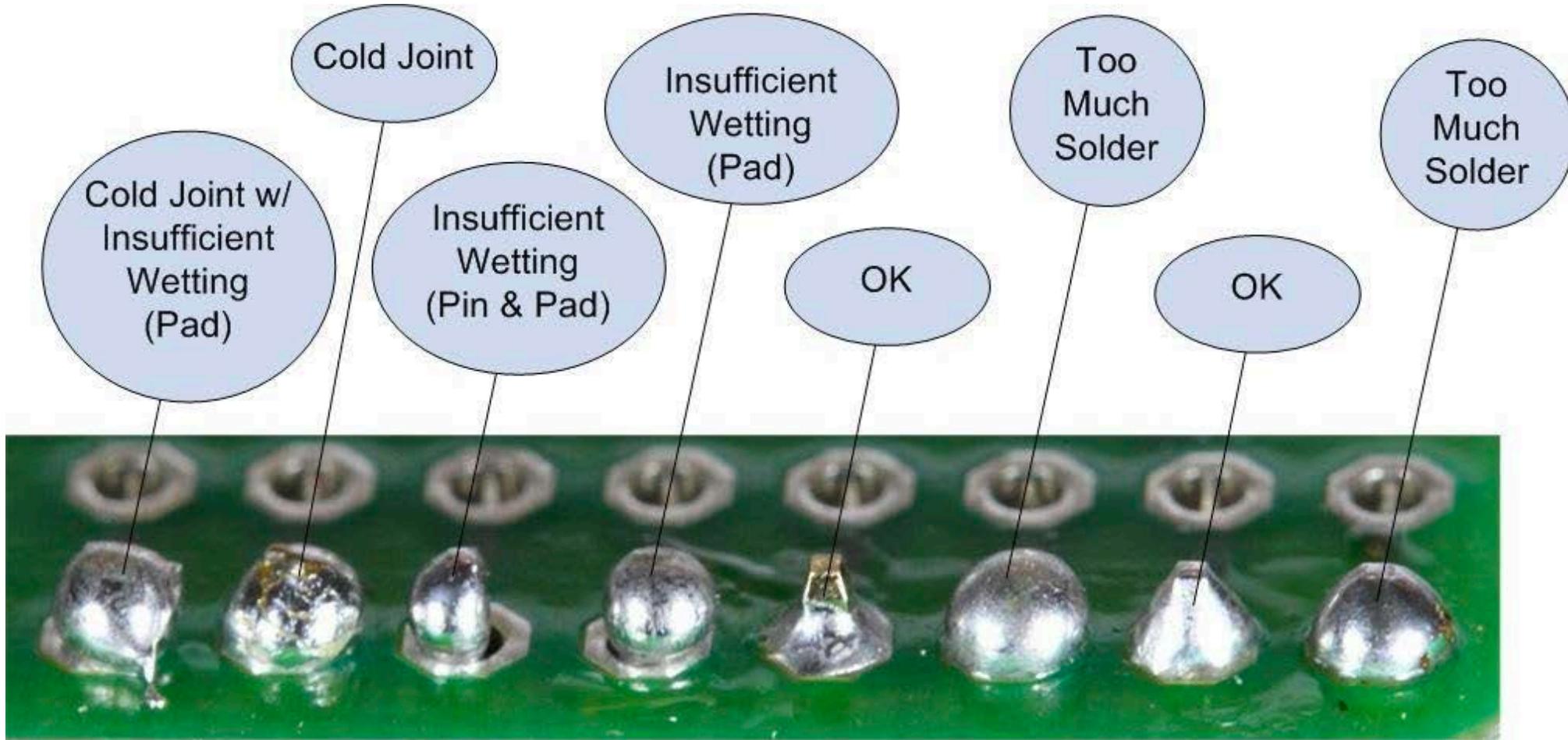
4. Place component leads/wires through perfboard. Immobilize the joint. Components should not move while being soldered.

5. Use a third hand or other vise to securely hold perfboard. Again, it's important that the board is secure so it won't move during soldering and also improves safety.



Use a **third hand** for holding components when soldering

COMMON SOLDERING PROBLEMS



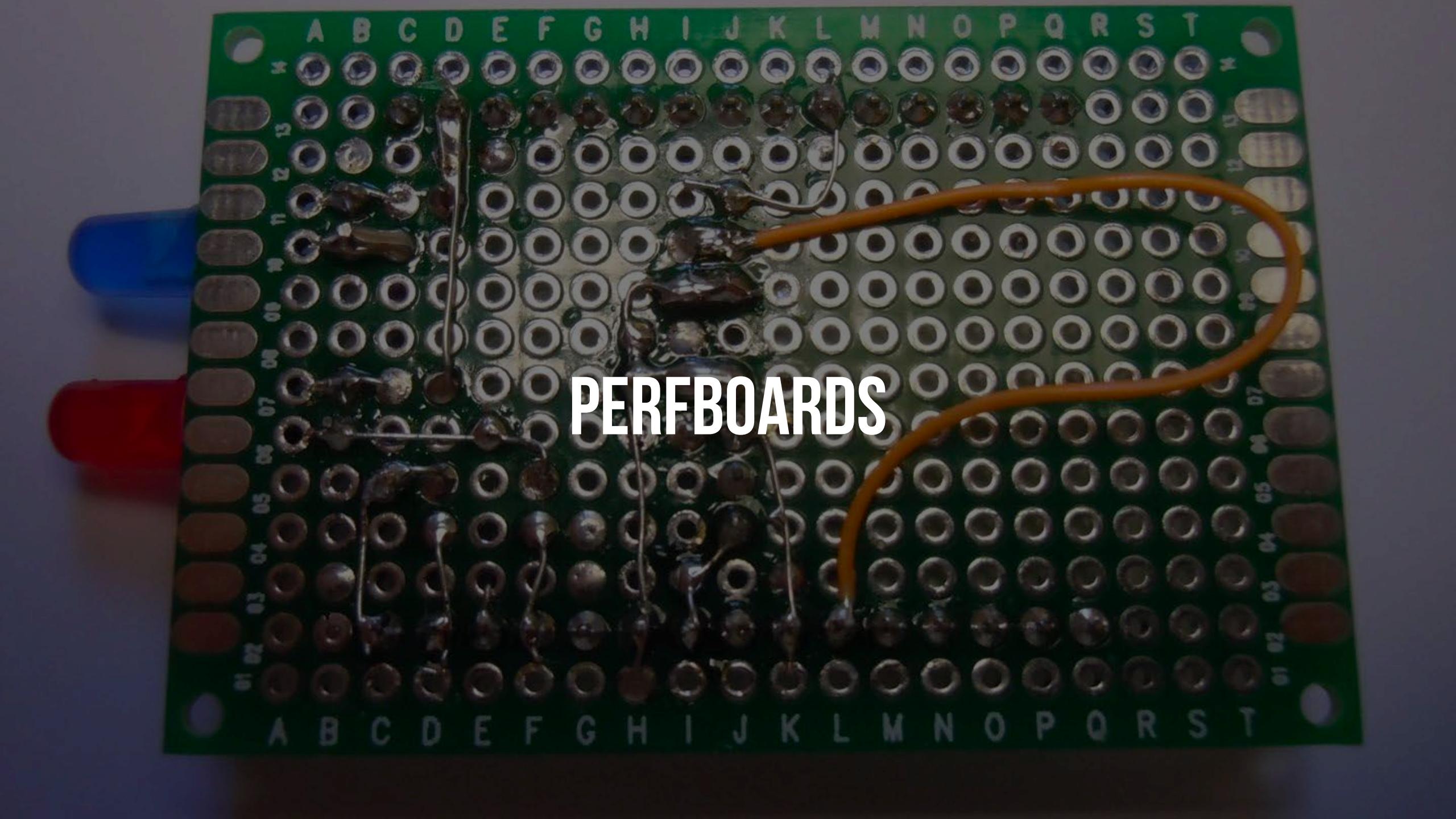
WHEN YOU FINISH SOLDERING



1. Tin soldering tip. Again, apply a small amount of solder to the tip before returning the soldering iron to the holster



2. Turn off soldering iron. Holster the iron. The tip will stay warm for a little while, so be careful.

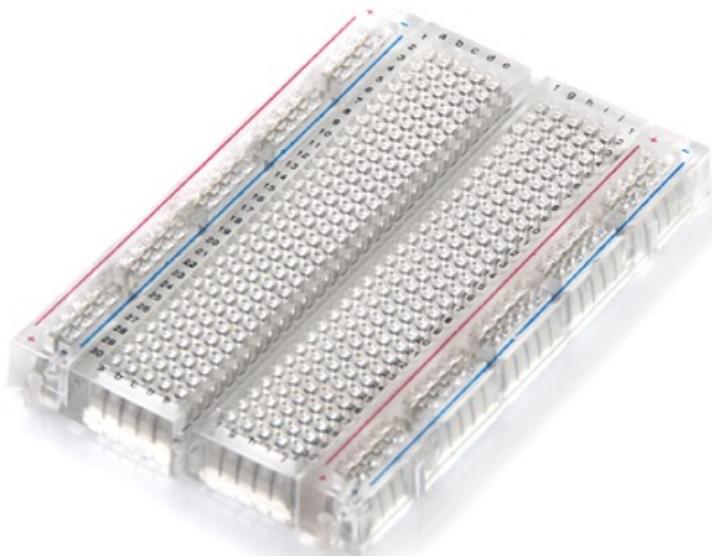


PERFBOARDS

PERFBOARDS

BREADBOARDS -> PERFBOARDS

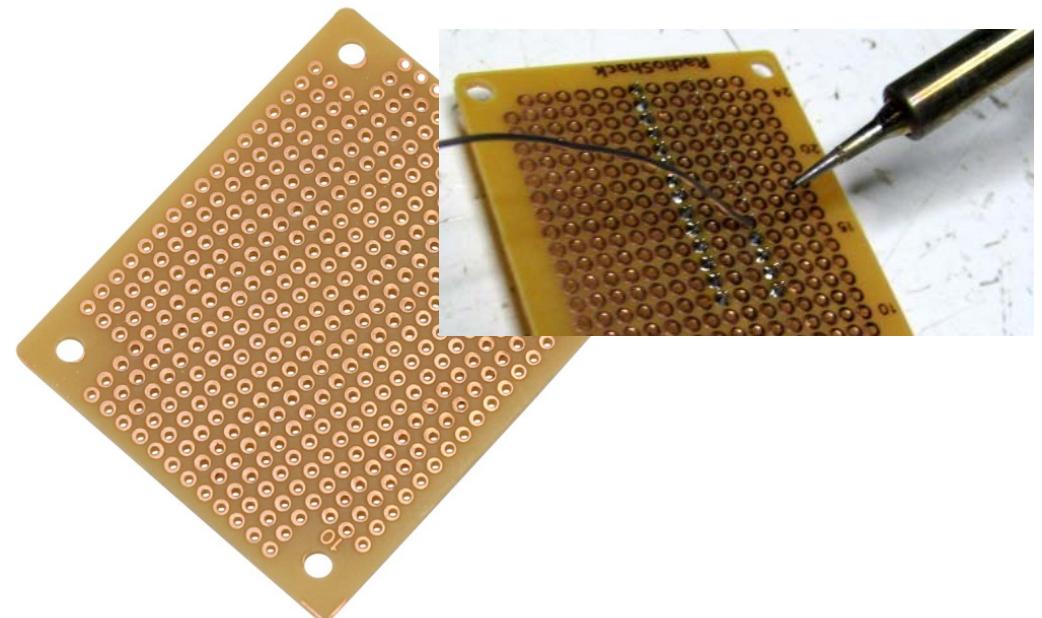
Typically, you start prototyping on a breadboard but then switch over to something like a perfboard once your design is starting to solidify or you want something more permanent. Perfboards require soldering.



Breadboard



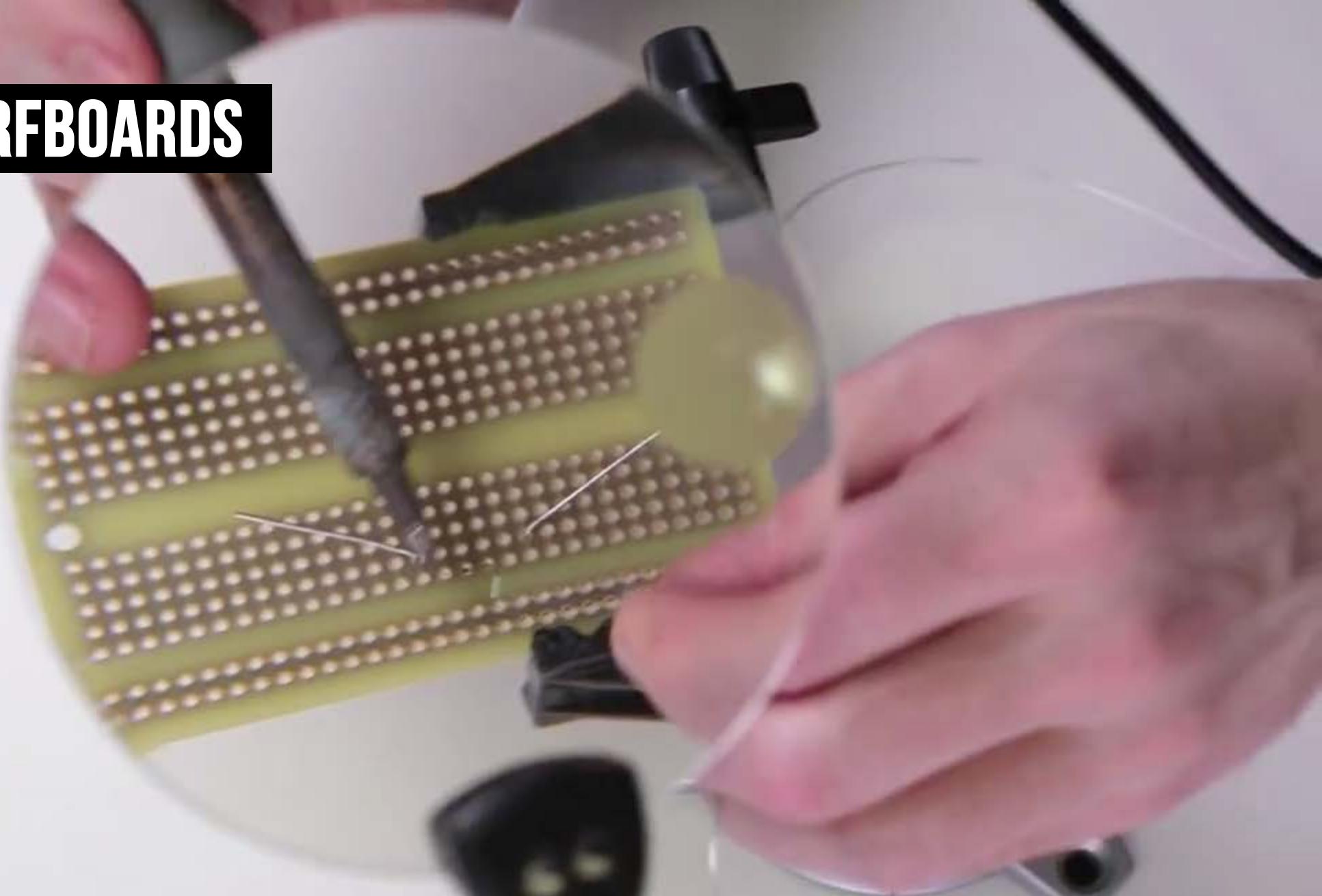
Once design solidifies,
move to perfboard



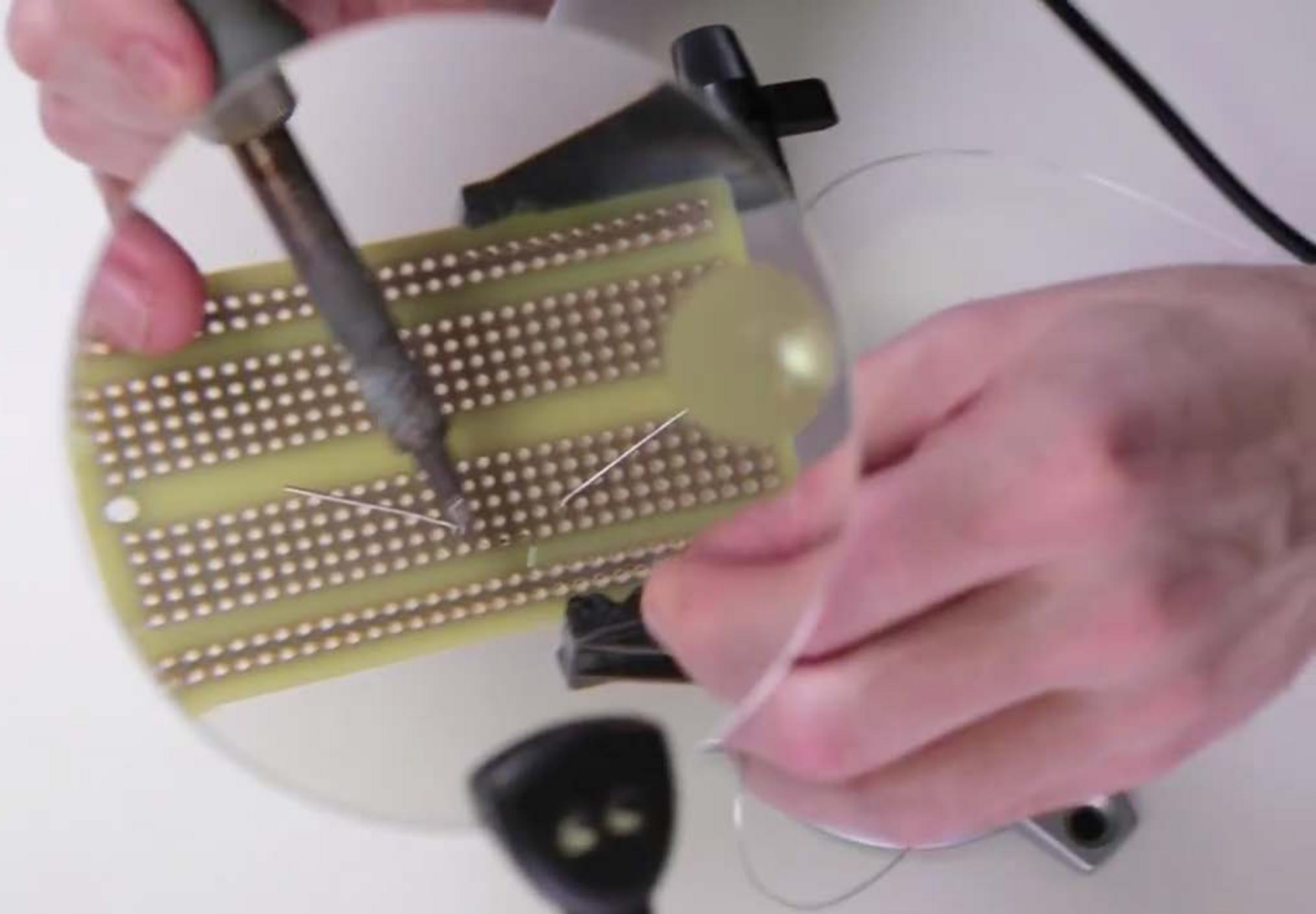
Perfboard

PERFBOARDS

SOLDERING PERFCARDS

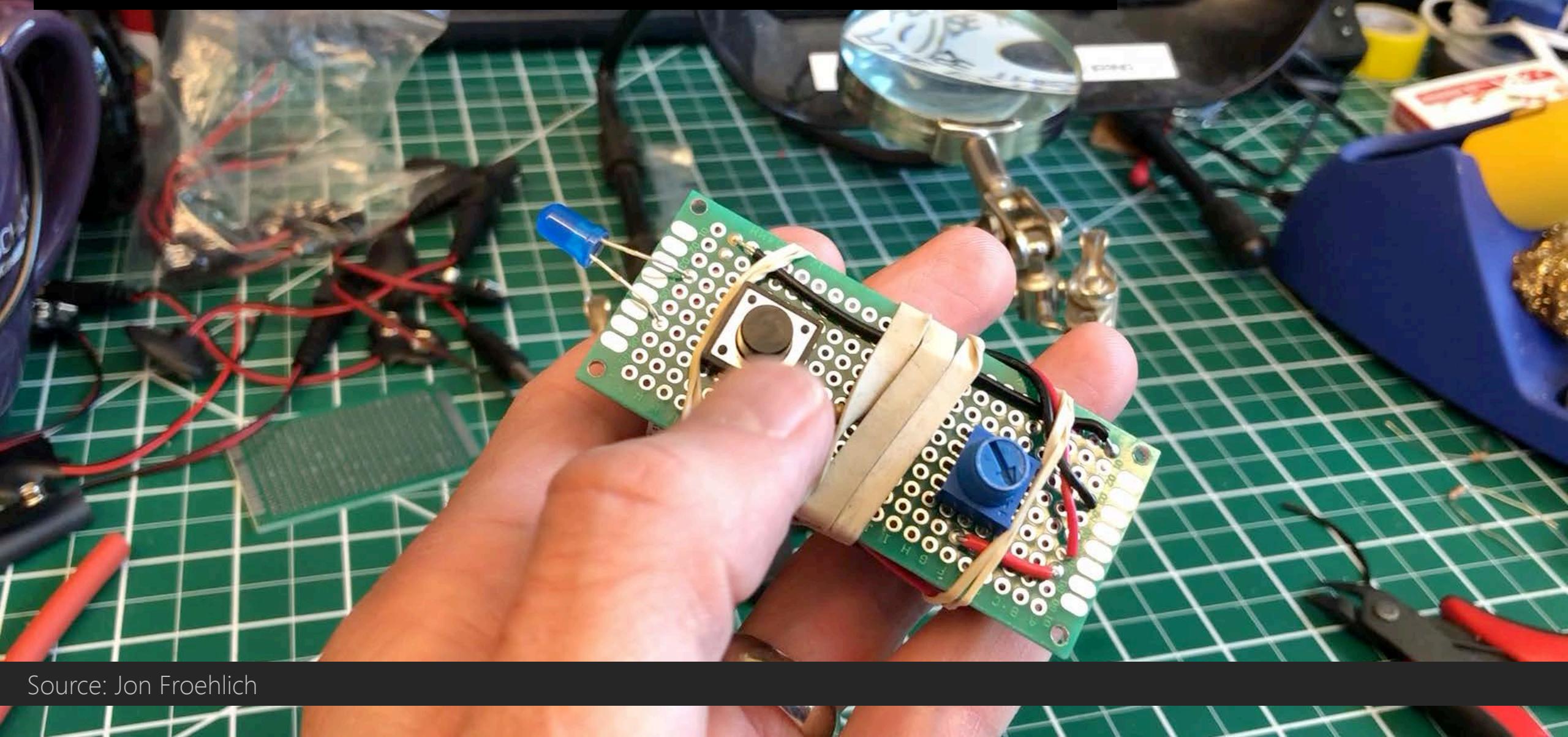


Source: Adafruit, Breadboards and Perfboards, <https://youtu.be/w0c3t0fJhXU>



ACTIVITY

BUILD AN LED FLASHLIGHT WITH A PERFBORD



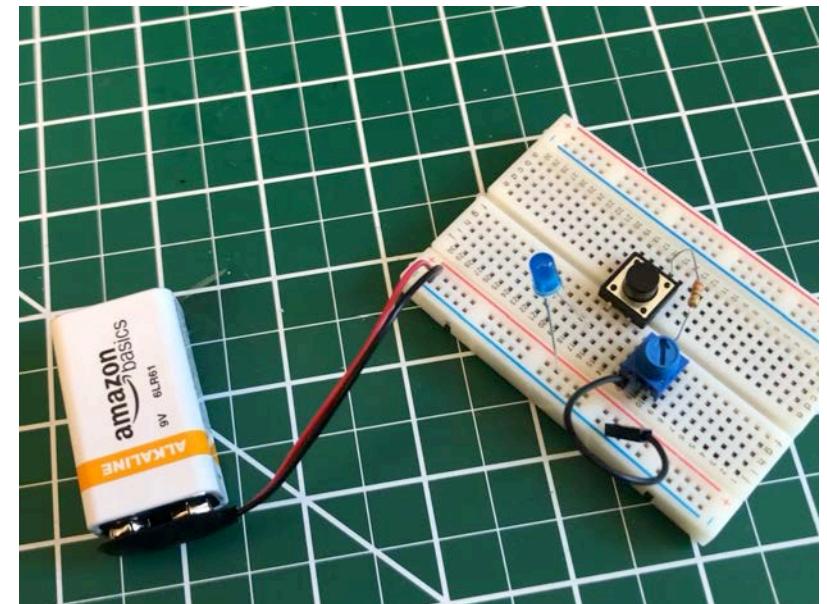
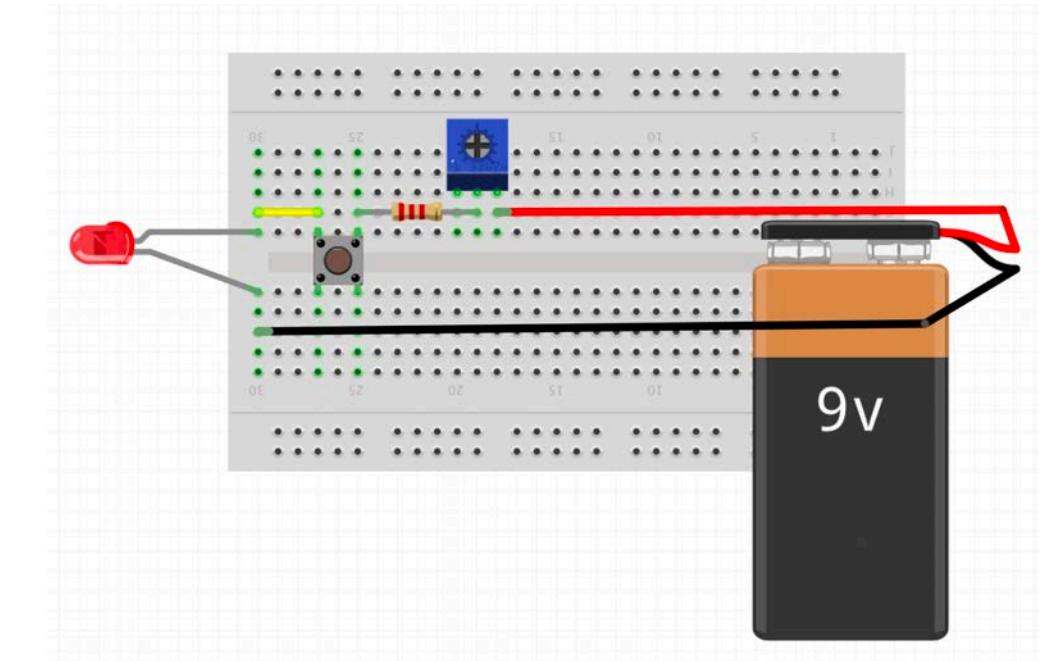
Source: Jon Froehlich

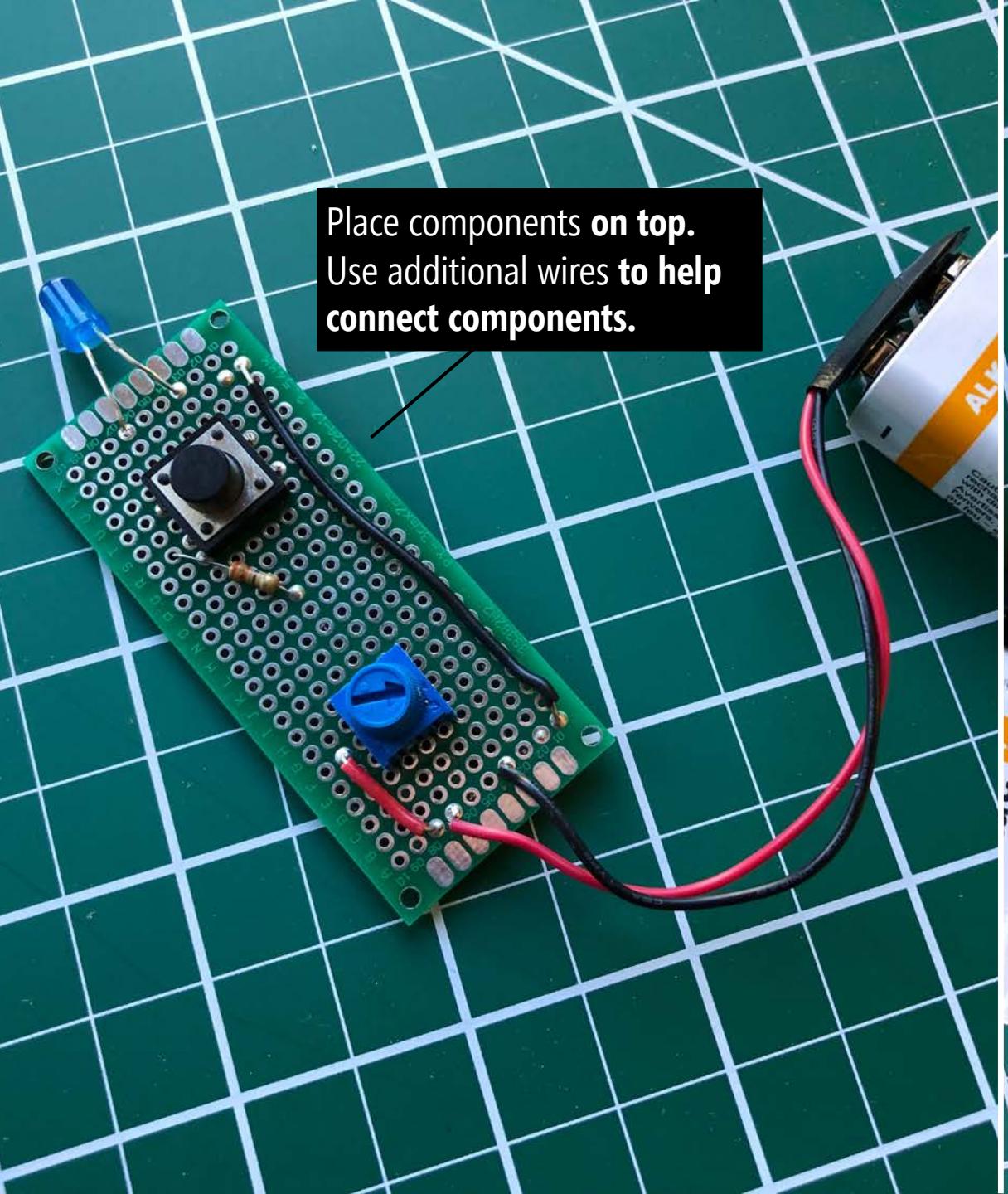
ACTIVITY

BUILD AN LED FLASHLIGHT

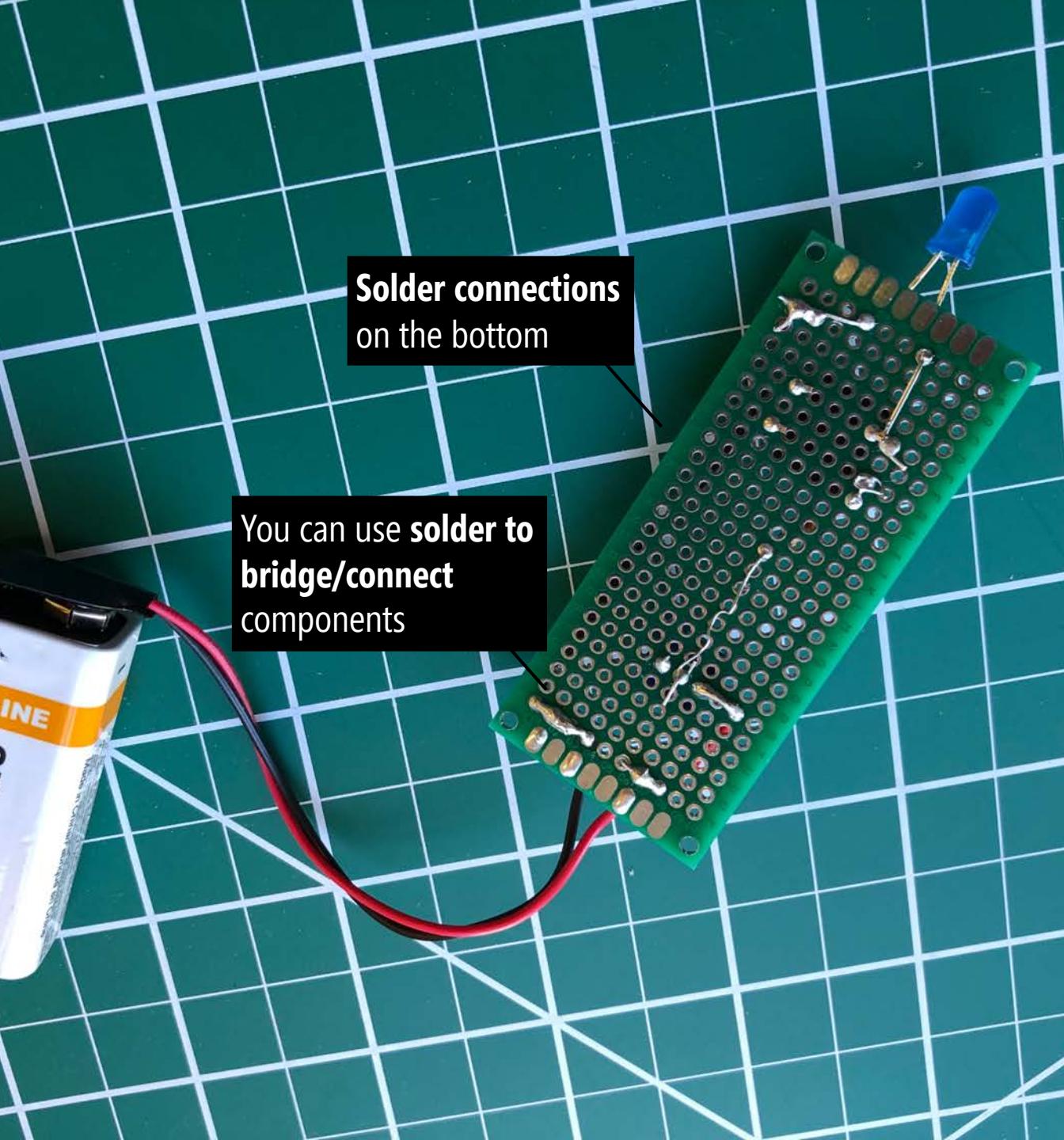
The flashlight must use a **button** to turn it on/off and a **trimpot** to set the **brightness**

Prototype a **breadboard design before soldering** a more permanent solution on a **perfboard**





Place components **on top**.
Use additional wires **to help connect components**.



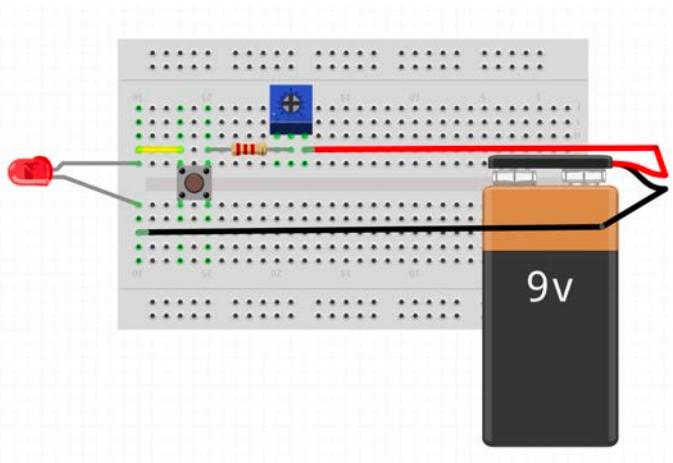
Solder connections
on the bottom

You can use **solder to bridge/connect**
components

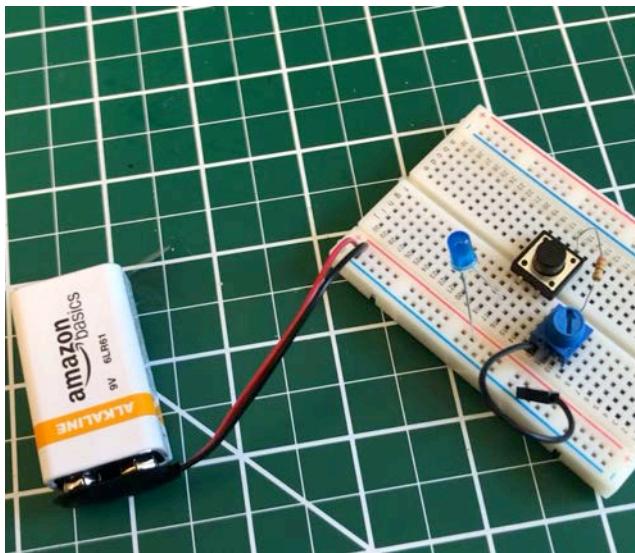
ACTIVITY

DESIGN PROCESS

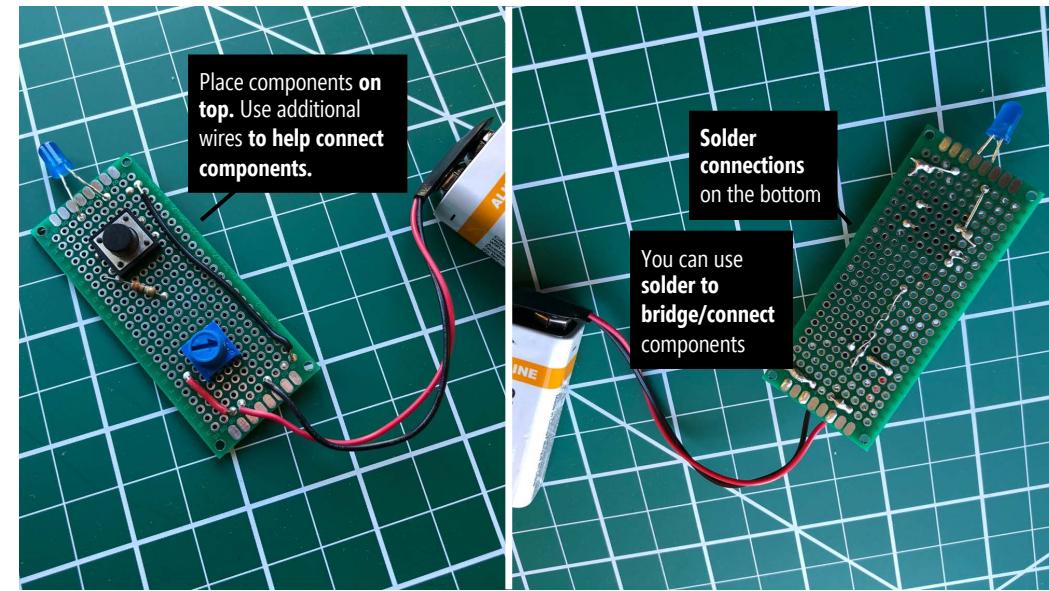
1. Design Circuit



2. Breadboard it

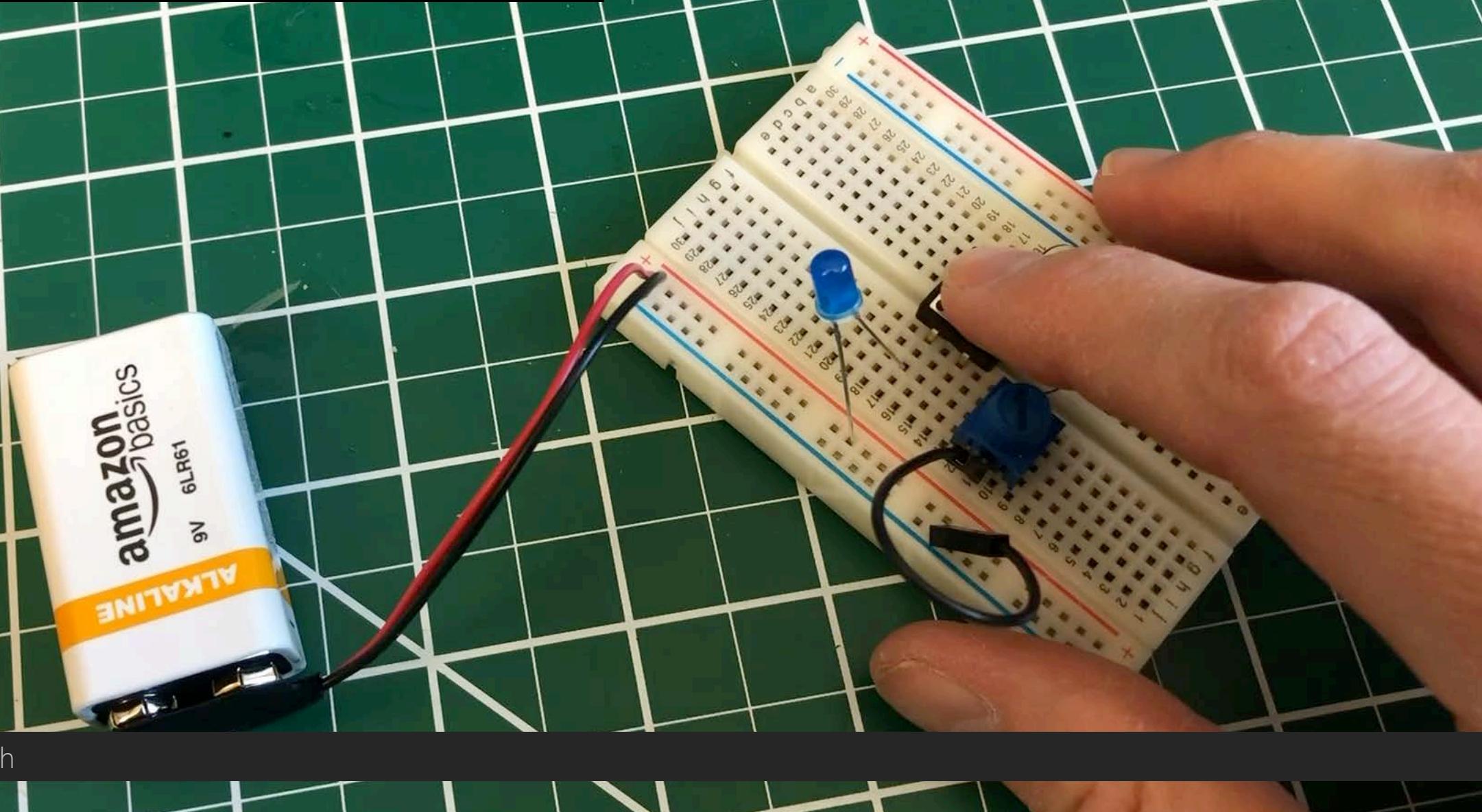


3. Perfboard + solder it



ACTIVITY

VIDEO OF FULL MAKING PROCESS



Source: Jon Froehlich



DESOLDERING

DESOLDERING

USING A SOLDER SUCKER & SOLDER WICK



Source: Adafruit Tutorial, Desoldering, https://youtu.be/N_dvf45hN6Y



HEAT SHRINK TUBING



ELECTRONIC HAND TOOLS

REPAIRING A WIRE WITH HEAT SHRINK TUBING



ELECTRONIC HAND TOOLS

OTHER USES FOR HEAT SHRINK TUBING



Source: Jon Froehlich

LEARNING GOALS

PROTOTYPING FORM 3: WIRE TOOLS + SOLDERING

Intro to **wires**

Intro to basic **electronic hand tools**

How to **solder**

How to use a **perfboard**

Design activity: **build an LED flashlight** with a perfboard

(If time) **Solder header pins** on ADXL335 accelerometer

Ken Yasuhara from Engineering Teaching and Learning Center

PROTOTYPING FORM 3: WIRE TOOLS/SOLDERING

CSE 599 Prototyping Interactive Systems | Lecture 9 | April 29

Jon Froehlich • Jasper Tran O'Leary (TA)