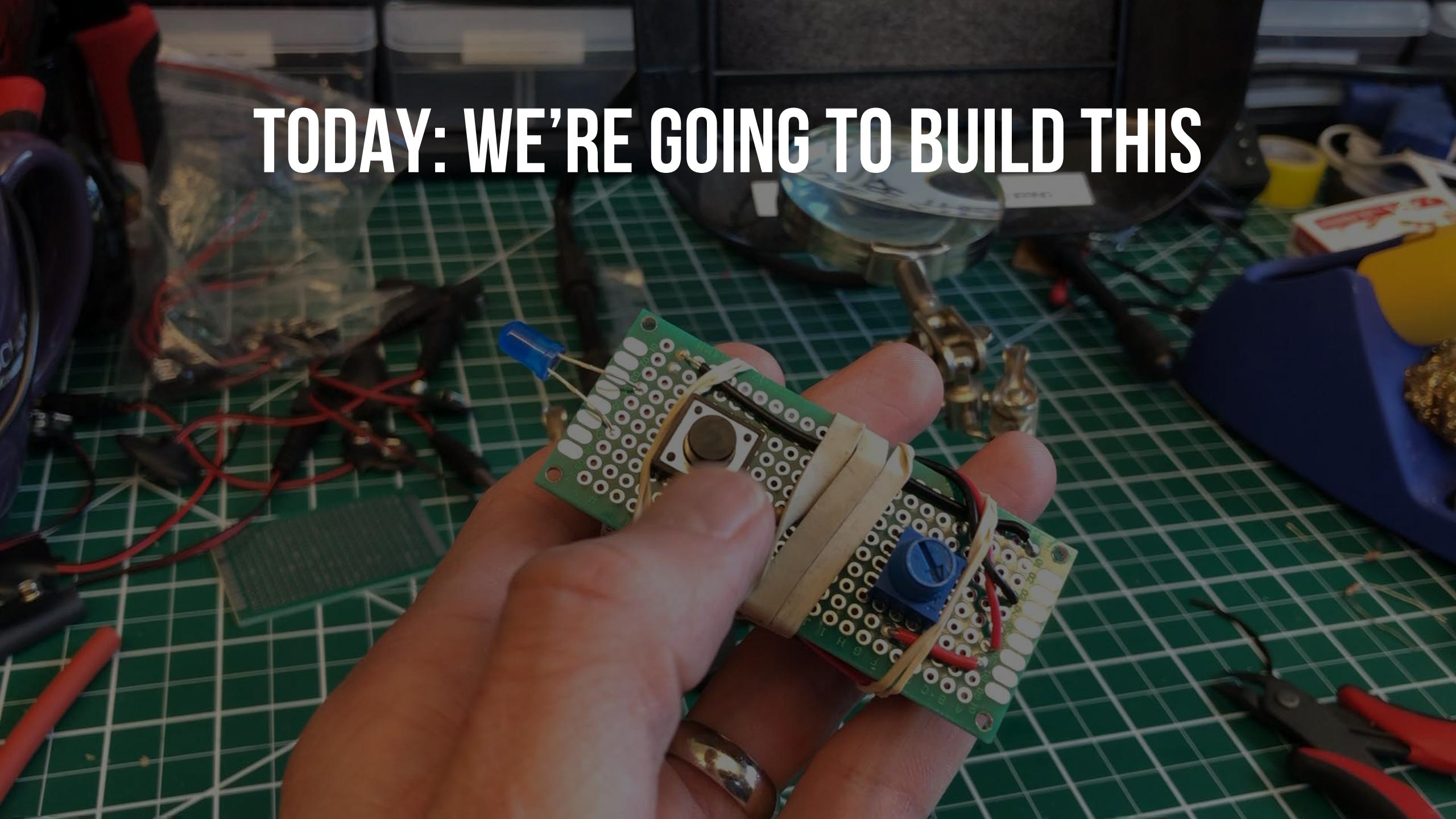


# PROTOTYPING FORM 2: WIRE TOOLS/SOLDERING

CSE 599 Prototyping Interactive Systems | Lecture 8 | Oct 22

**Jon Froehlich** • Liang He (TA)

# TODAY: WE'RE GOING TO BUILD THIS



Spring 2019

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# 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

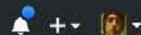
This assignment will illustrate and fabricate 3D-printed interactive and light-based products.

**Related Items**[SpeedGrader™](#)



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jonfroehlich Update README.md

Latest commit f49411d 4 hours ago

- Adafruit HUZZAH32 ESP32 Feather with Headers.iges Create Adafruit HUZZAH32 ESP32 Feather with Headers.iges 5 hours ago
- Huzzah32 Simple.iges Added Huzzah32 IGES model yesterday
- README.md Update README.md 4 hours ago

README.md



I created two Adafruit Huzzah32 ESP32 Feather models in Fusion360: [Huzzah32 Simple.iges](#), which contains the board, USB connector, and ESP chip, and [Adafruit HUZZAH32 ESP32 Feather with Headers.iges](#), which also includes the header pins and a JST connector.

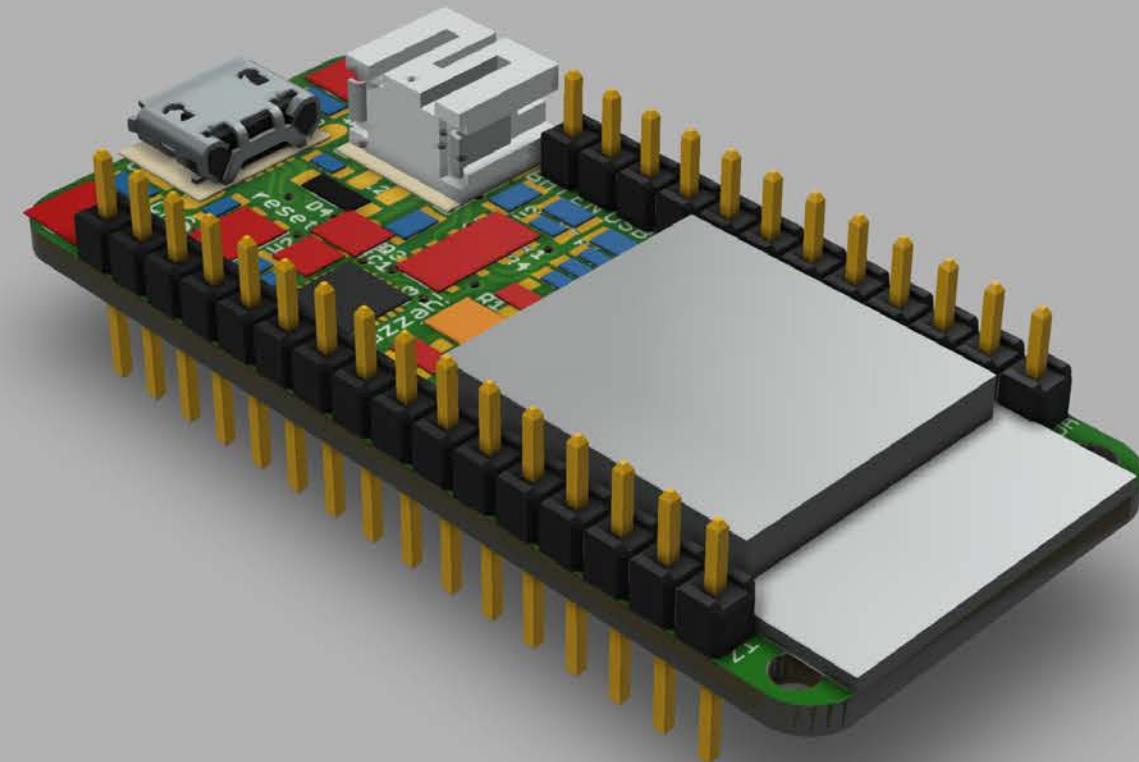
You can find the full Fusion 360 project here: <https://a360.co/2JaYhVX>.

Measurements based on an import of the [Adafruit HUZZAH32 ESP32 Feather.brd](#) Eagle Design files and some small amount of manual measurements (using calipers).

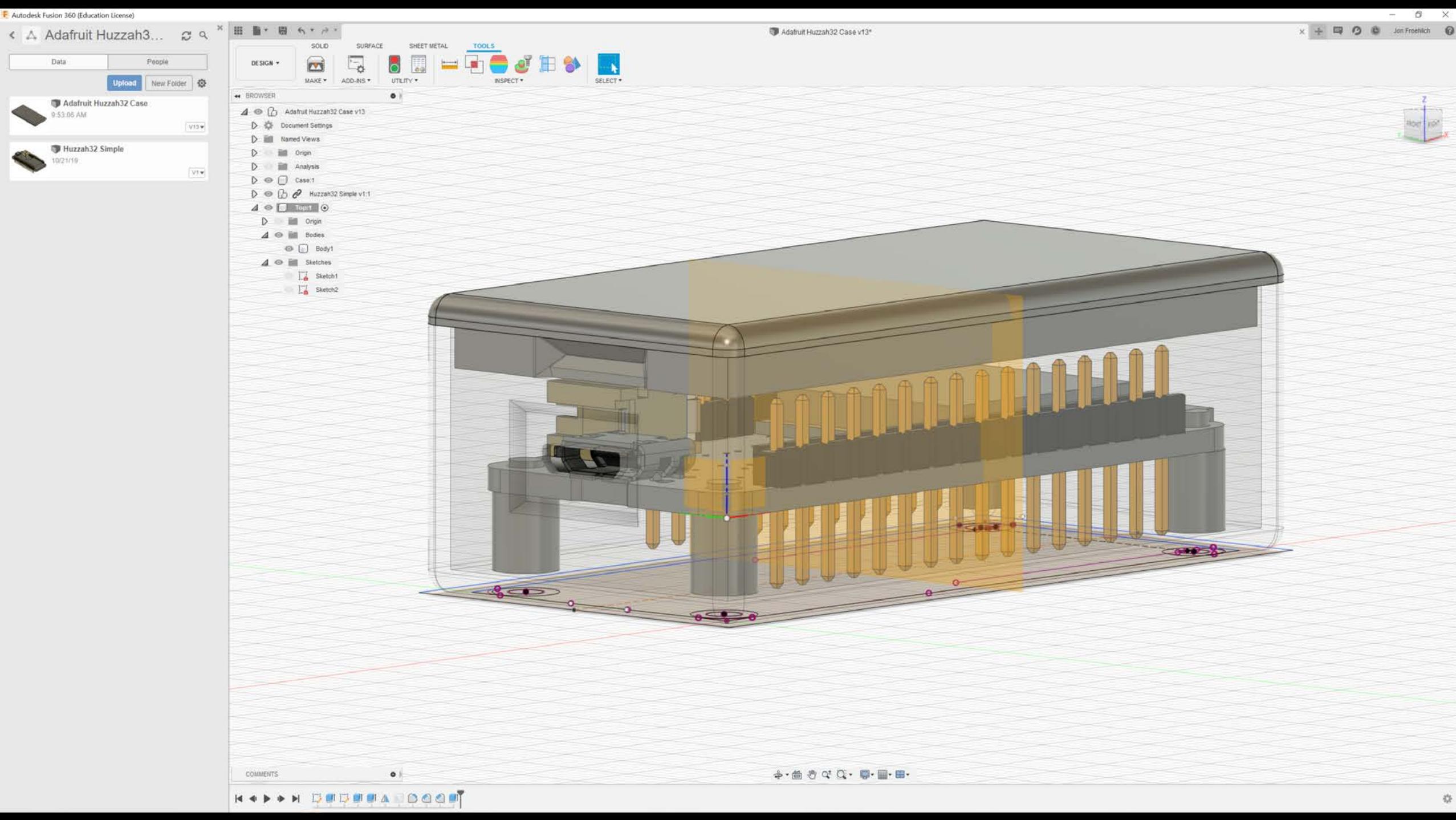
Imported models from:

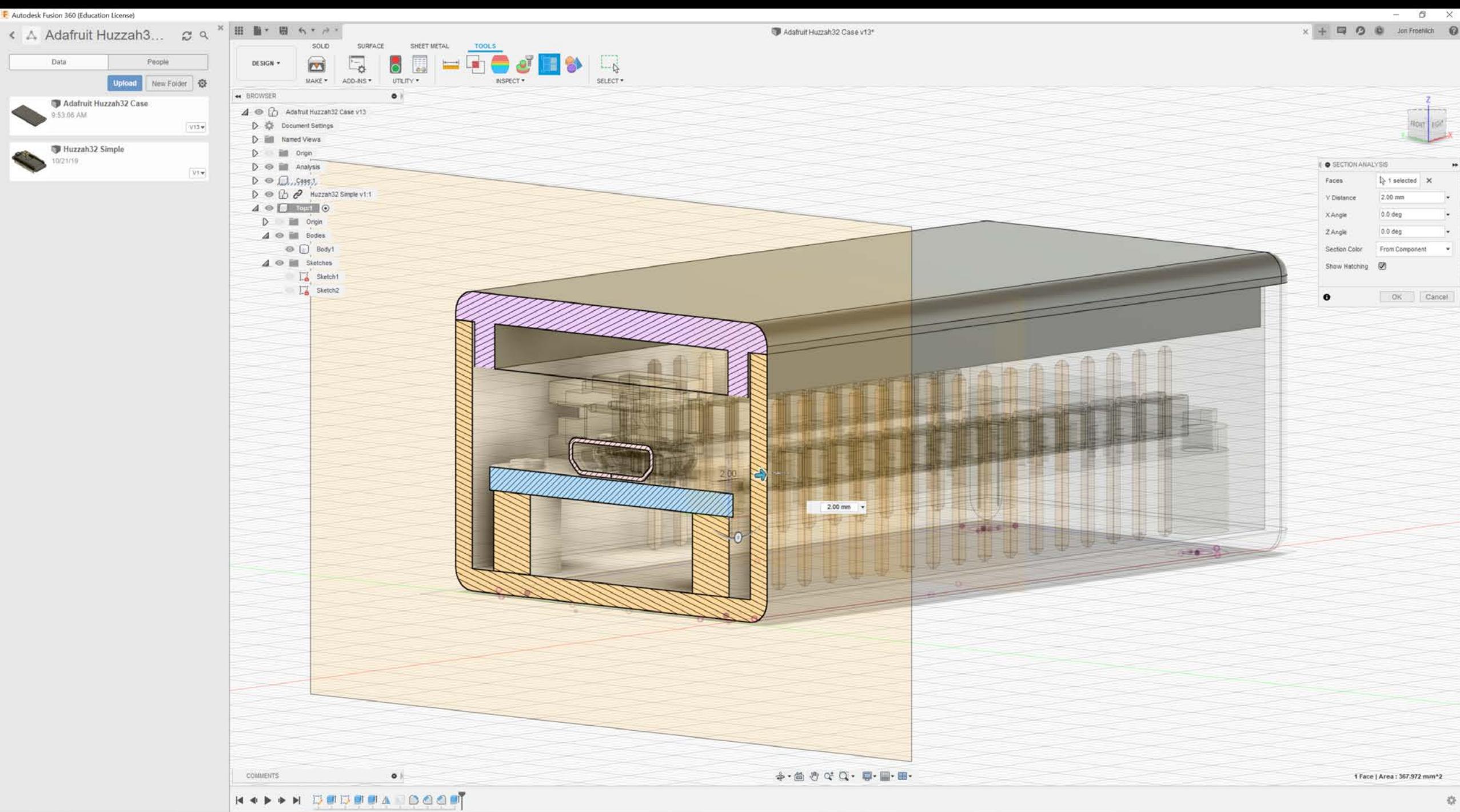
- [USB Micro-B Socket model](#) by Aron Rubin
- [JST B2B-PH-SM4-TB](#) by Andrey Sviyazov
- [Pin Headers Single Row](#) by singlefonts

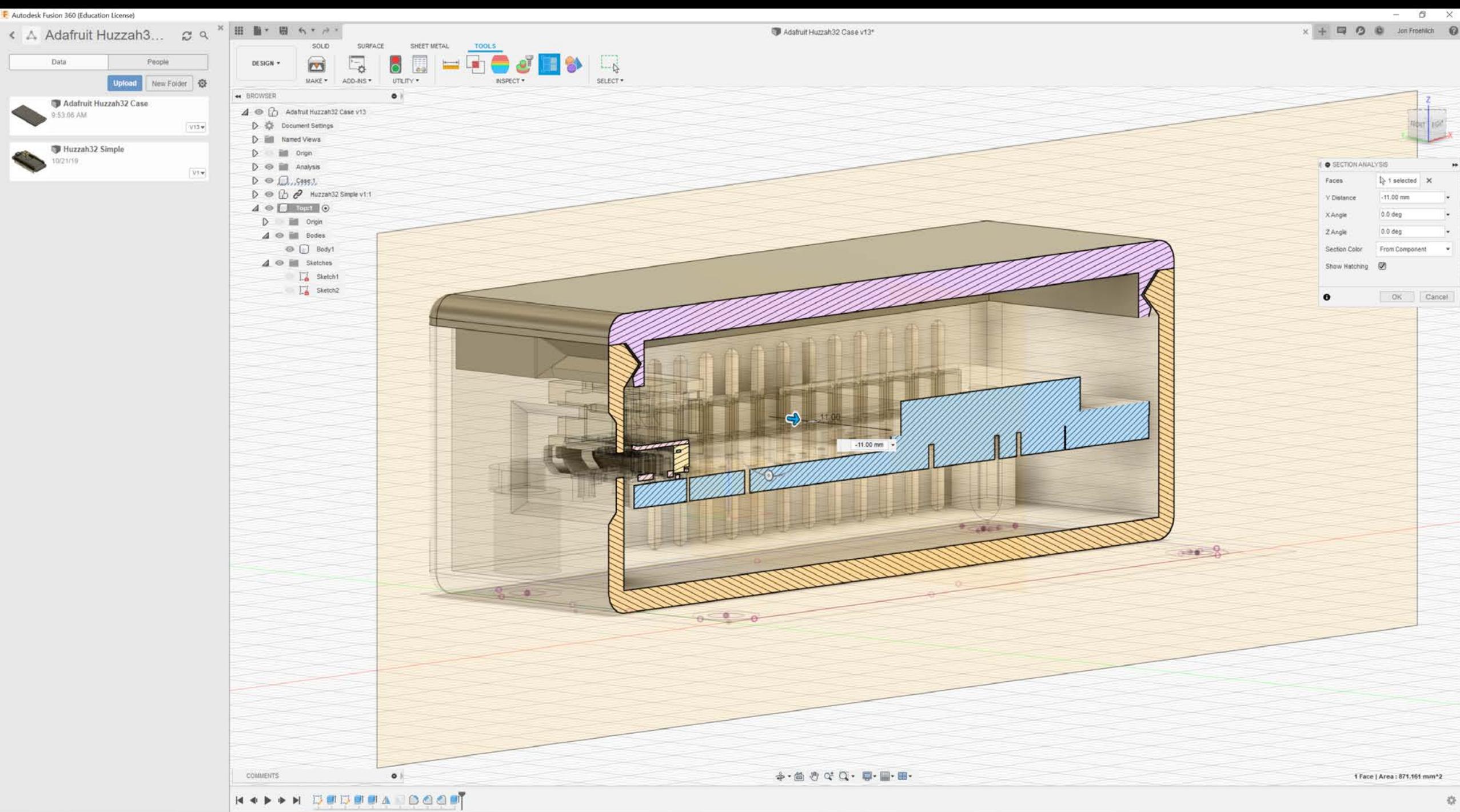


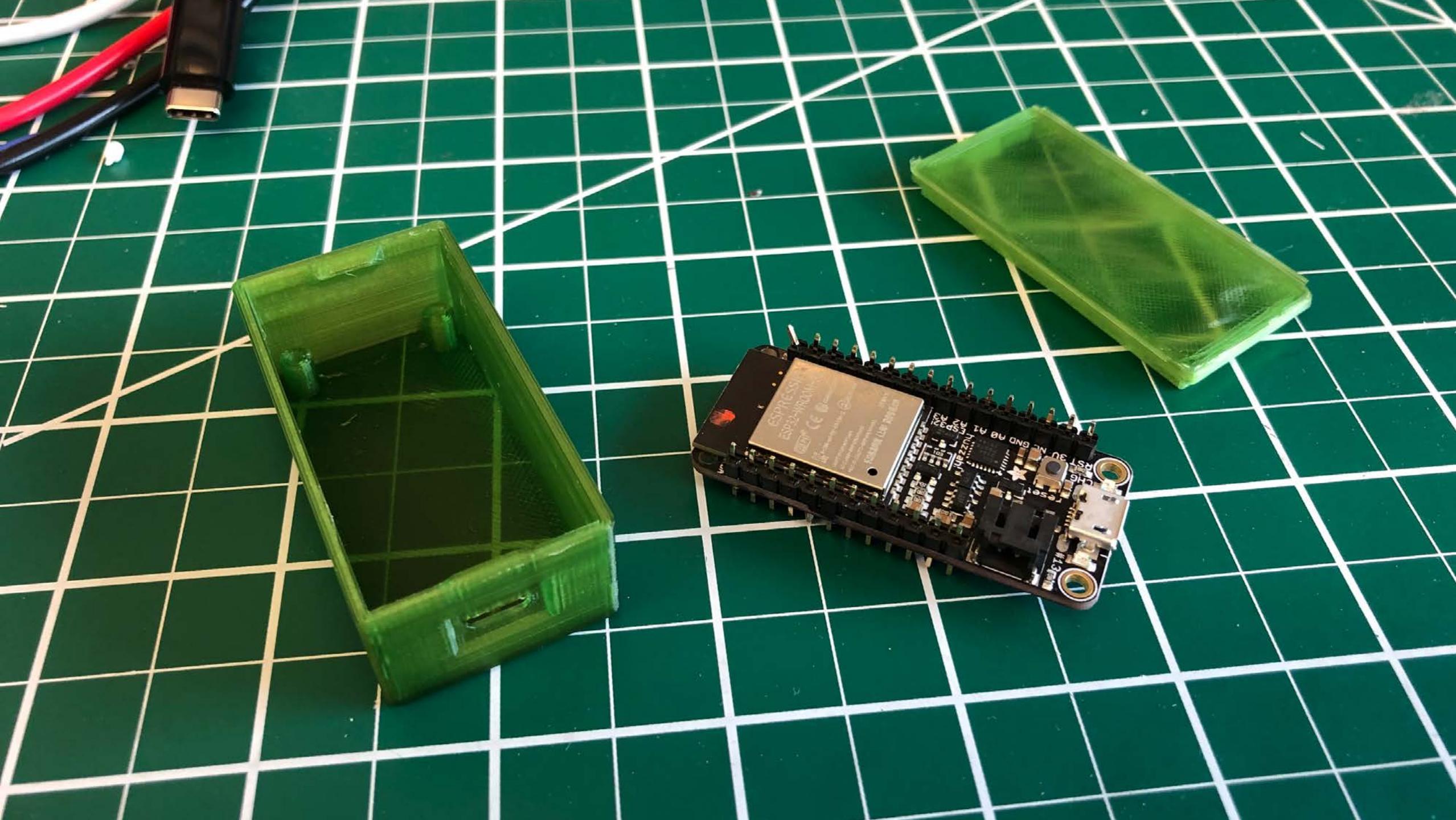


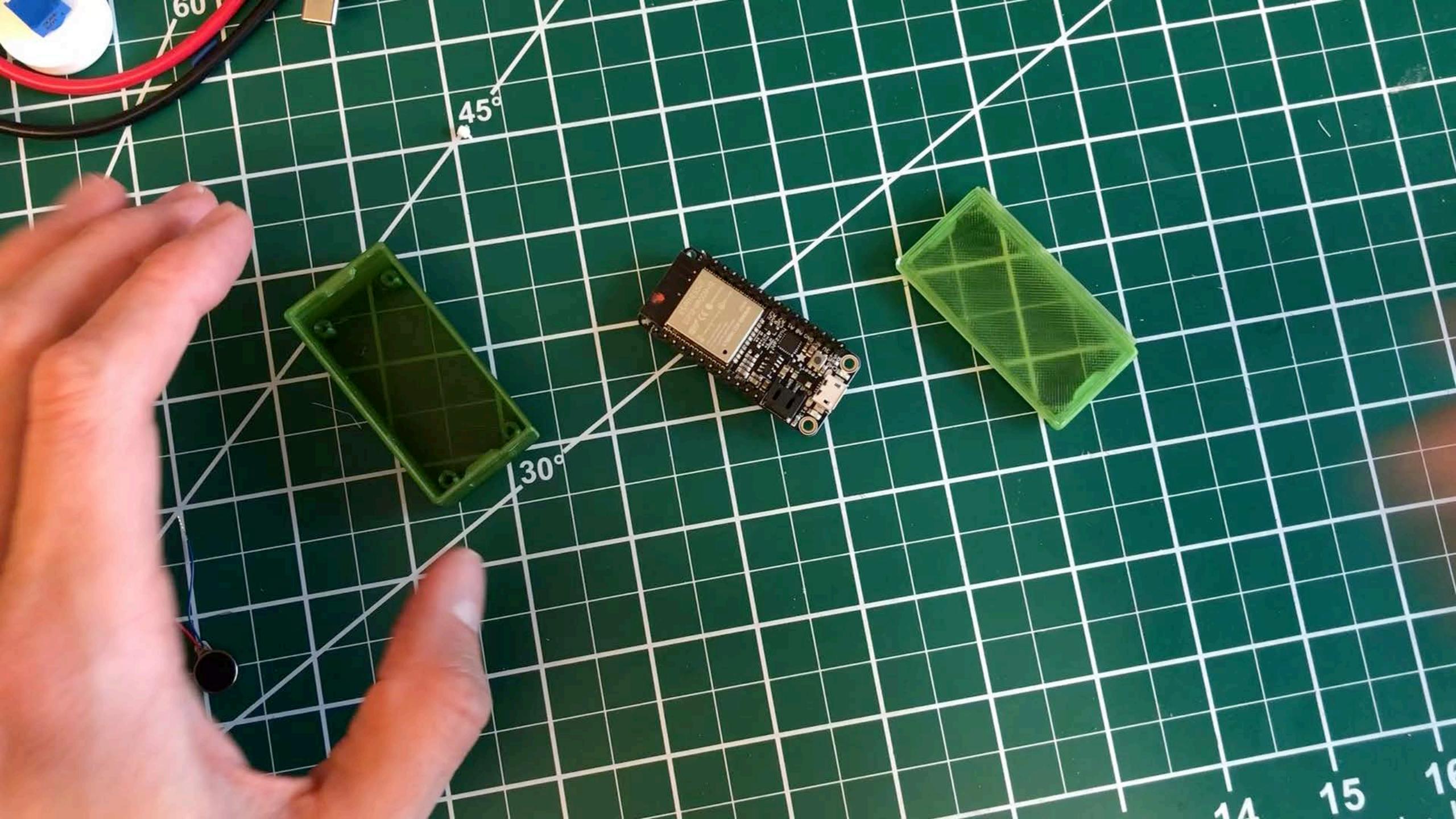
Source: Jon Froehlich, <https://a360.co/2JaYhVX>











45°

30°

14 15 16

## 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

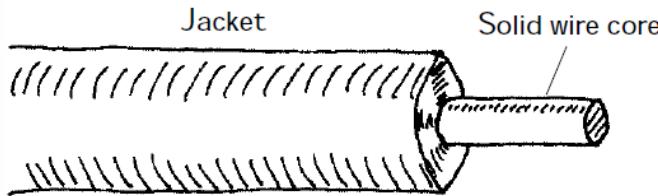
(If time) **Solder header pins** on Adafruit Huzzah32

A close-up photograph of a large bundle of optical fibers. The fibers are numerous, tightly packed, and exhibit a vibrant rainbow of colors including red, orange, yellow, green, blue, and purple. They are coiled in a complex, helical pattern, creating a sense of depth and texture. The background is dark, which makes the bright colors of the fibers stand out sharply.

WIRES

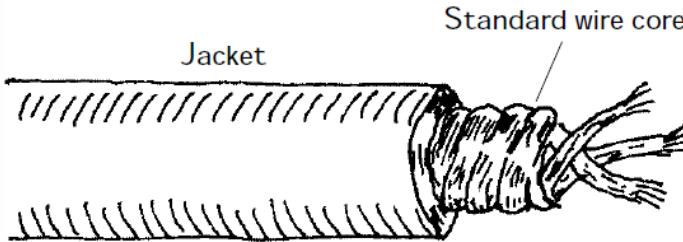
# COMMON WIRE TYPES

## Solid Core



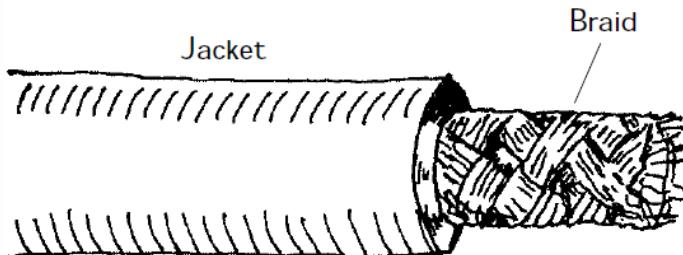
This wire is useful for **wiring breadboards**; the solid-core ends slip easily into breadboard sockets and will not fray in the process. However, these wires have the **tendency to snap** after a number of flexes

## 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**.

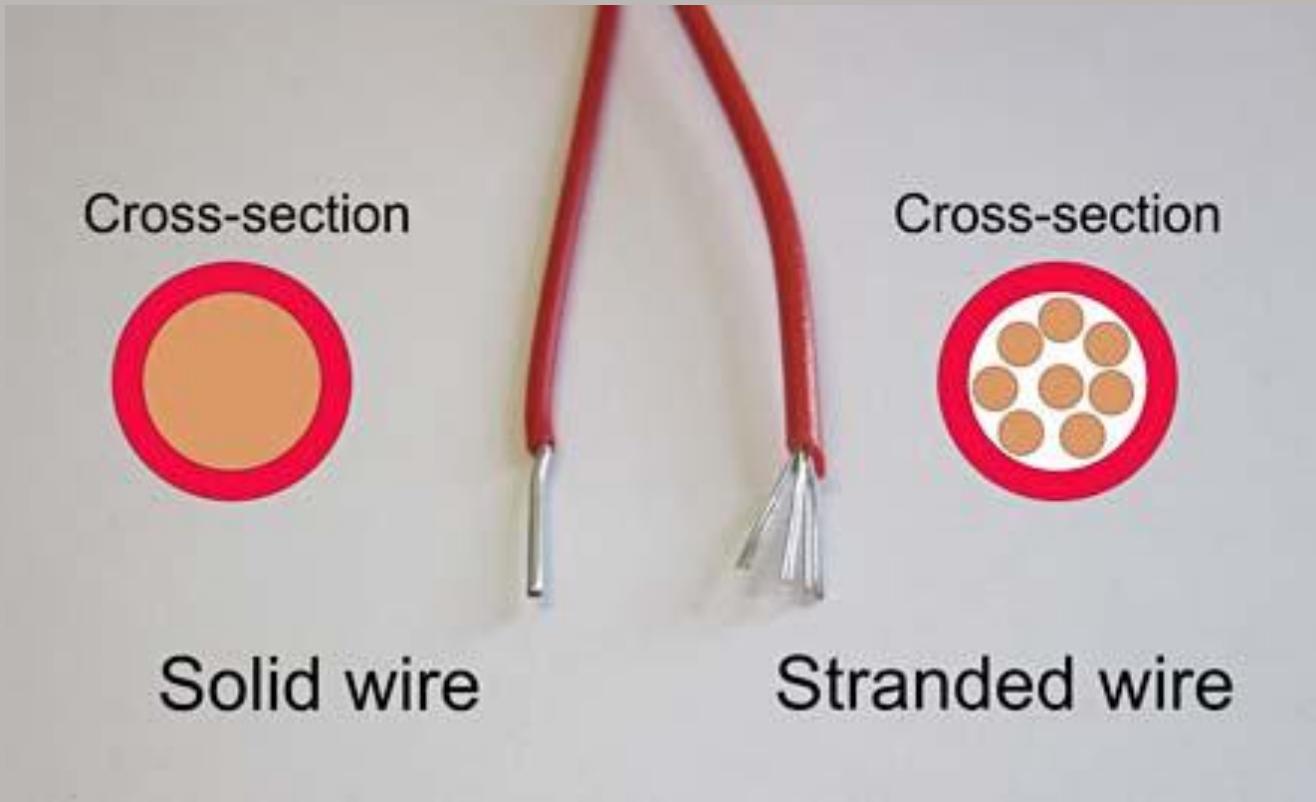
## Braided Wire



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.

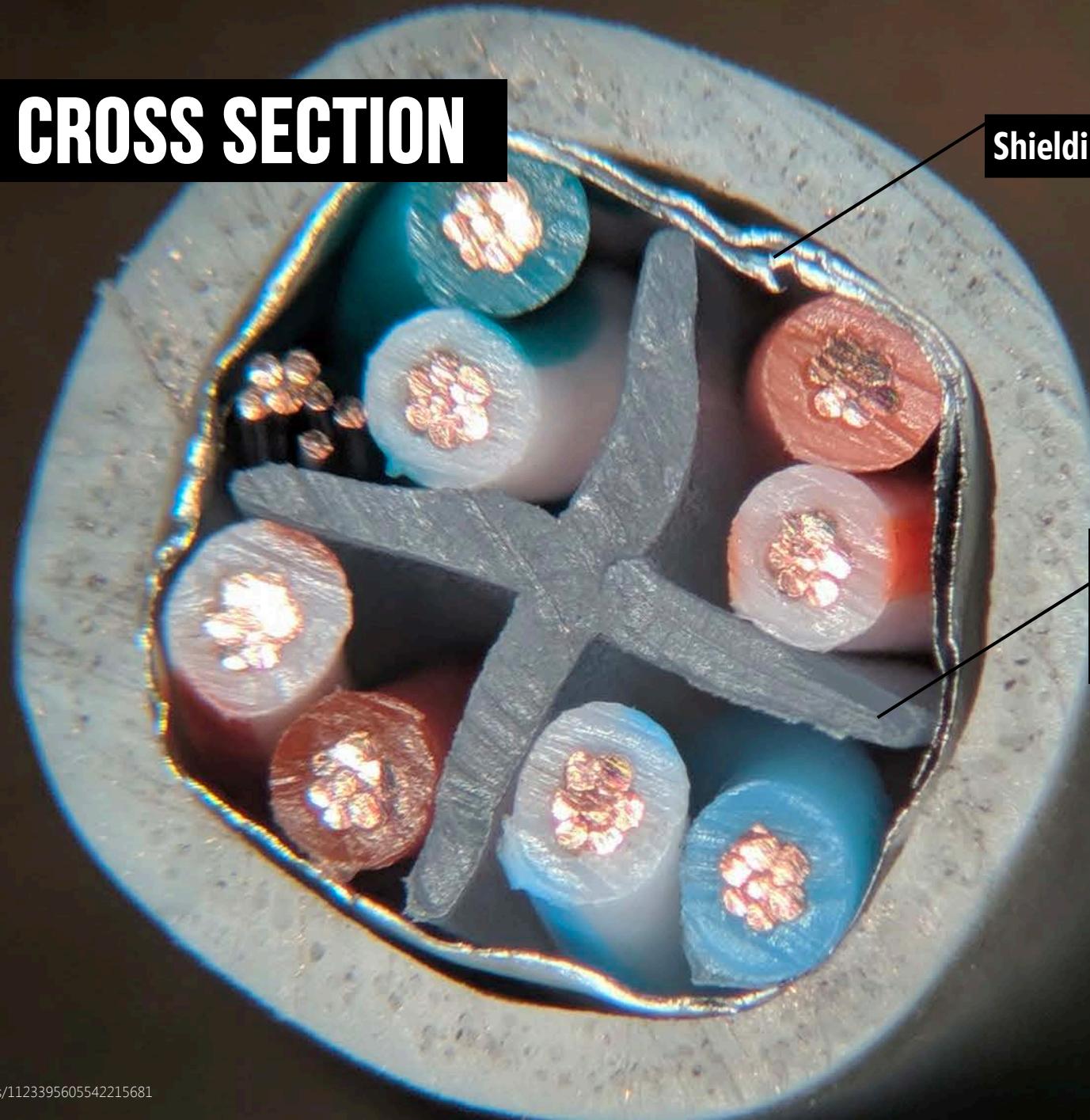
WIRES

# SOLID CORE VS. STRANDED



WIRES

# CAT6 CABLE CROSS SECTION



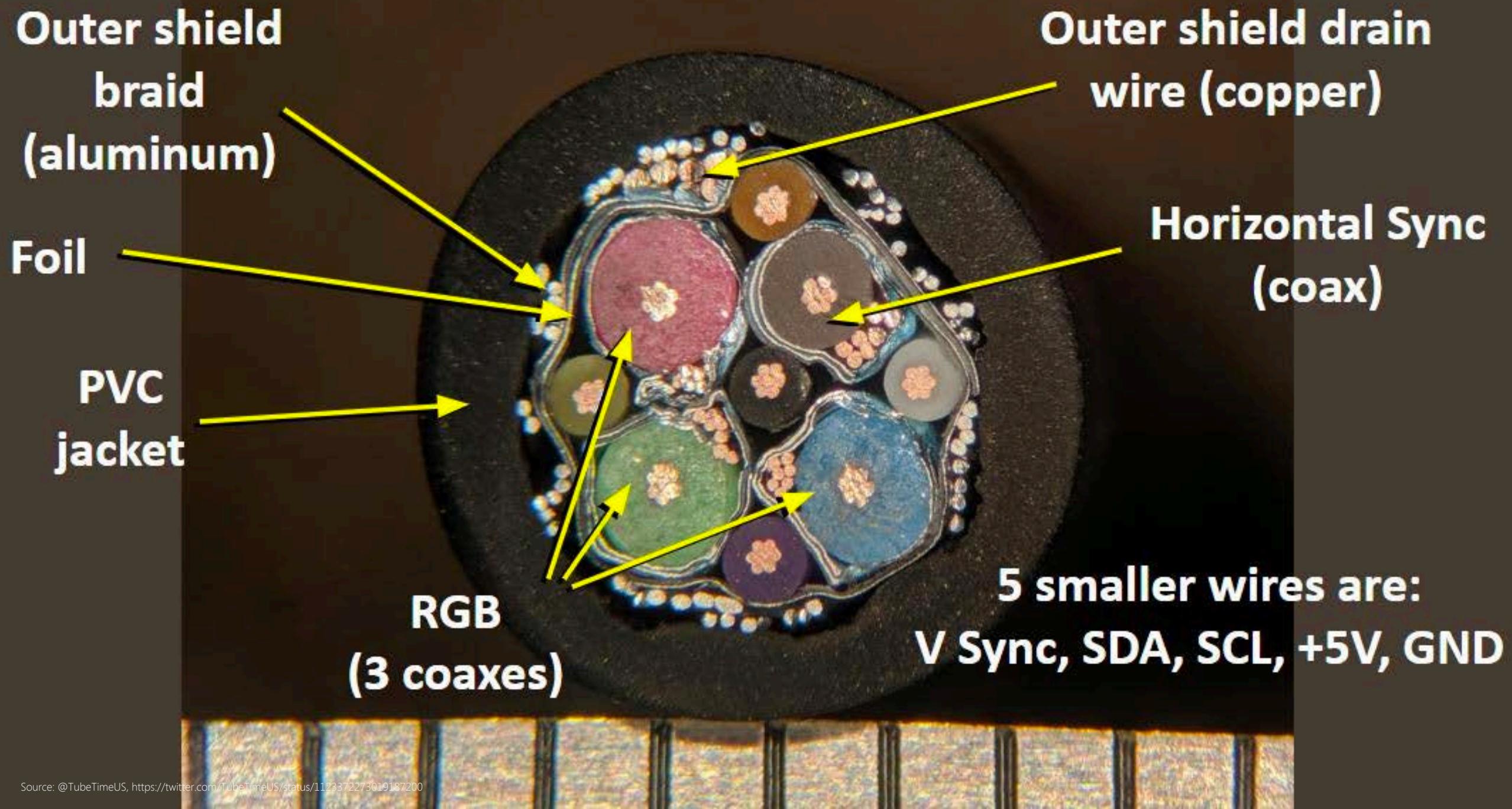
Shielding to reduce noise

Plastic "+" separator  
to reduce crosstalk  
between wire pairs

WIRES

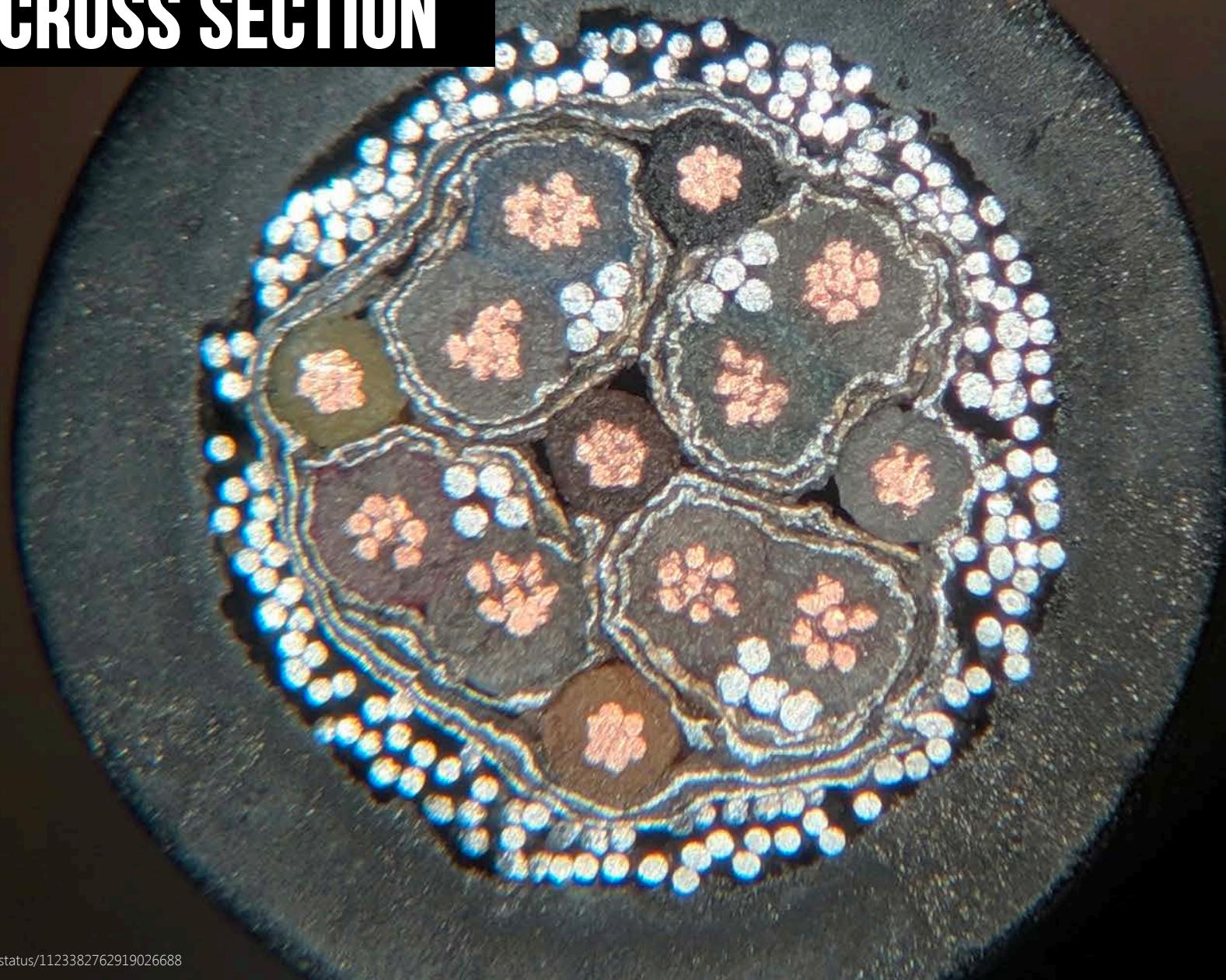
# VGA CABLE CROSS SECTION





WIRES

# DVI CABLE CROSS SECTION



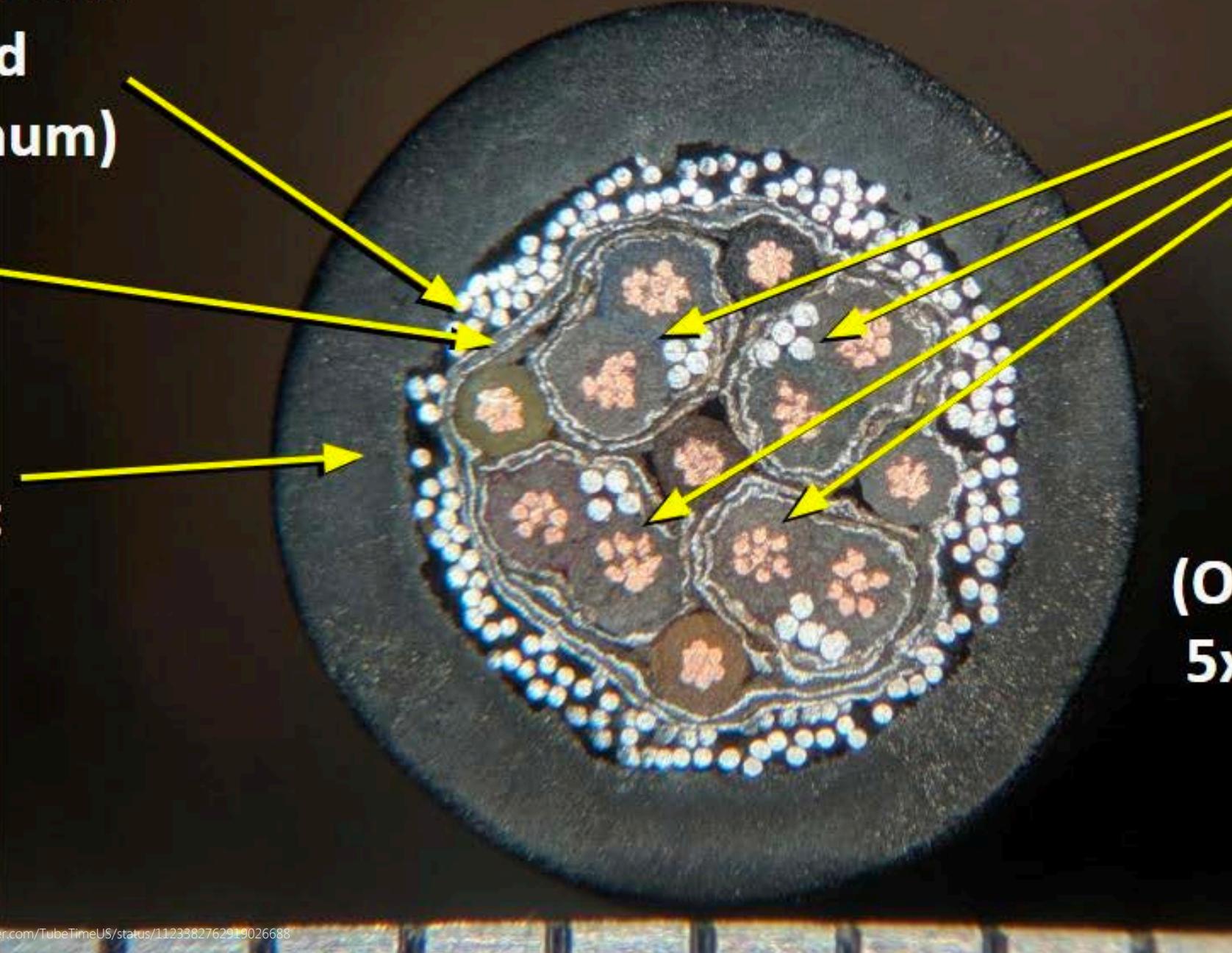
Outer shield  
braid  
(aluminum)

Foil

PVC  
jacket

3x TMDS +  
clock pair

(Other wires are  
5x DDC signals)



Outer shield  
braid  
(aluminum)

Foil

PVC  
jacket

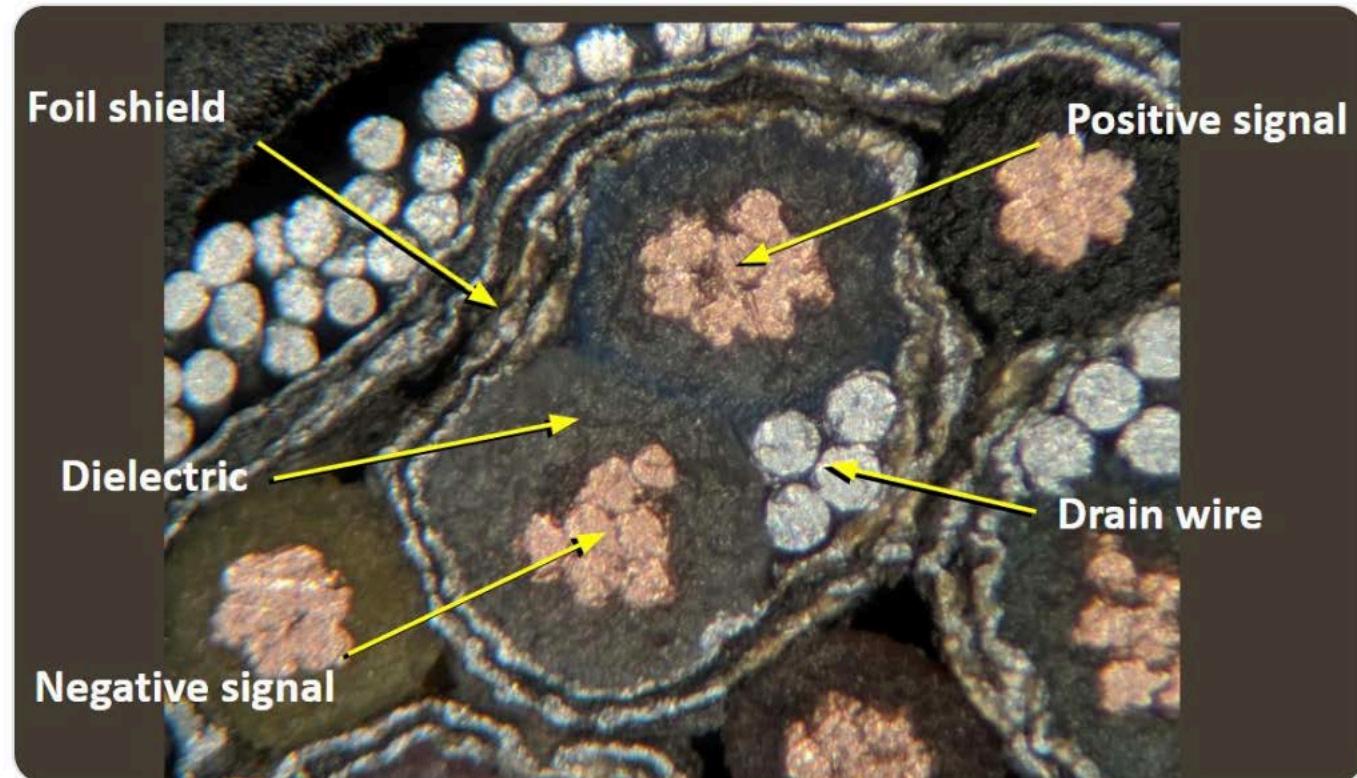
3x TMDS +  
clock pair

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

WIRES

# USB CABLE CROSS SECTION



**7-strand copper conductor**

**Colored PVC insulation**

**Ground (negative)**

**USB data (D-)**

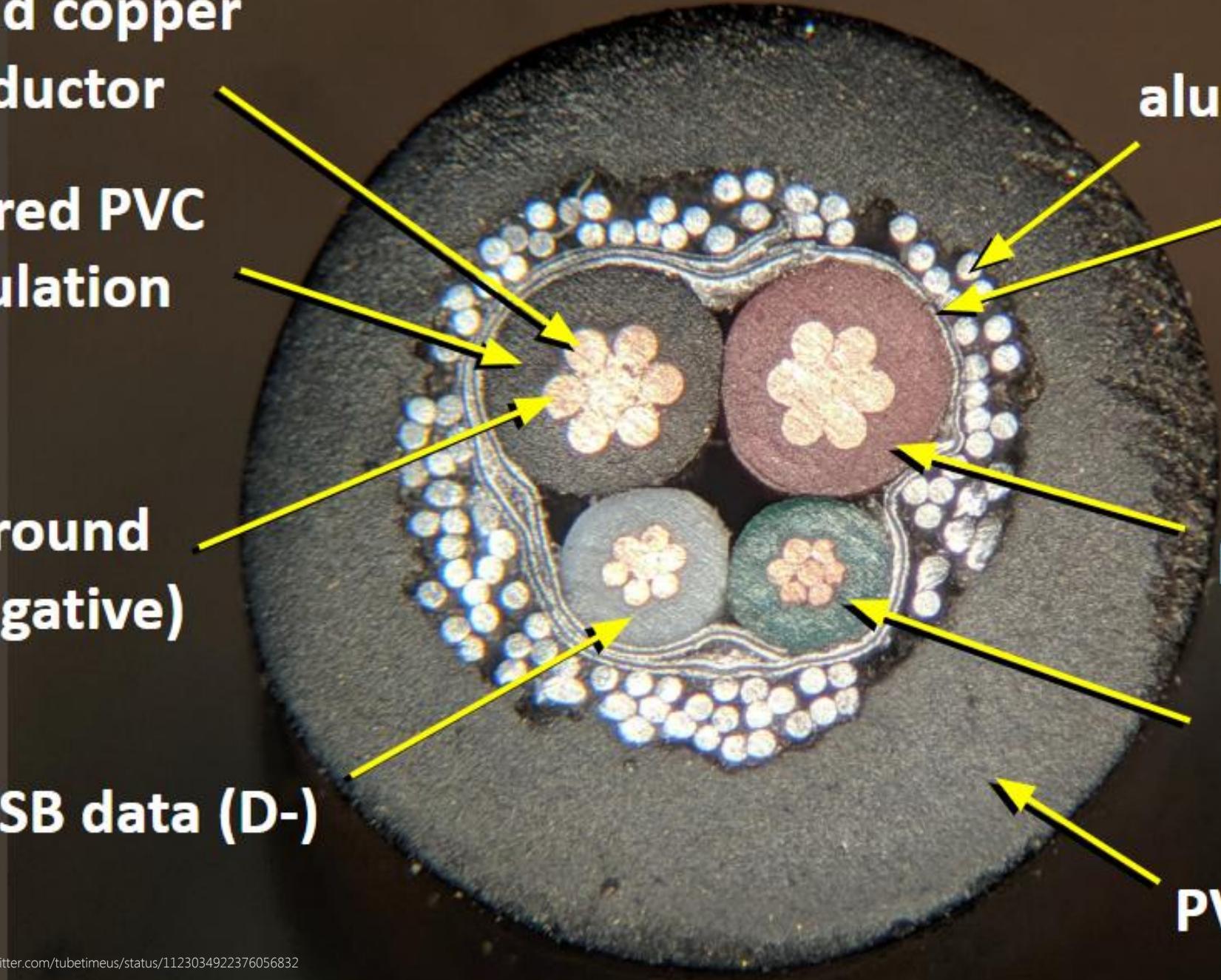
**Braided aluminum shield**

**Foil shield**

**Positive 5 volts**

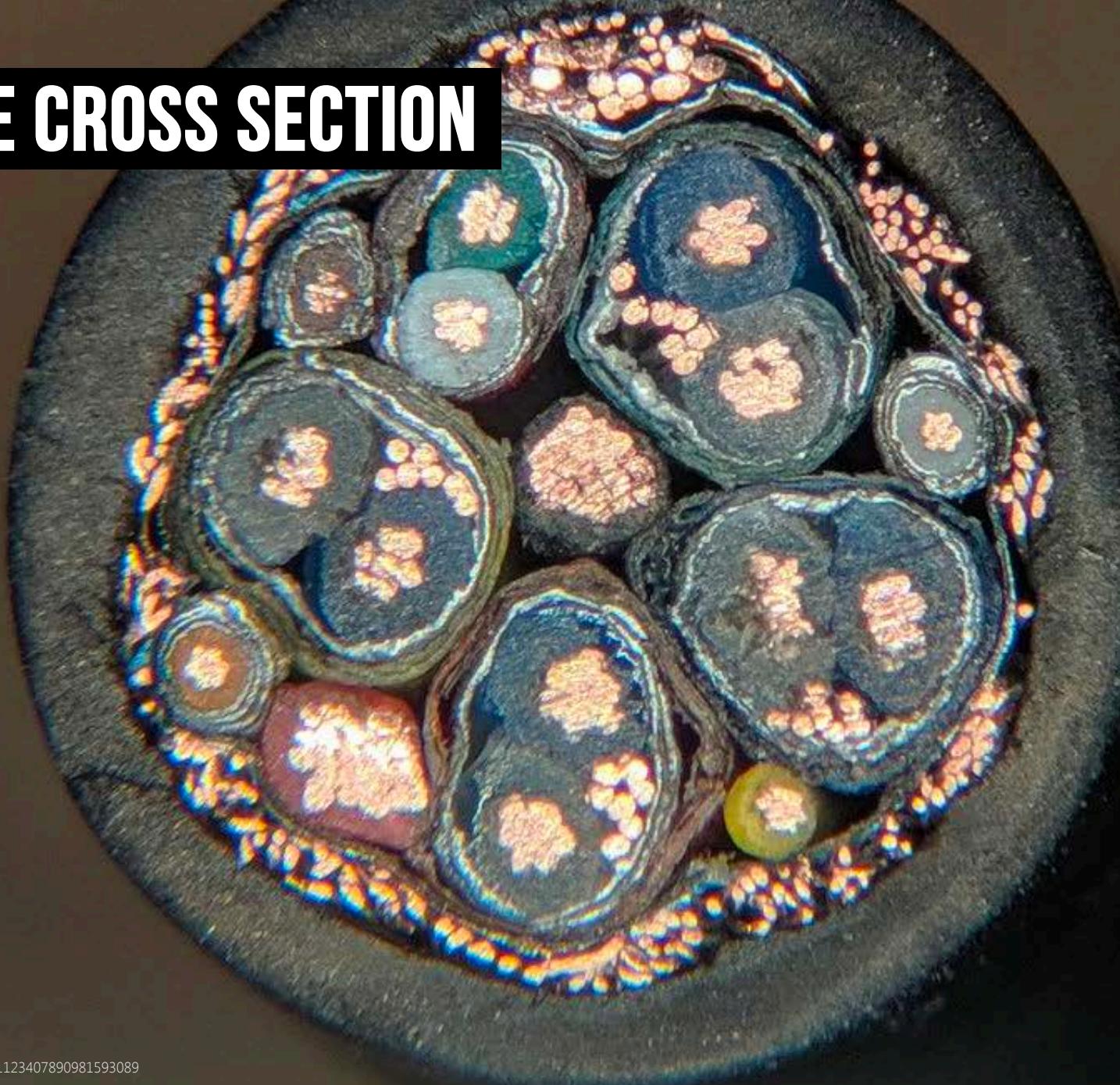
**USB data (D+)**

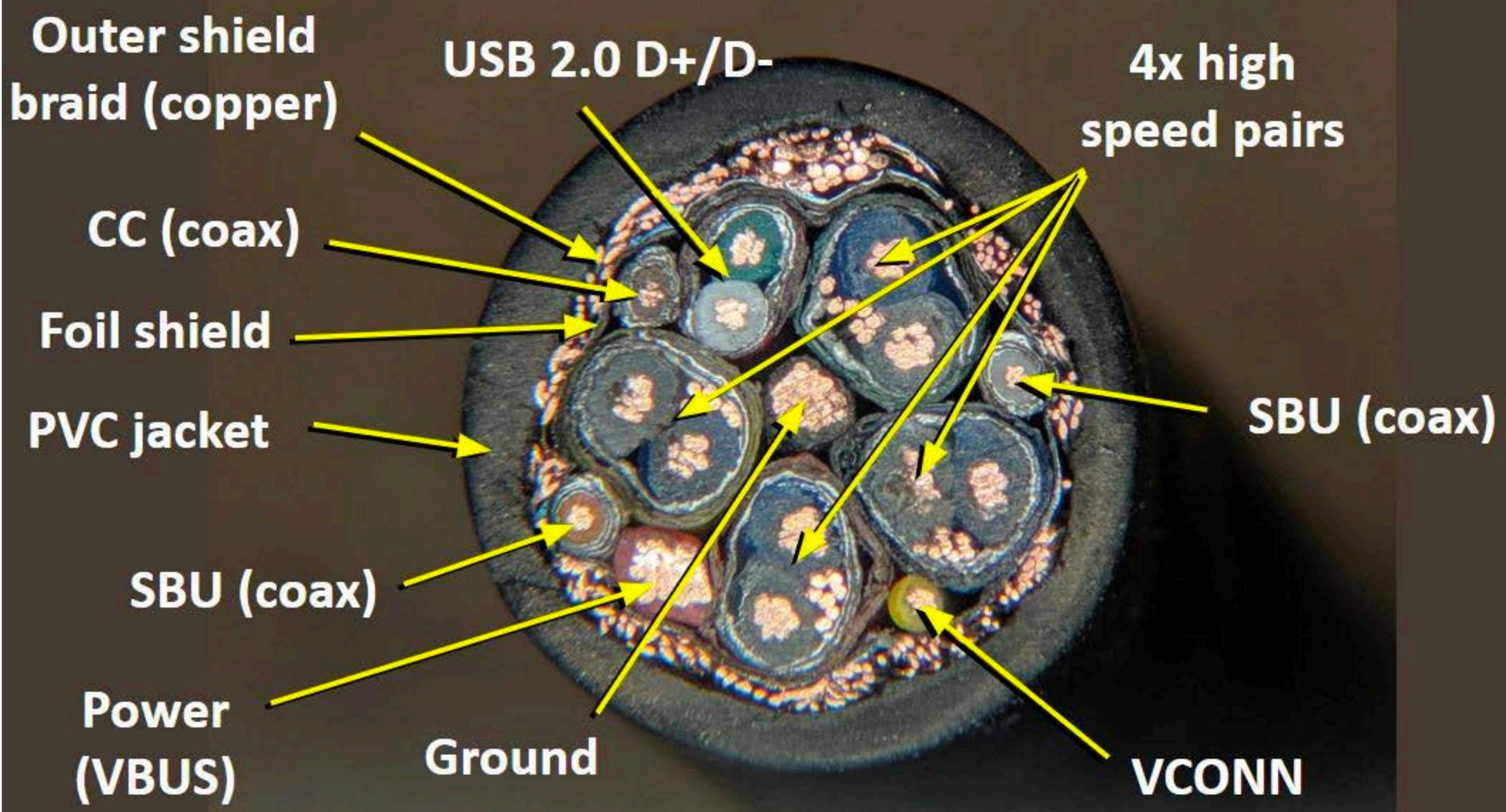
**PVC outer jacket**



WIRES

# USB-C CABLE CROSS SECTION



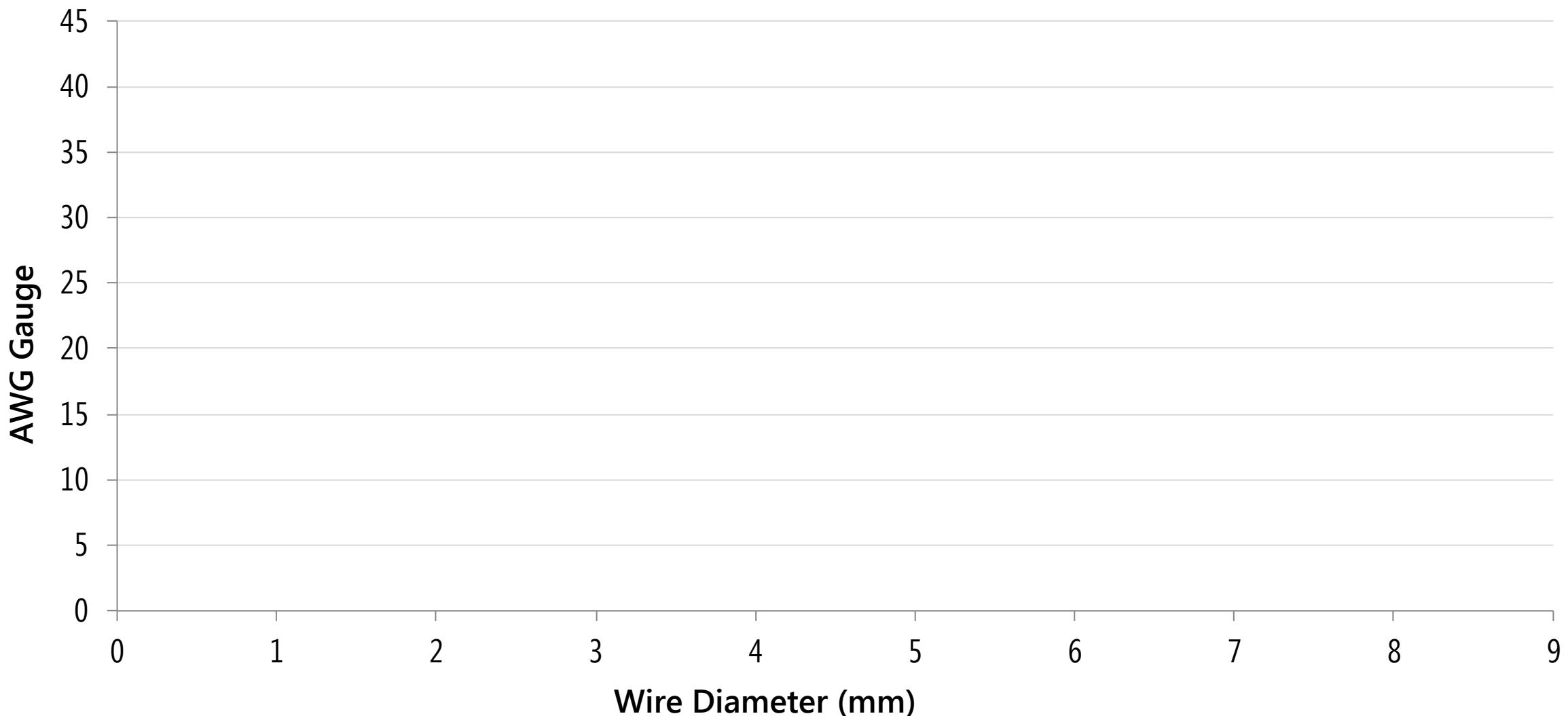




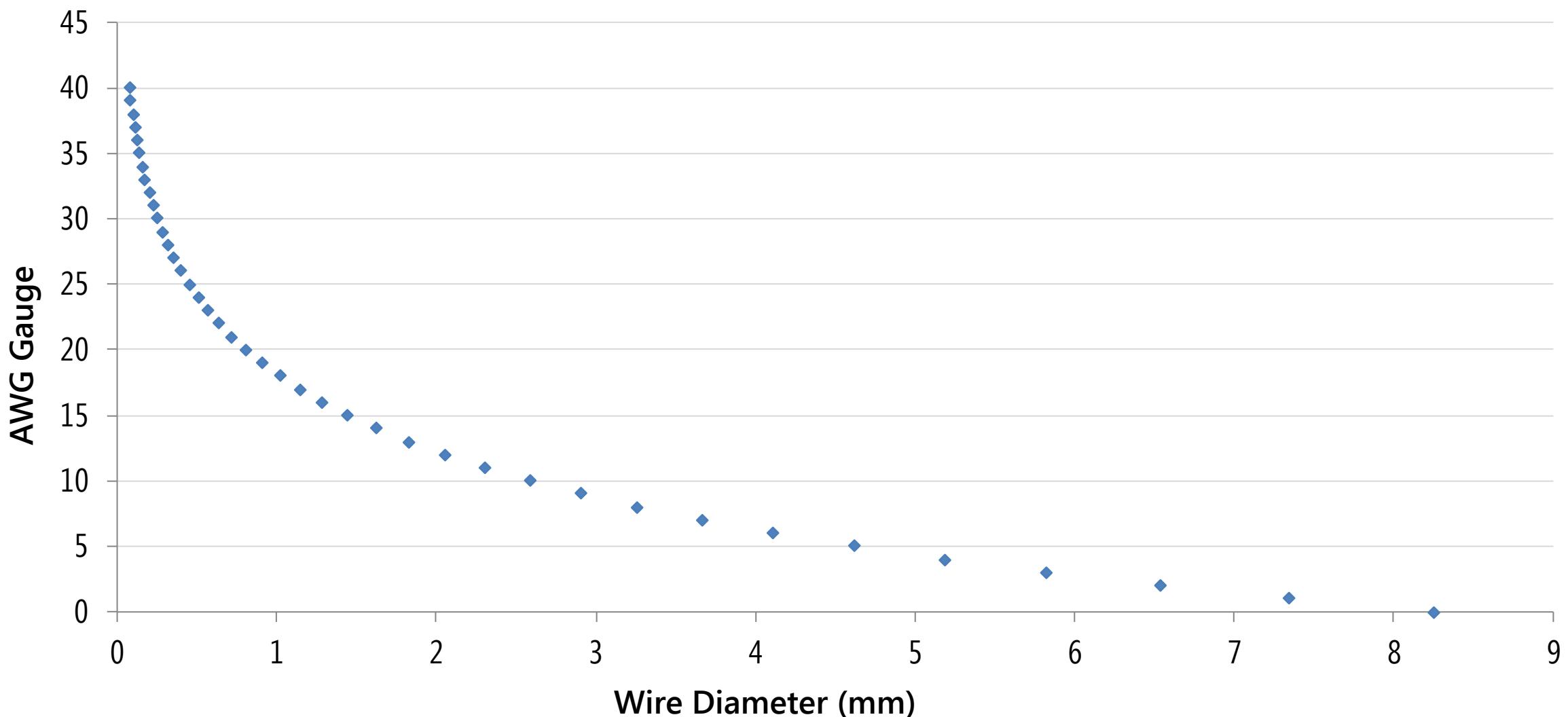




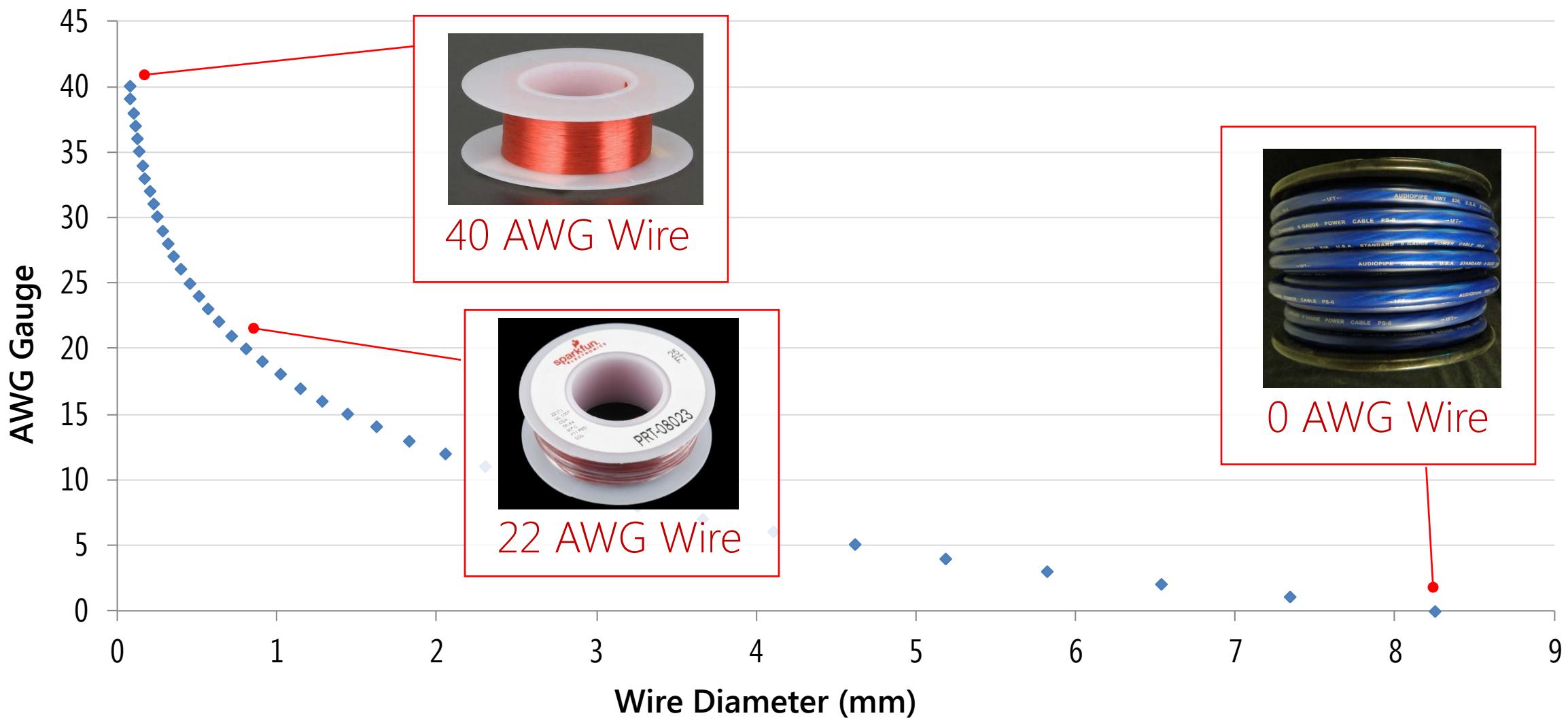
# AWG GAUGE VS. WIRE DIAMETER (MM)



# AWG GAUGE VS. WIRE DIAMETER (MM)

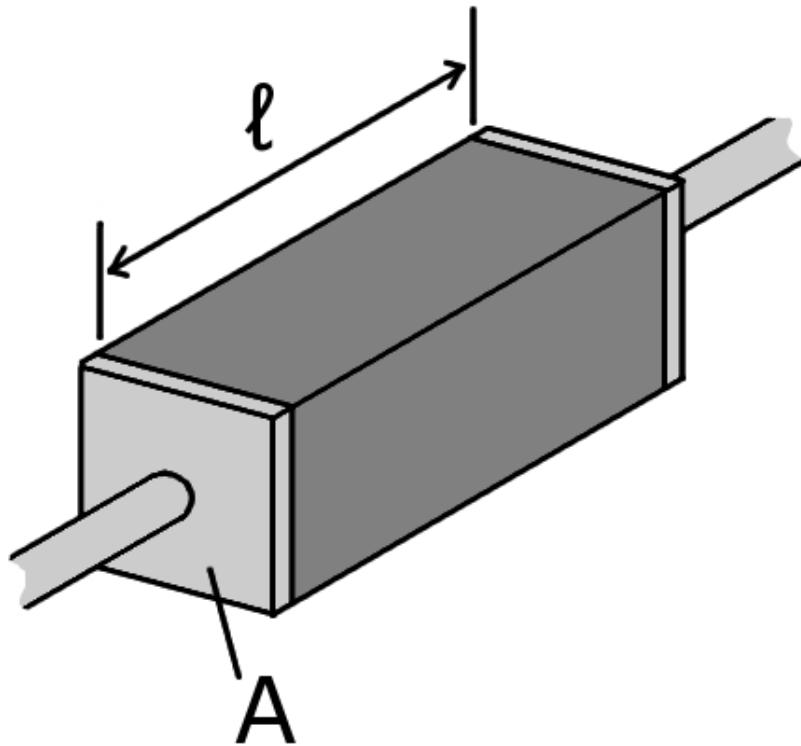


# AWG GAUGE VS. WIRE DIAMETER (MM)



# 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:

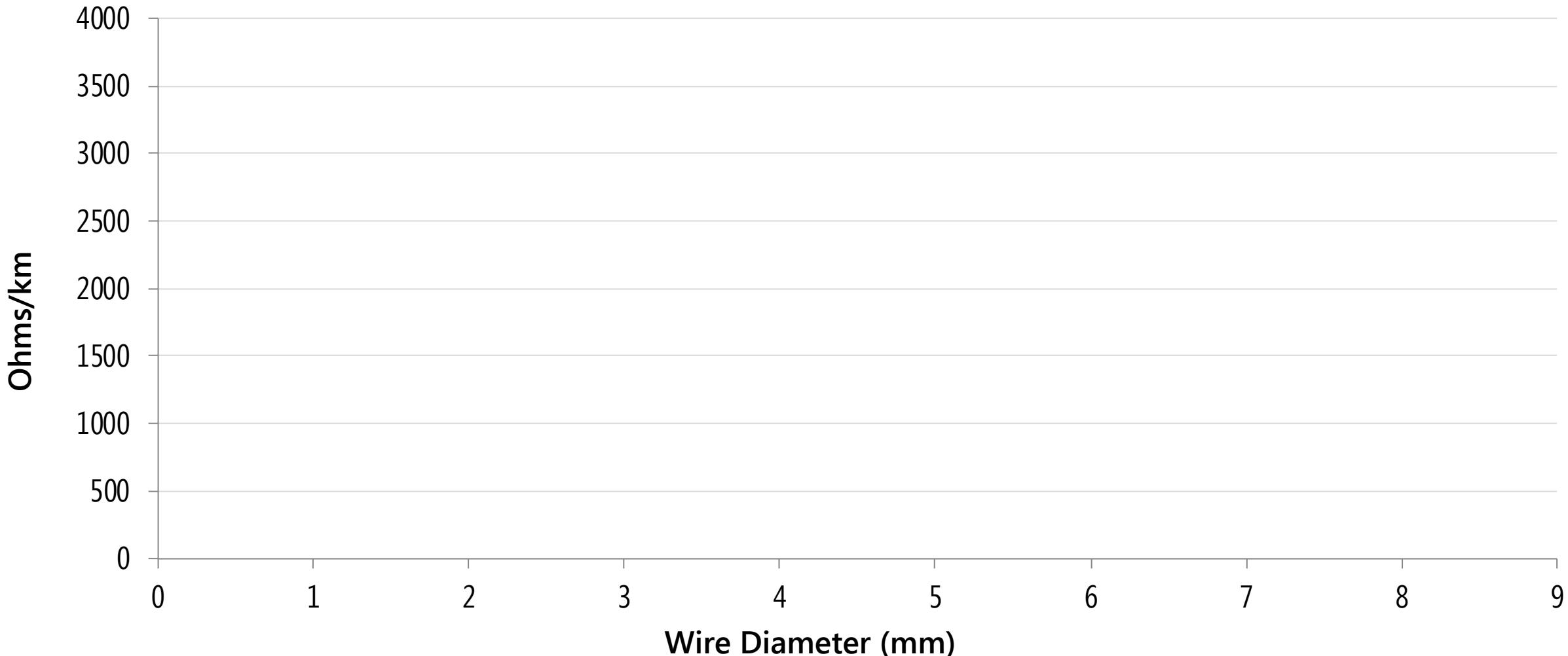
$$R = \rho \frac{\ell}{A}$$

$\rho$  is the electrical resistivity of the material measured in ohms-meters

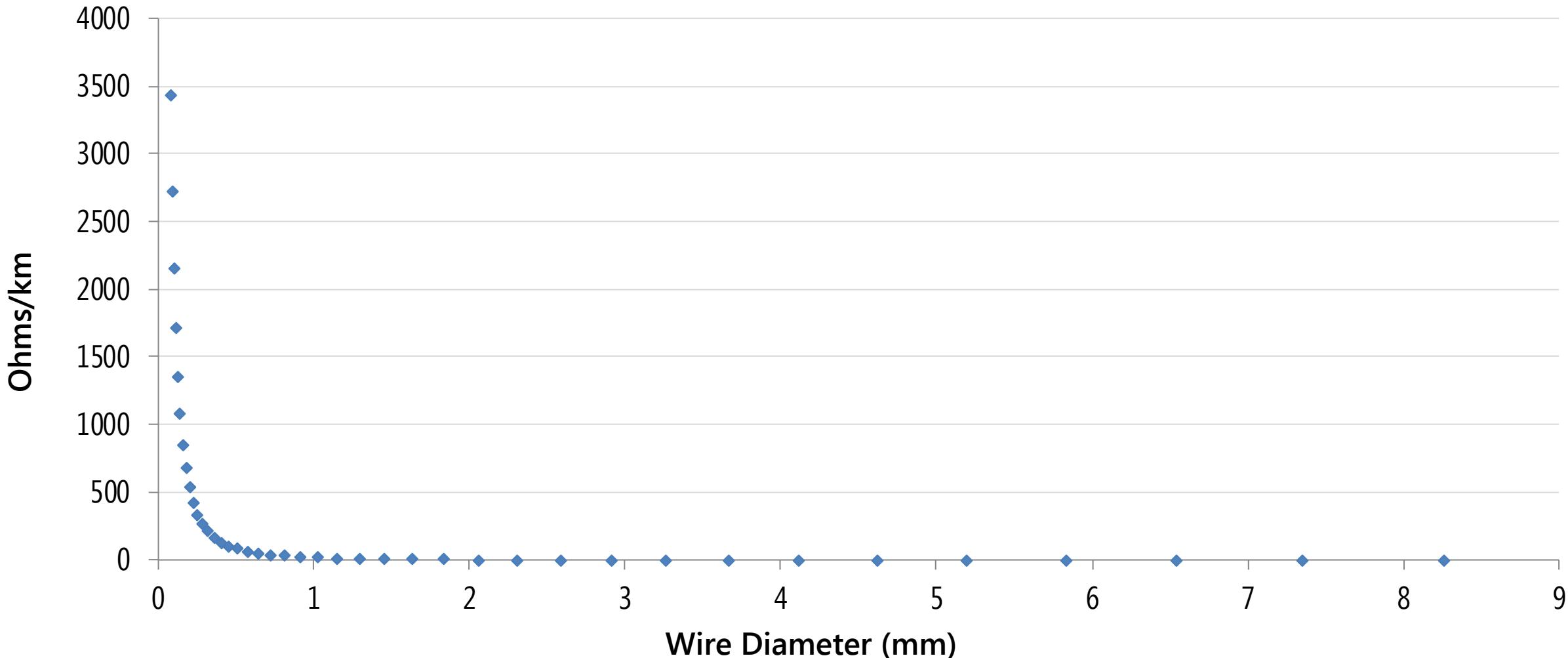
$\ell$  is the length of the piece of material (measured in meters, m)

$A$  is the cross-sectional area of the material (measured in square meters, m<sup>2</sup>).

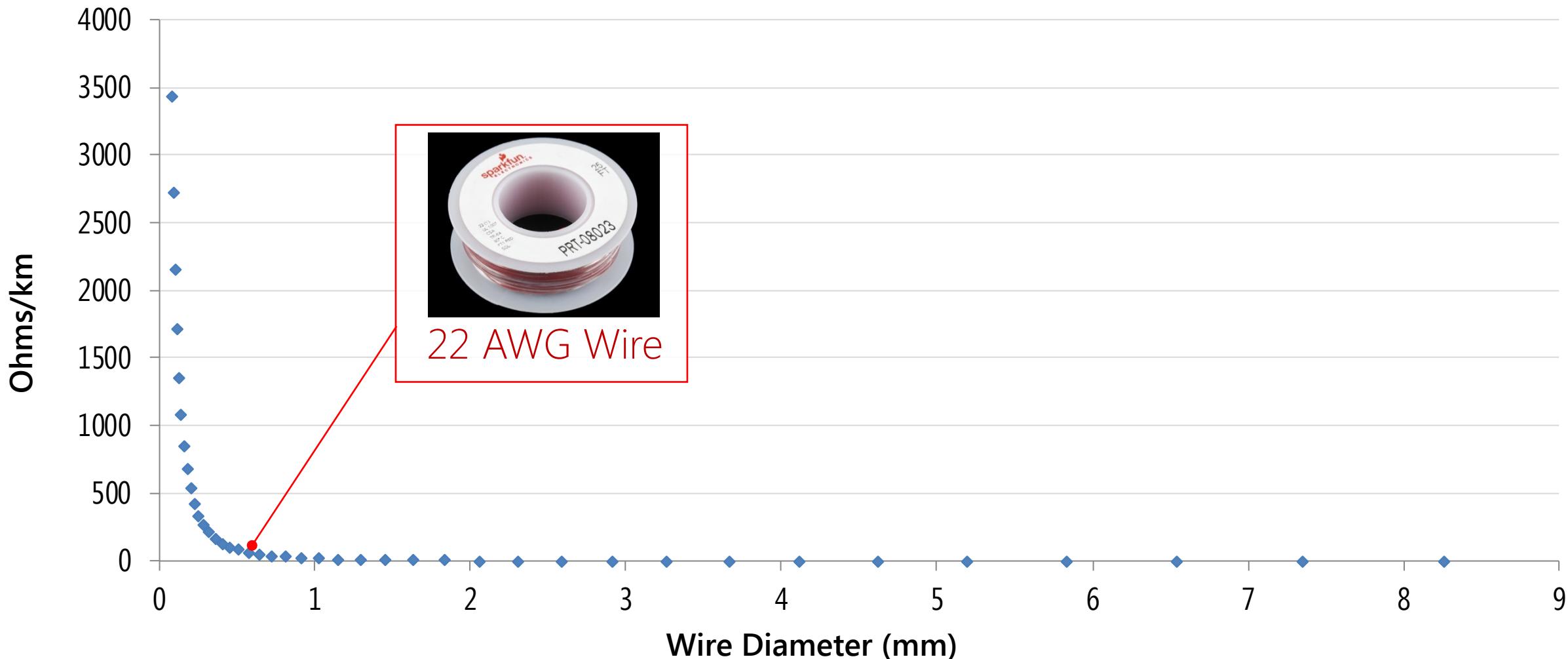
# RESISTANCE AS A FUNCTION OF WIRE DIAMETER



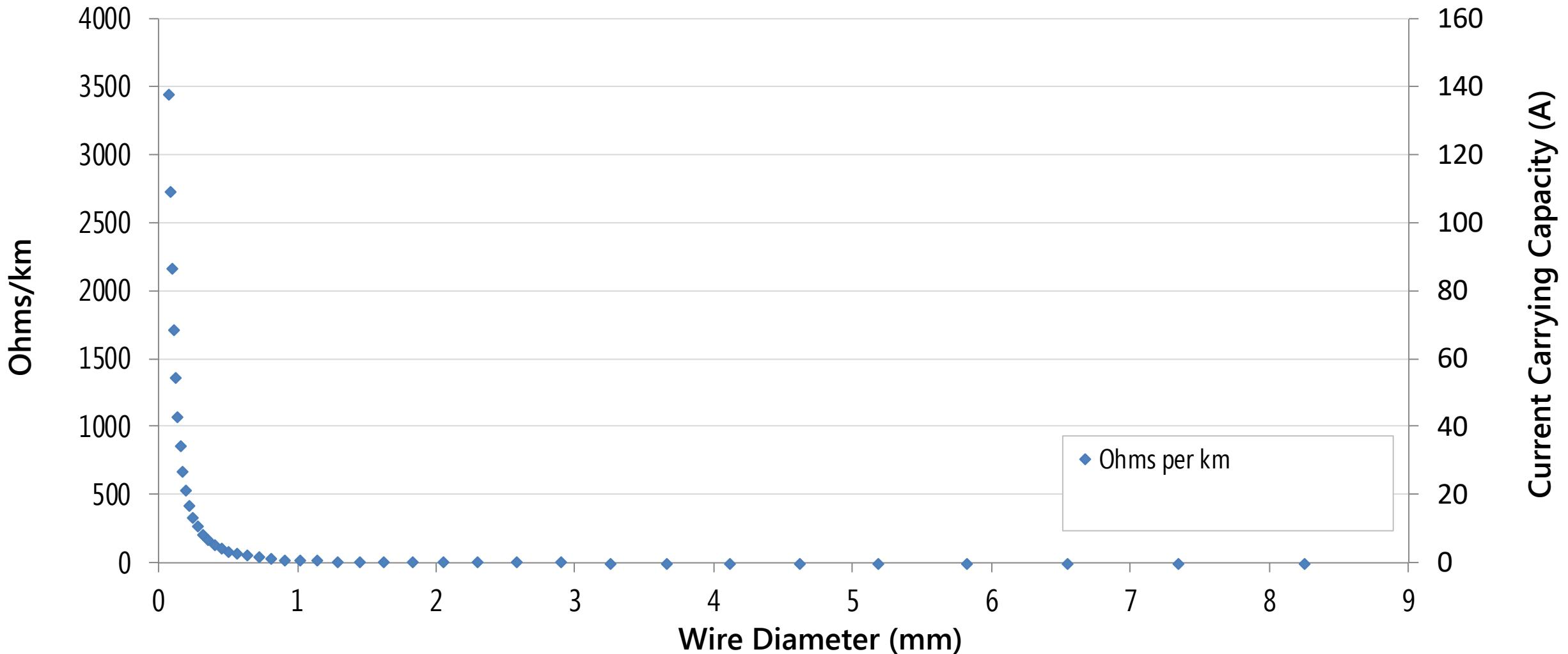
# RESISTANCE AS A FUNCTION OF WIRE DIAMETER



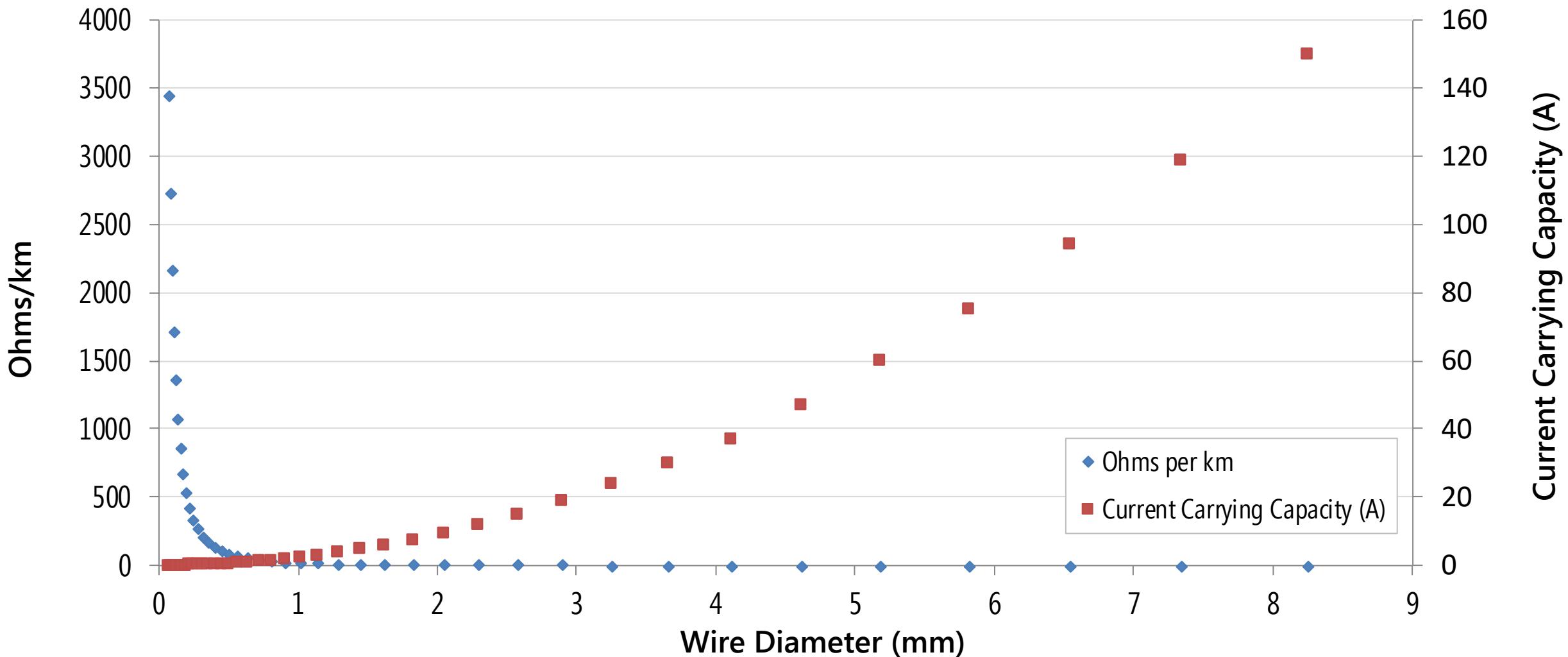
# RESISTANCE AS A FUNCTION OF WIRE DIAMETER



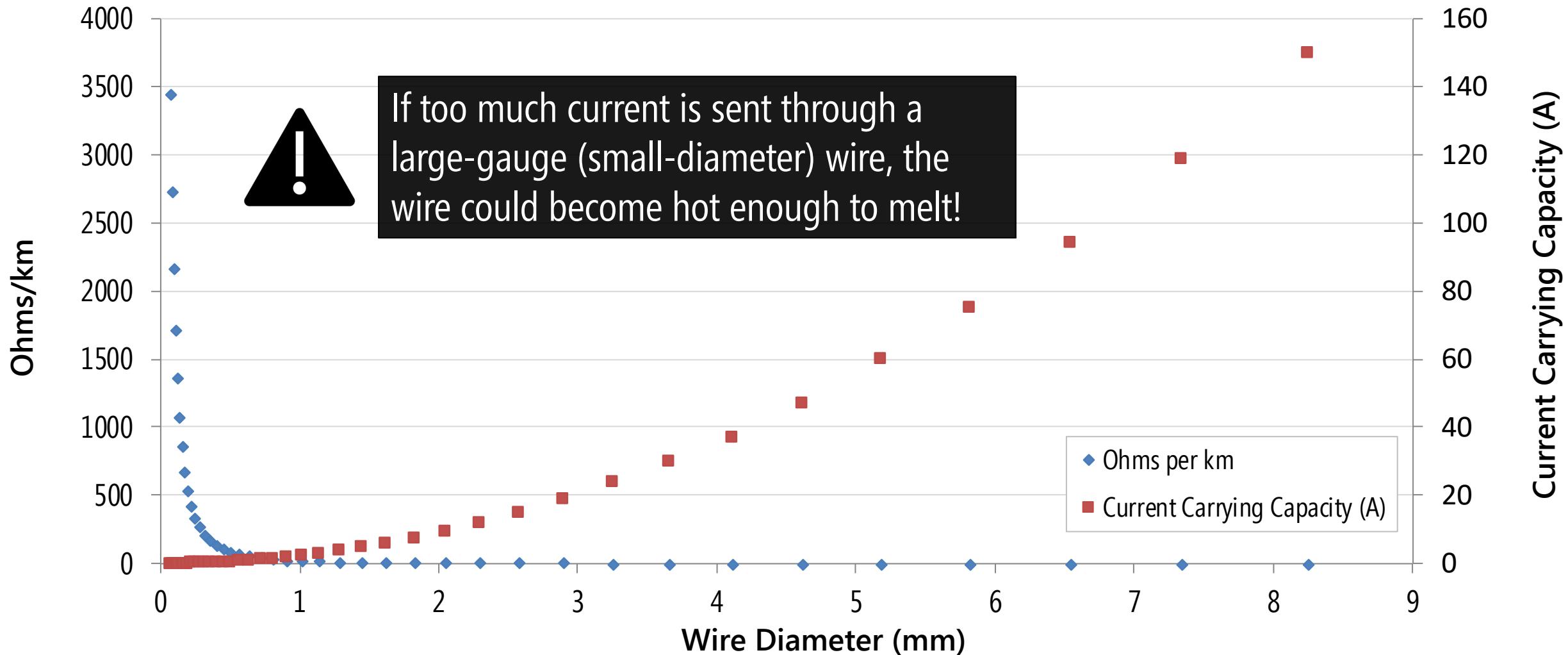
# CURRENT CARRYING CAPACITY & RESISTANCE



# CURRENT CARRYING CAPACITY & RESISTANCE



# CURRENT CARRYING CAPACITY & RESISTANCE



# CURRENT CAPACITY AS A FUNCTION OF SIZE

WIRE SIZE (AWG)	DIAMETER (MILS)*	AREA (CM) <sup>†</sup>	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.

<sup>†</sup>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.

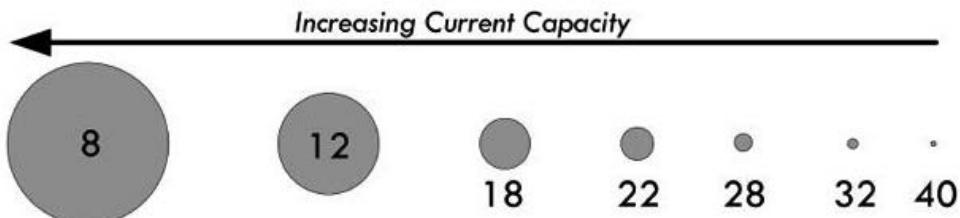


FIGURE 2.26

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

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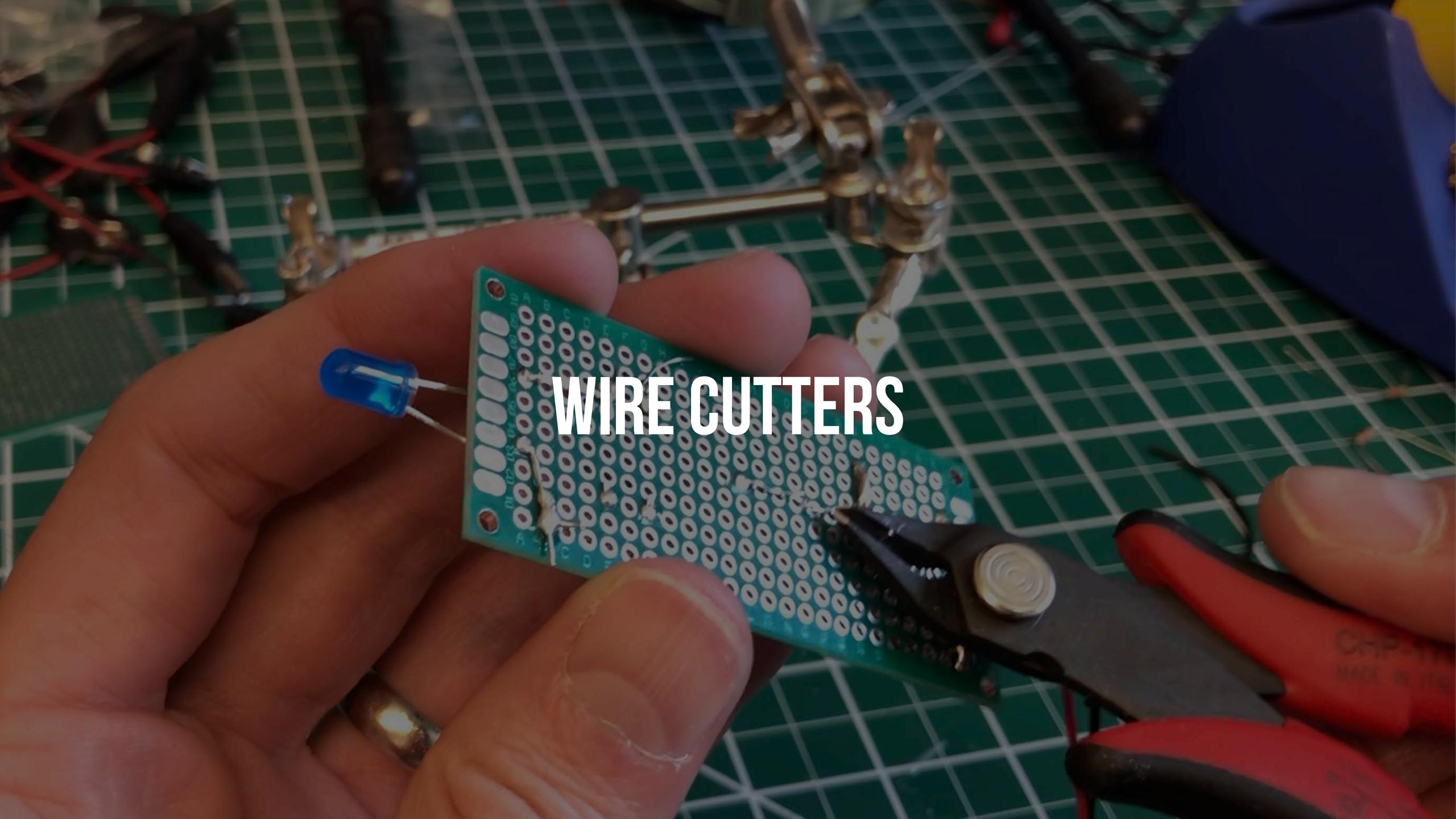
ELECTRONIC HAND TOOLS

# WIRE STRIPPERS



Source: Adafruit, Hand Tools, [https://youtu.be/J-1phA\\_vKDg](https://youtu.be/J-1phA_vKDg)





# WIRE CUTTERS



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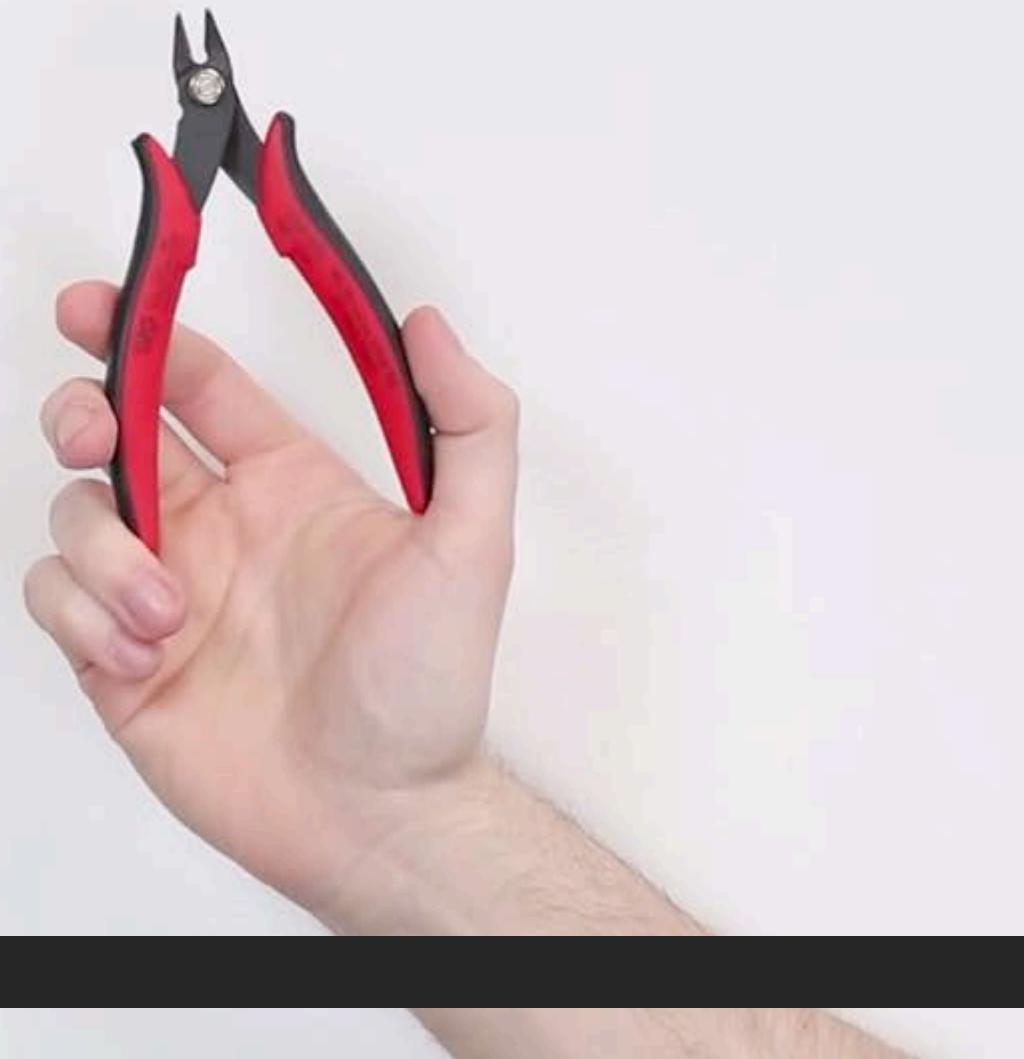
**Auto-wire stripper** for fast wire stripping (also called a 'self-adjusting wire stripper').



ELECTRONIC HAND TOOLS

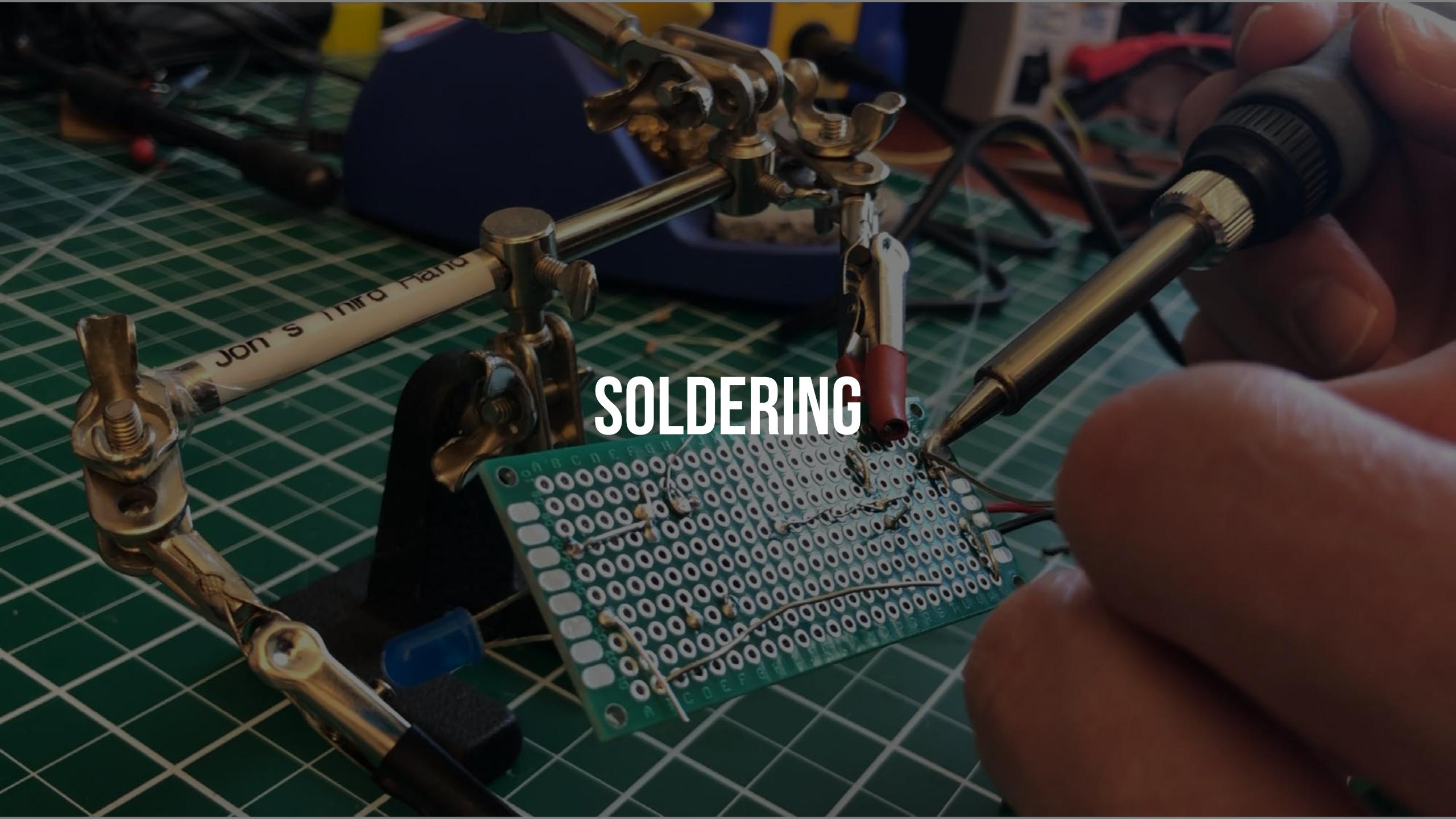
# WIRE CUTTERS

# CUTTERS



# CUTTERS

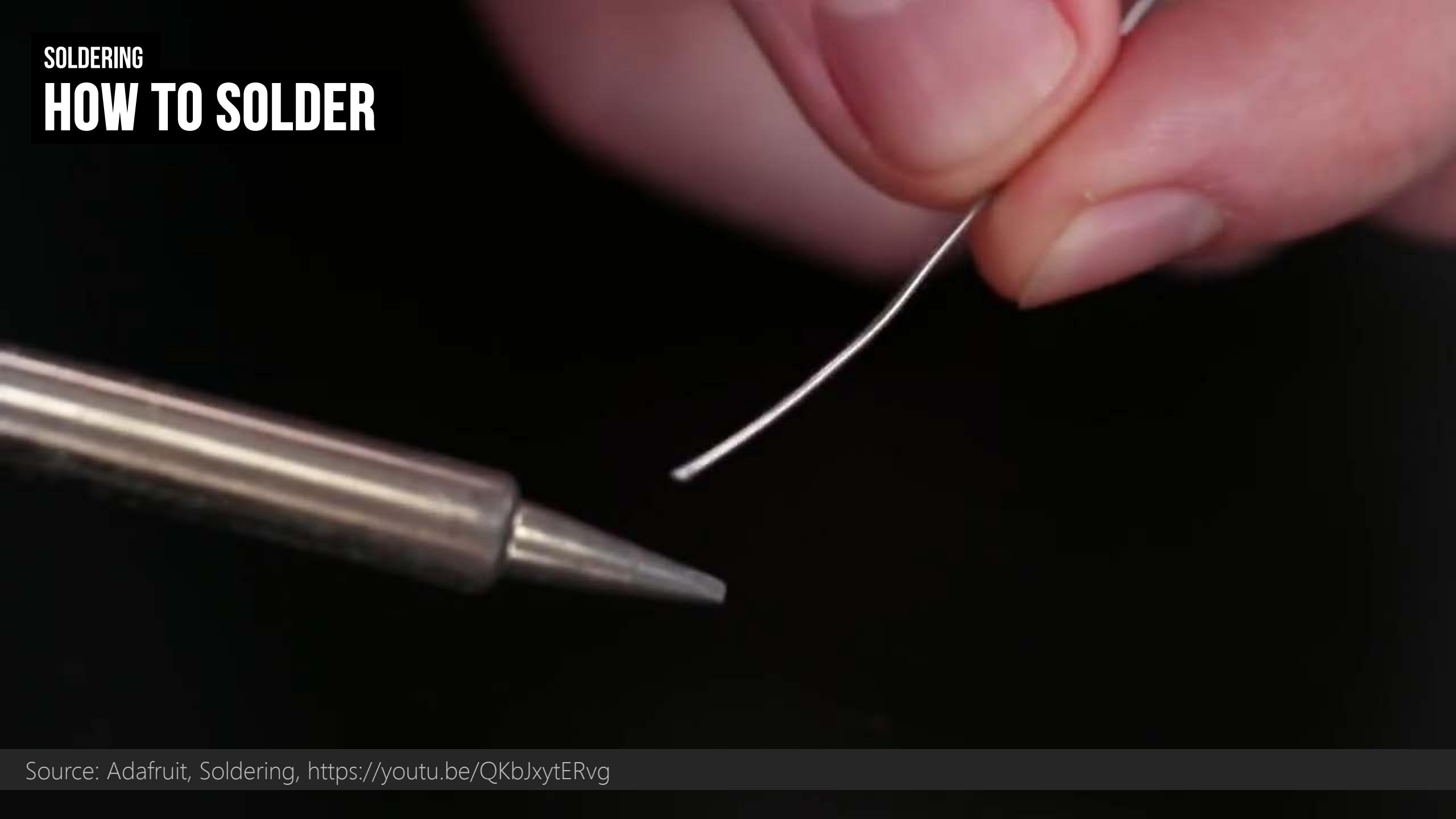




# SOLDERING

SOLDERING

# HOW TO SOLDER

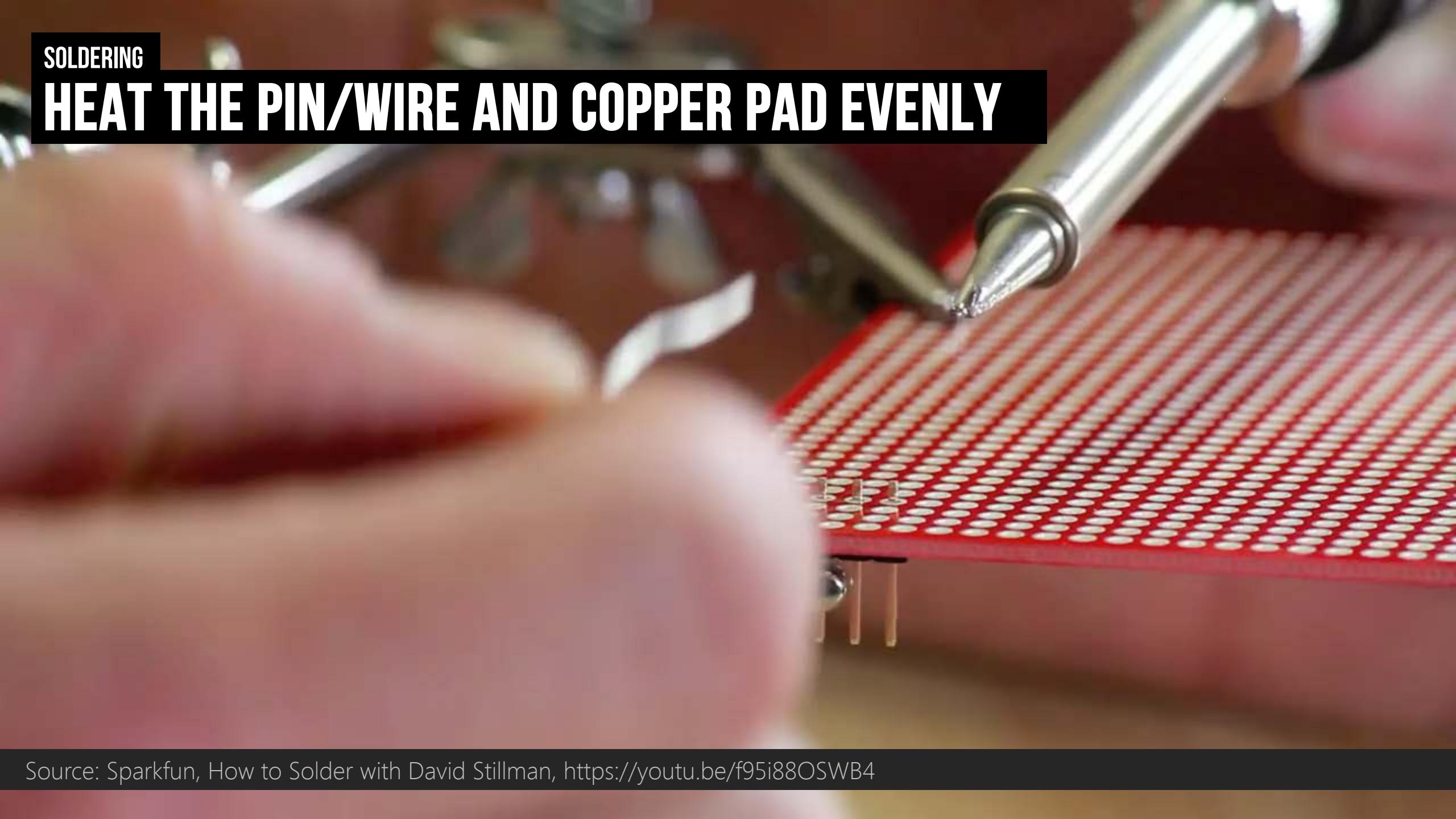


Source: Adafruit, Soldering, <https://youtu.be/QKbJxytERvg>

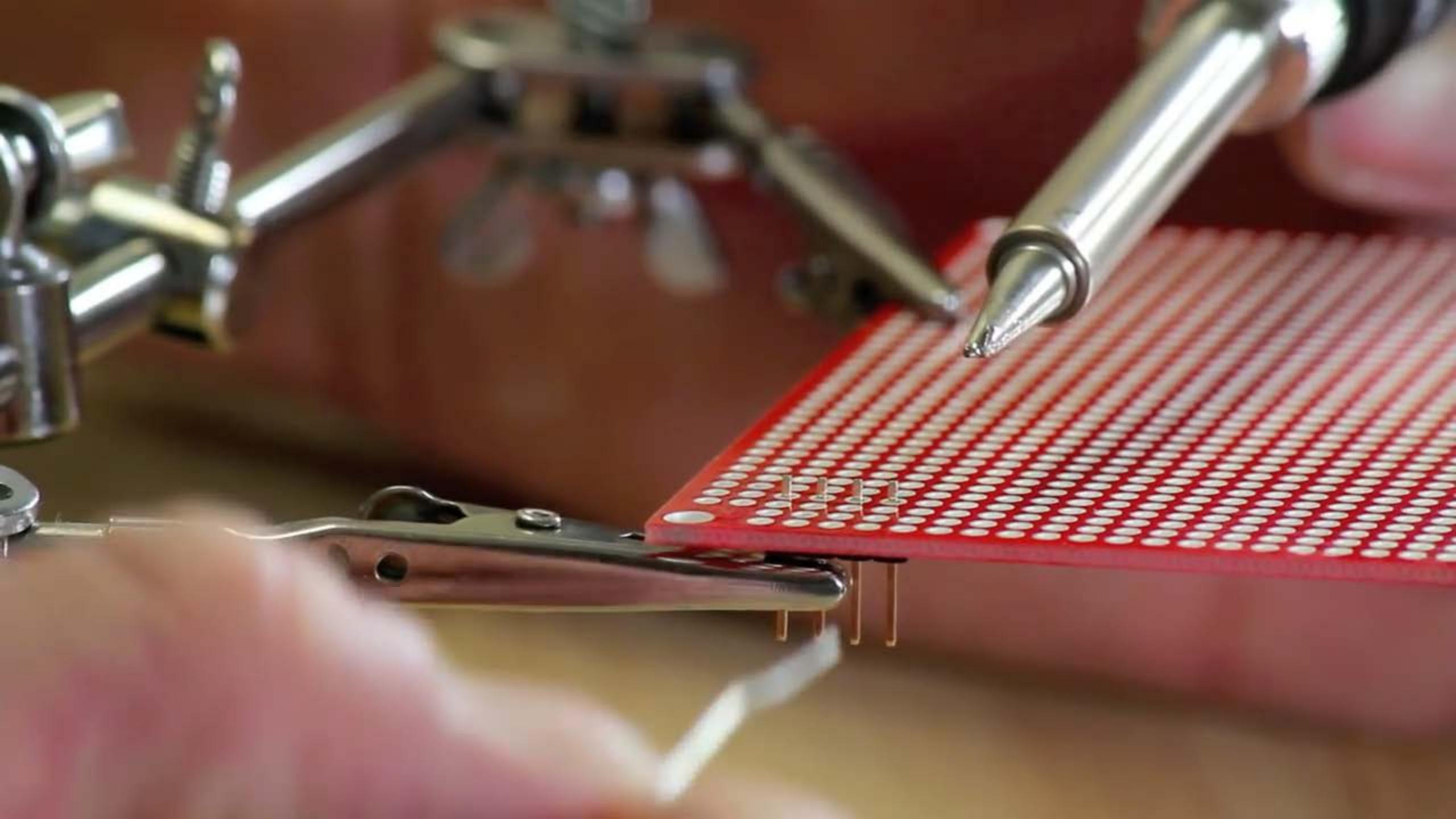


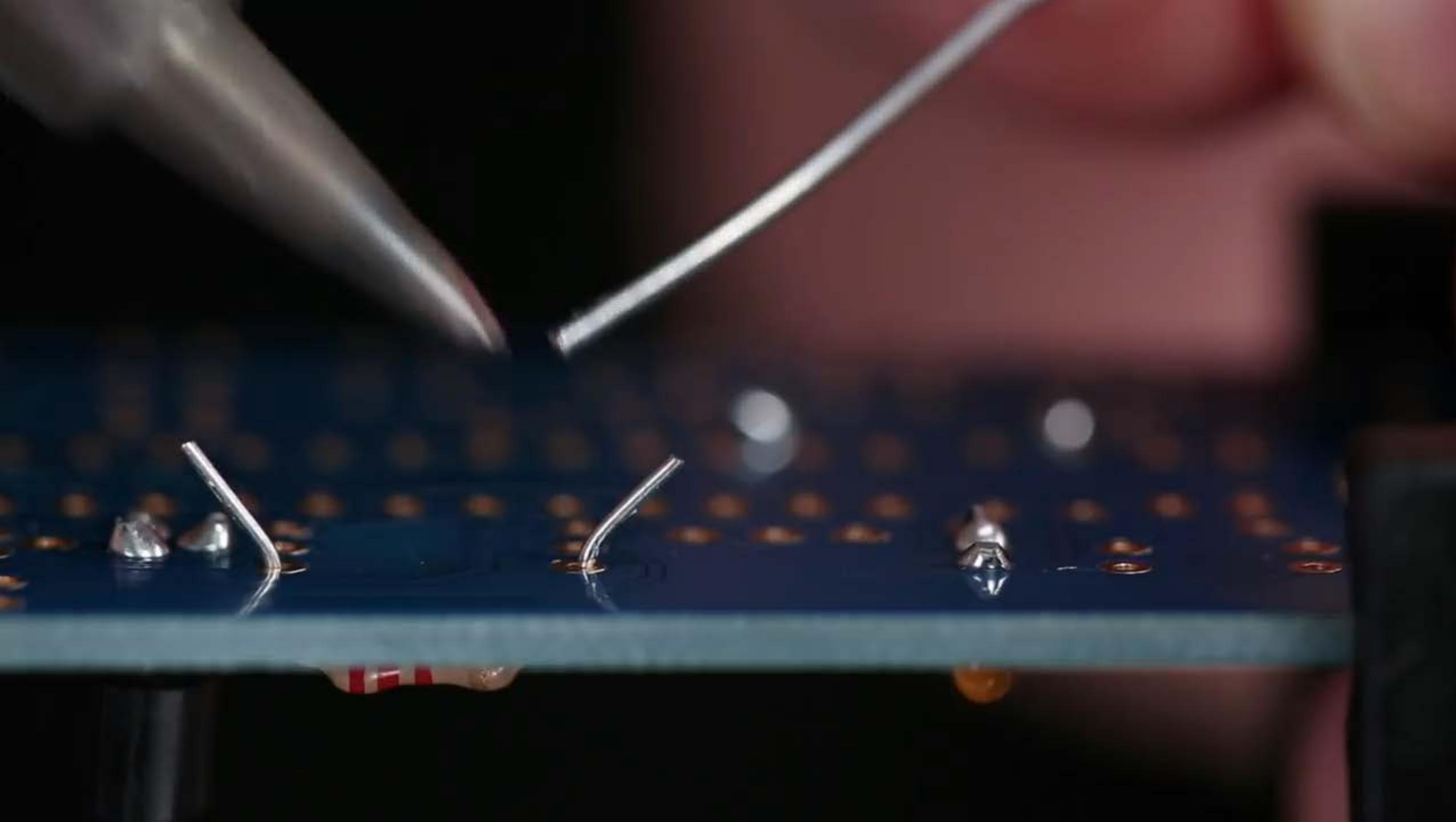
SOLDERING

# HEAT THE PIN/WIRE AND COPPER PAD EVENLY



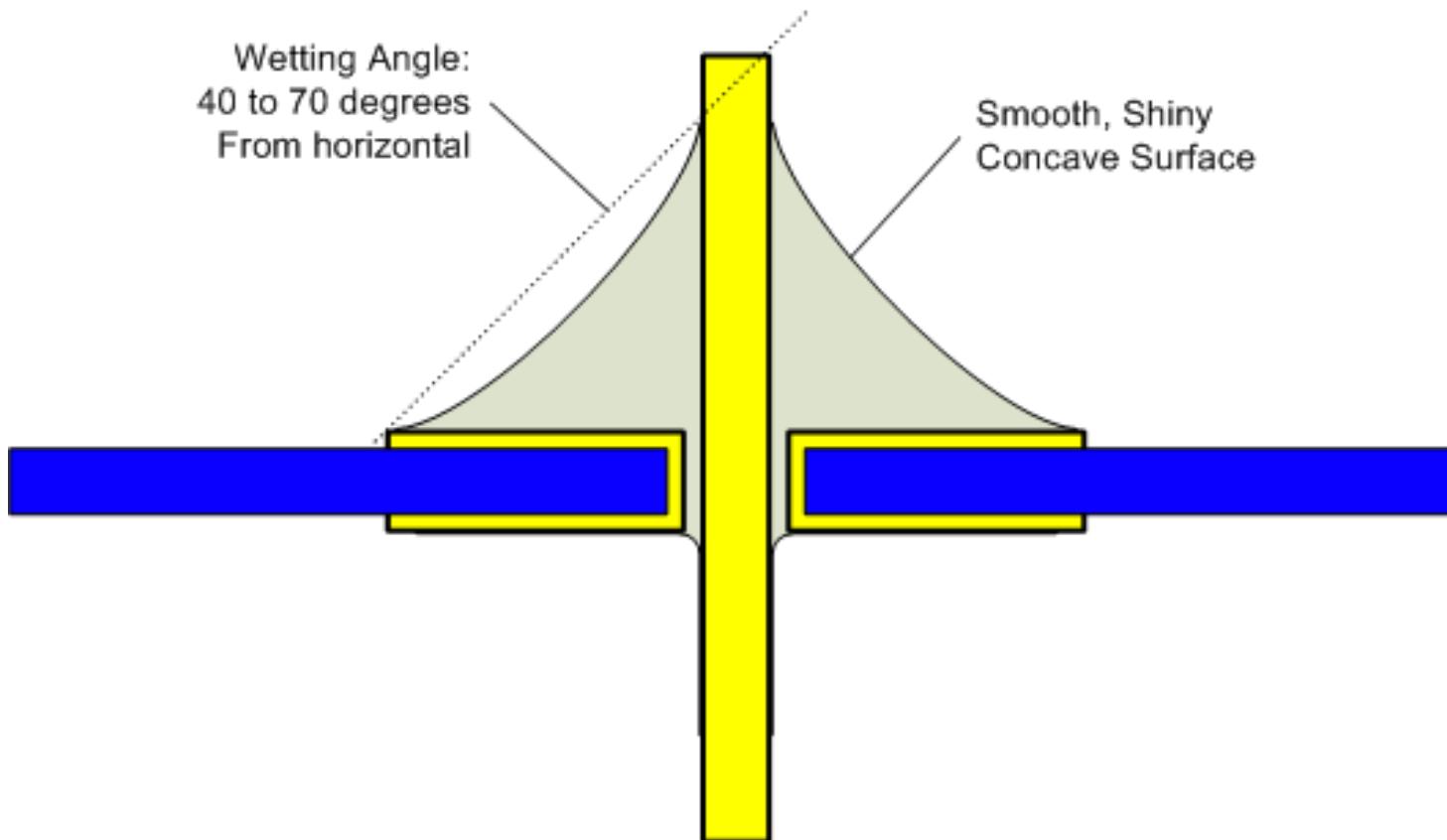
Source: Sparkfun, How to Solder with David Stillman, <https://youtu.be/f95i88OSWB4>





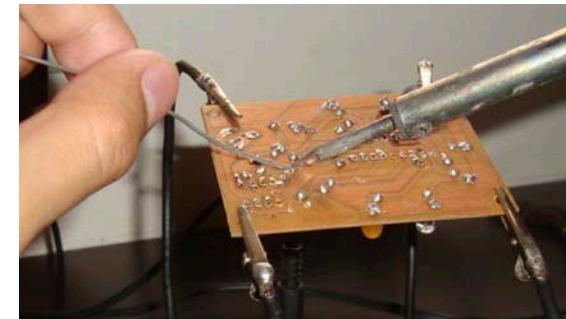
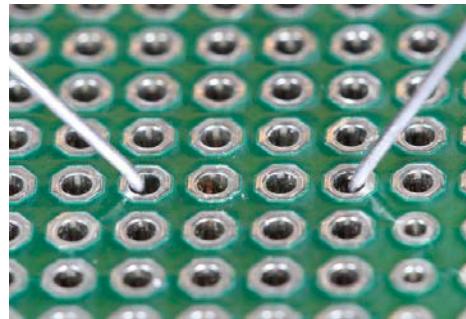
# IDEAL SOLDER JOINT

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.

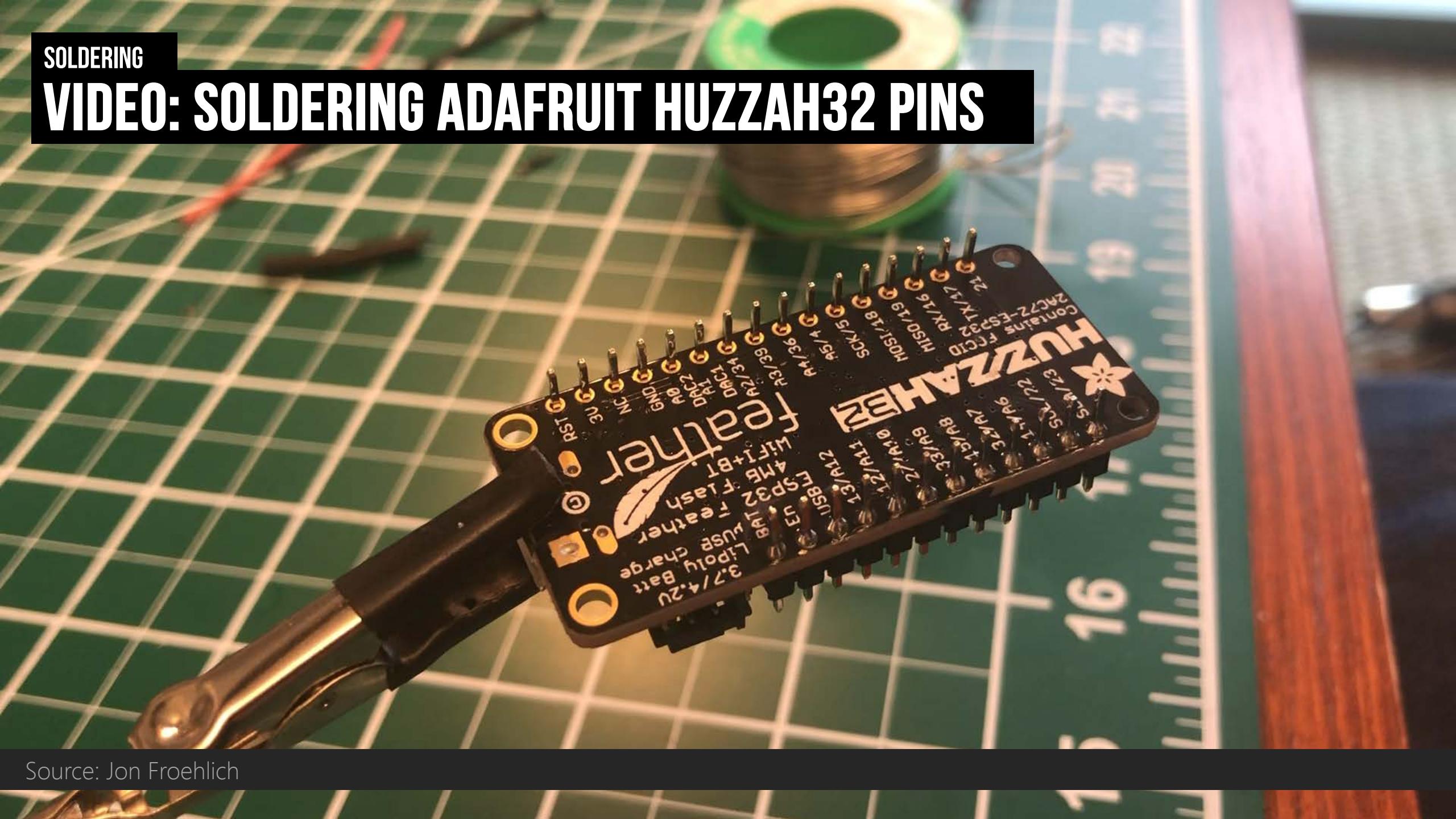
**4. Place component leads/wires through perfboard.** Immobilize the joint. Components should not move while being soldered.

**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.



SOLDERING

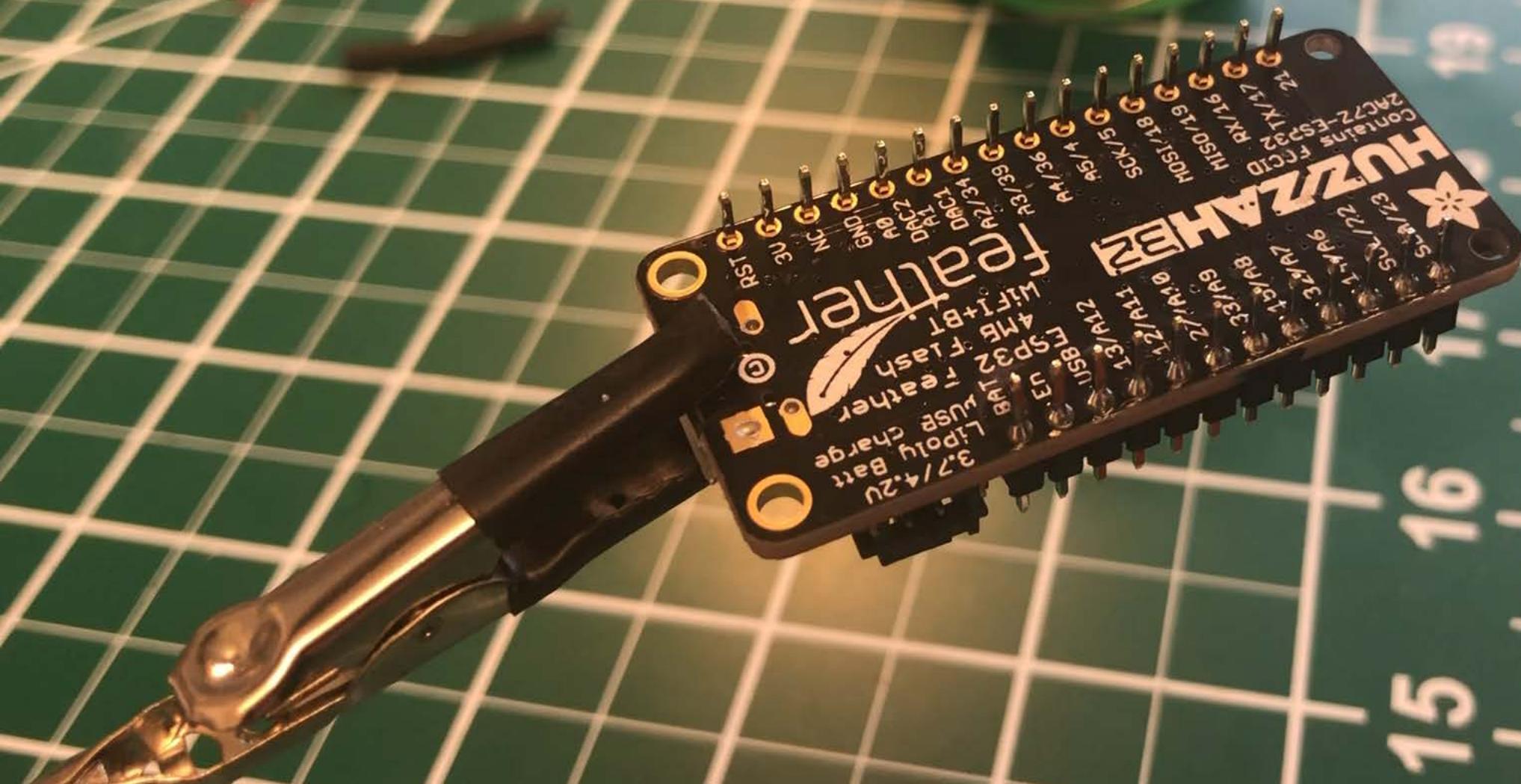
# VIDEO: SOLDERING ADAFRUIT HUZZAH32 PINS



Source: Jon Froehlich

15

16



# WHEN YOU FINISH SOLDERING

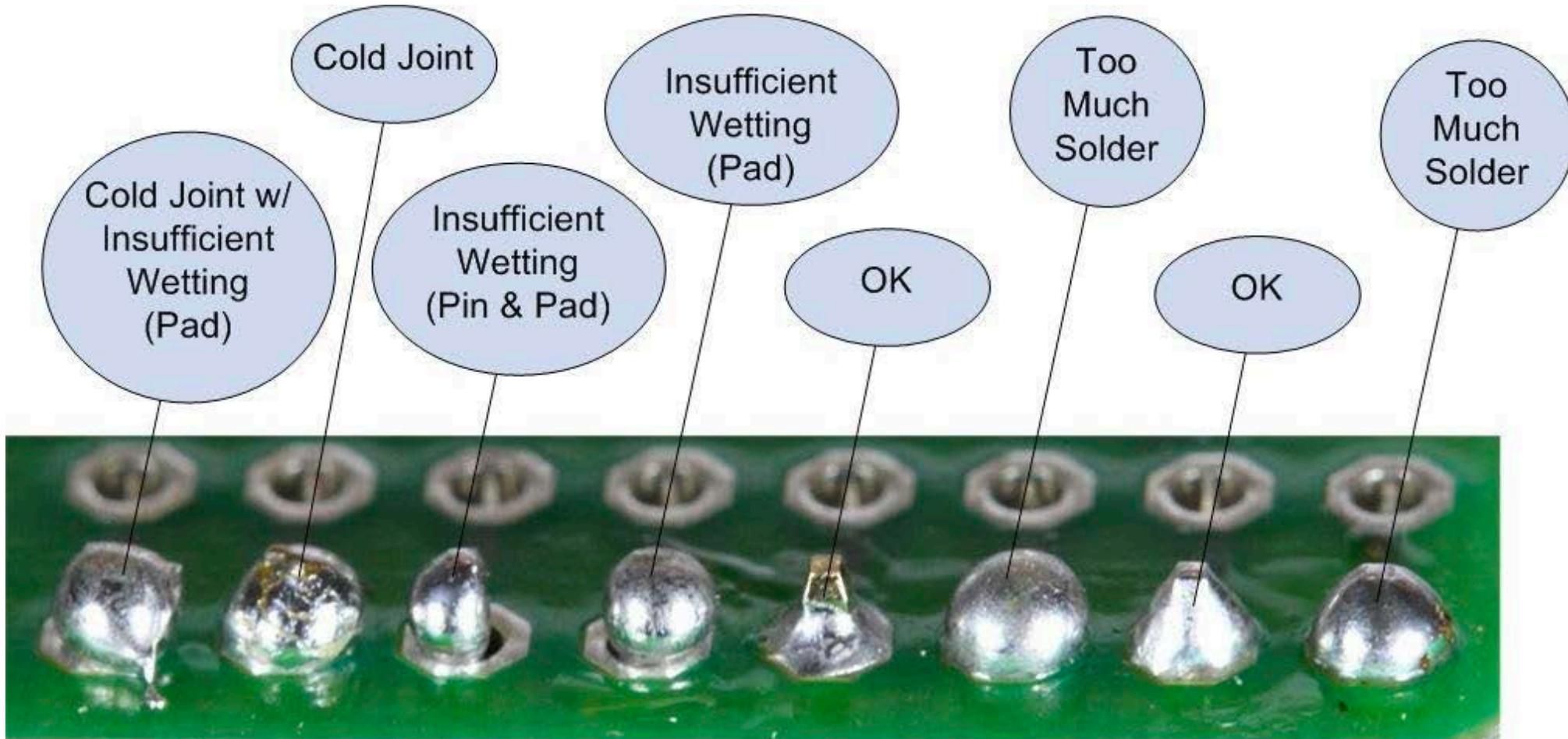


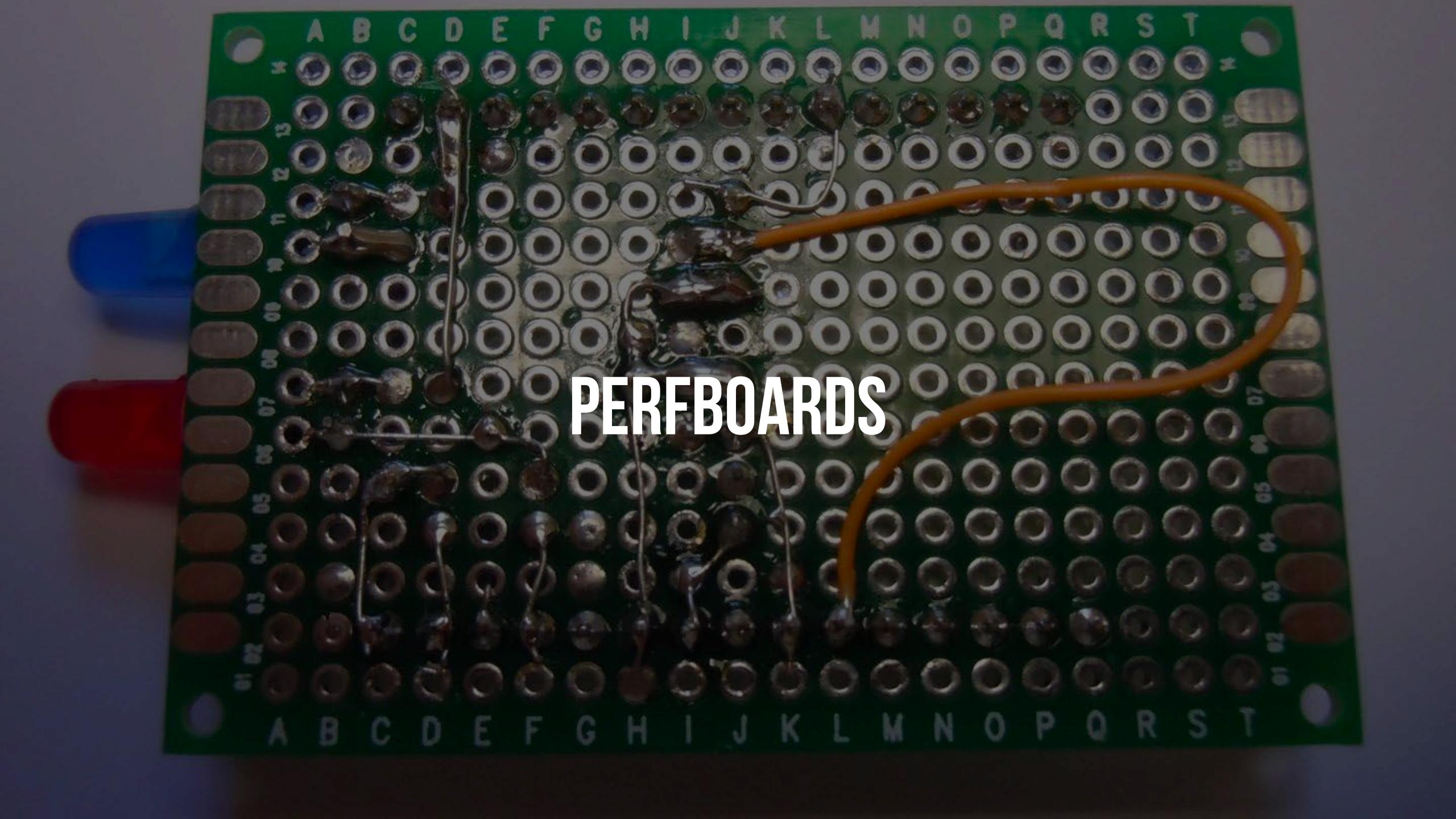
**1. Tin soldering tip.** Again, apply a small amount of solder to the tip before returning the soldering iron to the holster



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

# COMMON SOLDERING PROBLEMS



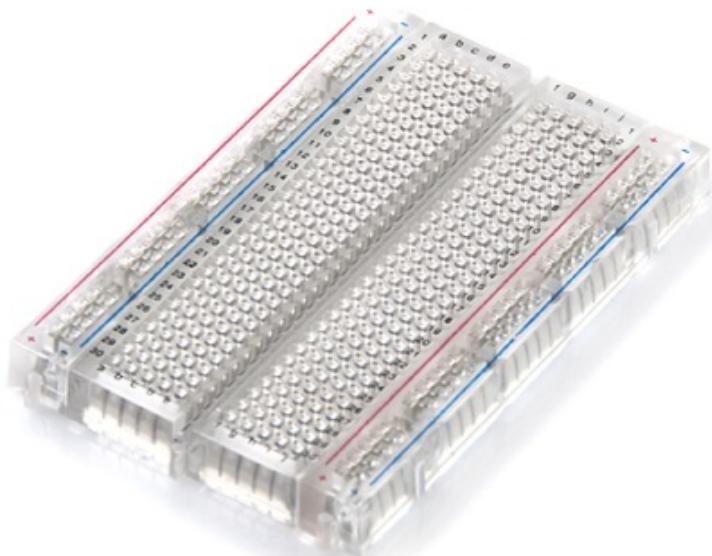


# PERFBOARDS

PERFBOARDS

# BREADBOARDS -> PERFBOARDS

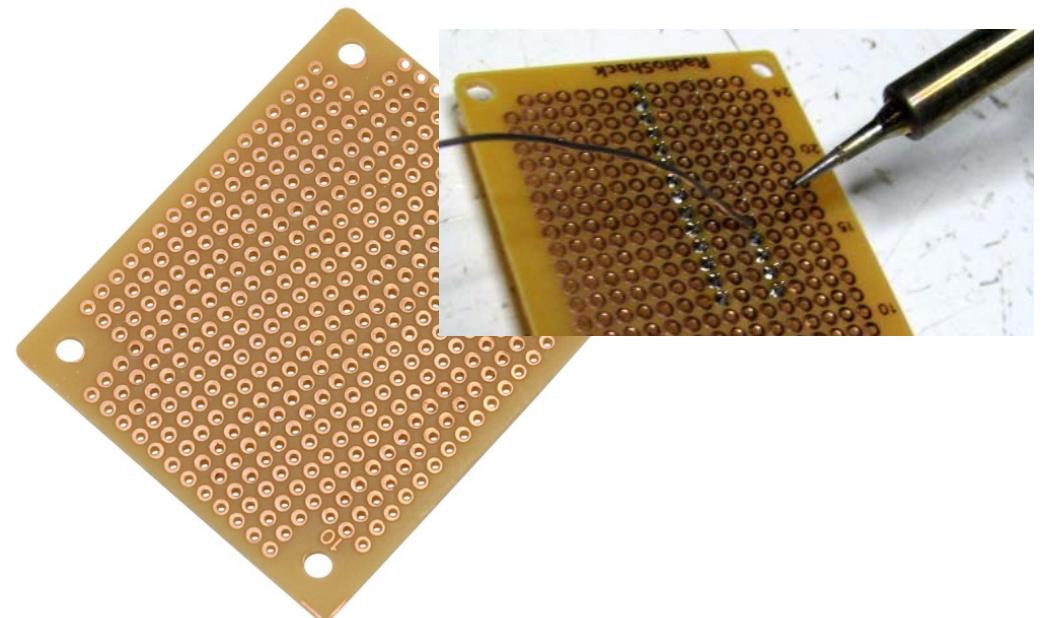
Typically, you start prototyping on a breadboard but then switch over to something like a perfboard once your design is starting to solidify or you want something more permanent. Perfboards require soldering.



Breadboard



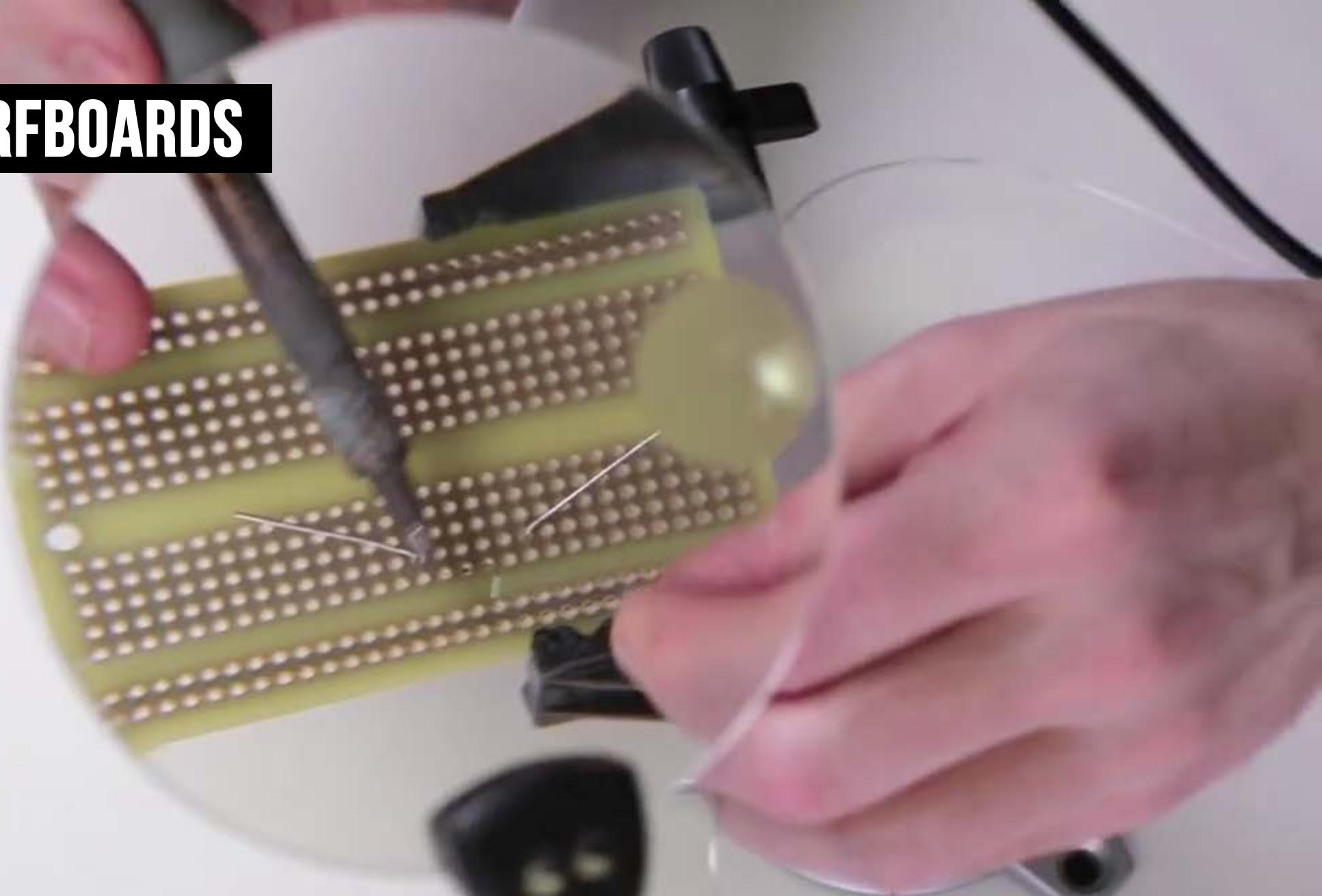
Once design solidifies, move  
to perfboard



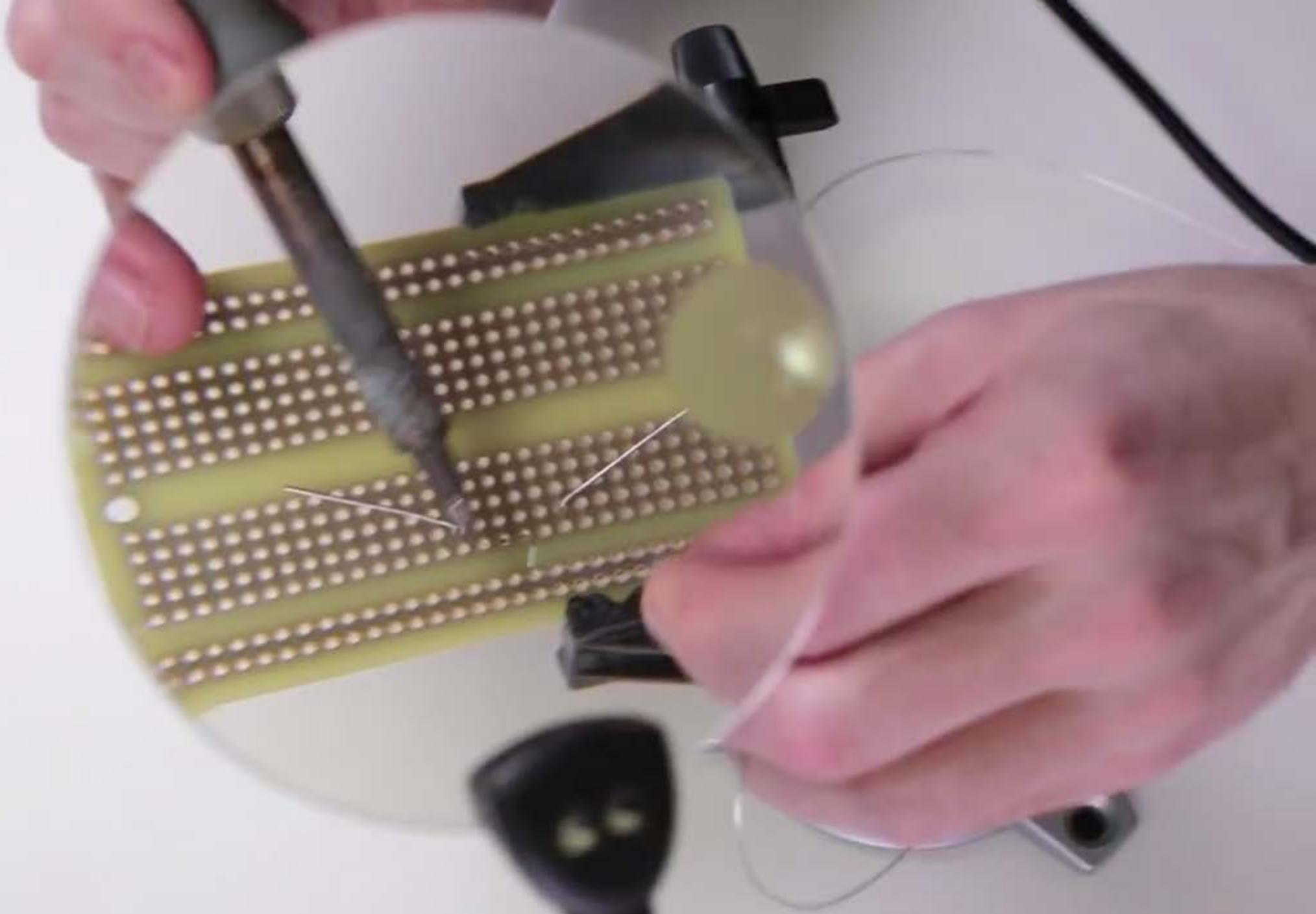
Perfboard

PERFBOARDS

# SOLDERING PERFCARDS

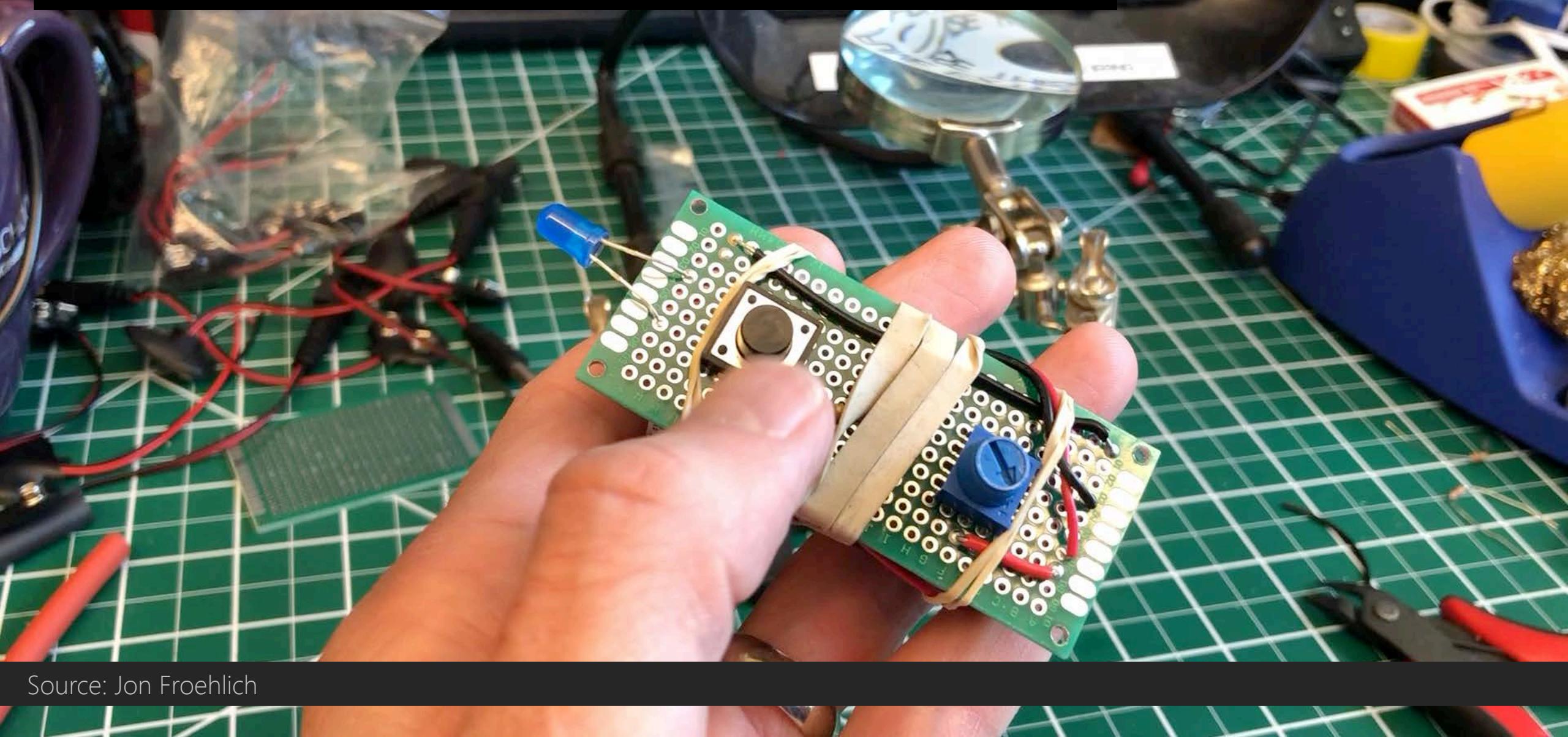


Source: Adafruit, Breadboards and Perfboards, <https://youtu.be/w0c3t0fJhXU>



ACTIVITY

# BUILD AN LED FLASHLIGHT WITH A PERFBORD



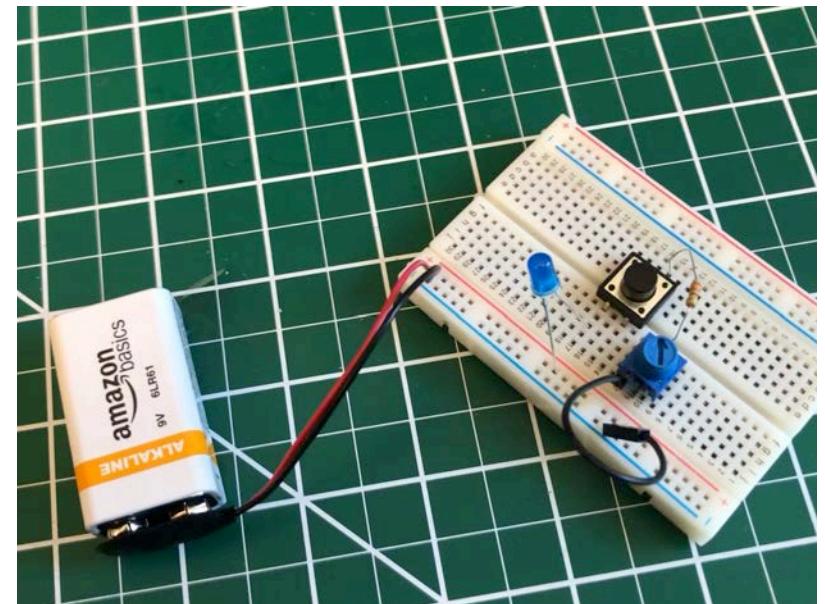
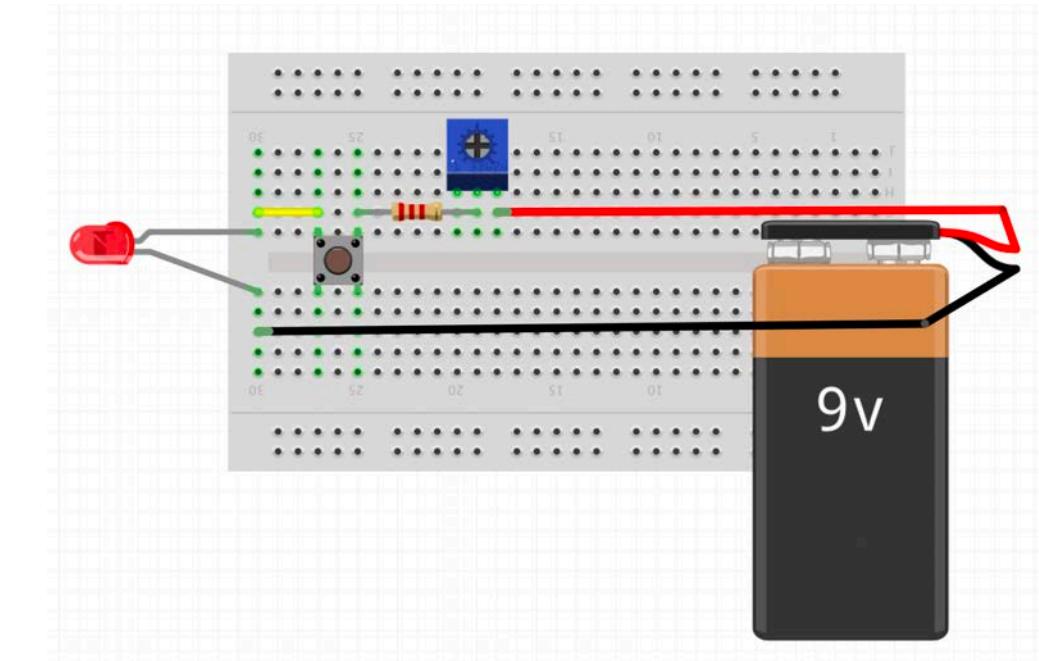
Source: Jon Froehlich

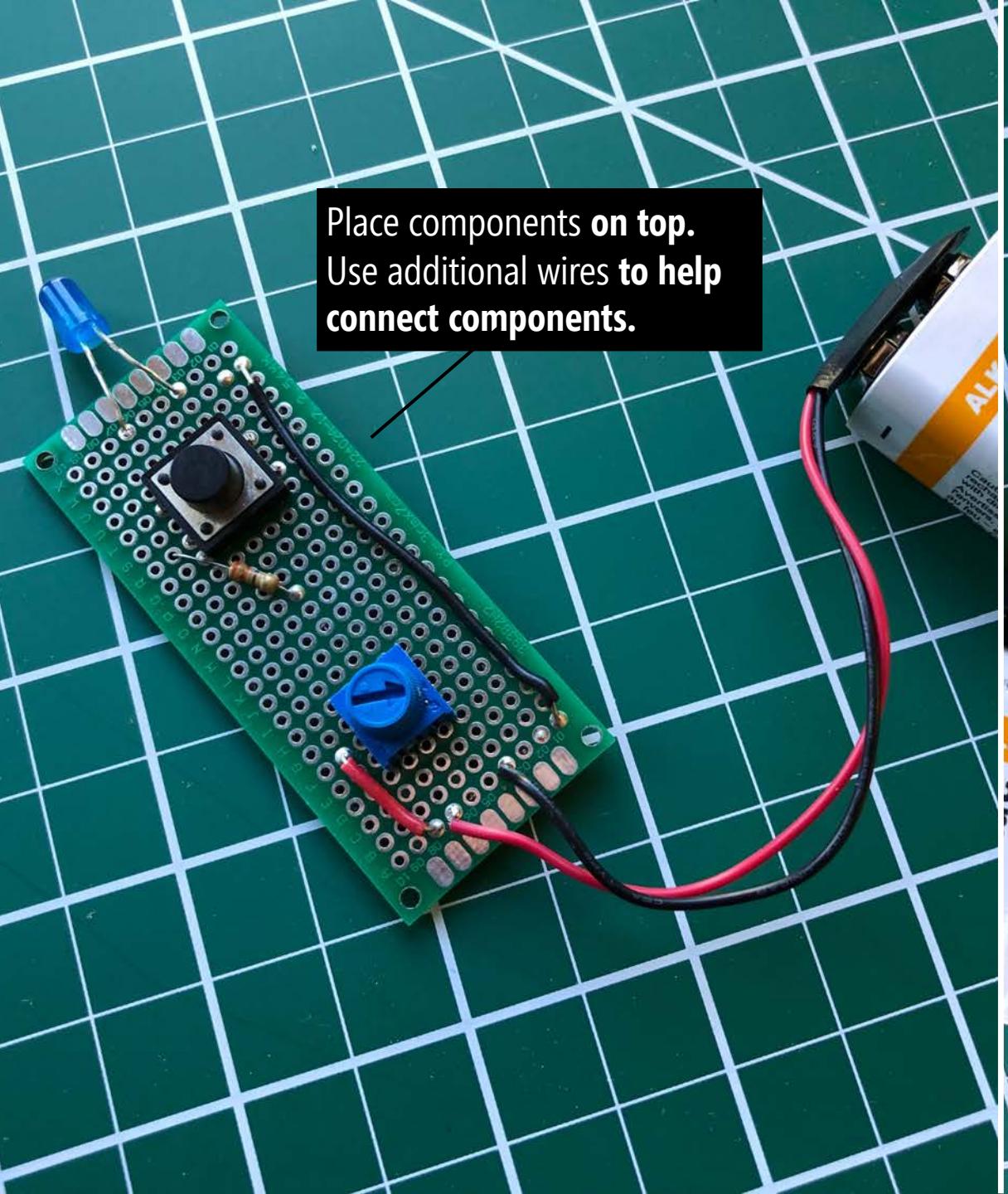
## ACTIVITY

# BUILD AN LED FLASHLIGHT

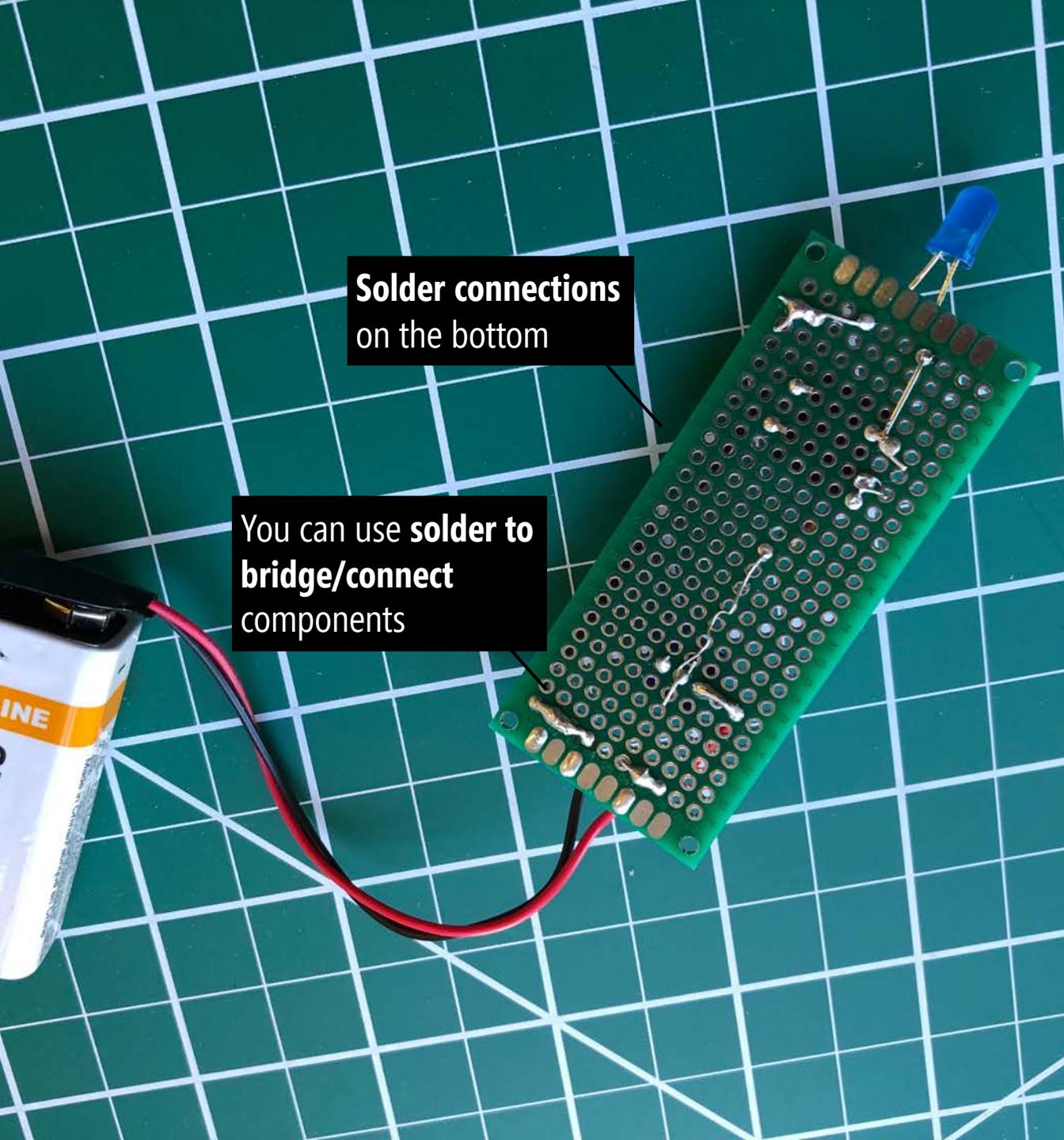
The flashlight must use a **button** to turn it on/off and a **trimpot** to set the **brightness**

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





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



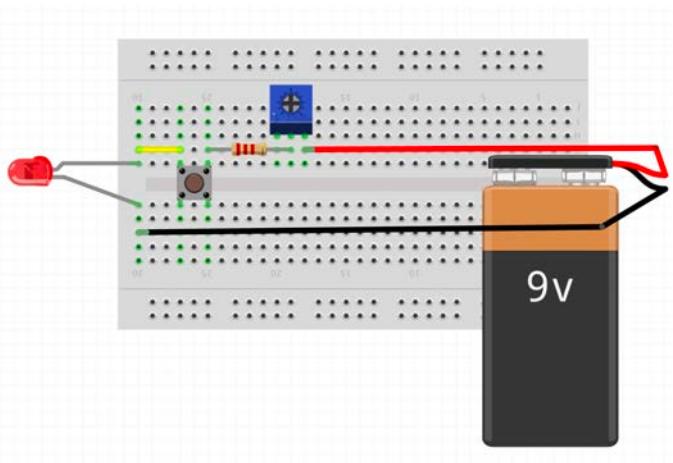
**Solder connections**  
on the bottom

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

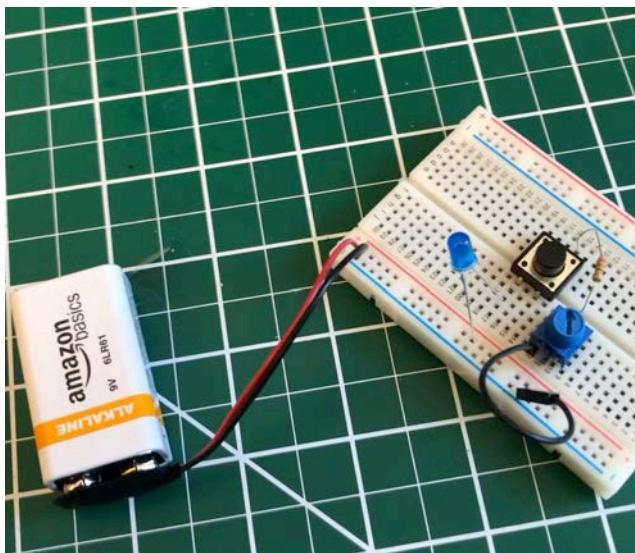
## ACTIVITY

# DESIGN PROCESS

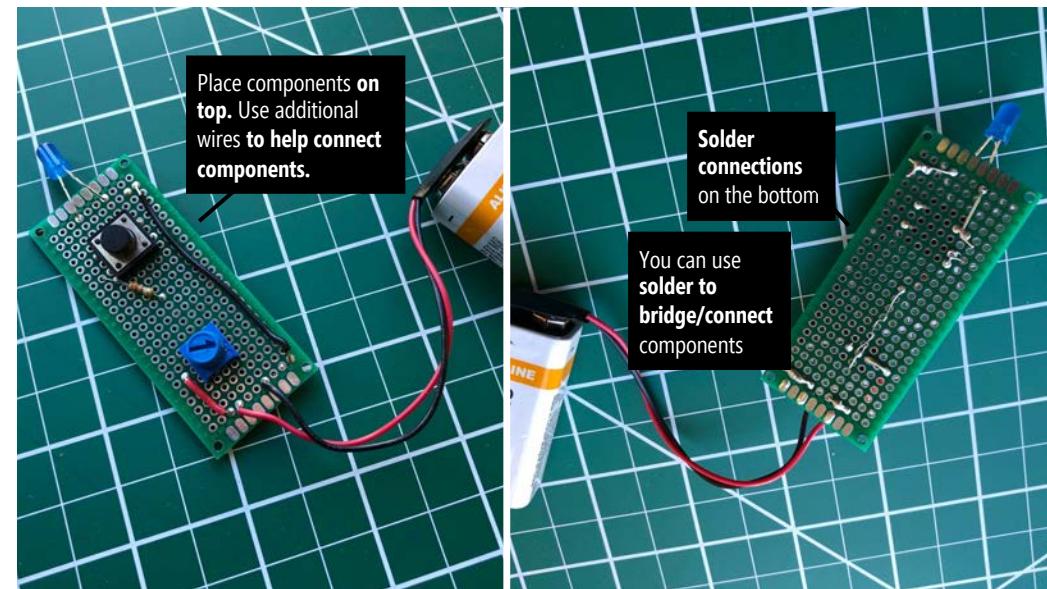
1. Design Circuit



2. Breadboard it

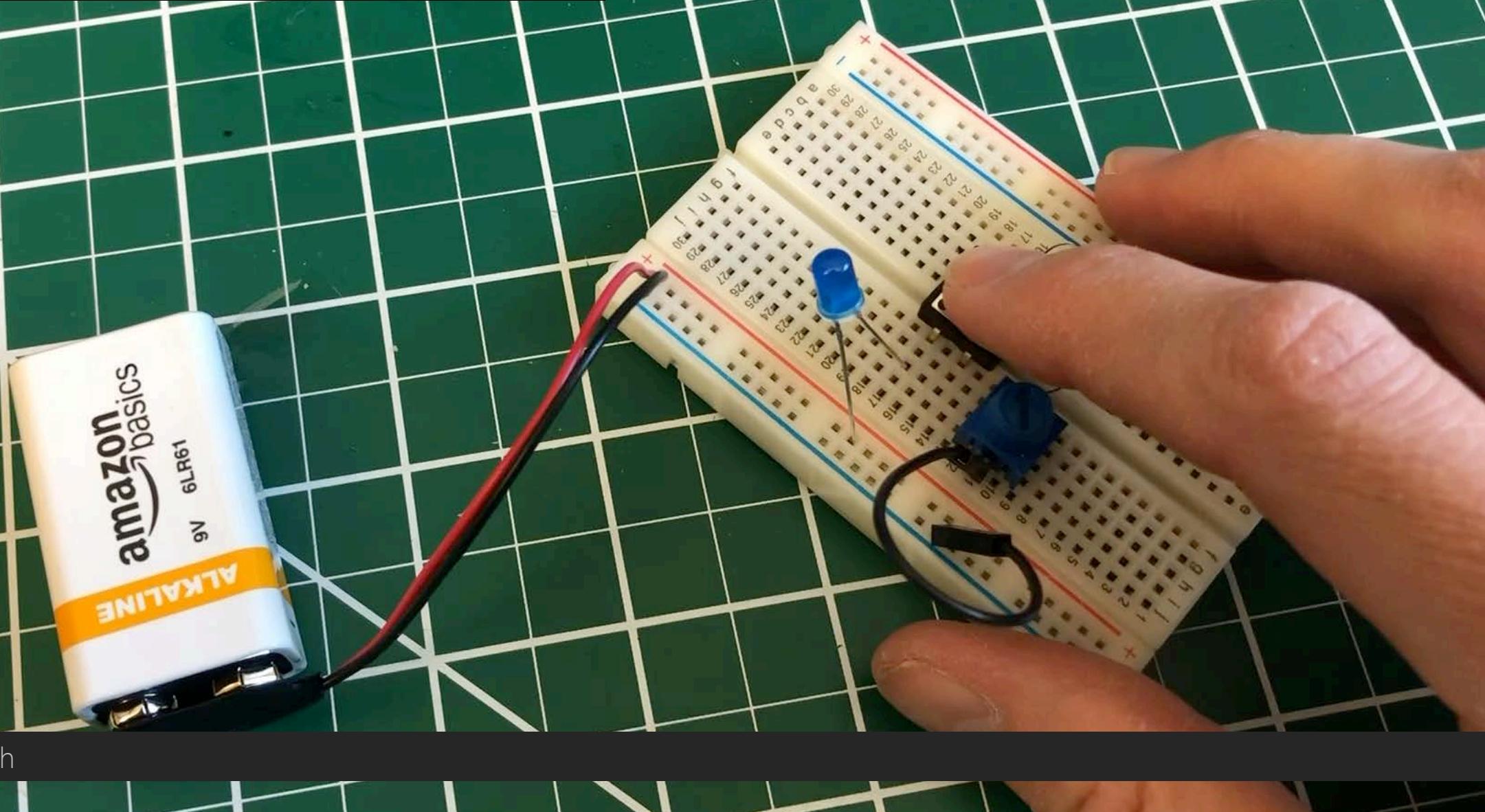


3. Perfboard + solder it



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](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