PROTOTYPING FORM 2: WIRE TOOLS/SOLDERING

CSE 599 Prototyping Interactive Systems | Lecture 8 | Oct 22

Jon Froehlich • Liang He (TA)

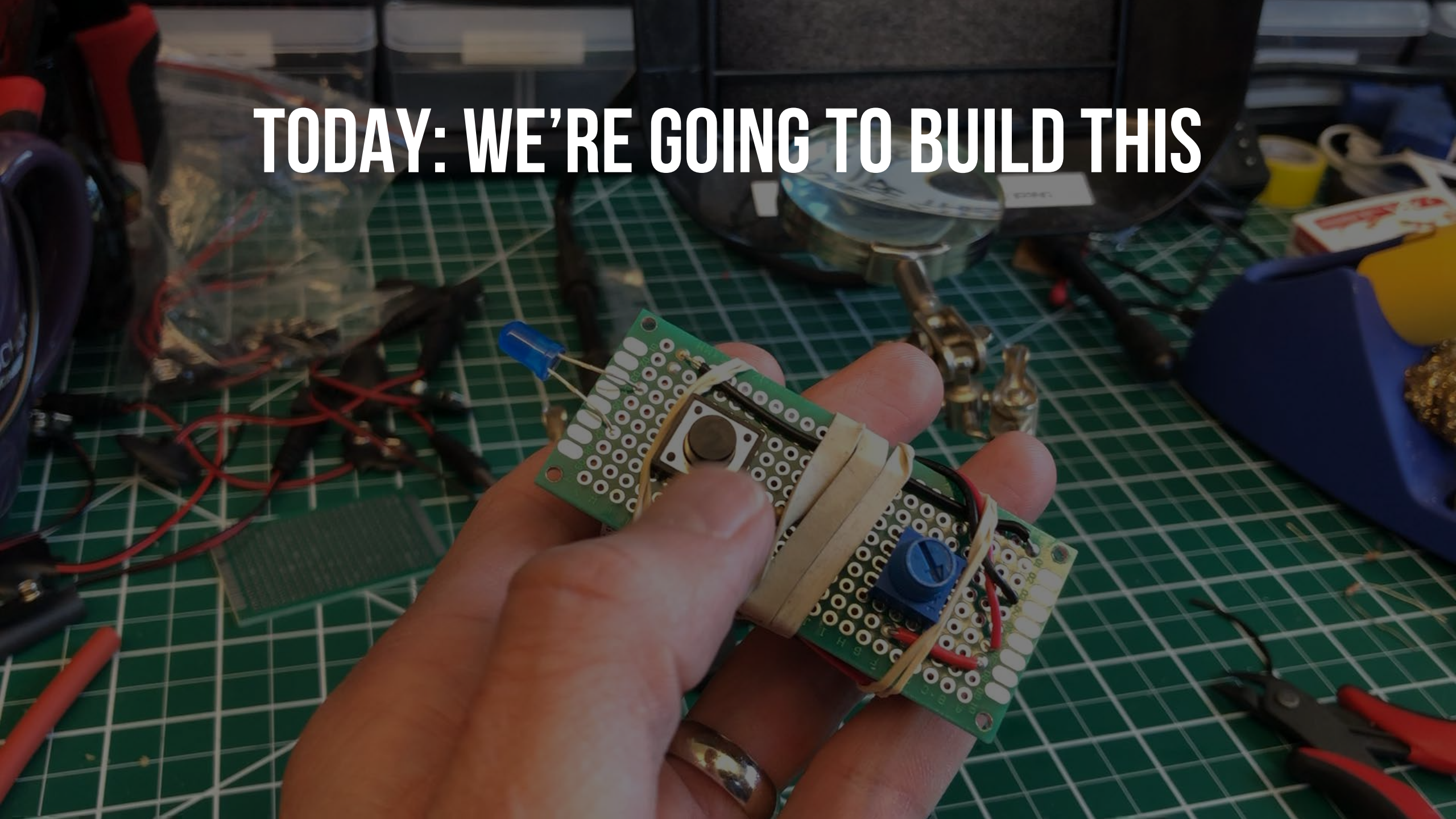
DESIGN USE BUILD

MAKEABILITY LAB

PAUL G. ALLEN SCHOOL OF COMPUTER SCIENCE & ENGINEERING

UNIVERSITY of WASHINGTON

TODAY: WE'RE GOING TO BUILD THIS



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A2: Fabrication: 3D-Printed Interactive Night Light

Published | Edit

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

Related Items
SpeedGrader™

jonfroehlich / CSE599Au2019

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jonfroehlich Update README.md — Latest commit f49411d 4 hours ago

..		
Adafruit HUZZAH32 ESP32 Feather with ...	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

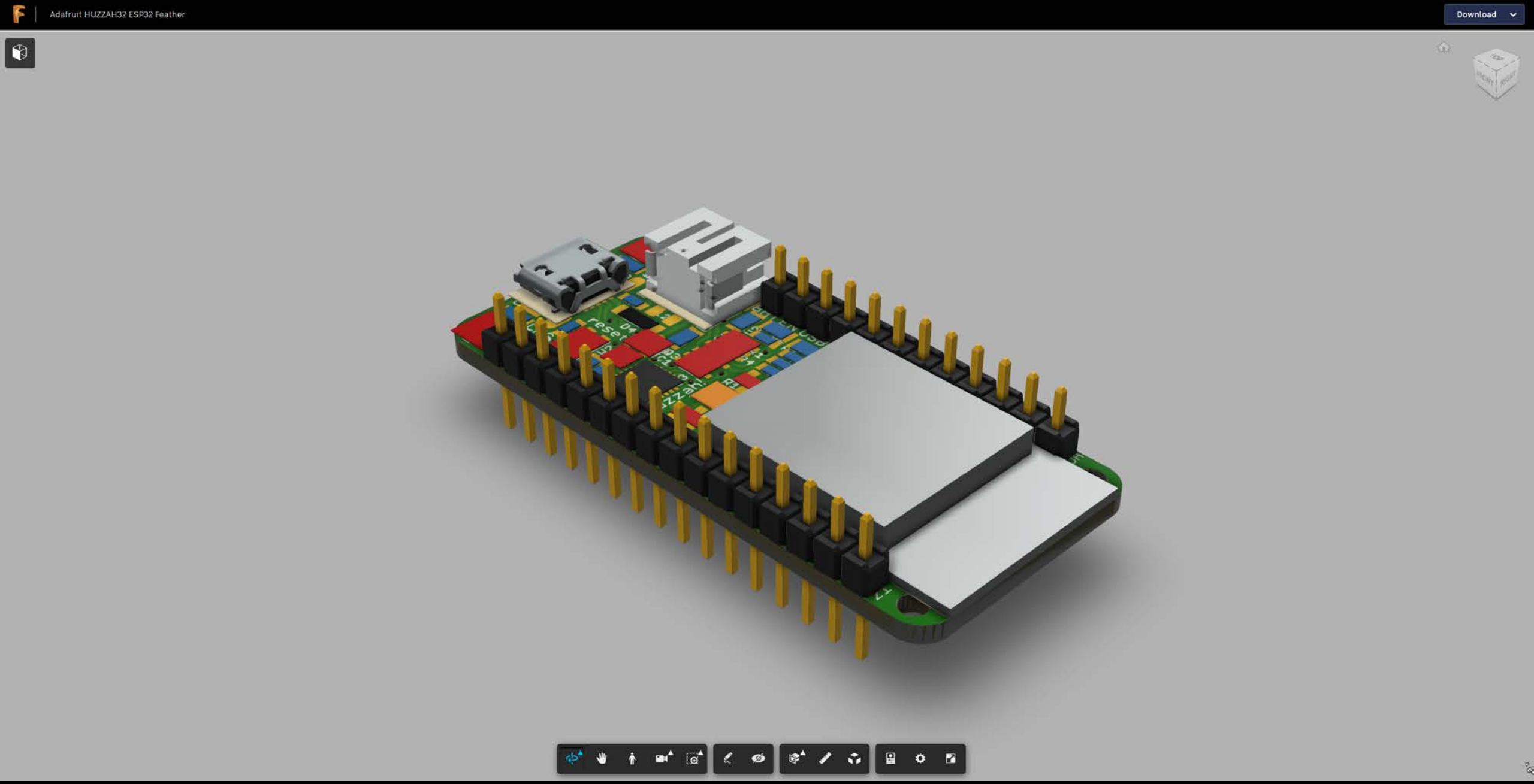
I created two Adafruit Huzzah ESP32 Feather models in Fusion360: `Huzzah32 Simple.iges`, which contains the board, USB connector, and ESP chip, and `Adafruit HUZZAH32 ESP32 Feather with Headers.iges`, which also includes the header pins and a JST connector.

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

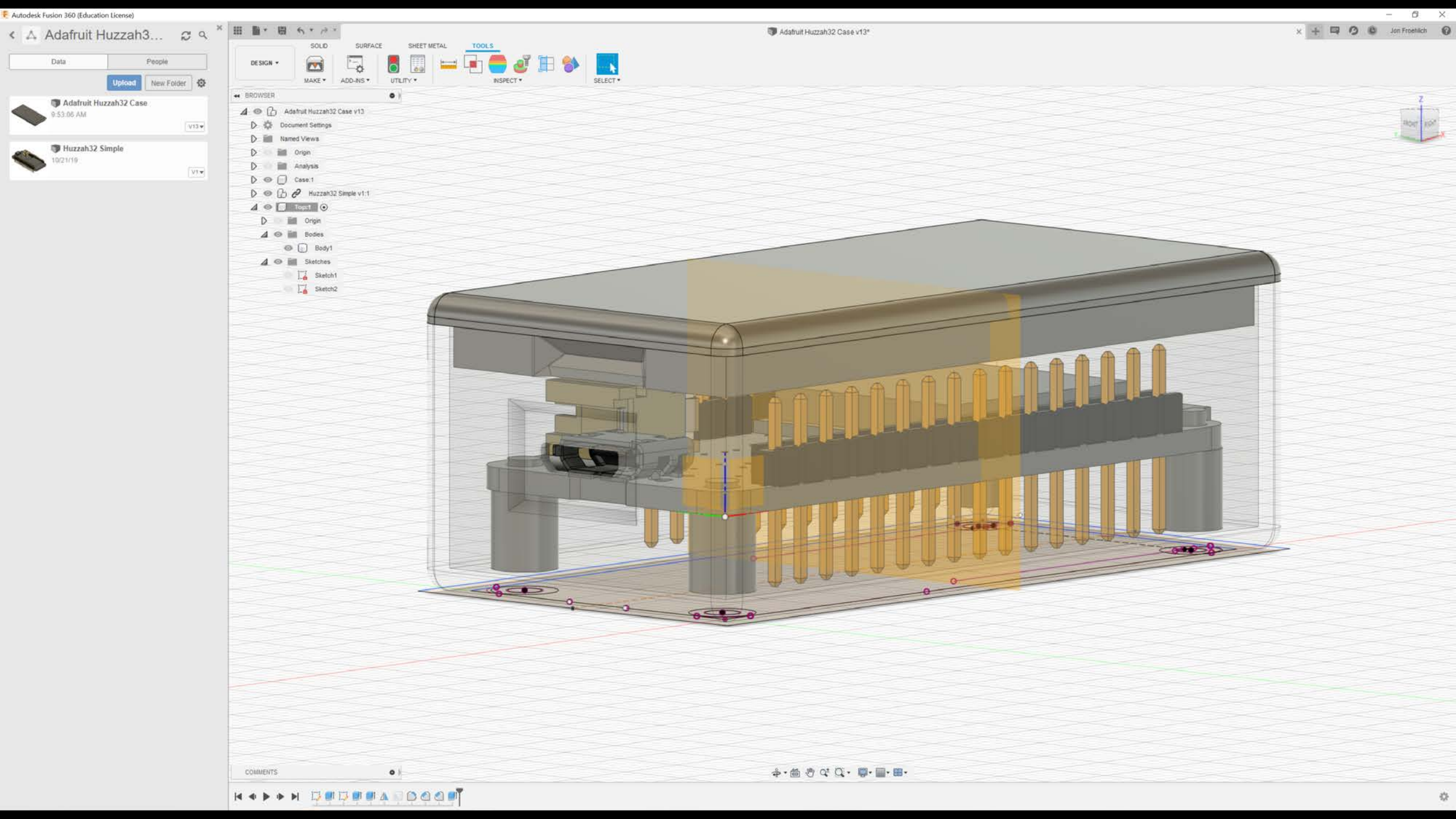
Measurements based on an import of the Adafruit HUZZAH32 ESP32 Feather.brd Eagle Design files and some small amount of manual measurements (using calipers).

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


Autodesk Fusion 360 (Education License)
Adafruit Huzzah3...
Data
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Adafruit Huzzah32 Case
9:53:06 AM
V13
Huzzah32 Simple
10/21/19
V1
Adafruit Huzzah32 Case v13*
Jon Froehlich
SOLID
SURFACE
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Adafruit Huzzah32 Case v13
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Huzzah32 Simple v1:1
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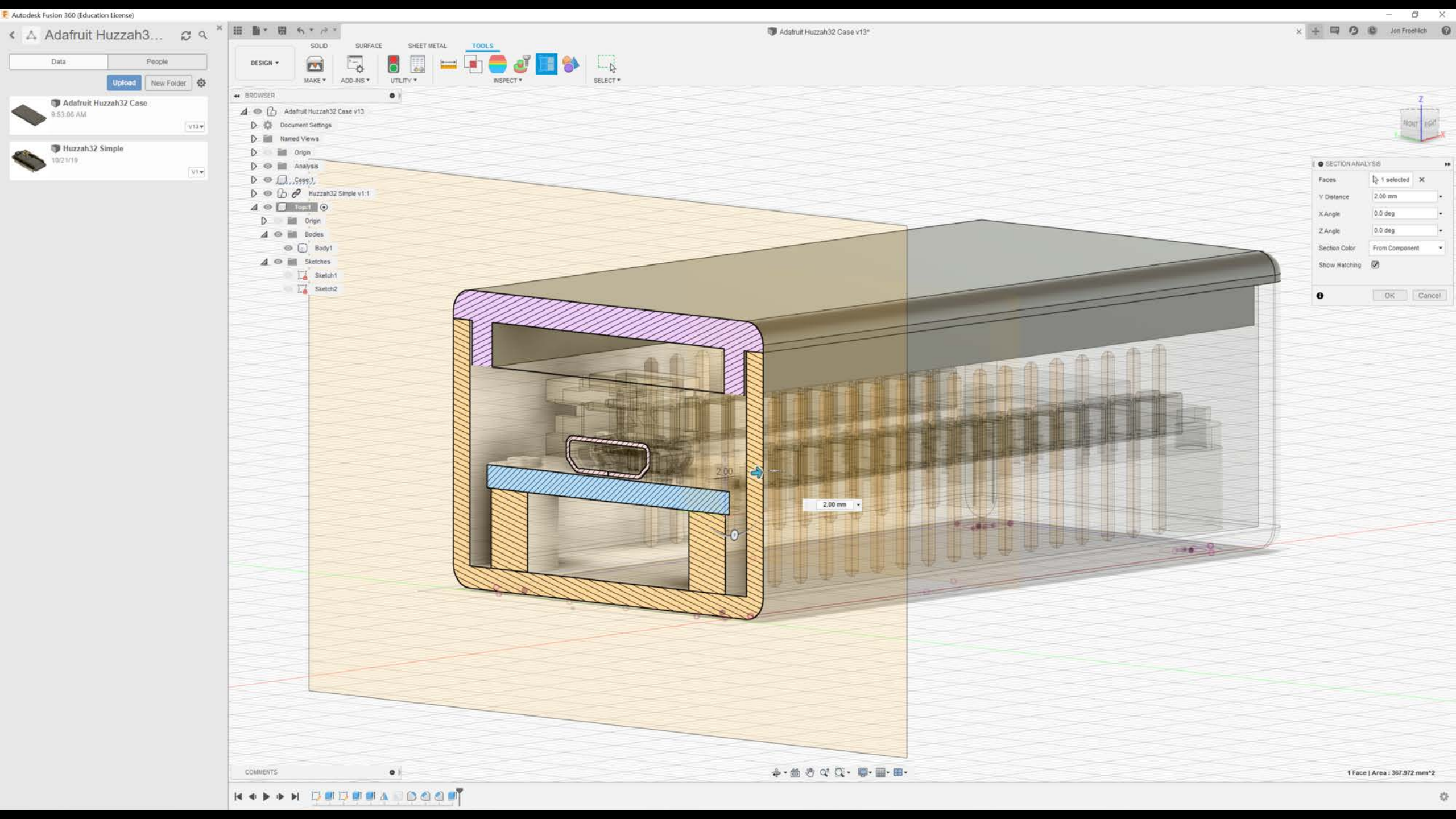
Body1
Sketches
Sketch1
Sketch2
COMMENTS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SECTION ANALYSIS
Faces
1 selected
Y Distance
2.00 mm
X Angle
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Z Angle
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From Component
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OK
Cancel
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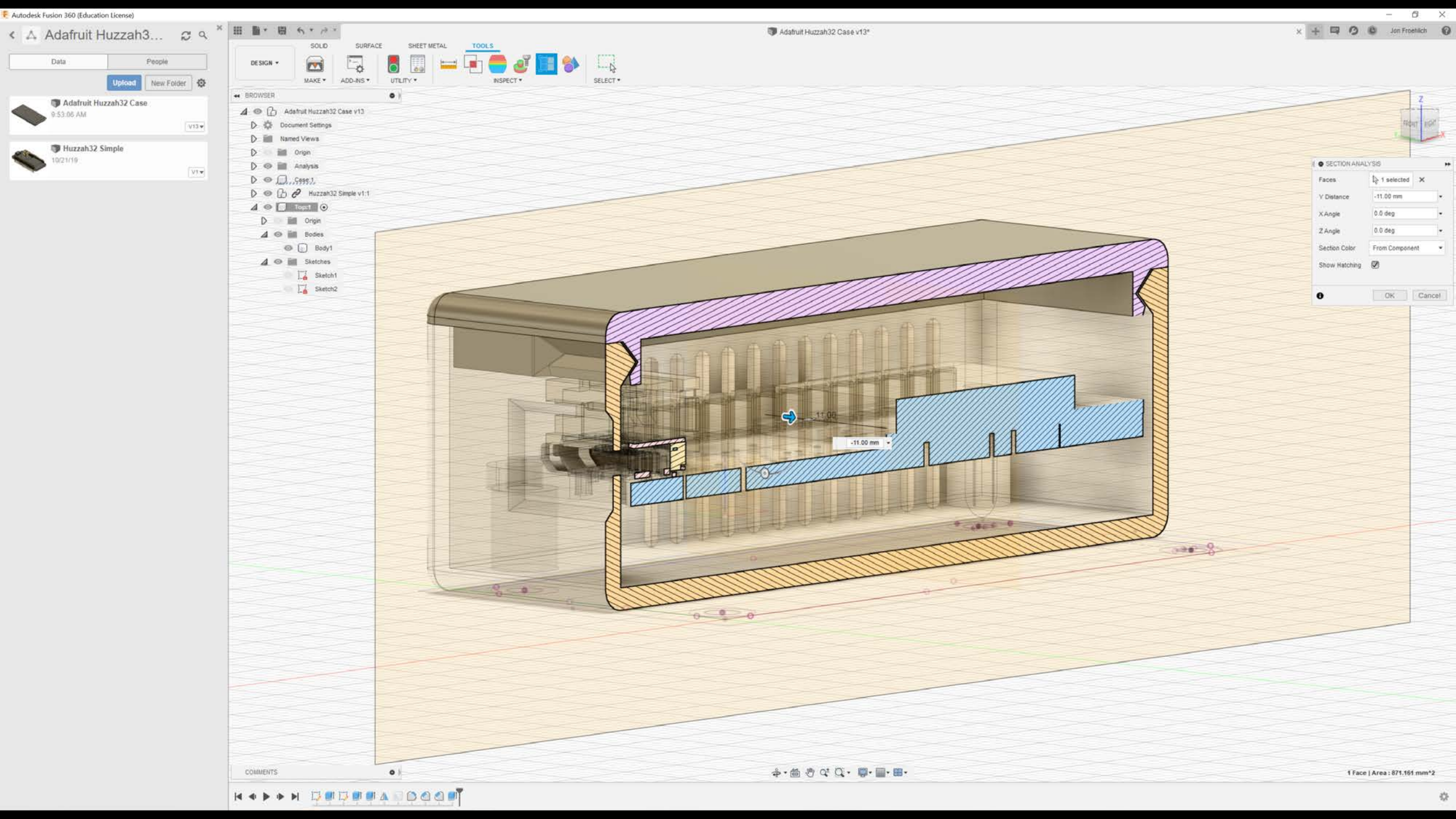
2.00 mm
COMMENTS
1 Face | Area : 367.972 mm^2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Huzzah32 Simple
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Sketches
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SECTION ANALYSIS
Faces
1 selected
V Distance
-11.00 mm
X Angle
0.0 deg
Z Angle
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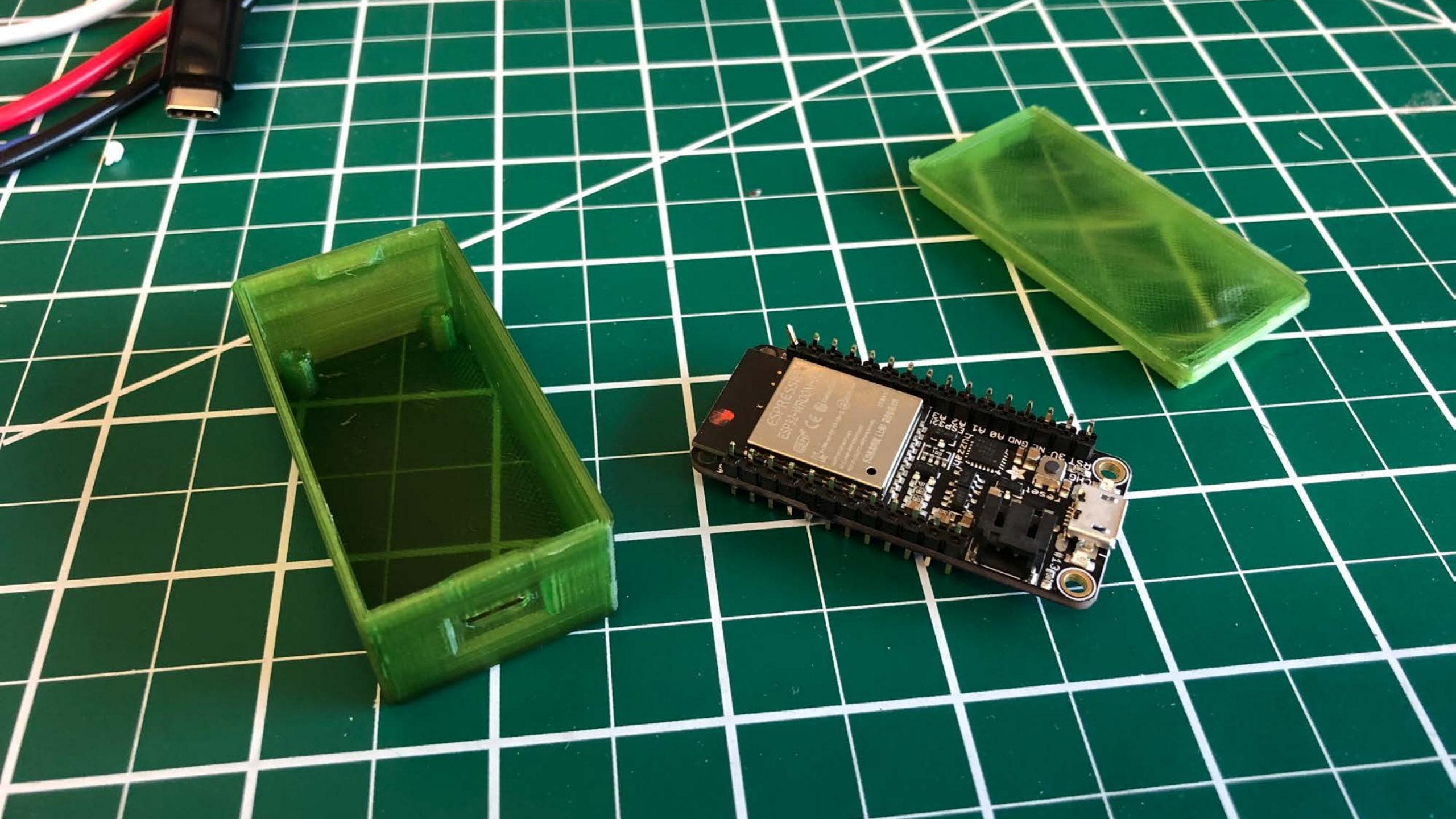
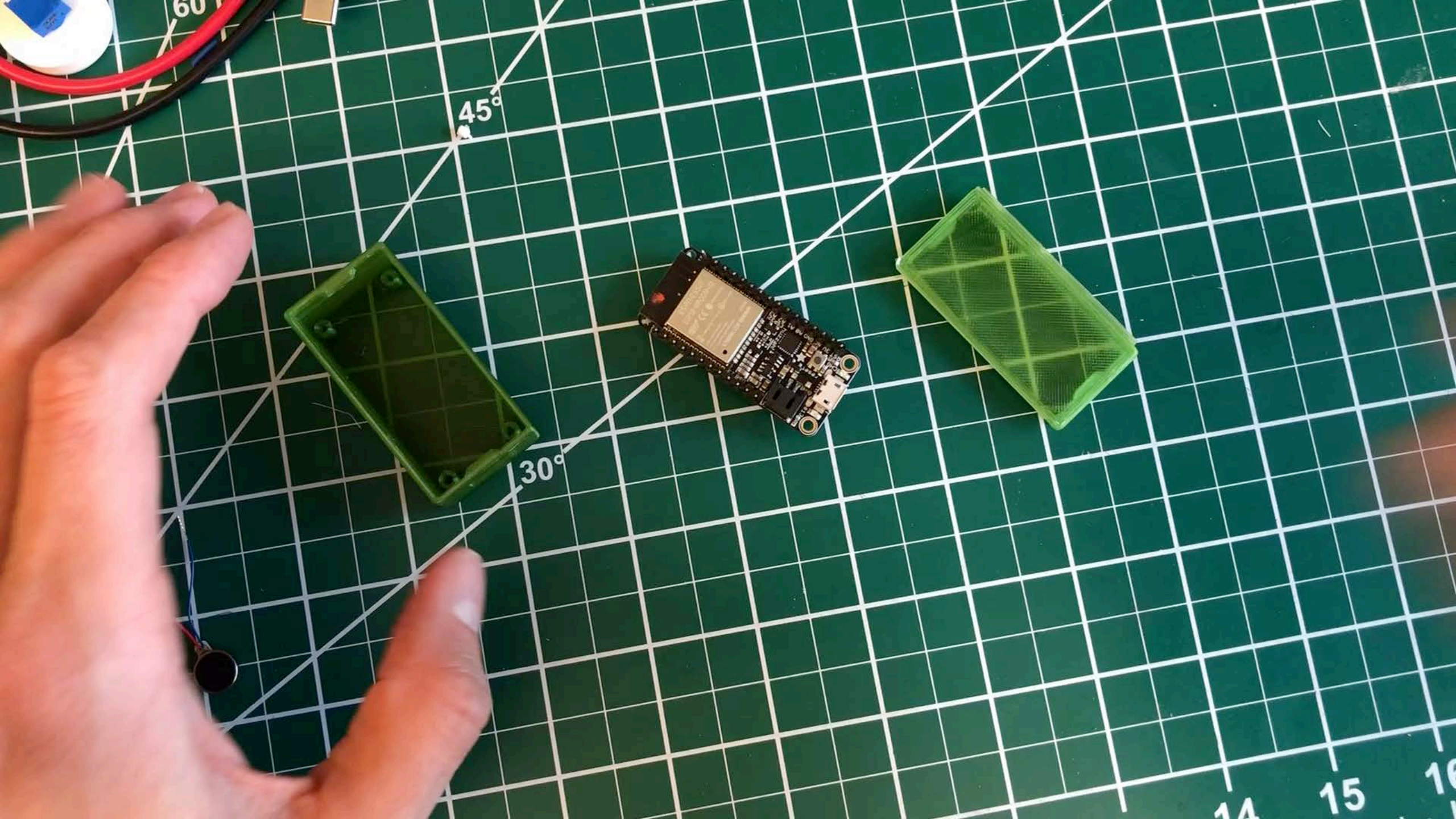
Section Color
From Component
Show Hatching
OK
Cancel
COMMENTS
1 Face | Area : 871.161 mm^2




60°
45°
30°
14
15

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

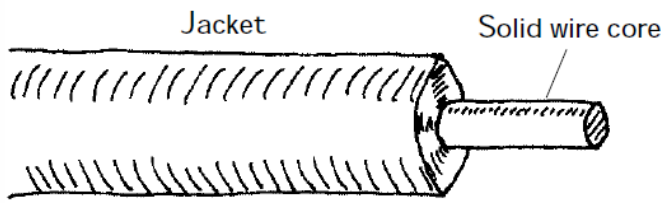
(If time) **Solder header pins** on Adafruit Huzzah32 accelerometer


WIRES

WIRES

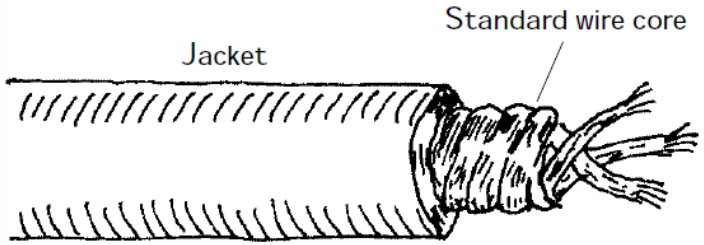
COMMON WIRE TYPES

Solid Core



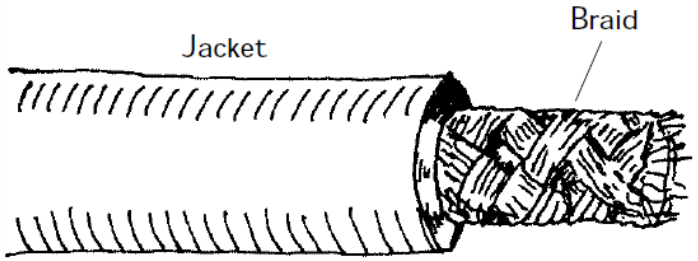
This wire is useful for **wiring breadboards**; the solid-core ends slip easily into breadboard sockets and will not fray in the process. However, these wires have the **tendency to snap** after a number of flexes

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

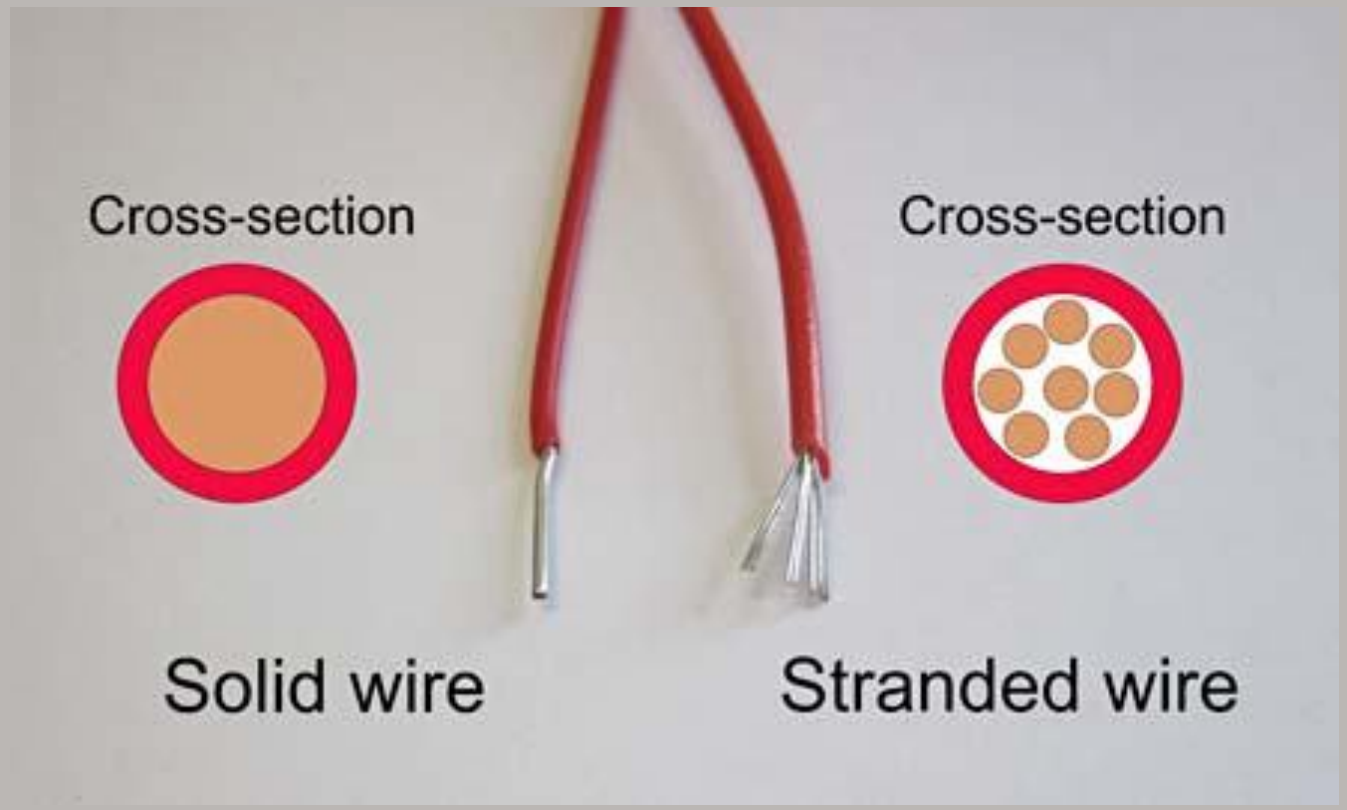


Made up of a number of **individual strands of wire braided** together. Like stranded wires, better conductors than solid-core wires, and will not break easily when flexed. Often used as an **electromagnetic shield** in noise reduction Cables.

Source: Chapter 3 of Scherz & Monk, Practical Electronics, 3rd Edition, 2013

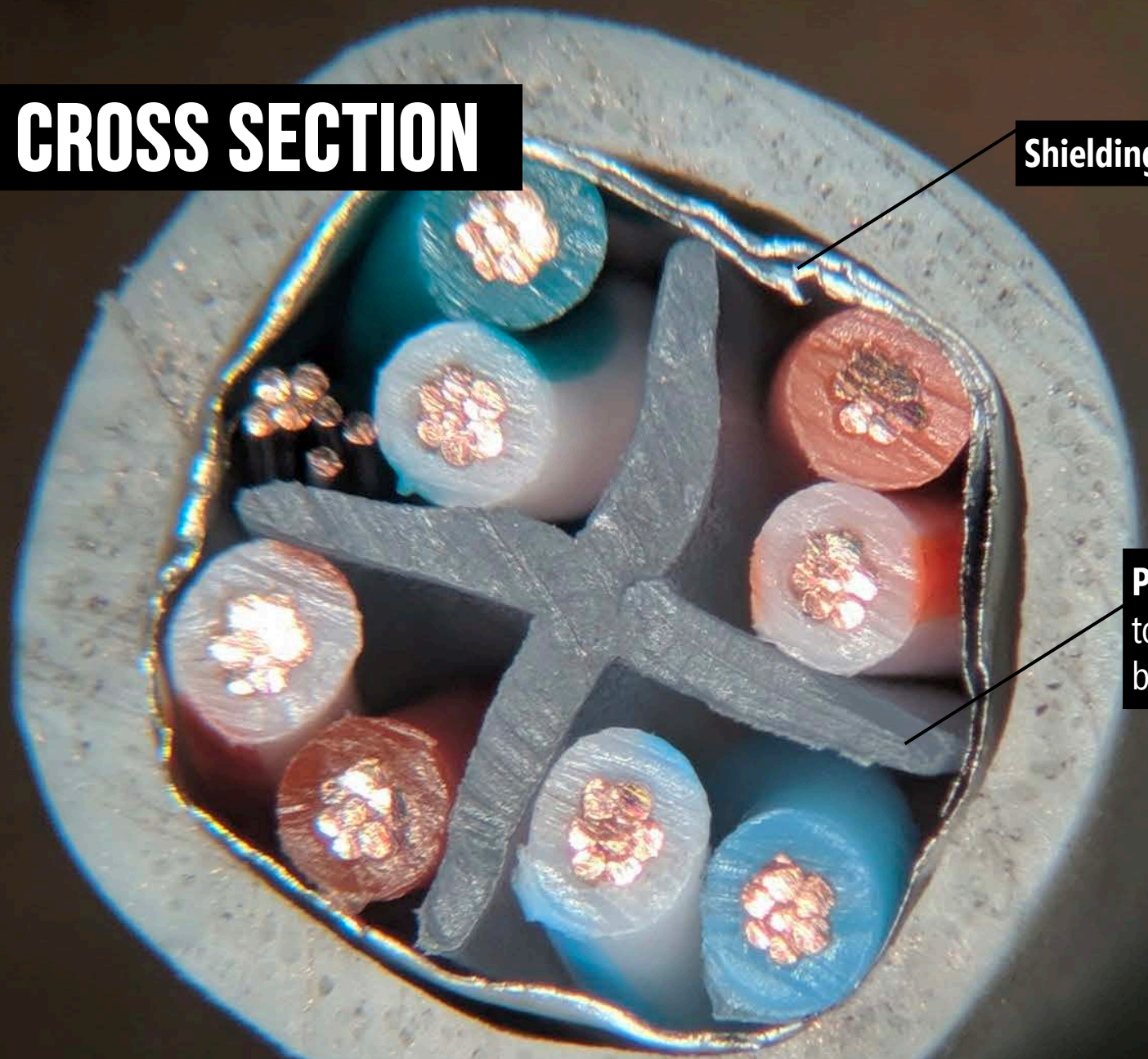
WIRES

SOLID CORE VS. STRANDED



WIRES

CAT6 CABLE CROSS SECTION



Shielding to reduce noise

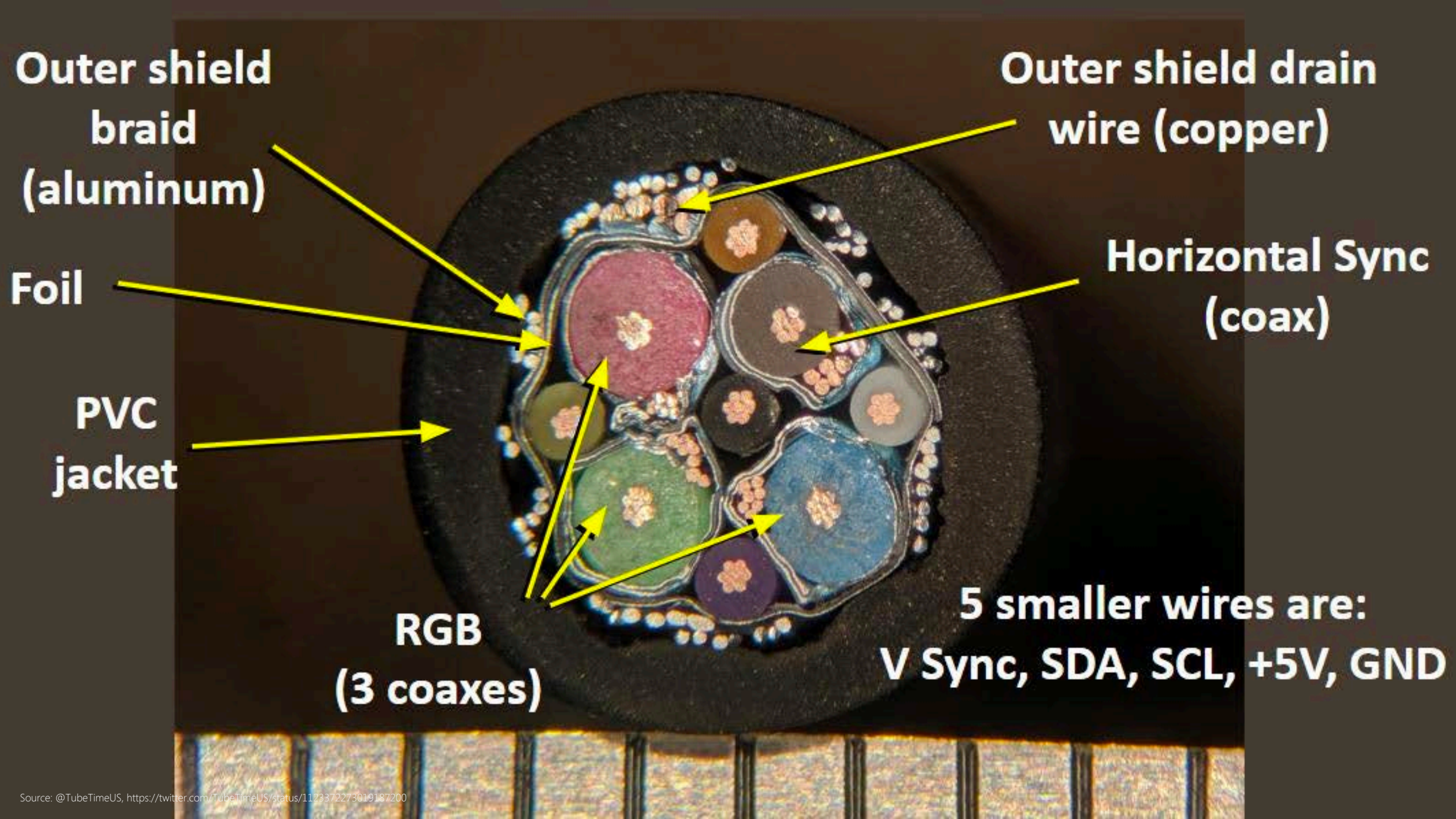
Plastic "+" separator to reduce crosstalk between wire pairs

Source: @TubeTimeUS, https://twitter.com/TubeTimeUS/status/1123395605542215681

WIRES

VGA CABLE CROSS SECTION

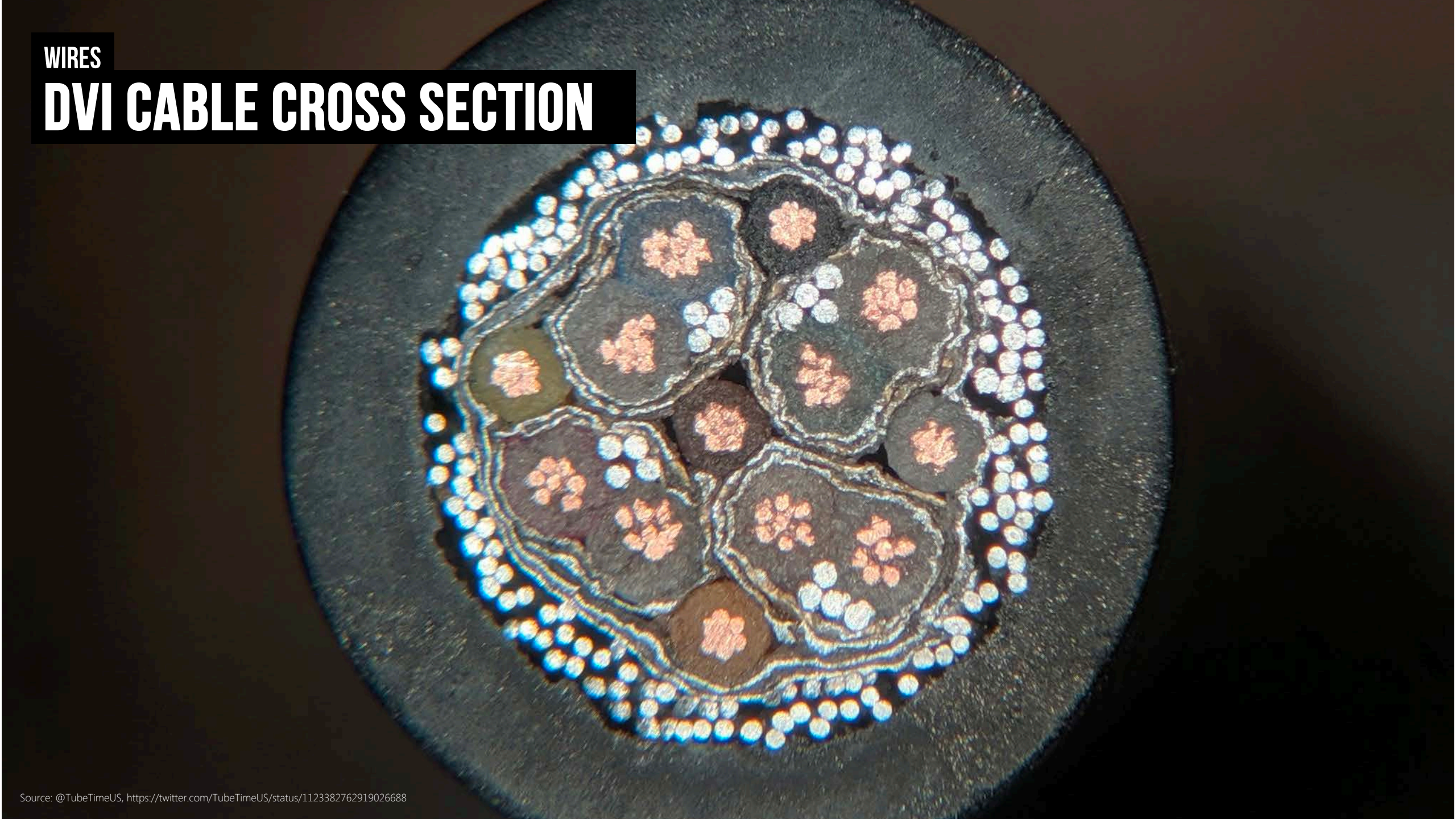
Source: @TubeTimeUS, https://twitter.com/TubeTimeUS/status/1123372273019187200



Source: @TubeTimeUS, https://twitter.com/TubeTimeUS/status/1123372273019187200

WIRES

DVI CABLE CROSS SECTION



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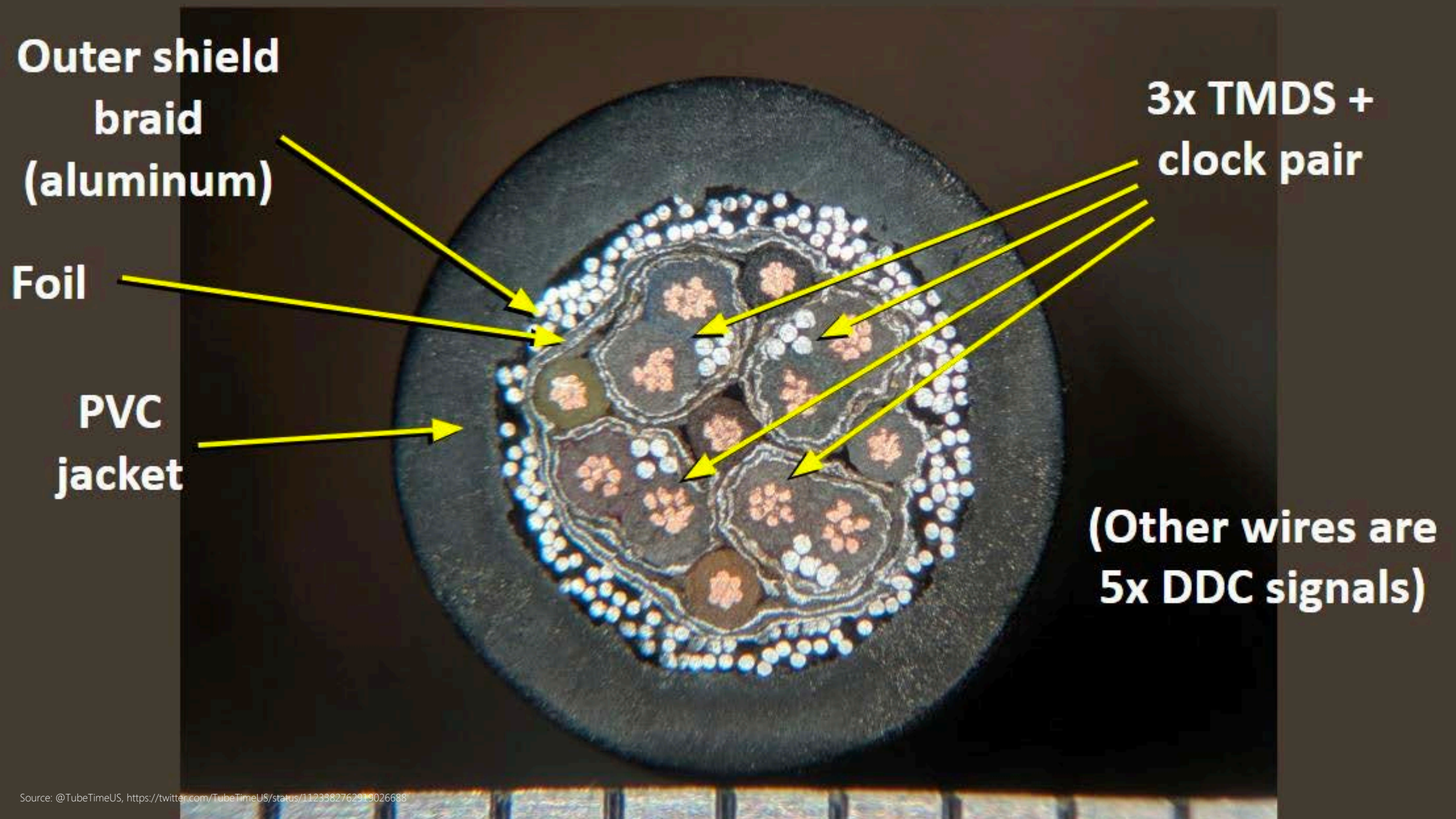


Source: @TubeTimeUS, https://twitter.com/TubeTimeUS/status/1123382762919026688

Outer shield braid (aluminum)

Foil

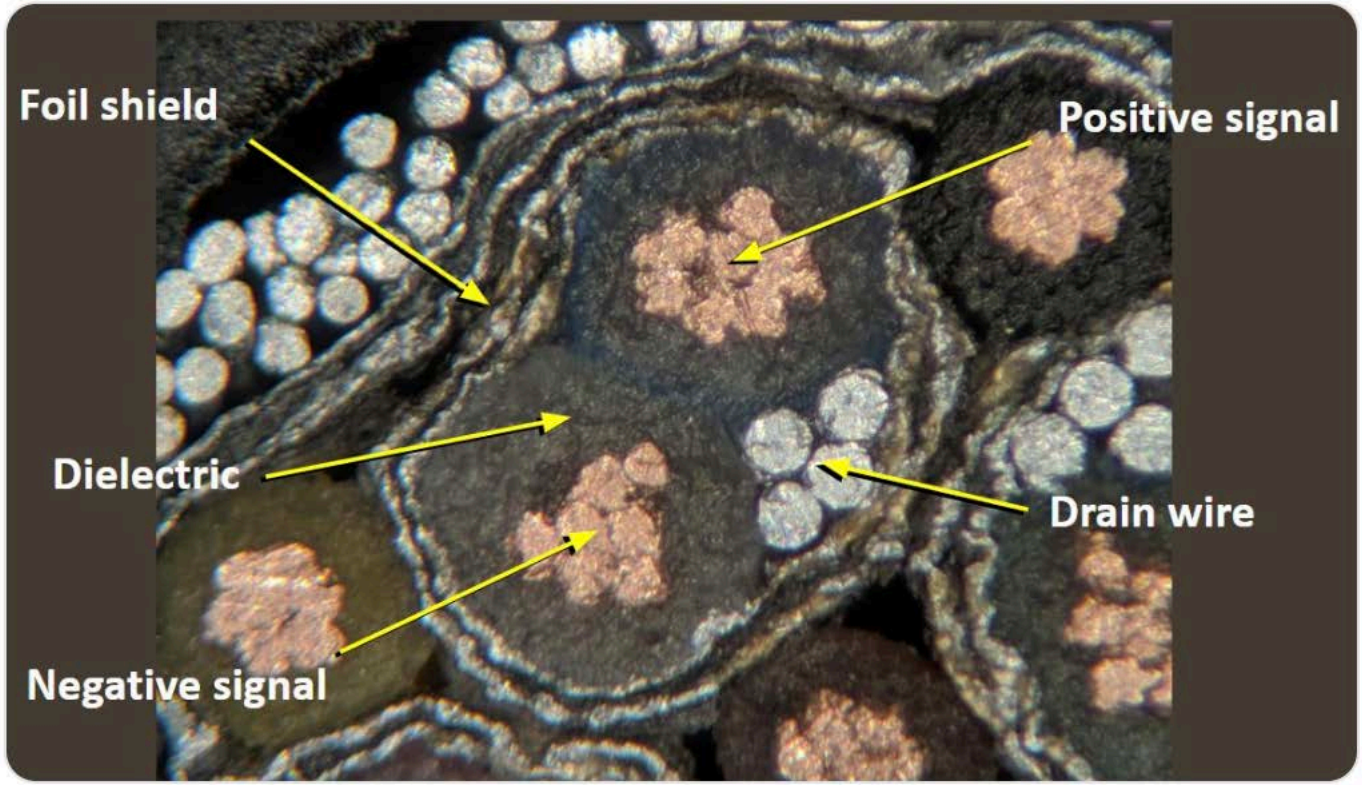
PVC jacket

3x TMDS + clock pair

her 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!



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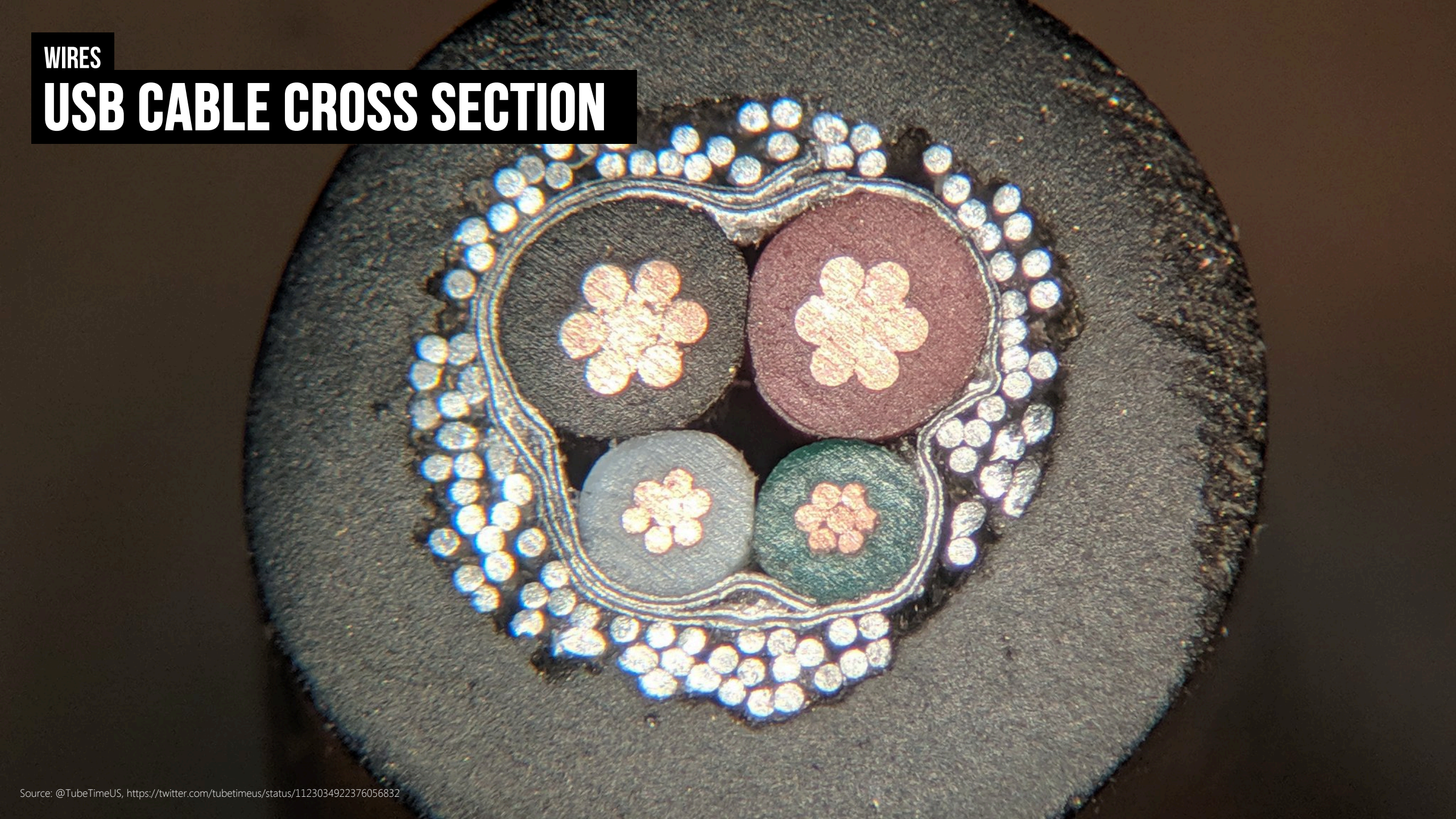
Source: @TubeTimeUS, https://twitter.com/TubeTimeUS/status/1123382762919026688

WIRES

USB CABLE CROSS SECTION



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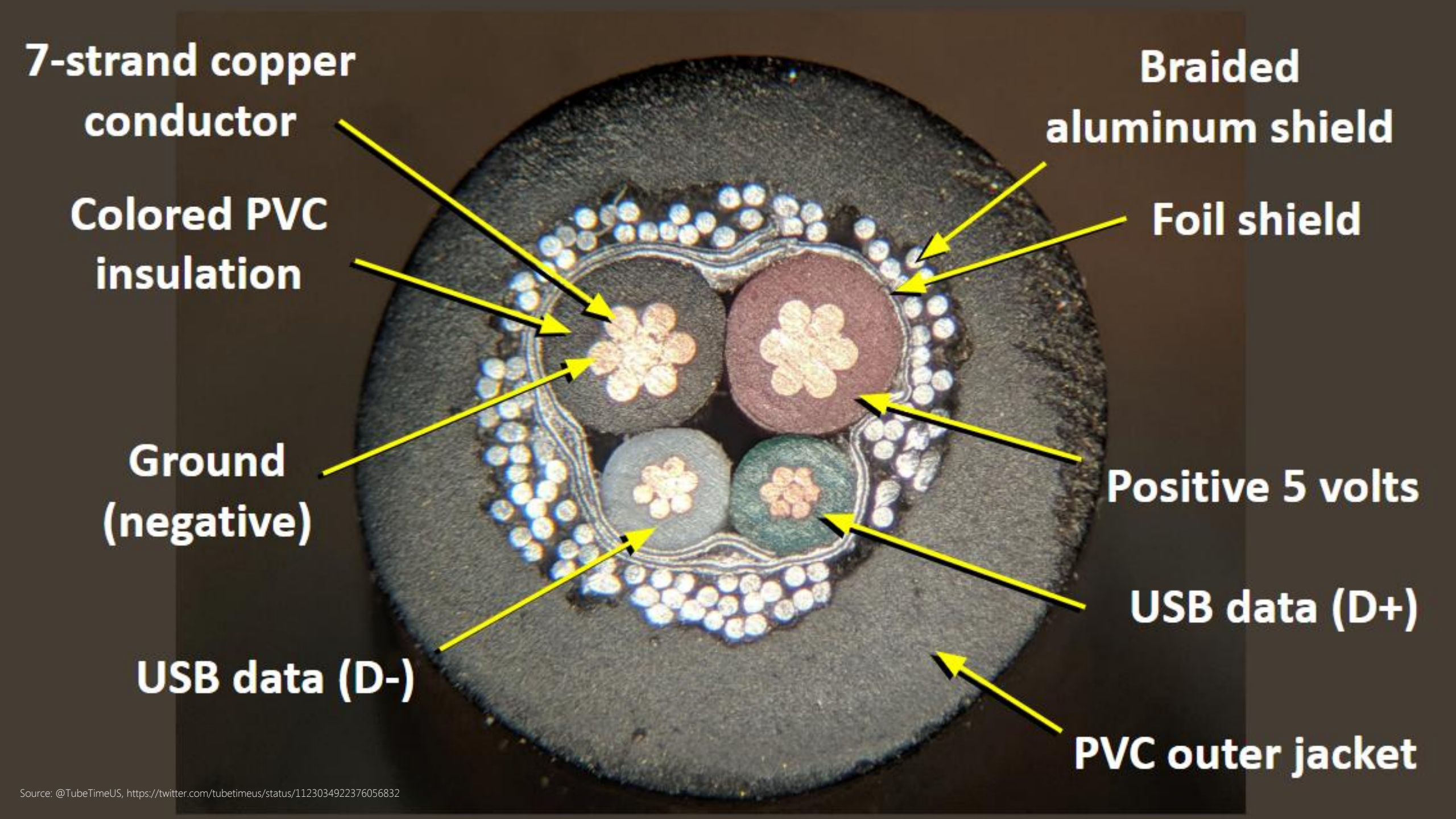
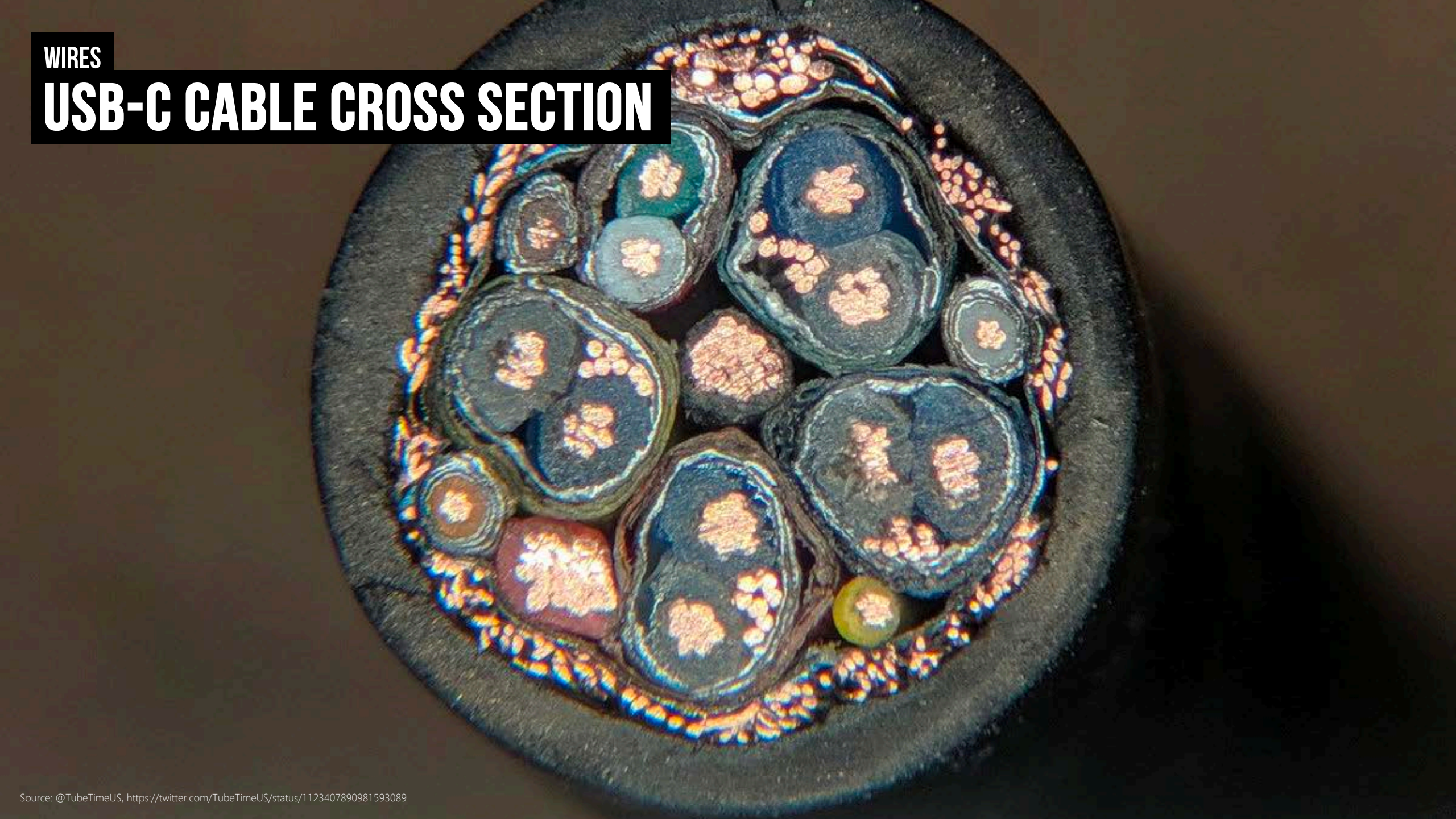


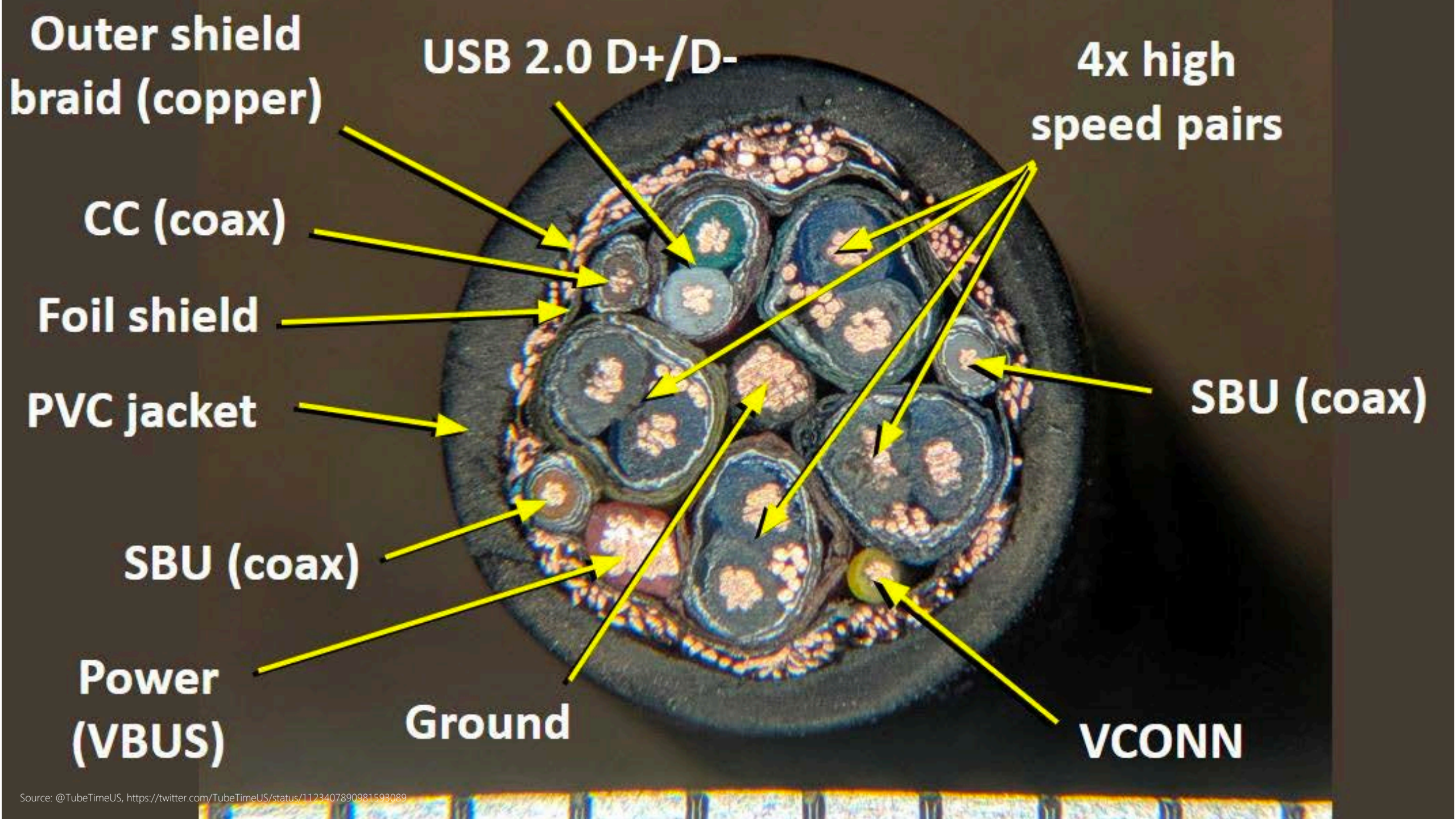
Source: @TubeTimeUS, https://twitter.com/tubetimeus/status/1123034922376056832

WIRES

USB-C CABLE CROSS SECTION



Source: @TubeTimeUS, https://twitter.com/TubeTimeUS/status/1123407890981593089



Source: @TubeTimeUS, https://twitter.com/TubeTimeUS/status/1123407890981593089

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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LCDs +
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Prototyping –
Batteries
Boards
Connectors
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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Batteries
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Connectors
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'.

$2.50

Add to Cart

1 quantity

121 in stock

$2.50 1+ units

$2.25 10+ units

$2.00 100+ units

Wish List

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

9 comments

Login or Register to post comments.

Jeremy1998 | about 3 years ago ★ 3

We want blue!

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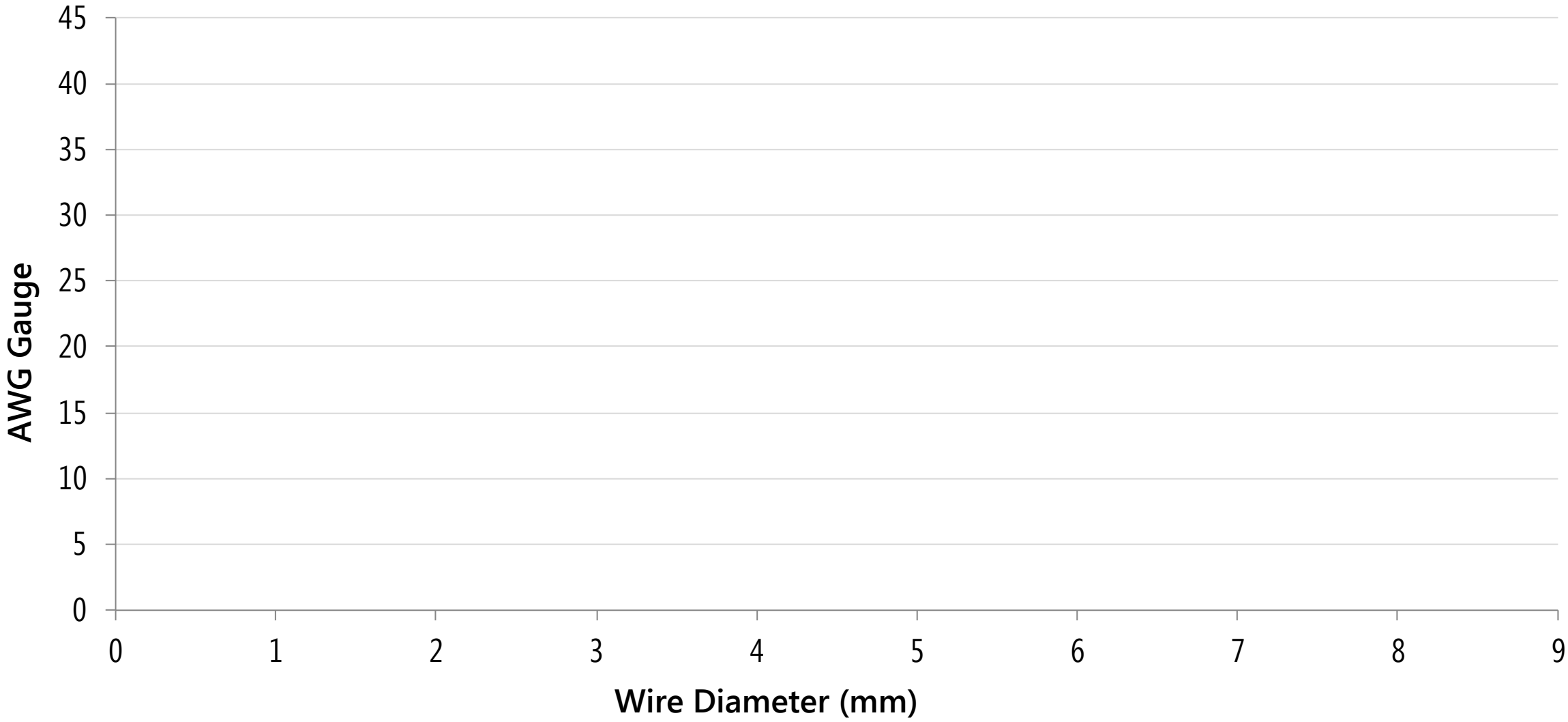
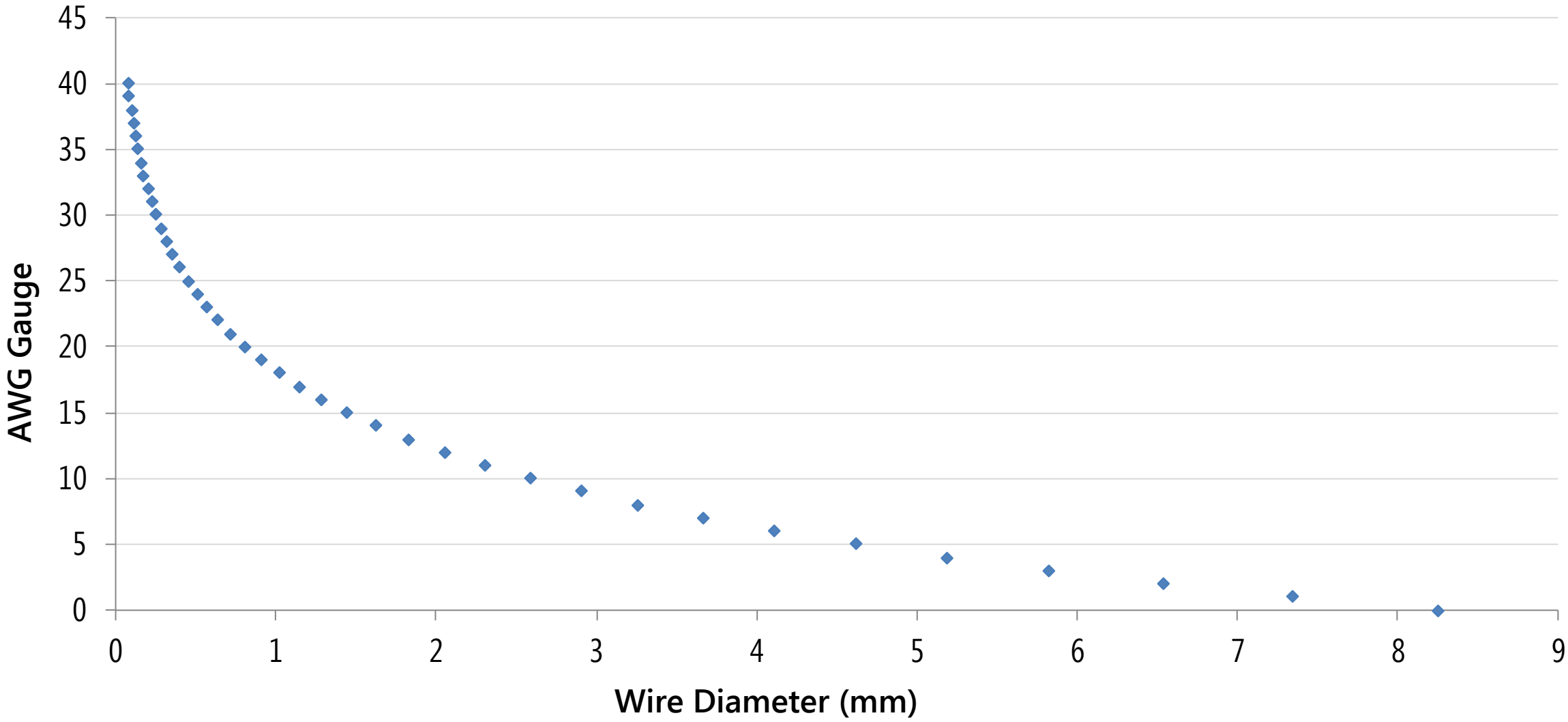
Is this wire copper?

AWG GAUGE VS. WIRE DIAMETER (MM)



Source:: Chapter 3 of Scherz & Monk, Practical Electronics, 3rd Edition, 2013

AWG GAUGE VS. WIRE DIAMETER (MM)



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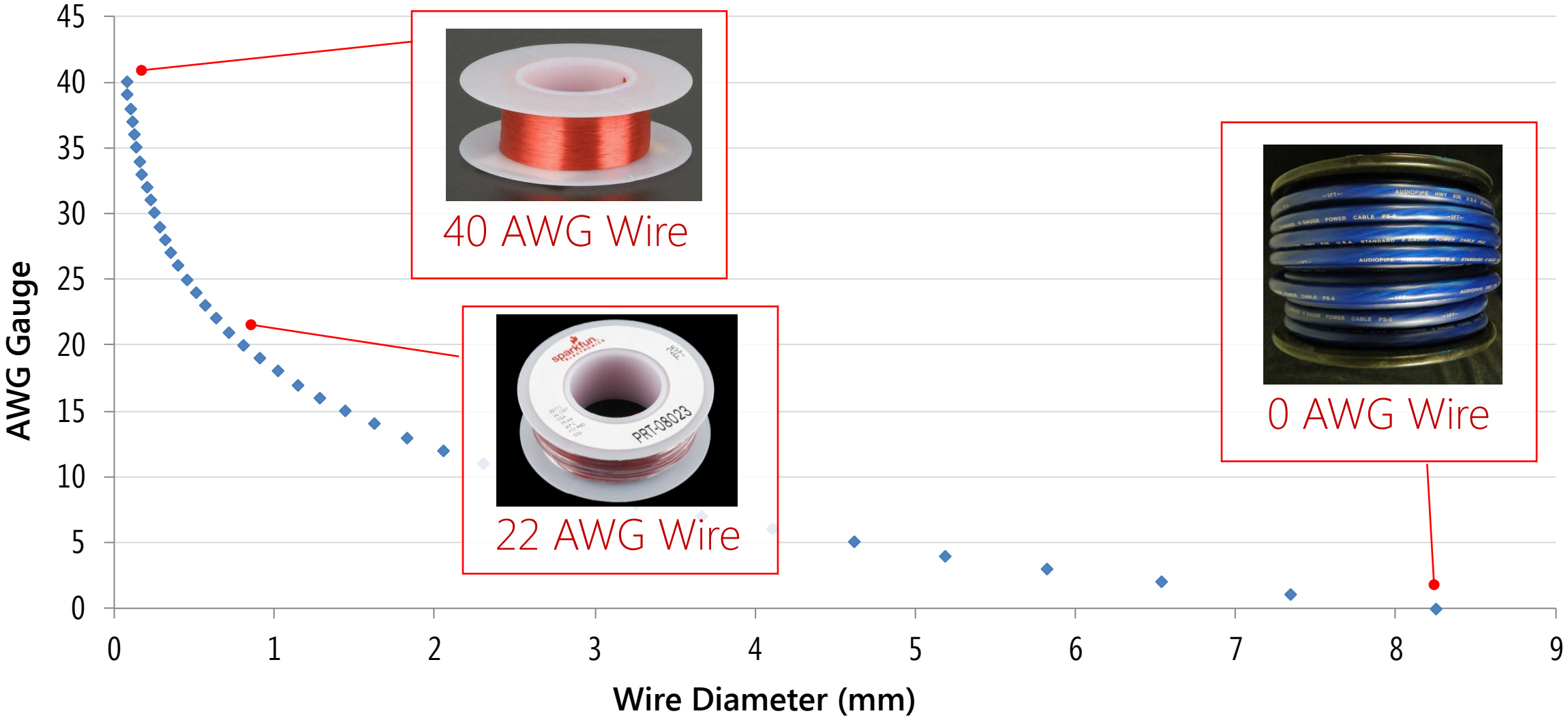
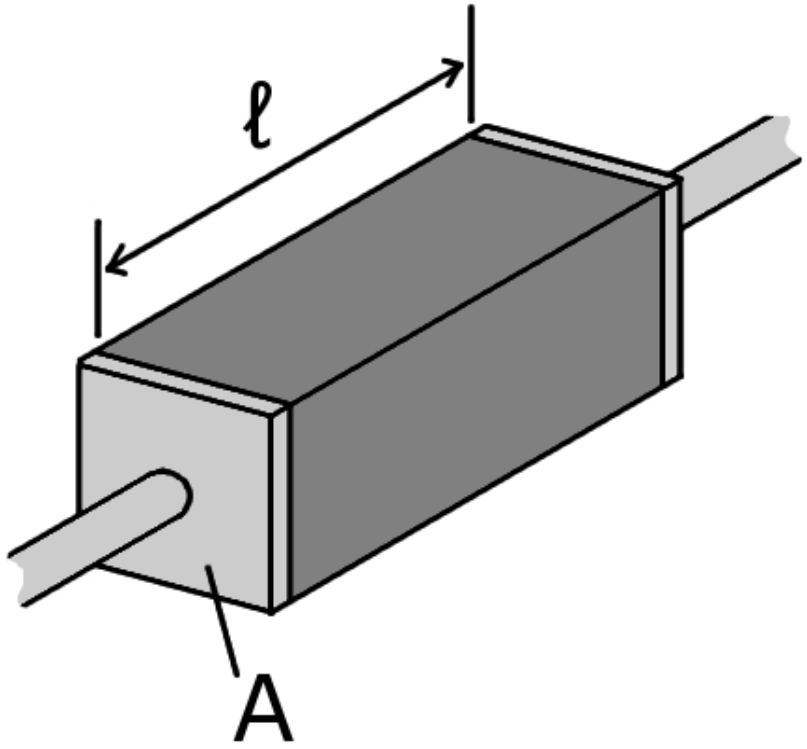
AWG GAUGE VS. WIRE DIAMETER (MM)



Source:: Chapter 3 of Scherz & Monk, Practical Electronics, 3rd Edition, 2013

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:

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

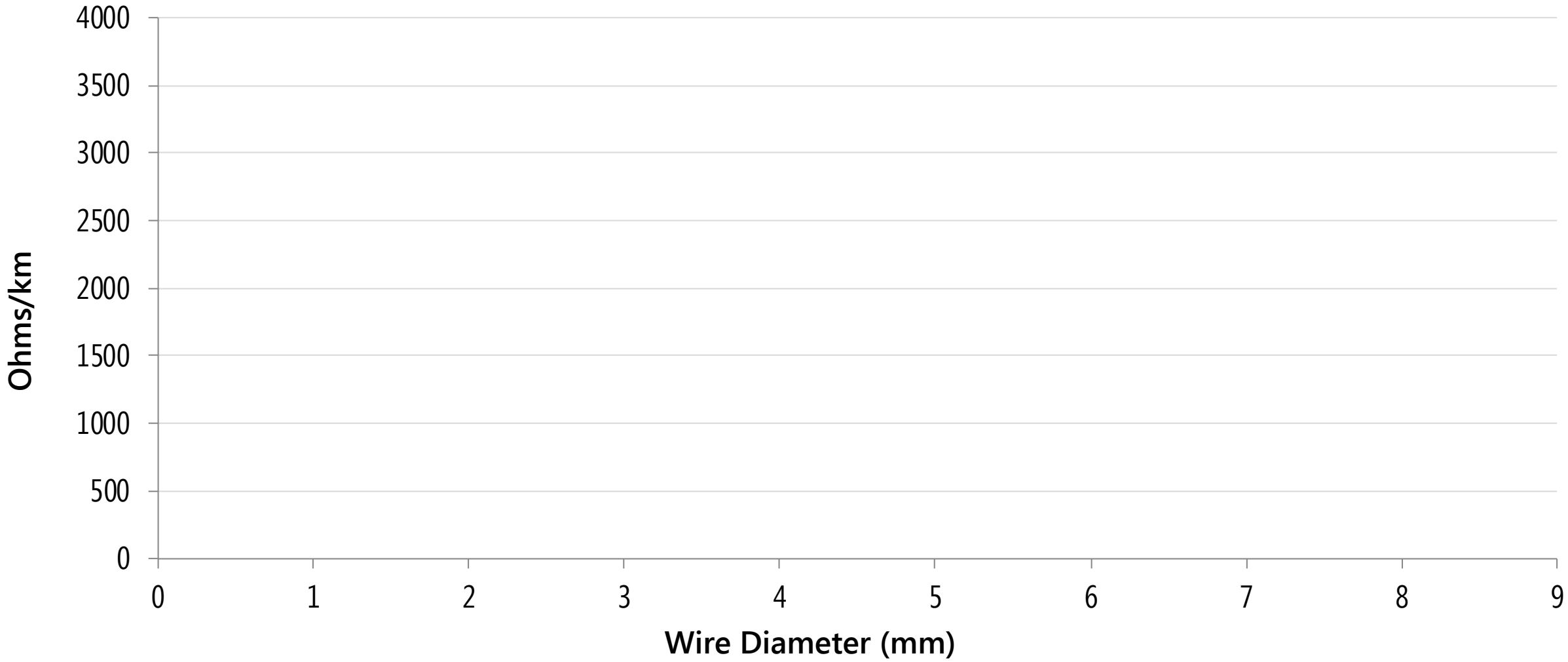
$\boldsymbol{\rho}$ is the electrical resistivity of the material measured in ohms-meters

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

$\boldsymbol{A}$ is the cross-sectional area of the material (measured in square meters, m^2).

Source: http://en.wikipedia.org/wiki/Electrical_conductivity; http://en.wikipedia.org/wiki/Electrical_resistance_and_conductance

RESISTANCE AS A FUNCTION OF WIRE DIAMETER



Source: Chapter 3 of Scherz & Monk, Practical Electronics, 3rd Edition, 2013

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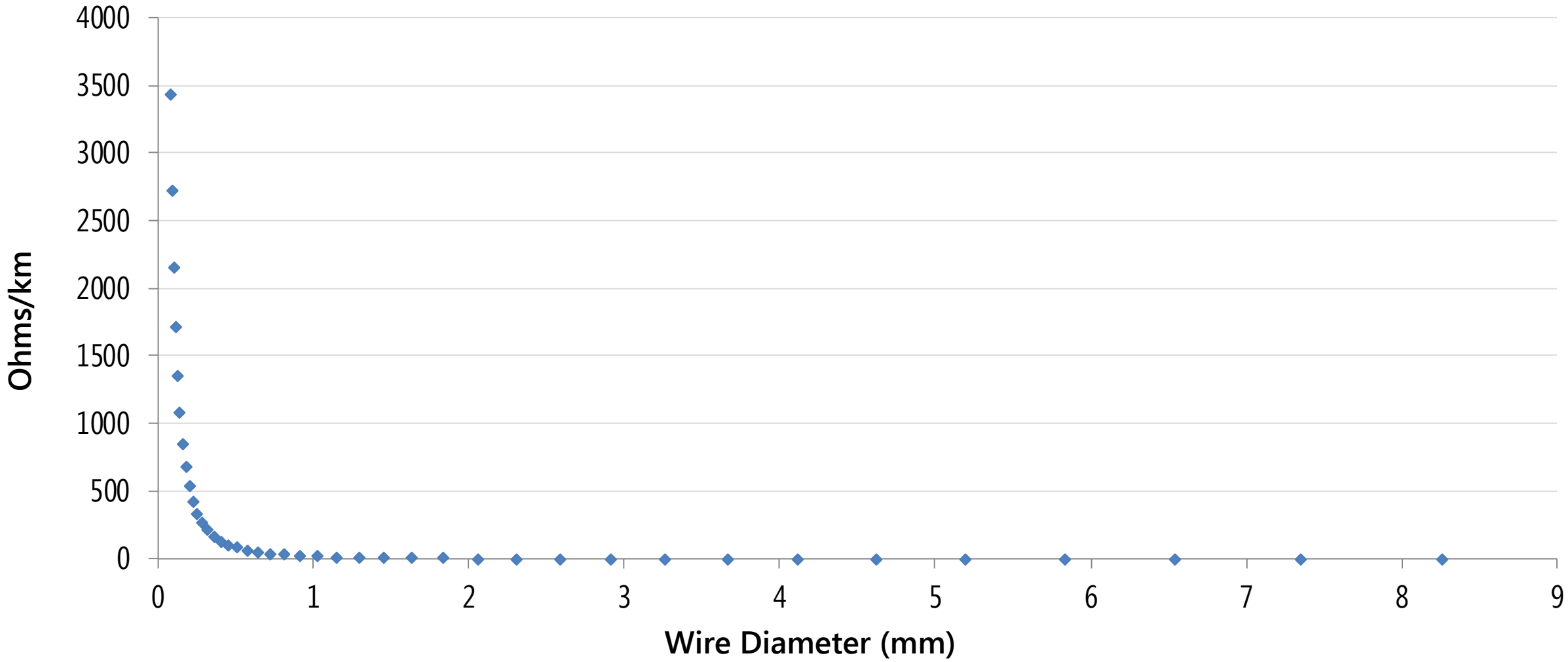

Source: Chapter 3 of Scherz & Monk, Practical Electronics, 3rd Edition, 2013

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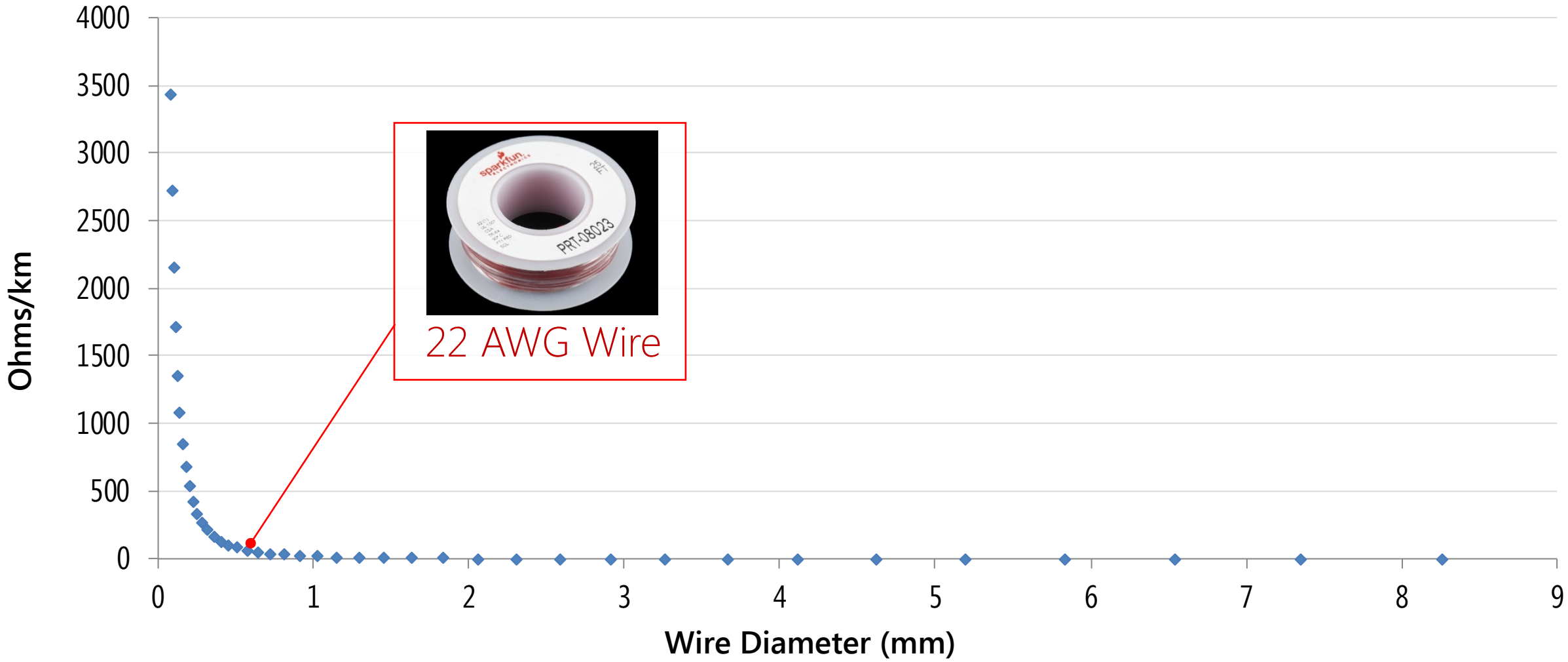
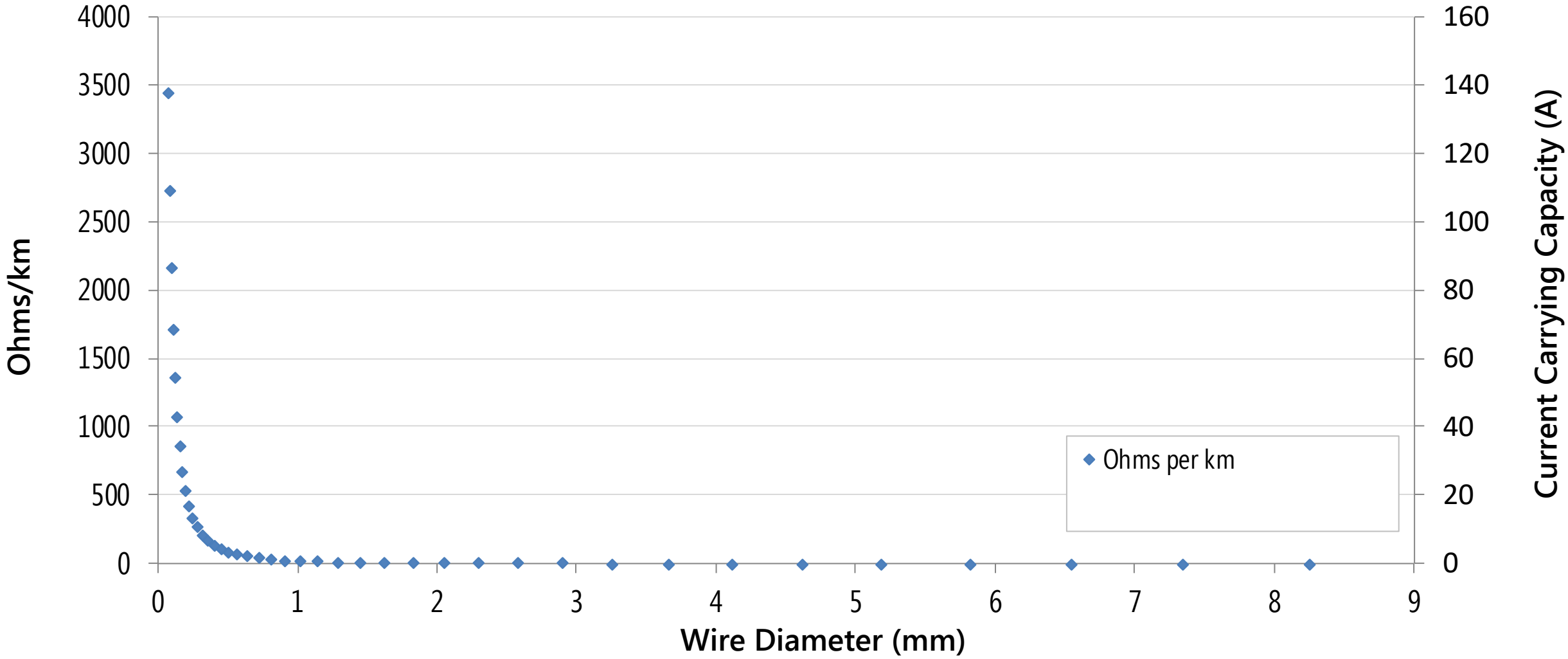


Source: Chapter 3 of Scherz & Monk, Practical Electronics, 3rd Edition, 2013

WIRES

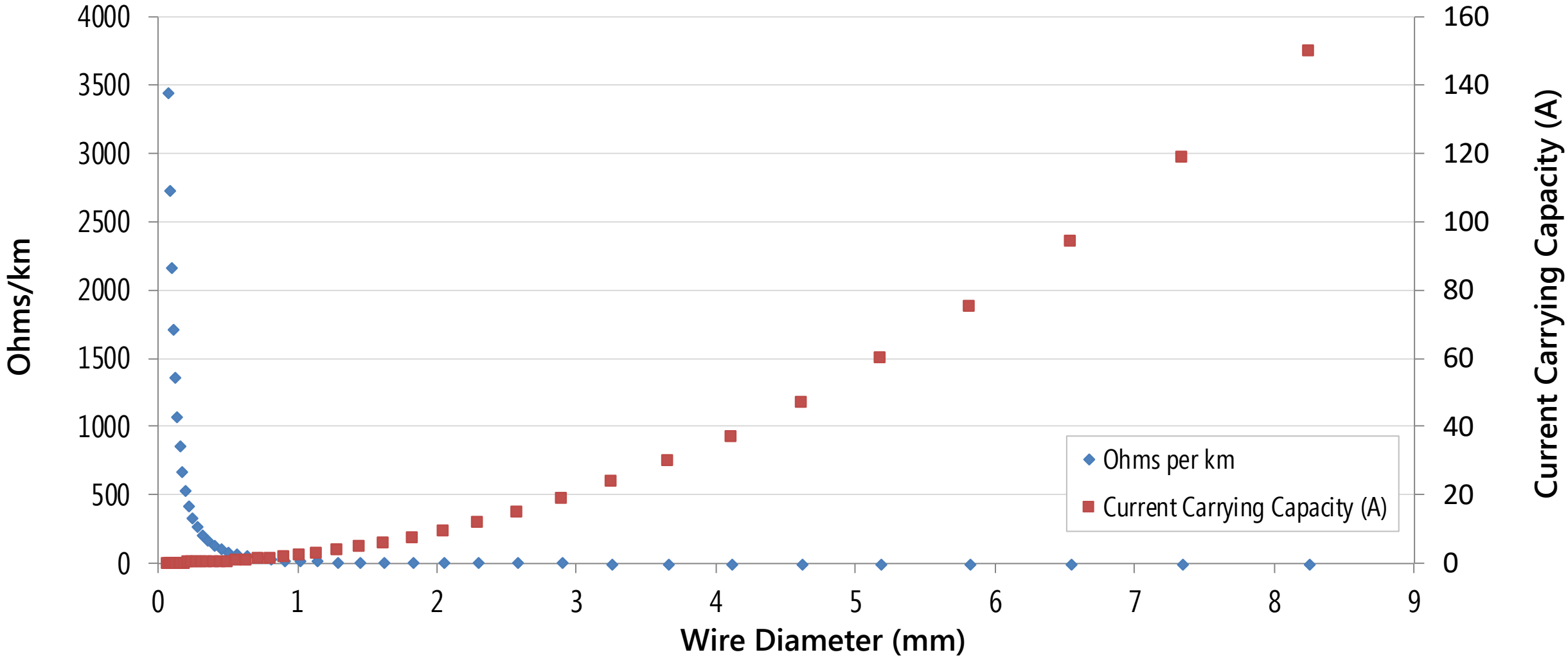
CURRENT CARRYING CAPACITY & RESISTANCE



Source: Chapter 3 of Scherz & Monk, Practical Electronics, 3rd Edition, 2013

WIRES

CURRENT CARRYING CAPACITY & RESISTANCE



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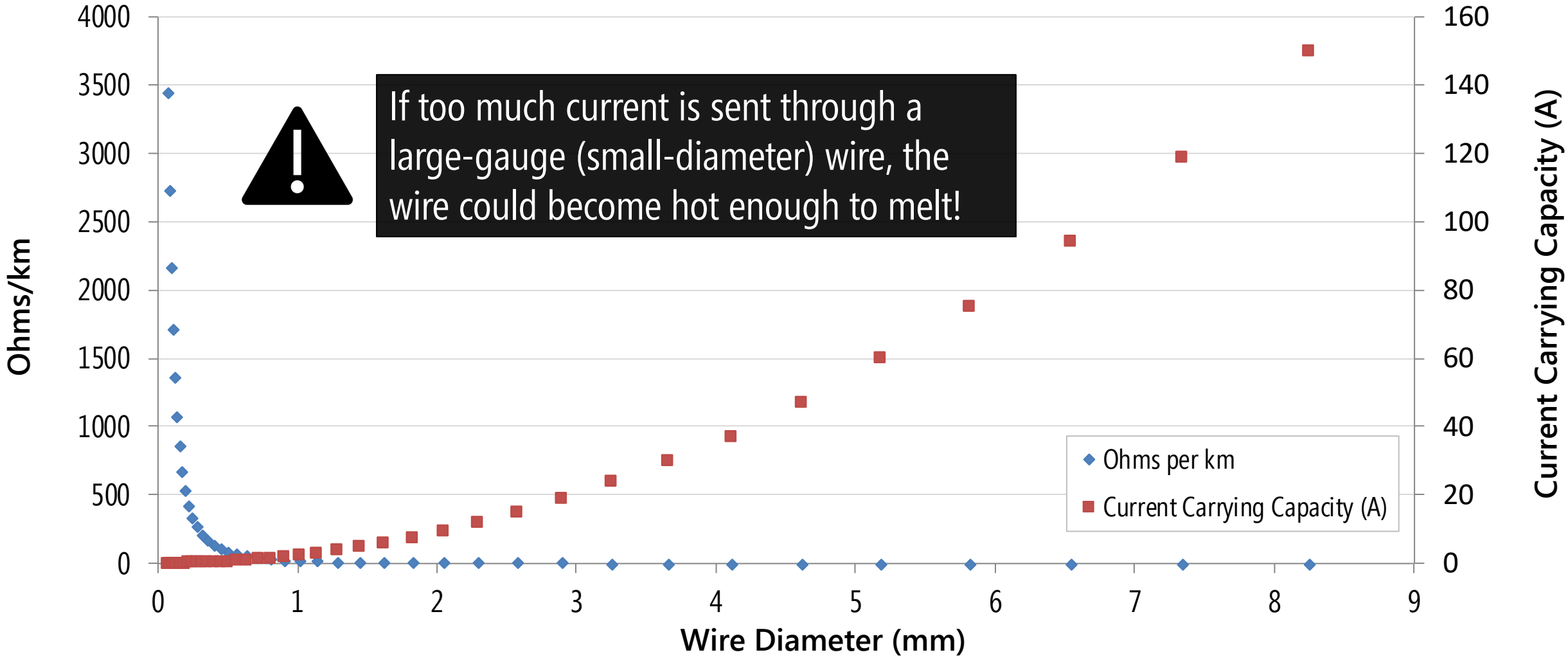
CURRENT CARRYING CAPACITY & RESISTANCE



Source: Chapter 3 of Scherz & Monk, Practical Electronics, 3rd Edition, 2013

WIRE

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.

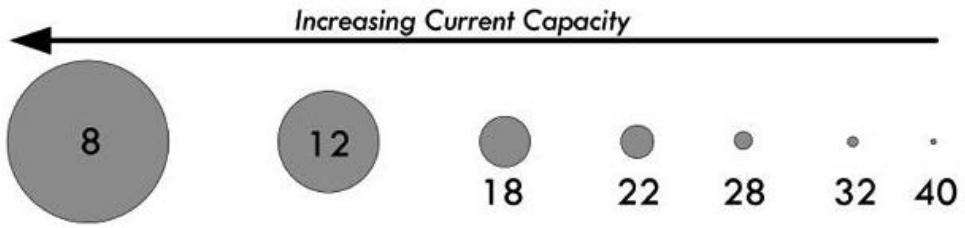


FIGURE 2.26

Source: Scherz & Monk, Practical Electronics for Inventors, 3rd Edition

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).
PAUL G. ALLEN SCHOOL
Jon's Third Hand
90°
45°
30°


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
Wire stripper used to strip wire at supported gauges. Typically, also has a built-in wire cutter and pliers end.
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PAUL G. ALLEN SCHOOL
Jon's Third Hand
90°
45°
30°

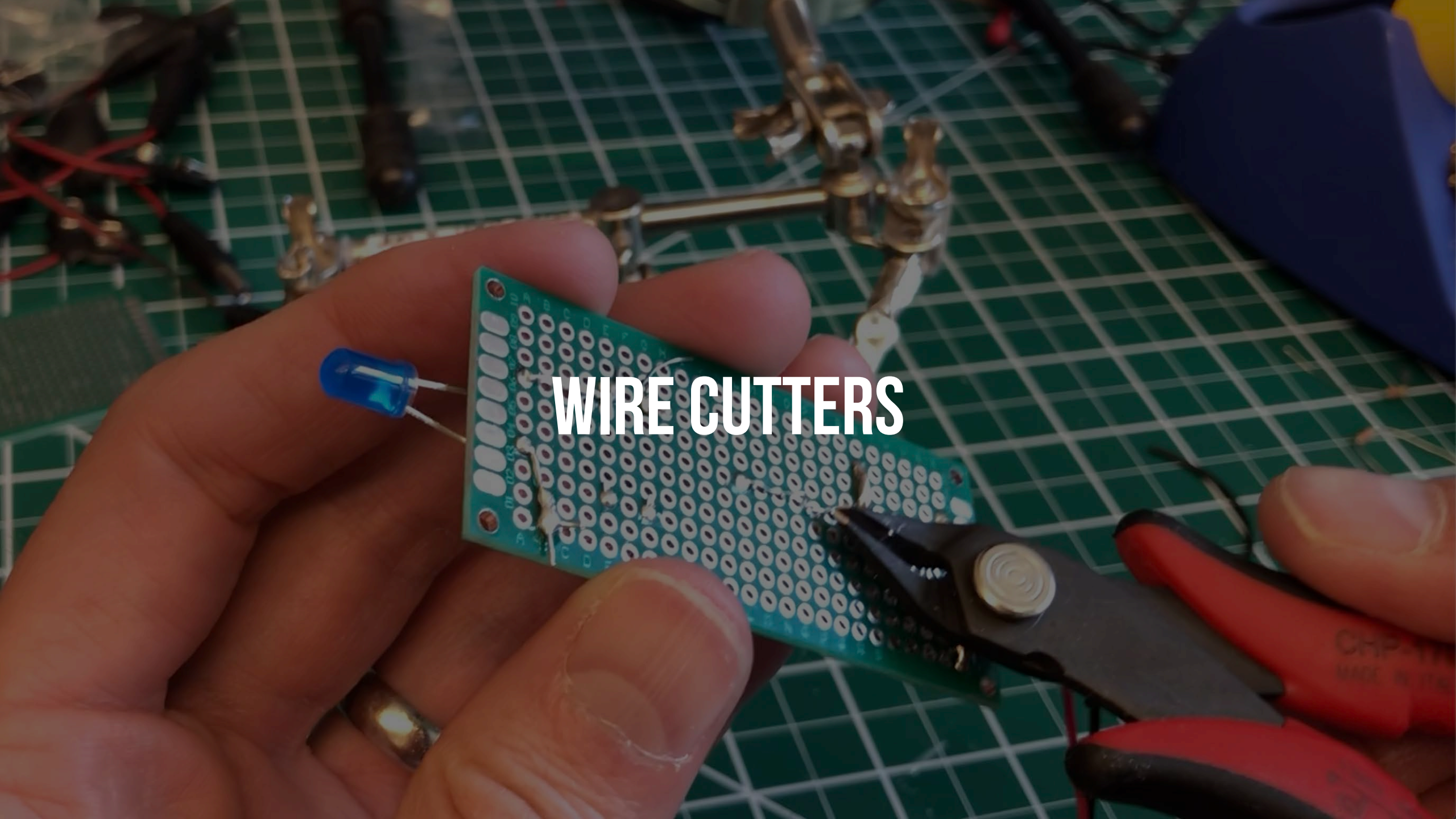

Auto-wire stripper for fast wire stripping (also called a 'self-adjusting wire stripper).
Wire stripper used to strip wire at supported gauges. Typically, also has a built-in wire cutter and pliers end.
Jon's Third Hand
90°
VISE-GRIP
INSUL CRIMPER 10-22 0.5-6 NON INSUL 12-10 4-6 22-14 0.5-2.5 AUTO 7-9MM
WARNING: HANDLES NOT INSULATED AND DO NOT PROTECT FROM ELECTRICAL SHOCK
NEVER USE ON LIVE CIRCUITS
LOOP
CUT COPPER ONLY


Wire stripping holes
Wire stripping cutter
Pliers grips

ELECTRONIC HAND TOOLS

WIRE STRIPPERS

Source: Adafruit, Hand Tools, 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
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Auto-wire stripper for fast wire stripping (also called a 'self-adjusting wire stripper).
PAUL G. ALLEN SCHOOL
Jon's Third Hand
90°
45°
30°


Wire cutter used to cut wire and component leads
INSUL
CRIMPER
10-22
0.5-6
NON INSUL
12-10
4-6
22-14
0.5-2.5
AUTO
7-8MM
WARNING: HANDLES NOT INSULATED AND DO NOT PROTECT FROM ELECTRICAL SHOCK
14
15
16
17
19
20
21
22
23

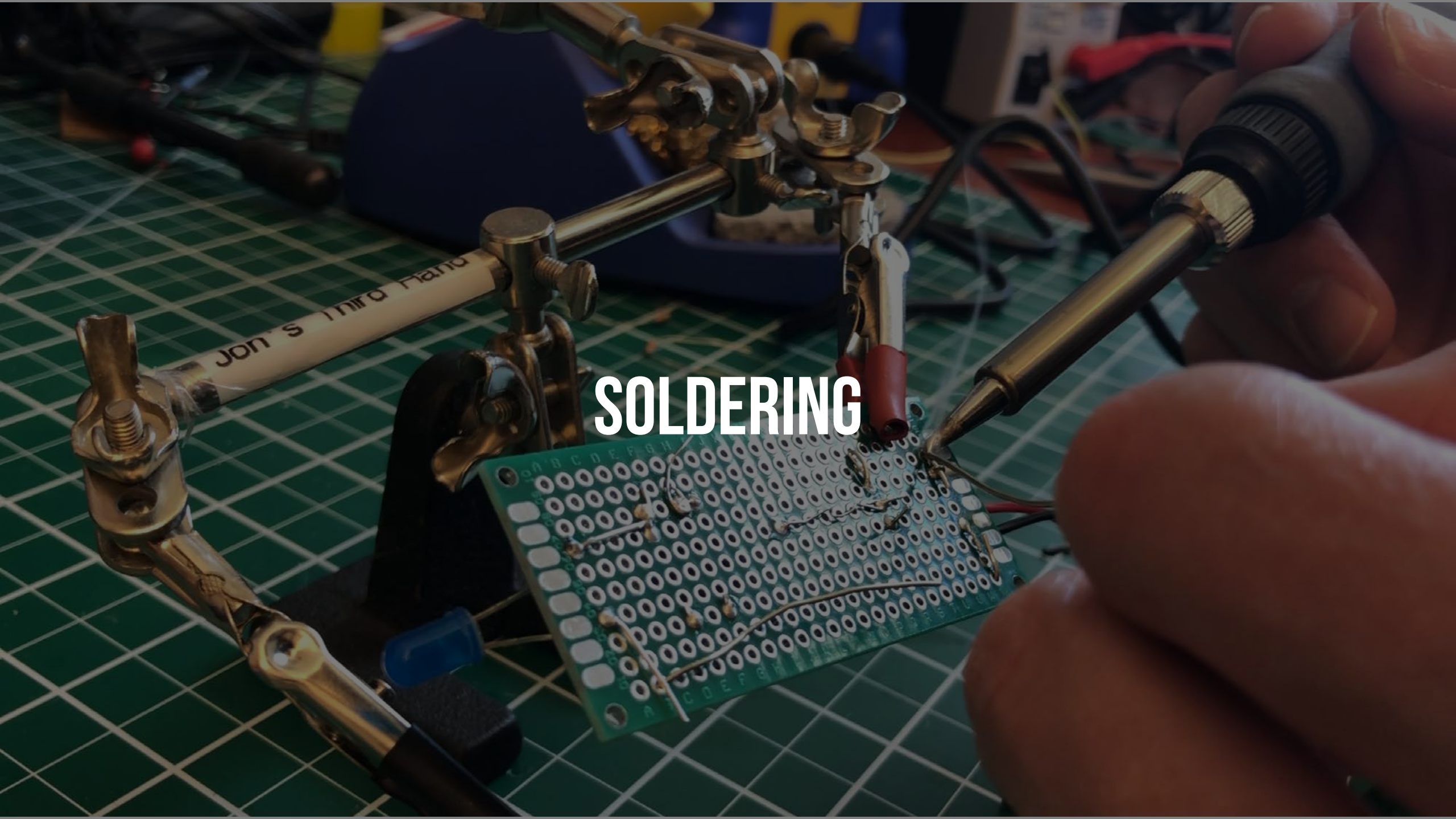
ELECTRONIC HAND TOOLS

WIRE CUTTERS

CUTTERS

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

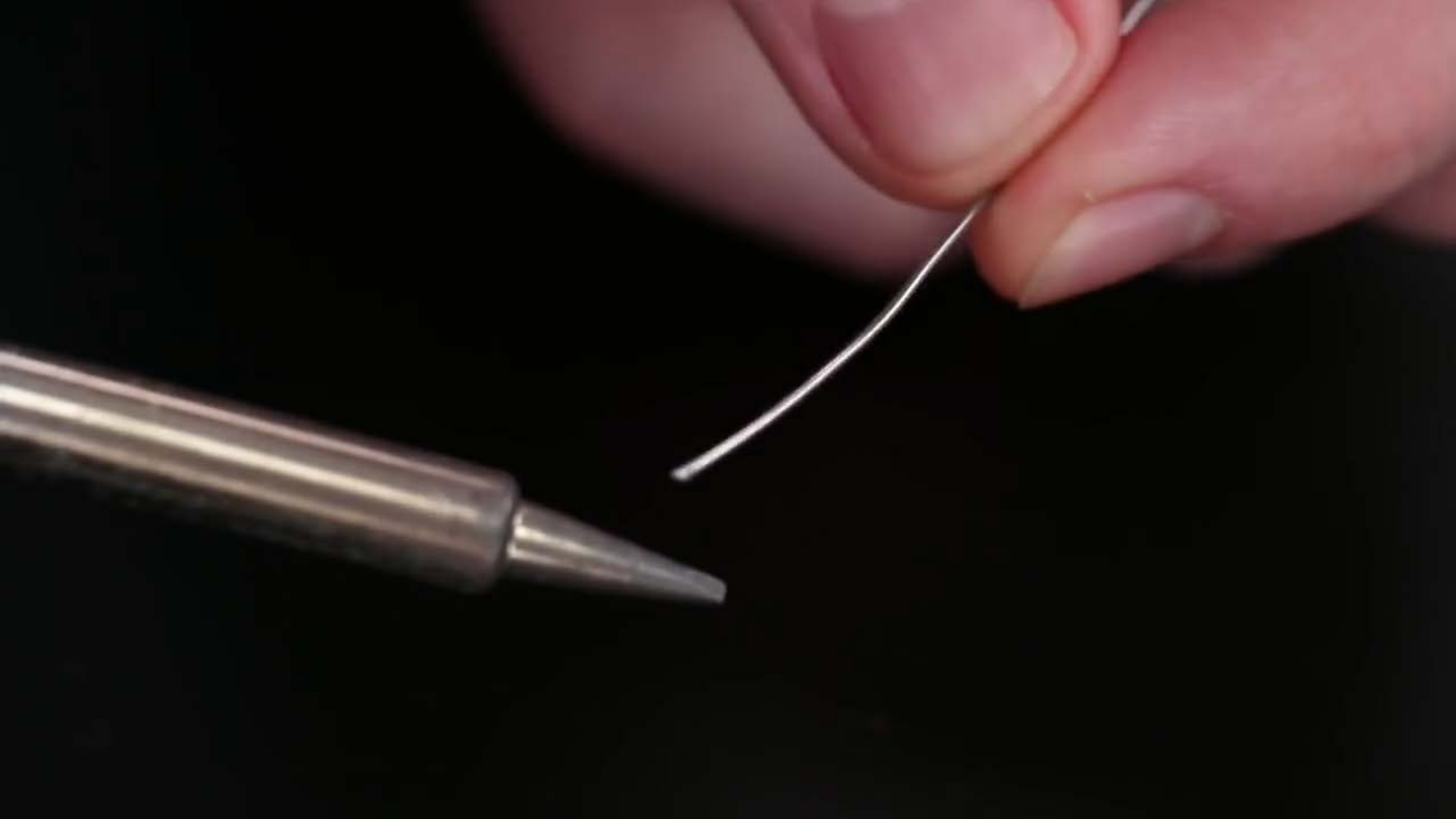
CUTTERS


SOLDERING

SOLDERING

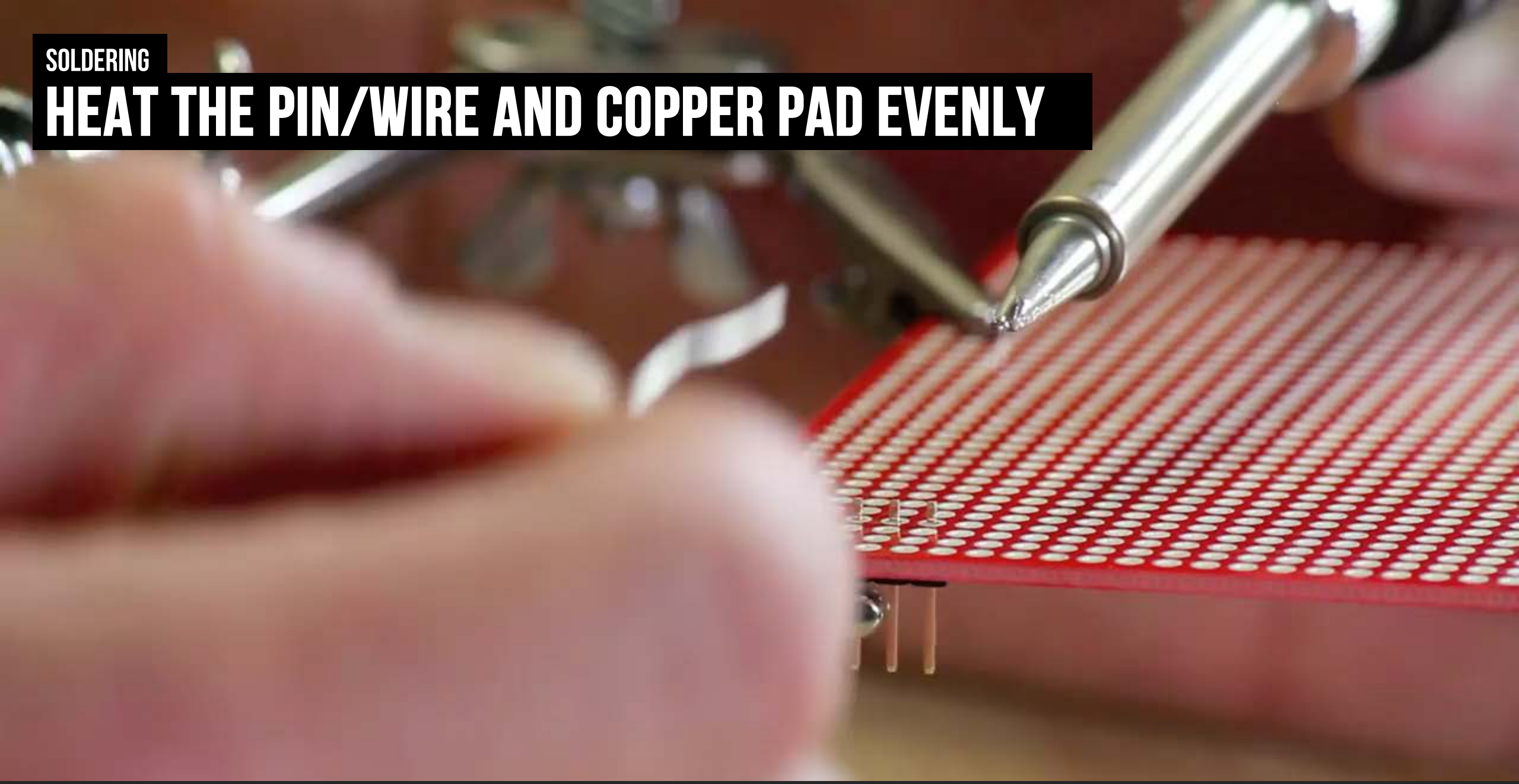
HOW TO SOLDER

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

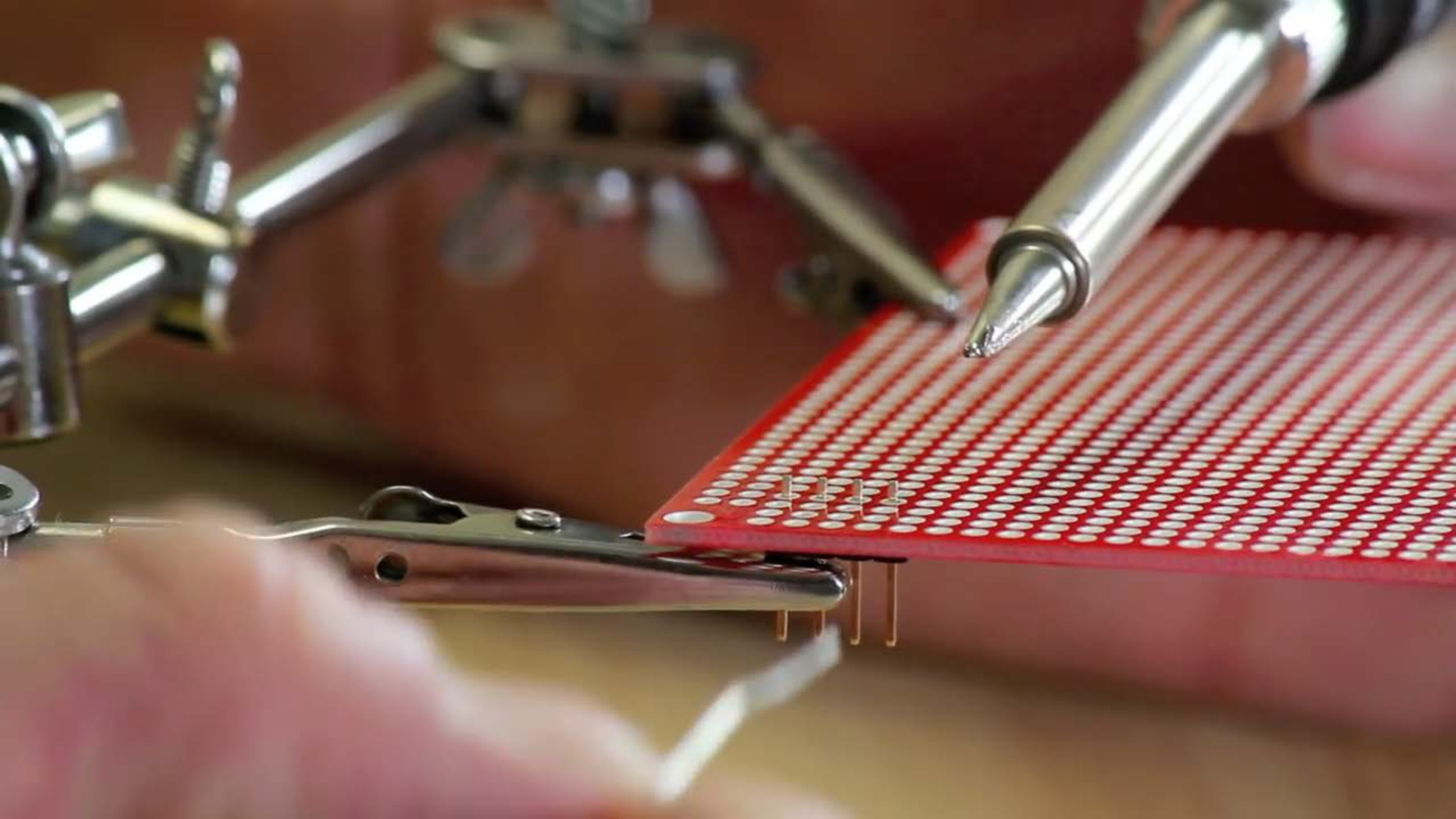


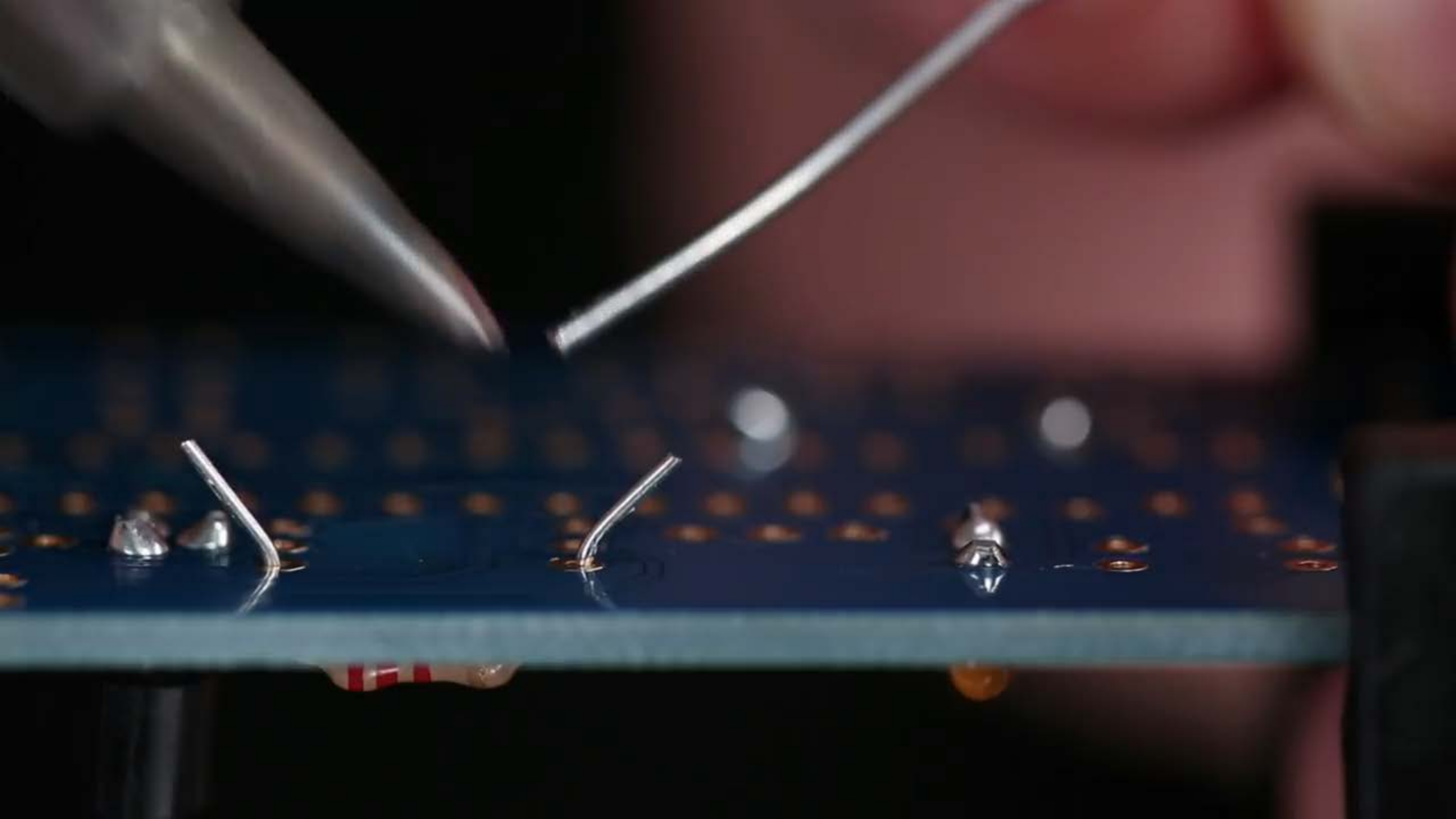
SOLDERING

HEAT THE PIN/WIRE AND COPPER PAD EVENLY



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

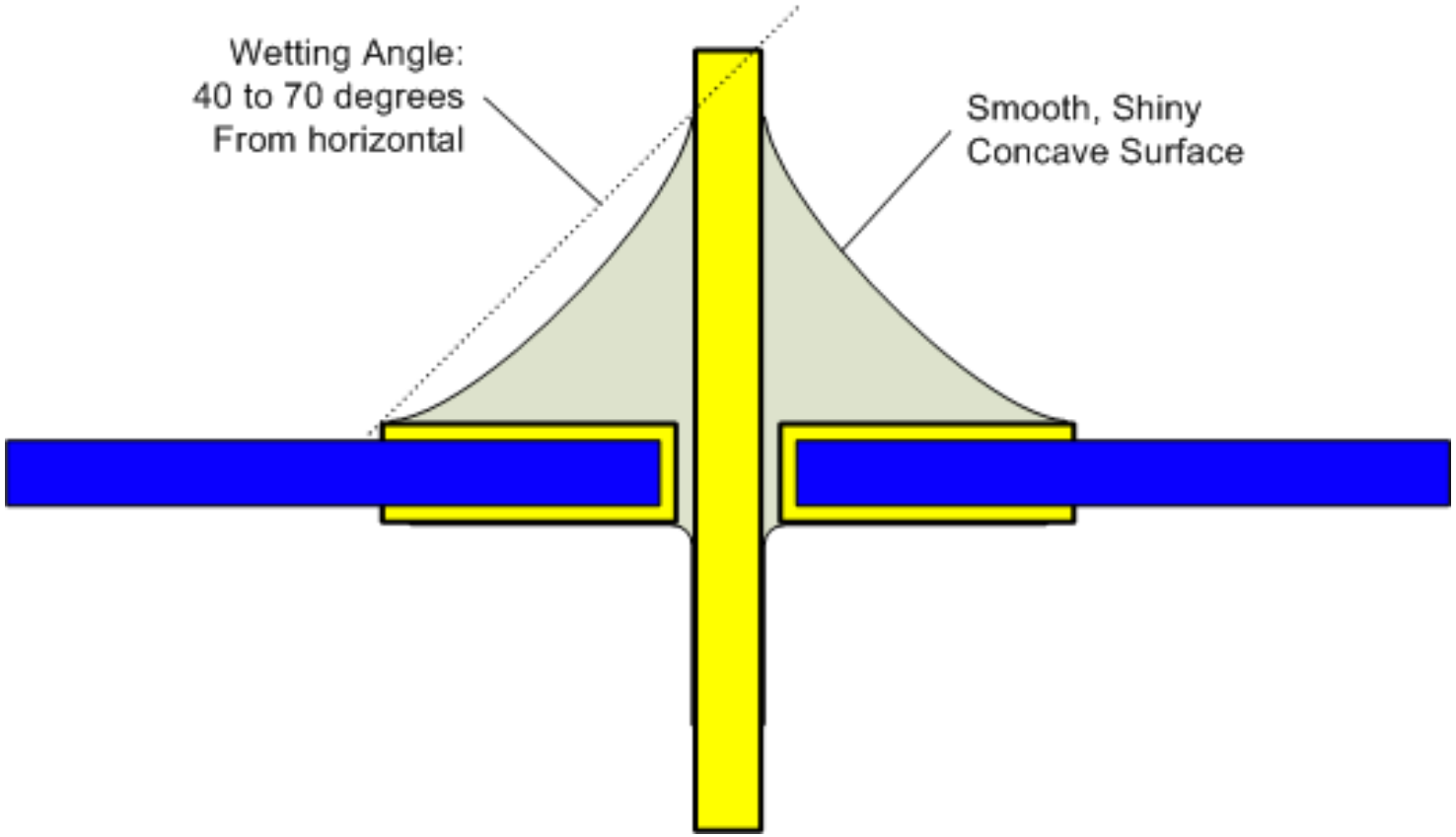




SOLDERING

IDEAL SOLDER JOINT

The ideal solder joint for through-hole components



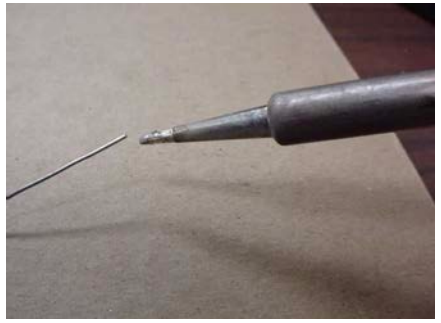
Source: https://learn.adafruit.com/adafruit-guide-excellent-soldering/common-problems

SOLDERING

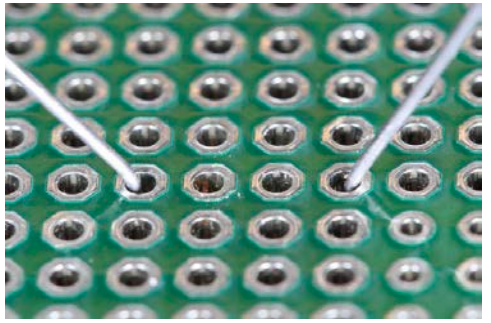
PREPARING TO SOLDER

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.

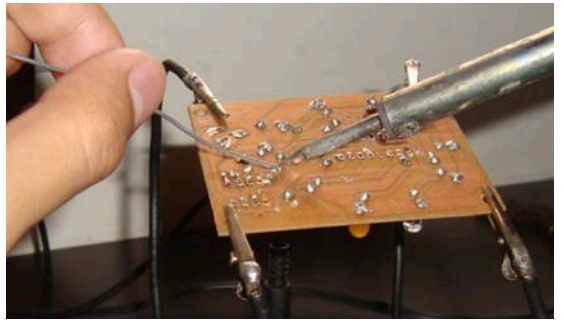
2. Turn on soldering iron. For lead-free solder, set iron to 700-720F. For leaded-solder, set iron to 750F. You can set the temperature by holding down the 'Enter' button until the LED output flashes and using the 'Up' button to select the temperature



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.



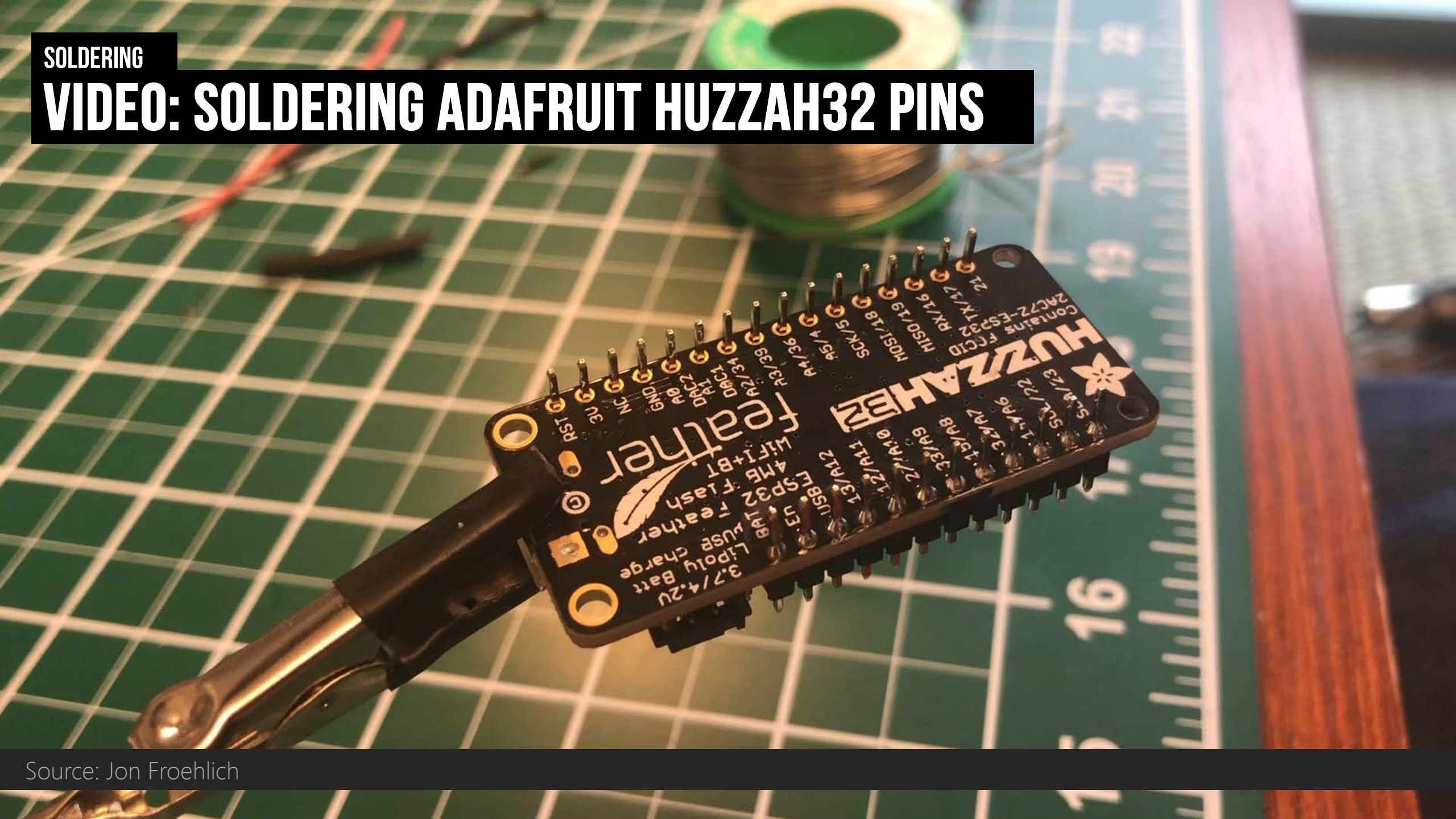
5. Use a third hand or other vise to securely hold perfboard. Again, it's important that the board is secure so it won't move during soldering and also improves safety.

Source: https://learn.adafruit.com/adafruit-guide-excellent-soldering/preparation

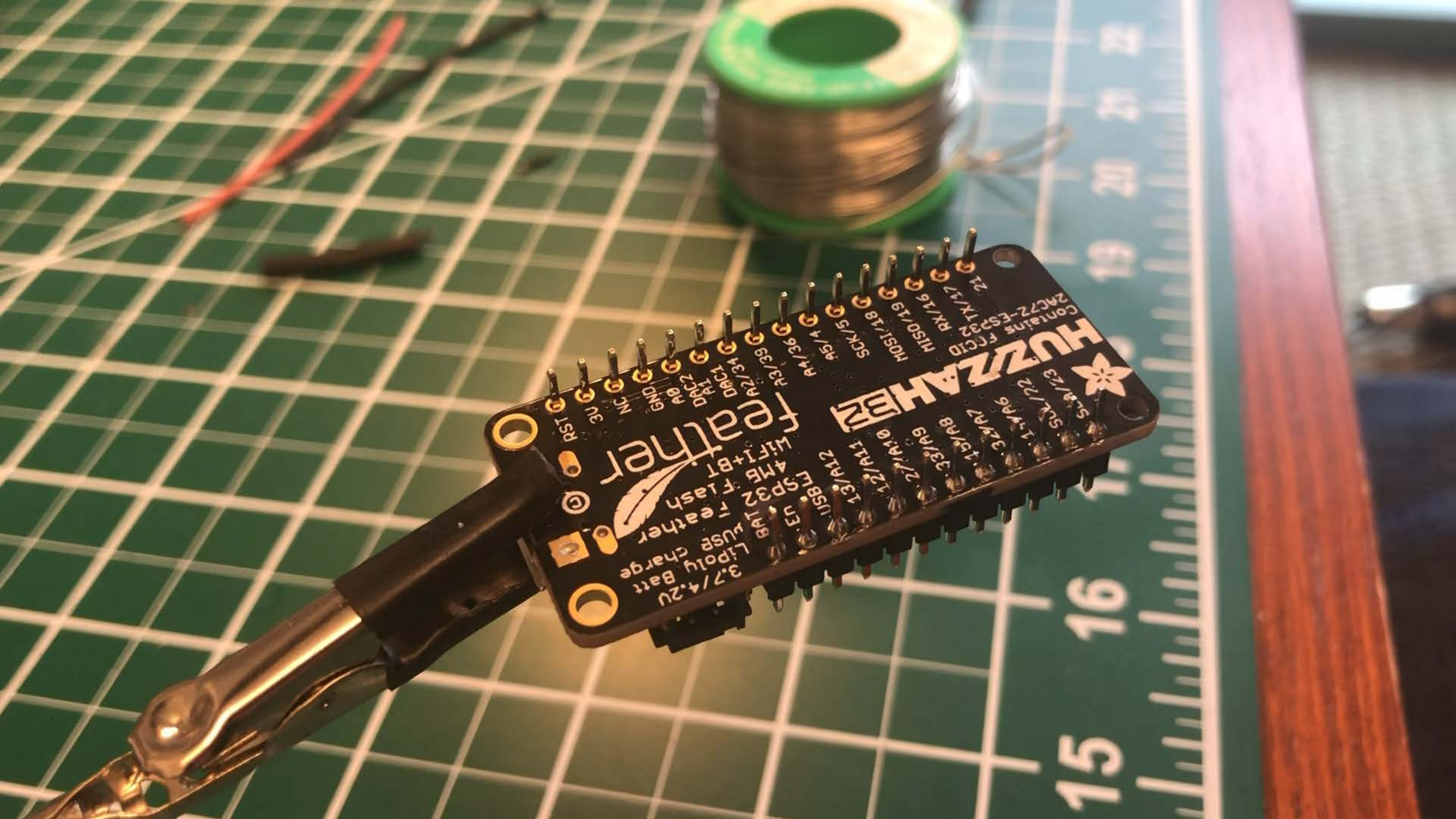

BBC

SOLDERING

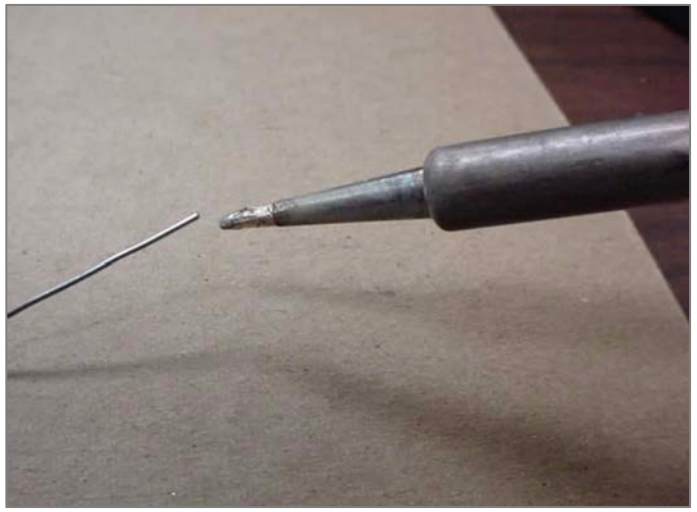
VIDEO: SOLDERING ADAFRUIT HUZZAH32 PINS



Source: Jon Froehlich


feather
HUZZAH
RST
3V
NC
GND
A0
A1
A2
A3
A4
A5
SCK/5
MOSI/18
MISO/19
RX/16
TX/17
22
SCL/23
SDA/22
3.7/4.2V Lipoly Batt
USB charge
ESP32 feather
4MB Flash
WiFi+BT
BAT
EN
USB
13/A12
12/A11
27/A10
33/A9
15/A8
32/A7
14/A6

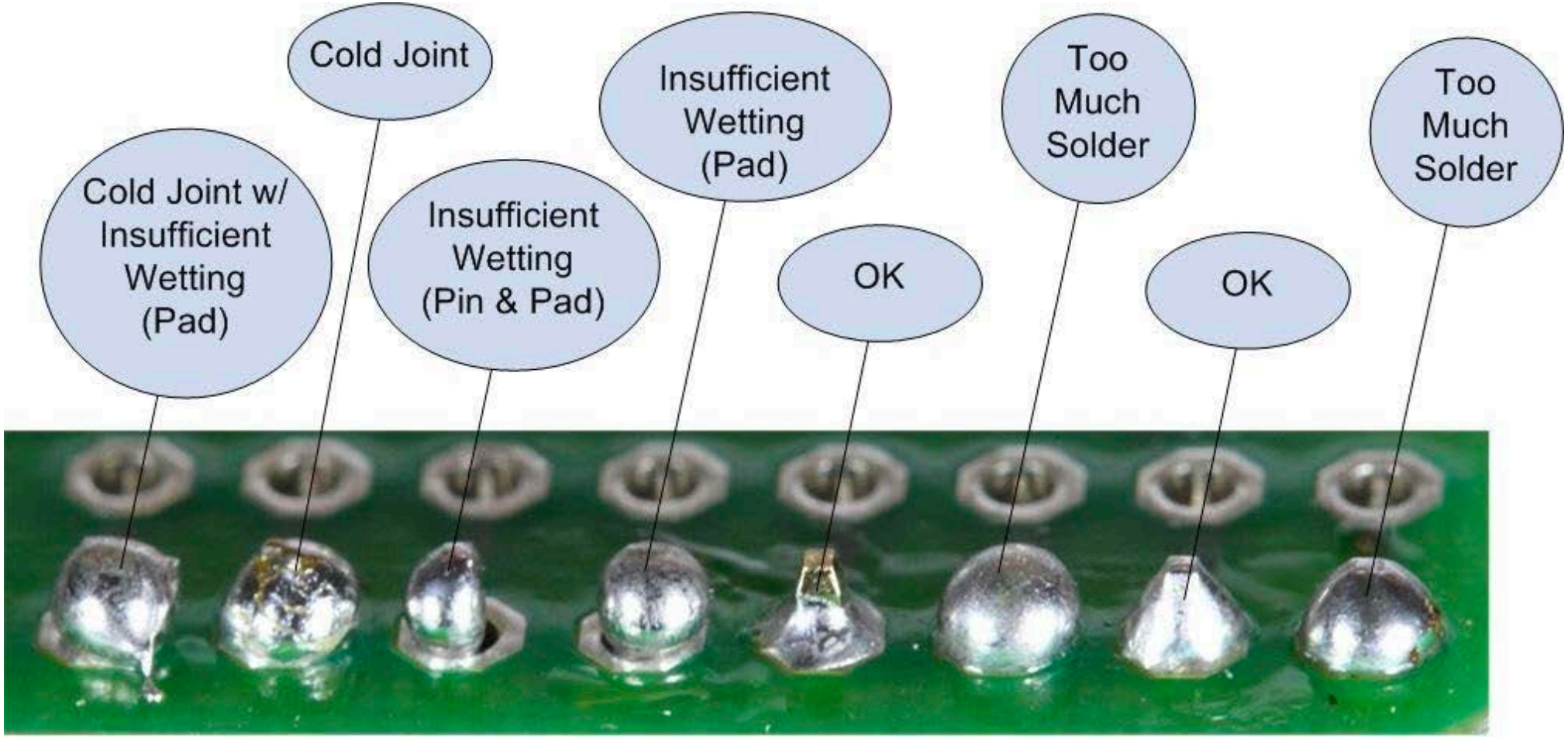
WHEN YOU FINISH SOLDERING



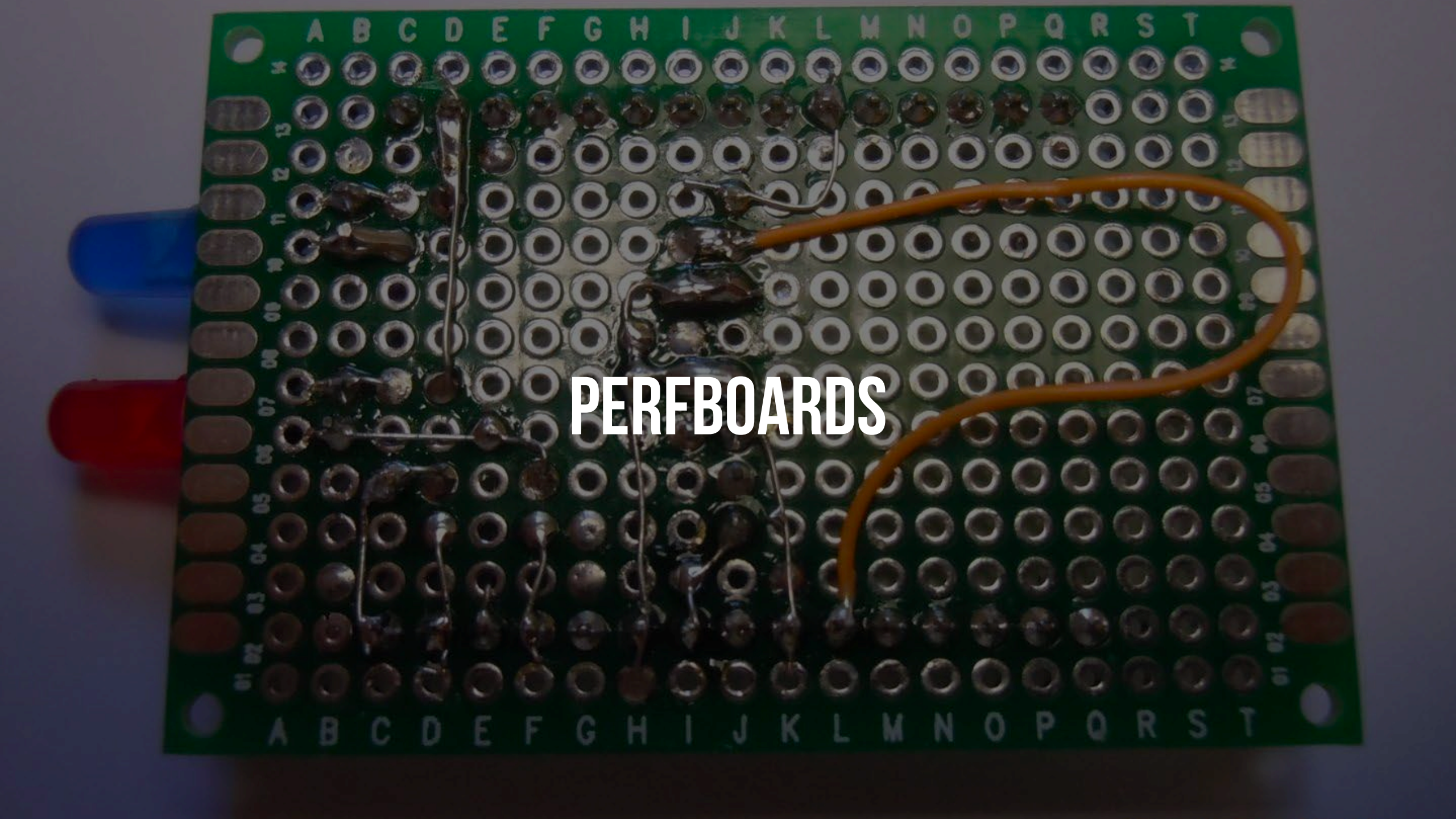
1. Tin soldering tip. Again, apply a small amount of solder to the tip before returning the soldering iron to the holster

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

COMMON SOLDERING PROBLEMS

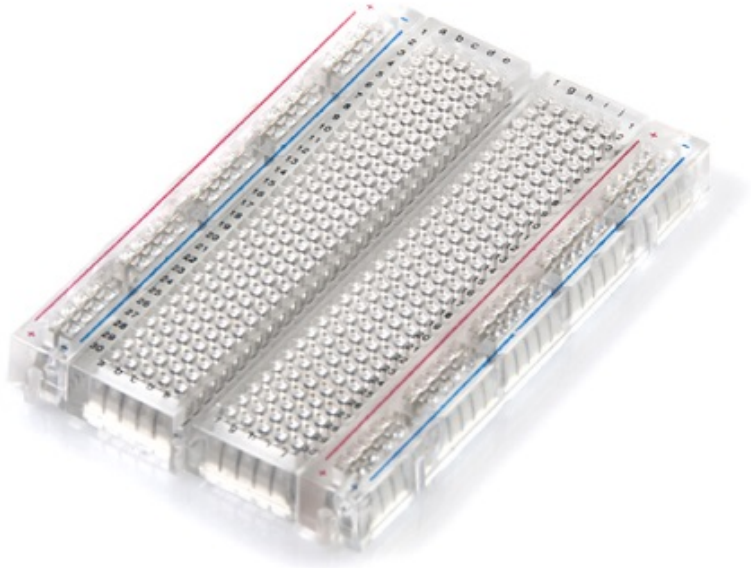


Source: https://learn.adafruit.com/adafruit-guide-excellent-soldering/common-problems


PERFBOARDS

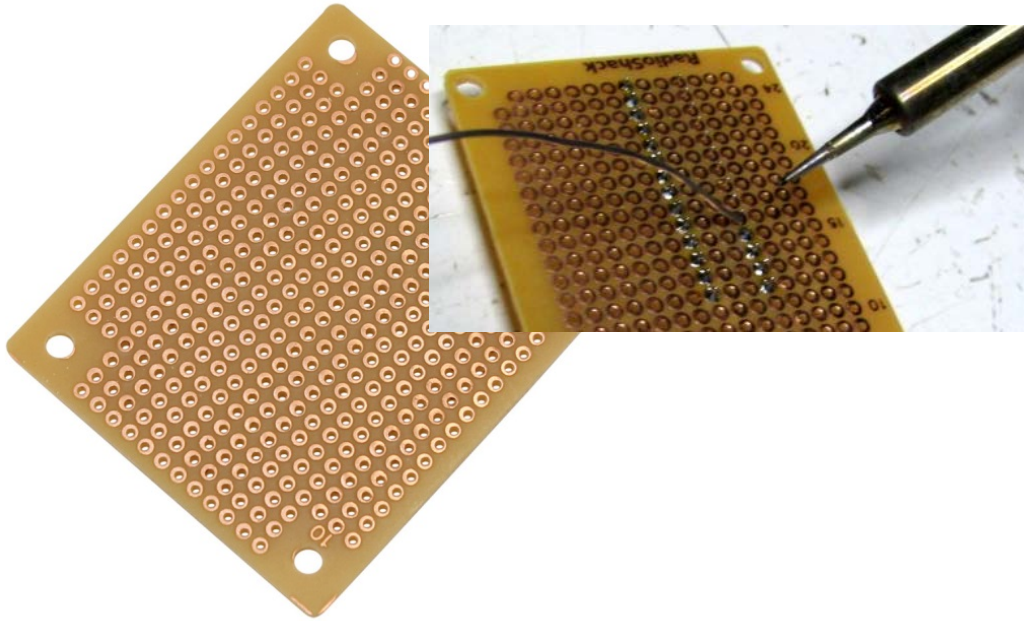
BREADBOARDS -> PERFBOARDS

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

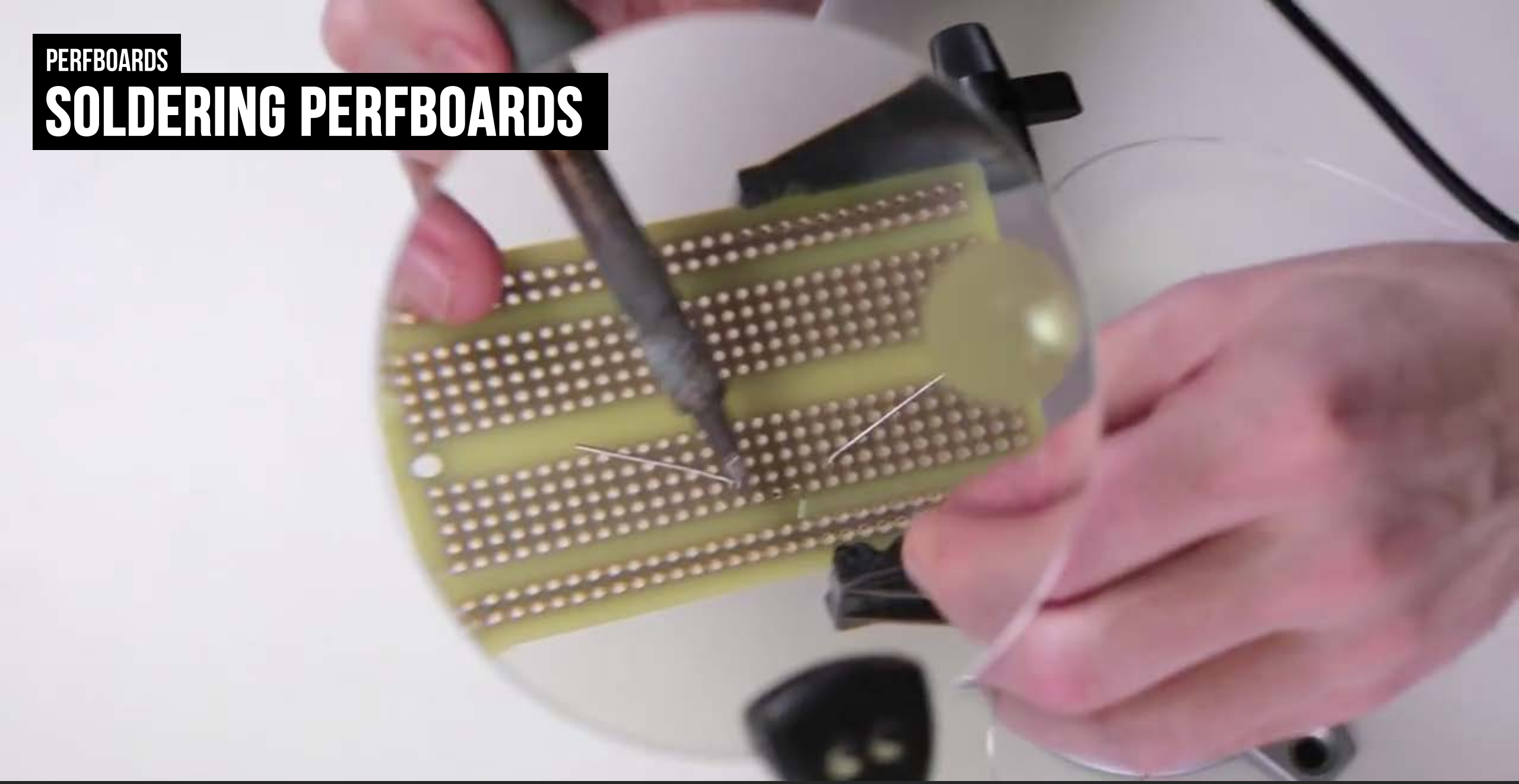


Perfboard

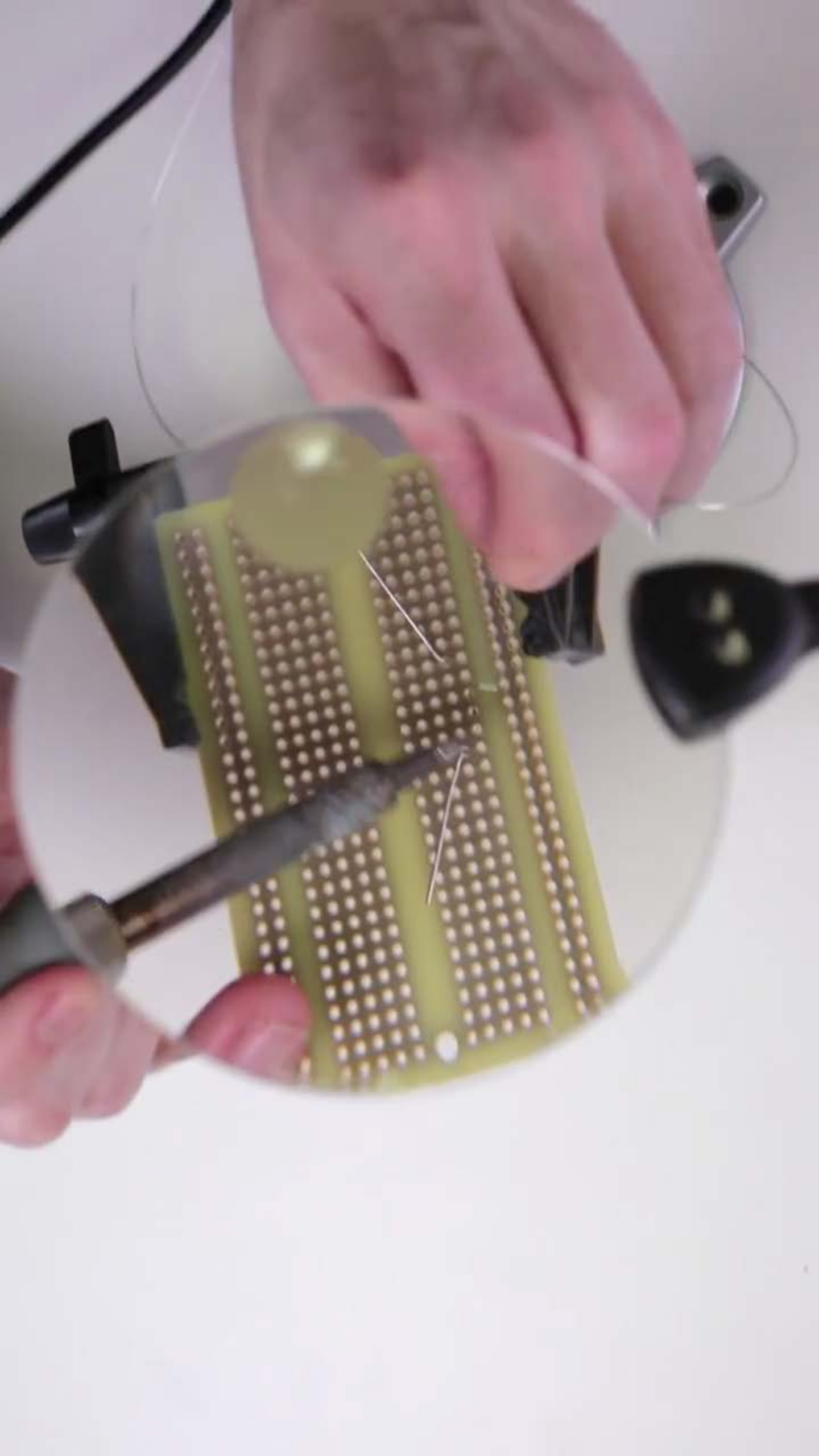
[source: https://learn.adafruit.com/collins-lab-breadboards-and-perfboards/transcript,]

PERFBOARDS

SOLDERING PERFBOARDS

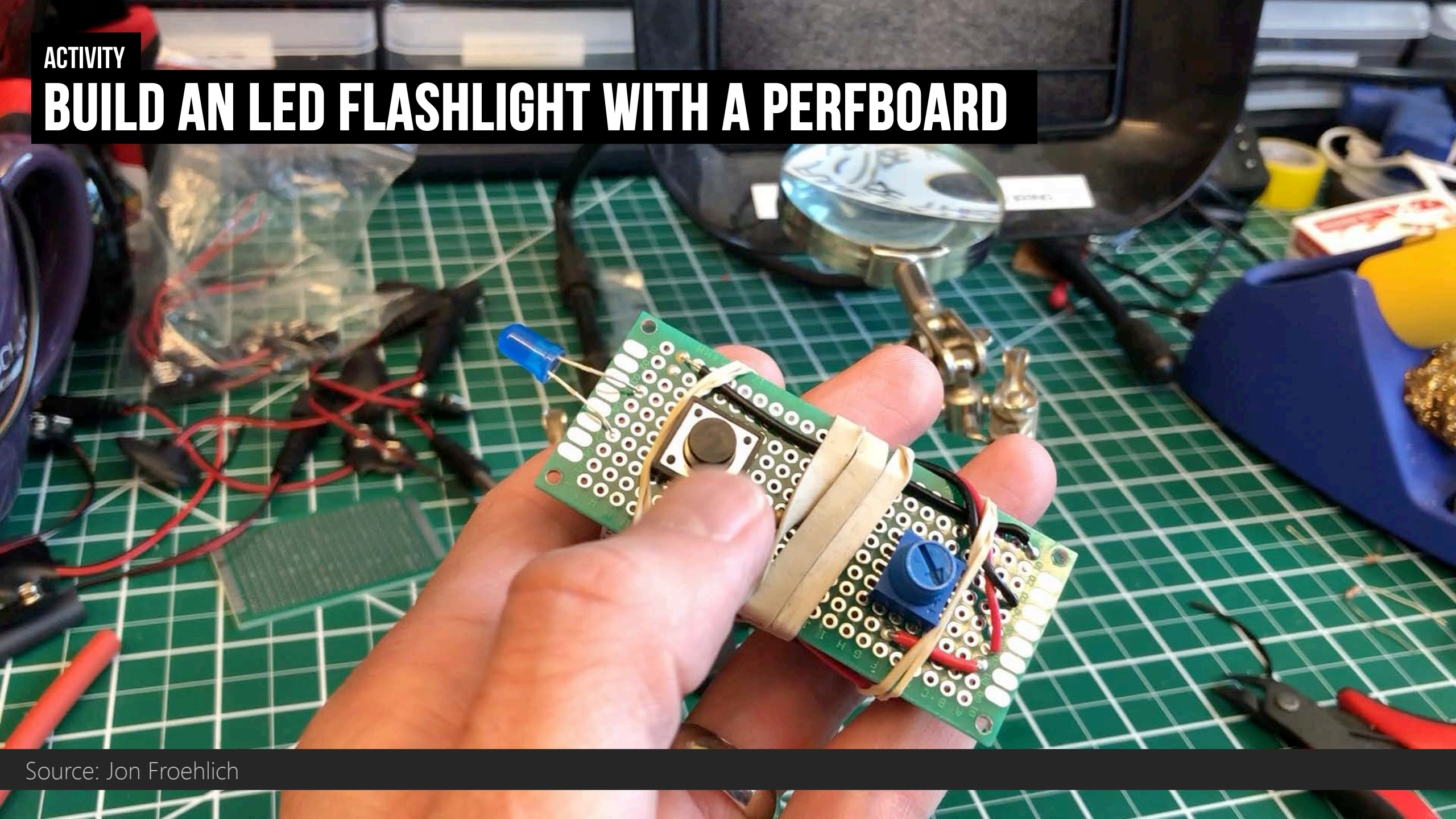


Source: Adafruit, Breadboards and Perfboards, https://youtu.be/w0c3t0fJhXU



ACTIVITY

BUILD AN LED FLASHLIGHT WITH A PERFBOARD



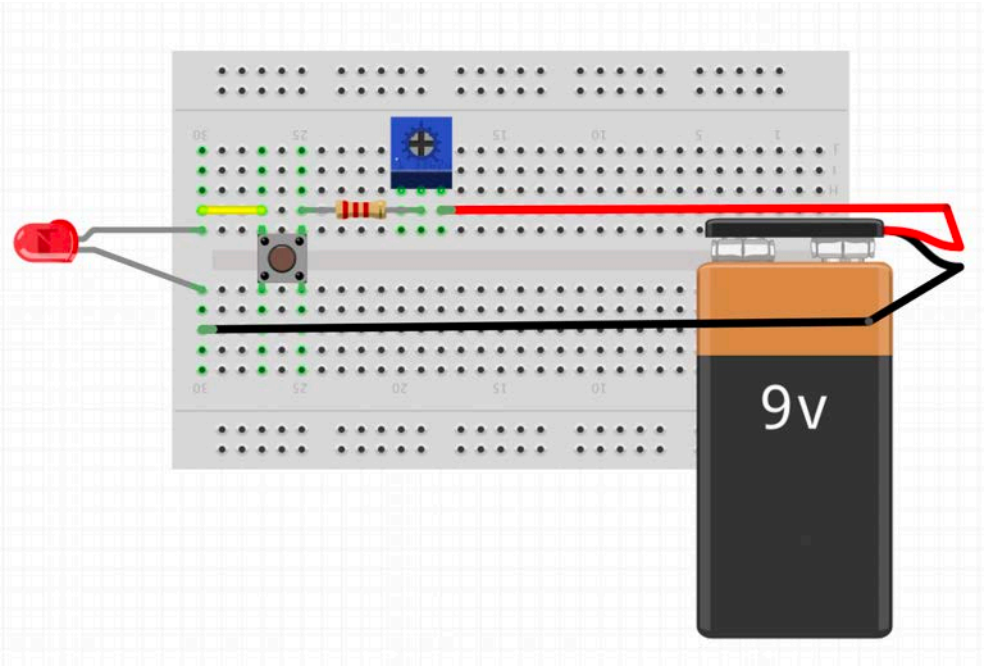
Source: Jon Froehlich

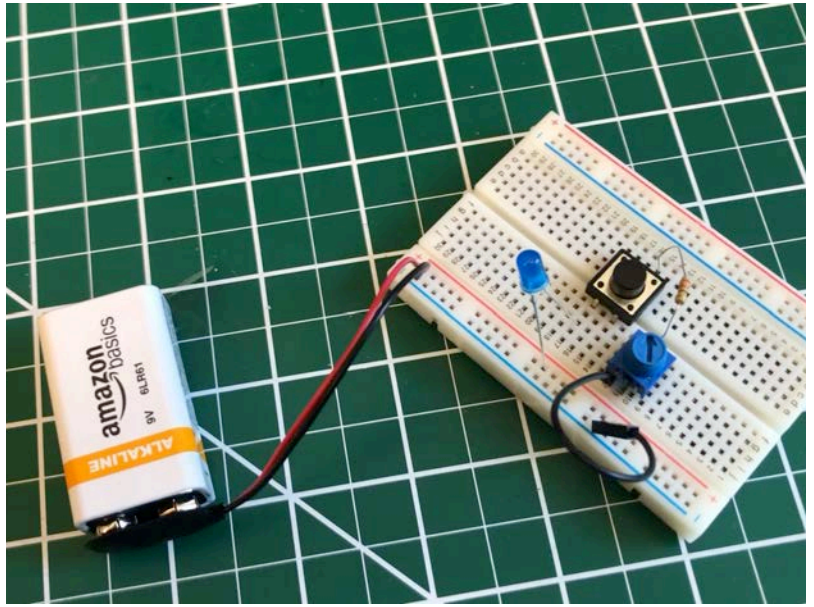
ACTIVITY

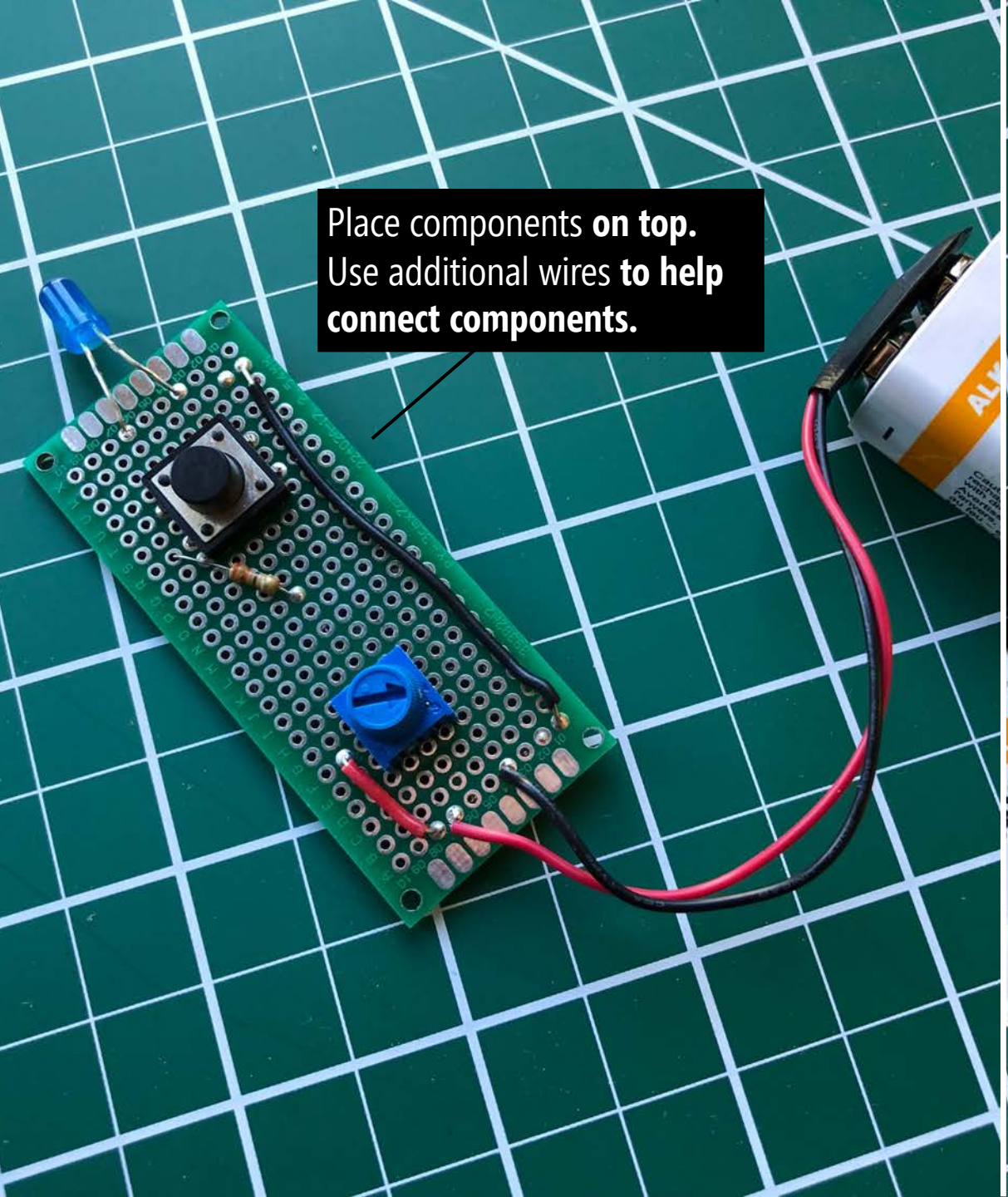
BUILD AN LED FLASHLIGHT

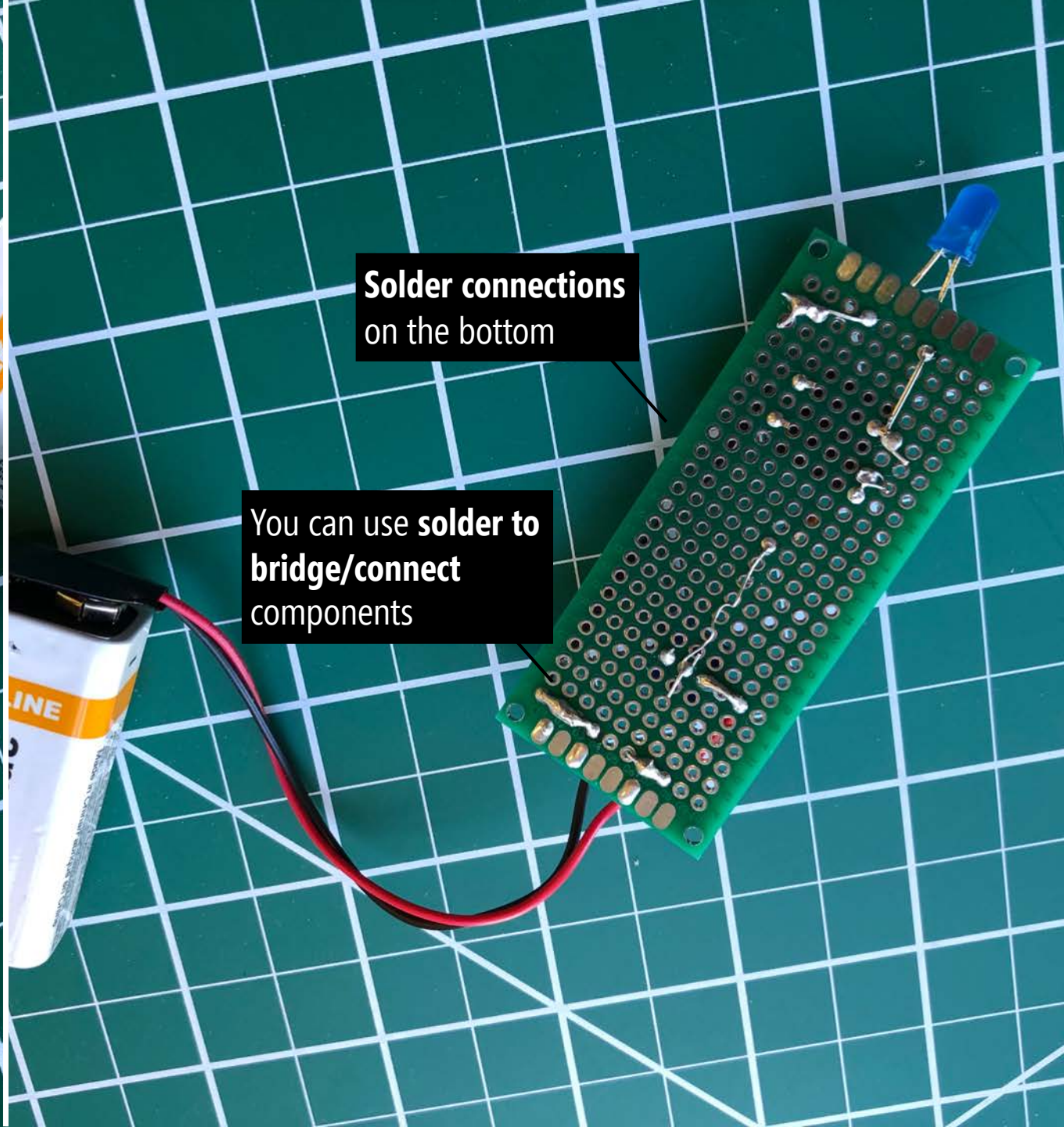
The flashlight must use a **button** to **turn it on**/off and a **trimpot** to **set** the **brightness**

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





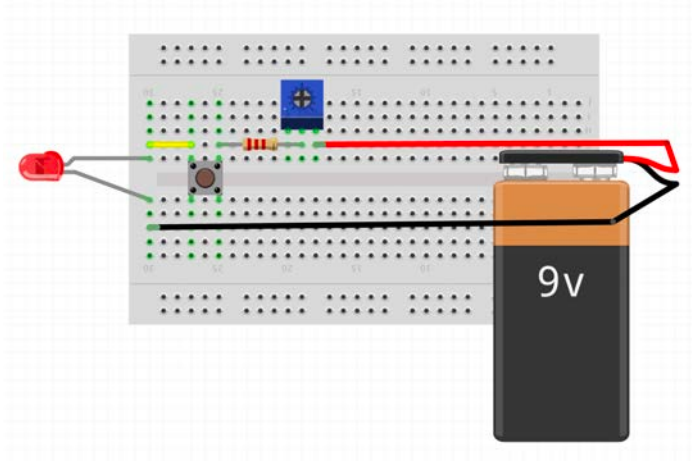

Place components **on top.**
Use additional wires **to help connect components.**


Solder connections
on the bottom
You can use **solder to bridge/connect**
components

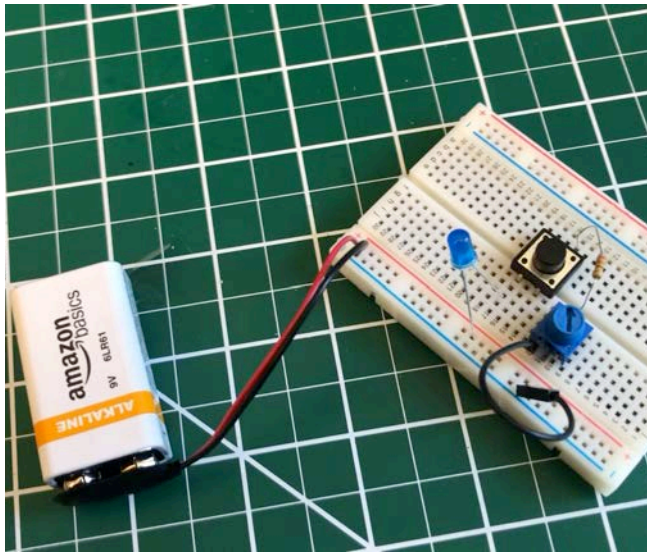
ACTIVITY

DESIGN PROCESS

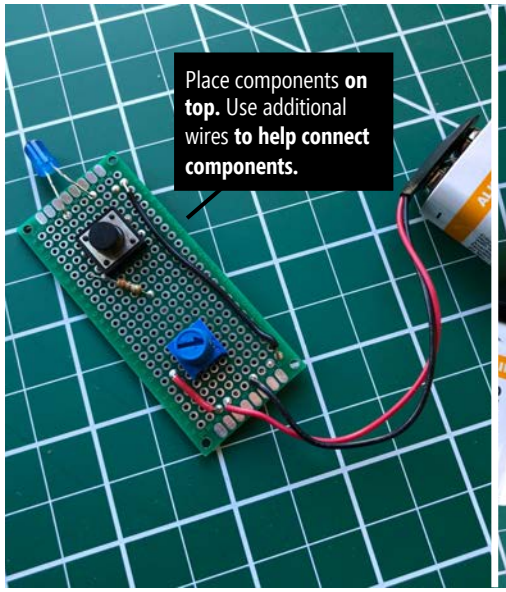
1. Design Circuit

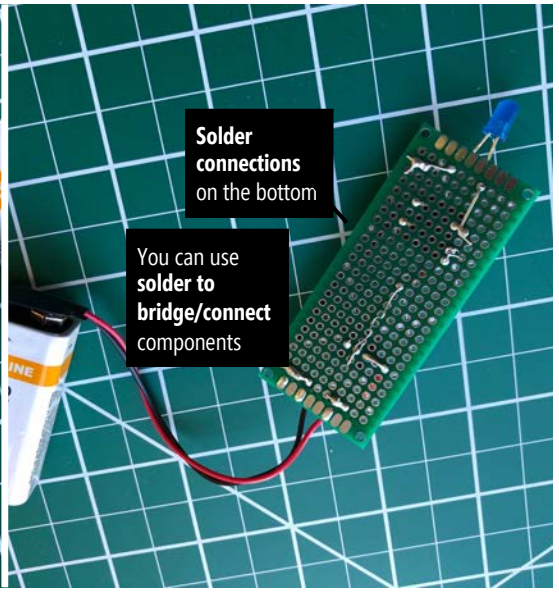


2. Breadboard it



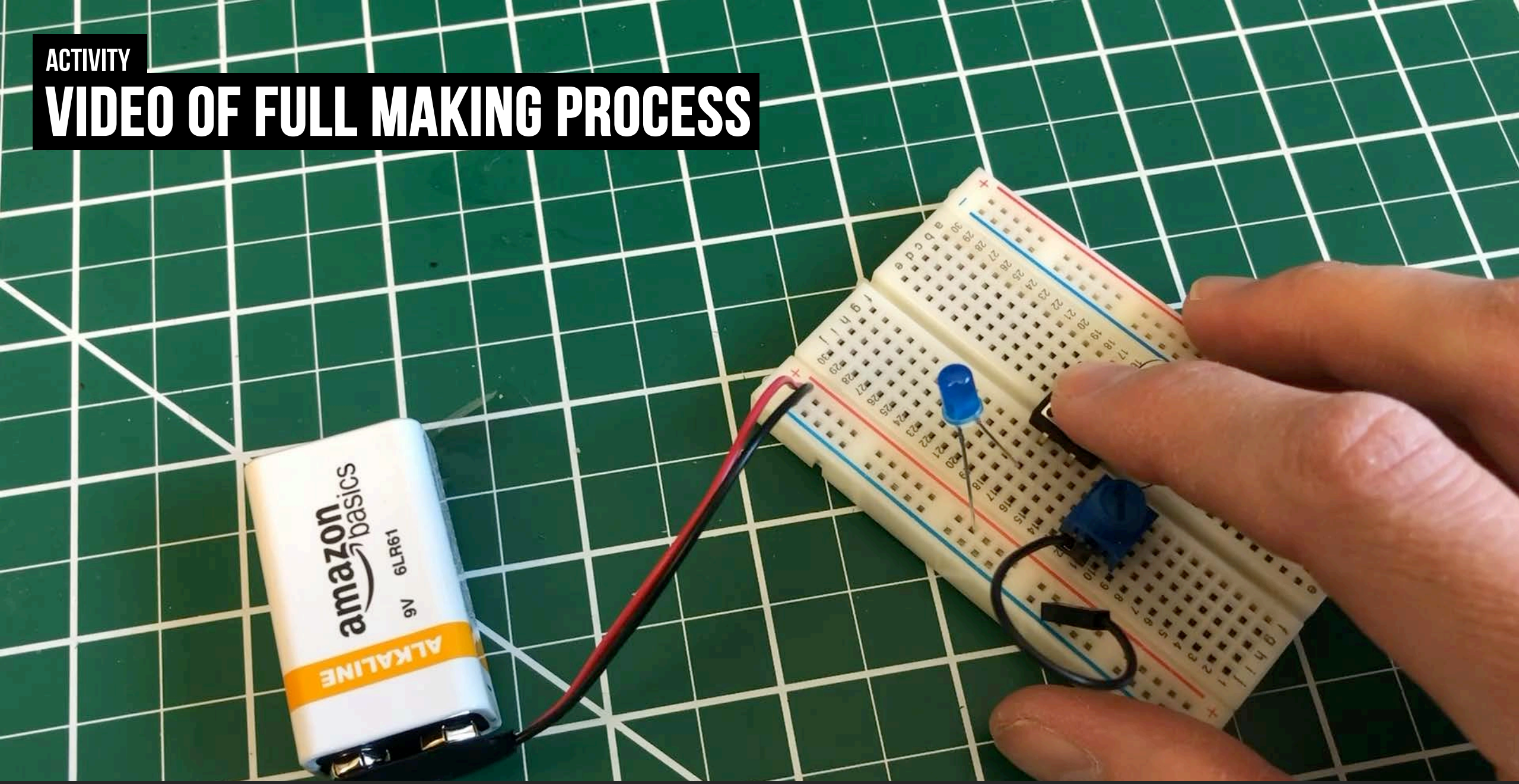
3. Perfboard + solder it



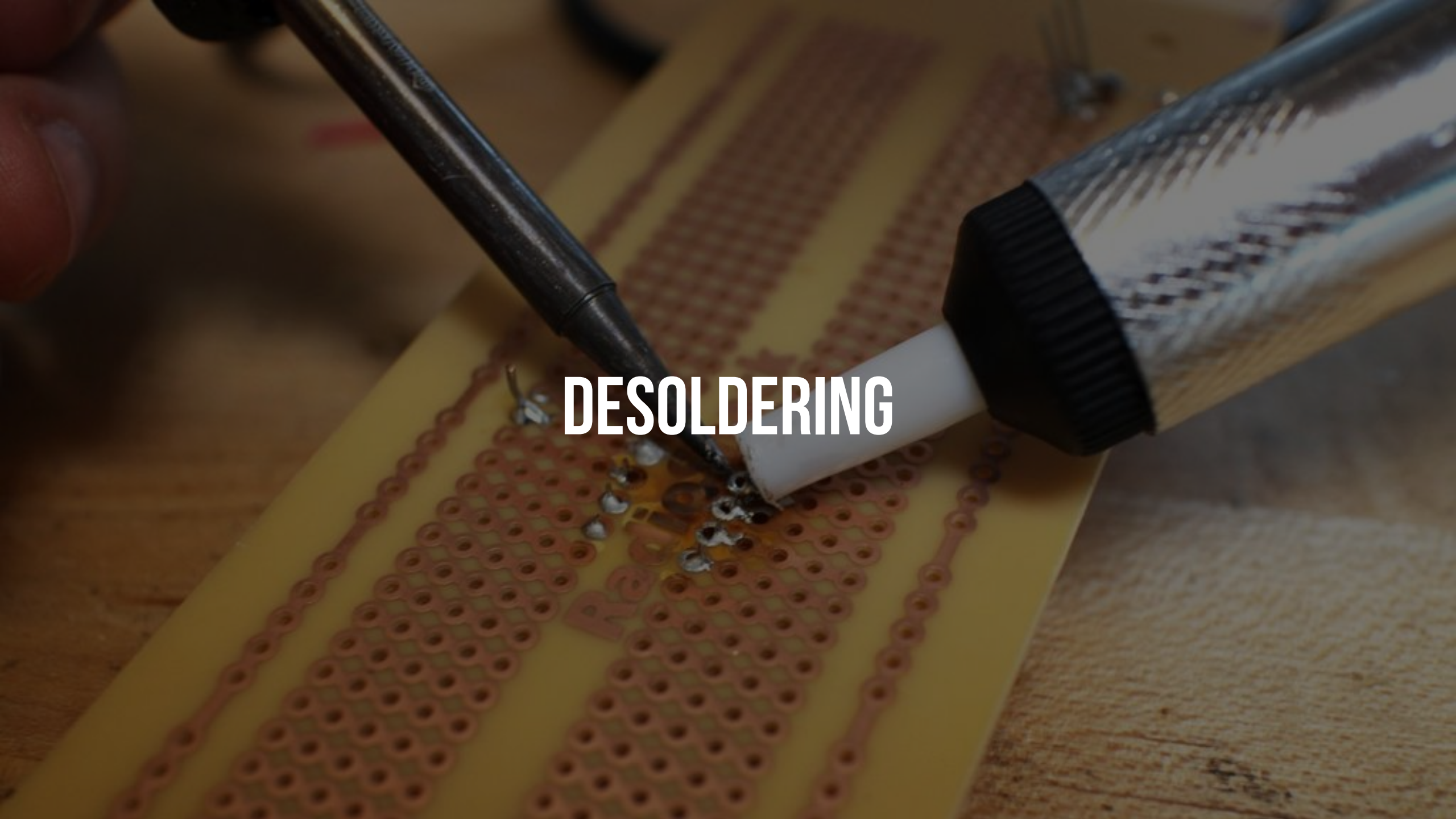


ACTIVITY

VIDEO OF FULL MAKING PROCESS



Source: Jon Froehlich


DESOLDERING

DESOLDERING

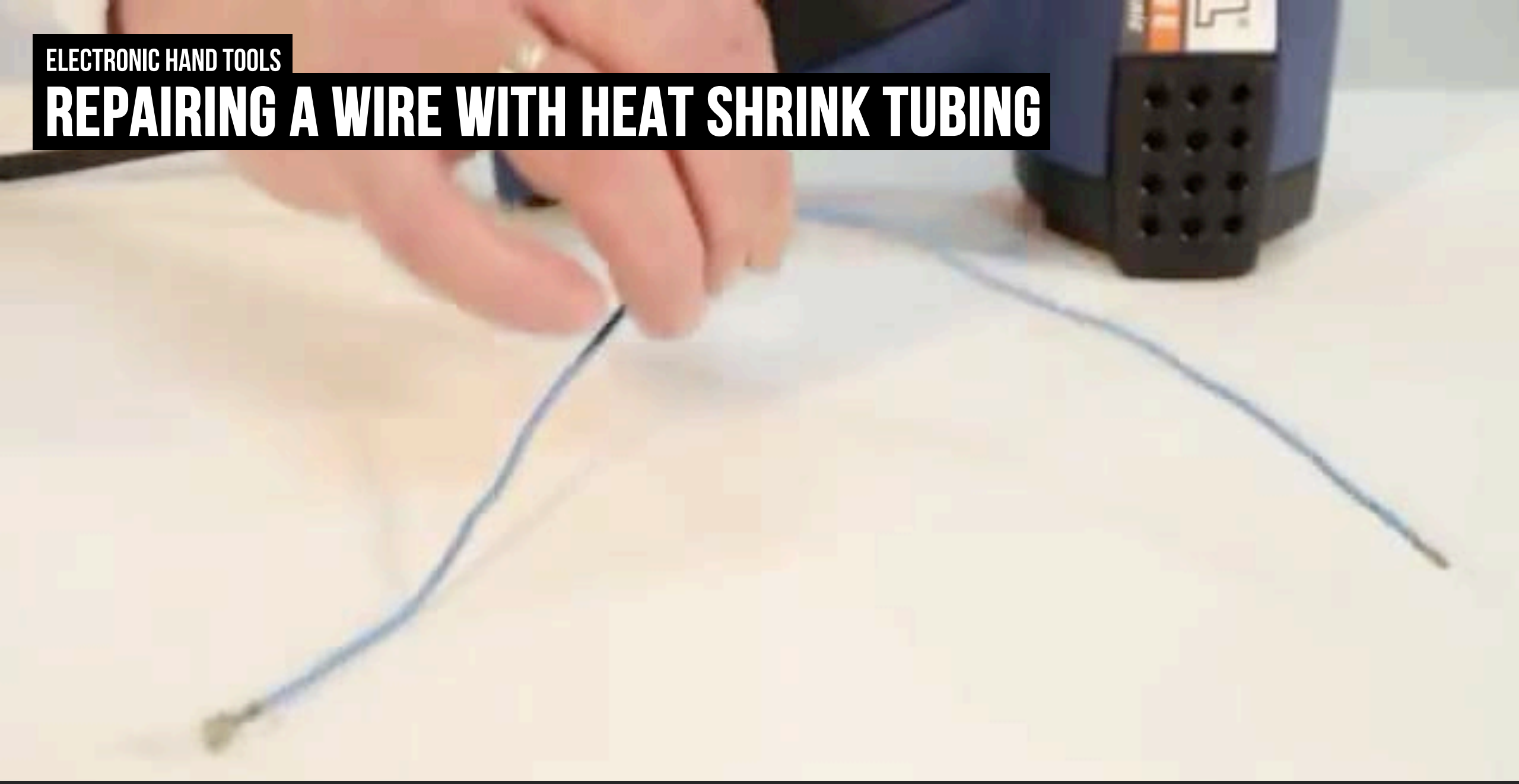
USING A SOLDER SUCKER & SOLDER WICK

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

HEAT SHRINK TUBING

ELECTRONIC HAND TOOLS

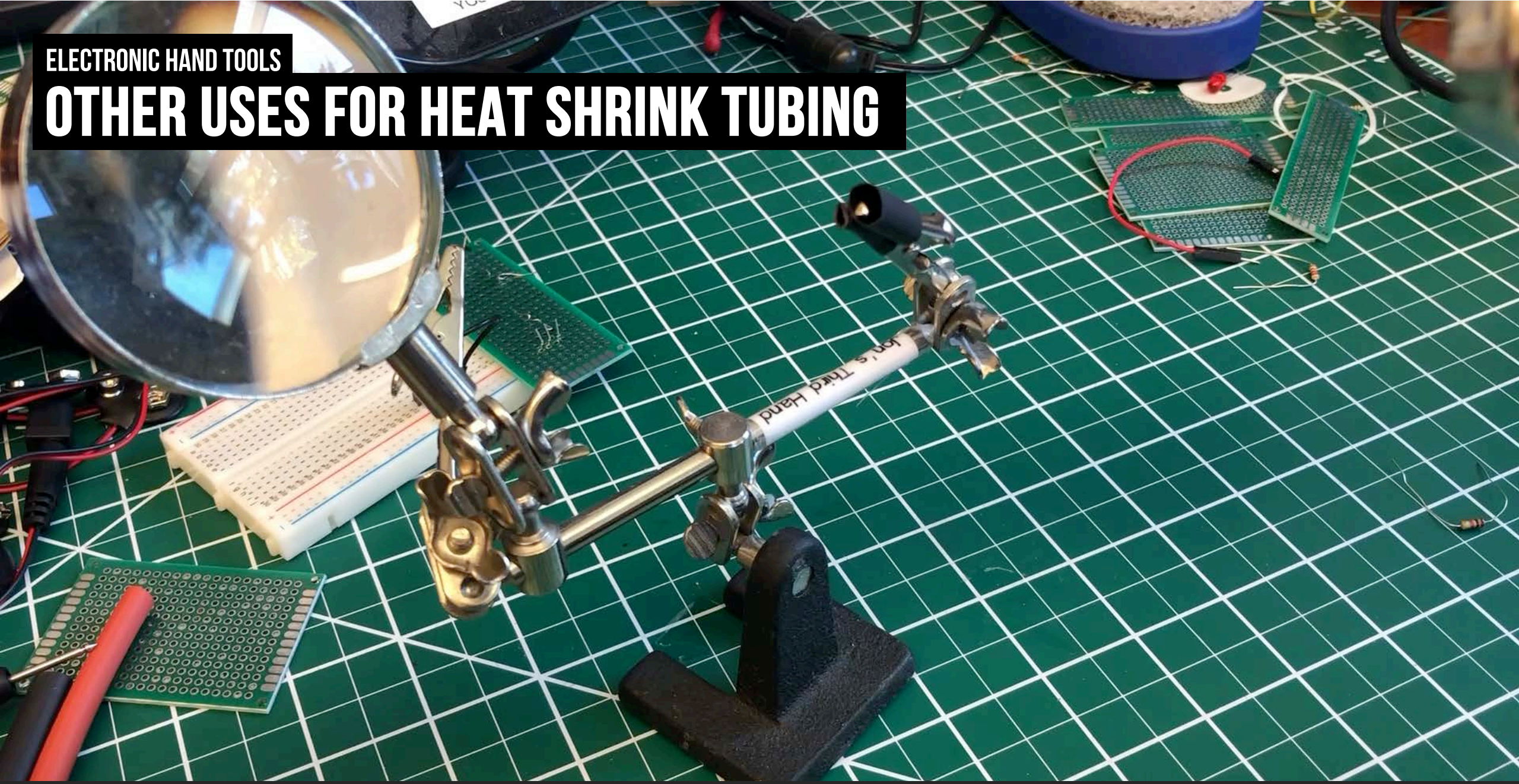
REPAIRING A WIRE WITH HEAT SHRINK TUBING



Source: https://youtu.be/qzTQaGxiUnk

ELECTRONIC HAND TOOLS

OTHER USES FOR HEAT SHRINK TUBING



Source: Jon Froehlich