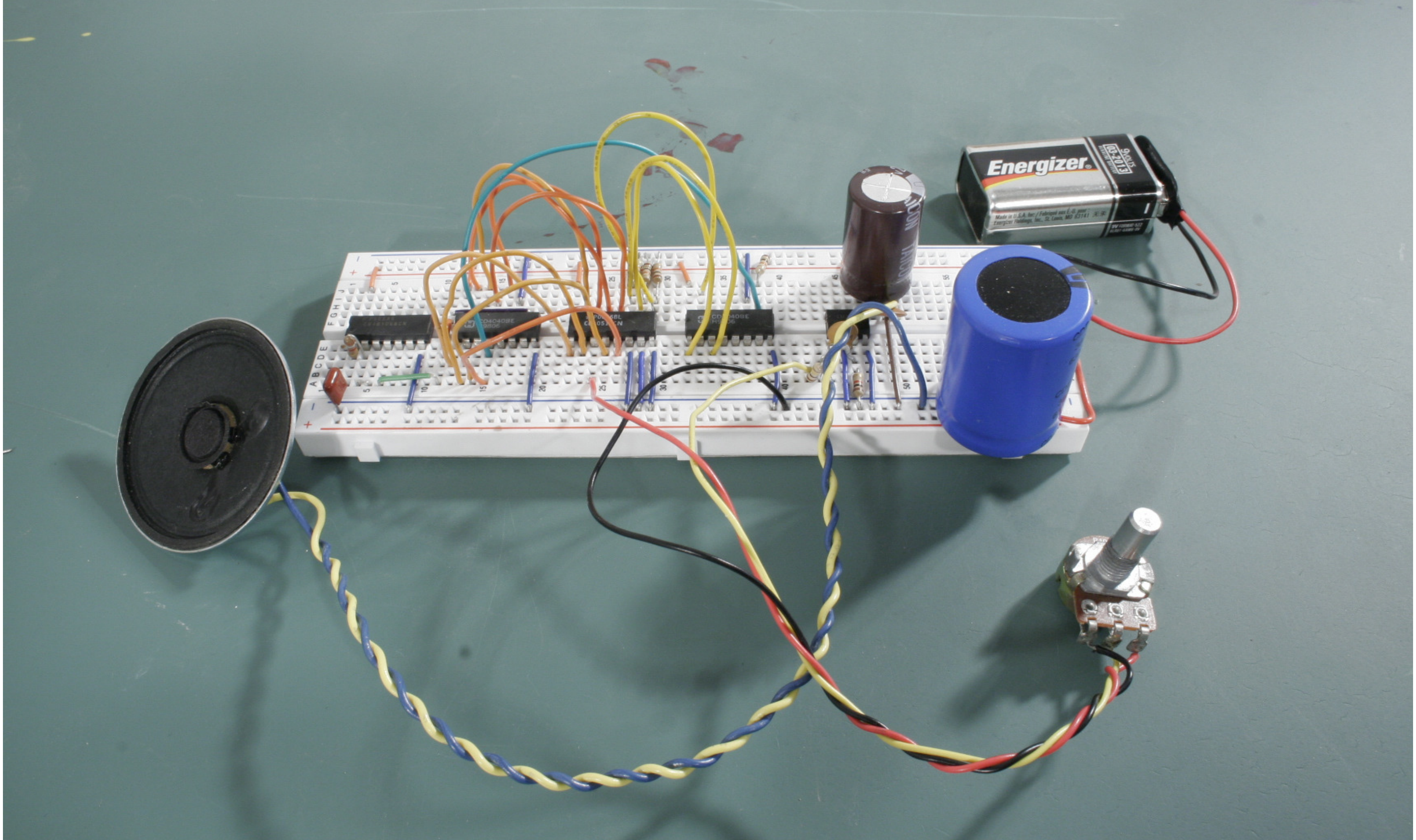
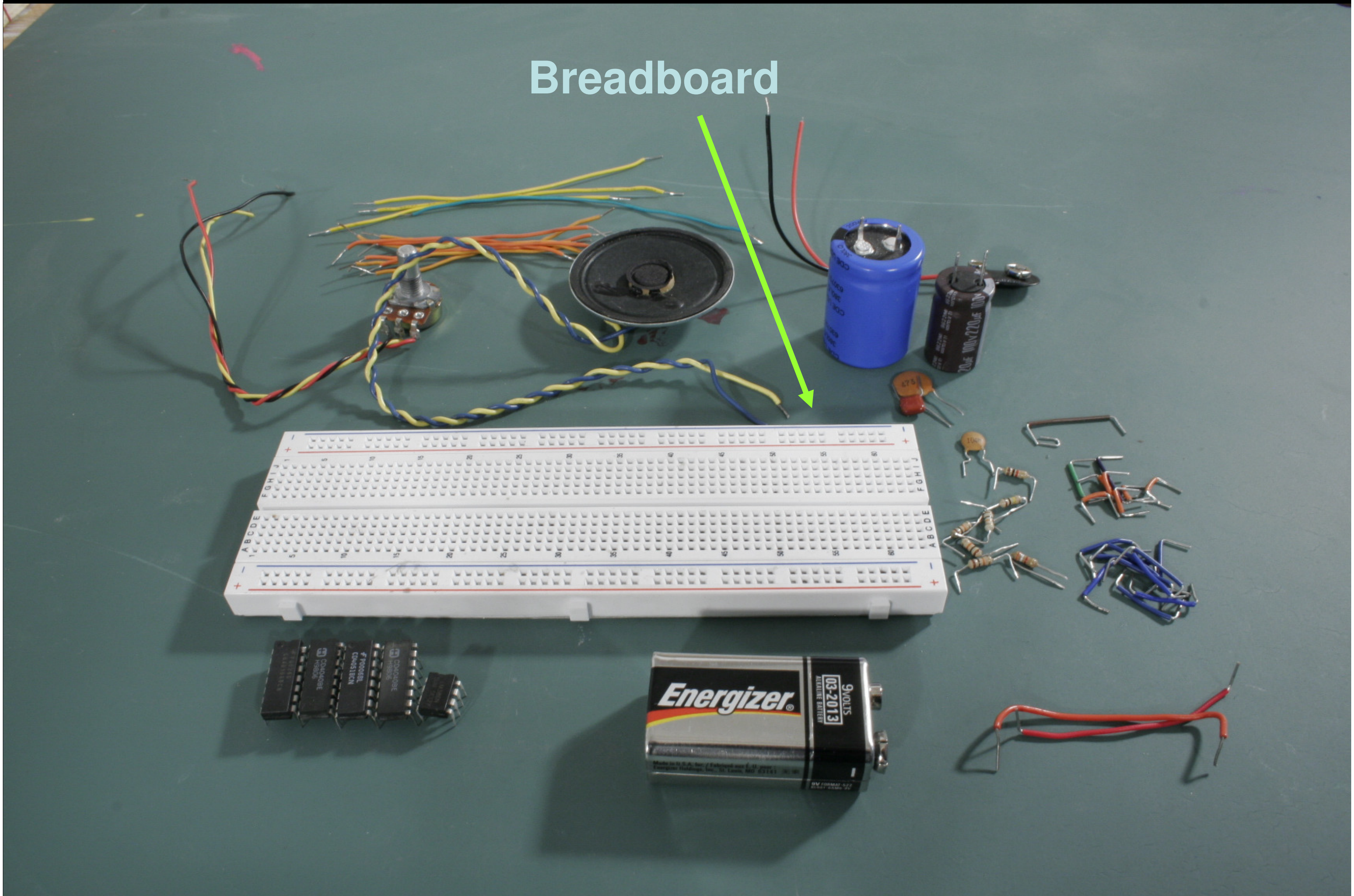
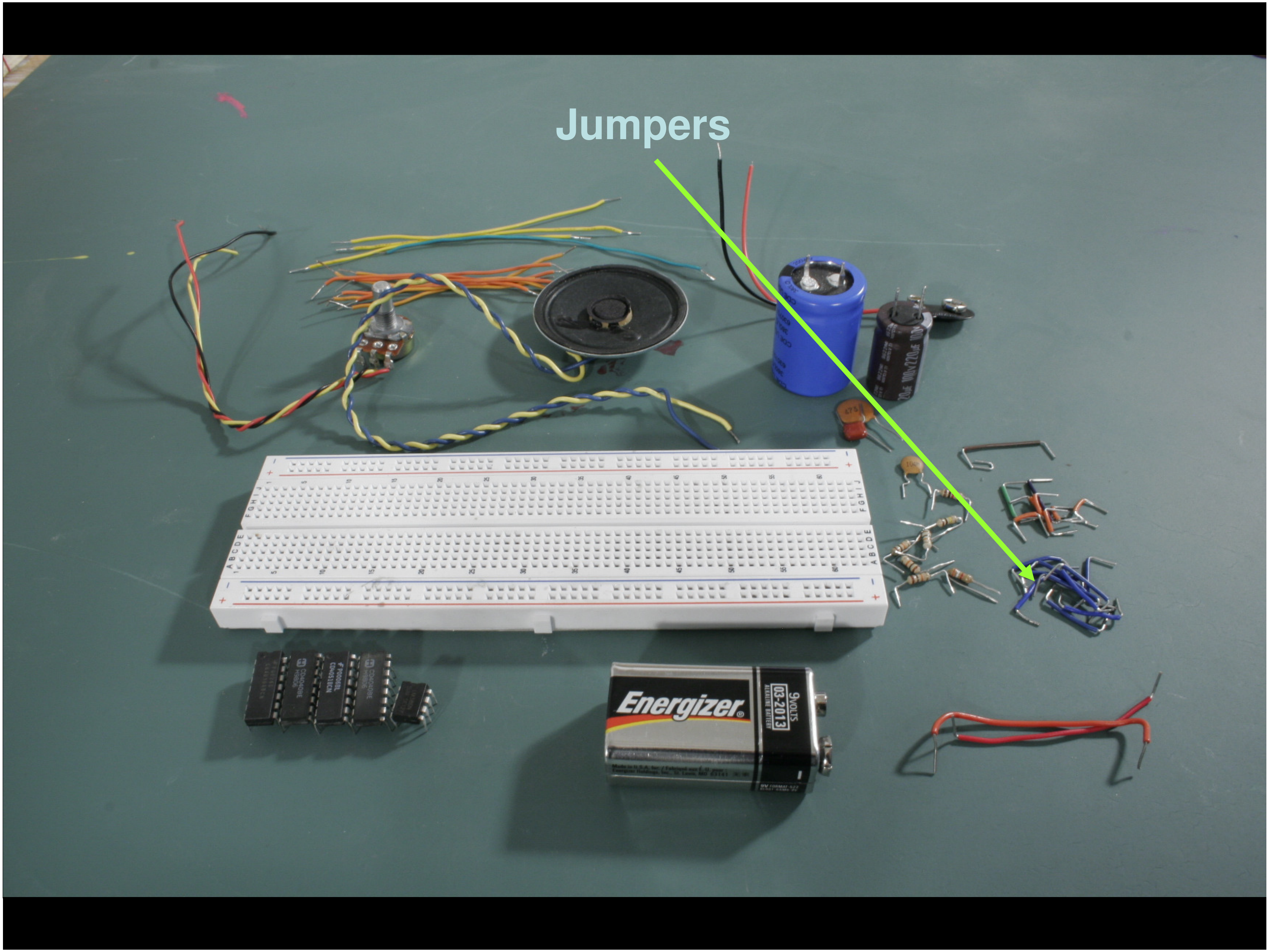
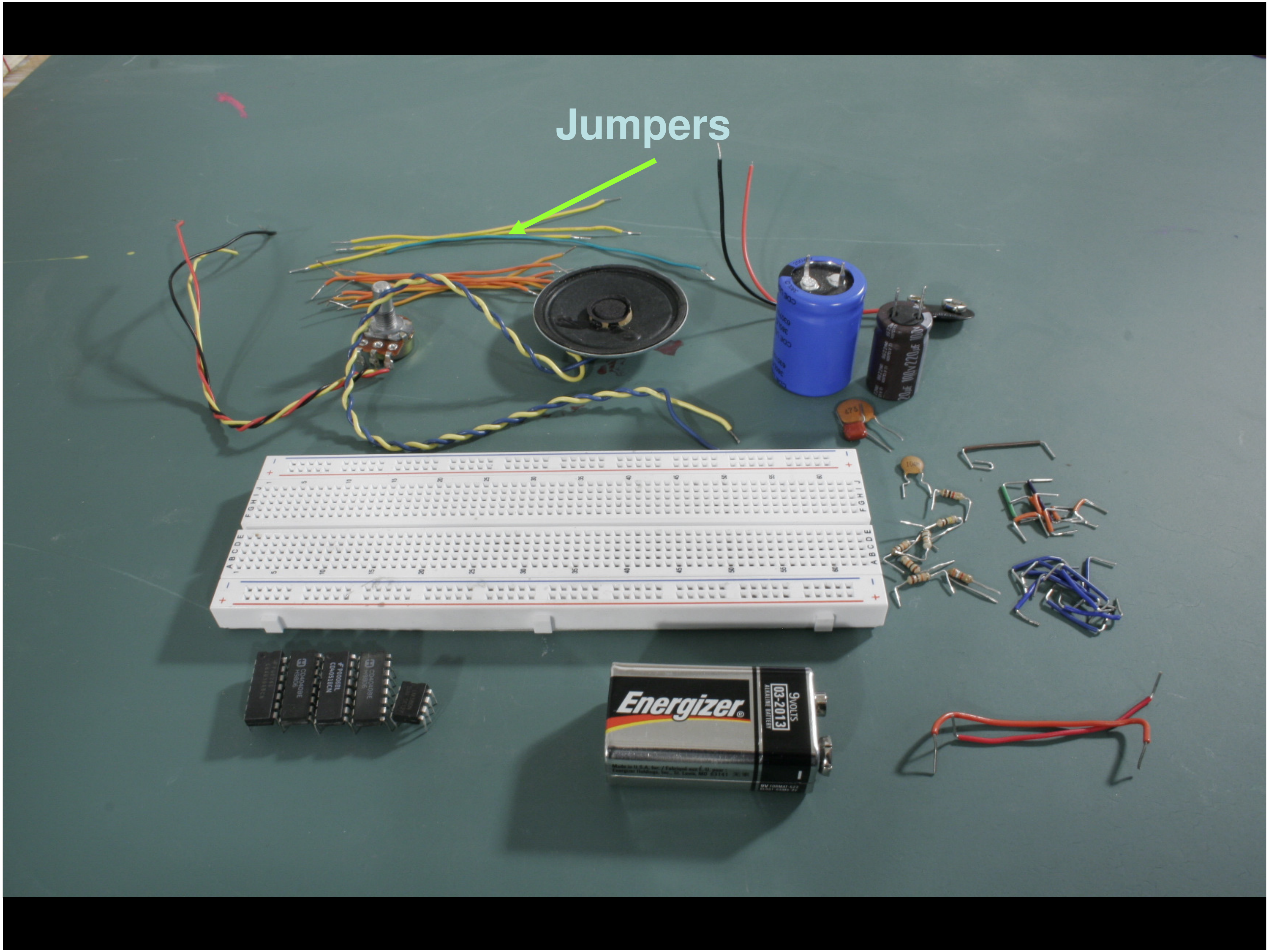
Welcome to the CMOS Music I – 1 bit synthesizer workshop!



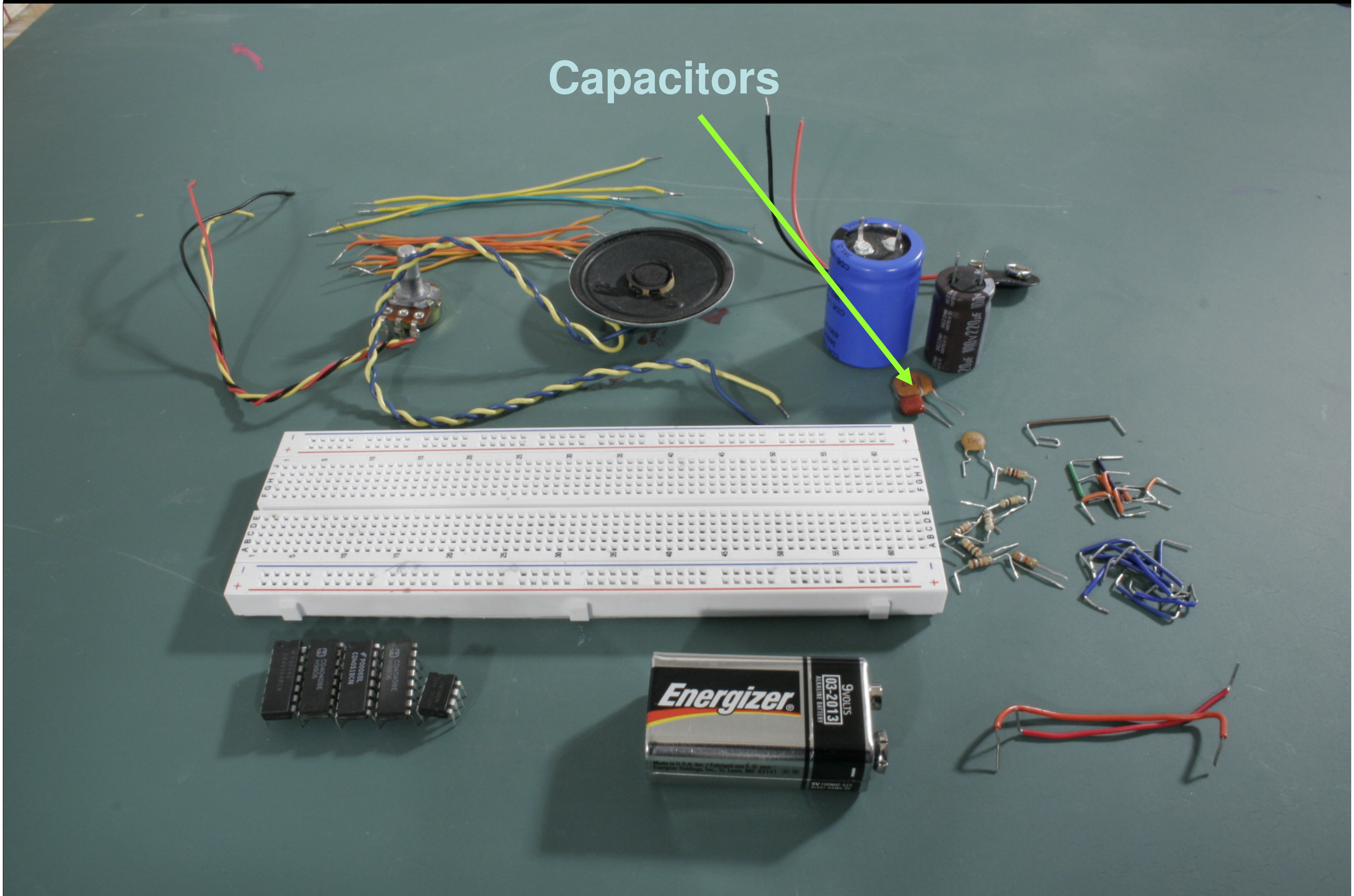
Parts in your kit for this workshop:

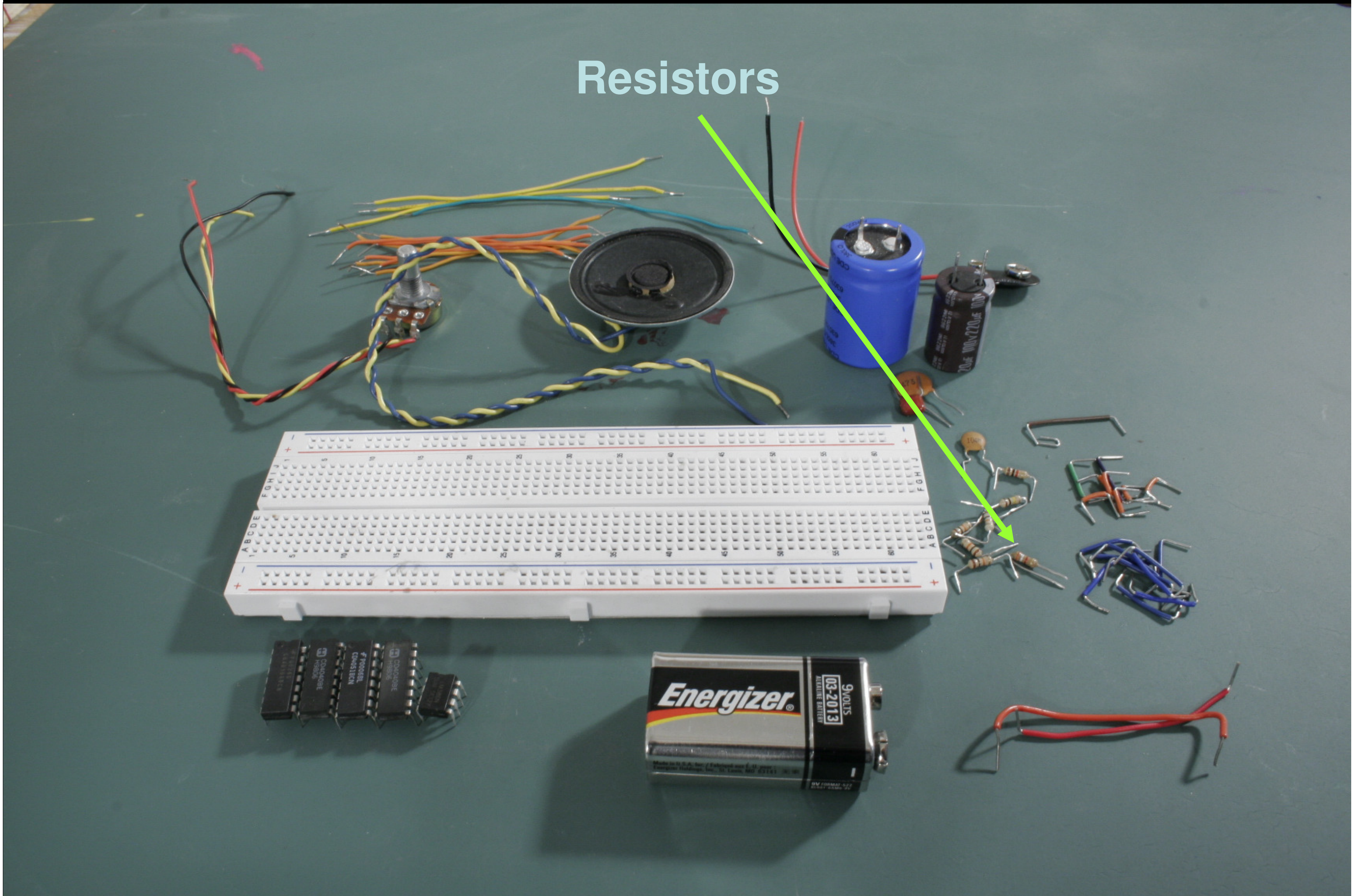

Breadboard
Energizer

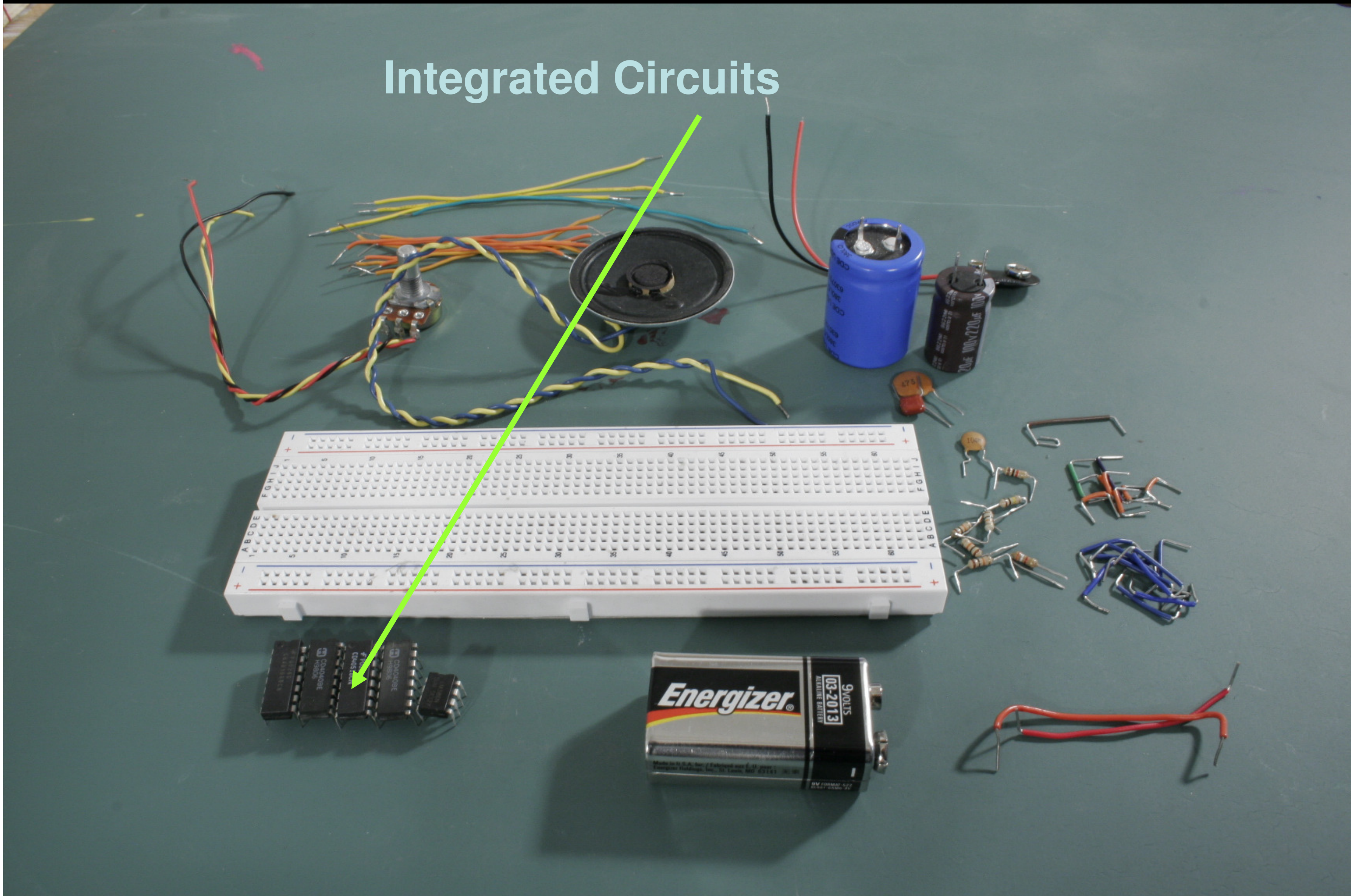

Jumpers
Energizer
9VOLTS
03-2013

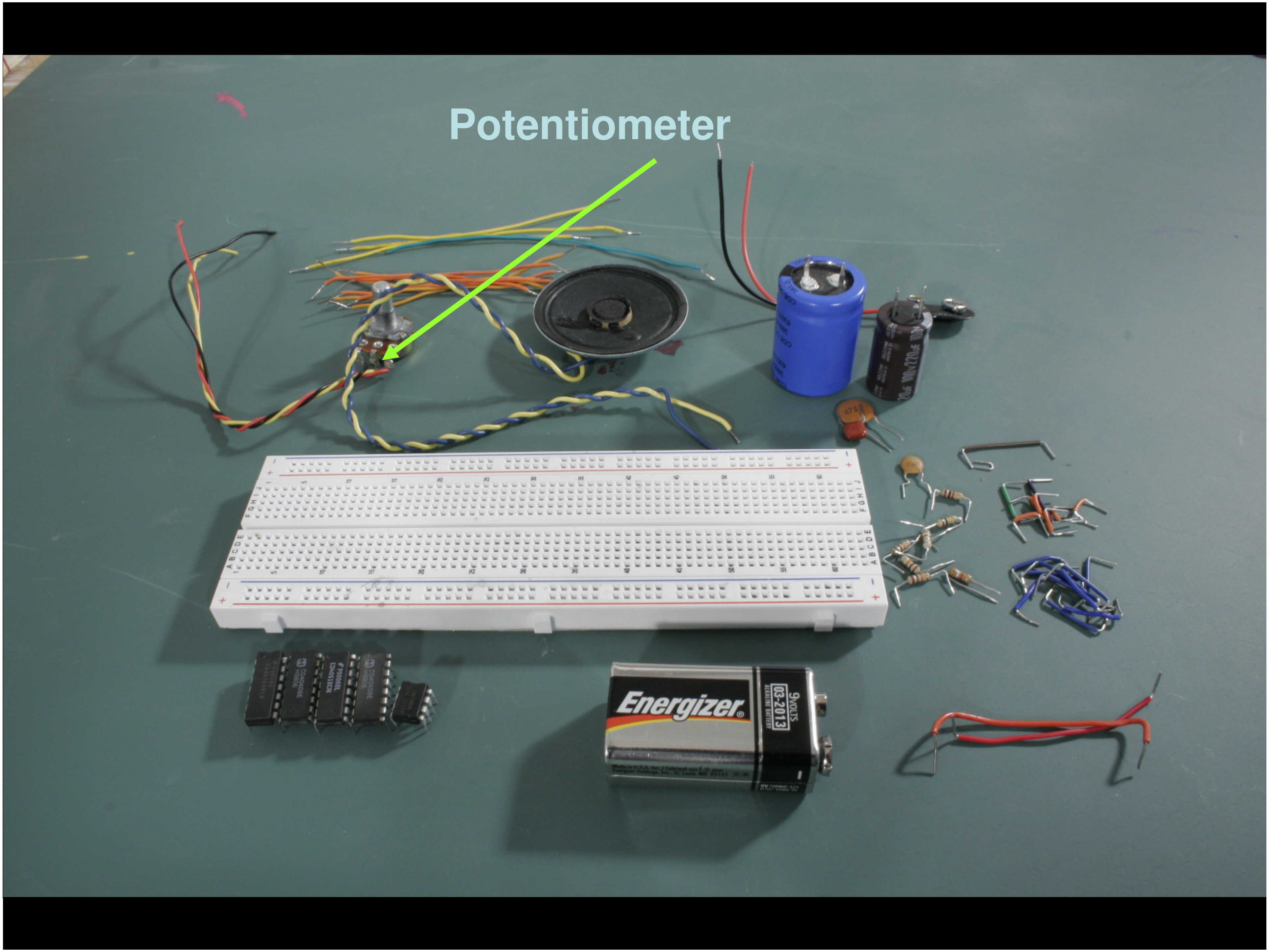


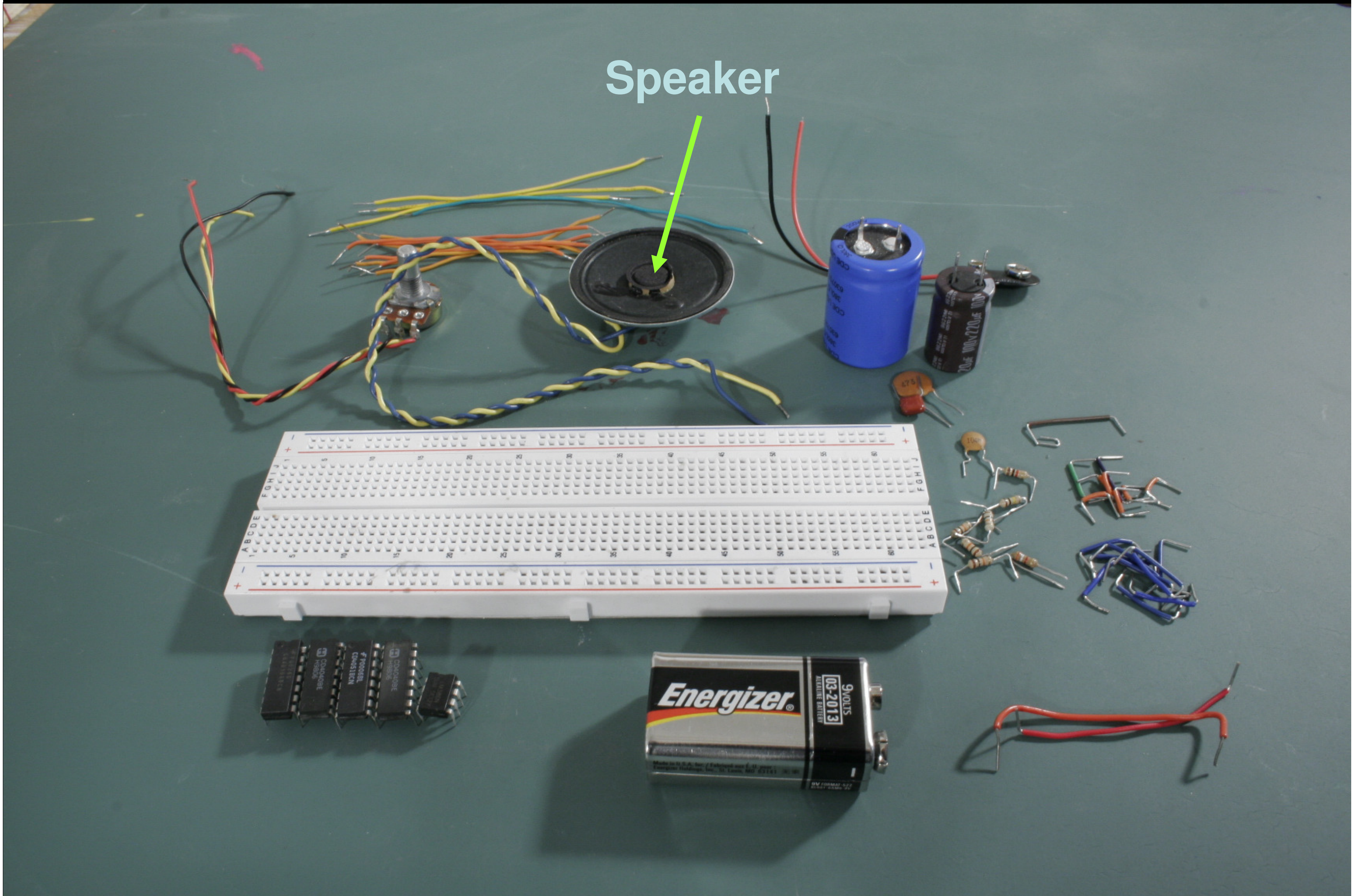
Jumpers
Energizer
9VOLTS
03-2013

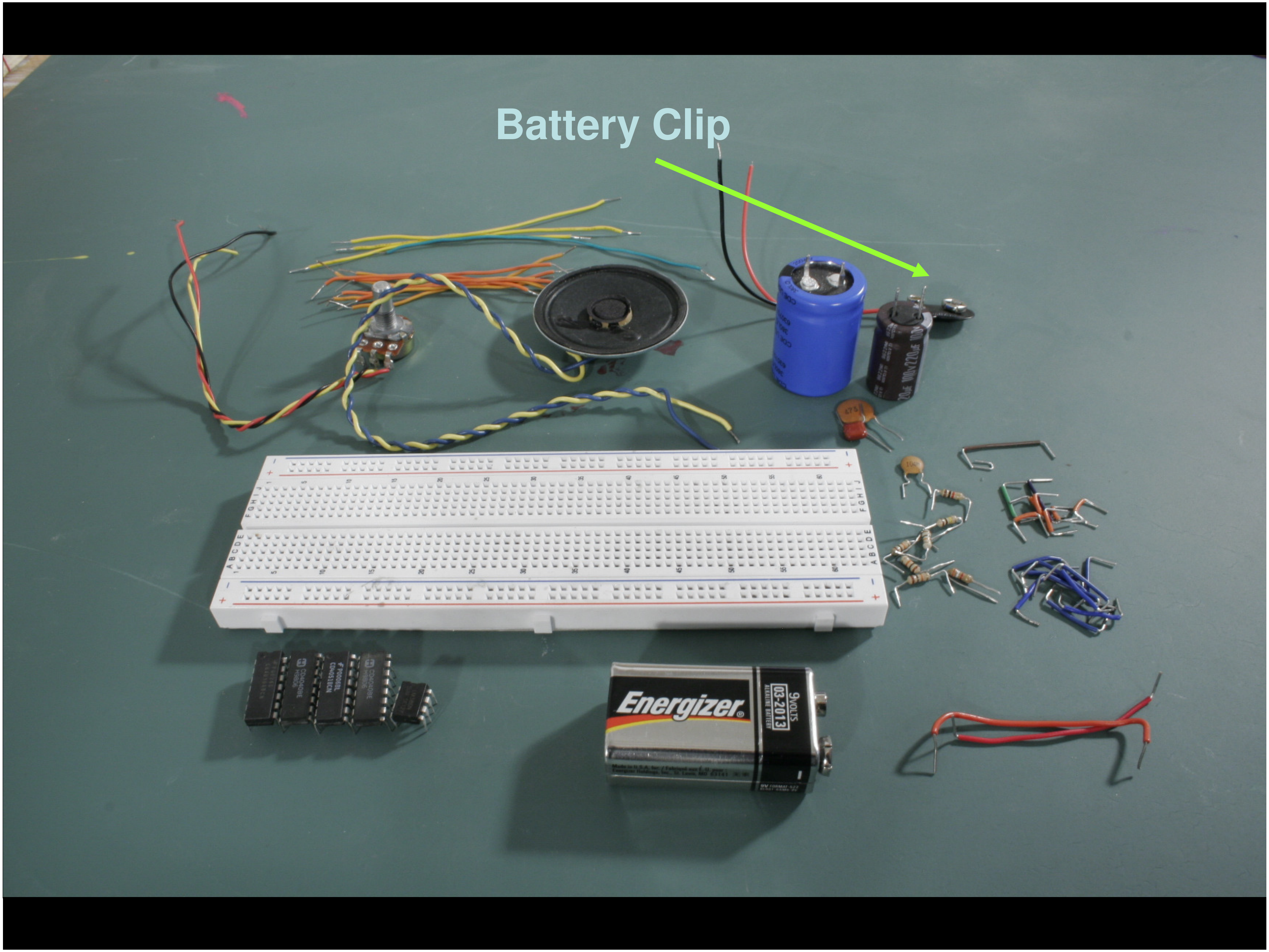

Capacitors
Energizer
9VOLTS
03-2013

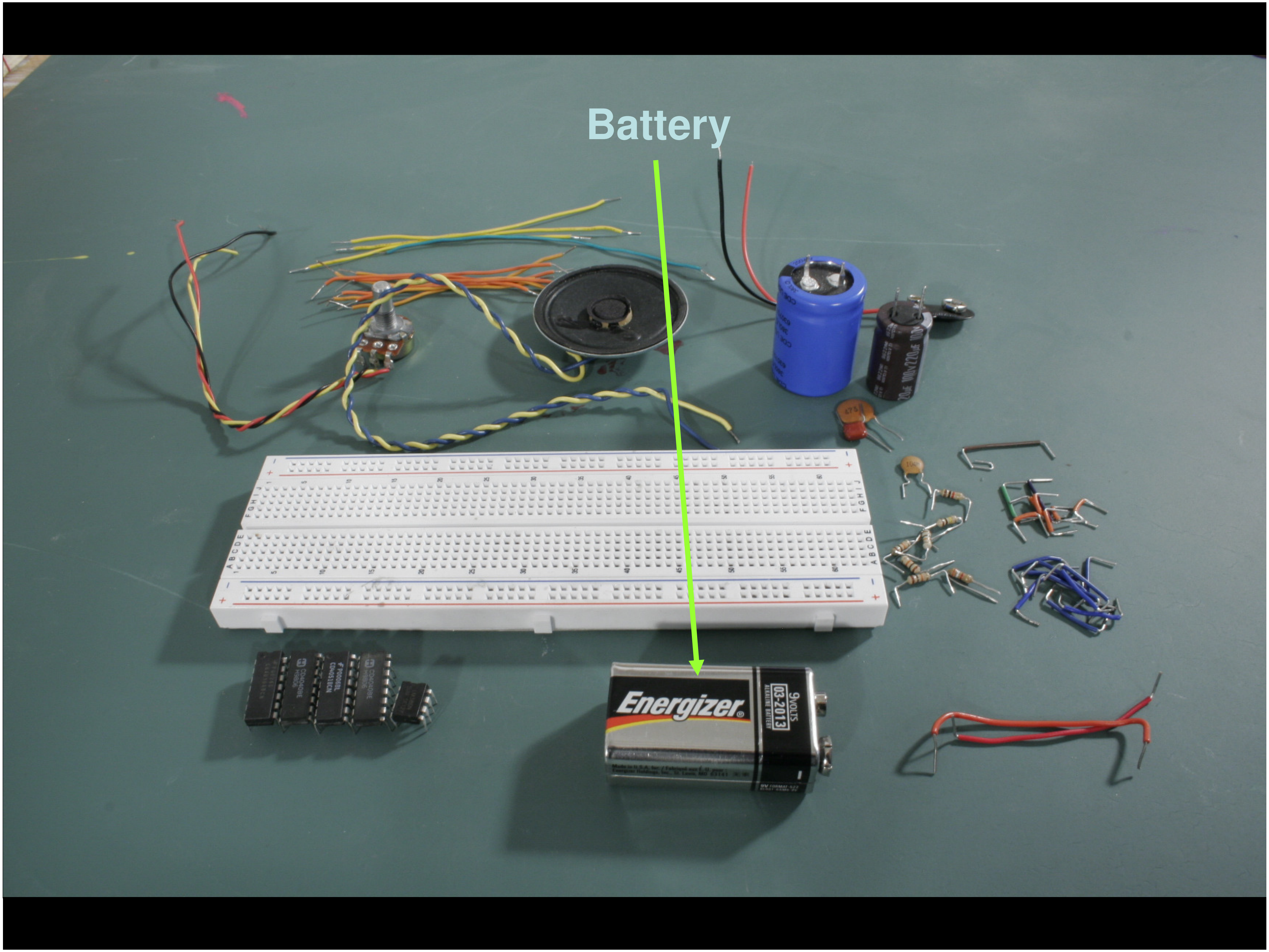

Resistors
Energizer
9VOLTS
03-2013


Integrated Circuits
Energizer
9 VOLTS
03-2013

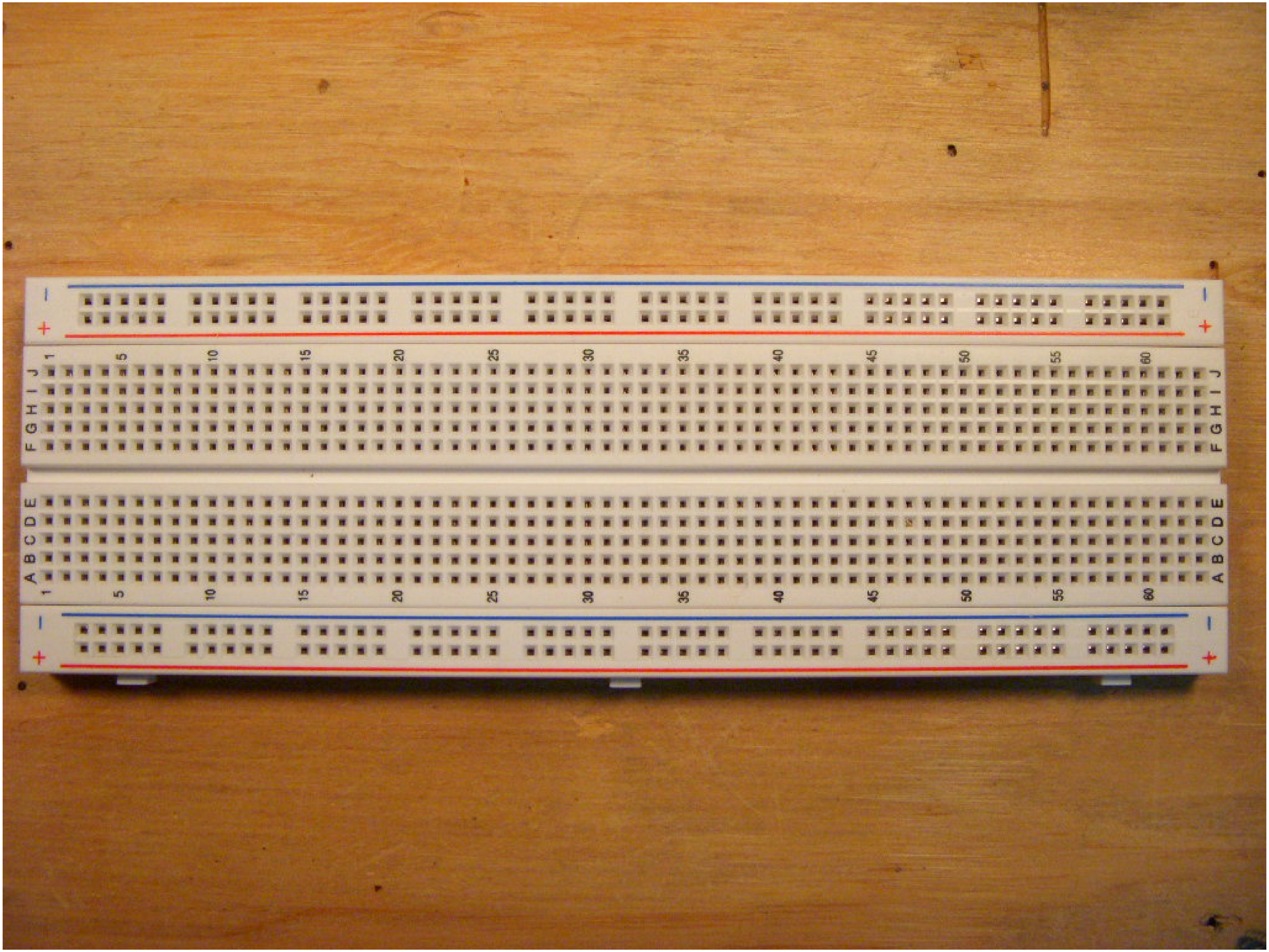

Potentiometer
Energizer


Speaker
Energizer
9VOLTS
03-2013


Battery Clip
Energizer
9VOLTS
03-2013

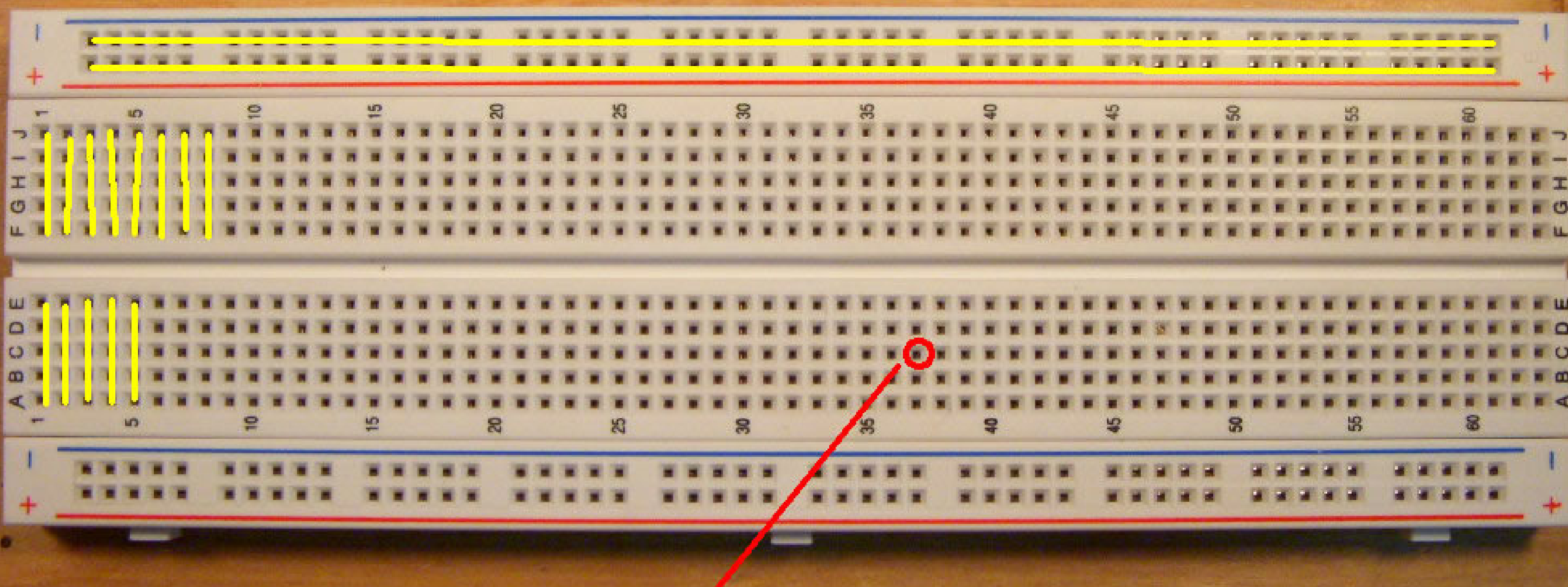

Battery
Energizer
9 VOLTS
03-2013

Parts	**Quantity**
Breadboard + Jumpers	1 (800+contacts) + 1 kit
Wire (24 AWG stranded)	3 different colors 16” each
9 volt Battery	1
Battery Clip	1
Speaker (8 ohm)	1
1k ohm resistor	1
10k ohm resistor	4
100k ohm resistor	1
100k ohm potentiometer	1
3.9k ohm resistor	1
CD40106 (IC)	1
CD4051 (IC)	1
CD4040 (IC)	2
LM386 (IC)	1
1500pF or .0015 uF Capacitor	1
.047 uF Capacitor	1
.1 uF Capacitor	1
220 uF Capacitor	1

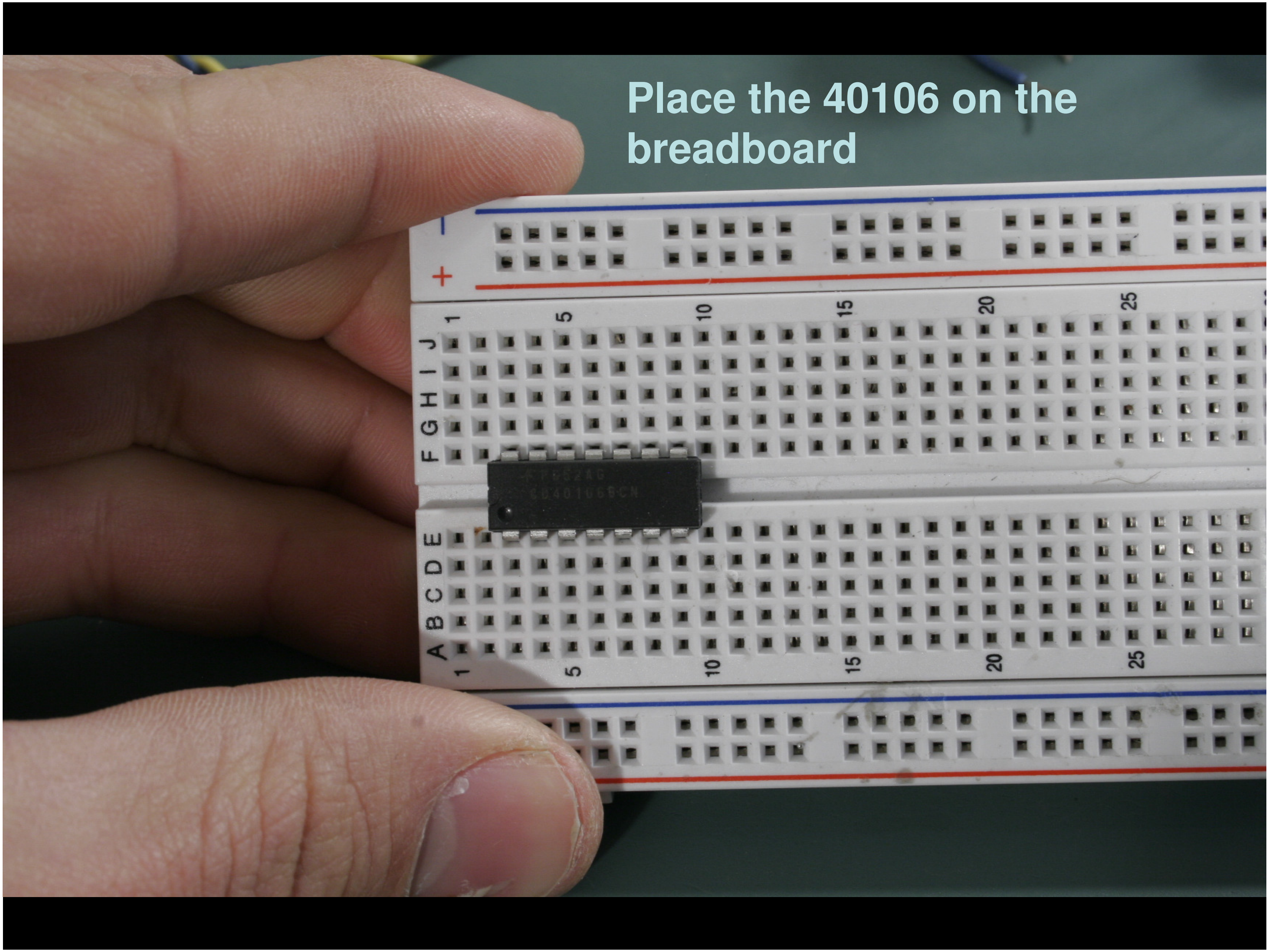


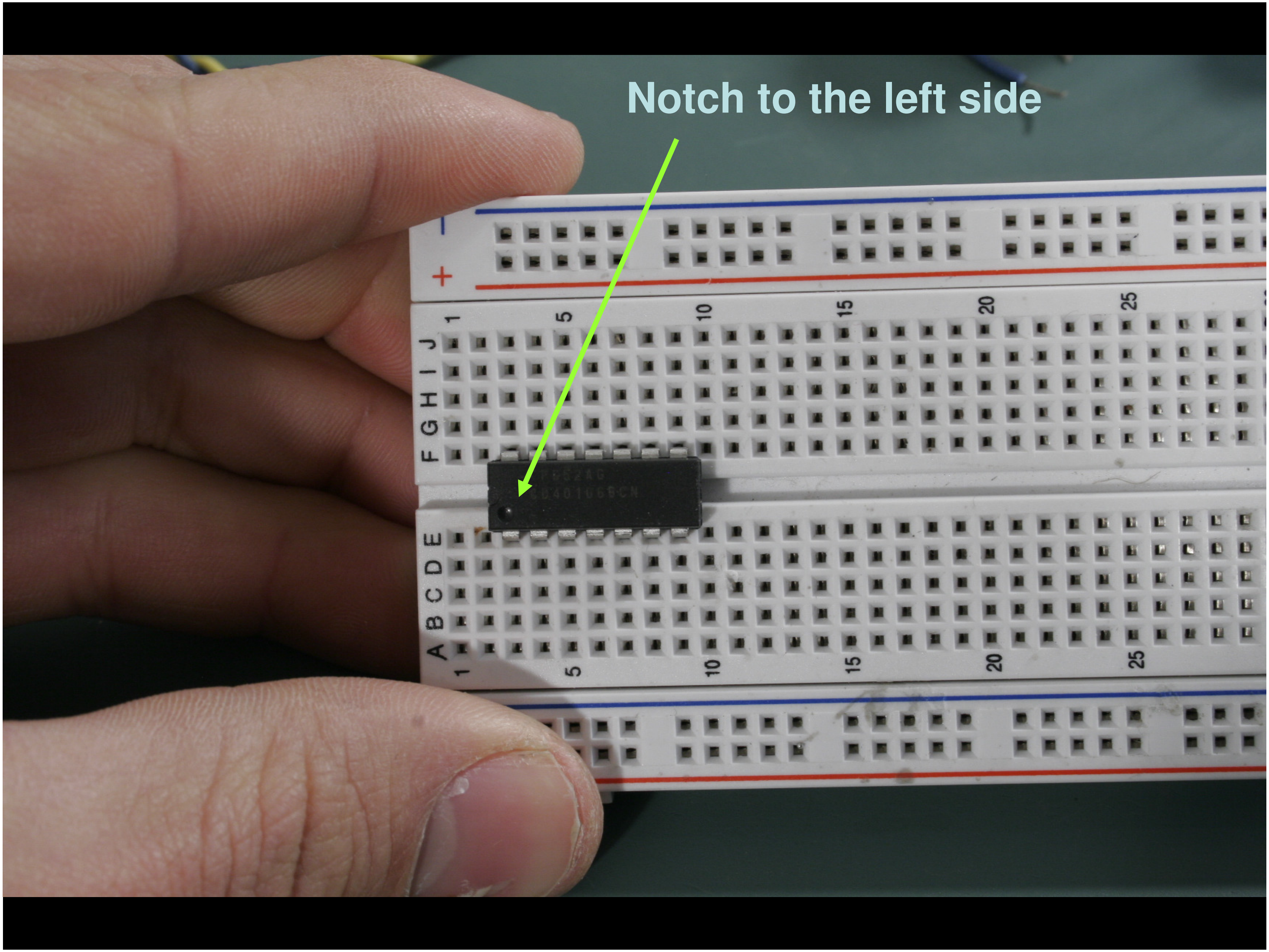
J I H G F
E D C B A
1 5 10 15 20 25 30 35 40 45 50 55 60
+ −

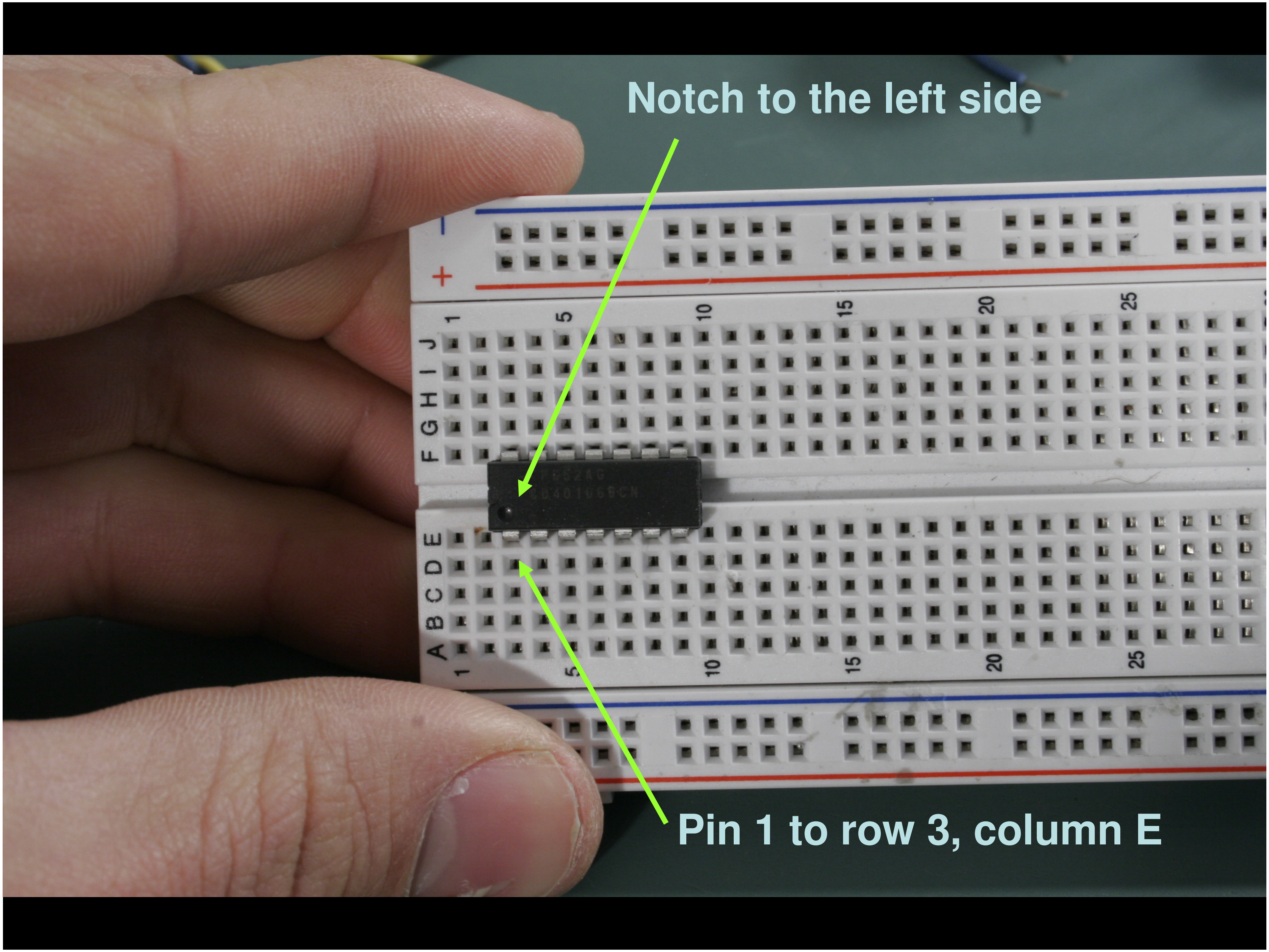
Bread boards contain hundreds of contact points. Each point is connected to other points in rows and columns via strips of metal indicated by the yellow lines below.

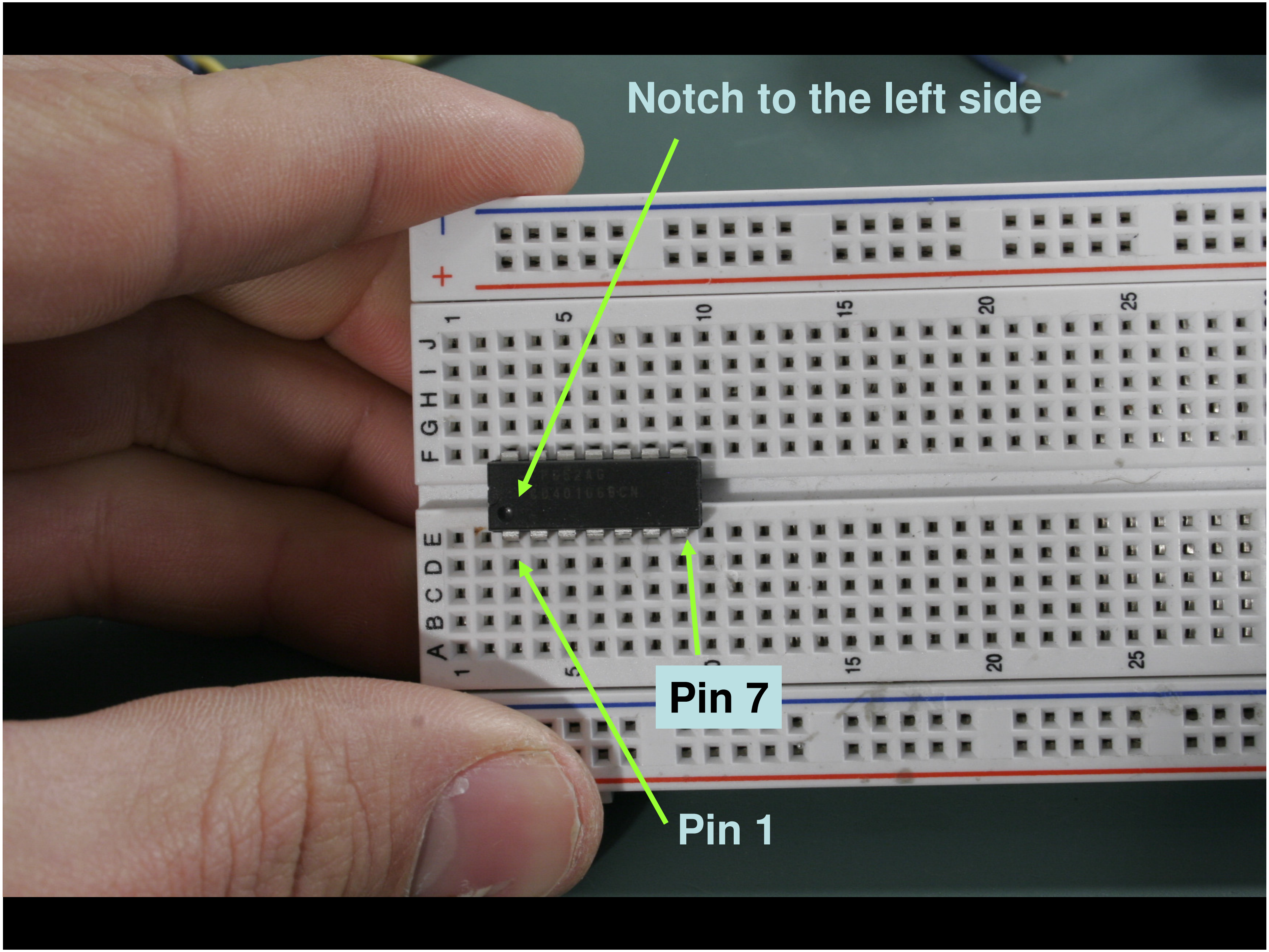


Each point has an alpha numeric coordinate. This point is C-37 -- column C, row 37.

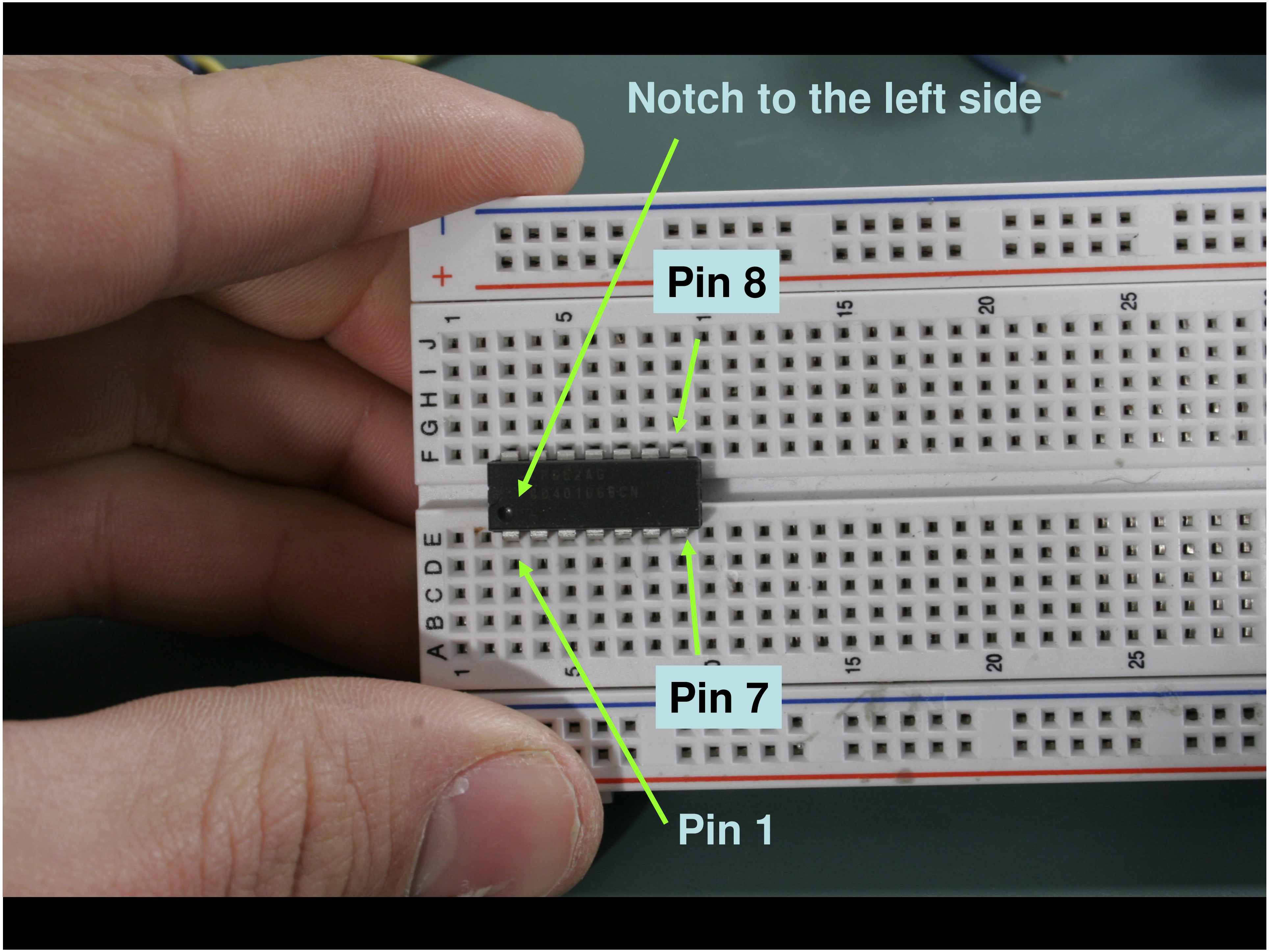

Place the 40106 on the breadboard

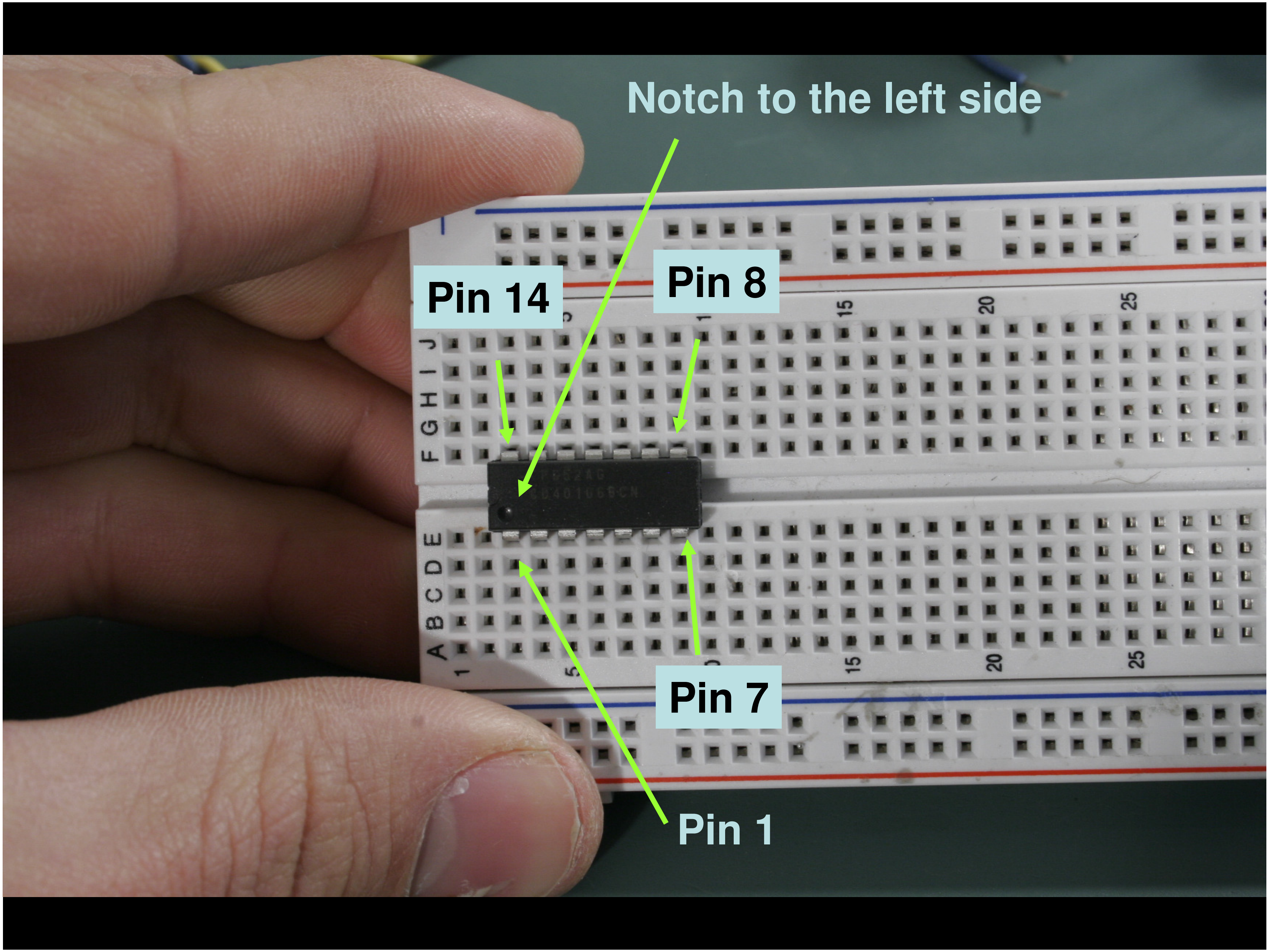

Notch to the left side

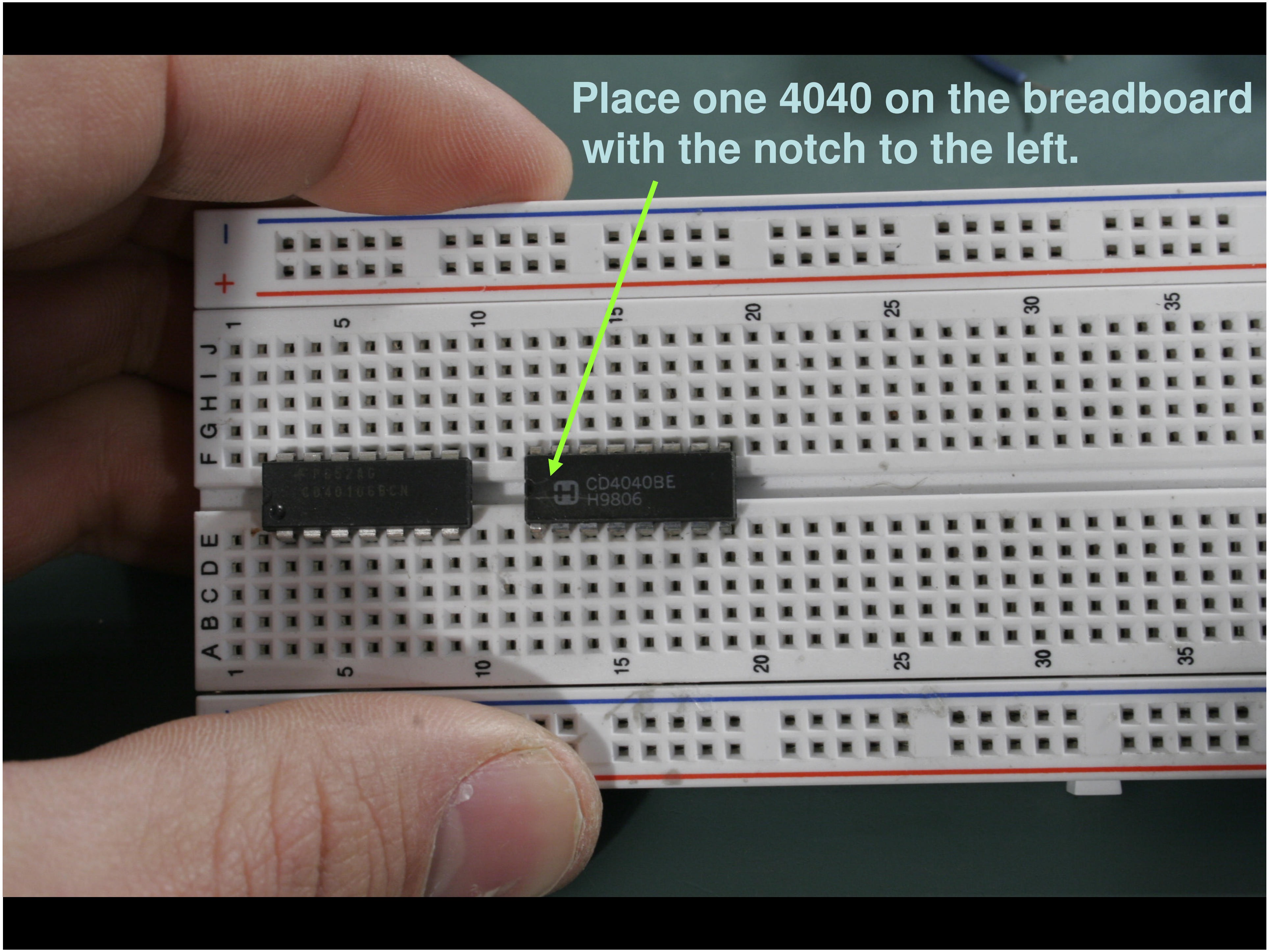

Notch to the left side
Pin 1 to row 3, column E

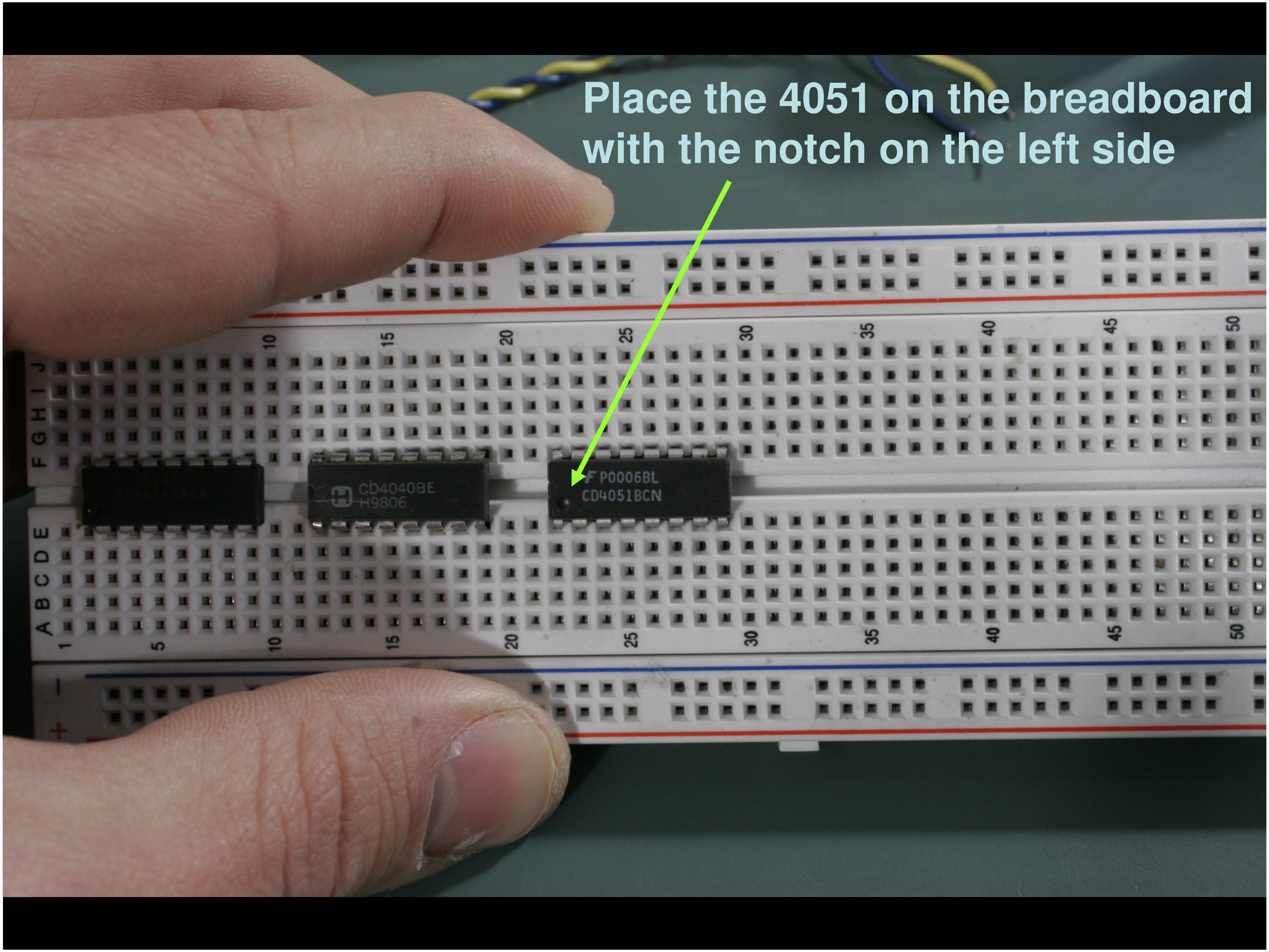


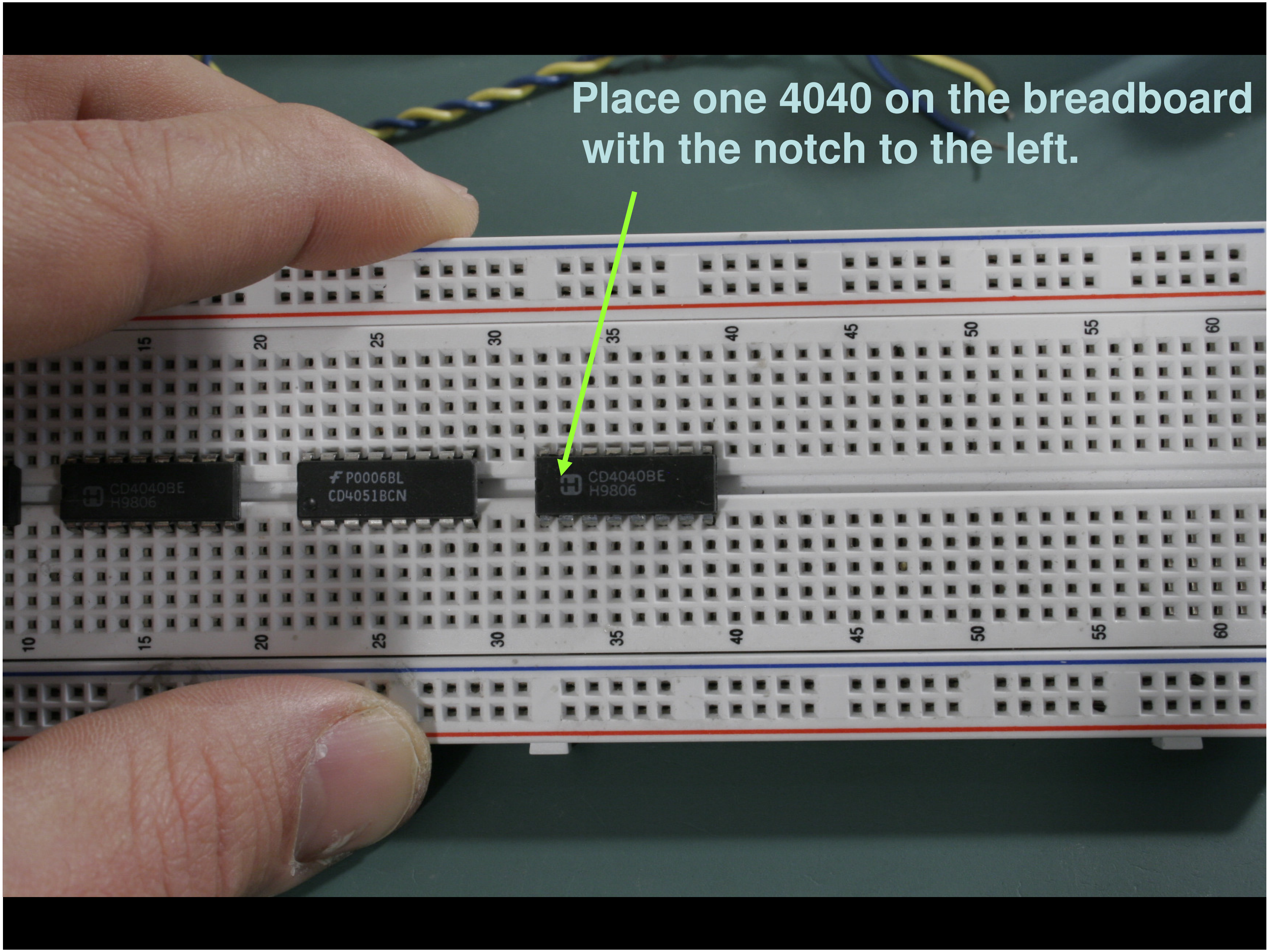
Notch to the left side
Pin 7
Pin 1

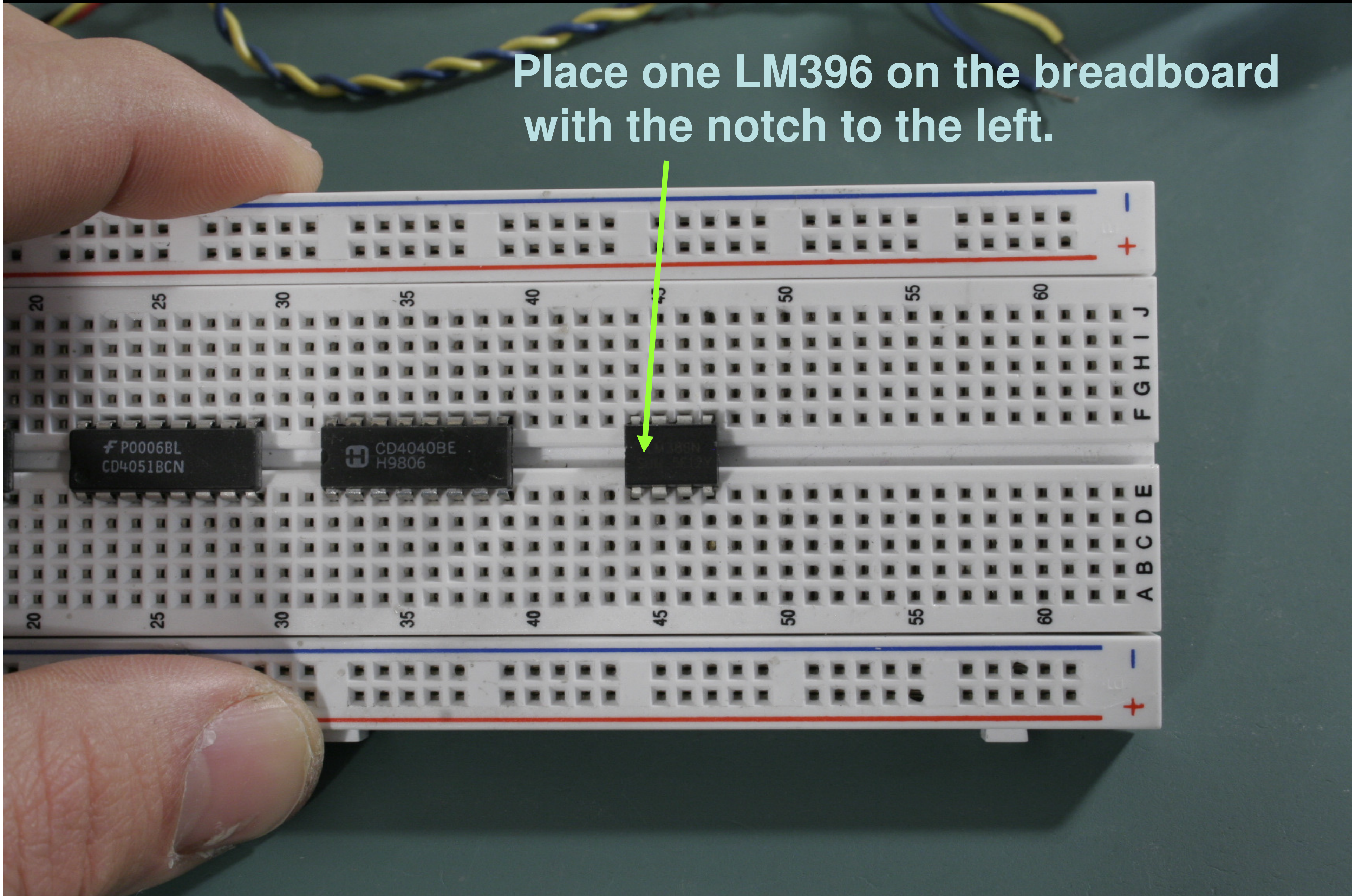

Notch to the left side
Pin 8
Pin 7
Pin 1


Notch to the left side
Pin 14
Pin 8
Pin 7
Pin 1

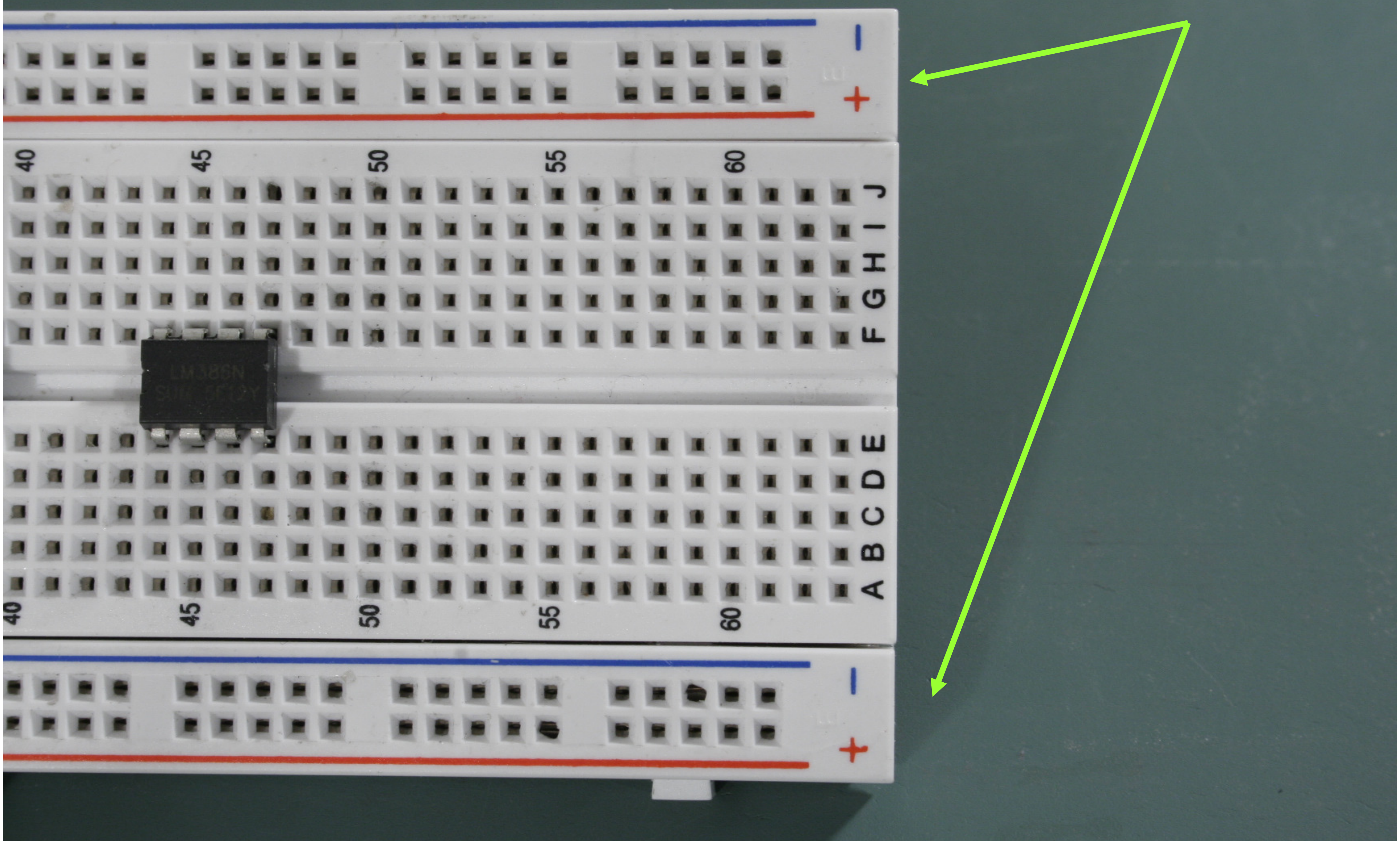

Place one 4040 on the breadboard
with the notch to the left.
CD4040BE
H9806

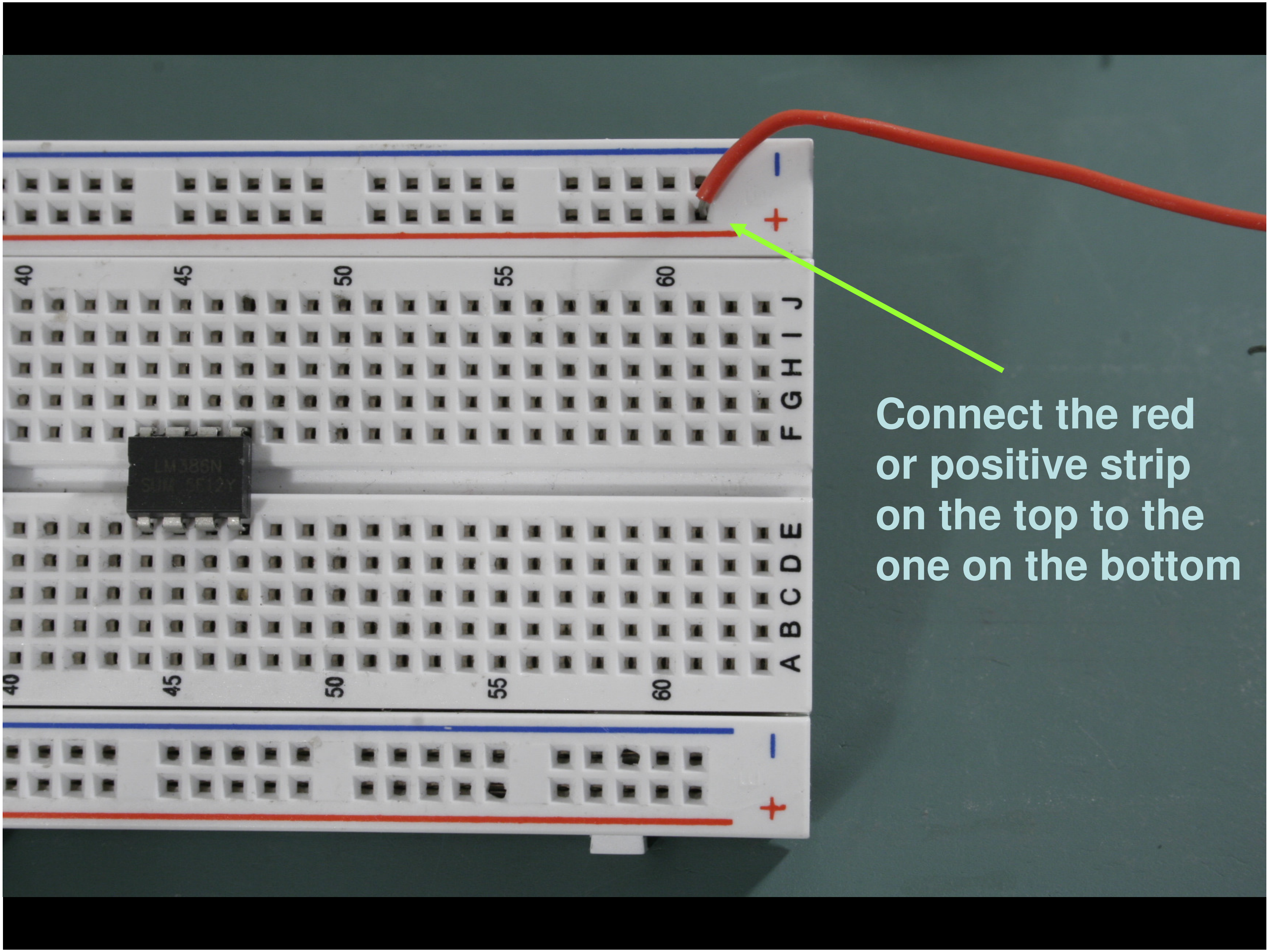

Place the 4051 on the breadboard
with the notch on the left side
CD4040BE
H9806
P0006BL
CD4051BCN

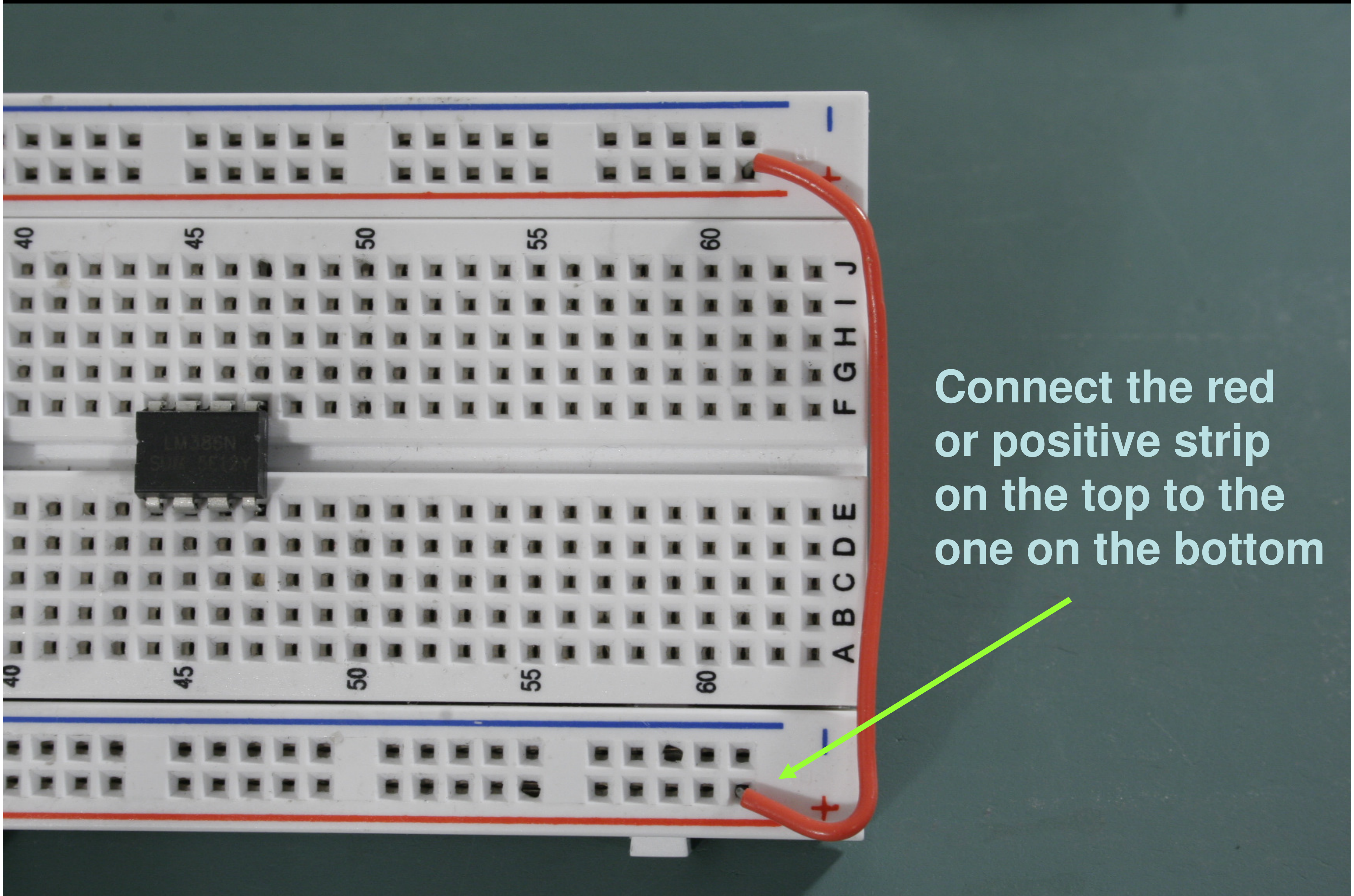

Place one 4040 on the breadboard
with the notch to the left.
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806

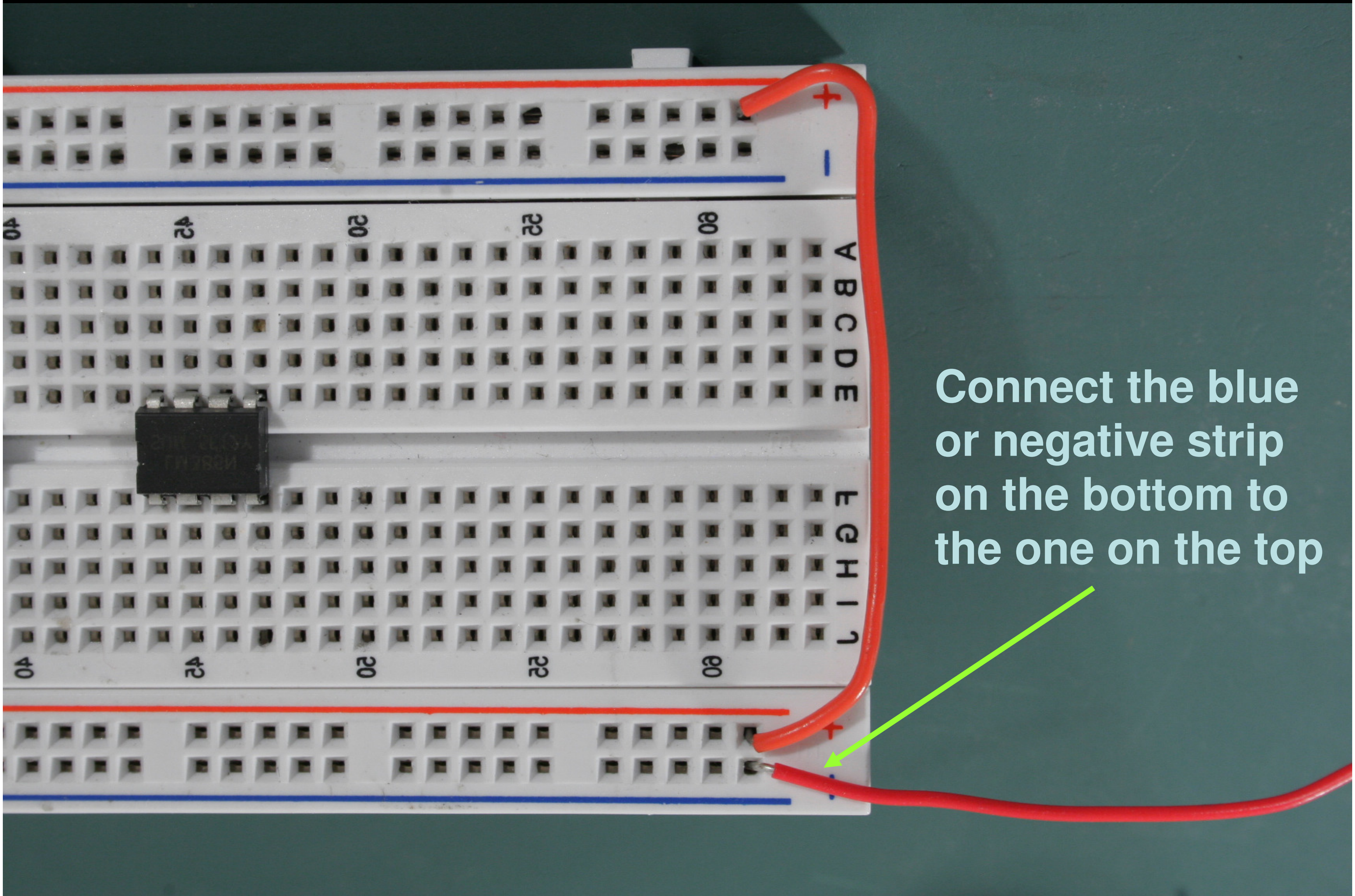

Place one LM396 on the breadboard
with the notch to the left.
P0006BL
CD4051BCN
CD4040BE
H9806

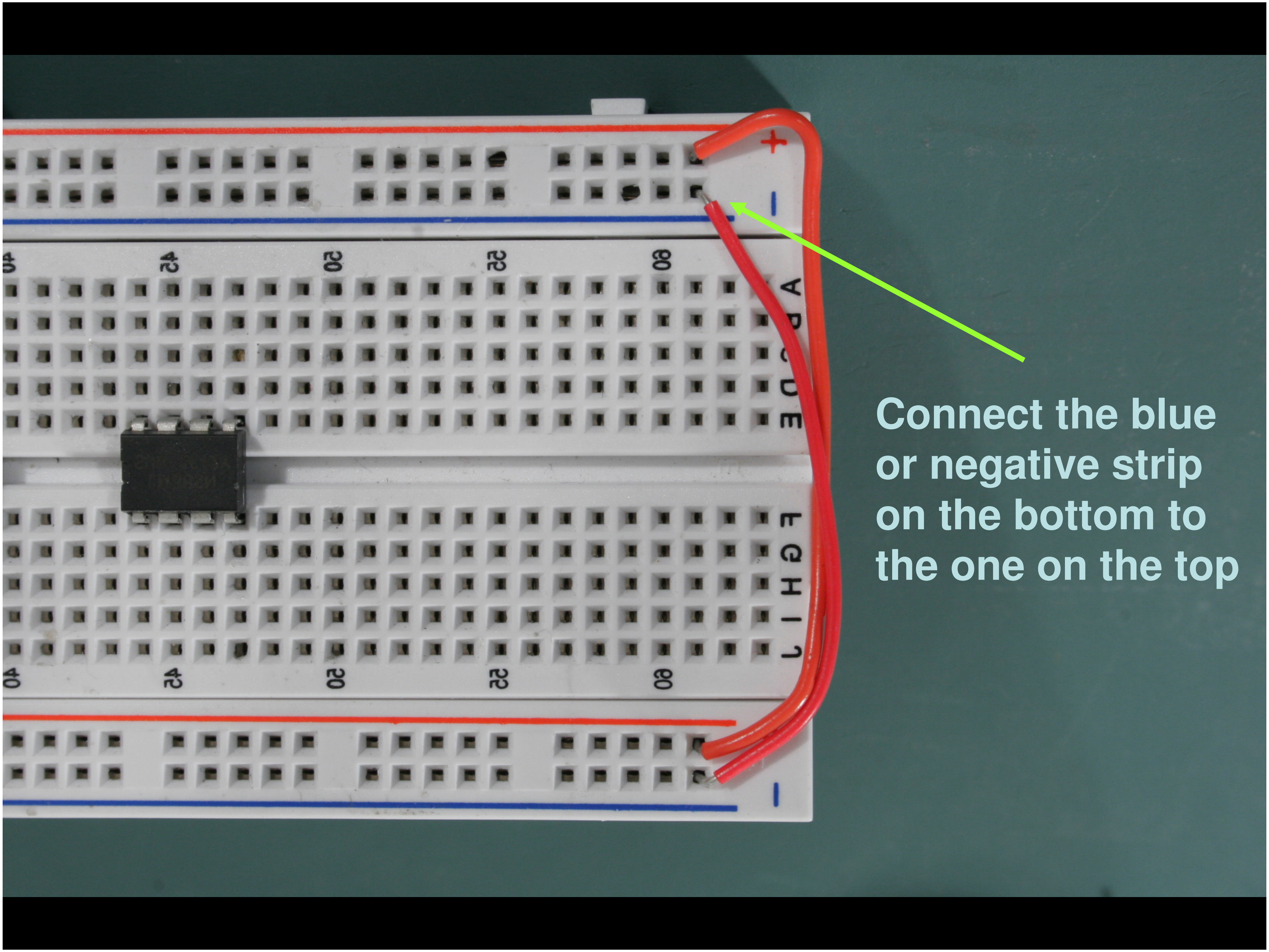
Connect the top and bottom power strips

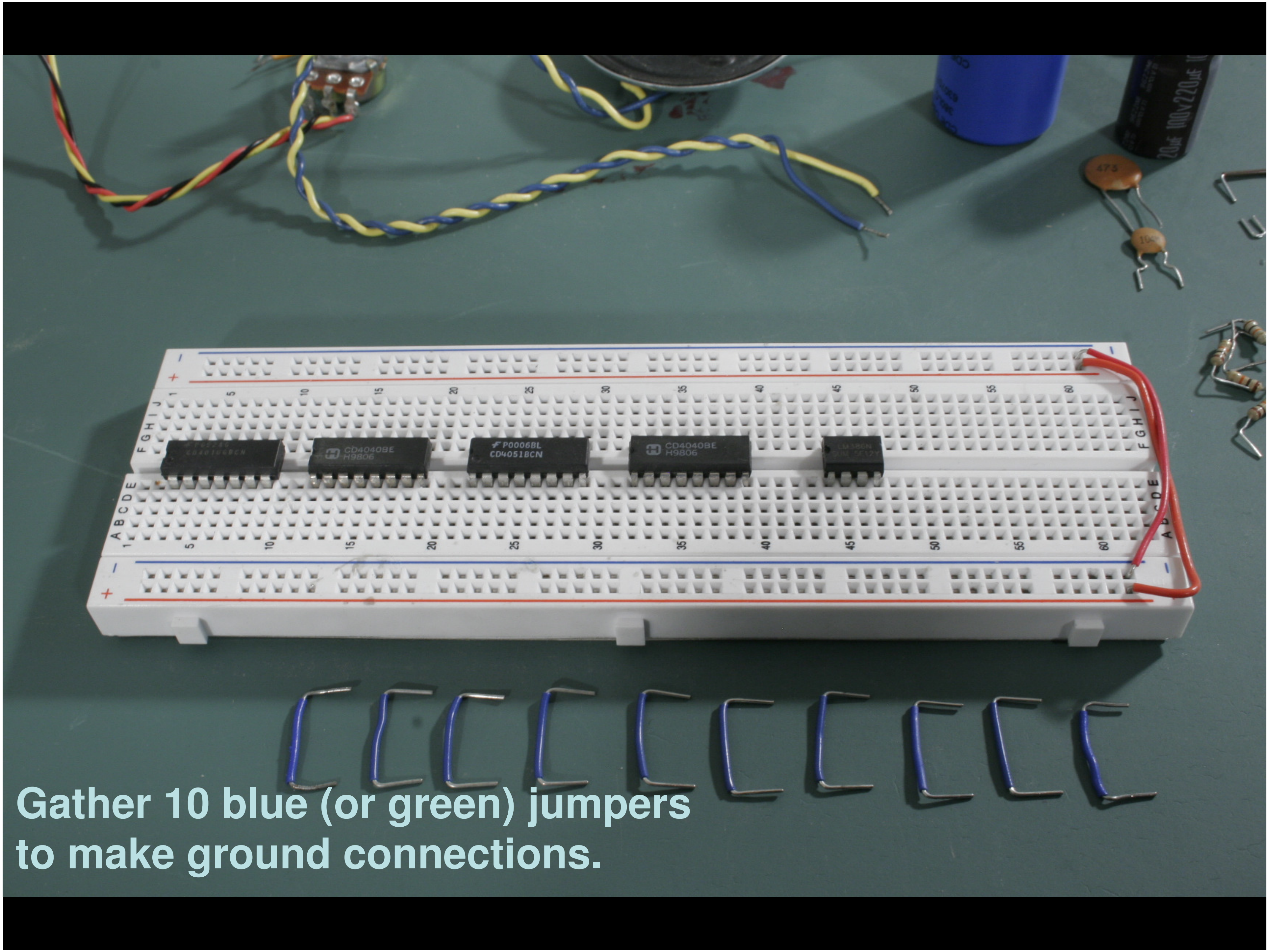



Connect the red
or positive strip
on the top to the
one on the bottom
LM386N


Connect the red
or positive strip
on the top to the
one on the bottom

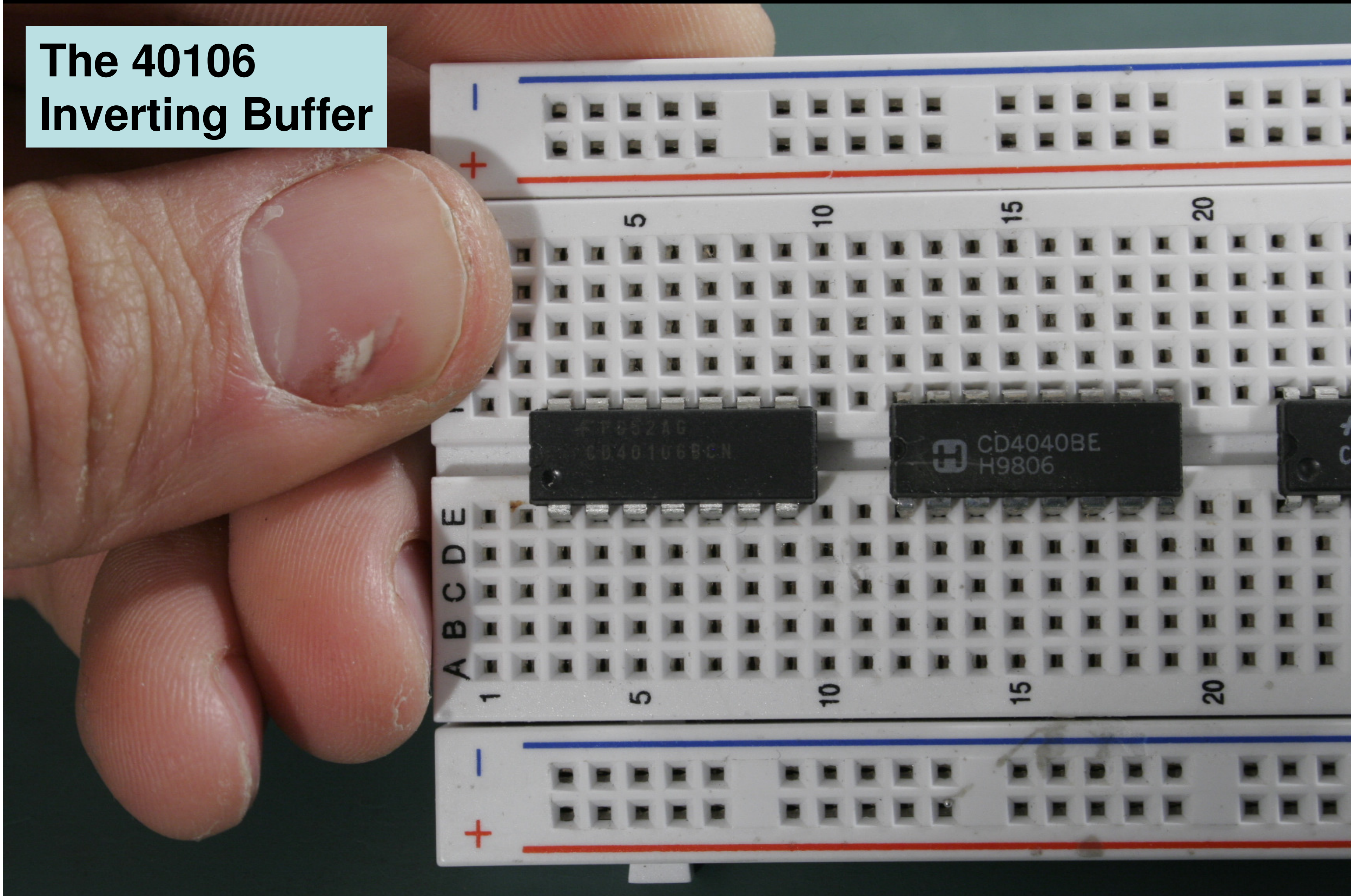

Connect the blue
or negative strip
on the bottom to
the one on the top


Connect the blue
or negative strip
on the bottom to
the one on the top

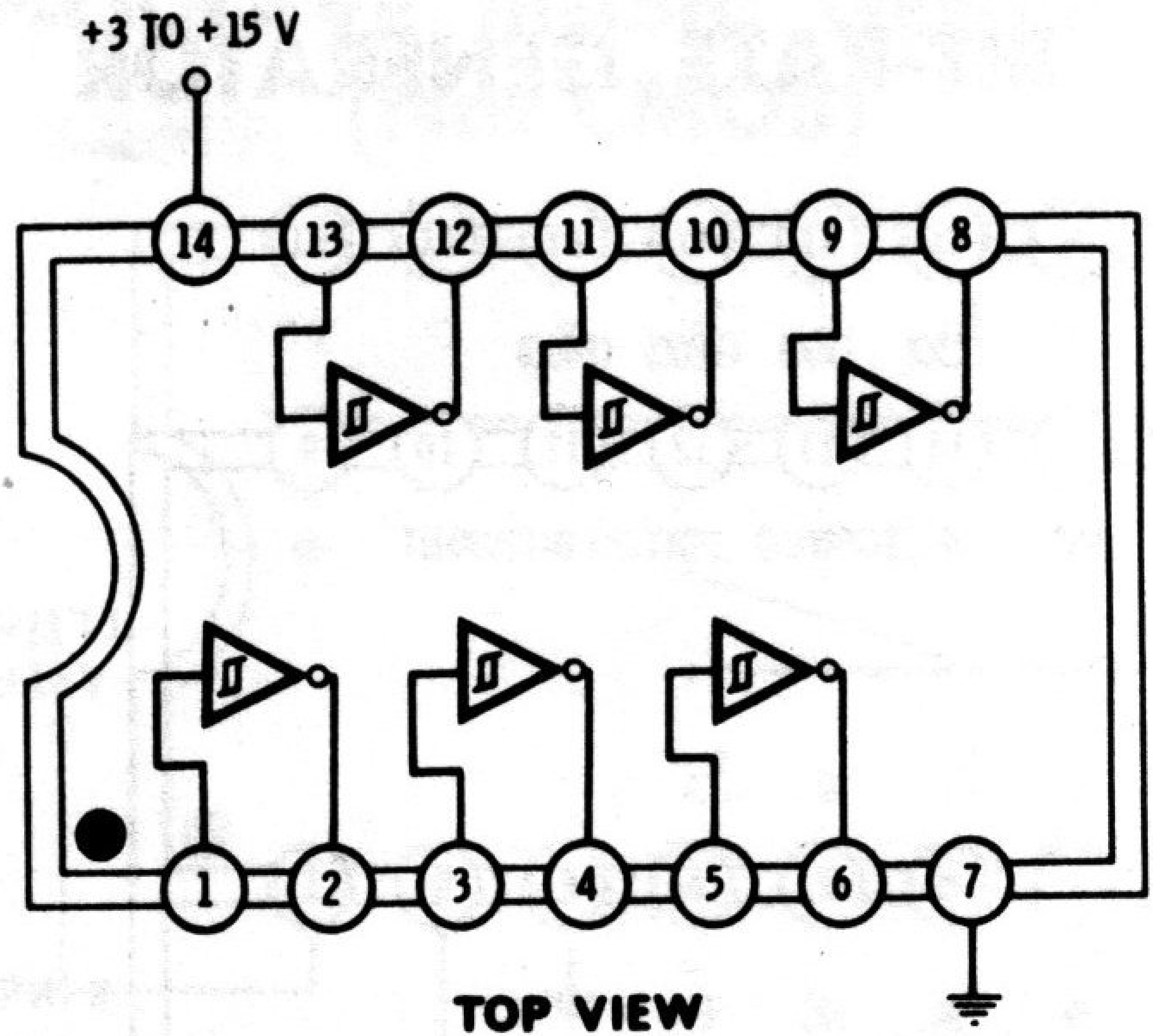


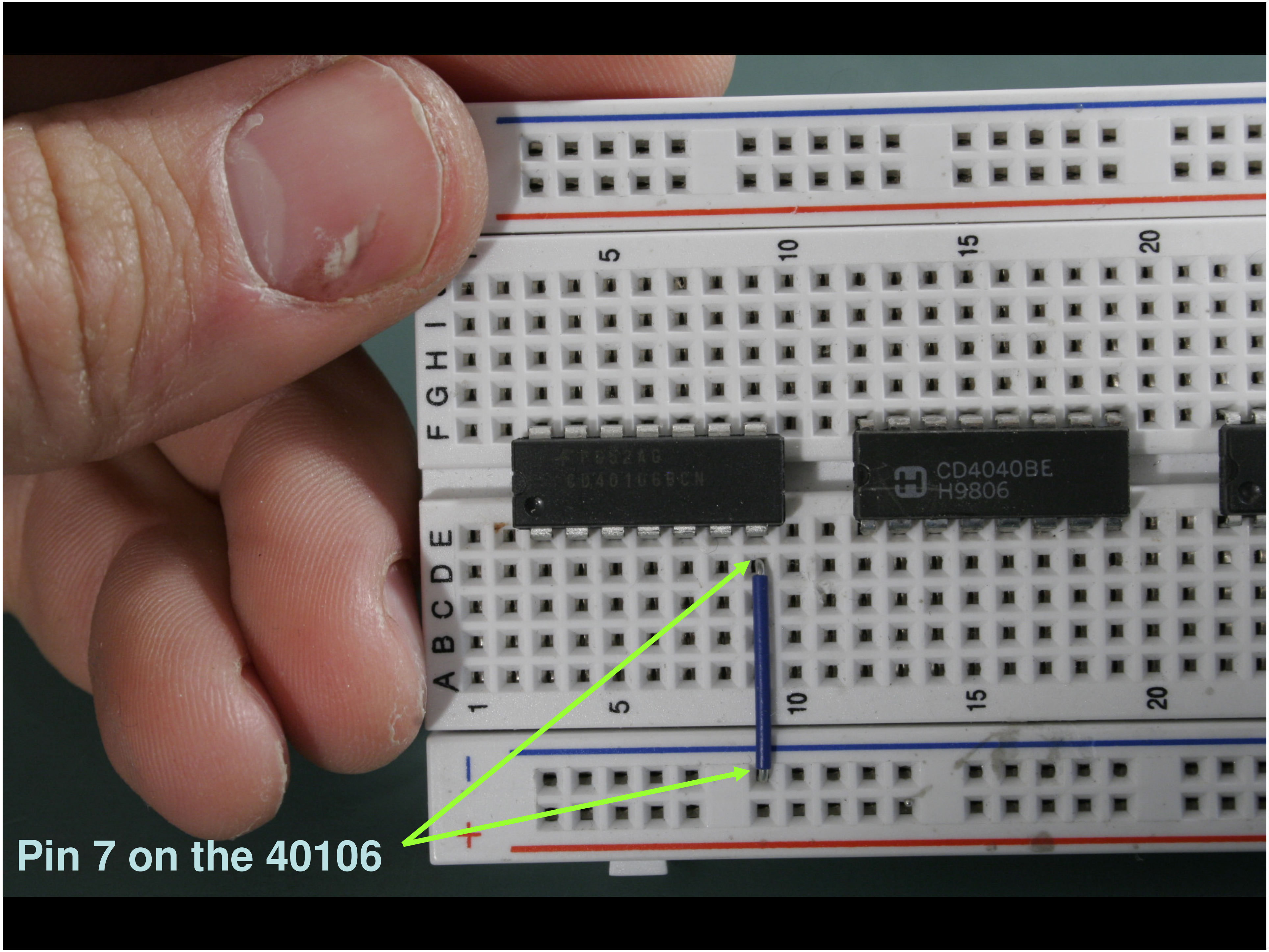
Gather 10 blue (or green) jumpers to make ground connections.

The 40106 Inverting Buffer

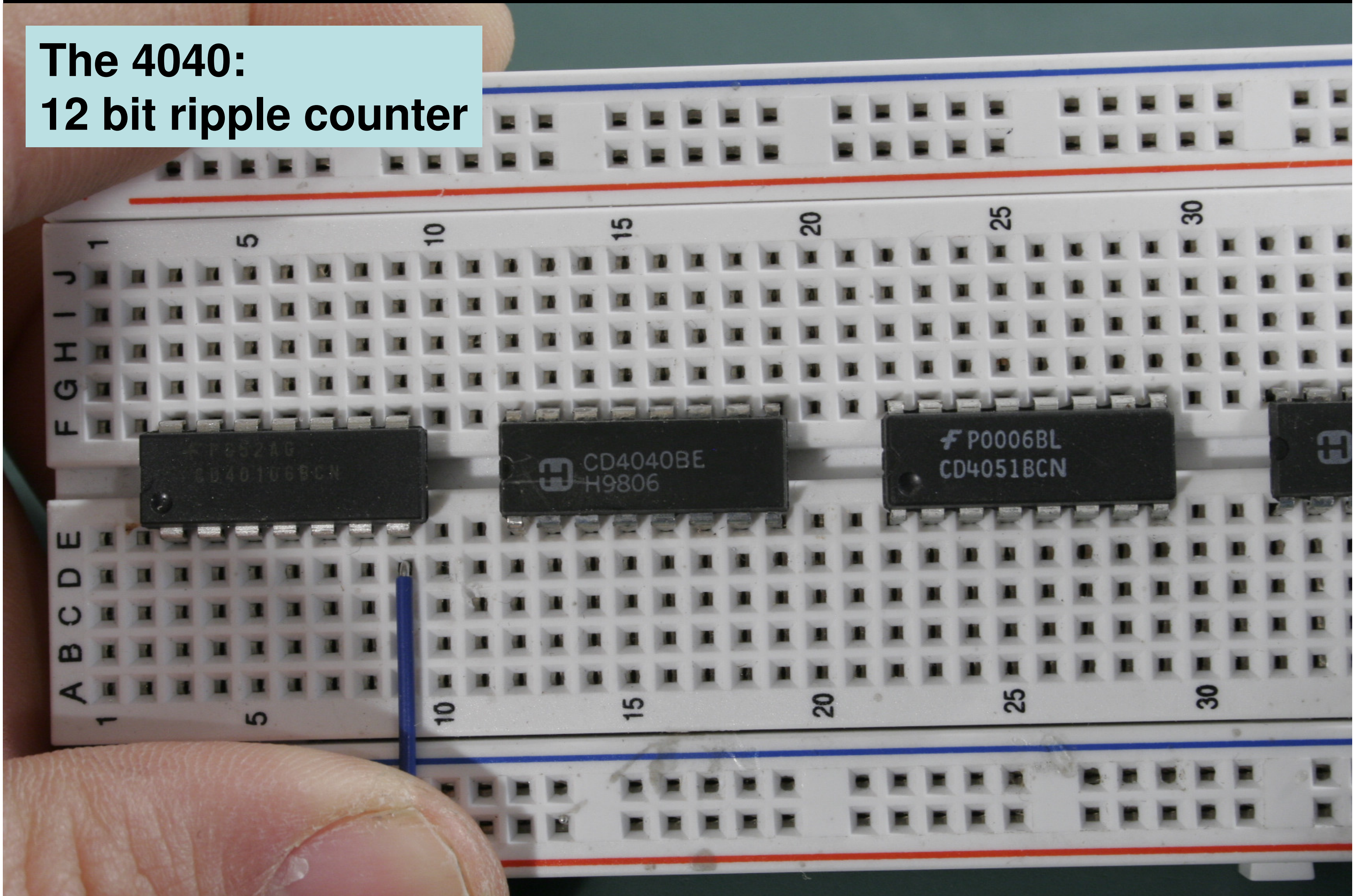


HEX SCHMITT TRIGGER

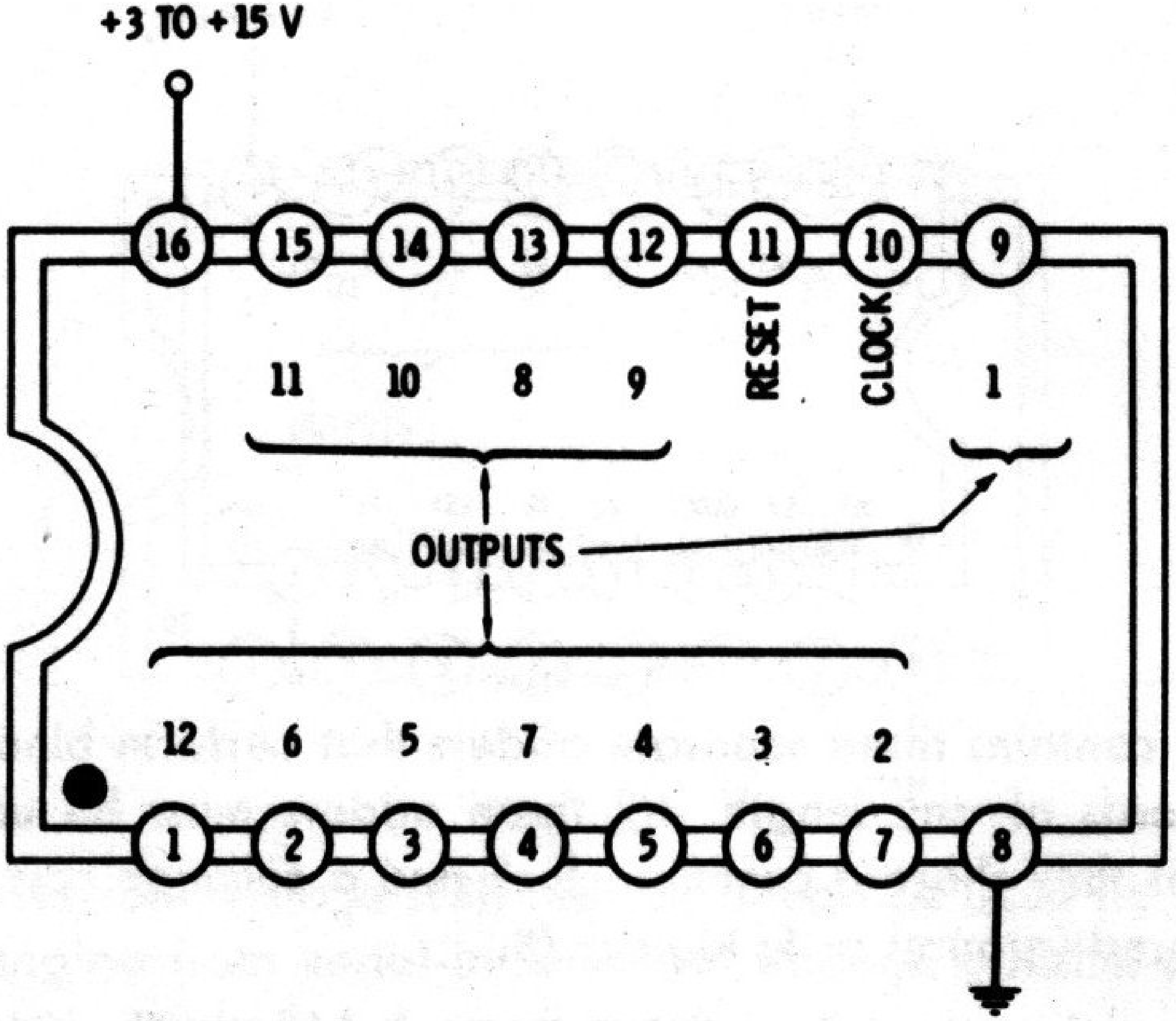



CD4040BE
H9806
Pin 7 on the 40106

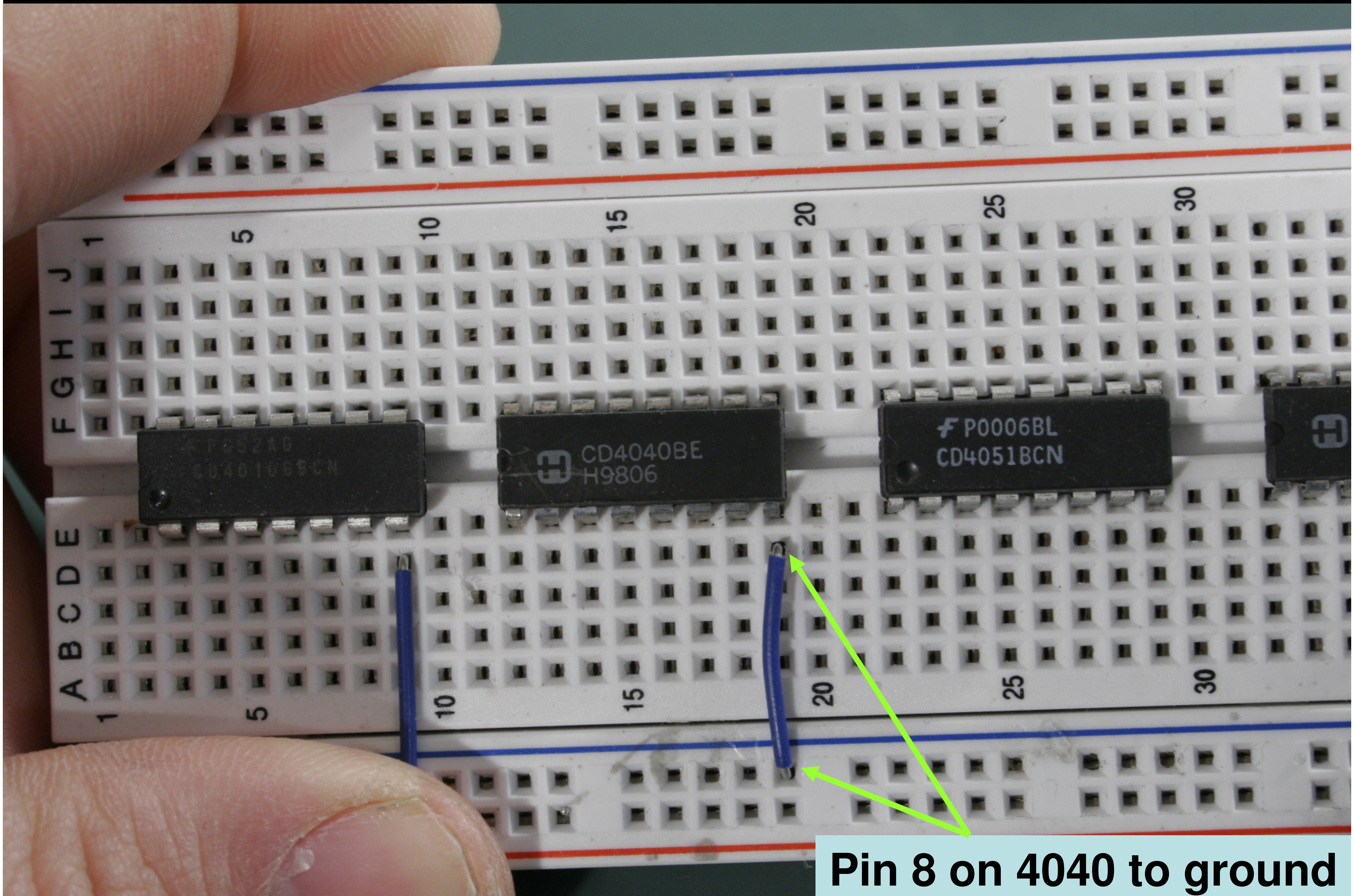
The 4040:
12 bit ripple counter

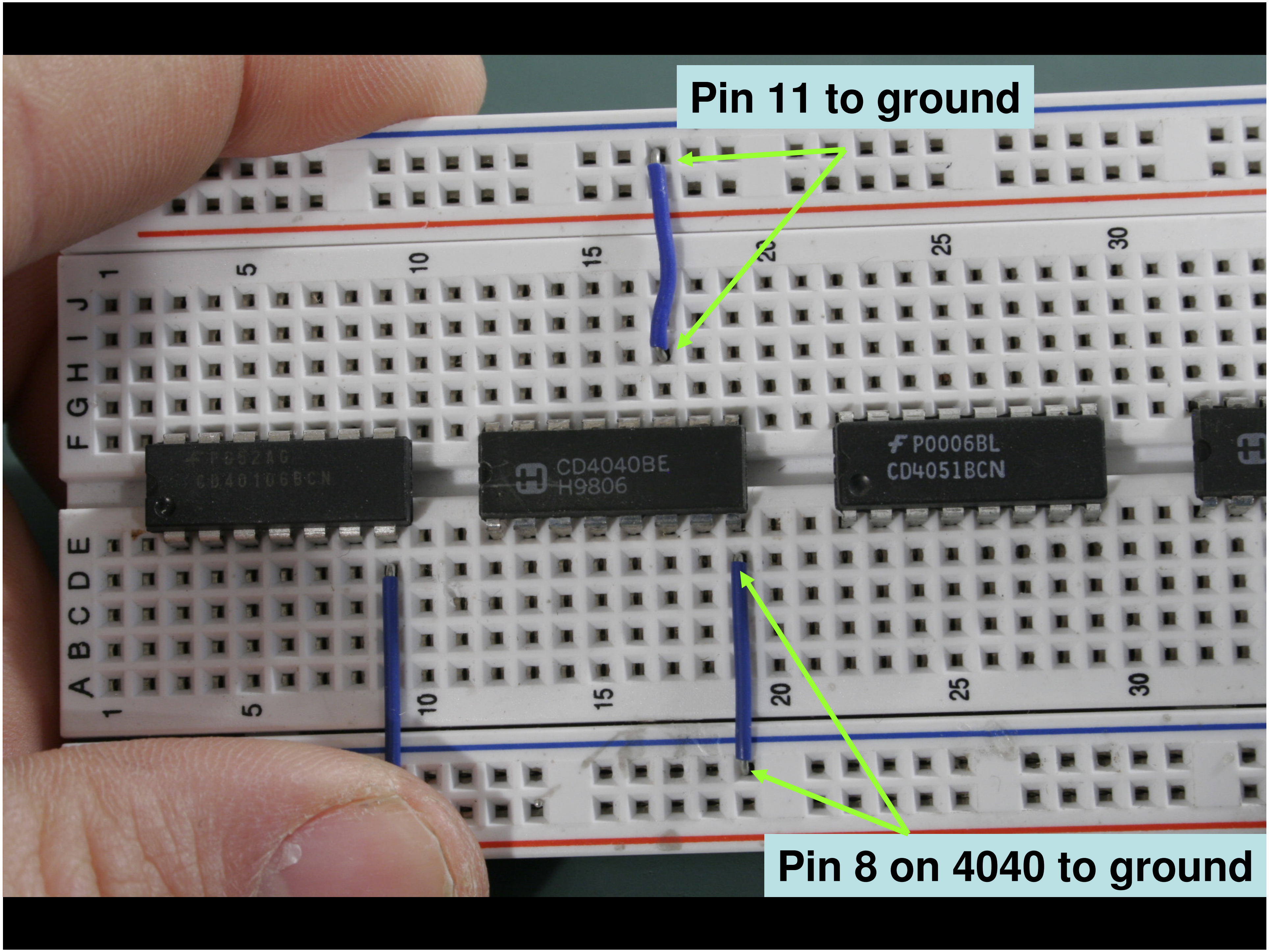


12-STAGE (÷4096) BINARY RIPPLE COUNTER

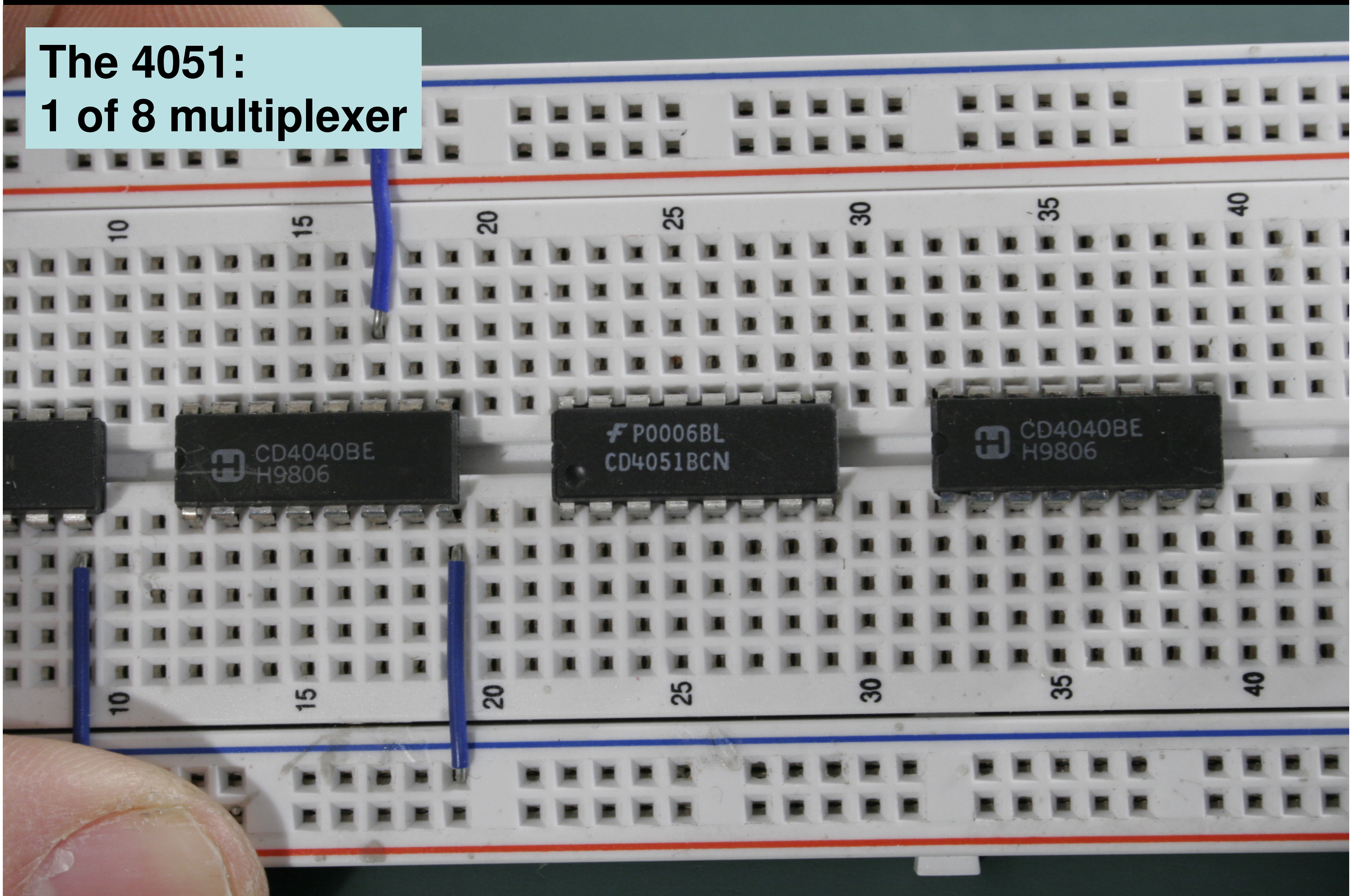


TOP VIEW

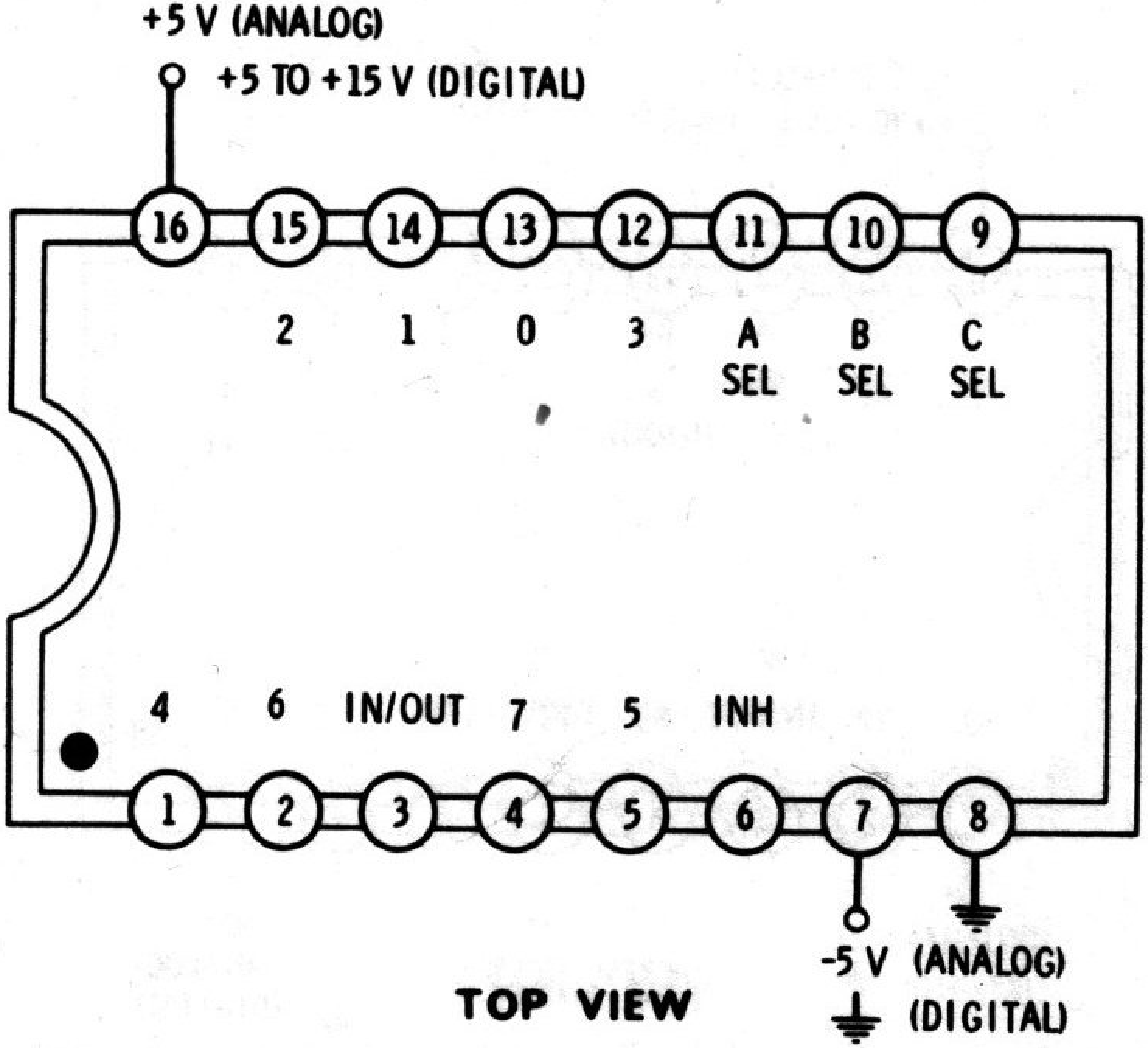

CD4040BE
H9806
P0006BL
CD4051BCN
Pin 8 on 4040 to ground


Pin 11 to ground
CD4040BE
H9806
P0006BL
CD4051BCN
Pin 8 on 4040 to ground

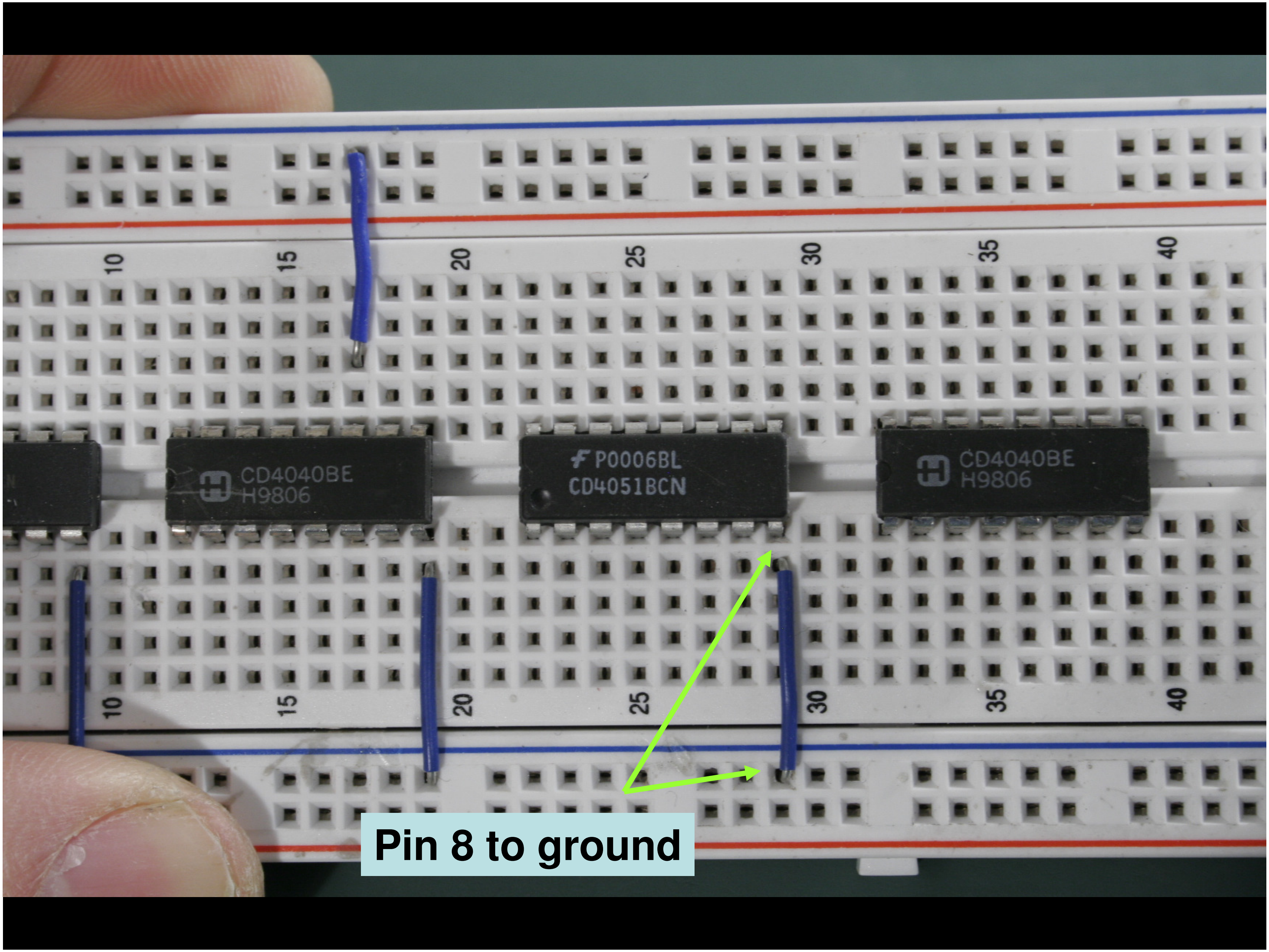
The 4051:
1 of 8 multiplexer



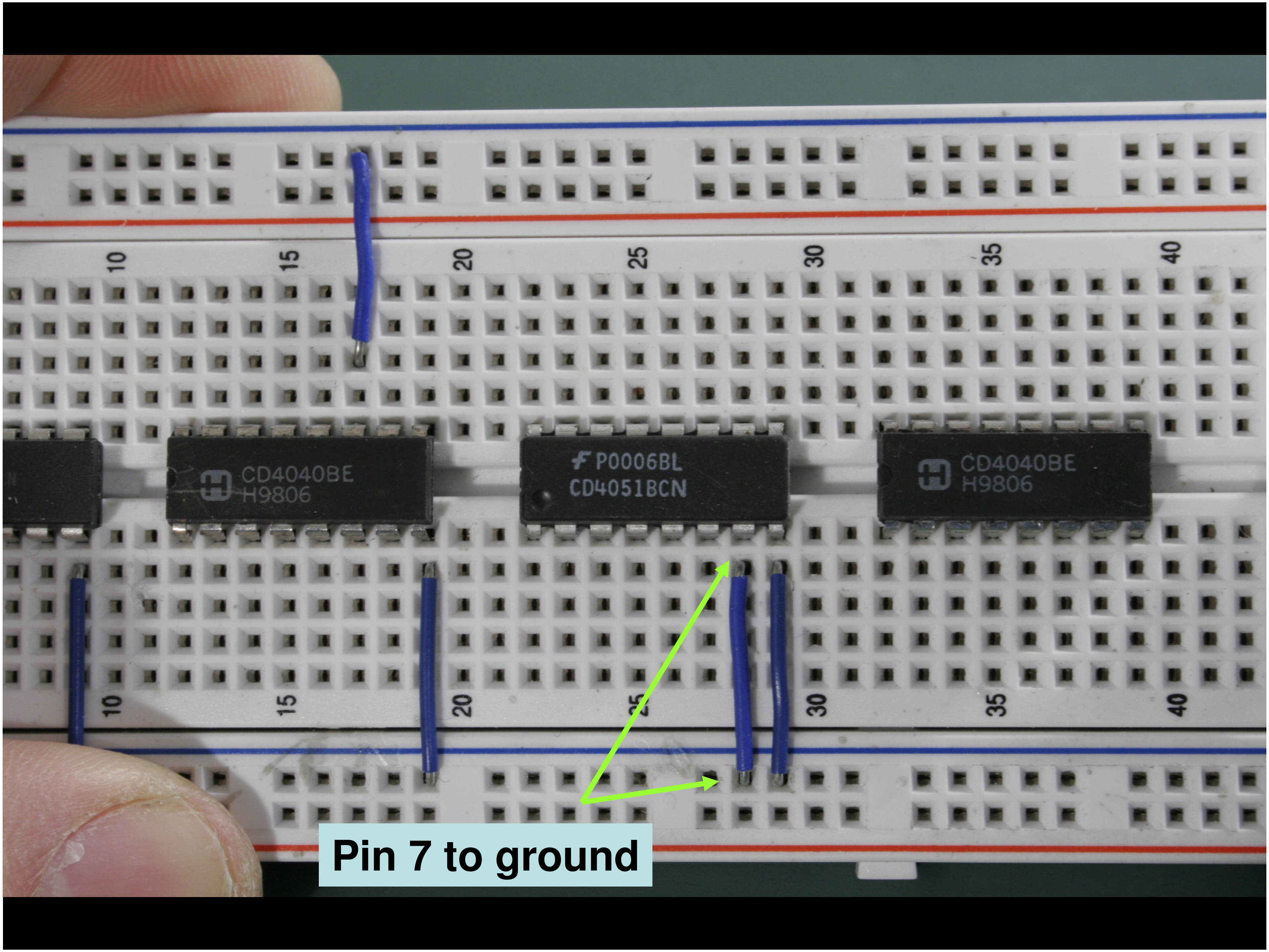
1-OF-8 SWITCH

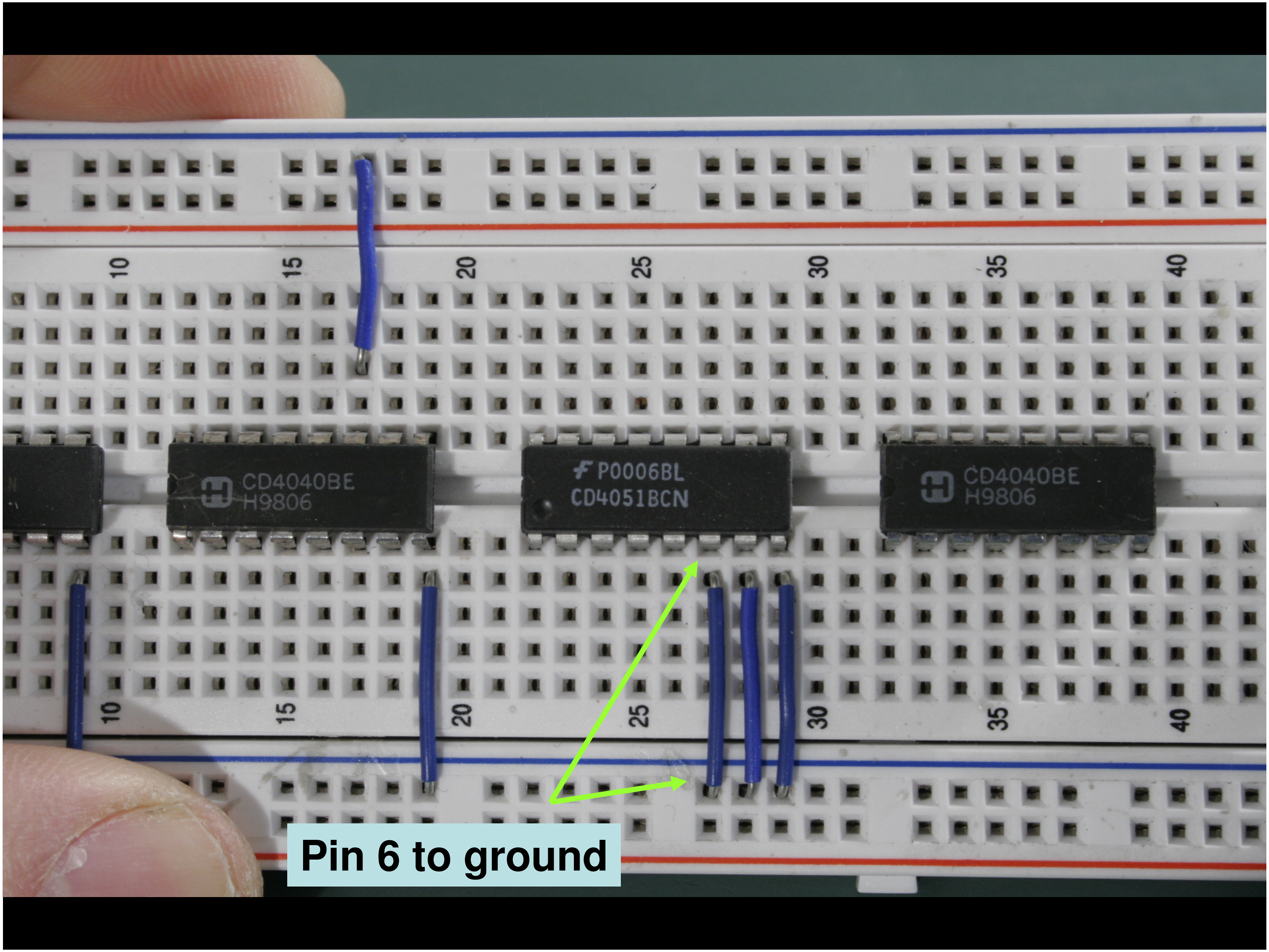


TOP VIEW



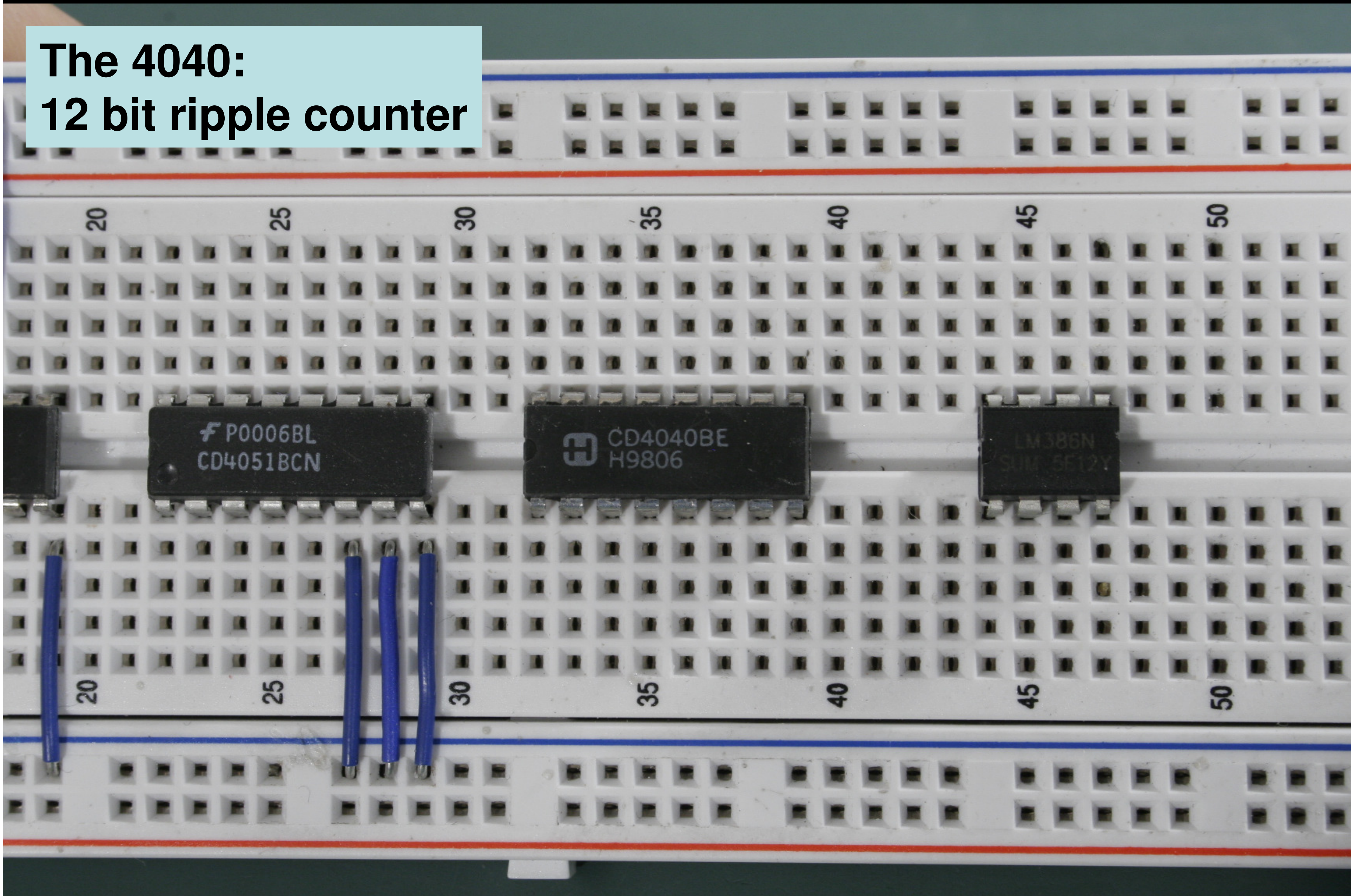
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
Pin 8 to ground

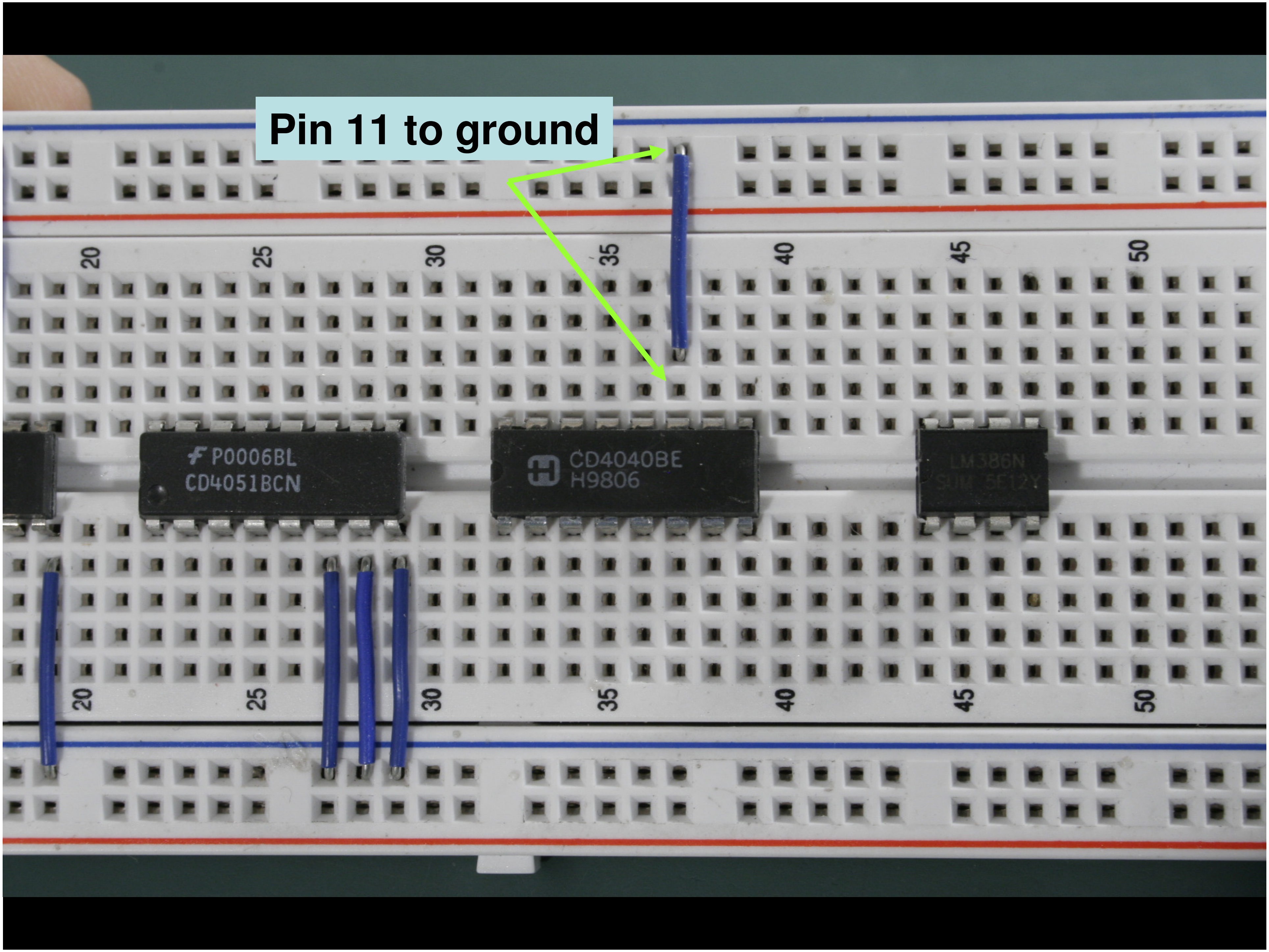

CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
Pin 7 to ground

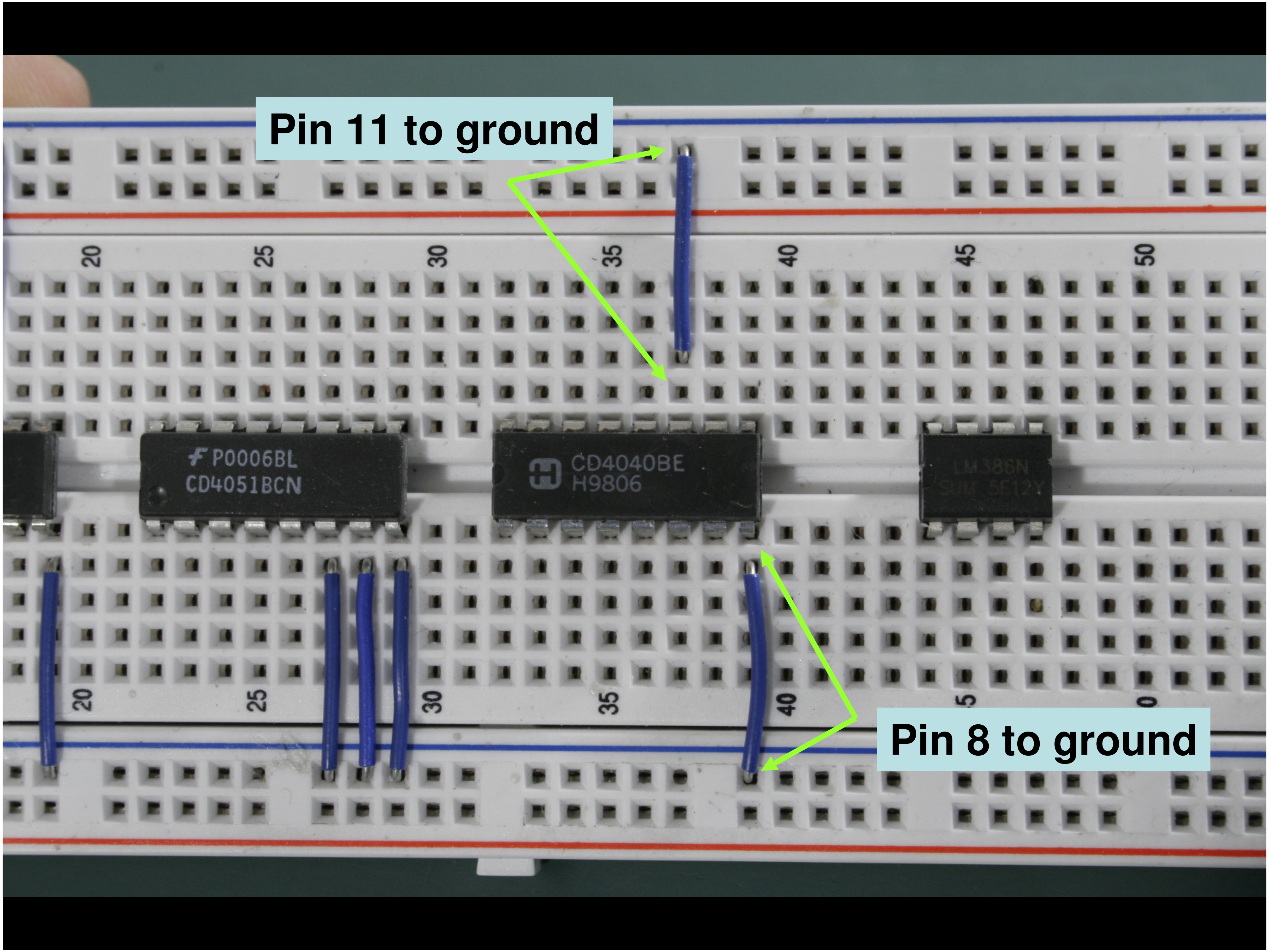


10
15
20
25
30
35
40
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
10
15
20
25
30
35
40
Pin 6 to ground

The 4040:
12 bit ripple counter

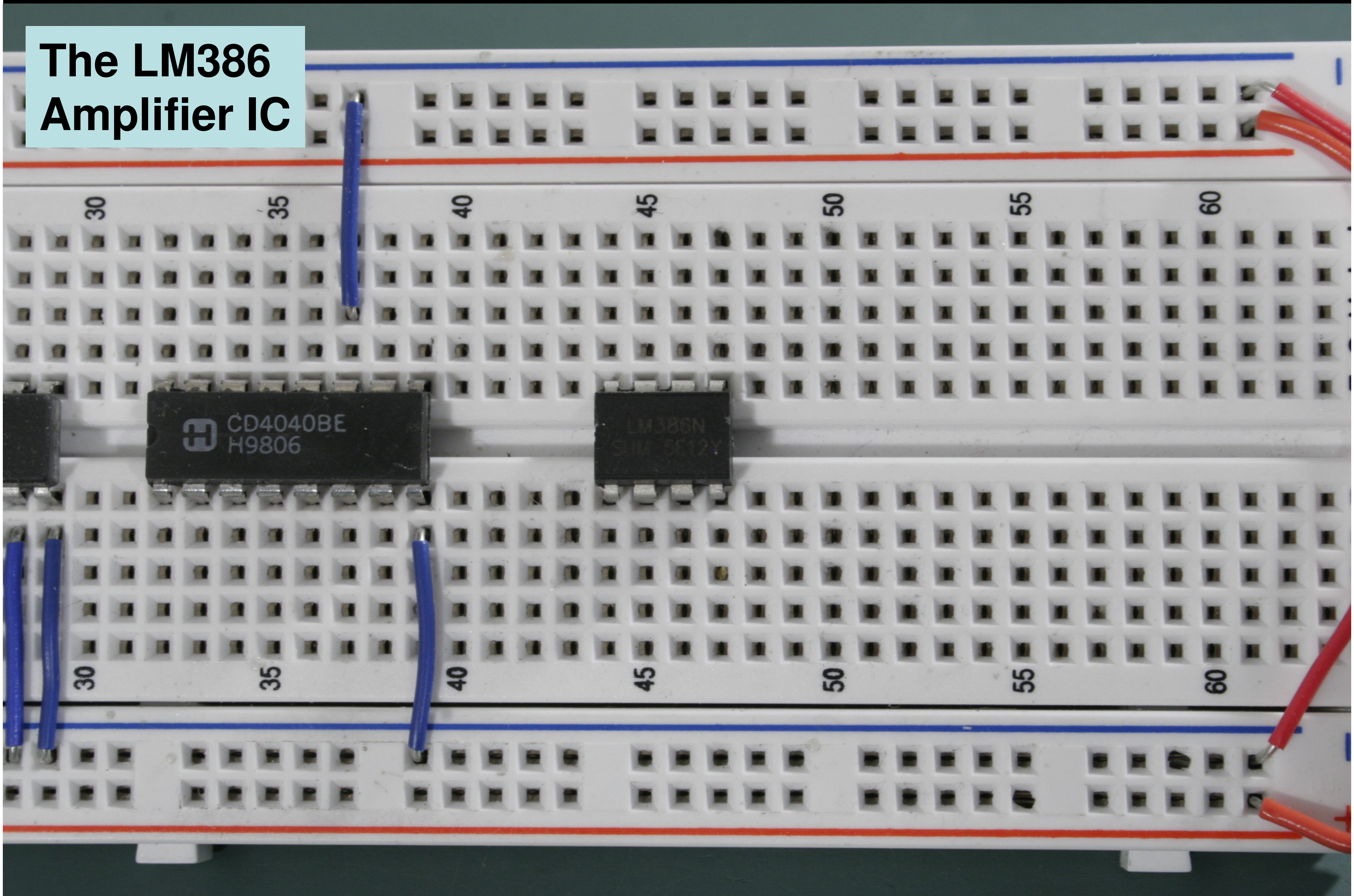



Pin 11 to ground
P0006BL
CD4051BCN
CD4040BE
H9806

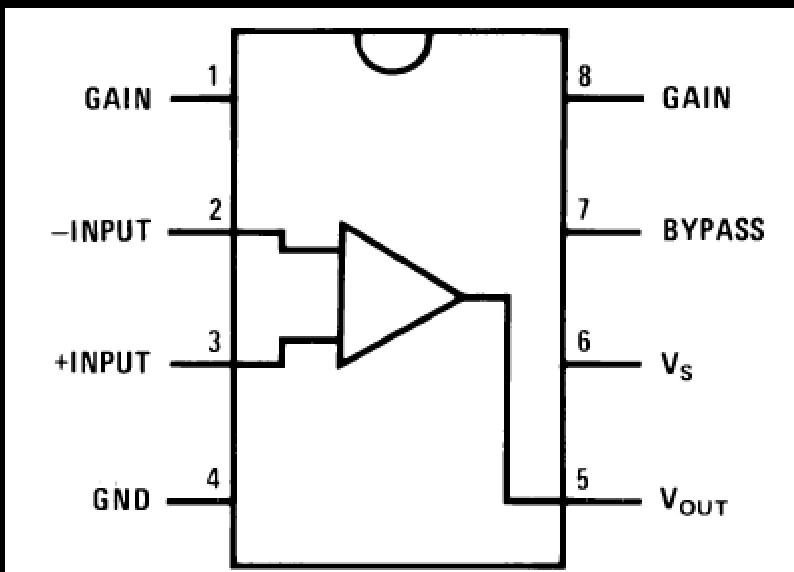


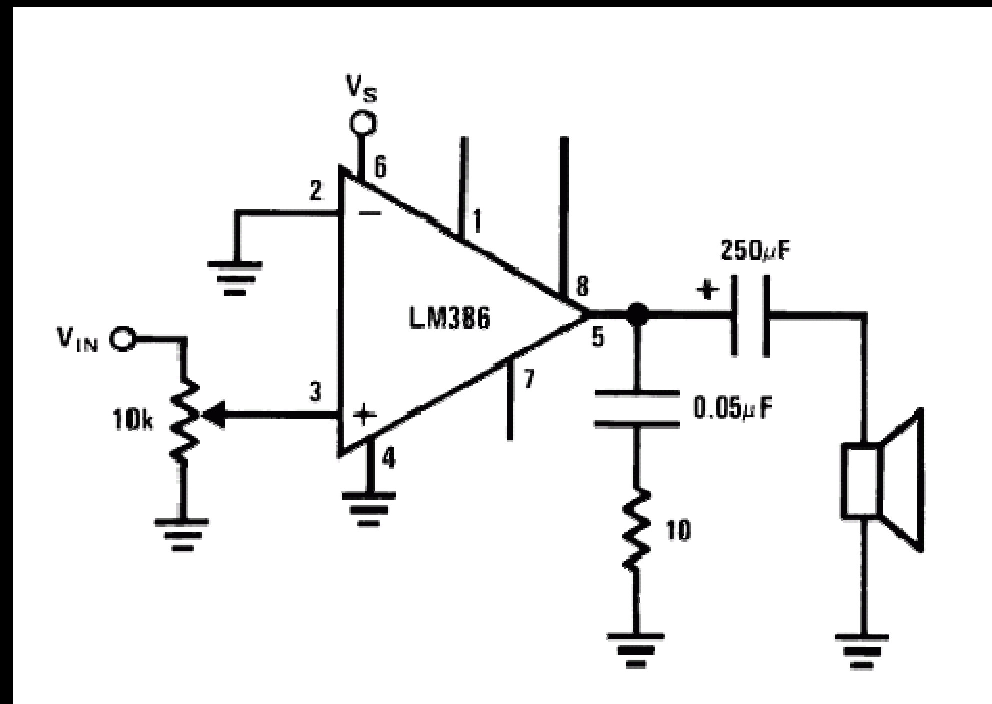
Pin 11 to ground
Pin 8 to ground
P0006BL
CD4051BCN
CD4040BE
H9806

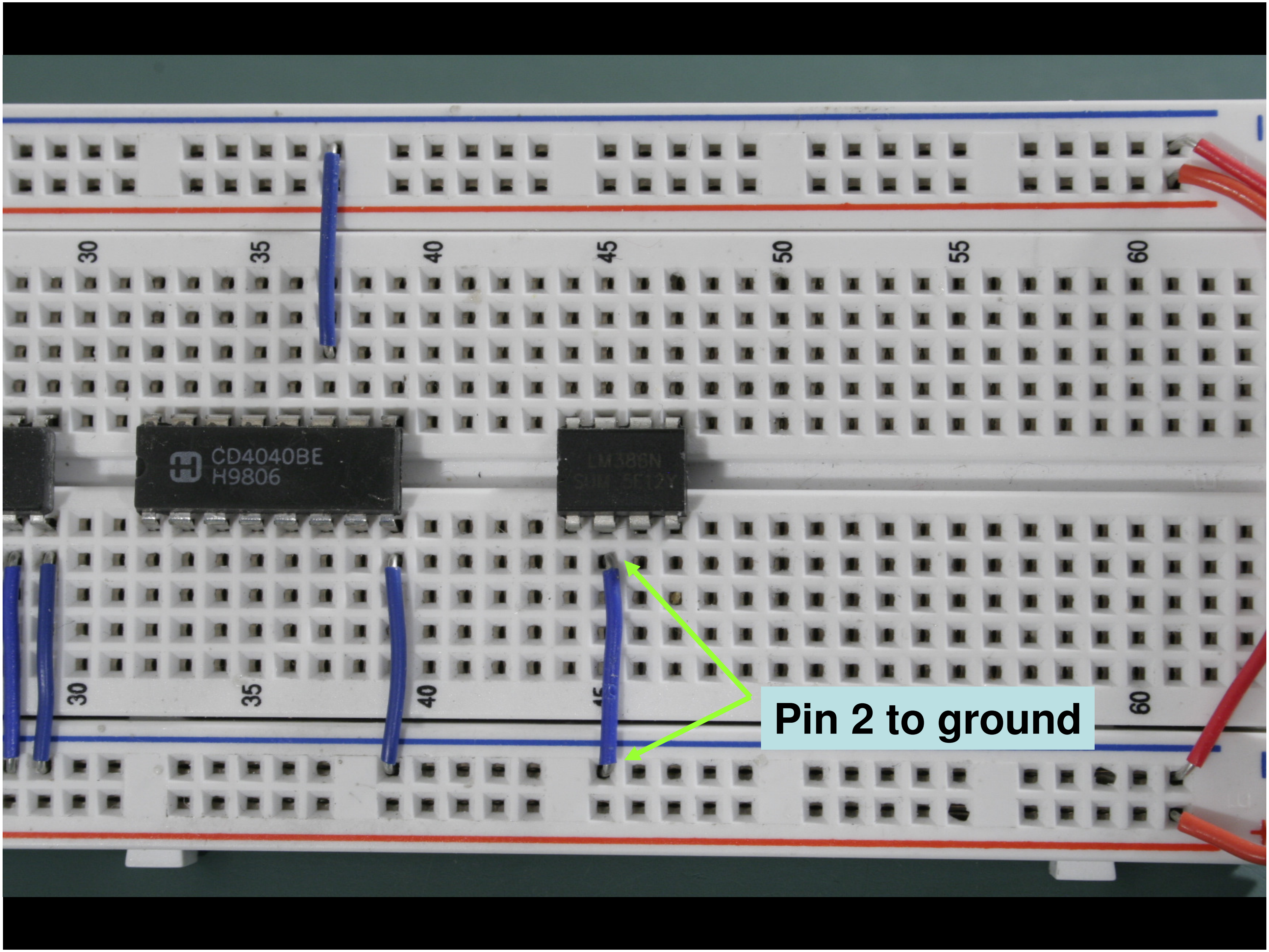
The LM386 Amplifier IC

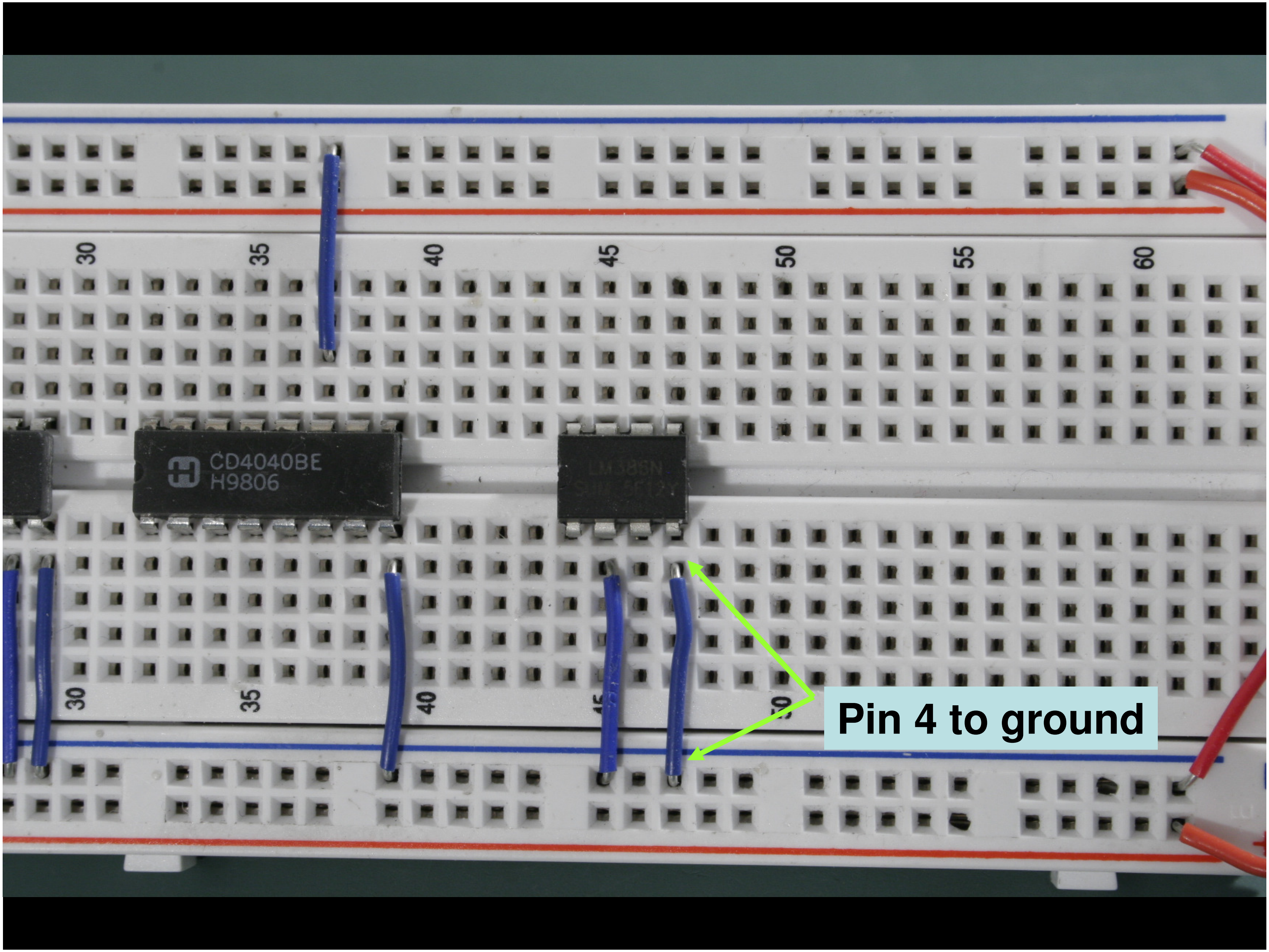


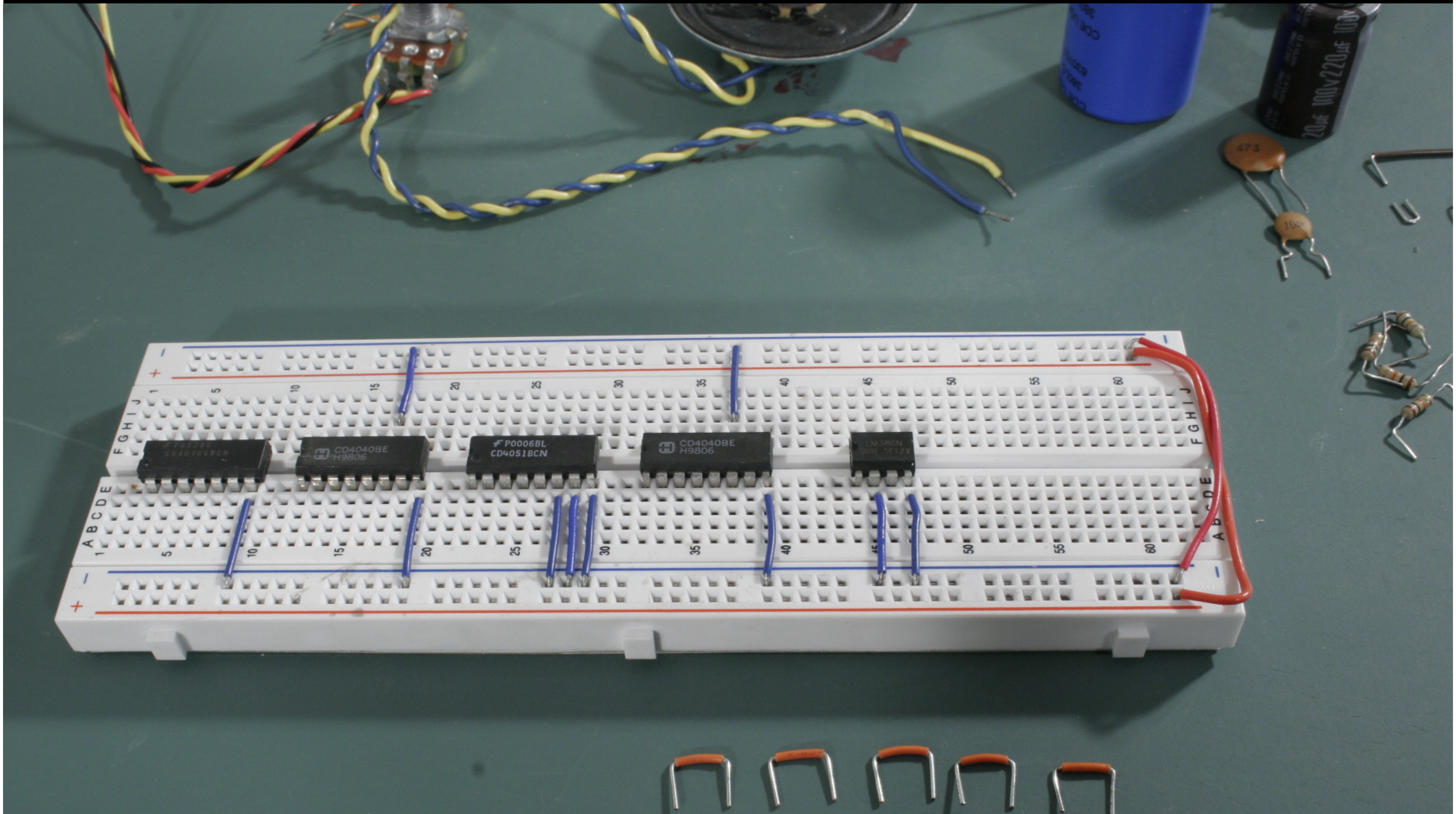
LM 386
Audio Amplifier



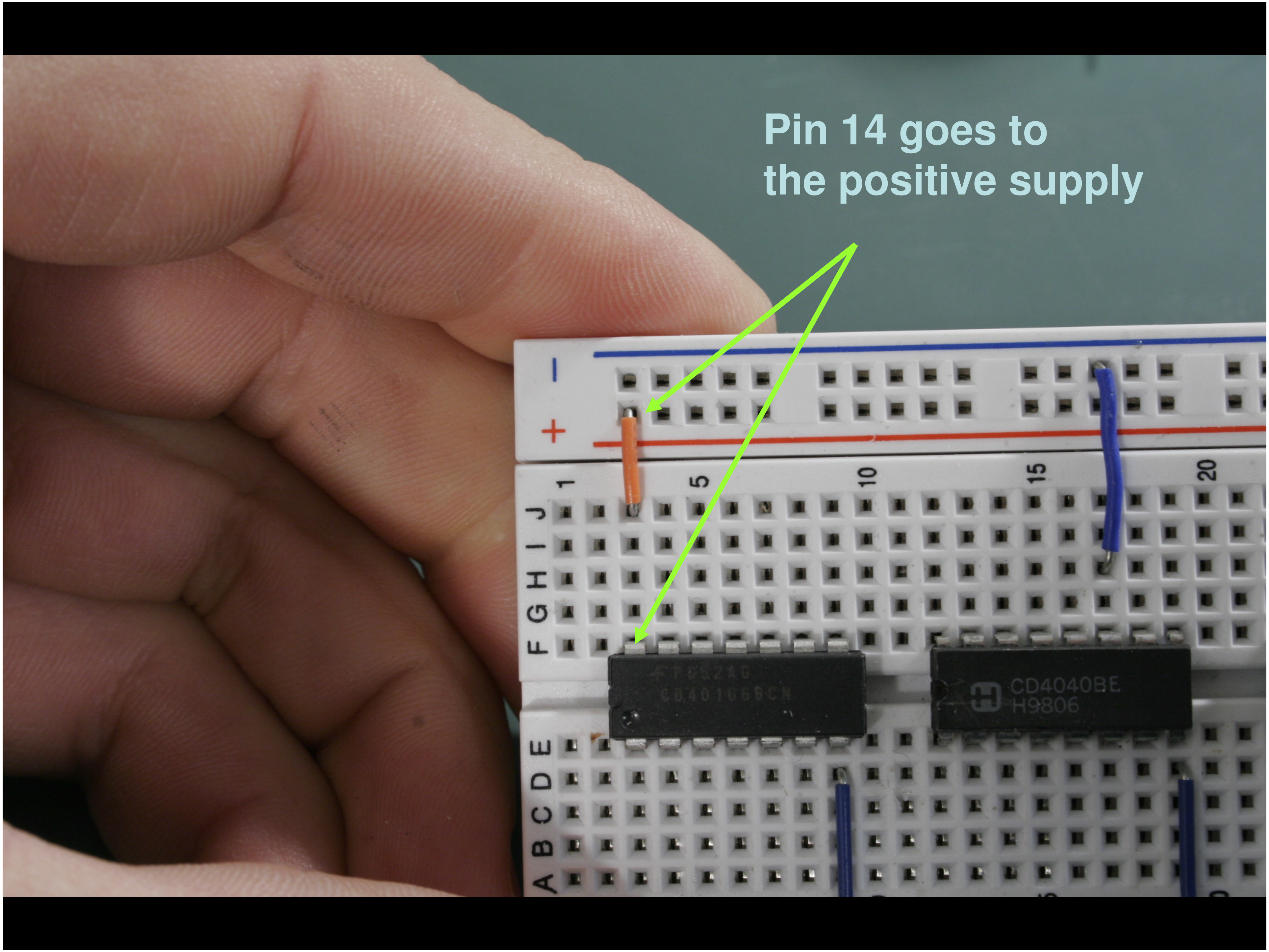


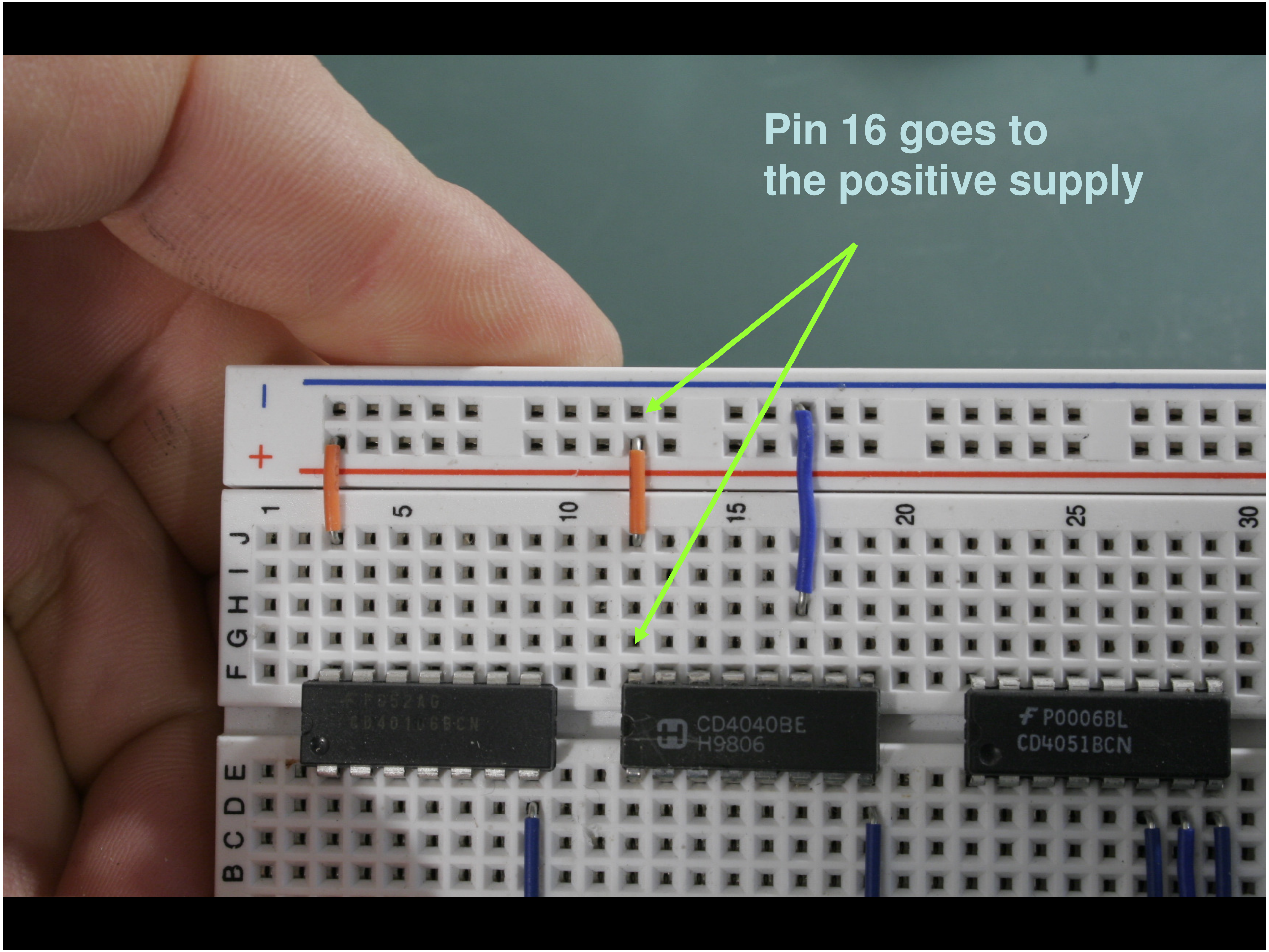

CD4040BE
H9806
Pin 2 to ground

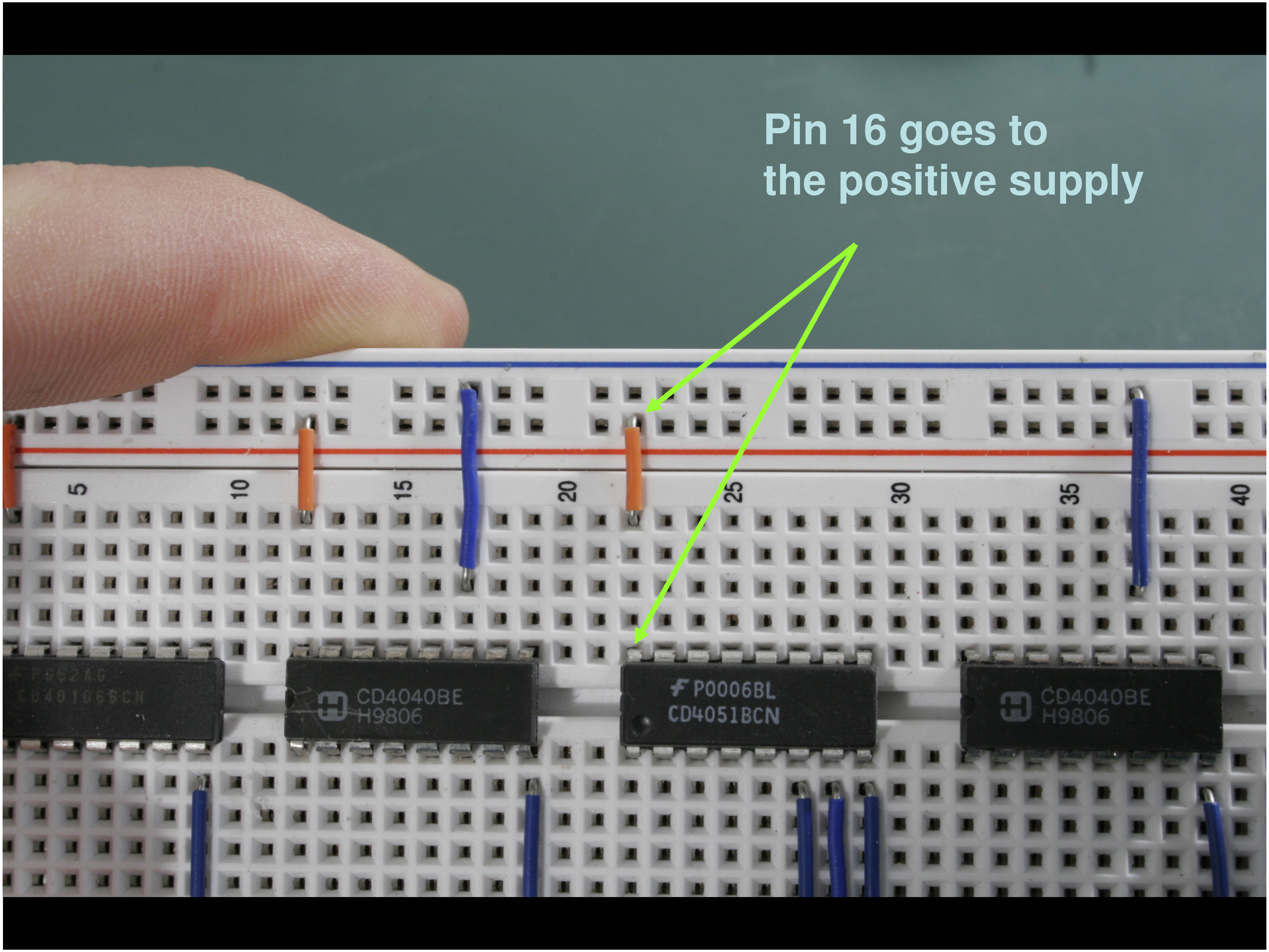

Pin 4 to ground
CD4040BE
H9806



Get 5 orange jumpers
to connect the chips to the positive voltage rail.


Pin 14 goes to
the positive supply
CD4040BE
H9806


Pin 16 goes to
the positive supply
CD4040BE
H9806
P0006BL
CD4051BCN


Pin 16 goes to
the positive supply
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
5
10
15
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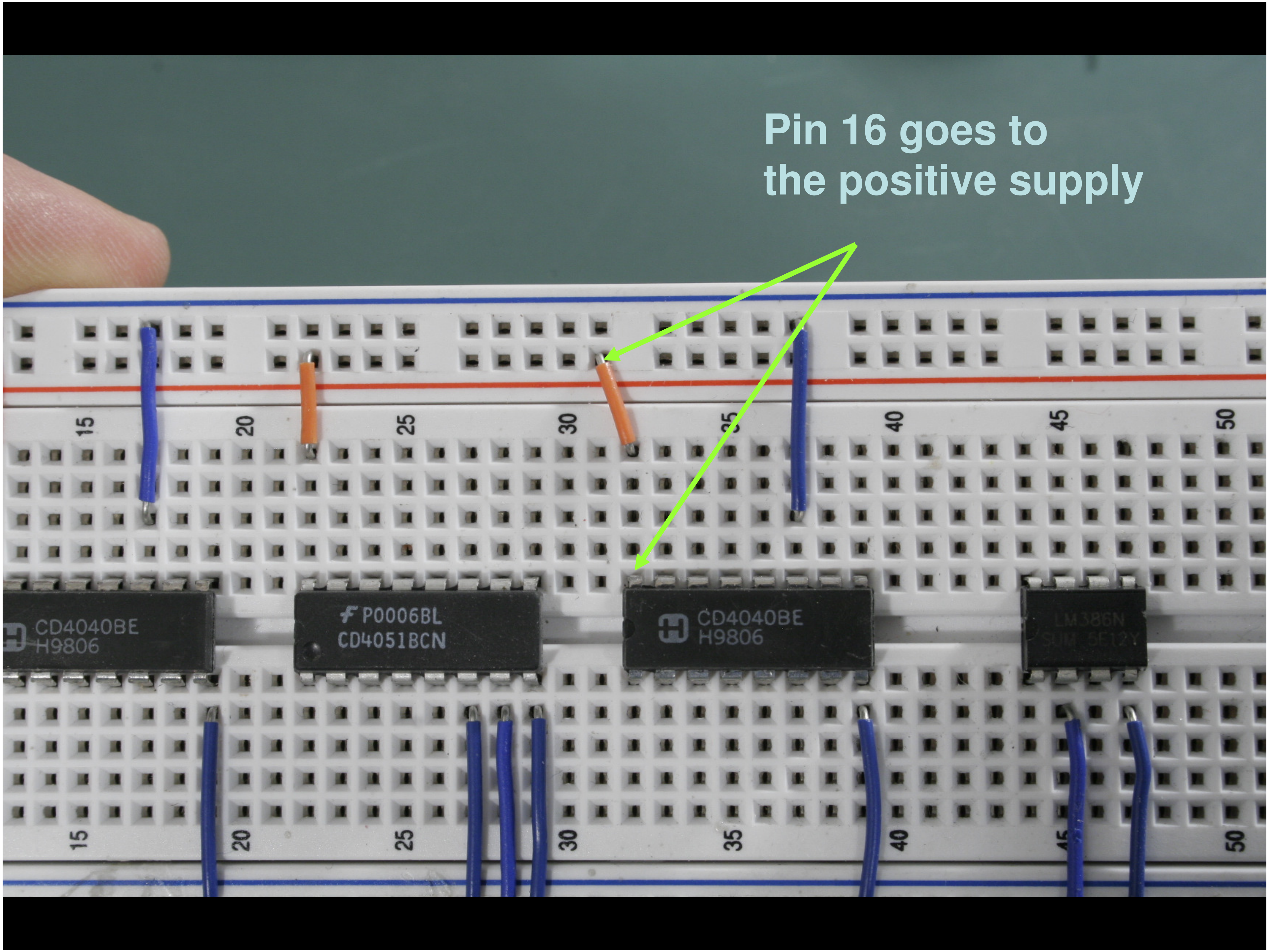
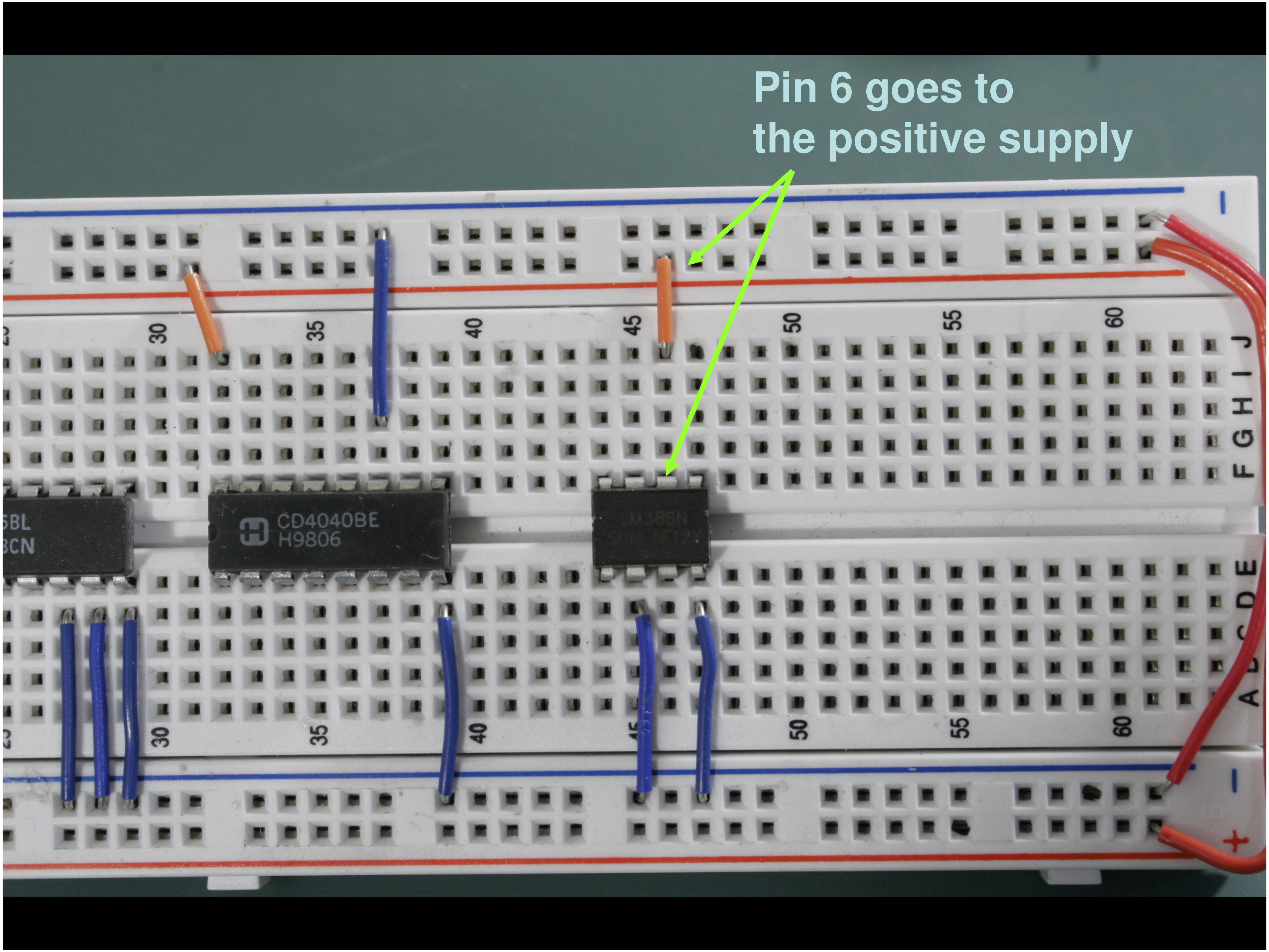
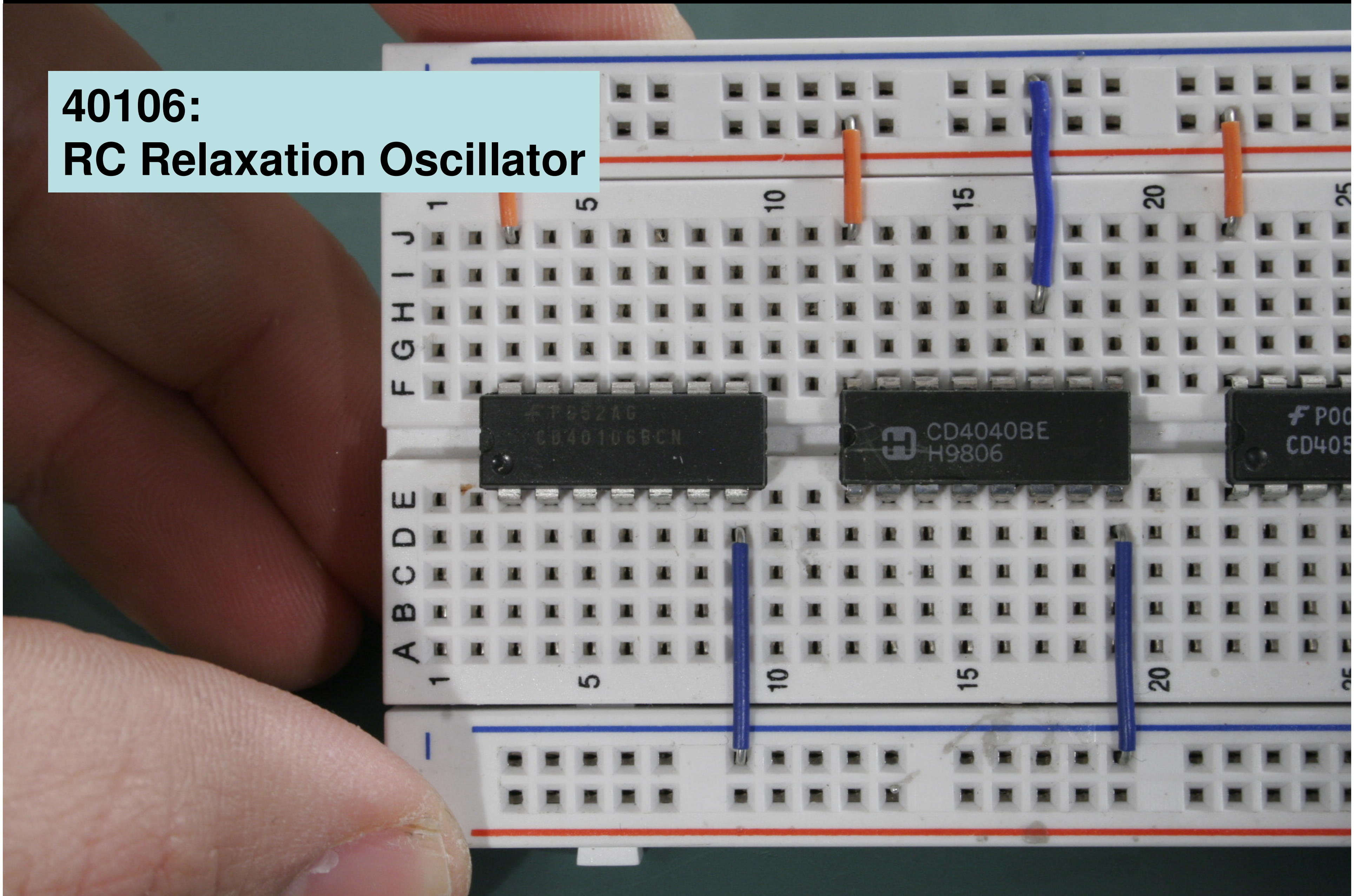
40

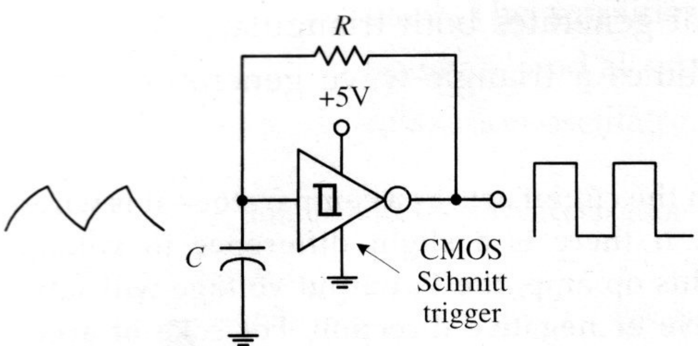

Pin 16 goes to
the positive supply
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806


Pin 6 goes to
the positive supply
CD4040BE
H9806

40106:
RC Relaxation Oscillator



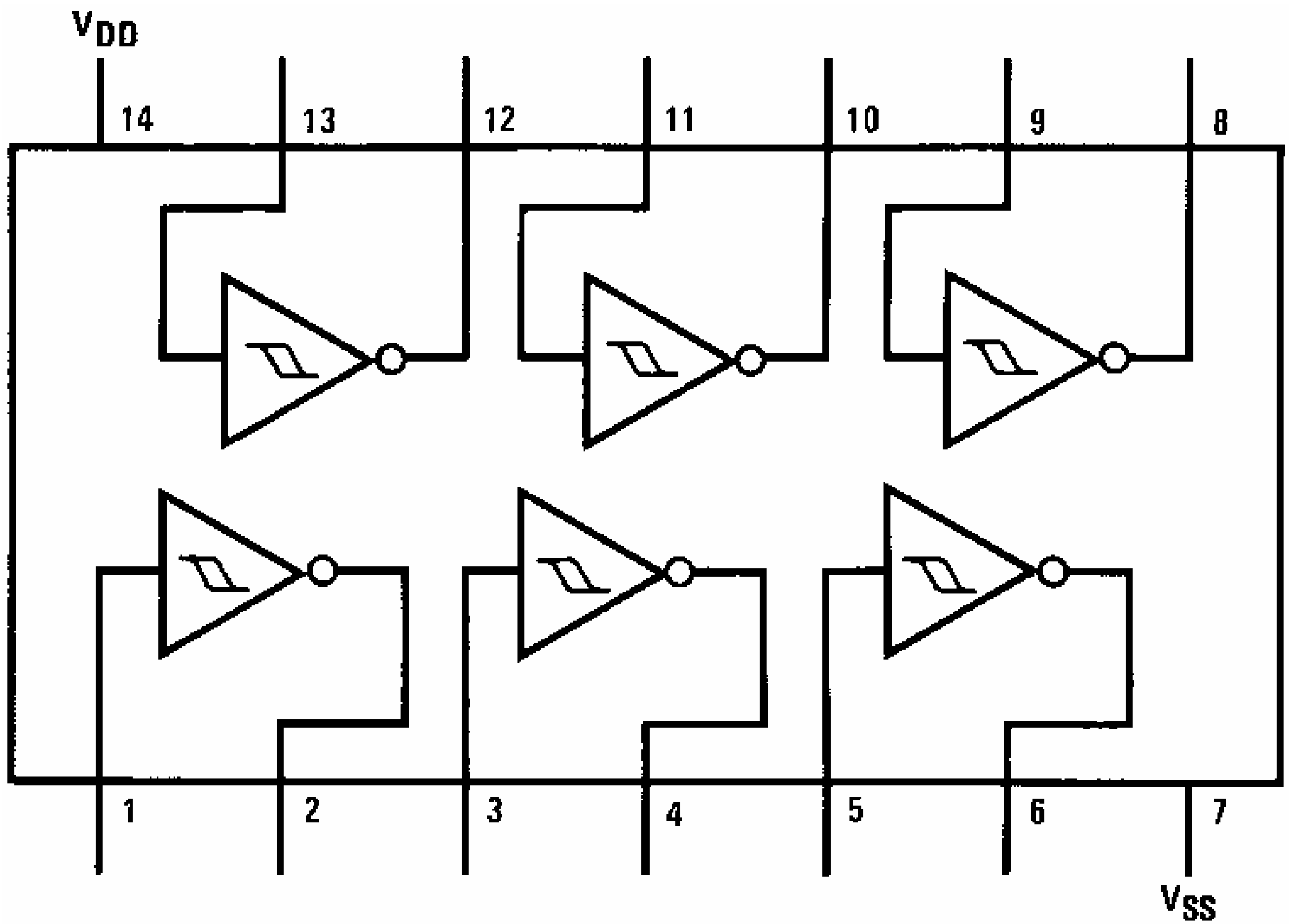
Digital oscillator
(using a Schmitt trigger inverter)



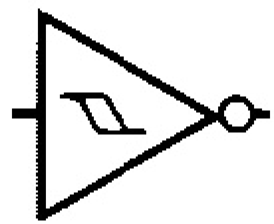
Digital oscillator (using inverters)

Here a simple relaxation oscillator is built from a Schmitt trigger inverter IC and an *RC* network. (Schmitt triggers are used to transform slowly changing input waveforms into sharply defined, jitter-free output waveforms (see Chap. 12). When power is first applied to the circuit, the voltage across *C* is zero, and the output of the inverter is high (+5 V). The capacitor starts charging up toward the output voltage via *R*. When the capacitor voltage reaches the positive-going threshold of the inverter (e.g., 1.7 V), the output of the inverter goes low (~0 V). With the output low, *C* discharges toward 0V. When the capacitor voltage drops below the negative-going threshold voltage of the inverter (e.g., 0.9V), the output of the inverter goes high. The cycle repeats. The on/off times are determined by the positive- and negative-going threshold voltages and the *RC* time constant.

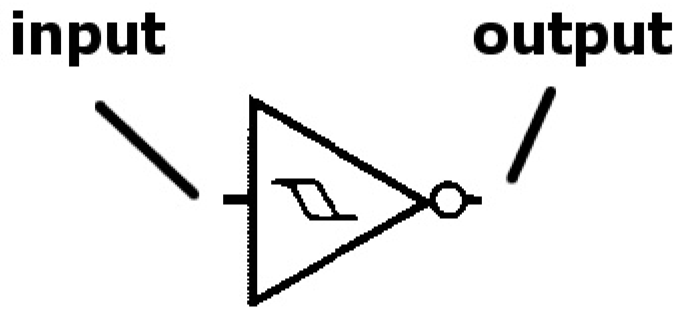
How does it work?



One of Six digital logic gates:
Inverter



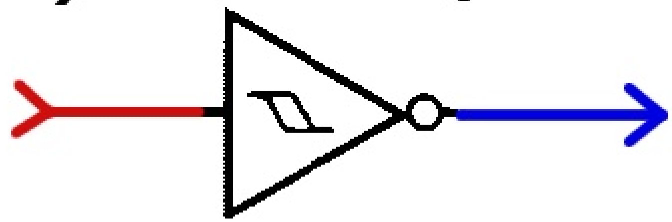
In digital circuits, positive logic interprets a positive voltage as logical 1, on or "yes". Zero volts or ground is interpreted as logical 0, off or "no."



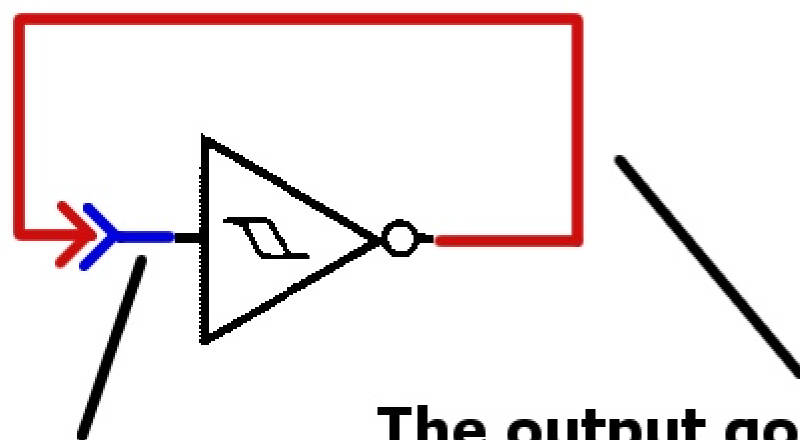
This inverter returns the logical inverse, or opposite, of the signal presented at its output.

Input +V: Logical 1
(typically 5 volts)

Output GND: Logical 0
(zero volts)



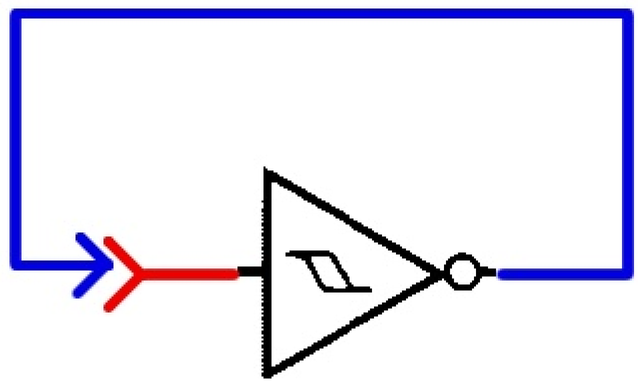
What happens when we connect the input to the output?



the input starts off as floating, or at ground

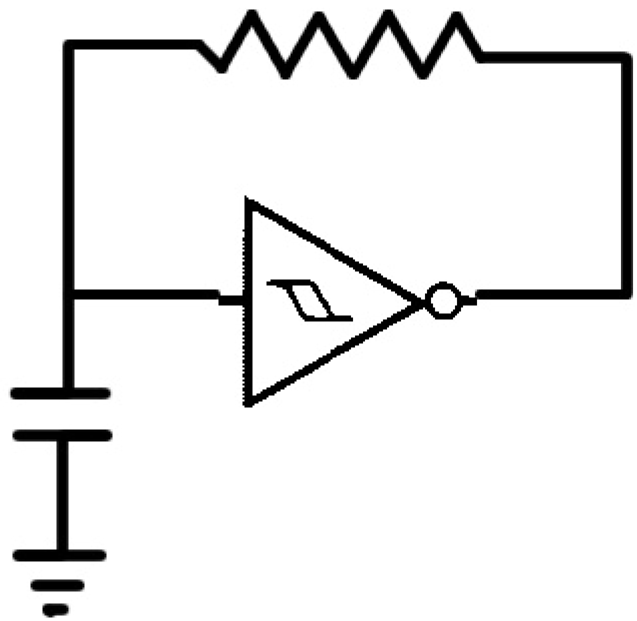
The output goes positive, then becomes the input.

What happens when we connect the input to the output?

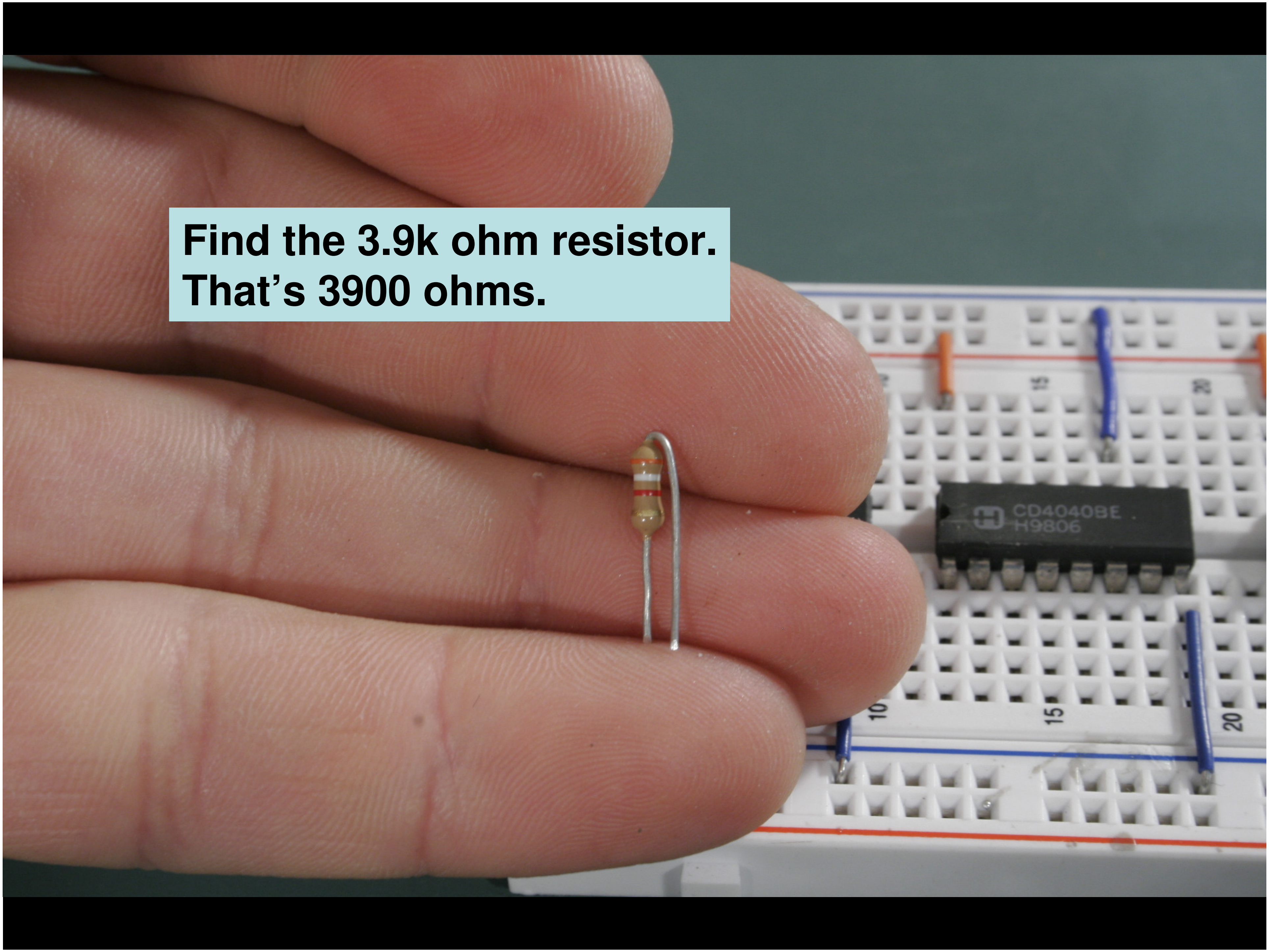


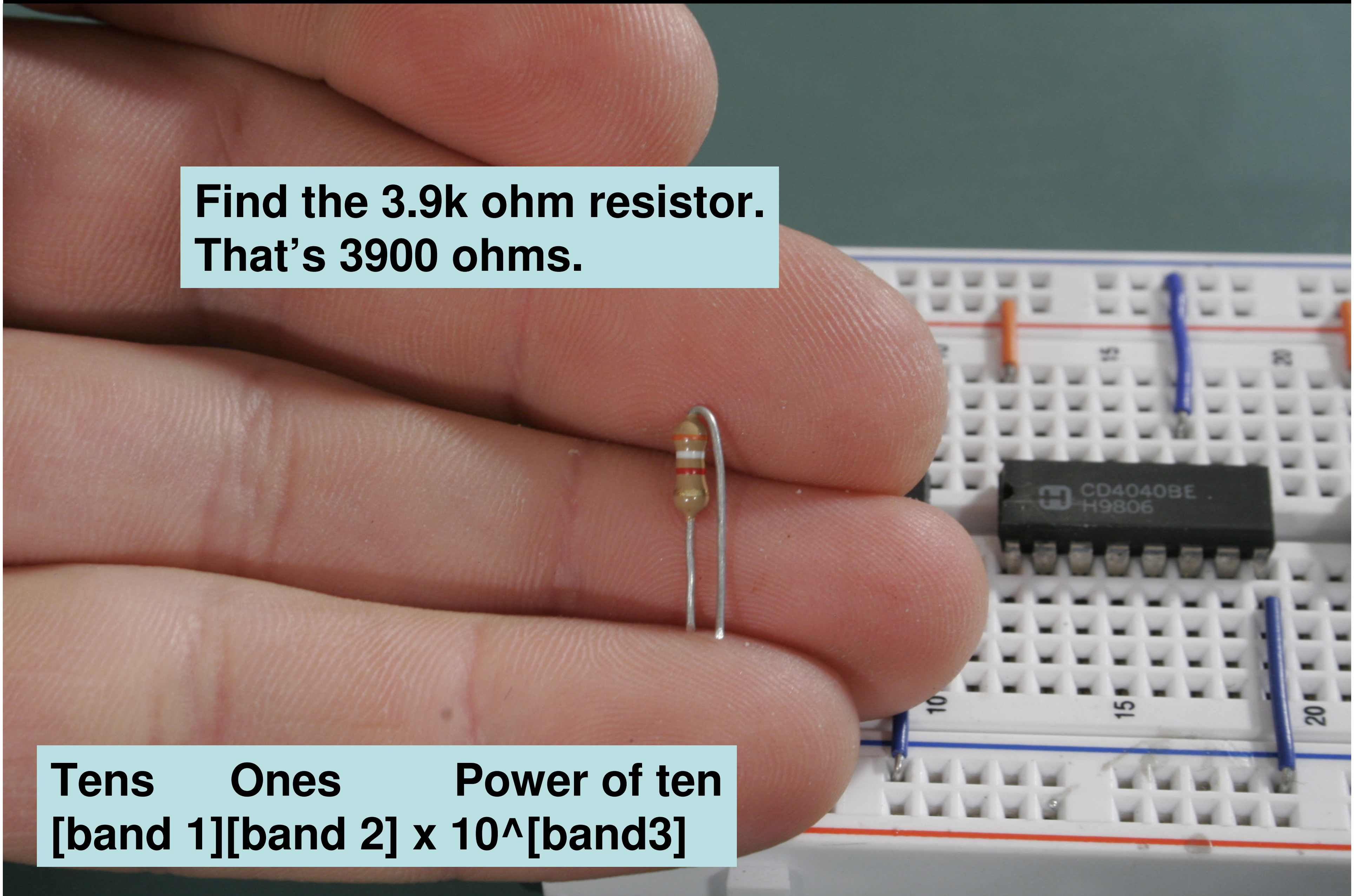
The postitive signal forces the output to ground, which becomes the input, thus forcing the output positive... and so on....

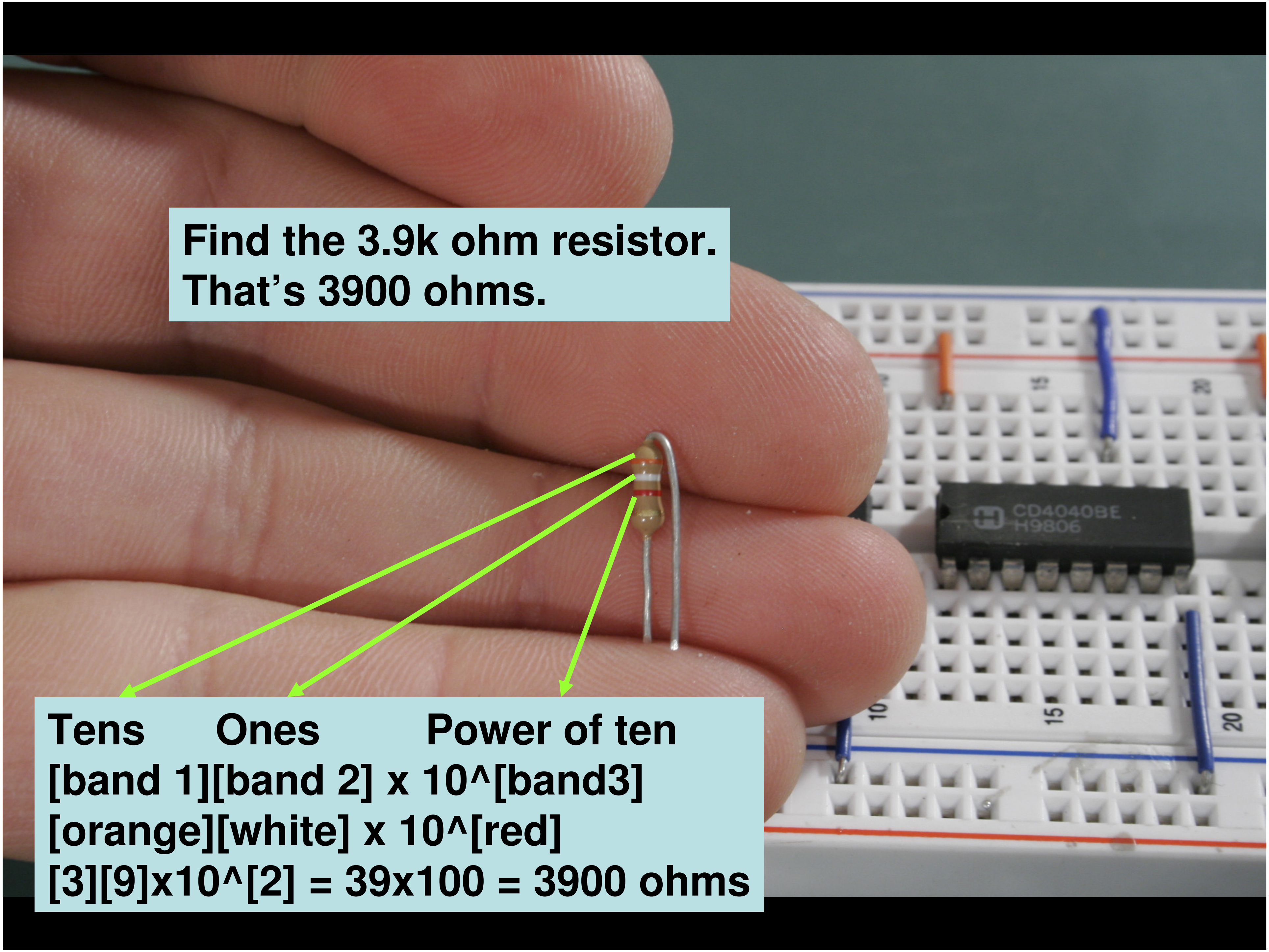
By inserting a resistor into the feedback loop and by connecting a capacitor between the input and ground, we can control the rate of the oscillations.

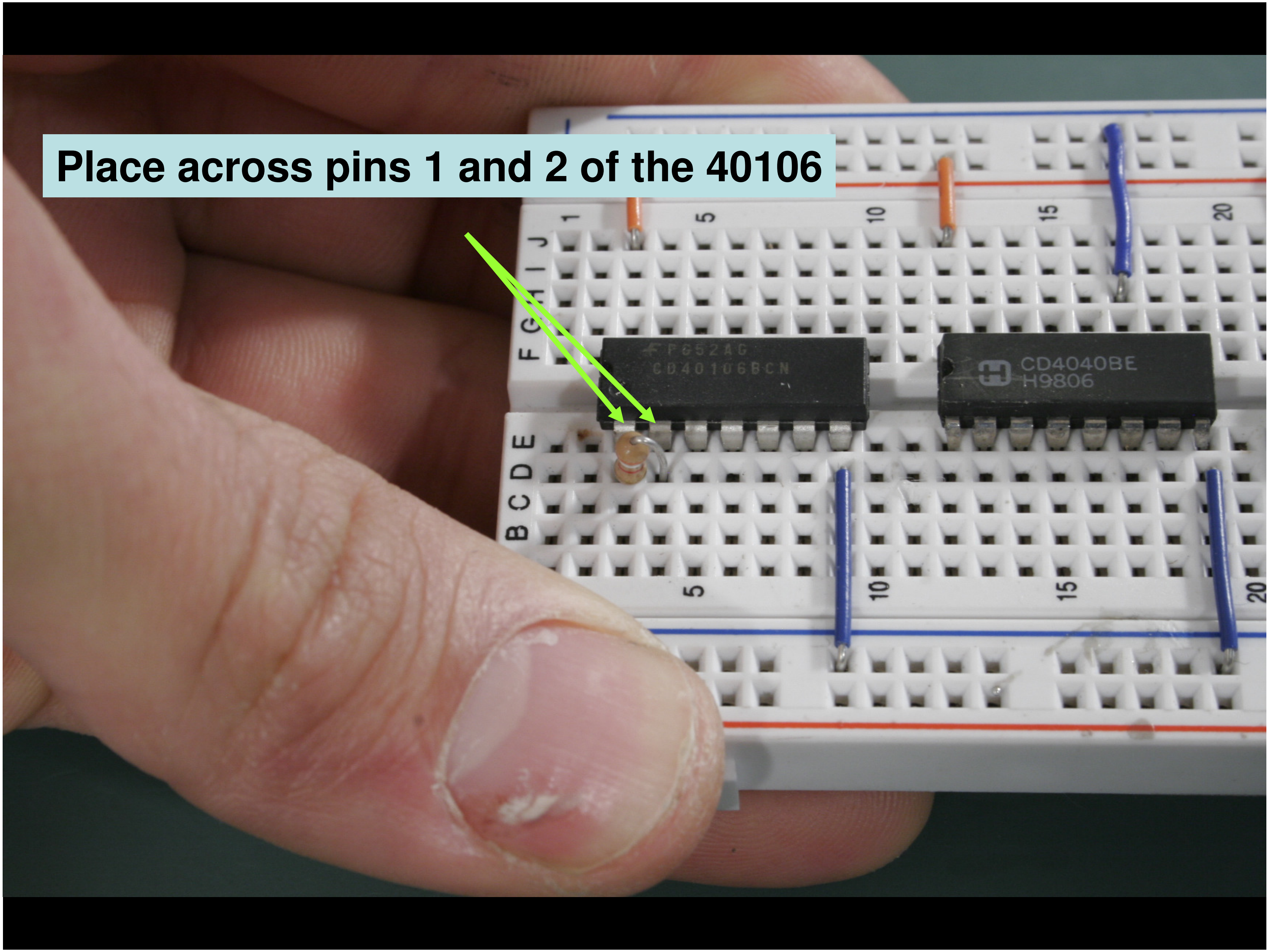


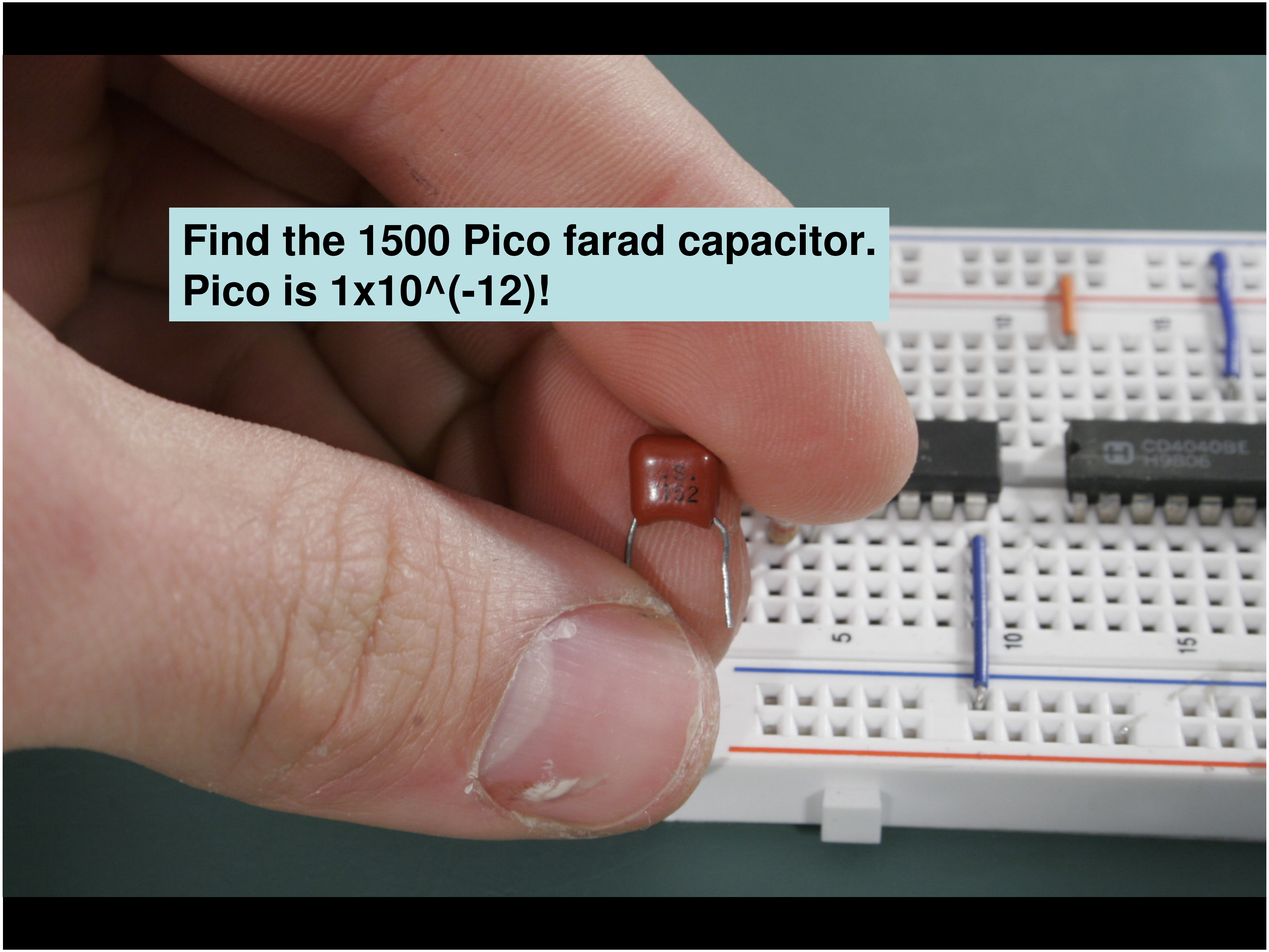
This is called a RC relaxation oscillator. R for resistances and C for capacitance.


Find the 3.9k ohm resistor.
That’s 3900 ohms.
CD4040BE
H9806

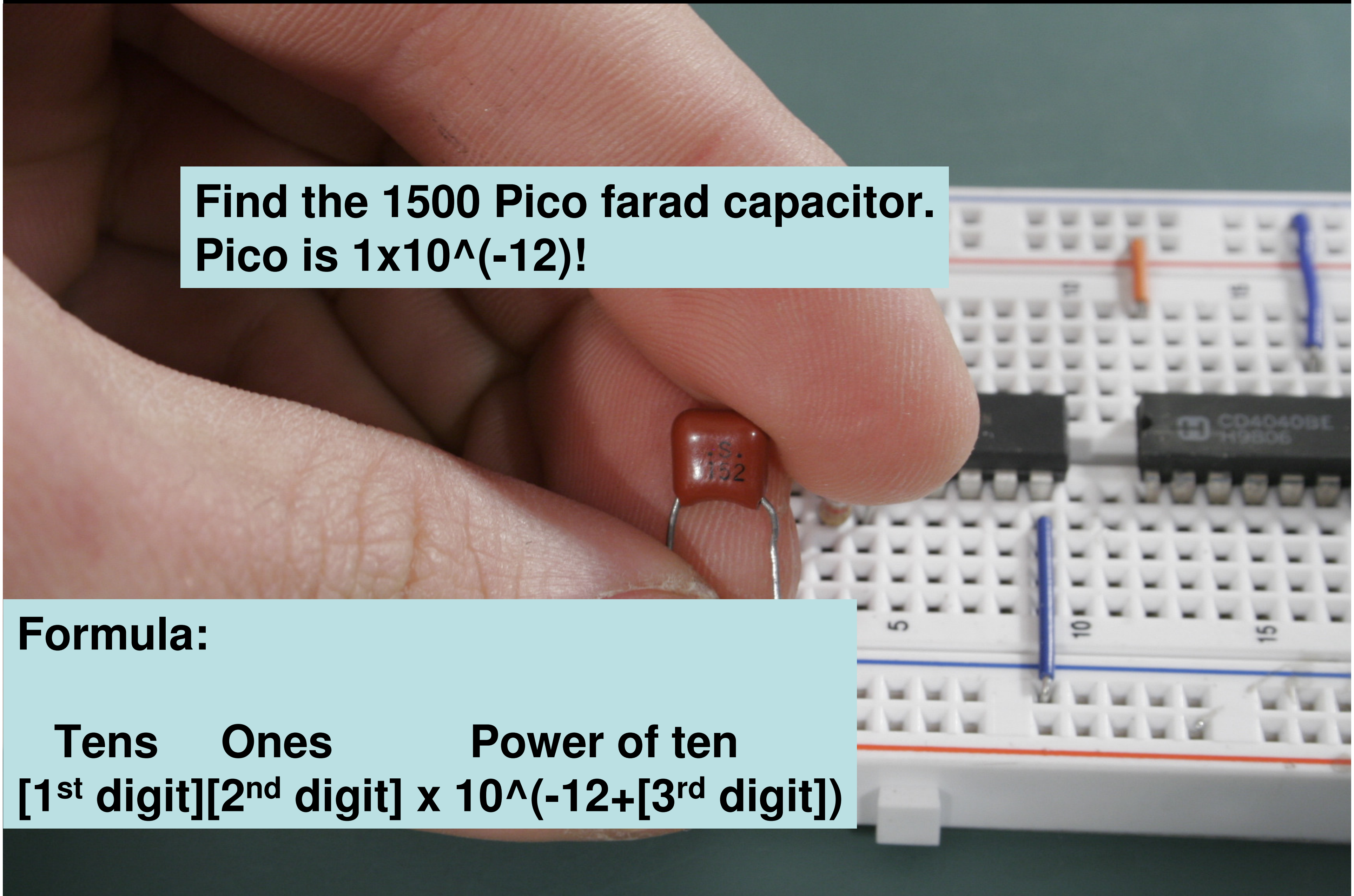

Find the 3.9k ohm resistor.
That’s 3900 ohms.
CD4040BE
H9806
Tens Ones Power of ten
[band 1][band 2] x 10^[band3]


Find the 3.9k ohm resistor.
That’s 3900 ohms.
Tens Ones Power of ten
[band 1][band 2] x 10^[band3]
[orange][white] x 10^[red]
[3][9]x10^[2] = 39x100 = 3900 ohms
CD4040BE
H9806


Place across pins 1 and 2 of the 40106
CD40106BCN
CD4040BE
H9806


Find the 1500 Pico farad capacitor.
Pico is 1x10^(-12)!

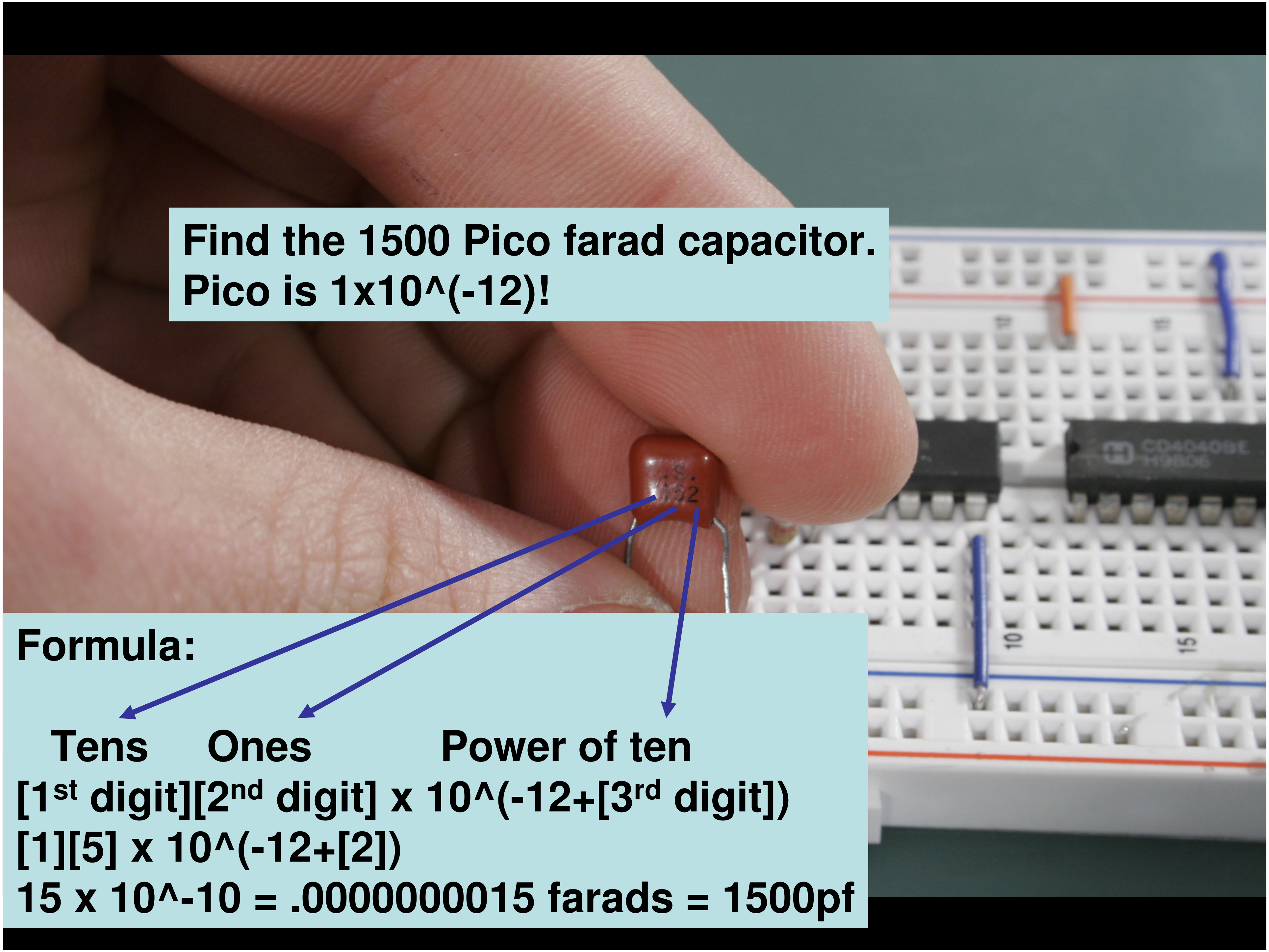
Find the 1500 Pico farad capacitor.
Pico is 1x10^(-12)!



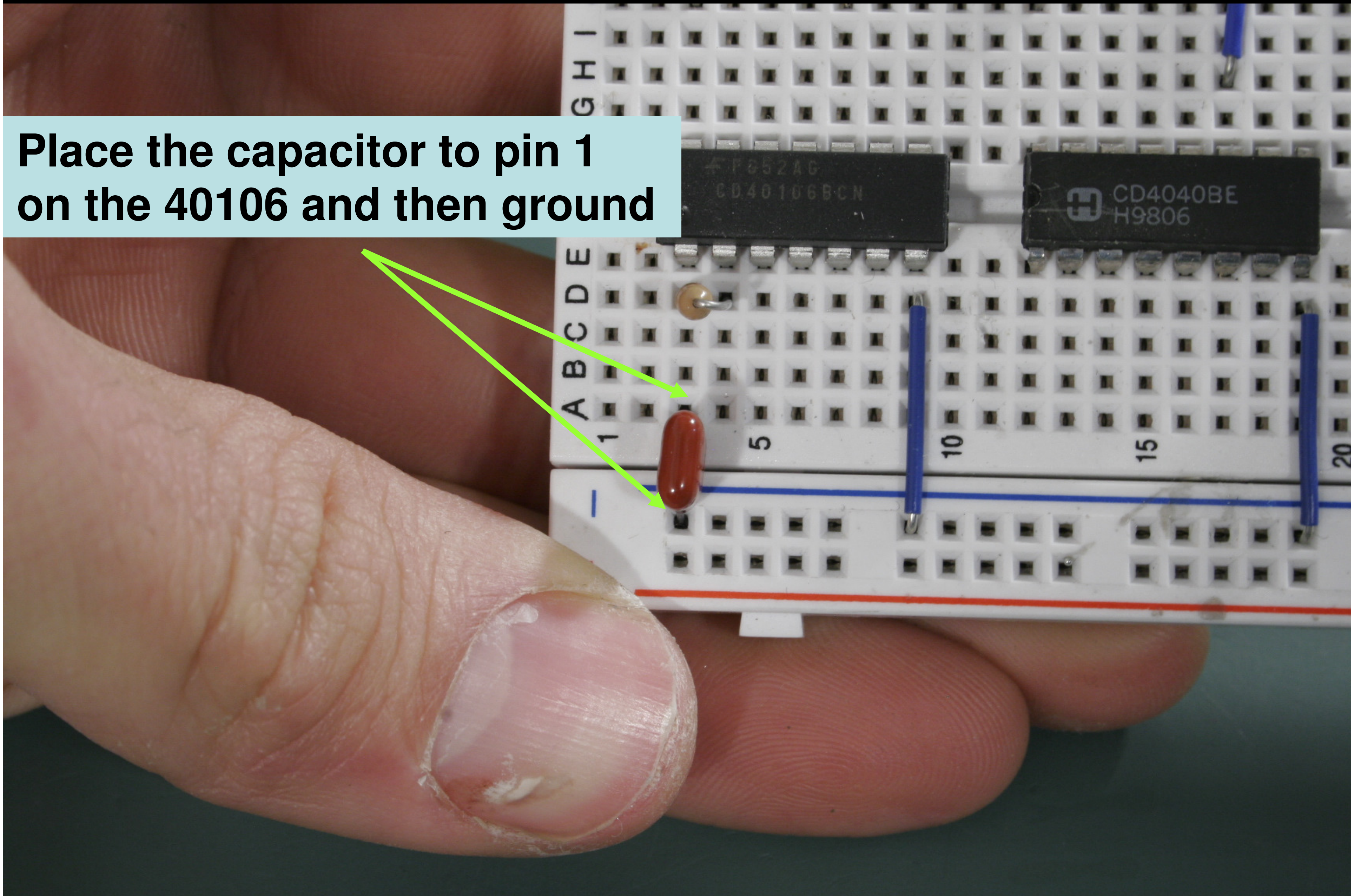
Formula:

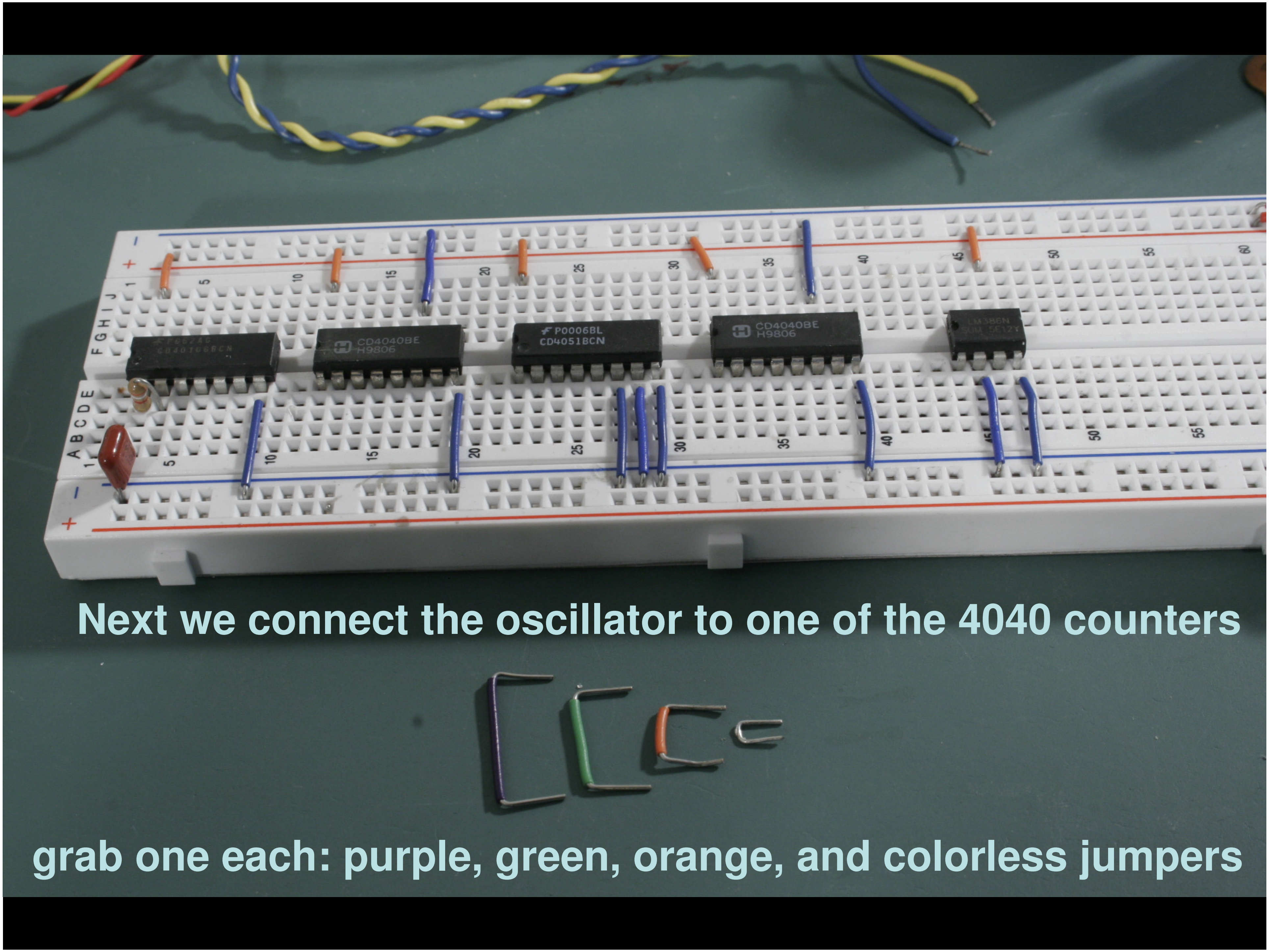
Tens Ones Power of ten

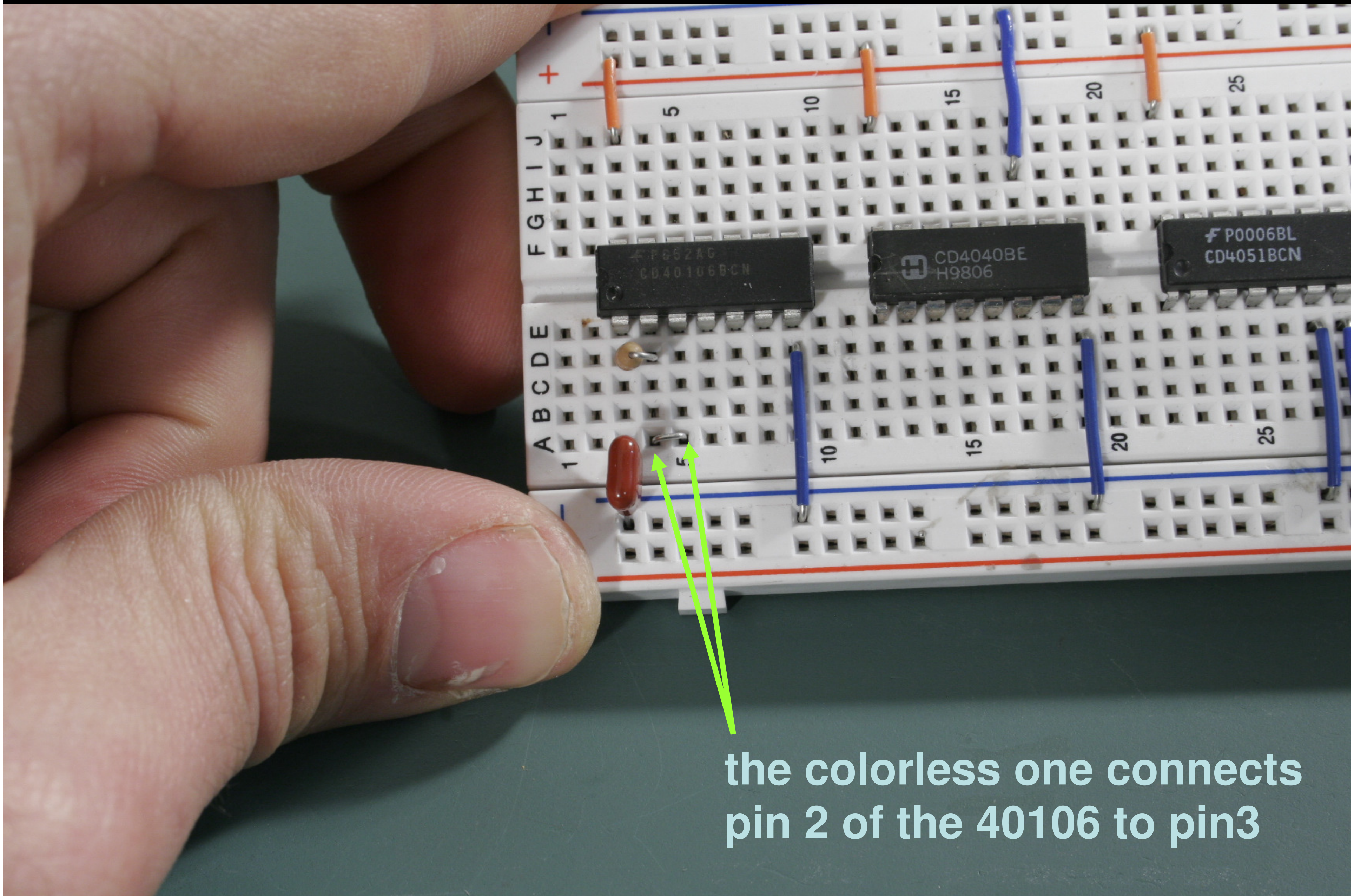
[1st digit][2nd digit] x 10^(-12+[3rd digit])


Find the 1500 Pico farad capacitor.
Pico is 1x10^(-12)!
Formula:
Tens Ones Power of ten
[1st digit][2nd digit] x 10^(-12+[3rd digit])
[1][5] x 10^(-12+[2])
15 x 10^-10 = .0000000015 farads = 1500pf

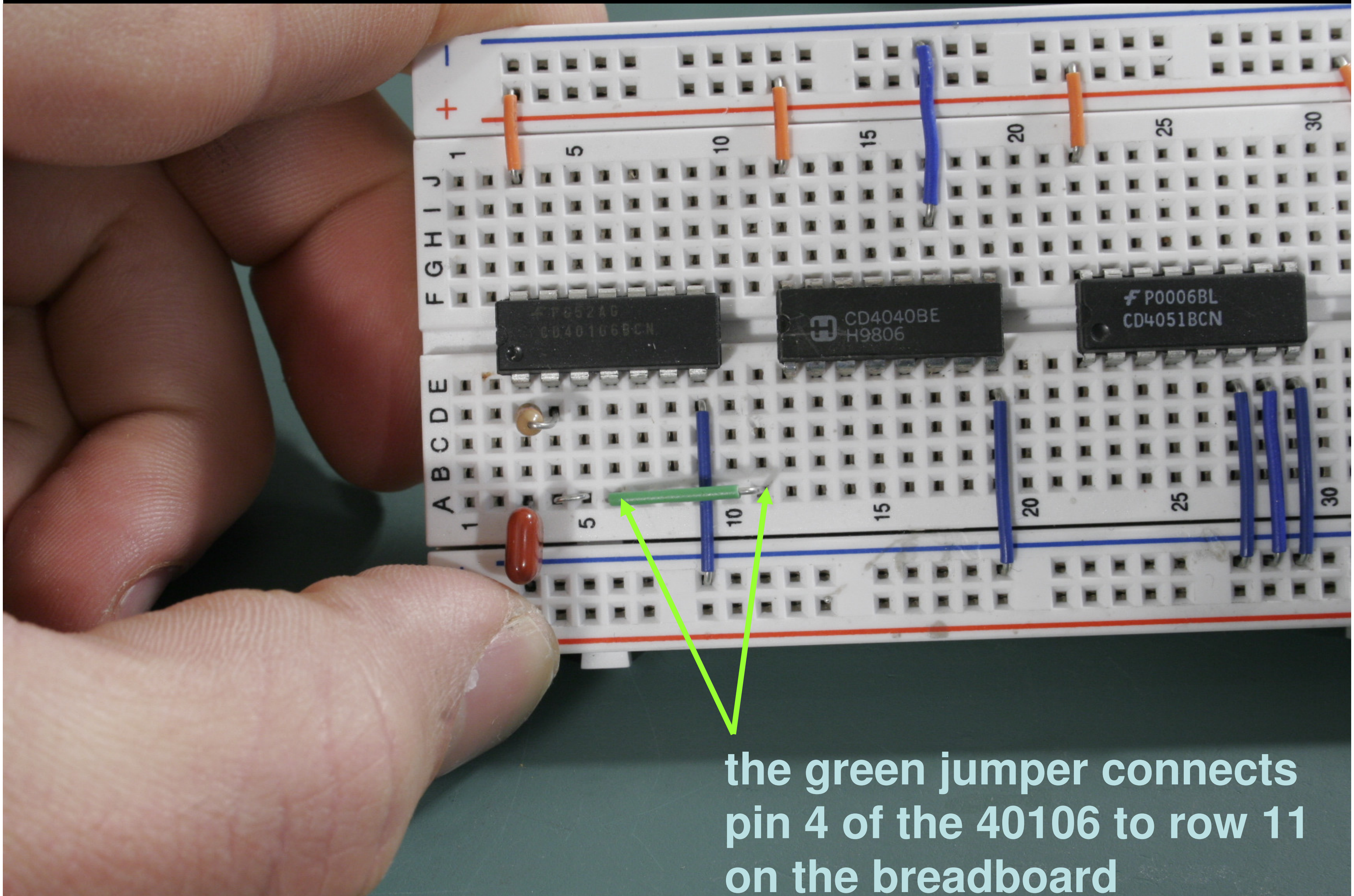
Place the capacitor to pin 1 on the 40106 and then ground

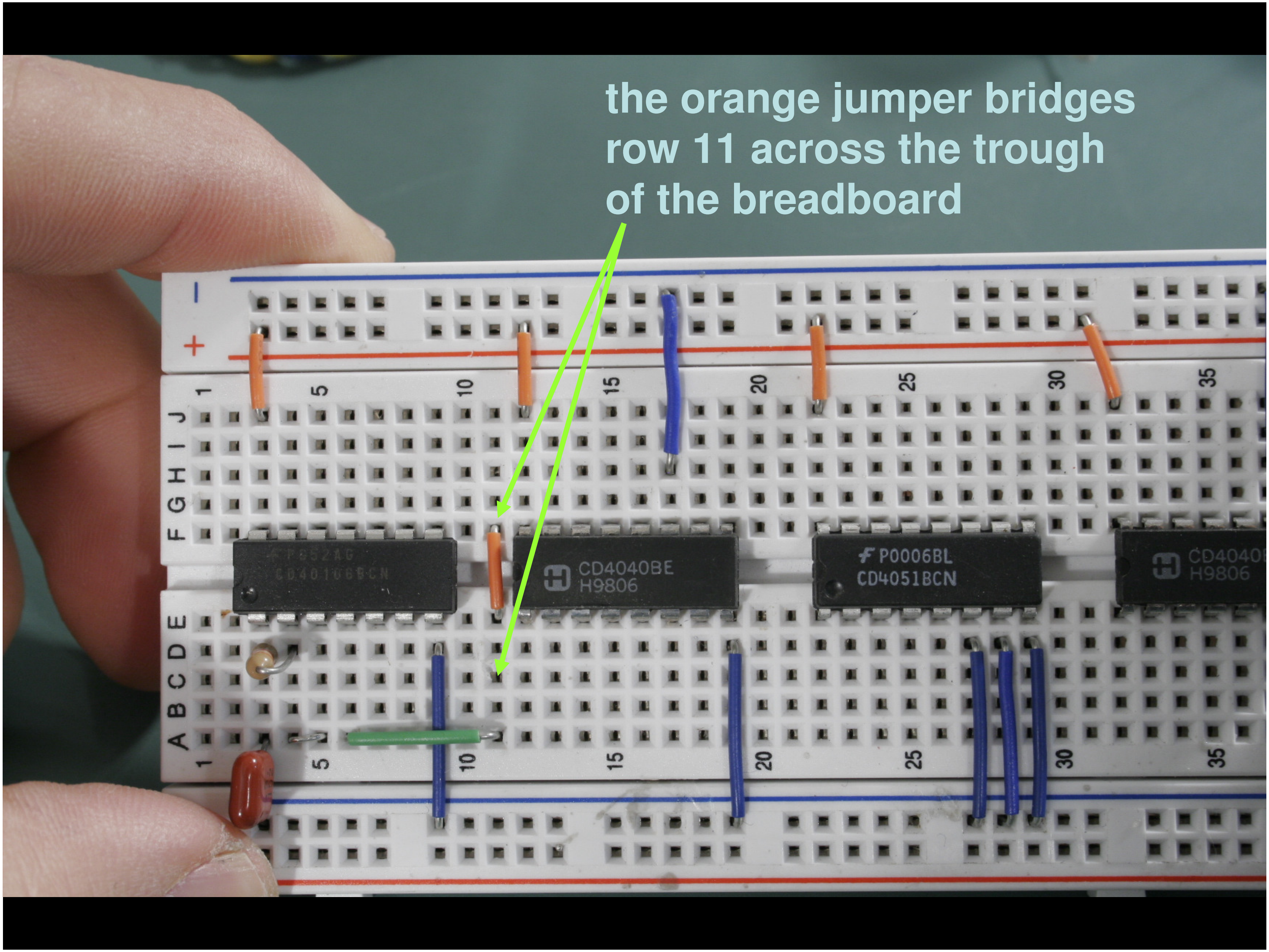


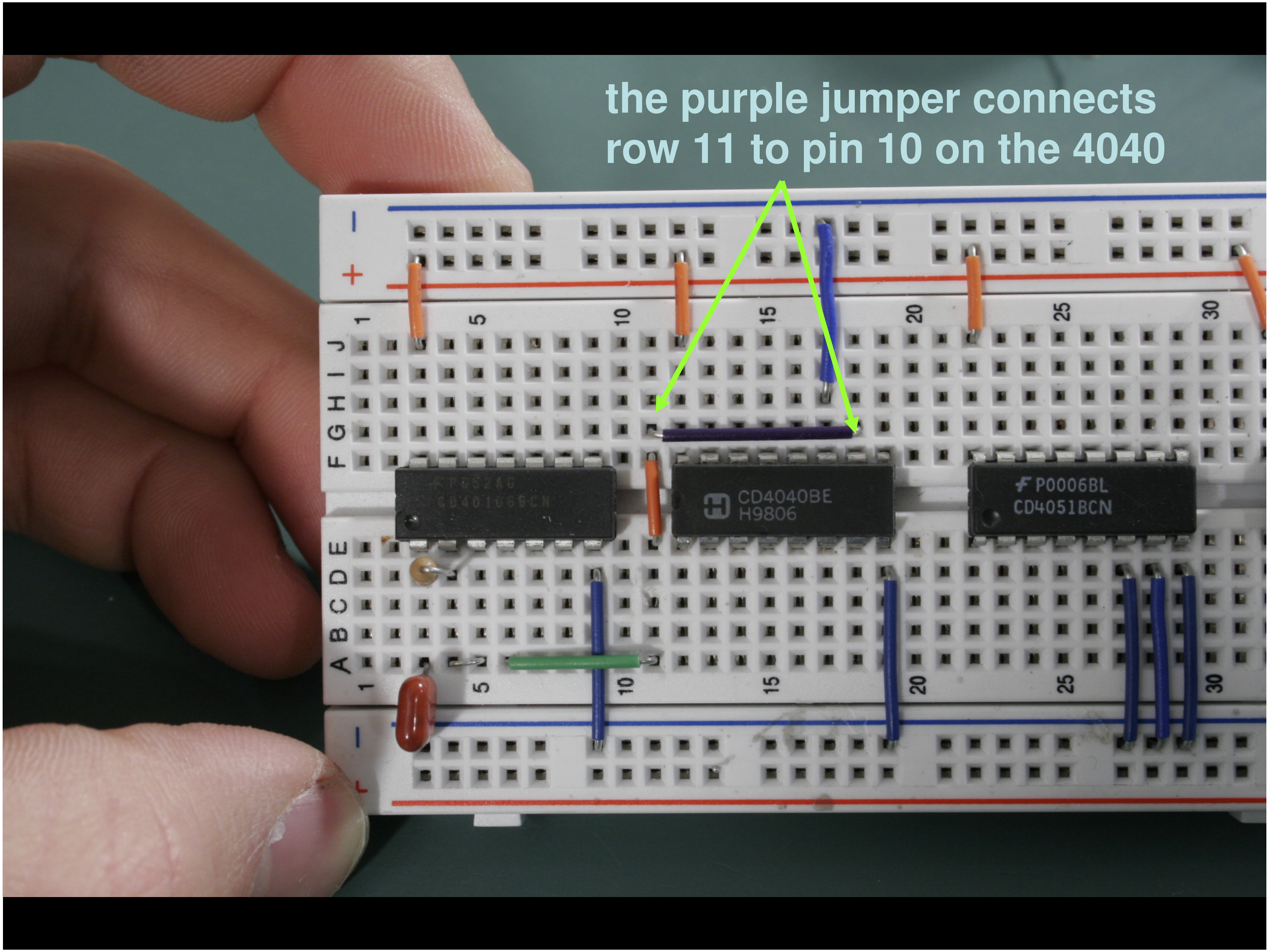

CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
Next we connect the oscillator to one of the 4040 counters
grab one each: purple, green, orange, and colorless jumpers

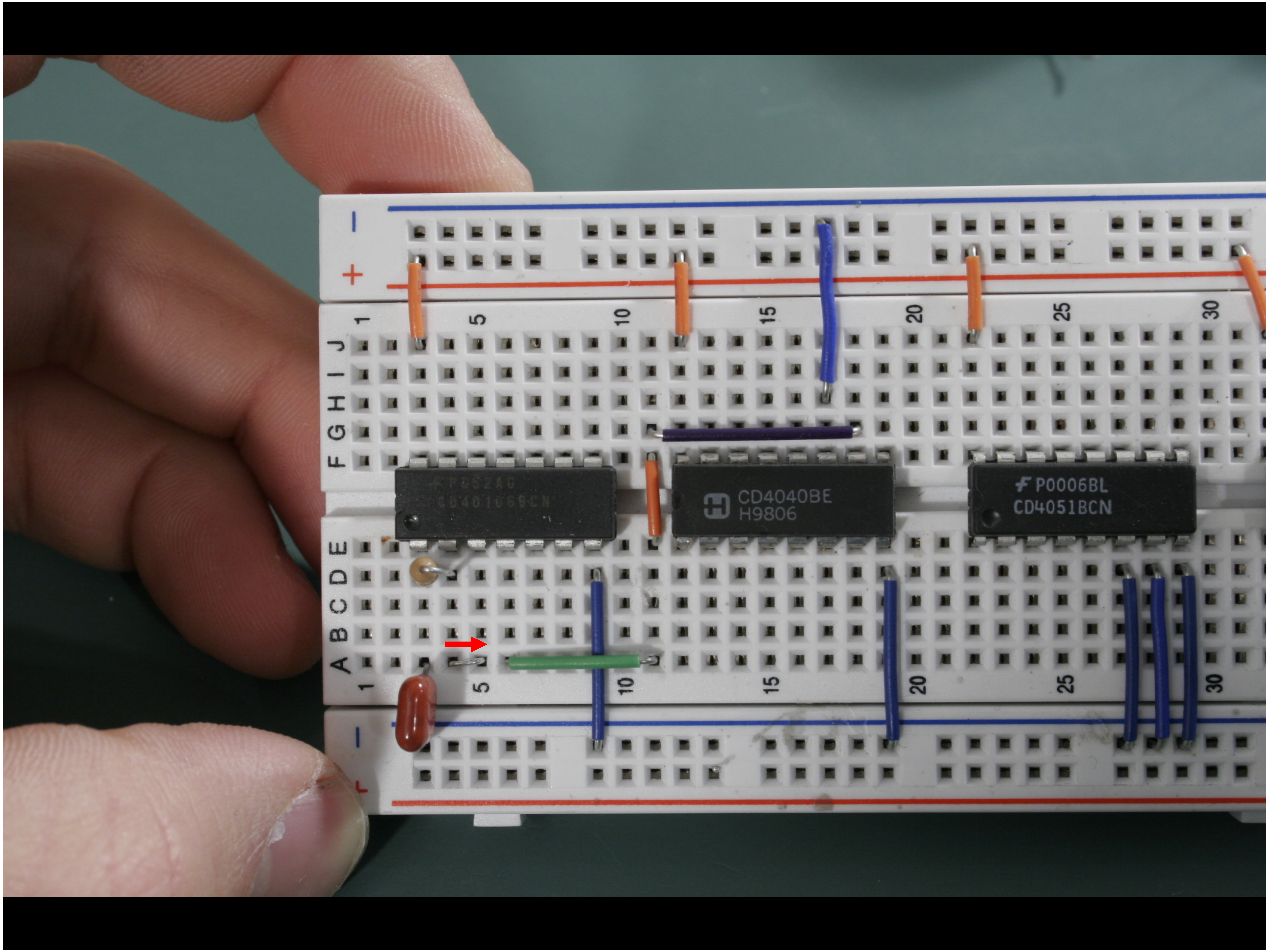


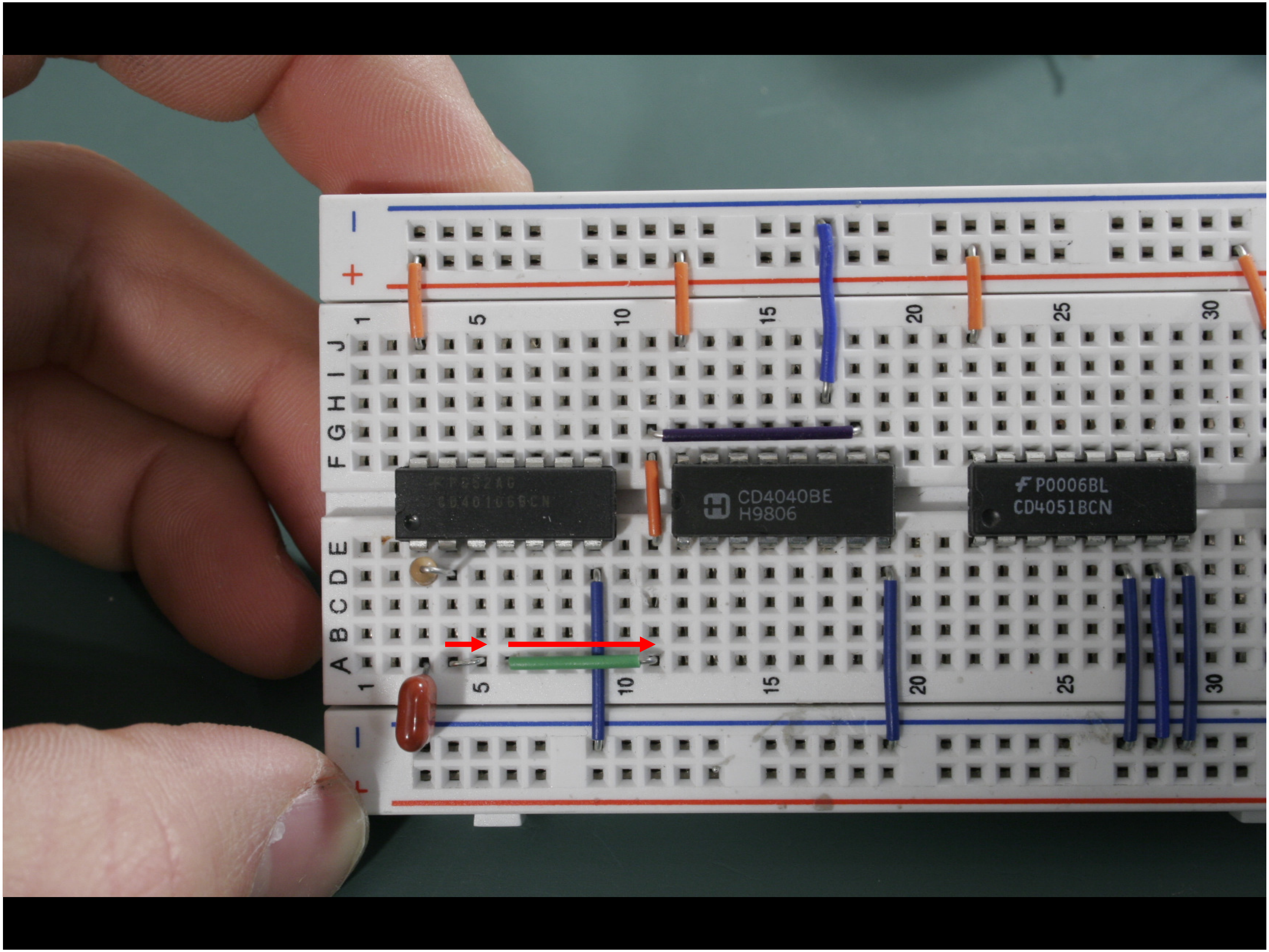
the colorless one connects
pin 2 of the 40106 to pin3

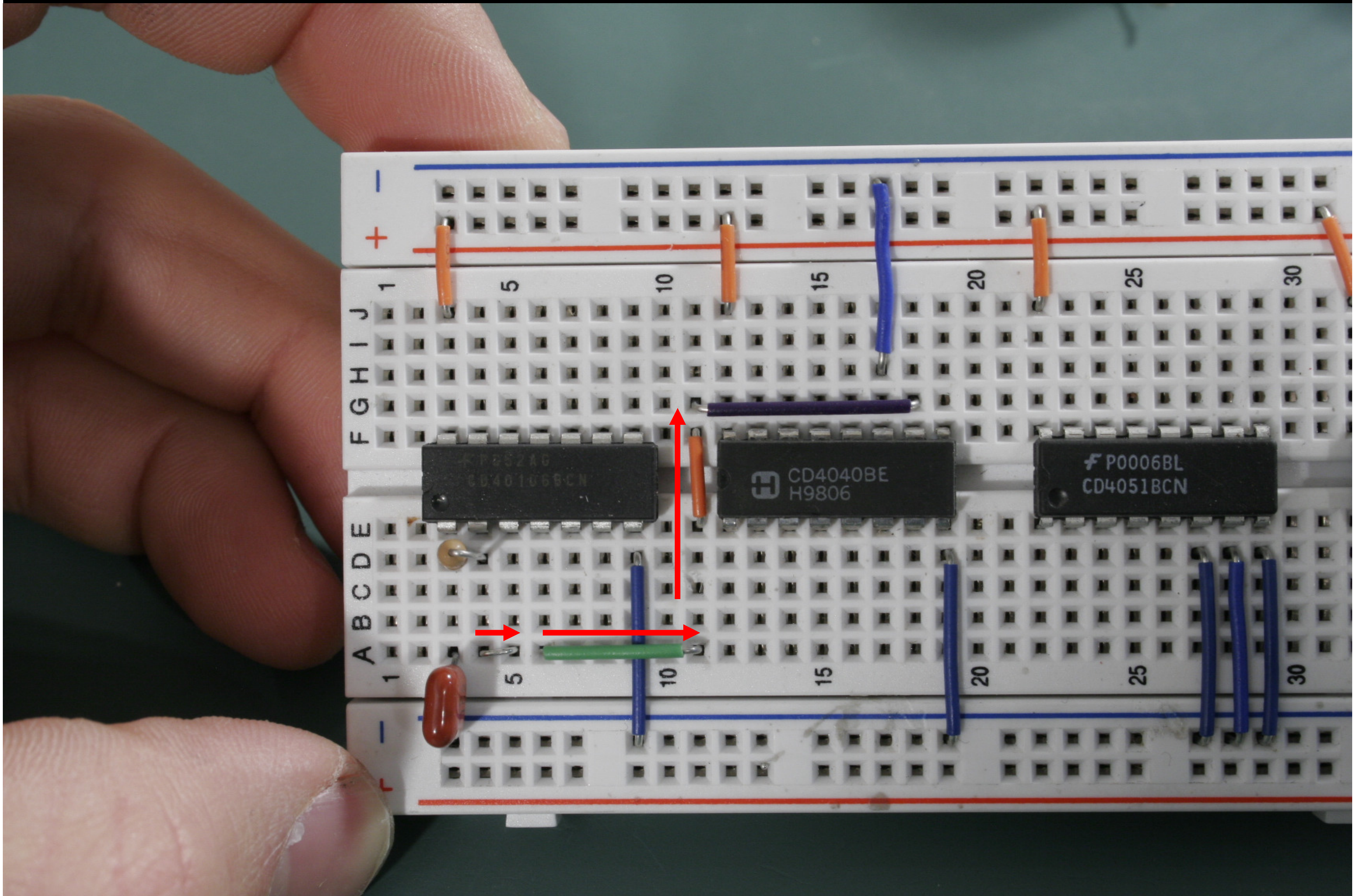

CD4040BE
H9806
P0006BL
CD4051BCN
the green jumper connects
pin 4 of the 40106 to row 11
on the breadboard

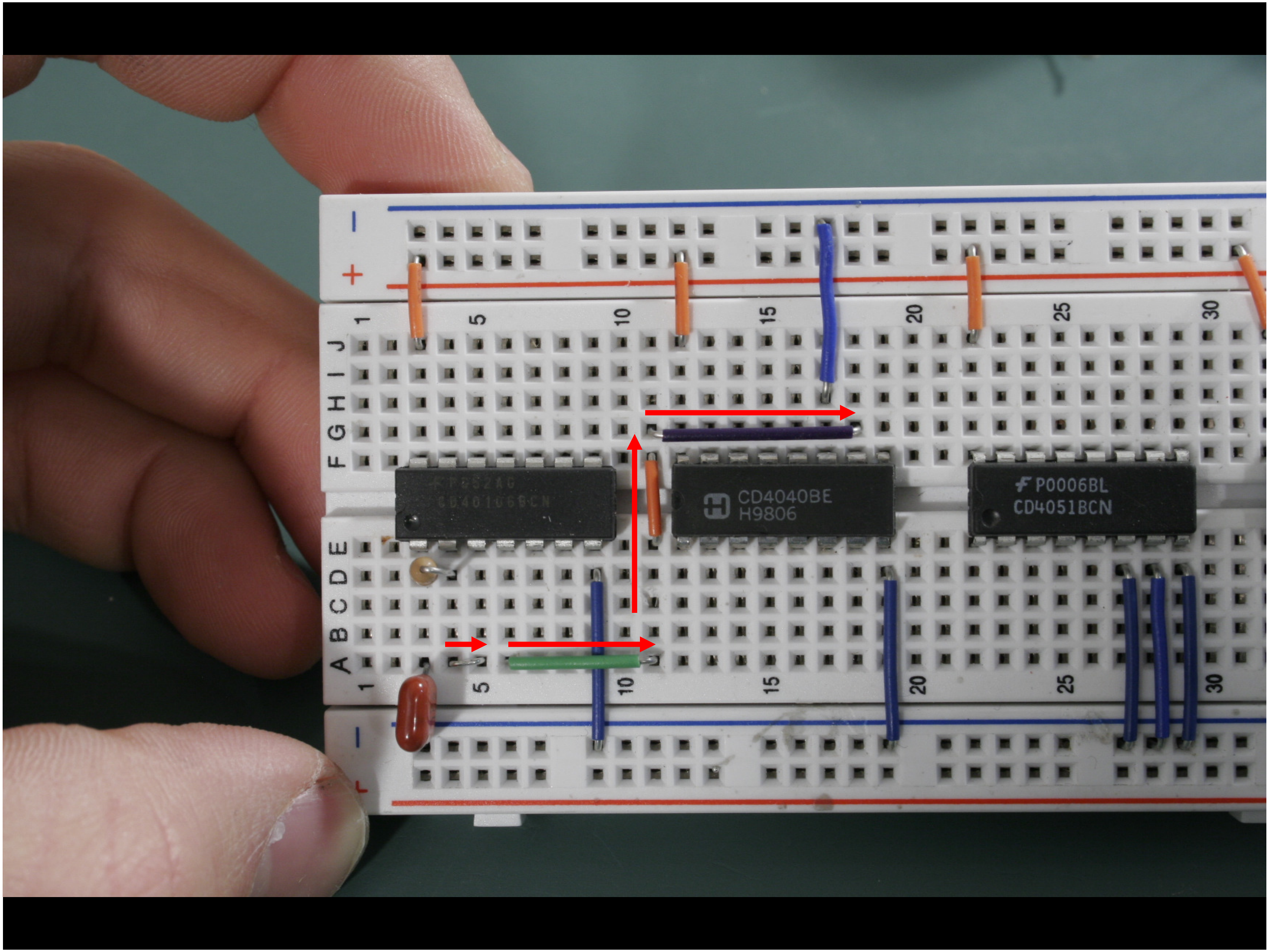

the orange jumper bridges
row 11 across the trough
of the breadboard
CD4040BE
H9806
P0006BL
CD4051BCN


the purple jumper connects
row 11 to pin 10 on the 4040
CD4040BE
H9806
P0006BL
CD4051BCN


CD4040BE
H9806
P0006BL
CD4051BCN

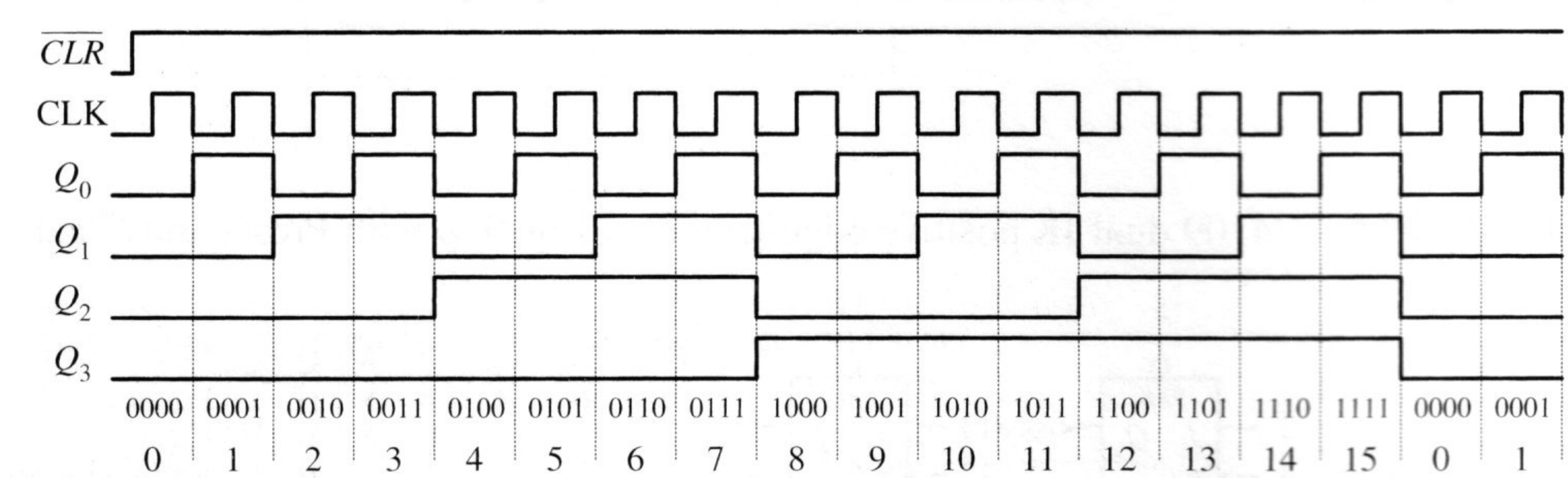

CD4040BE
H9806
P0006BL
CD4051BCN


CD4040BE
H9806
P0006BL
CD4051BCN

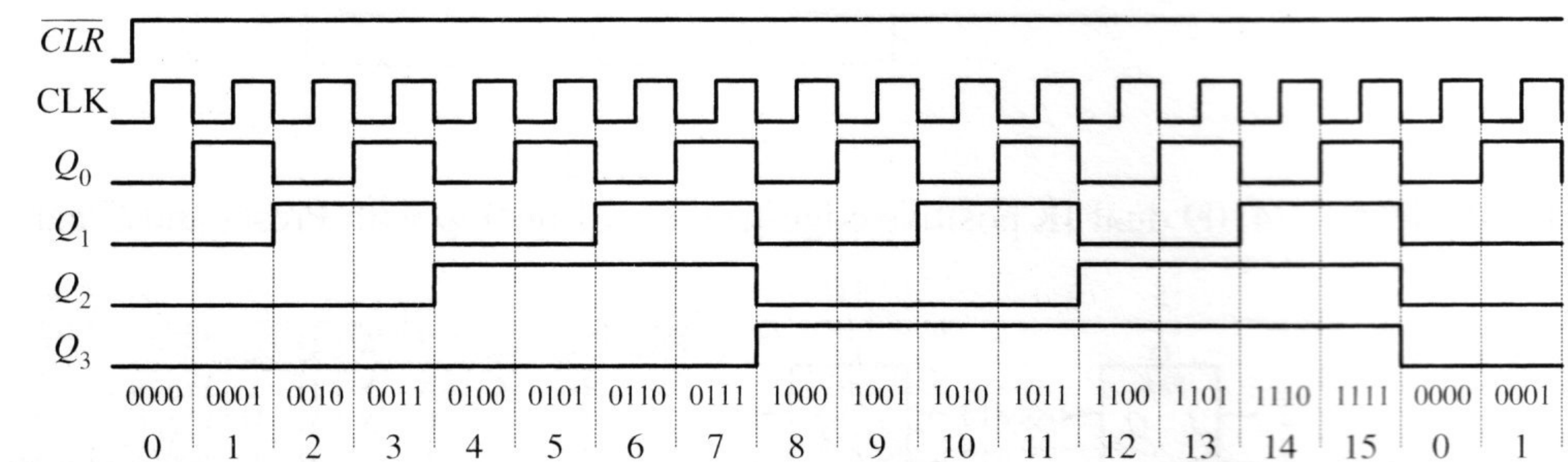


CD4040BE
H9806
P0006BL
CD4051BCN

The 4040 binary counter has the following output.
The frequency of output Q0 is ½ the clock,
Q1 is ¼, Q2 is 1/8th, Q3 is 1/16th, and so on…

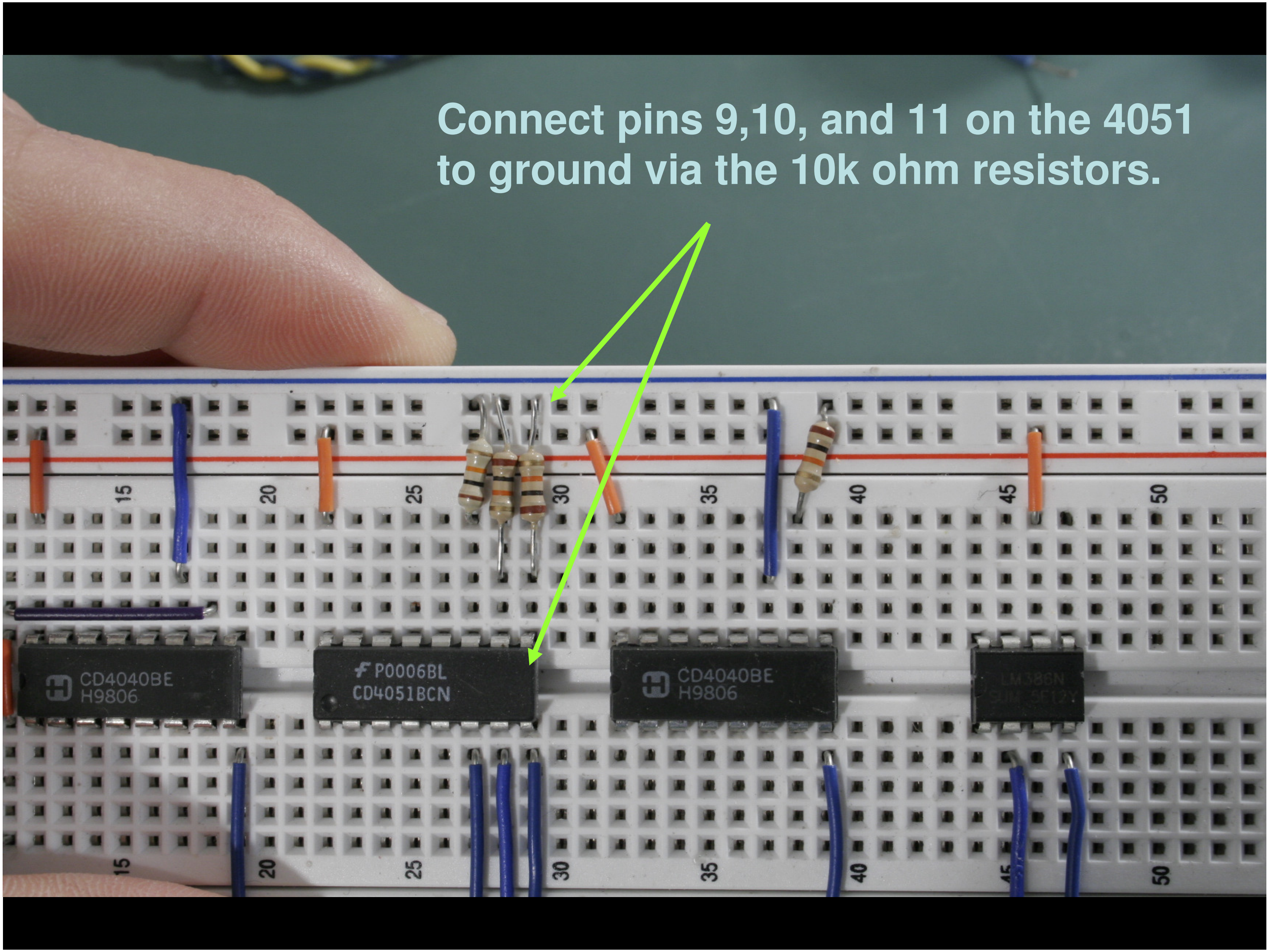


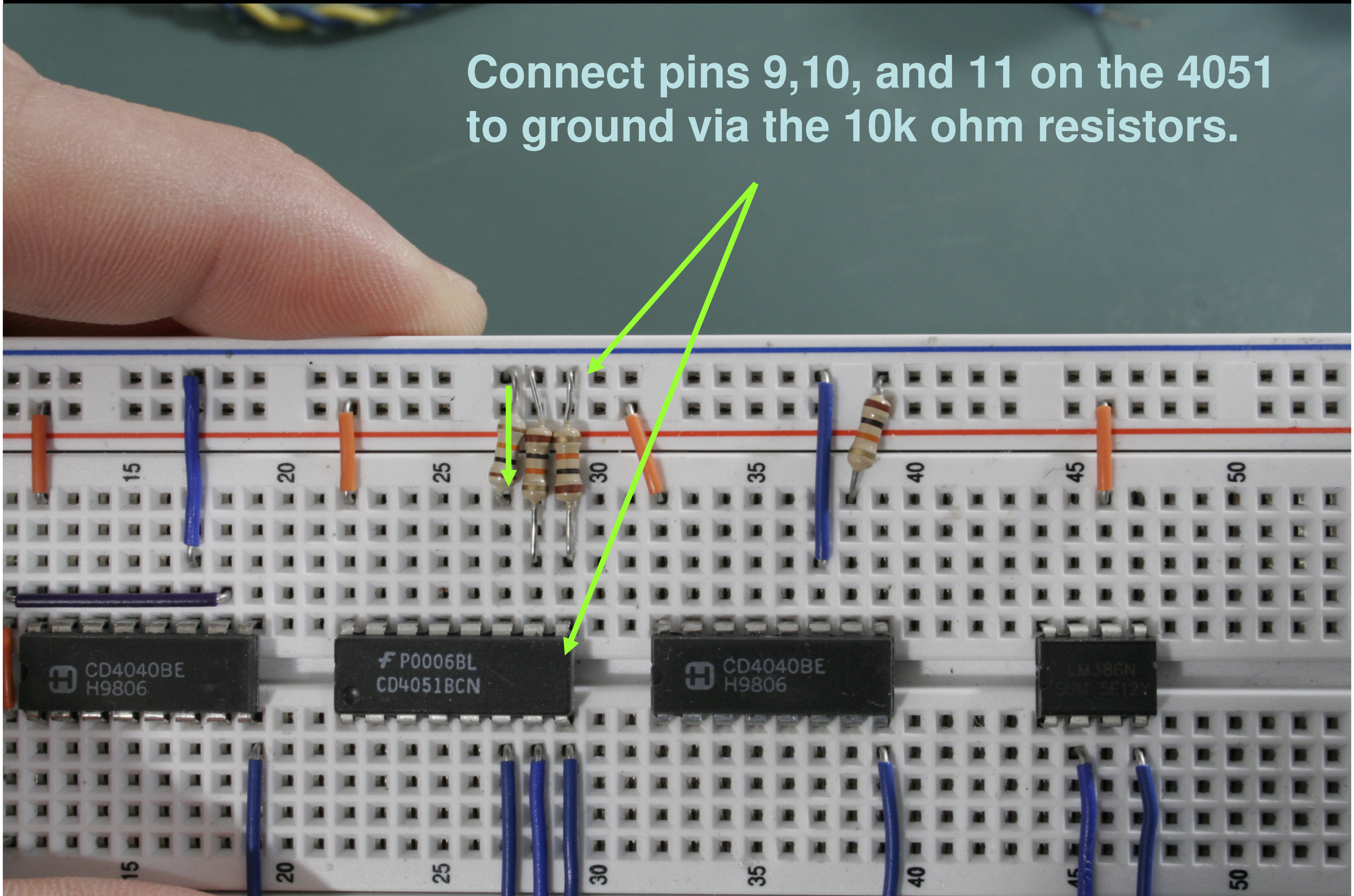
Each output is a sub-octave of the clock input.
Each output is one octave lower than the previous one.

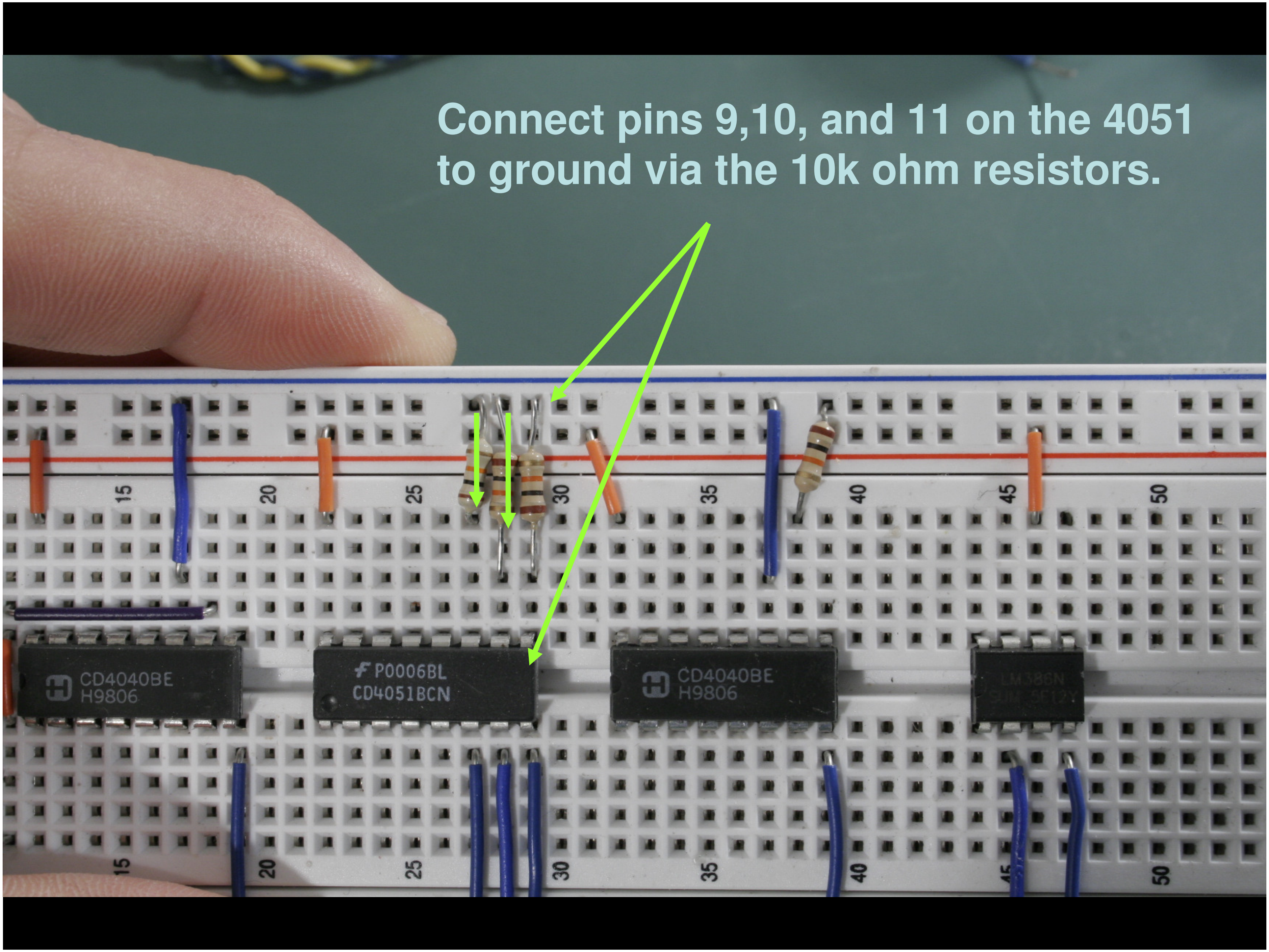


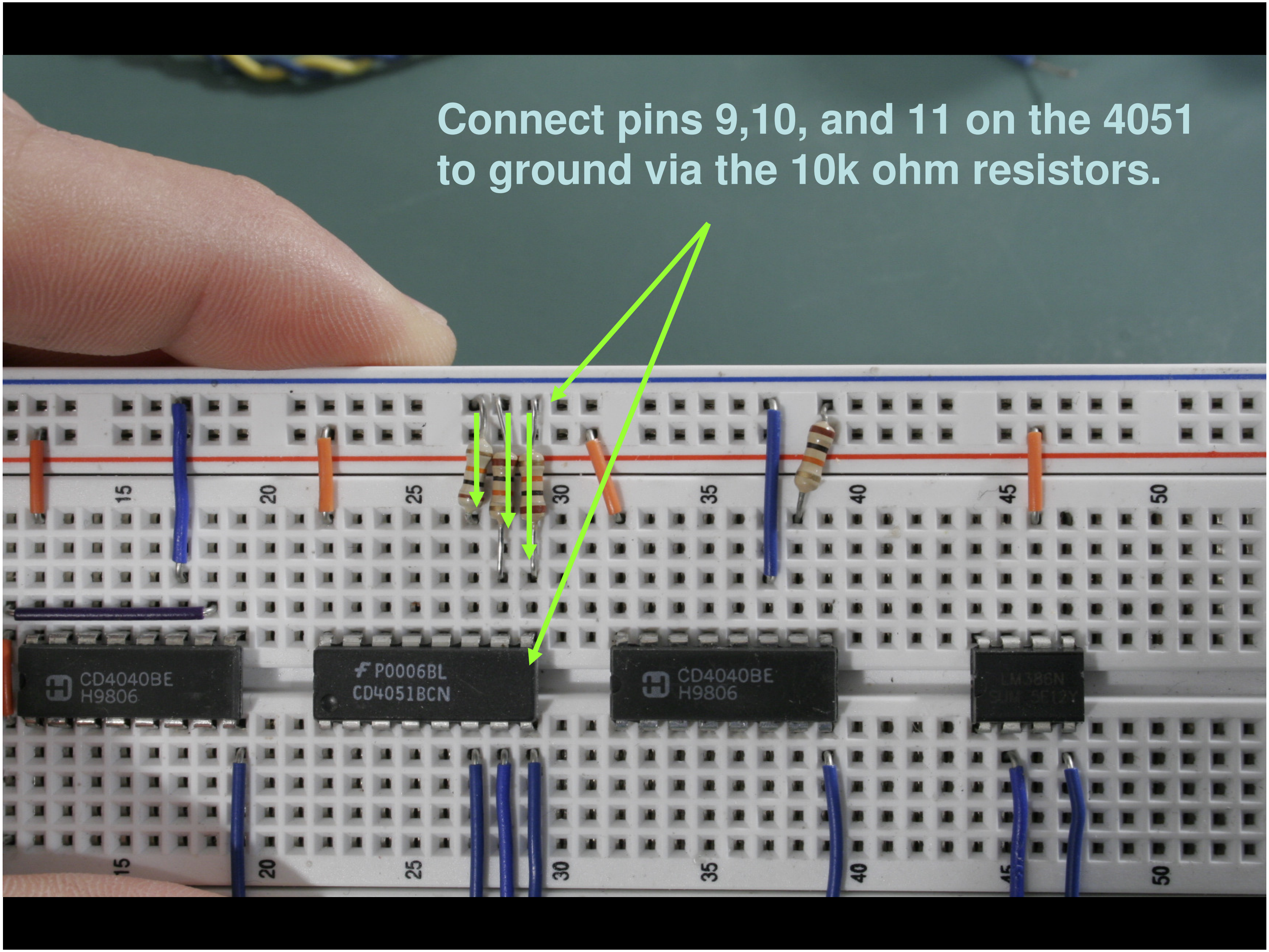

Gather four 10k ohm resistors.
That’s 10,000 ohms!

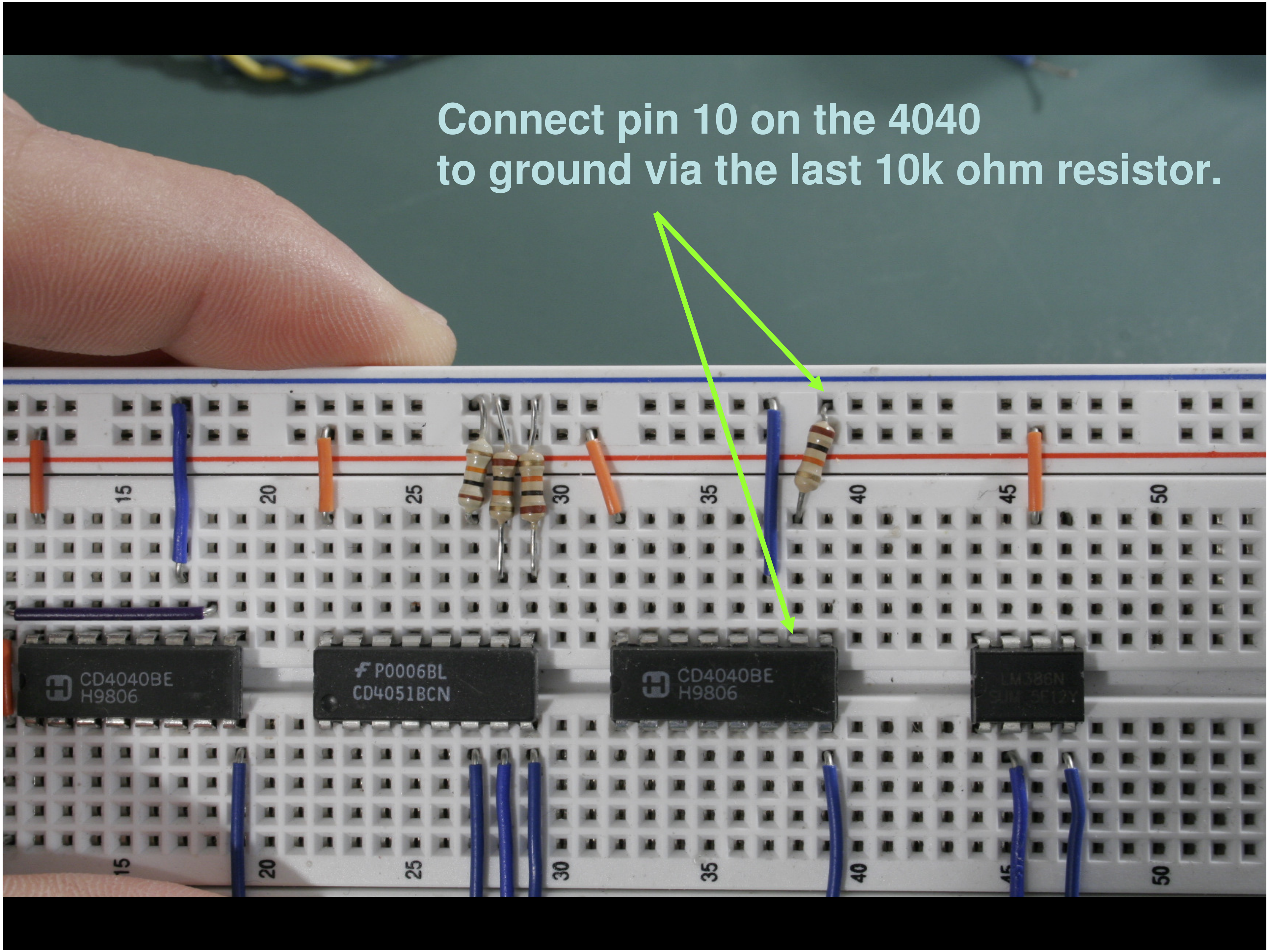

Gather four 10k ohm resistors.
That’s 10,000 ohms!
Color Code: Brown Black Orange Gold

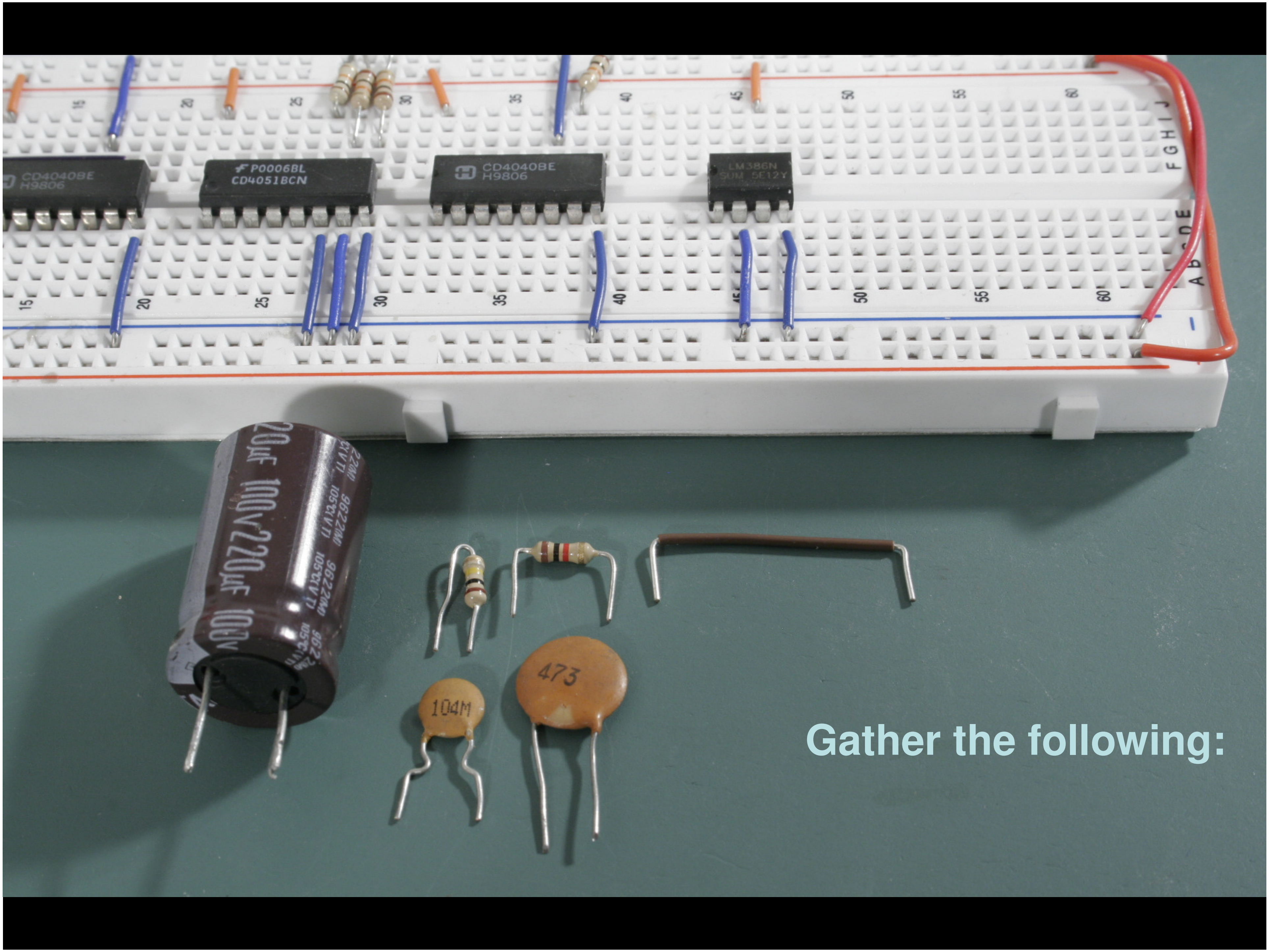

Connect pins 9,10, and 11 on the 4051
to ground via the 10k ohm resistors.
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806

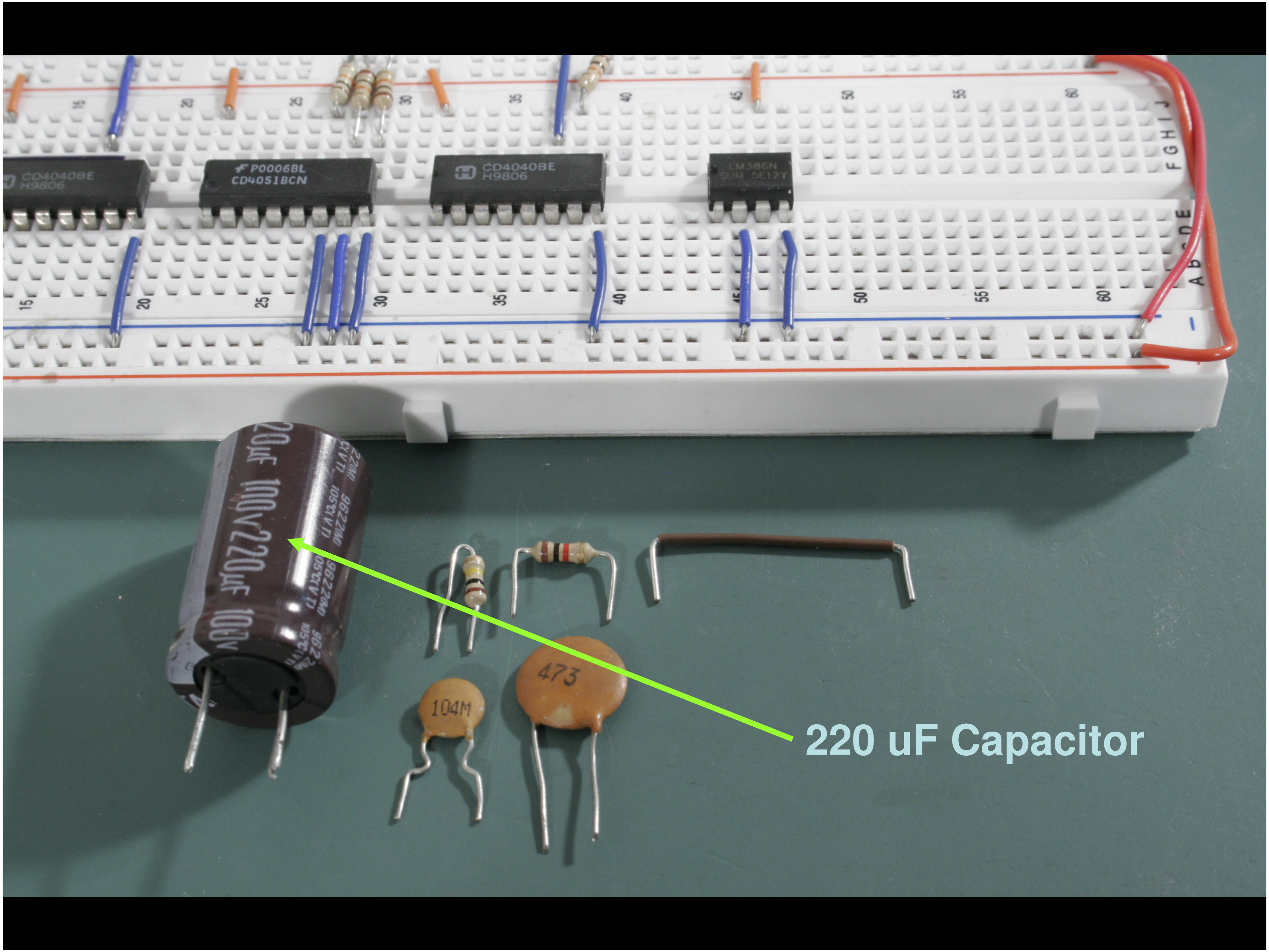

Connect pins 9,10, and 11 on the 4051
to ground via the 10k ohm resistors.
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806

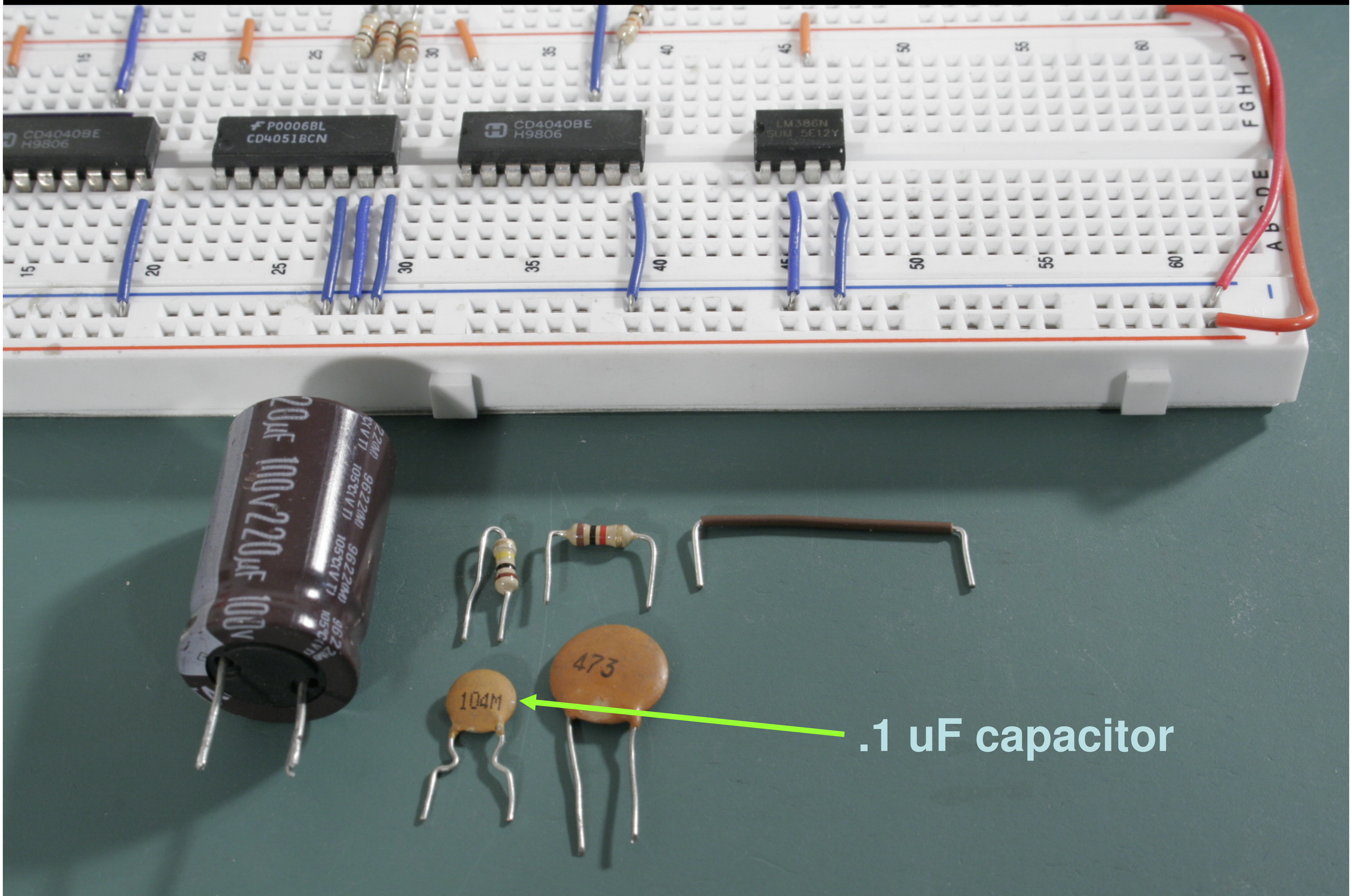

Connect pins 9,10, and 11 on the 4051
to ground via the 10k ohm resistors.
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
15
20
25
30
35
40
45
50

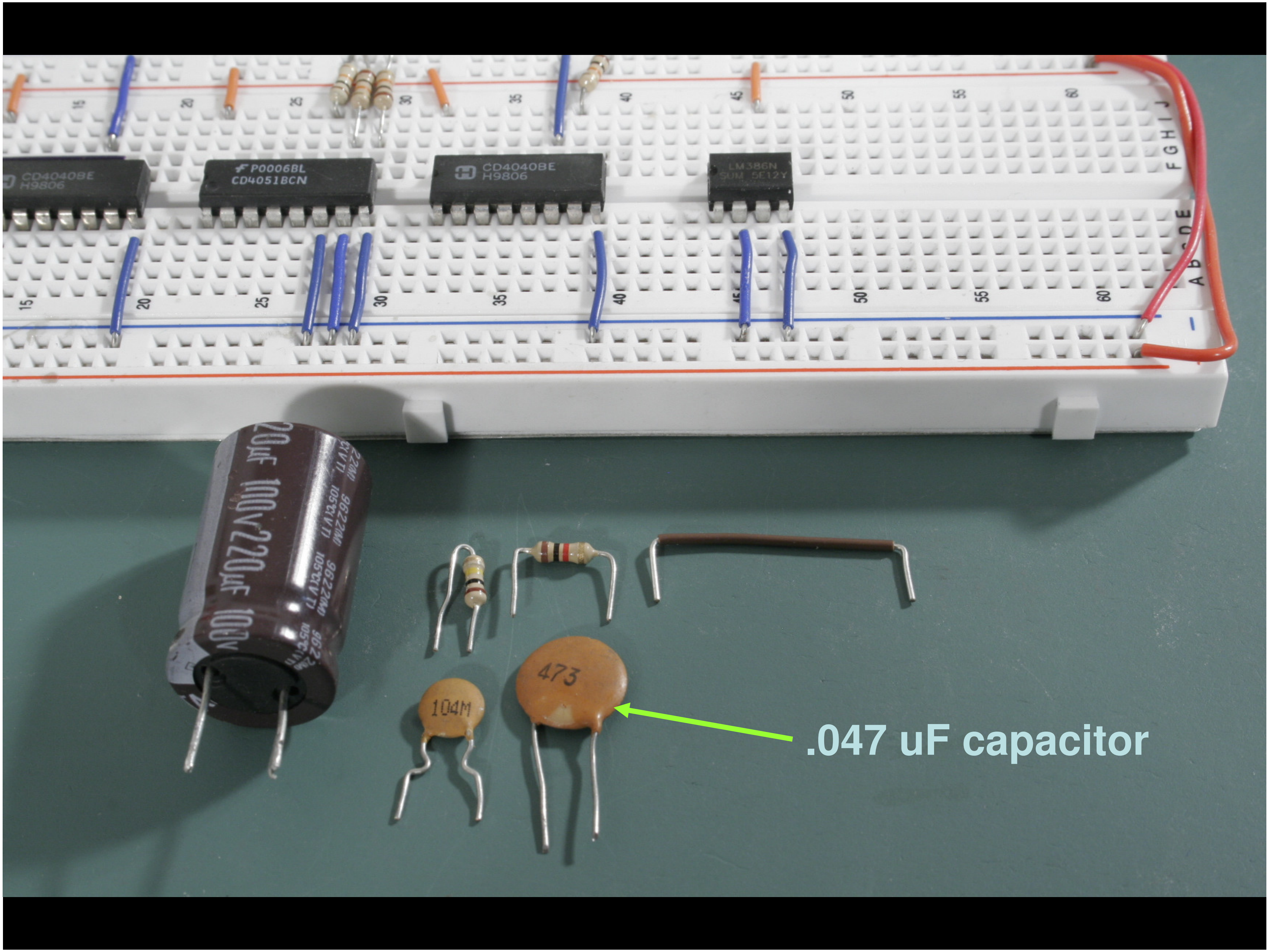

Connect pins 9,10, and 11 on the 4051
to ground via the 10k ohm resistors.
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
LM386N

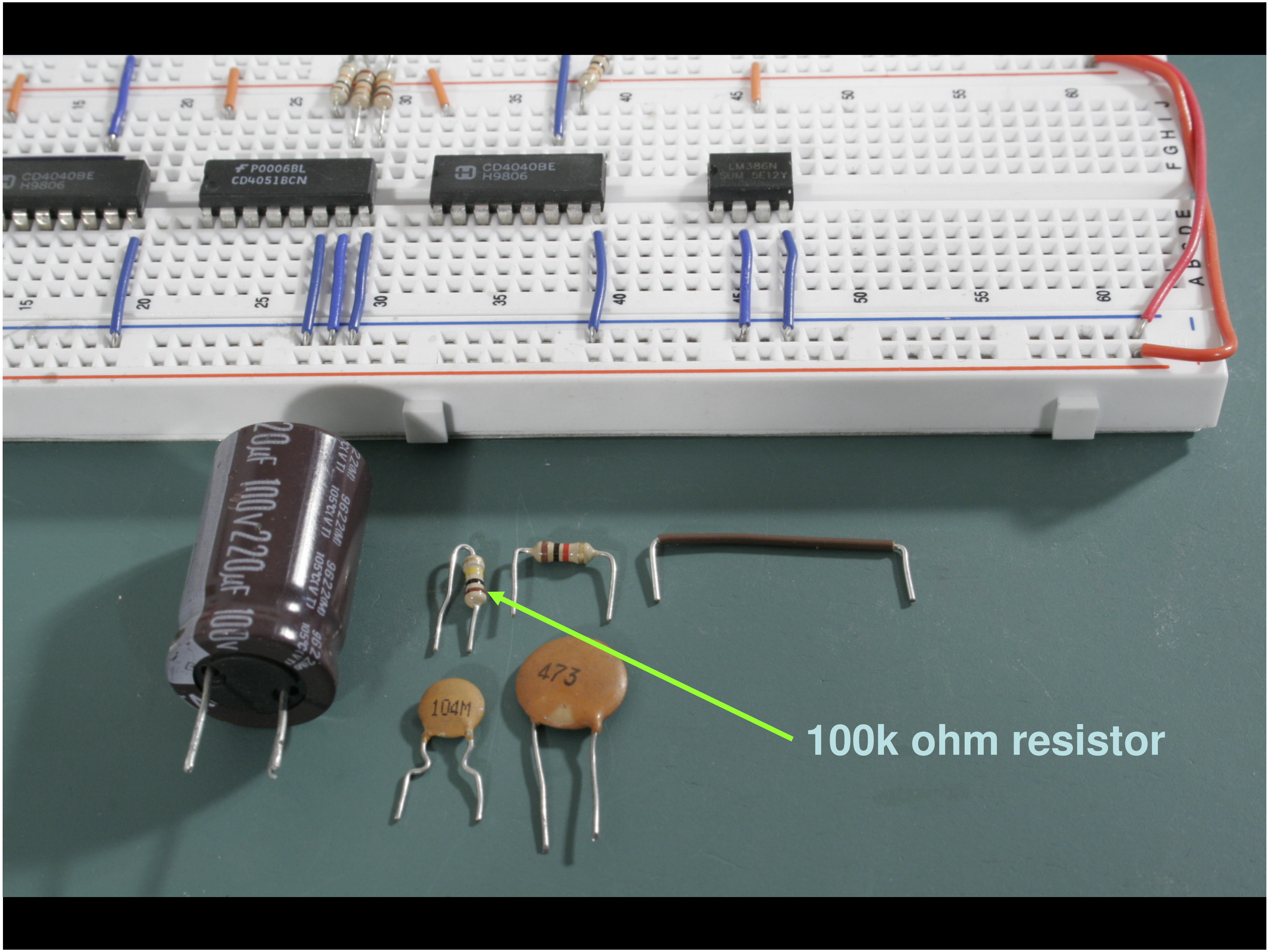

Connect pin 10 on the 4040
to ground via the last 10k ohm resistor.
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806

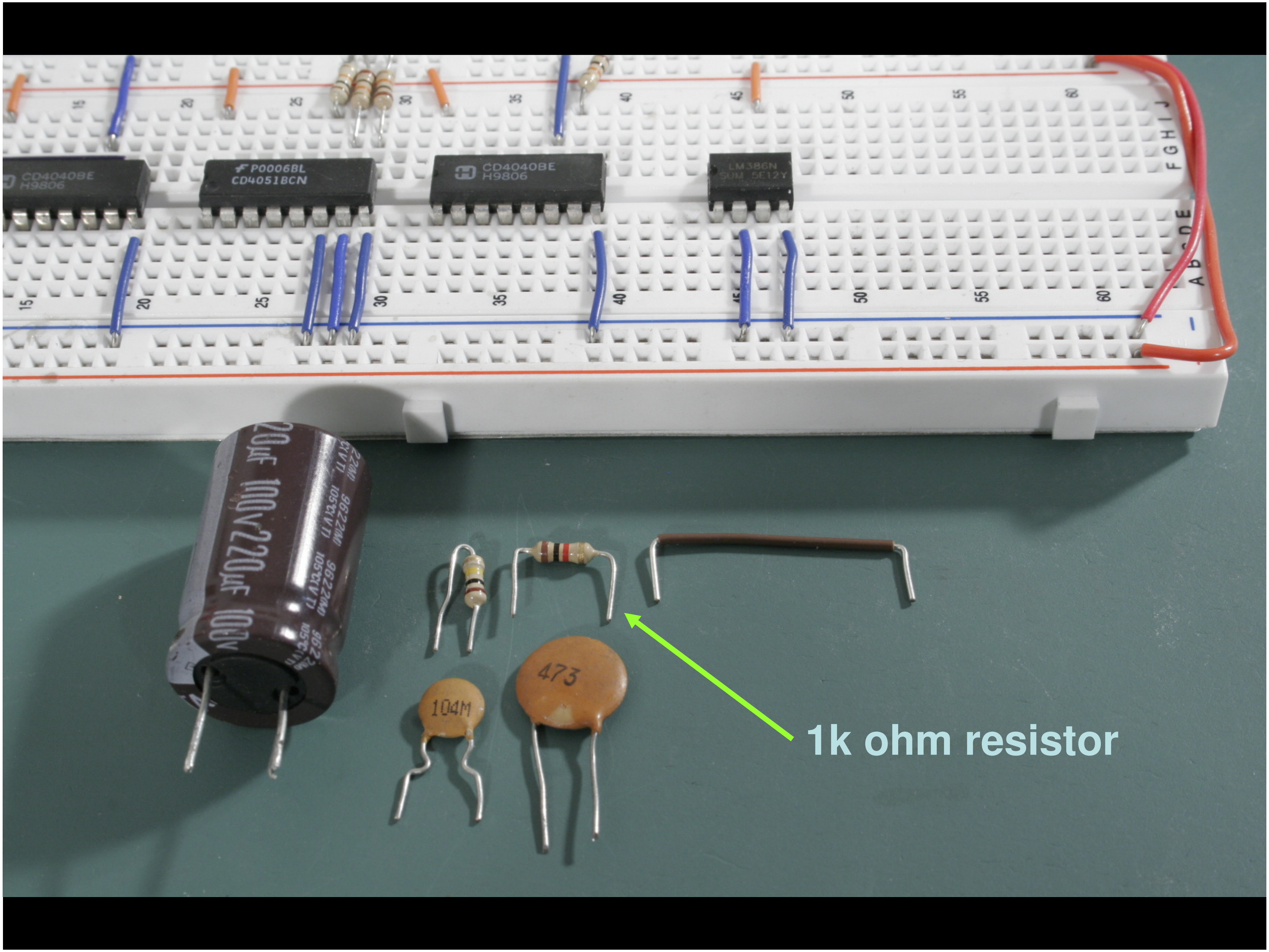

CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
LM386N
220µF 100V
104M
473
Gather the following:

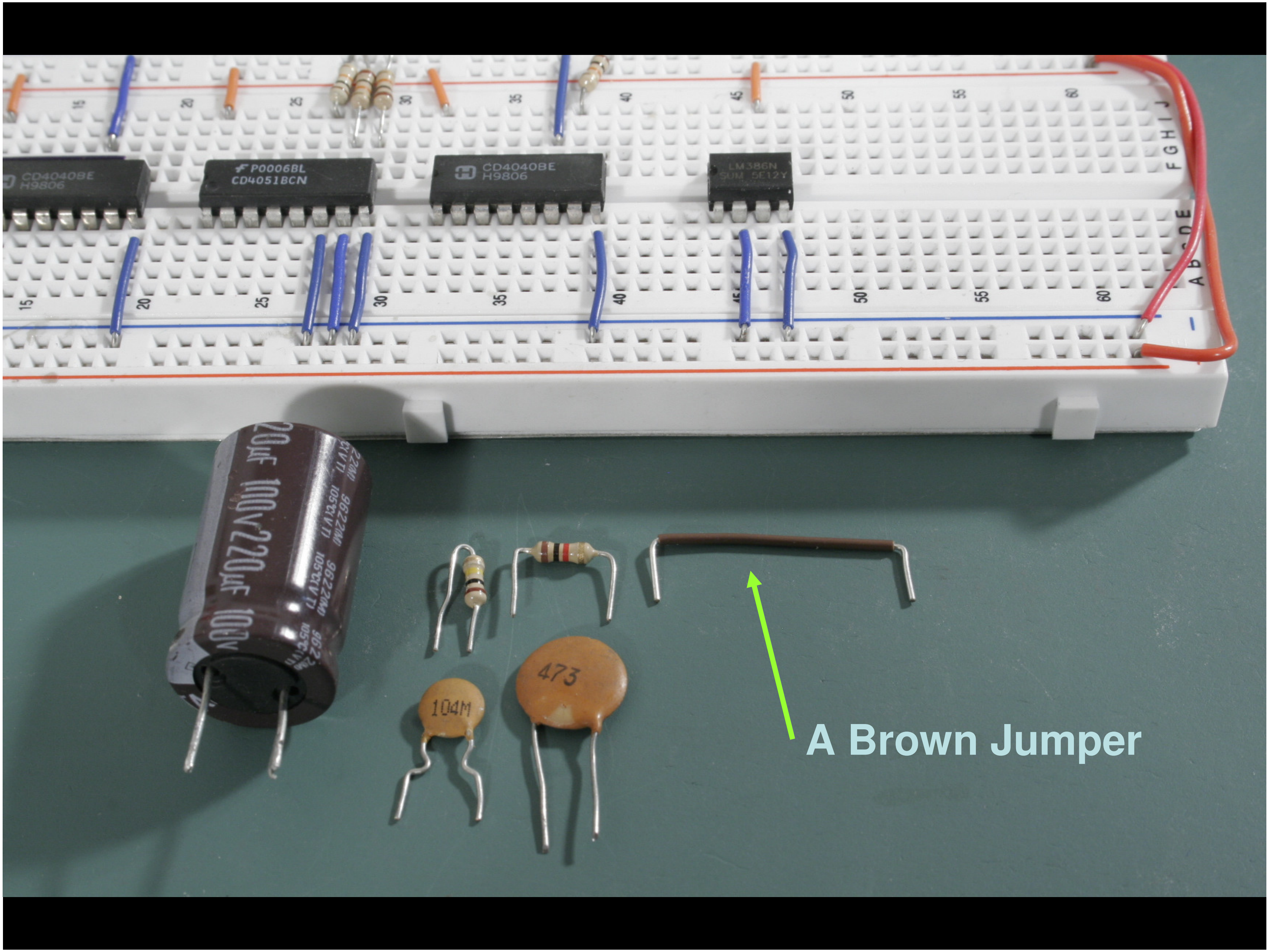

CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
220µF 100V
473
104M
220 uF Capacitor


.1 uF capacitor
CD4040BE
H9806
P0006BL
CD4051BCN
LM386N
104M
473
220uF 100V

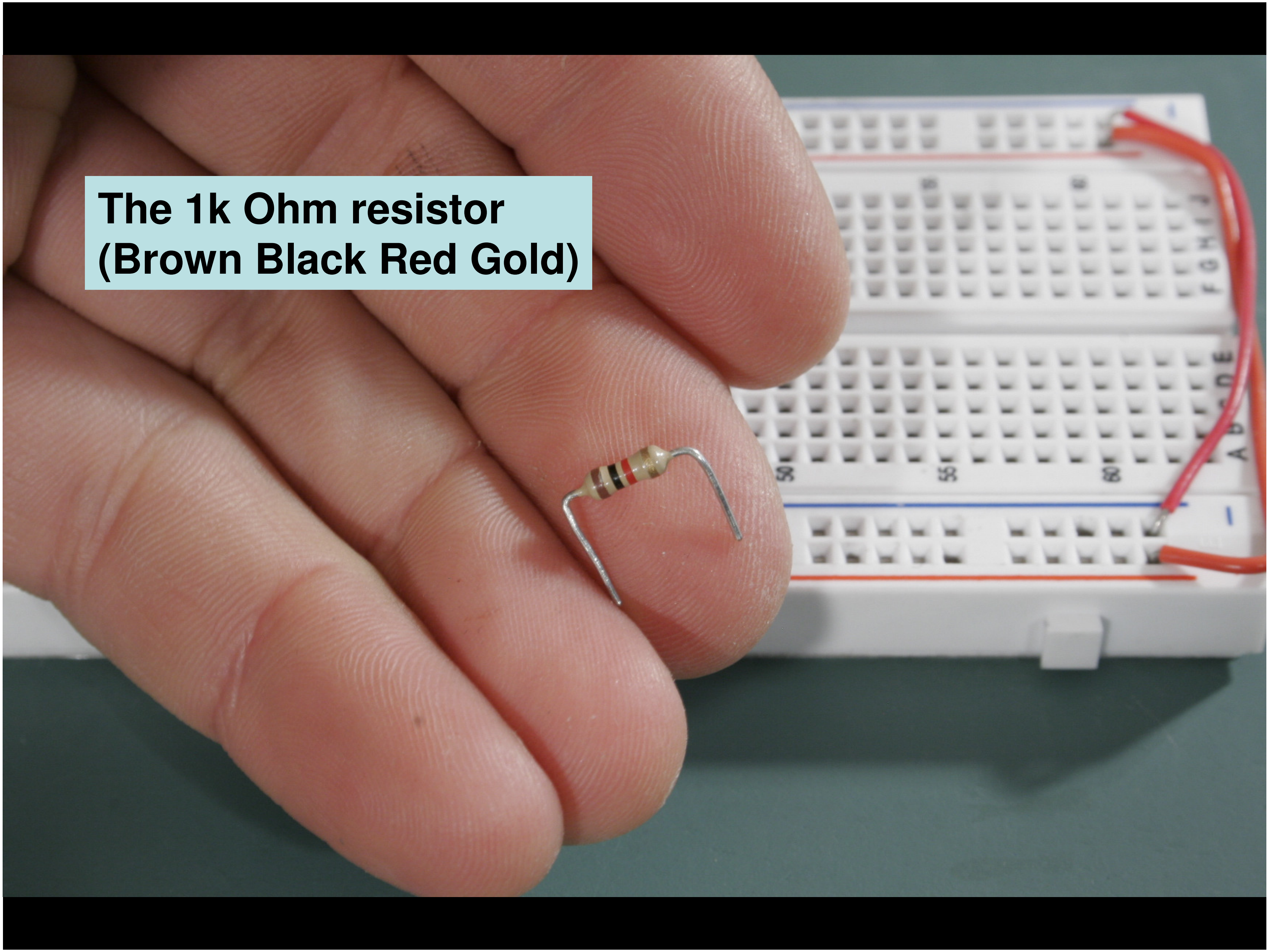

.047 uF capacitor
CD4040BE
H9806
P0006BL
CD4051BCN
LM386N
473
104M
100V 220uF

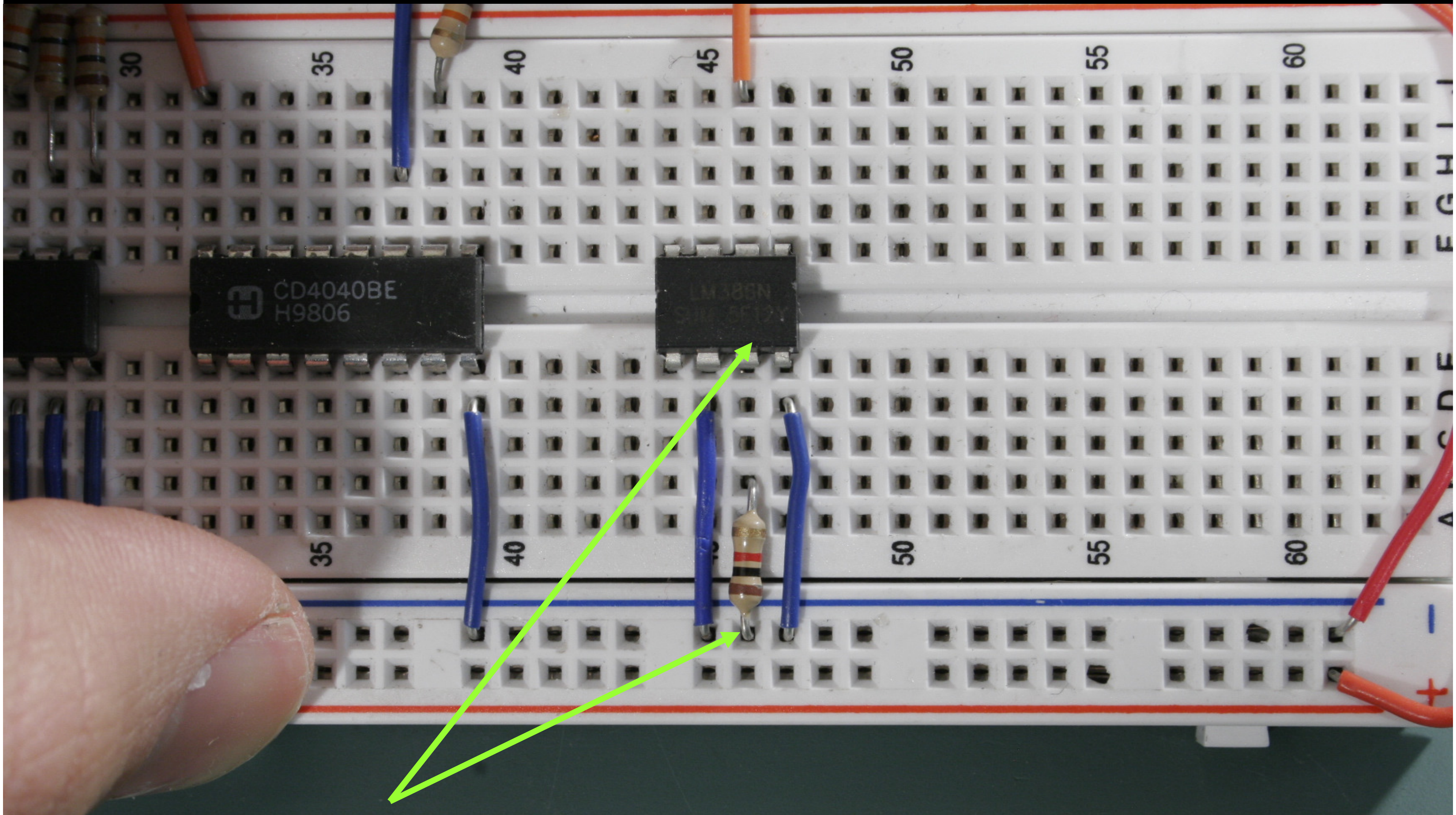

100k ohm resistor
CD4040BE
H9806
P0006BL
CD4051BCN
LM386N
104M
473
220µF 100V


1k ohm resistor
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
LM386N
473
104M
220µF 100V



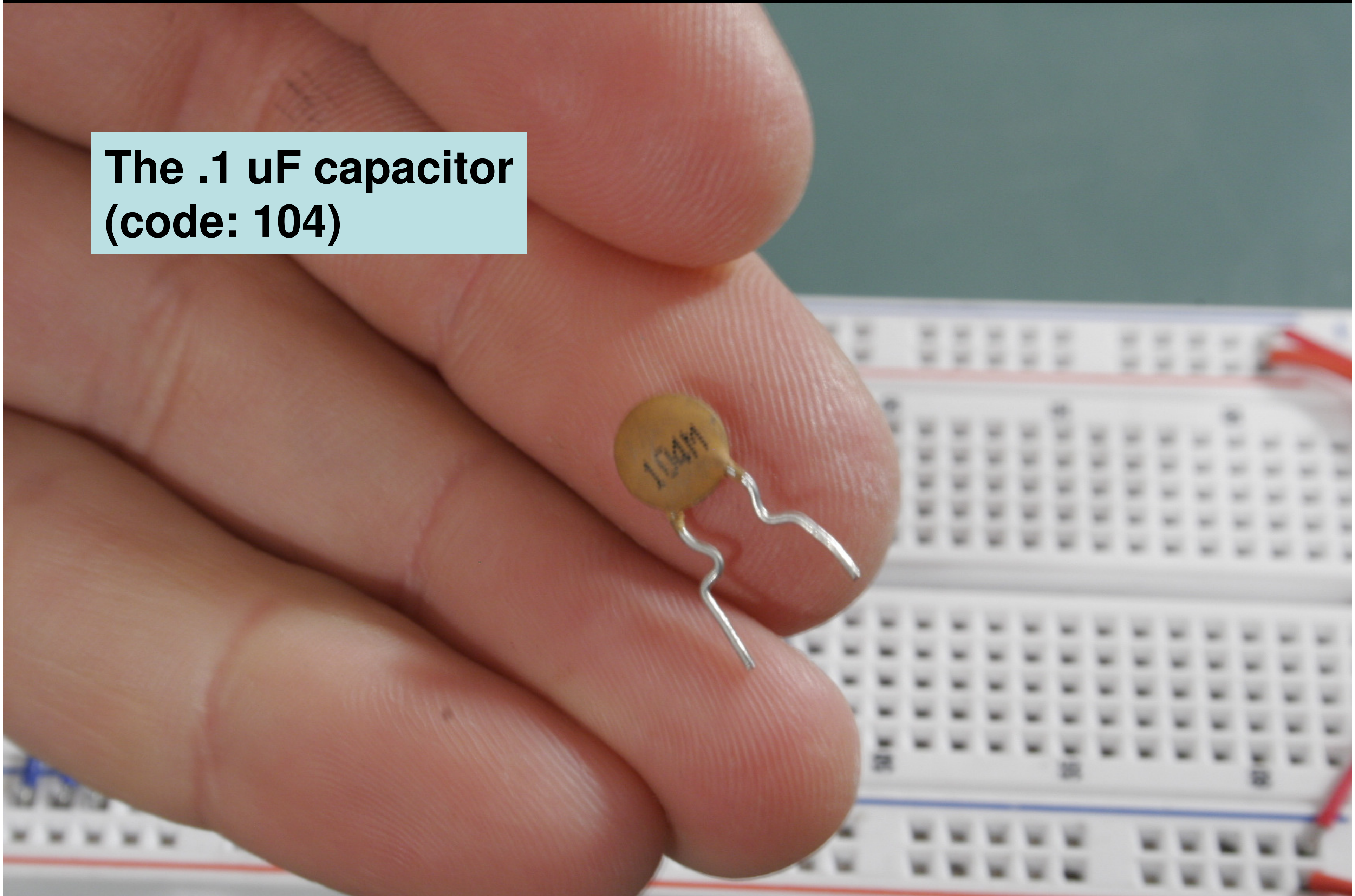
CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
LM386N
100V 220µF
104M
473
A Brown Jumper

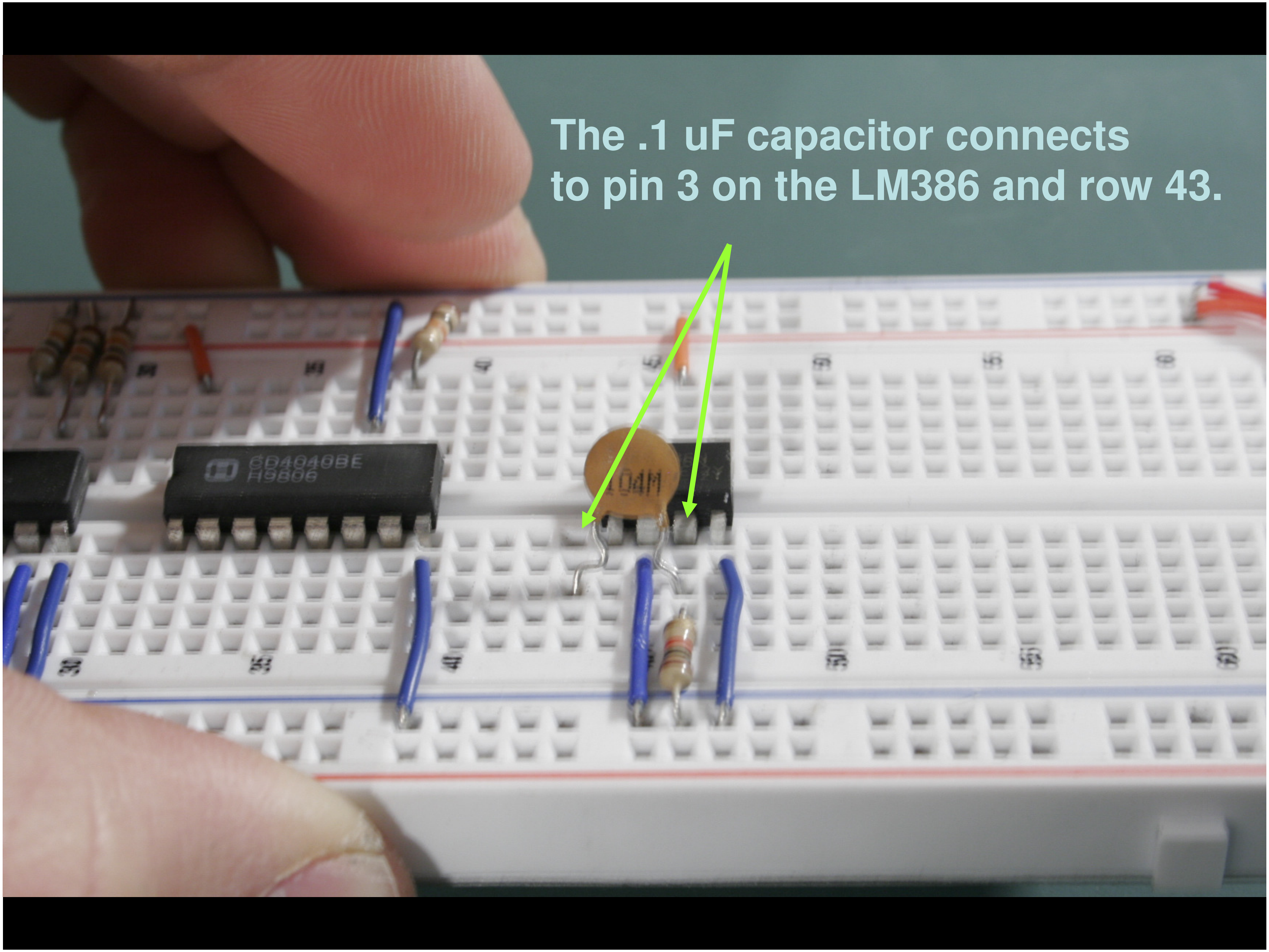

The 1k Ohm resistor
(Brown Black Red Gold)

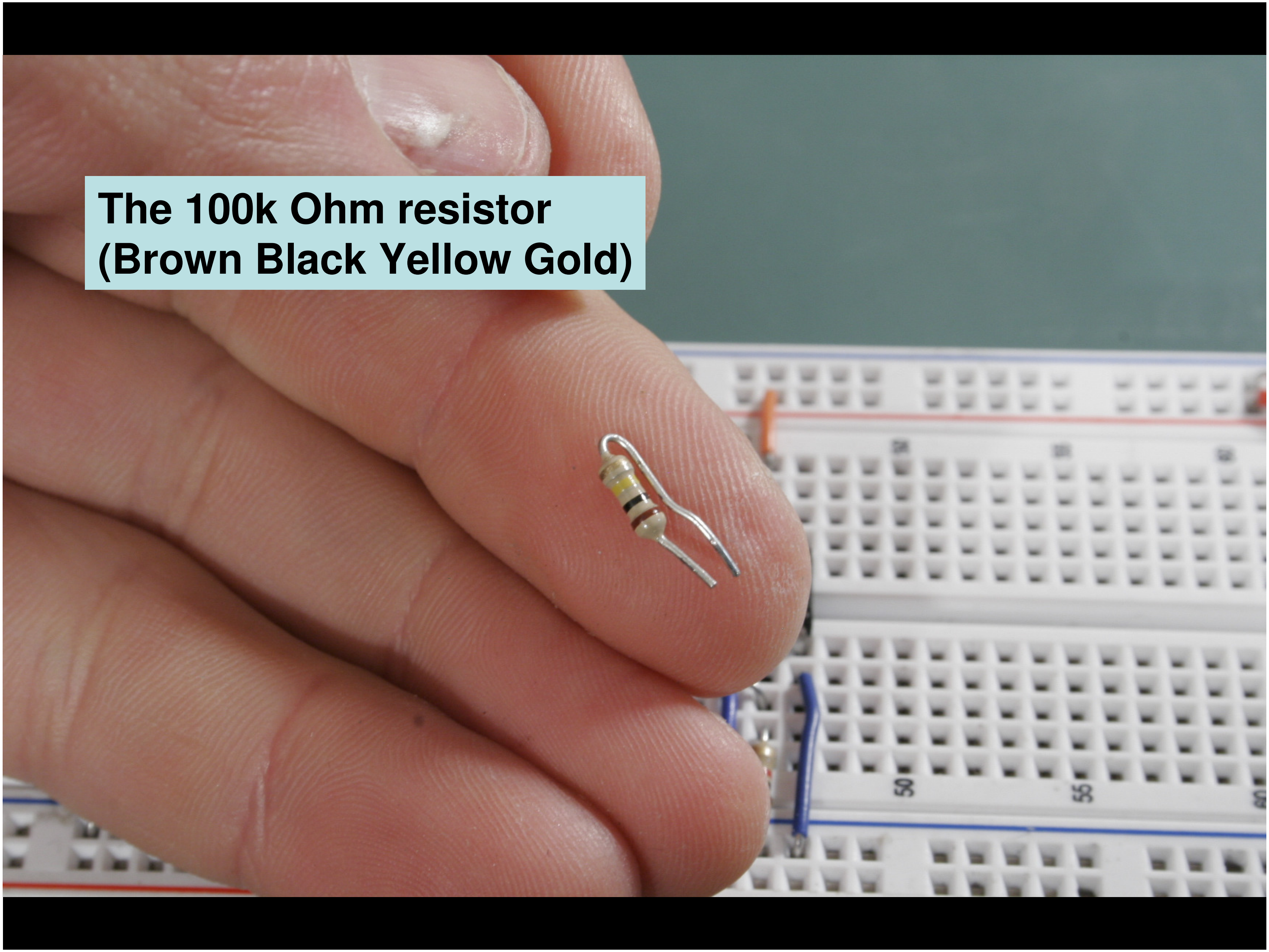


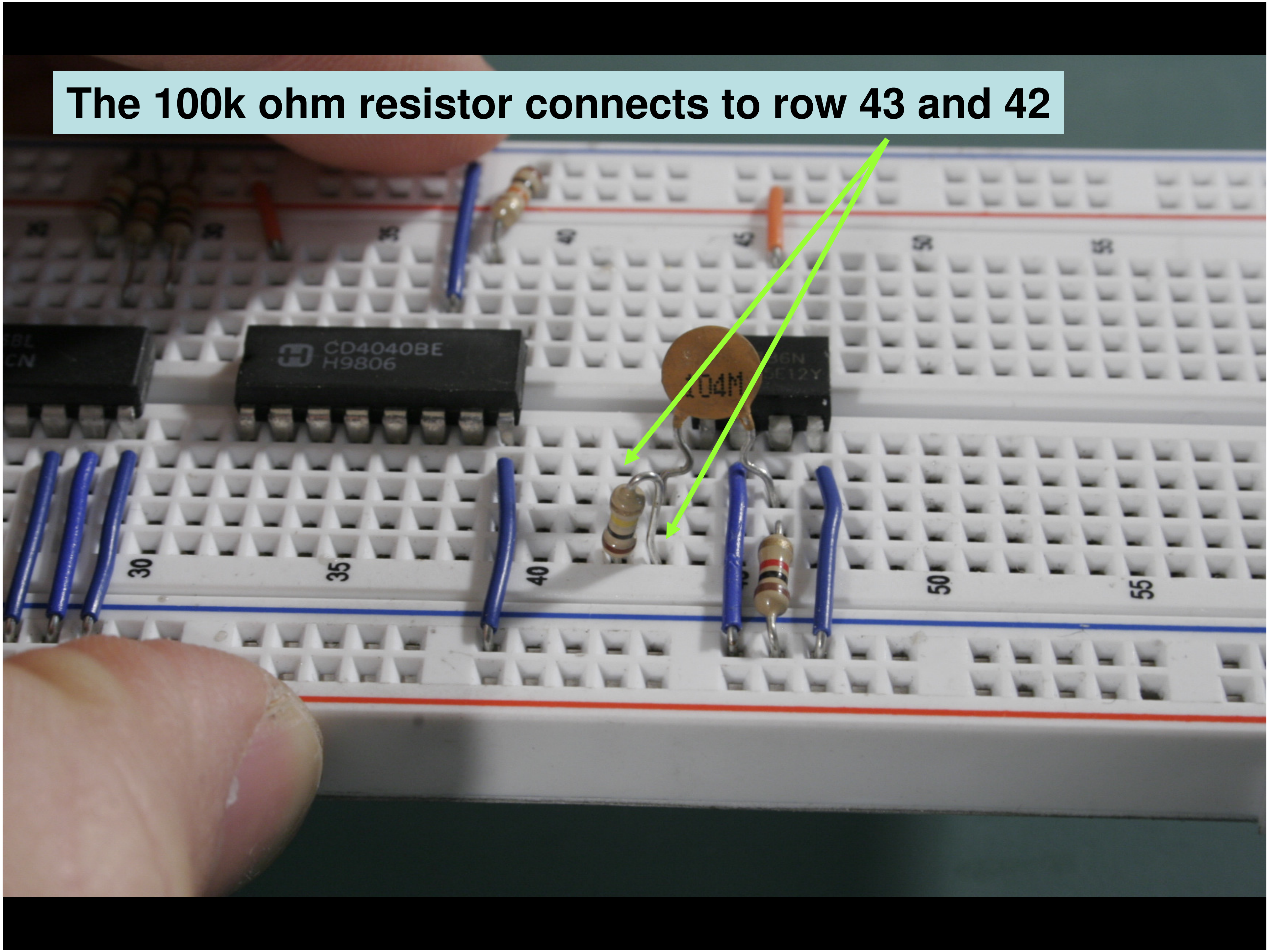
Connect pin 3 of the LM386 to ground through the 1k ohm resistor.

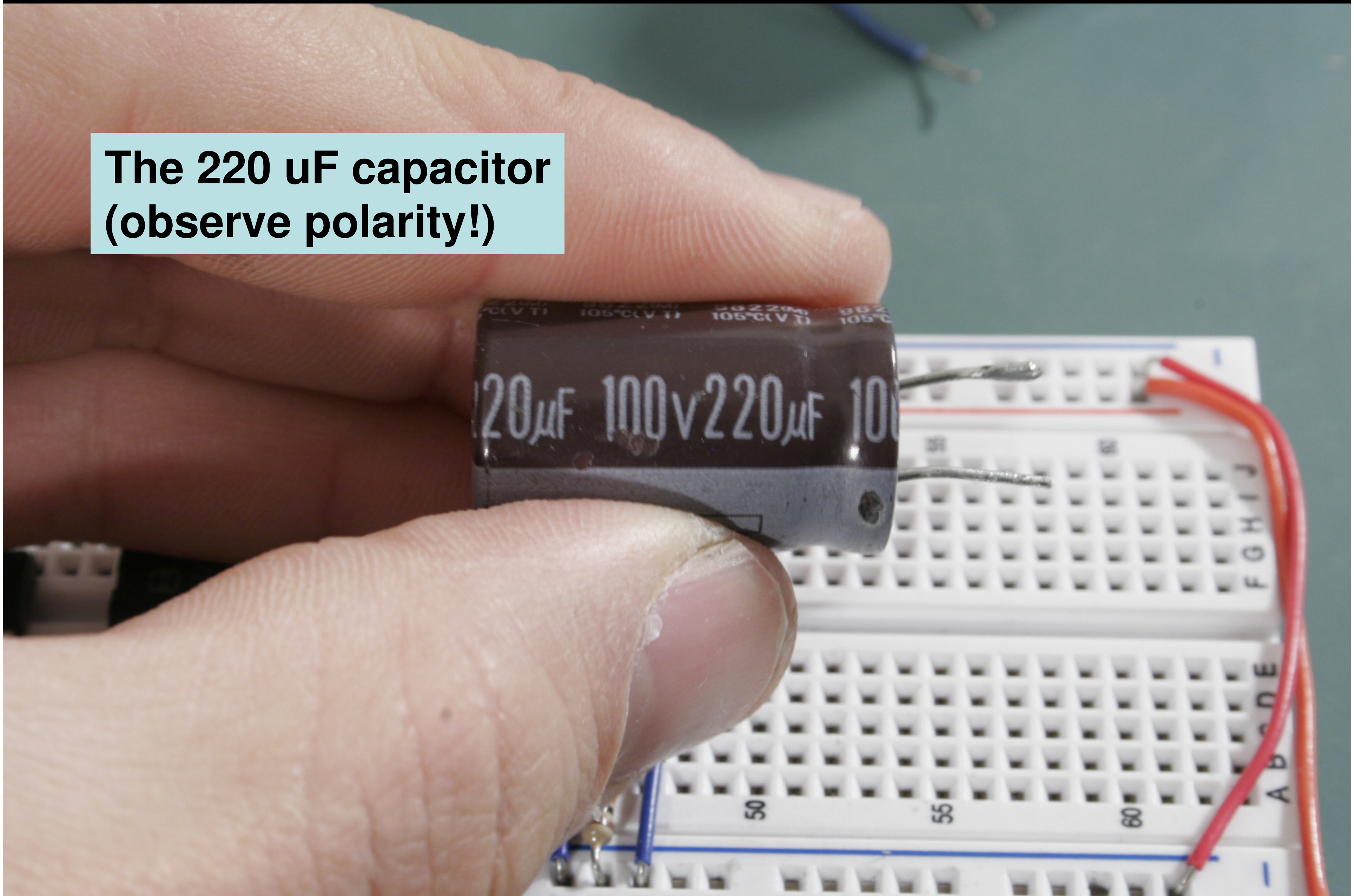
The .1 uF capacitor (code: 104)



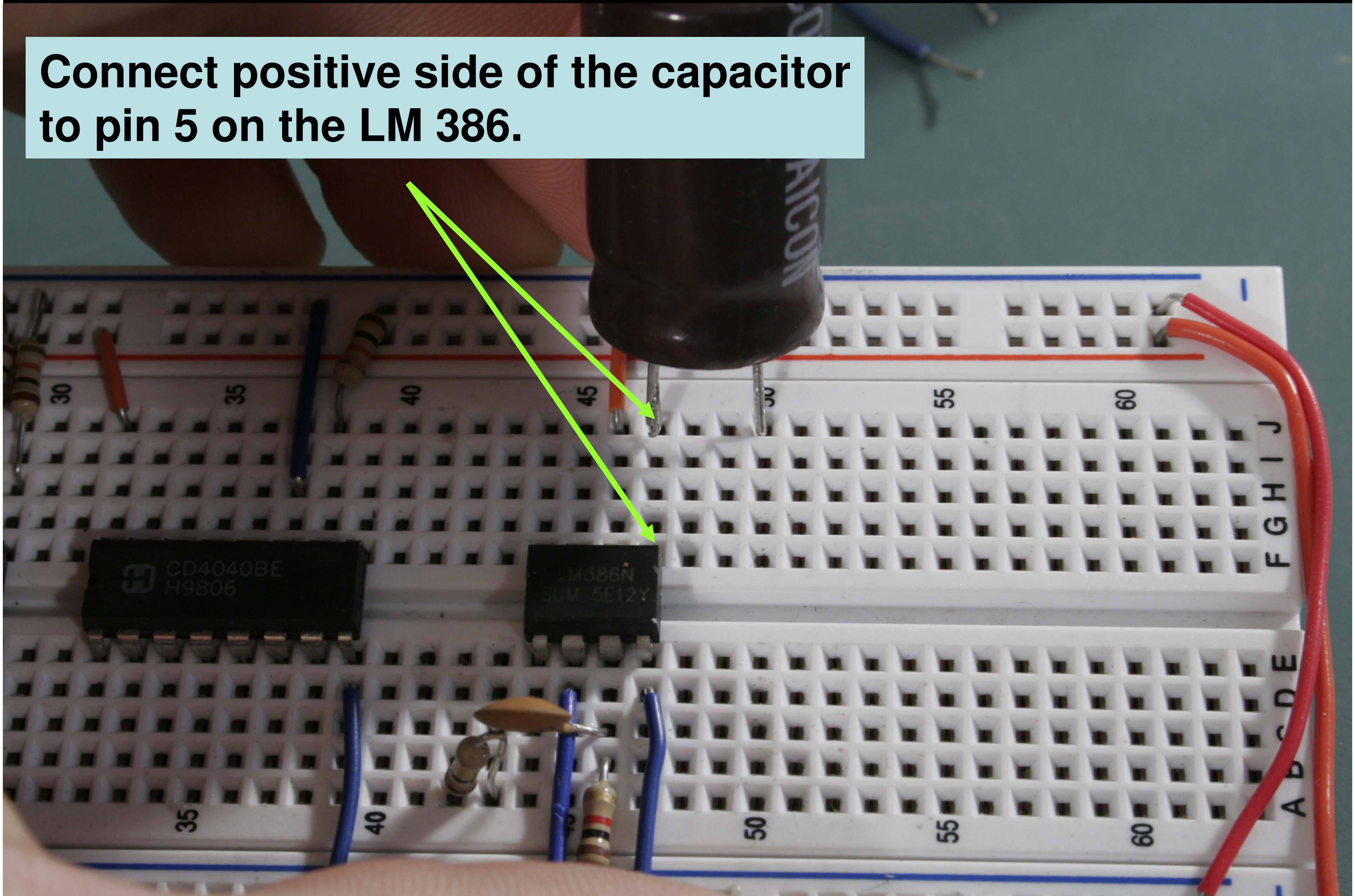

The .1 uF capacitor connects
to pin 3 on the LM386 and row 43.
CD4040BE
H9806
104M

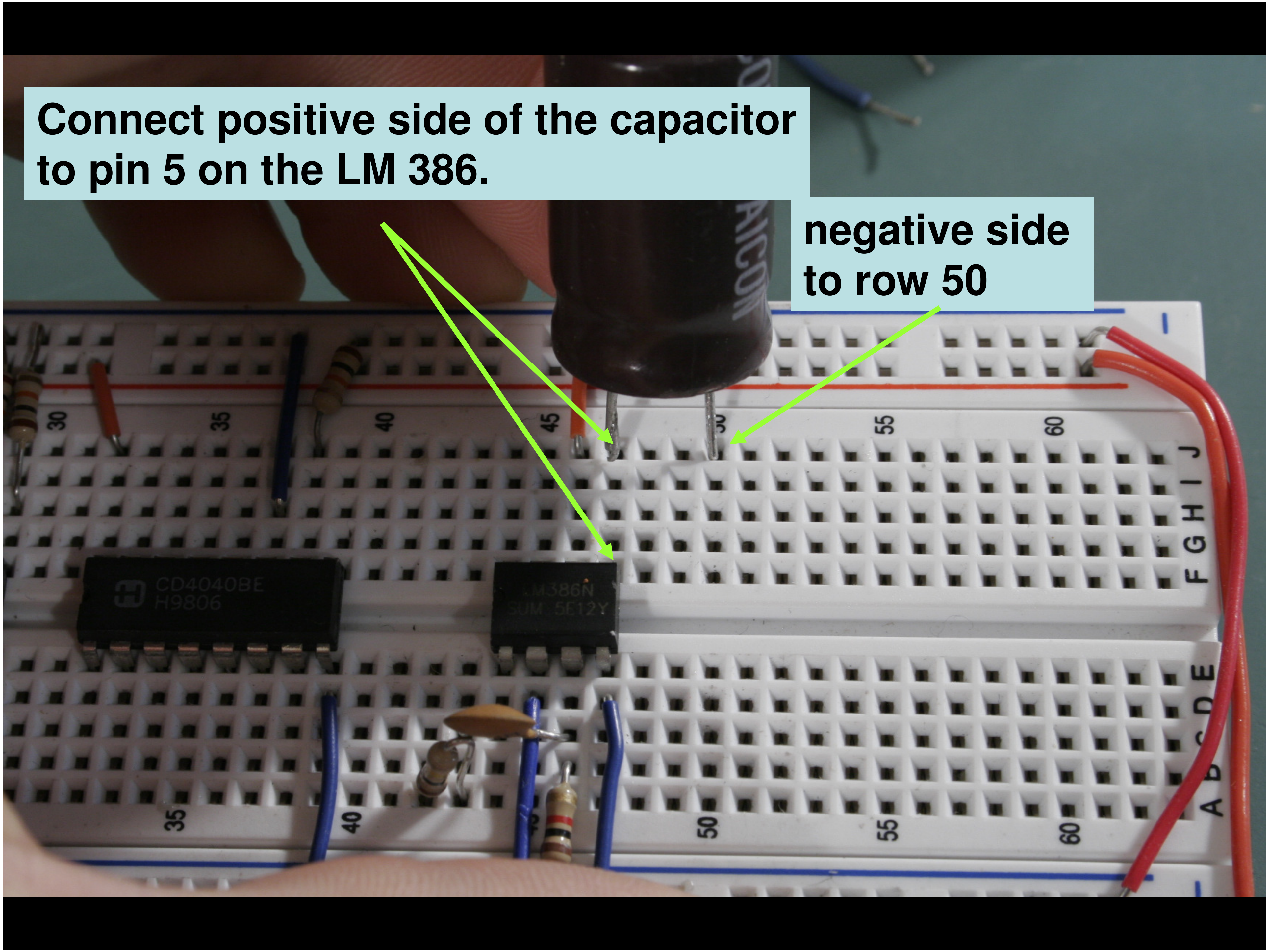

The 100k Ohm resistor
(Brown Black Yellow Gold)

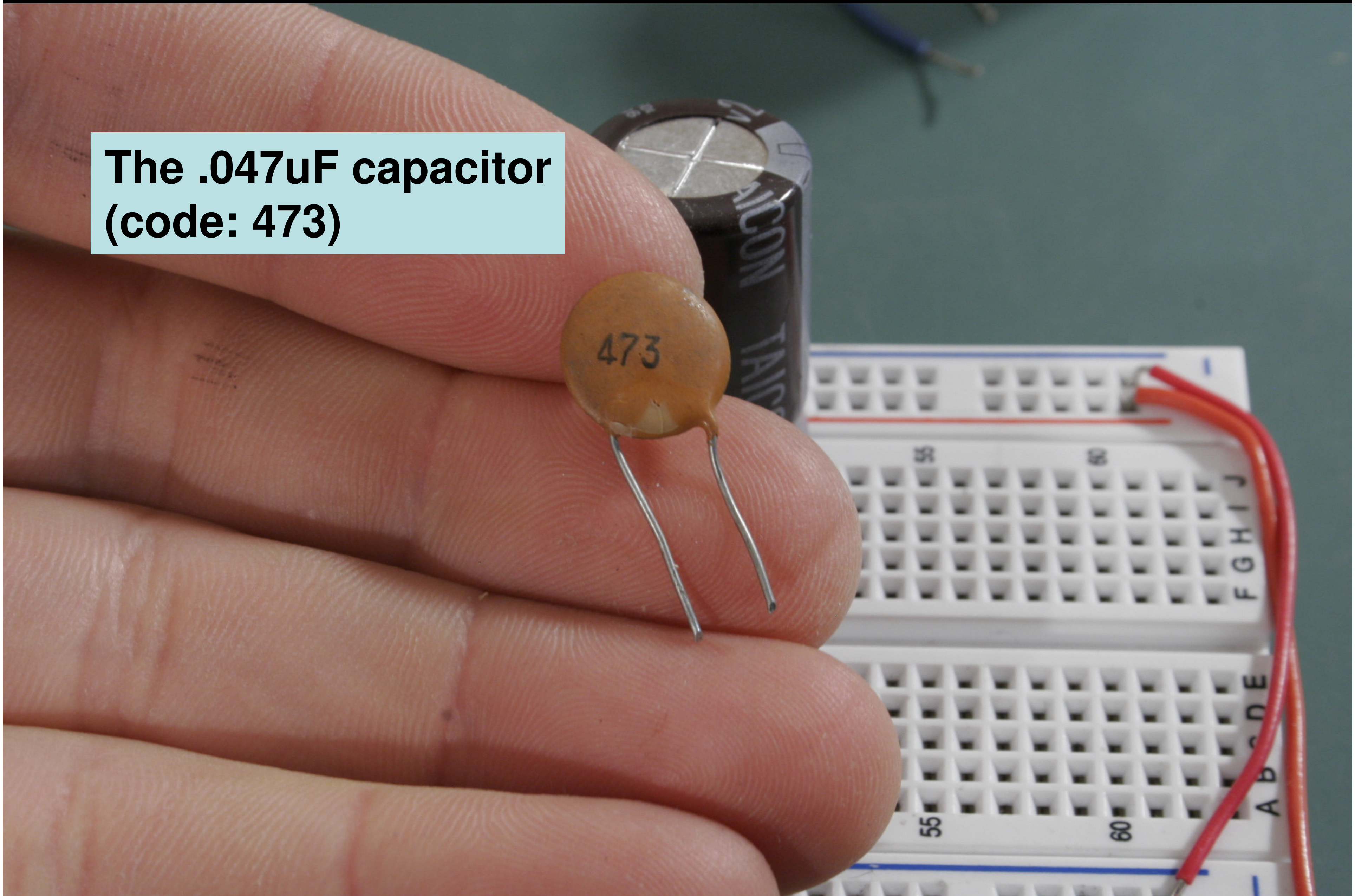

The 100k ohm resistor connects to row 43 and 42
CD4040BE
H9806
104M
30
35
40
50
55


The 220 uF capacitor
(observe polarity!)
220μF 100v 220μF

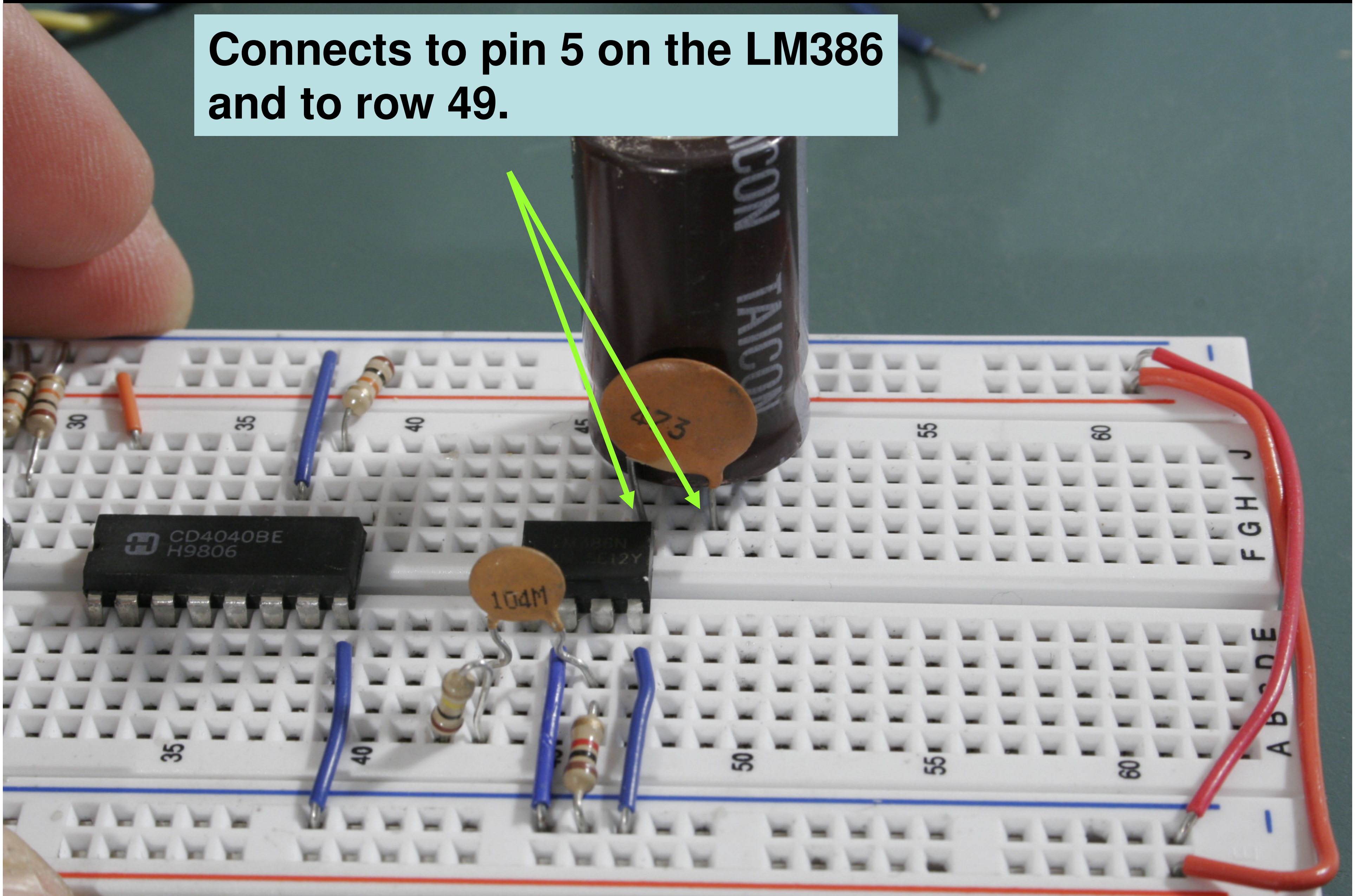
Connect positive side of the capacitor to pin 5 on the LM 386.

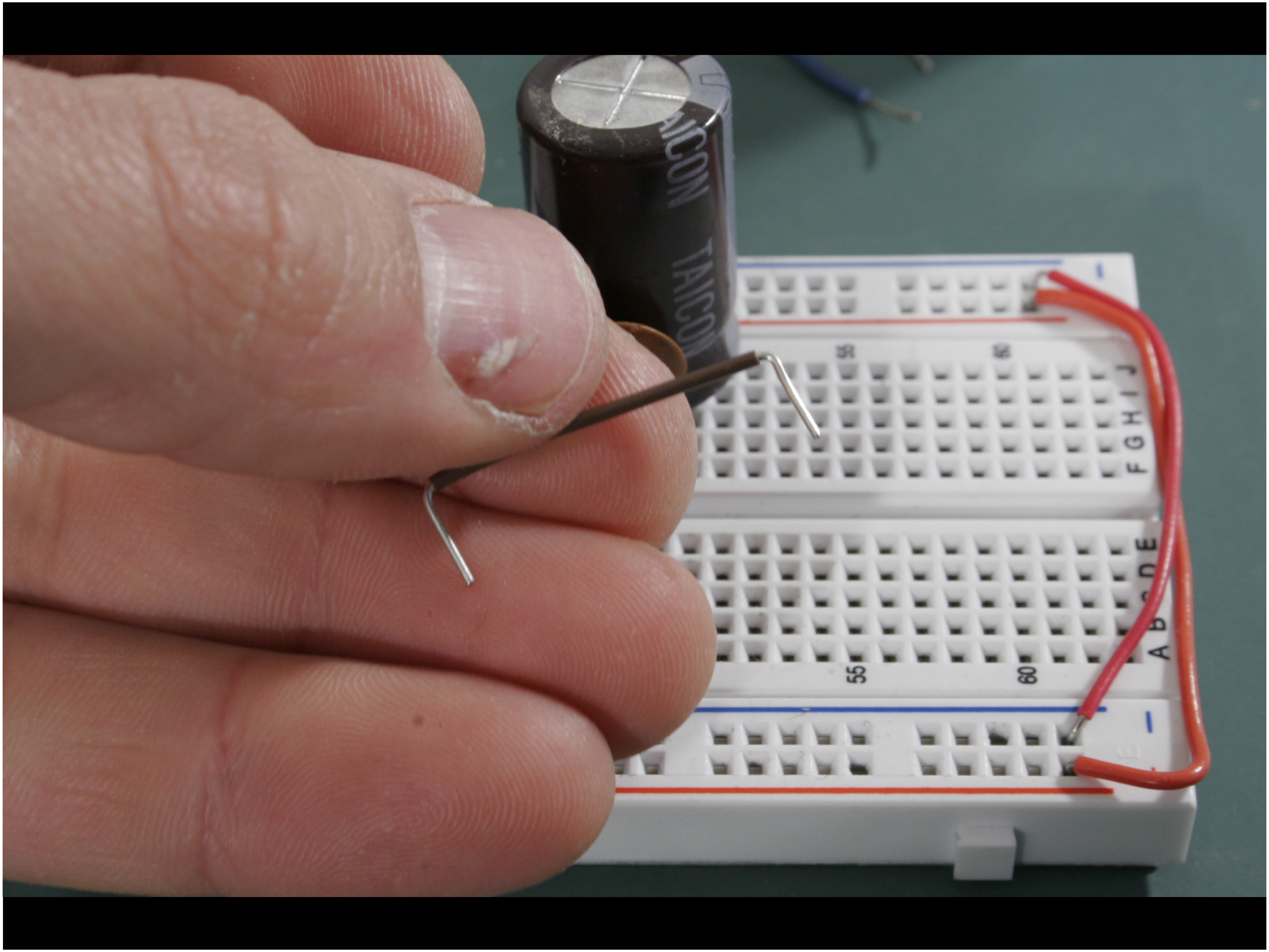


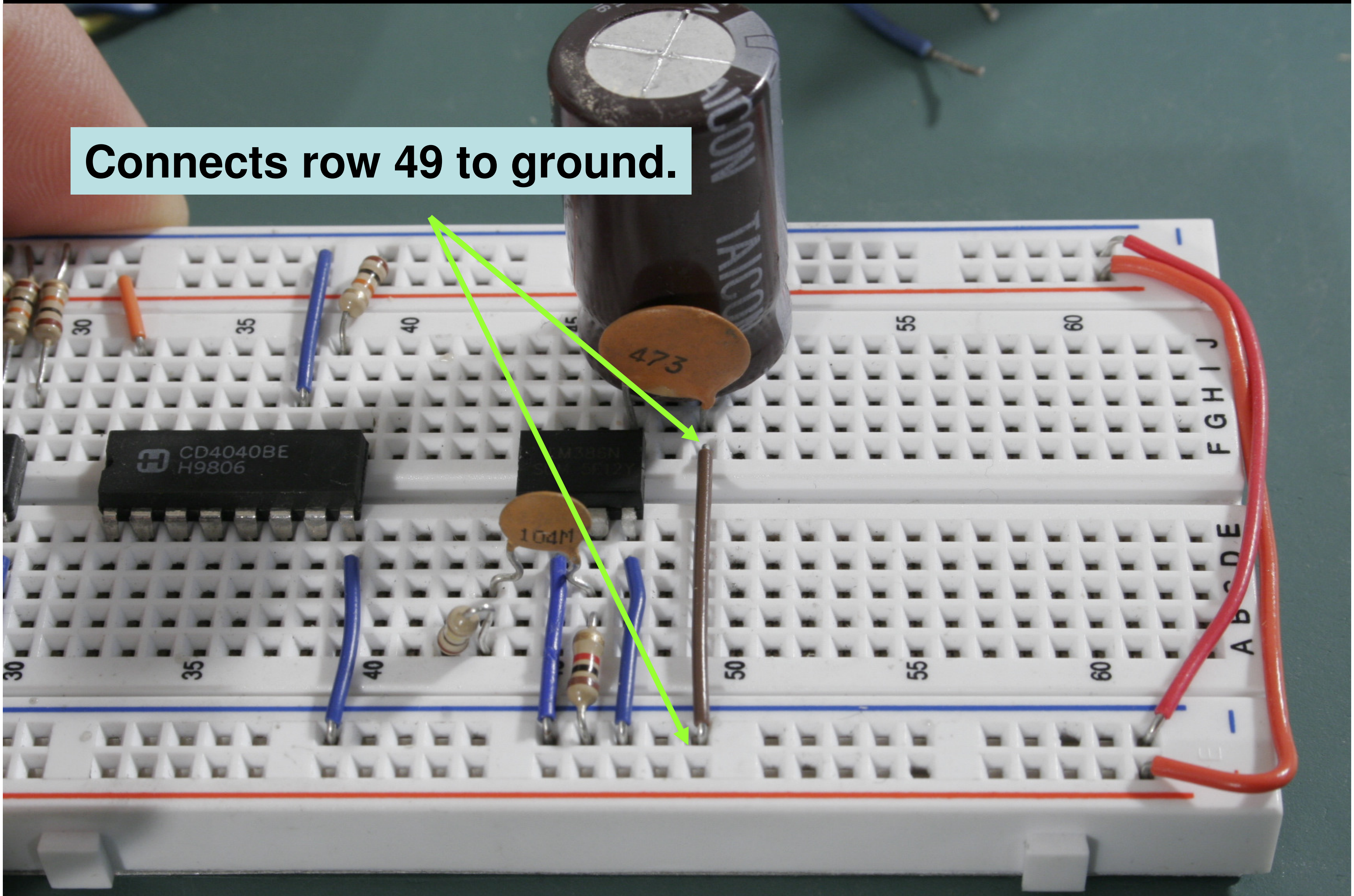

Connect positive side of the capacitor to pin 5 on the LM 386.
negative side to row 50

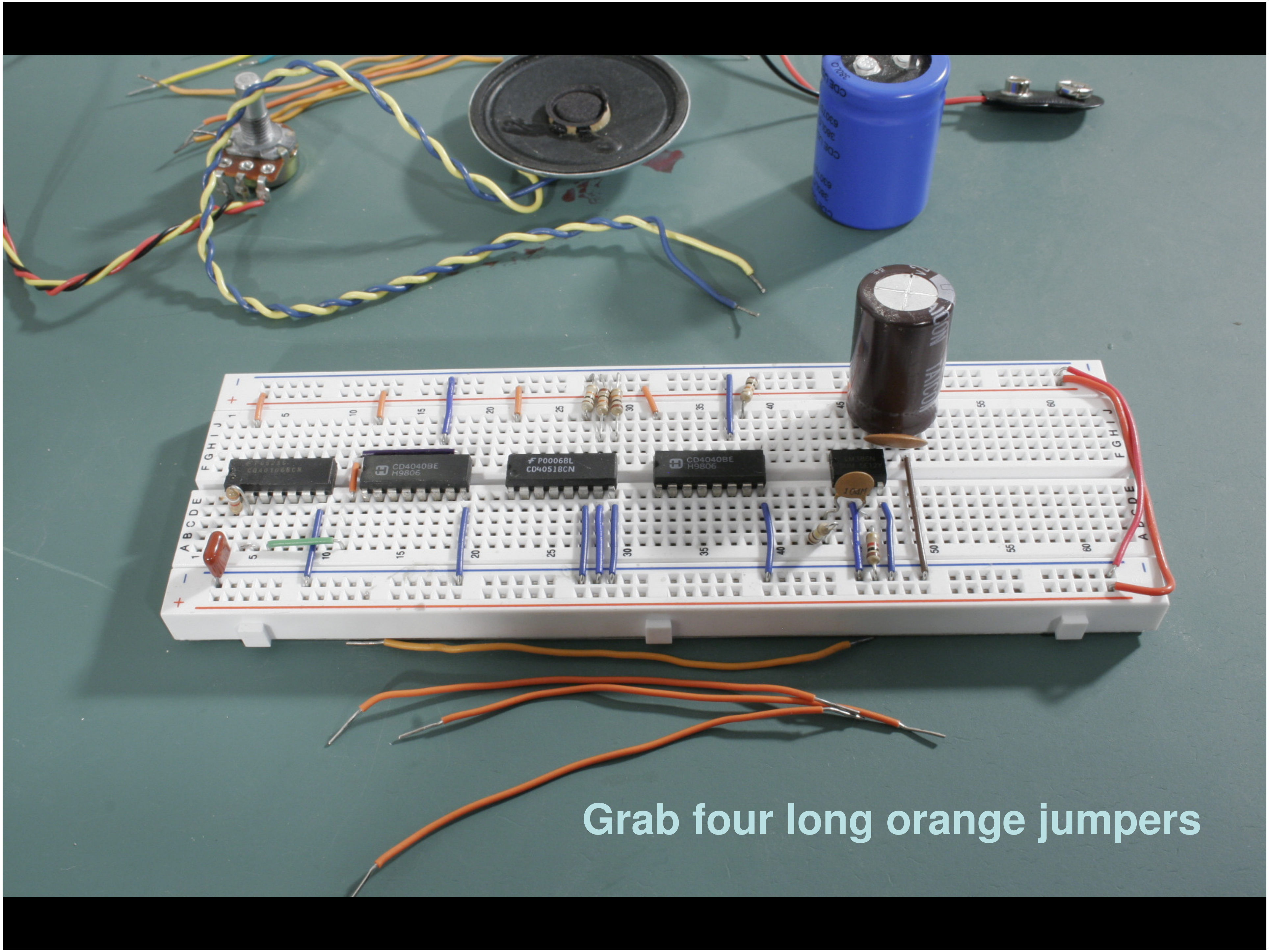

The .047uF capacitor
(code: 473)
473

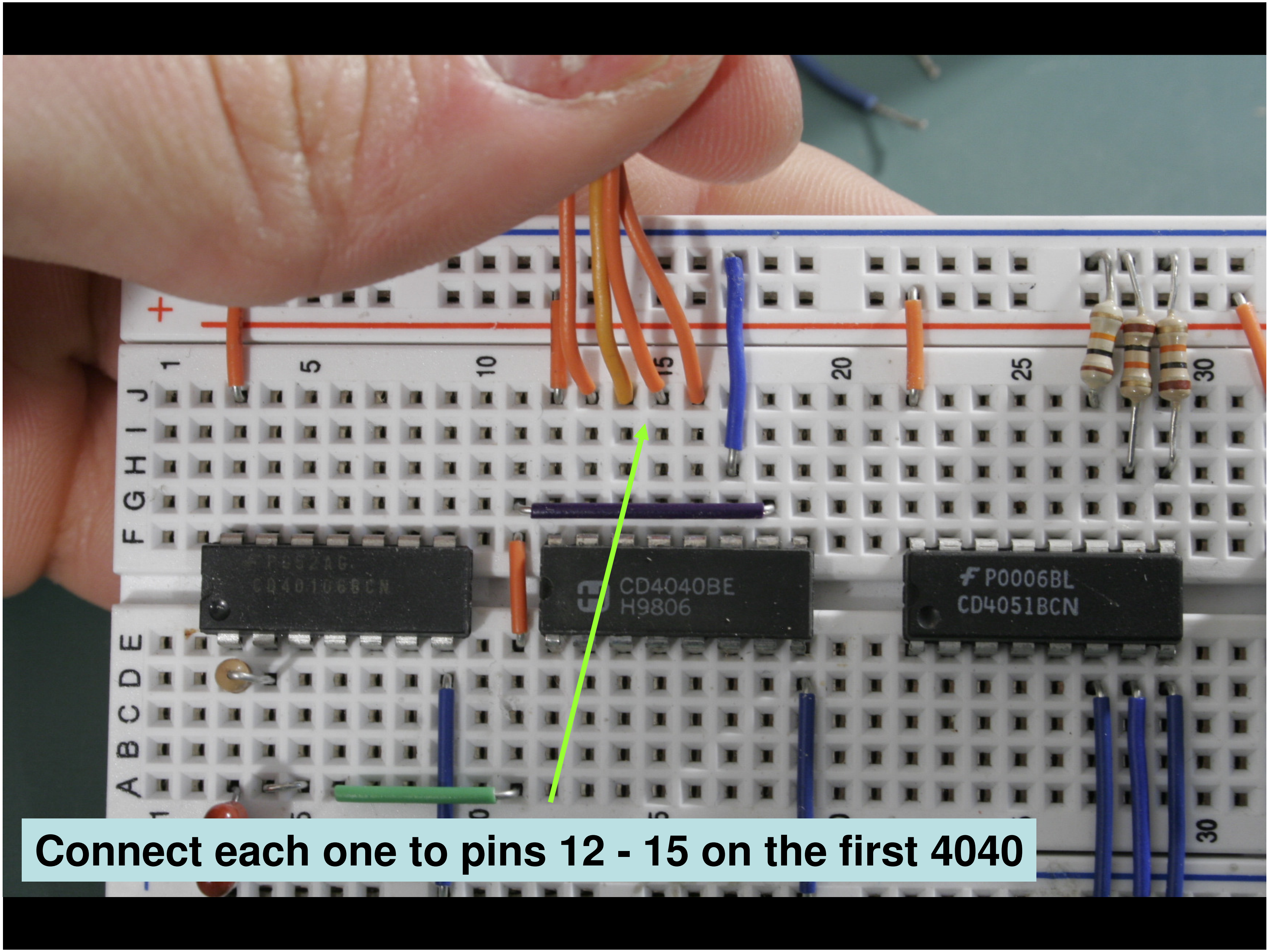
Connects to pin 5 on the LM386 and to row 49.

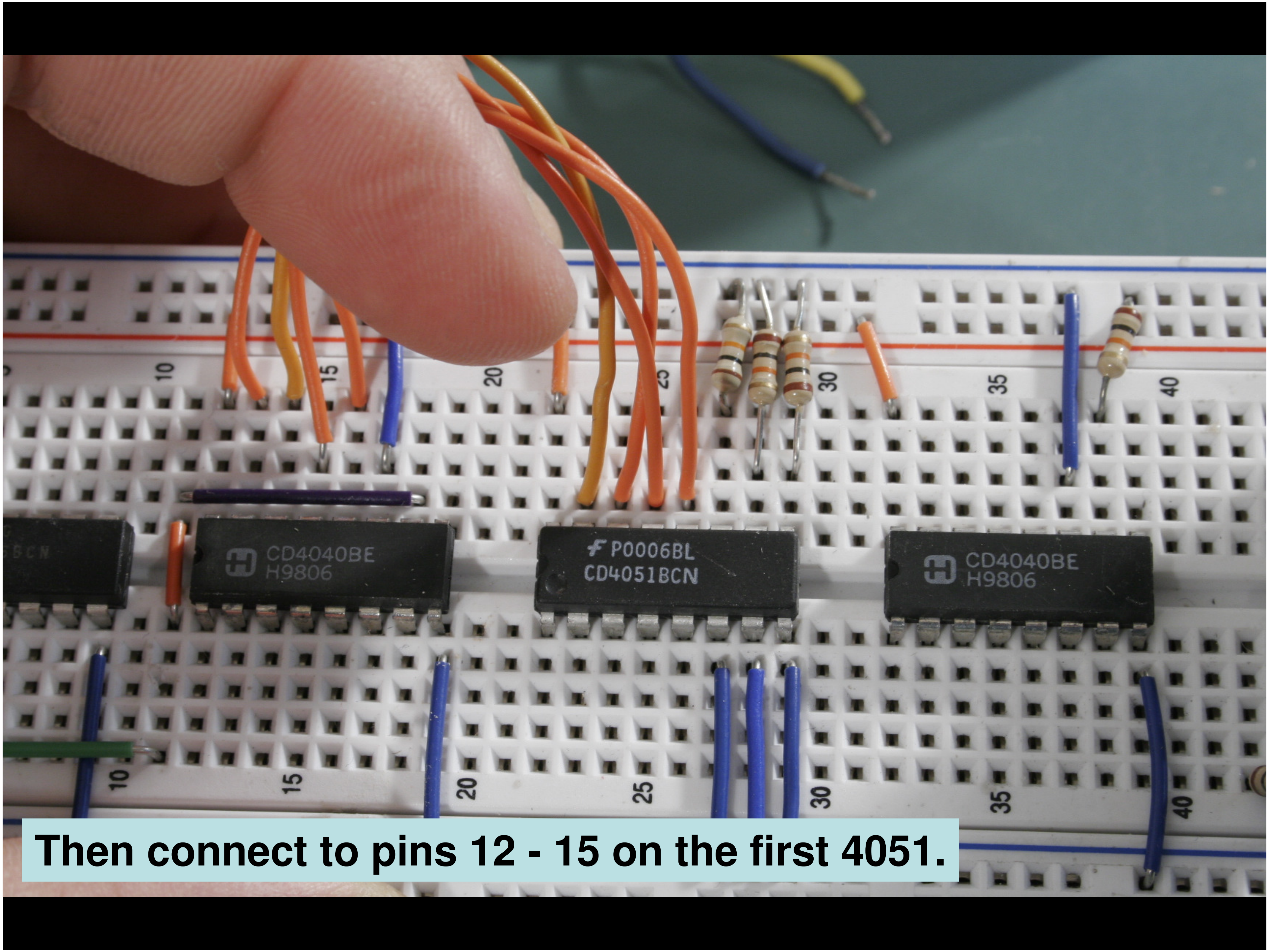



TAICON
55
60

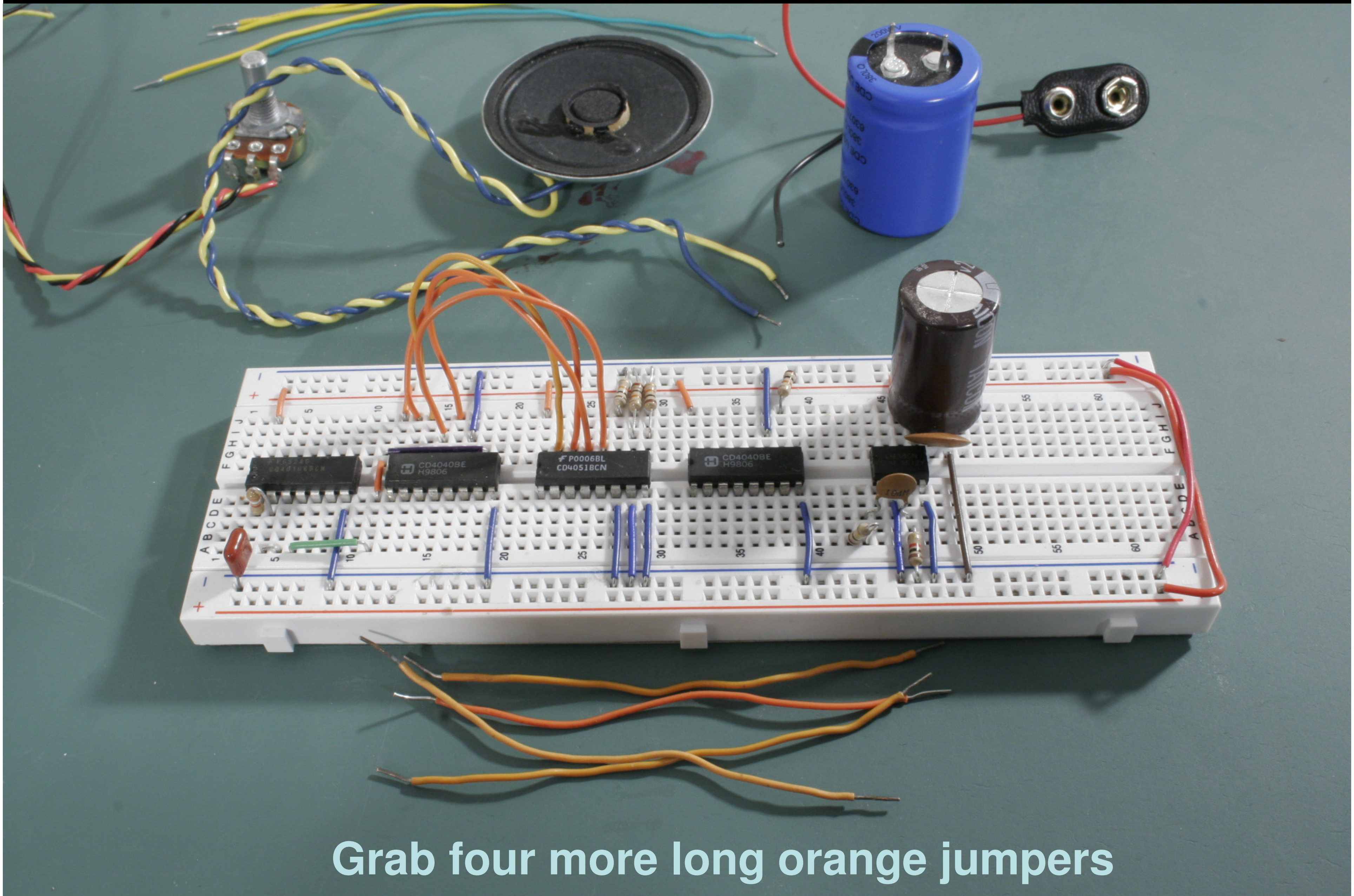

Connects row 49 to ground.
CD4040BE
H9806
473
104M


CD4040BE
H9806
P0006BL
CD4051BCN
CD4040BE
H9806
Grab four long orange jumpers

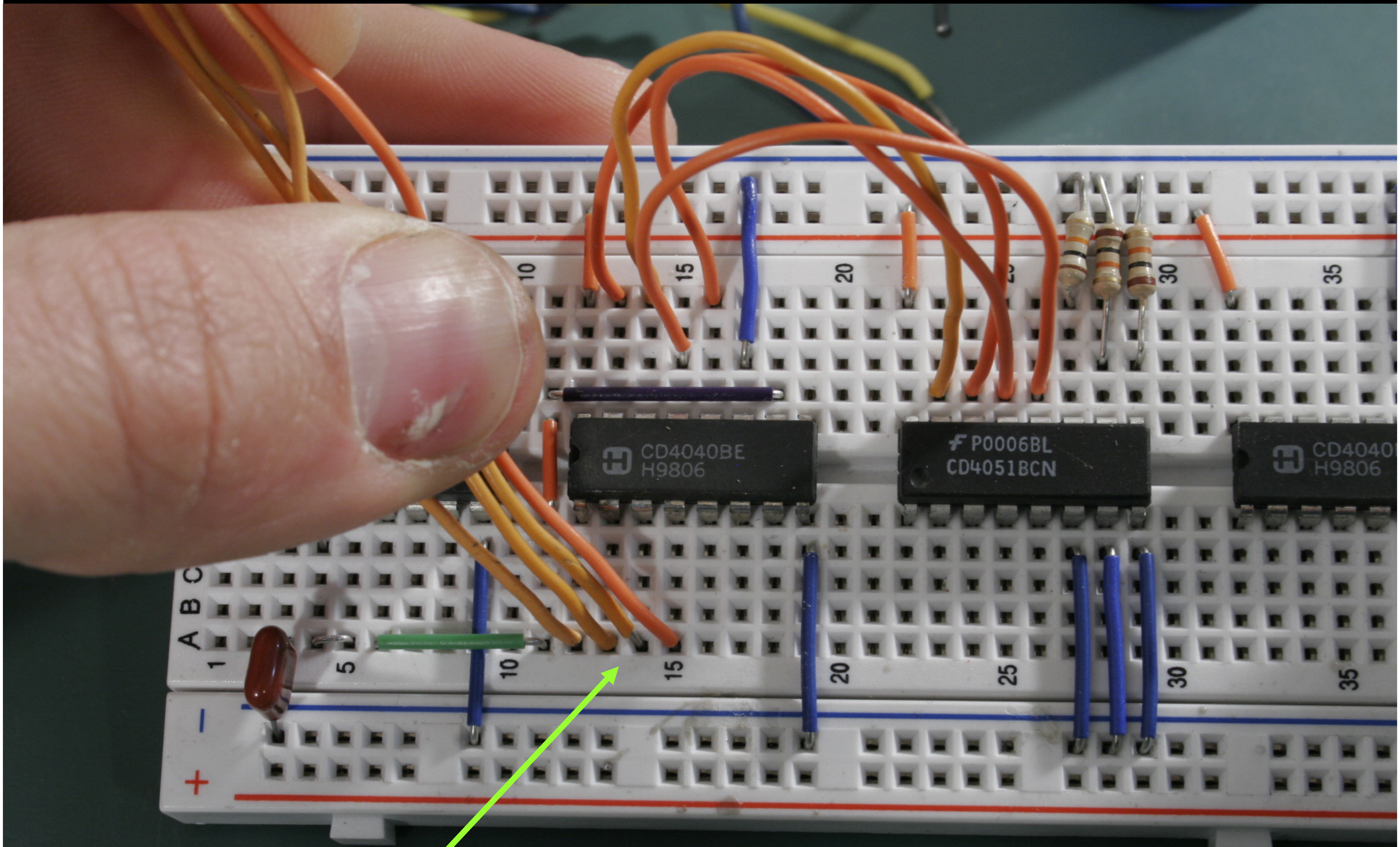

CD40106BCN
CD4040BE
H9806
P0006BL
CD4051BCN
Connect each one to pins 12 - 15 on the first 4040



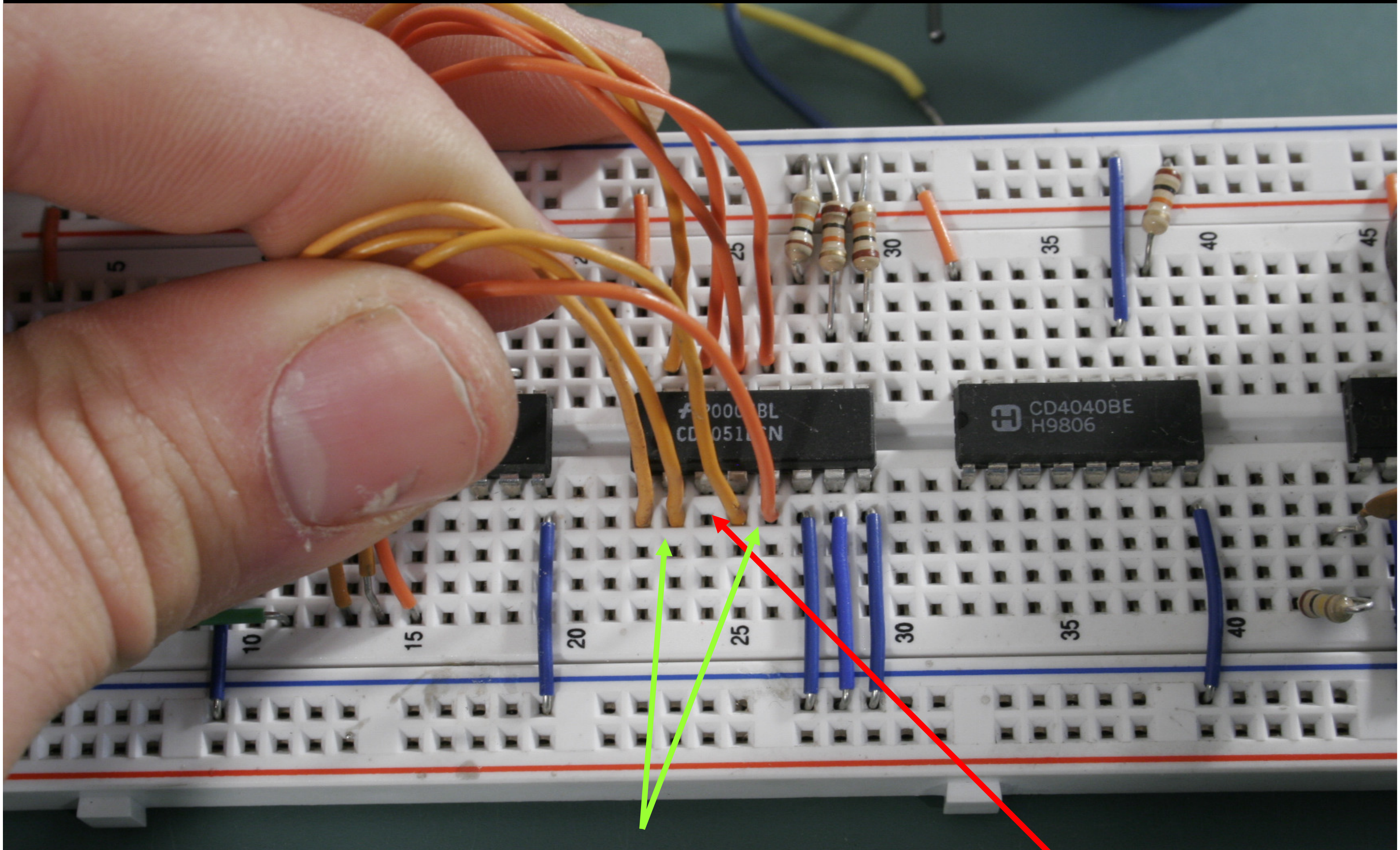
Then connect to pins 12 - 15 on the first 4051.



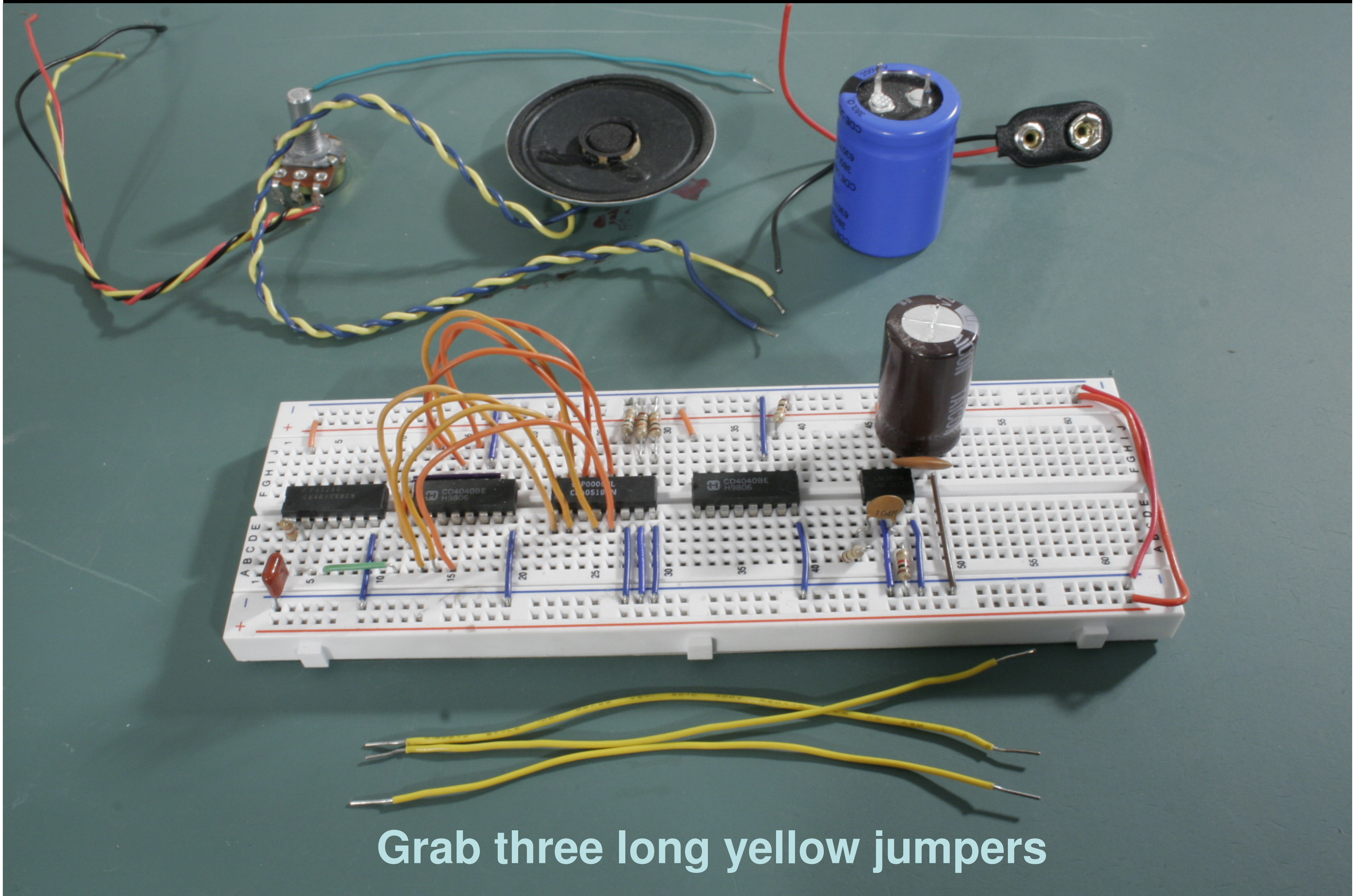
Grab four more long orange jumpers



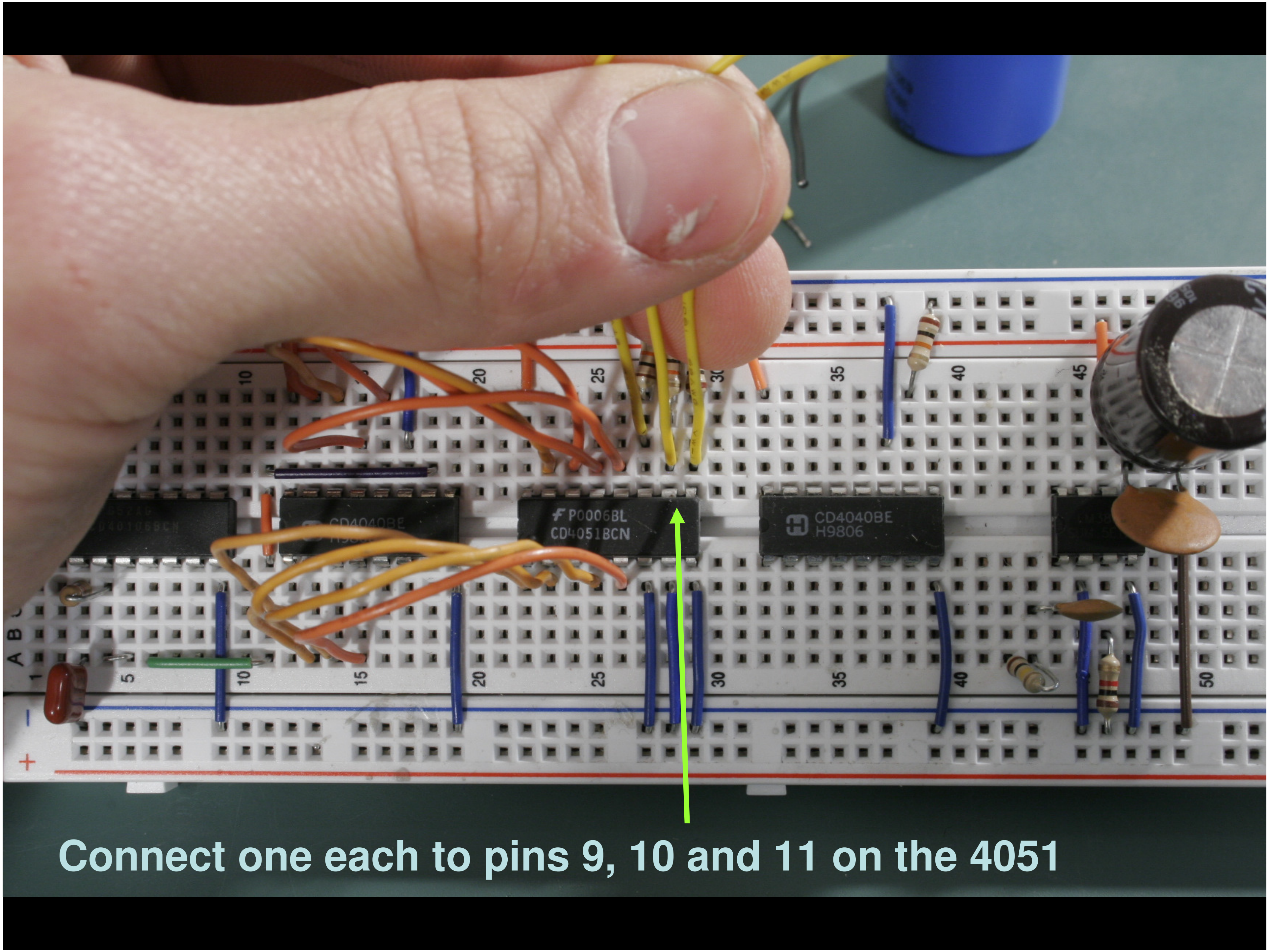
Connect each one to pins 1- 4 on the first 4040

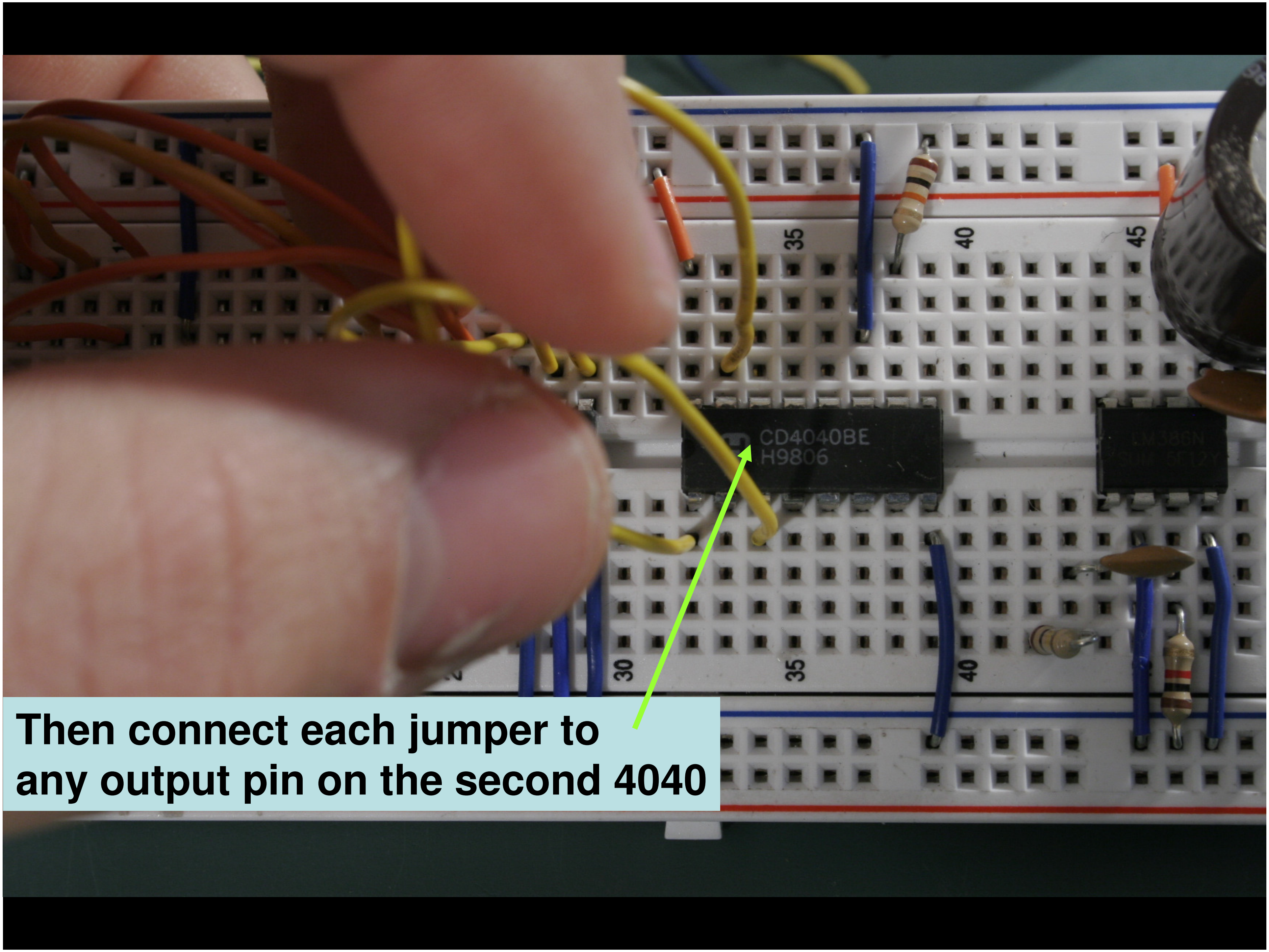


Connect each to pins 1,2, 4, and 5. SKIP PIN 3!

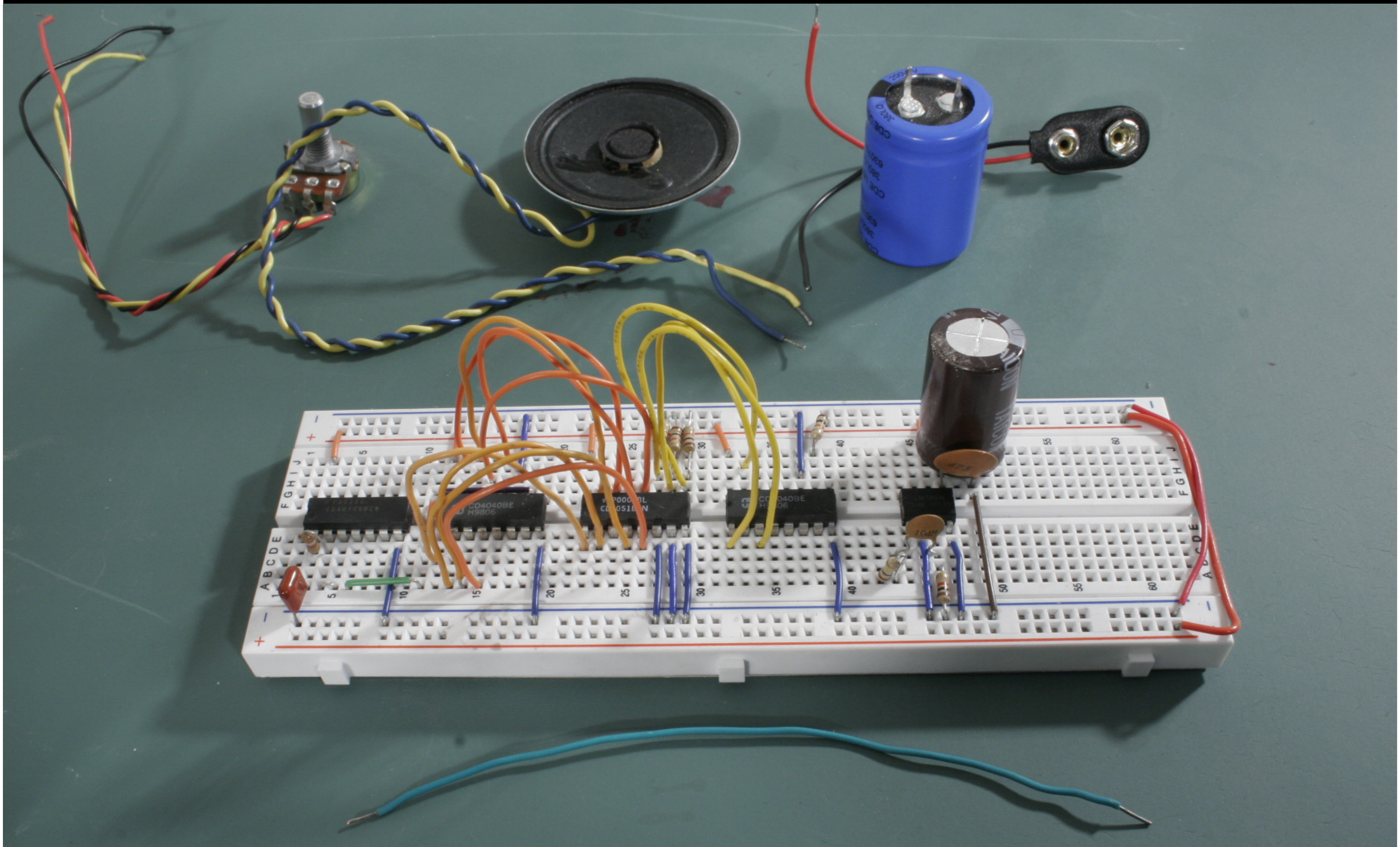


Grab three long yellow jumpers

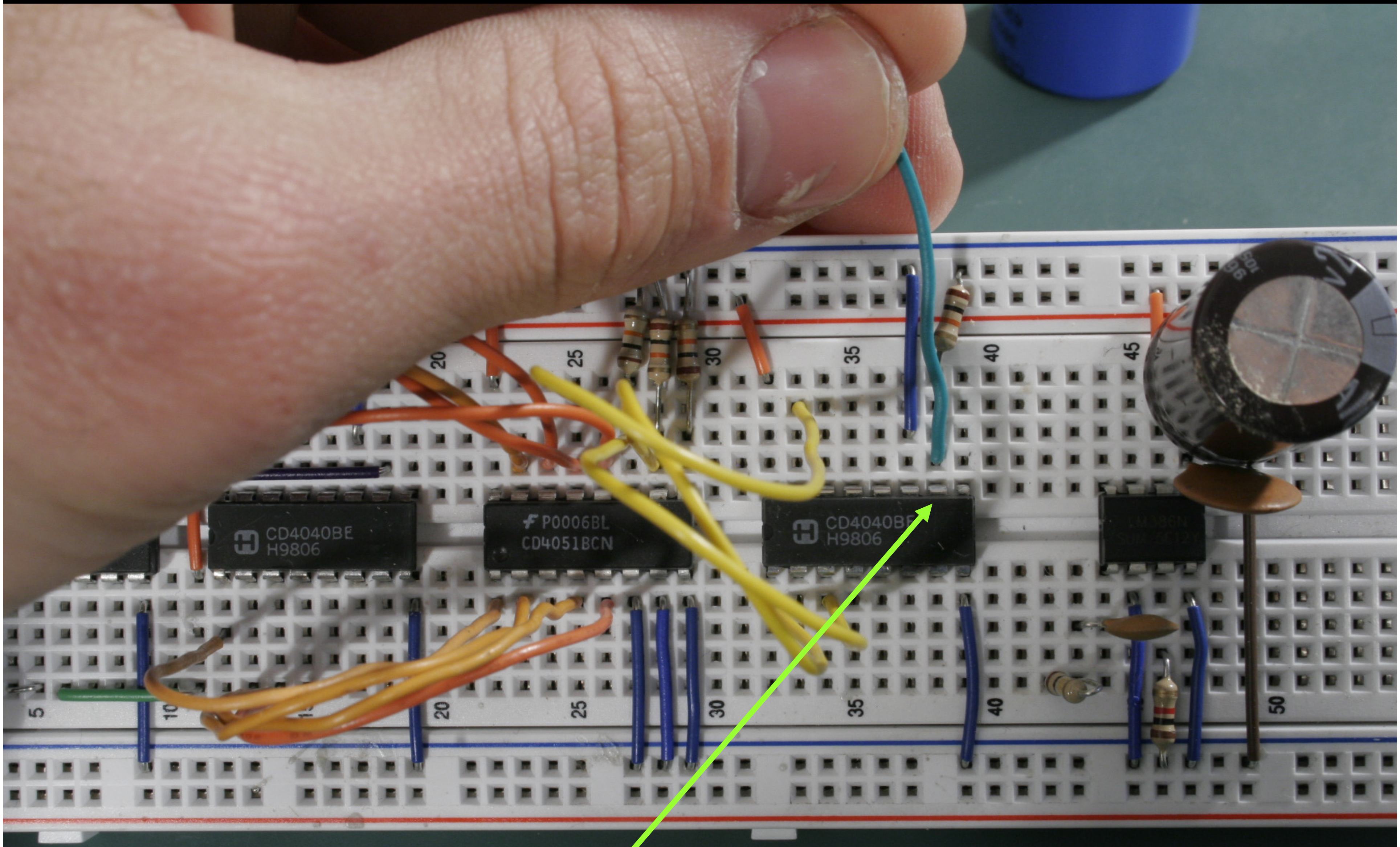

P0006BL
CD4051BCN
CD4040BE
H9806
Connect one each to pins 9, 10 and 11 on the 4051



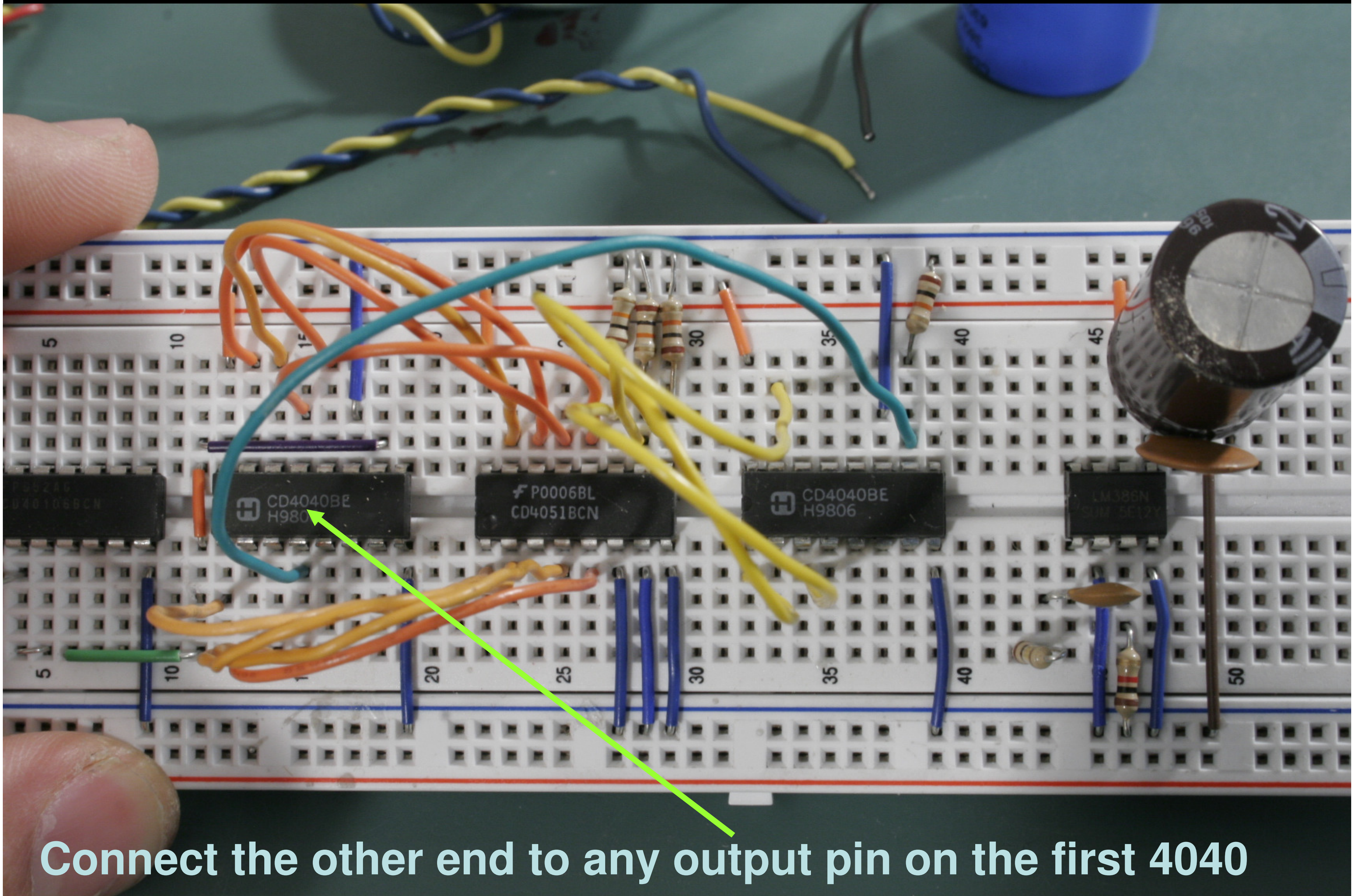
Then connect each jumper to any output pin on the second 4040



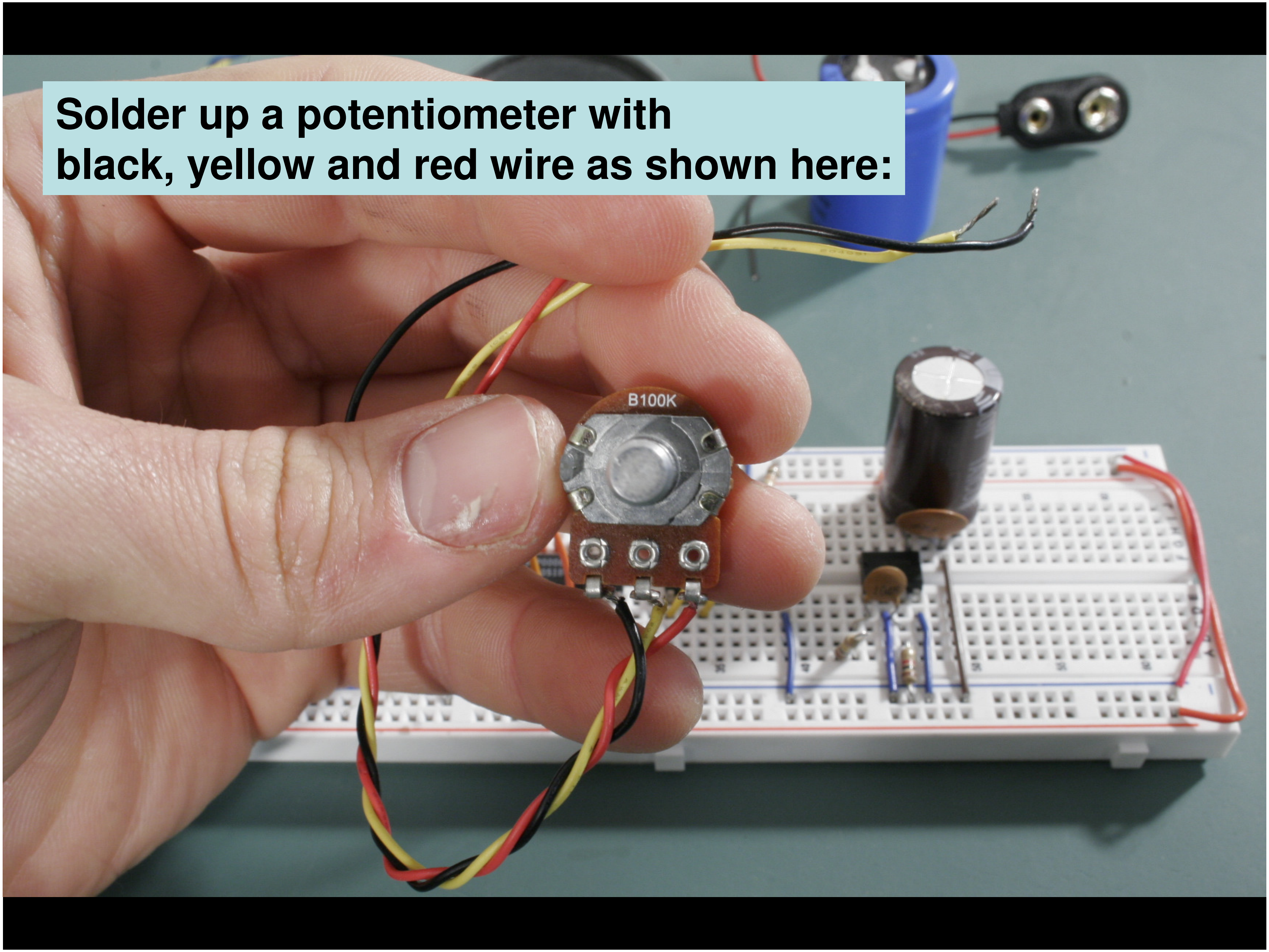
Grab one long green jumper

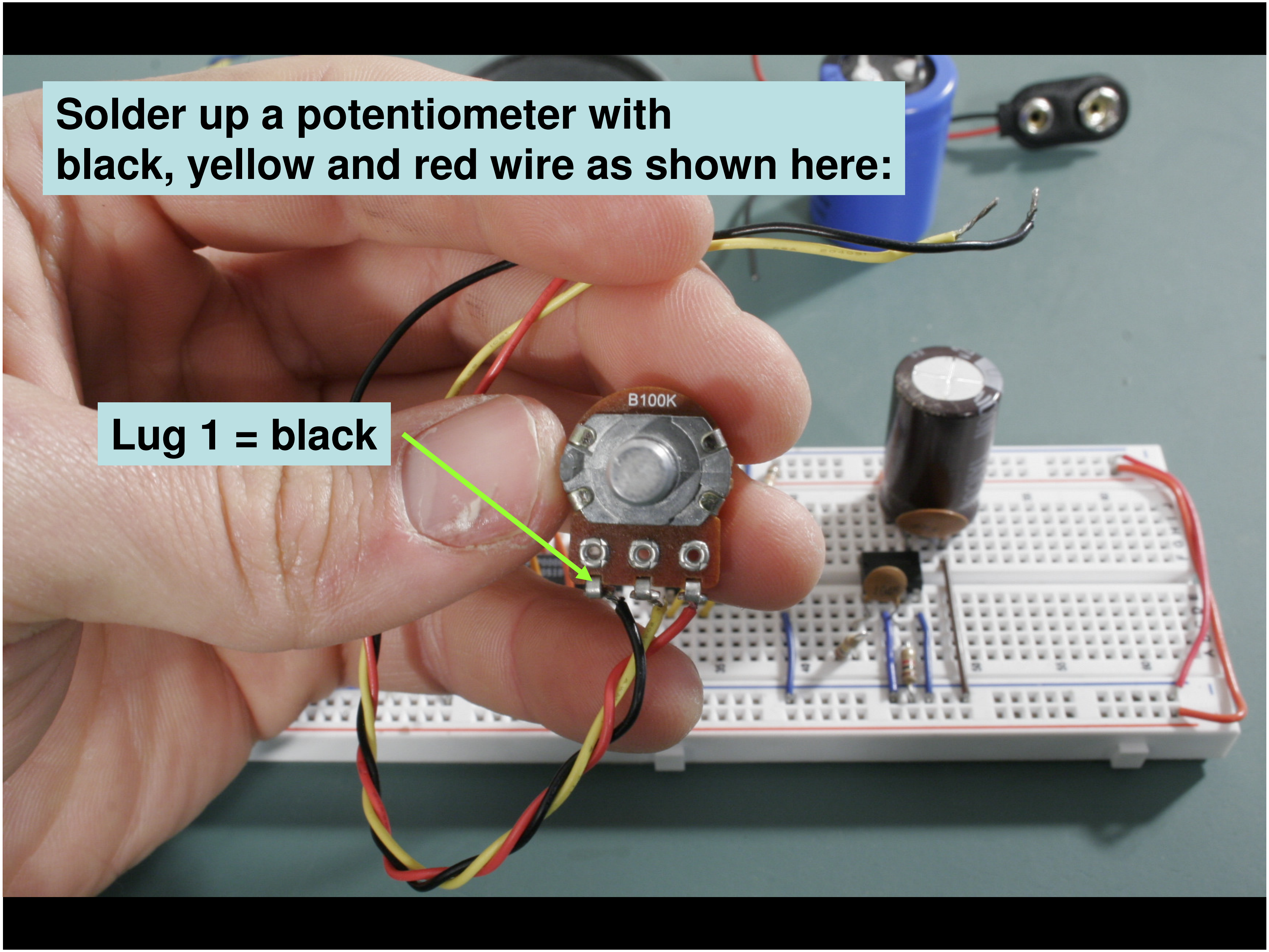


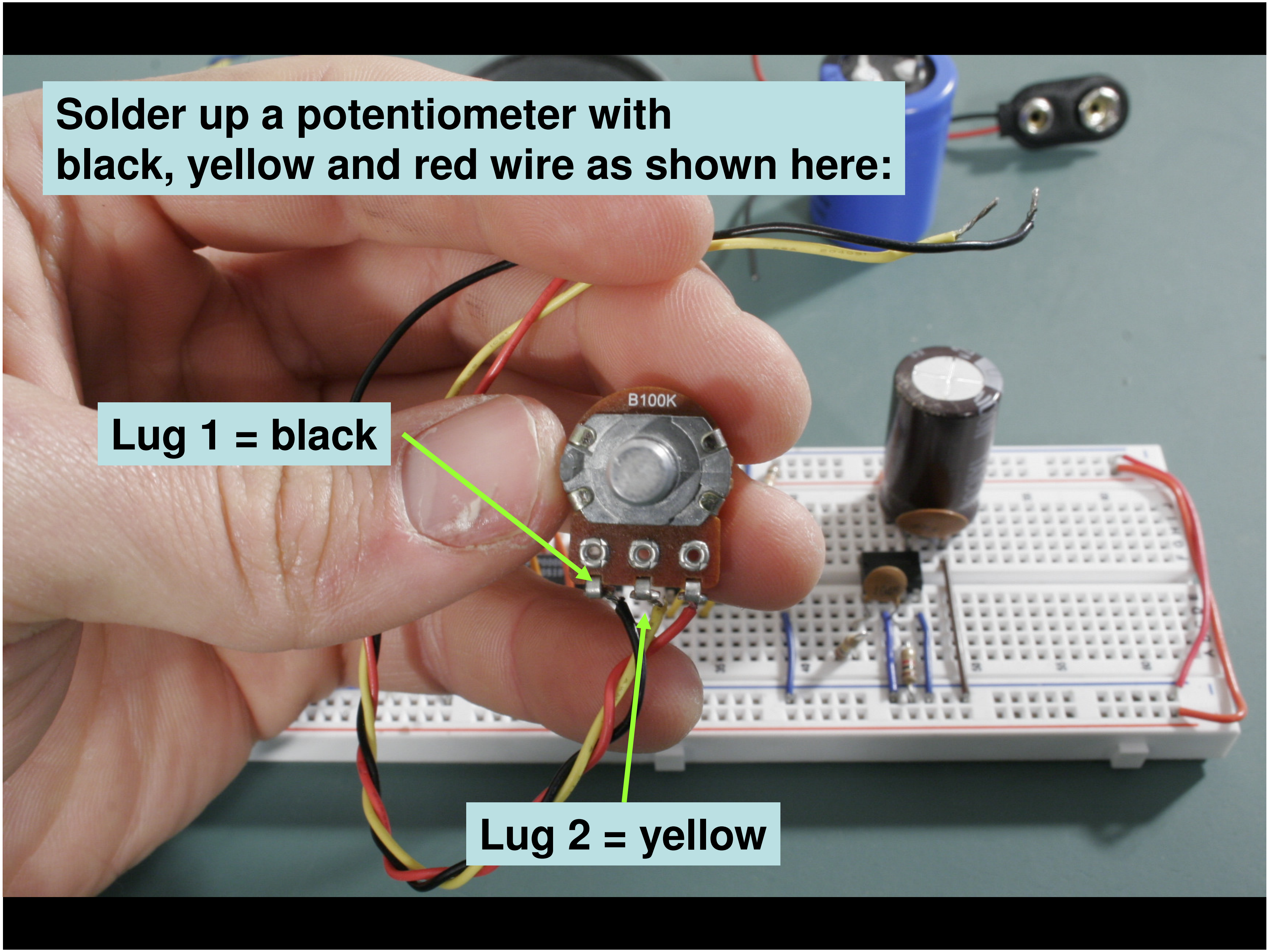
Connect one end to pin 10 on the second 4040

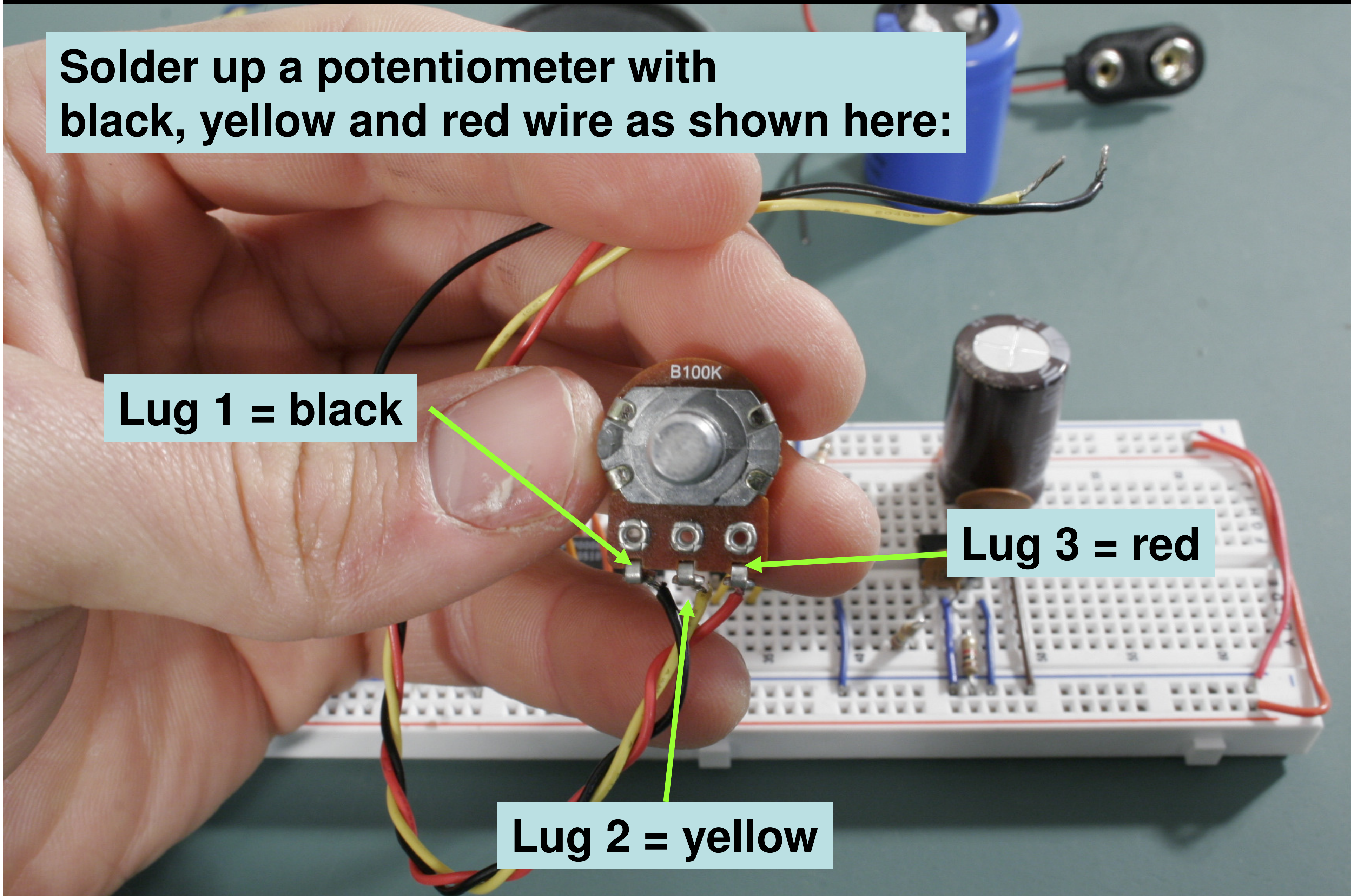


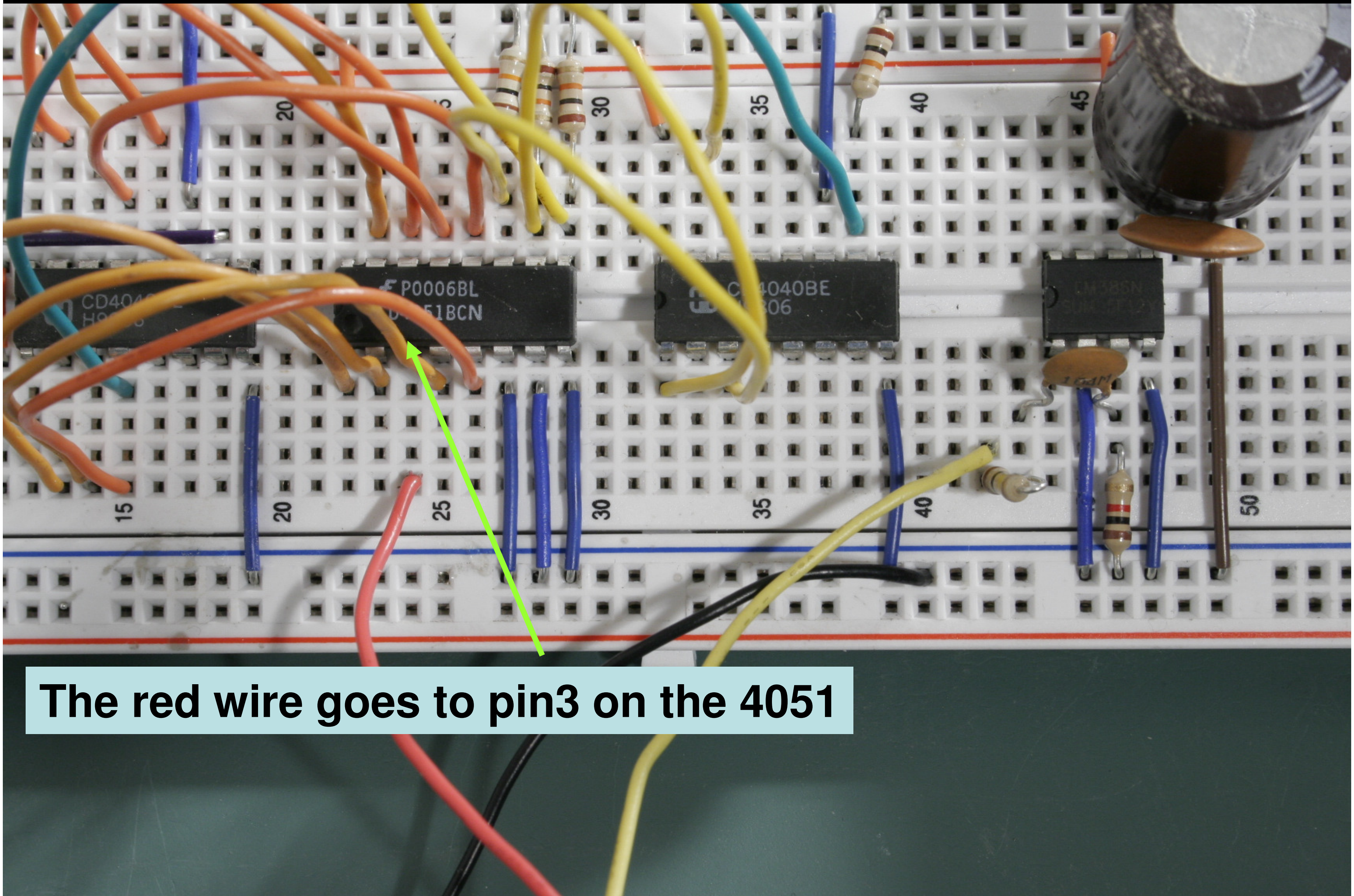
Connect the other end to any output pin on the first 4040


Solder up a potentiometer with
black, yellow and red wire as shown here:
B100K

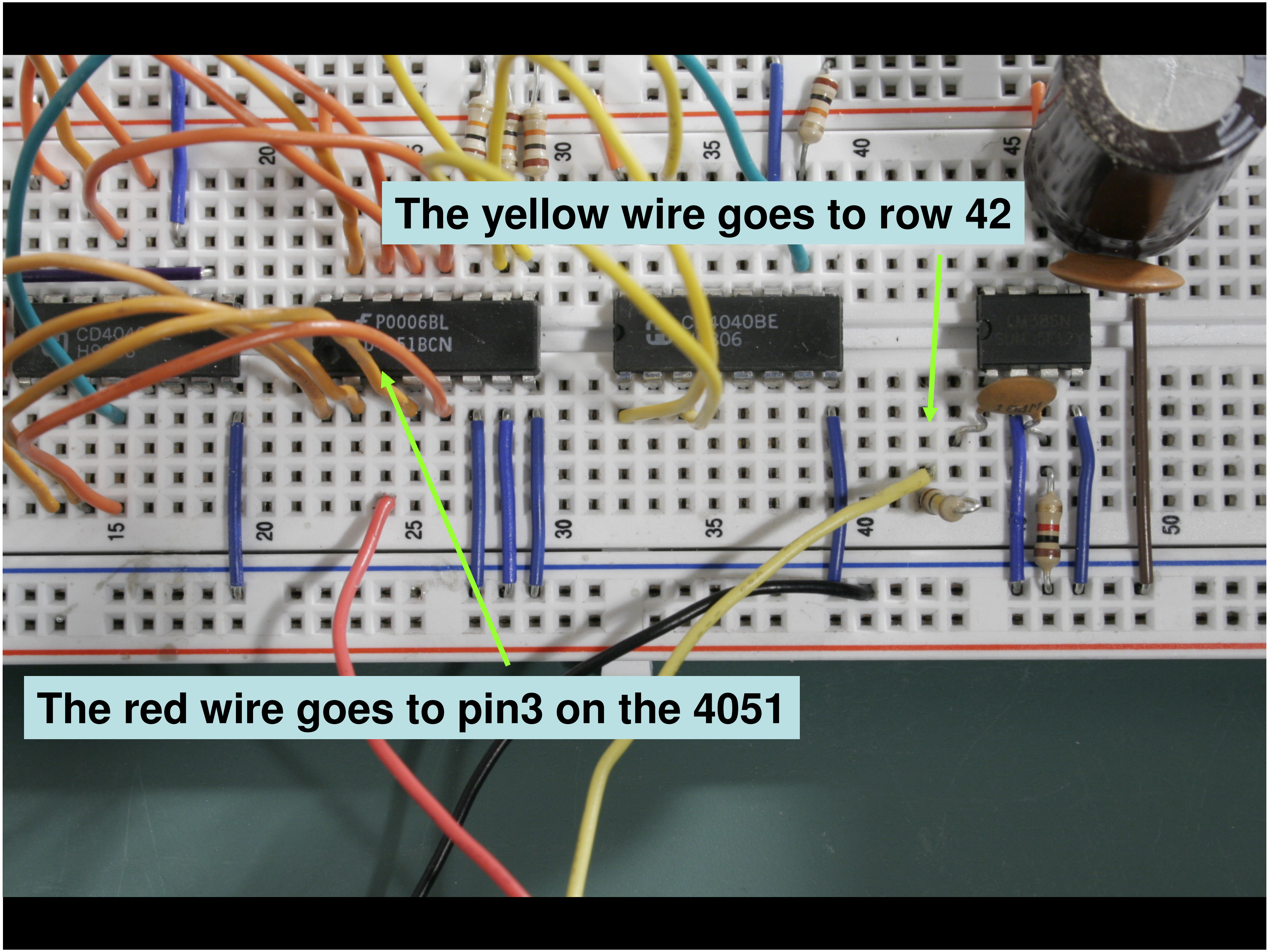

Solder up a potentiometer with
black, yellow and red wire as shown here:
Lug 1 = black
B100K

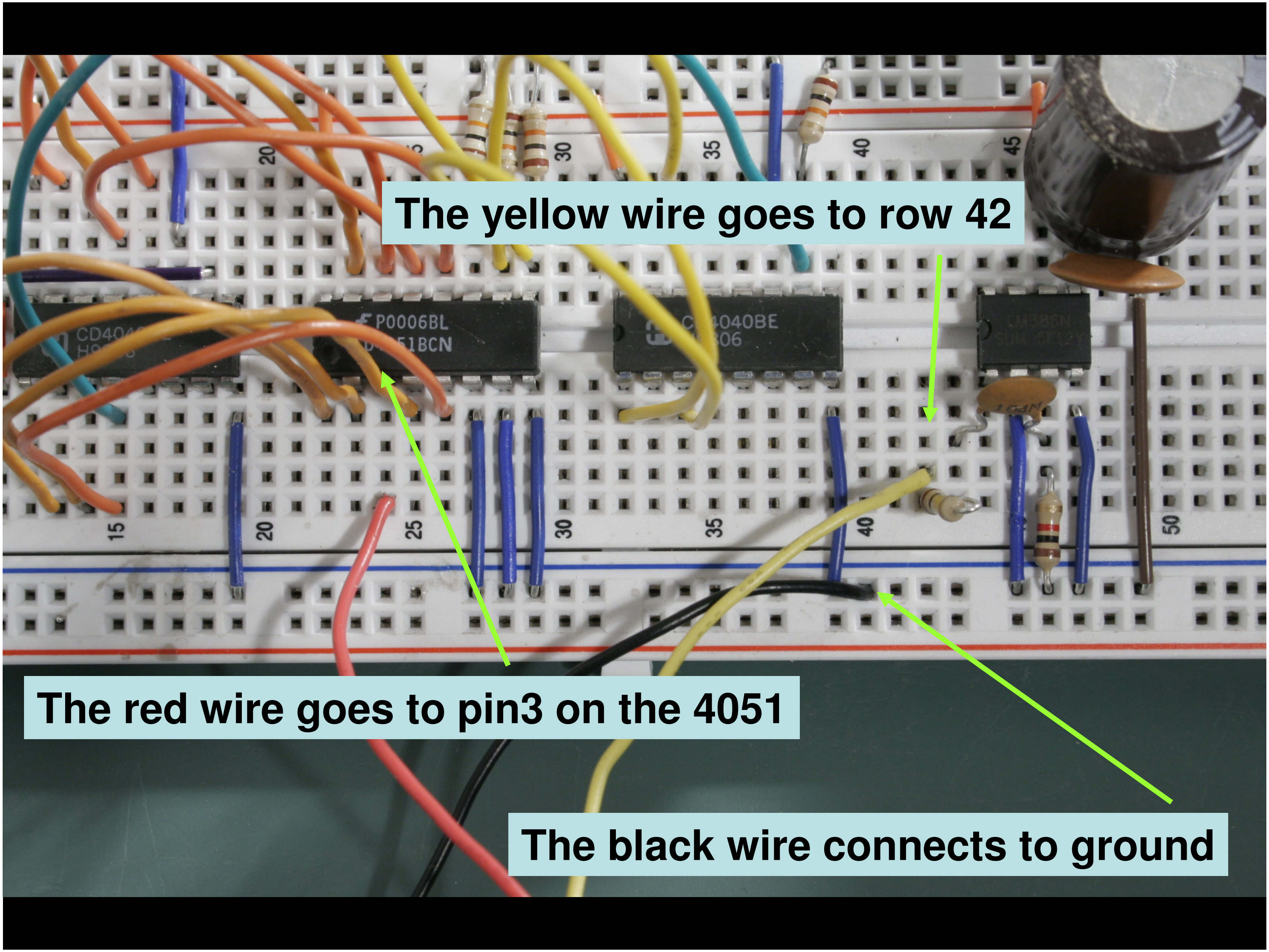

Solder up a potentiometer with
black, yellow and red wire as shown here:
B100K
Lug 1 = black
Lug 2 = yellow


Solder up a potentiometer with
black, yellow and red wire as shown here:
B100K
Lug 1 = black
Lug 3 = red
Lug 2 = yellow

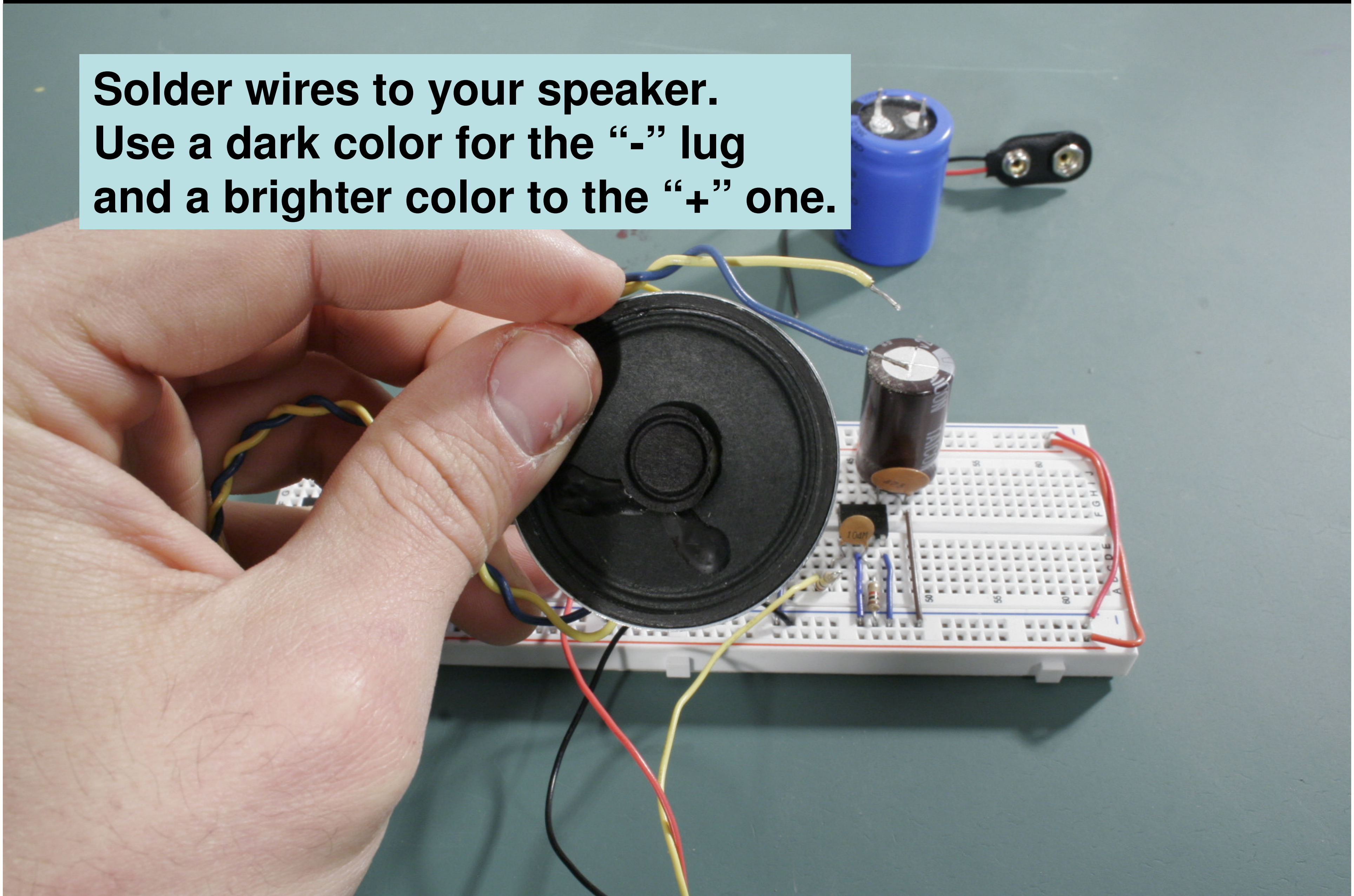


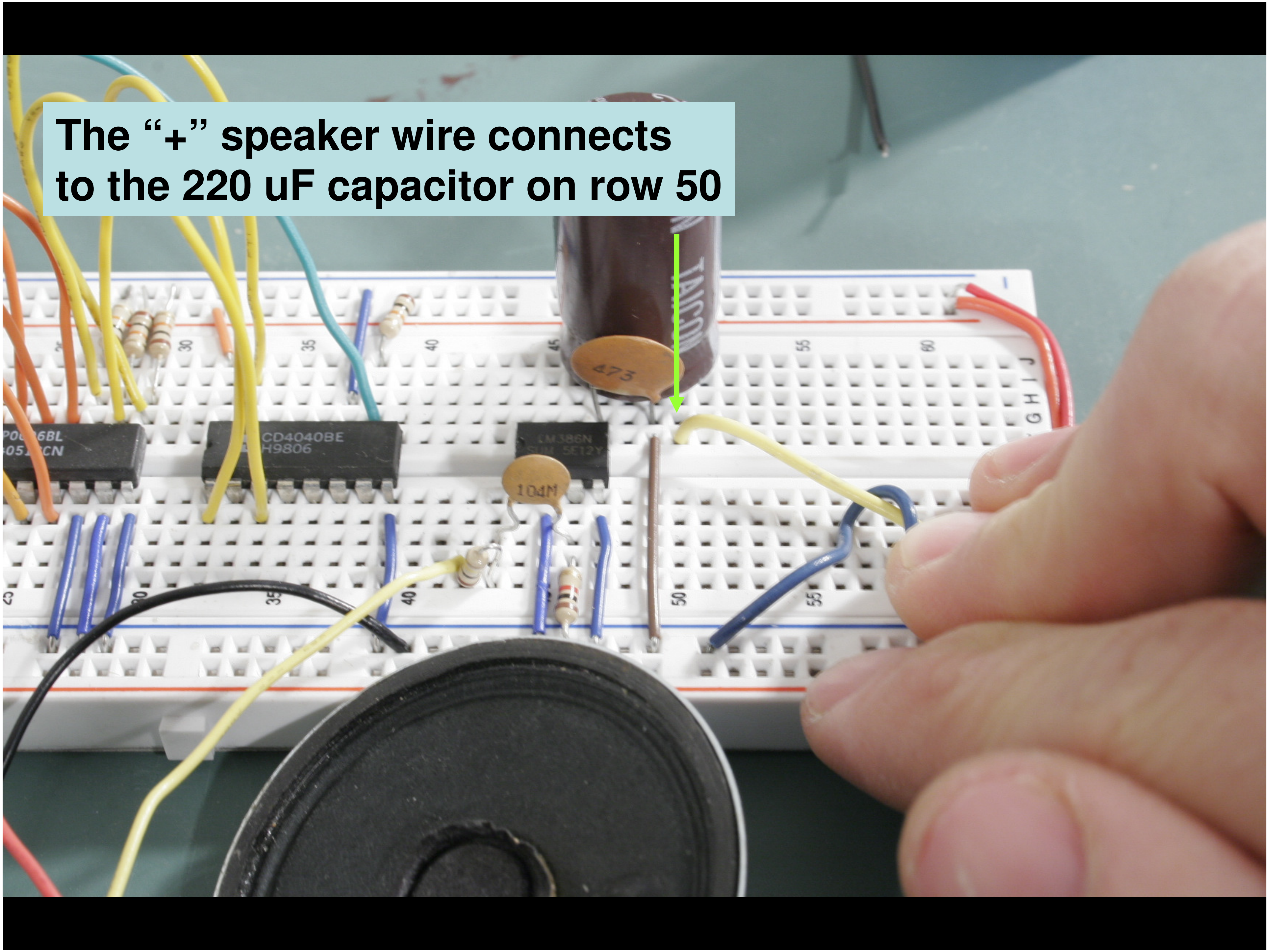
The red wire goes to pin3 on the 4051

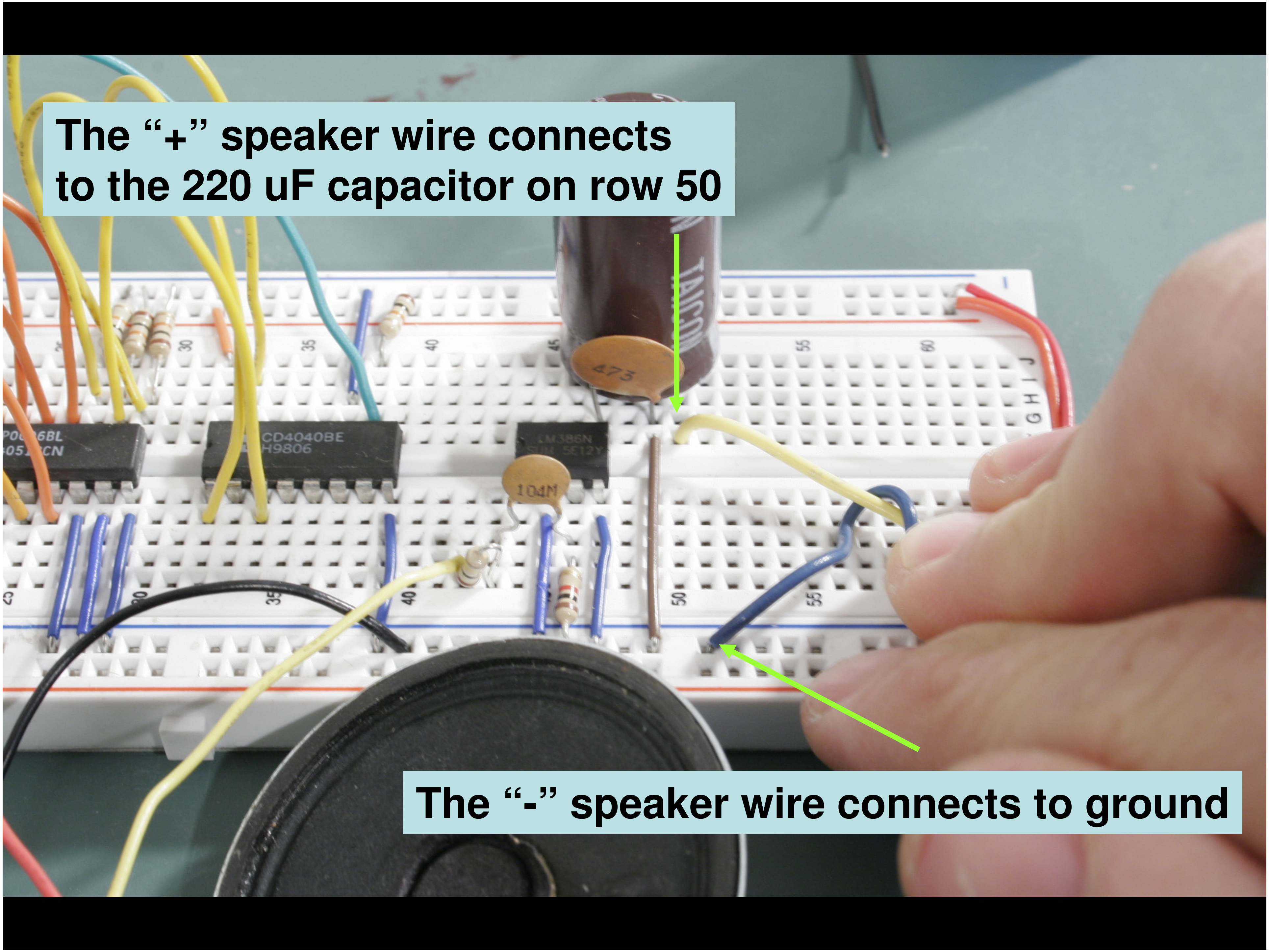

The yellow wire goes to row 42
The red wire goes to pin3 on the 4051

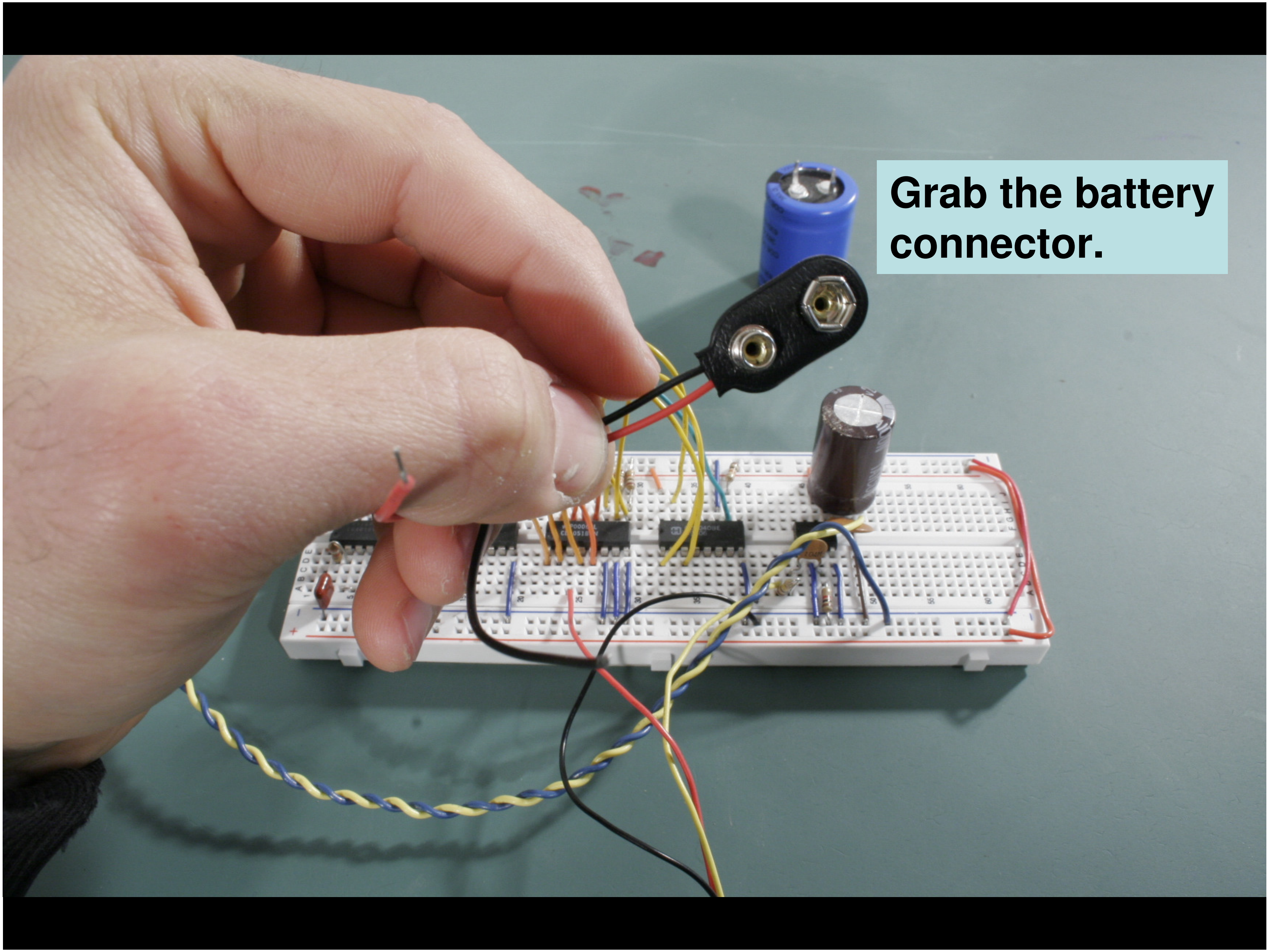

The yellow wire goes to row 42
The red wire goes to pin3 on the 4051
The black wire connects to ground

Solder wires to your speaker.
Use a dark color for the “-” lug
and a brighter color to the “+” one.

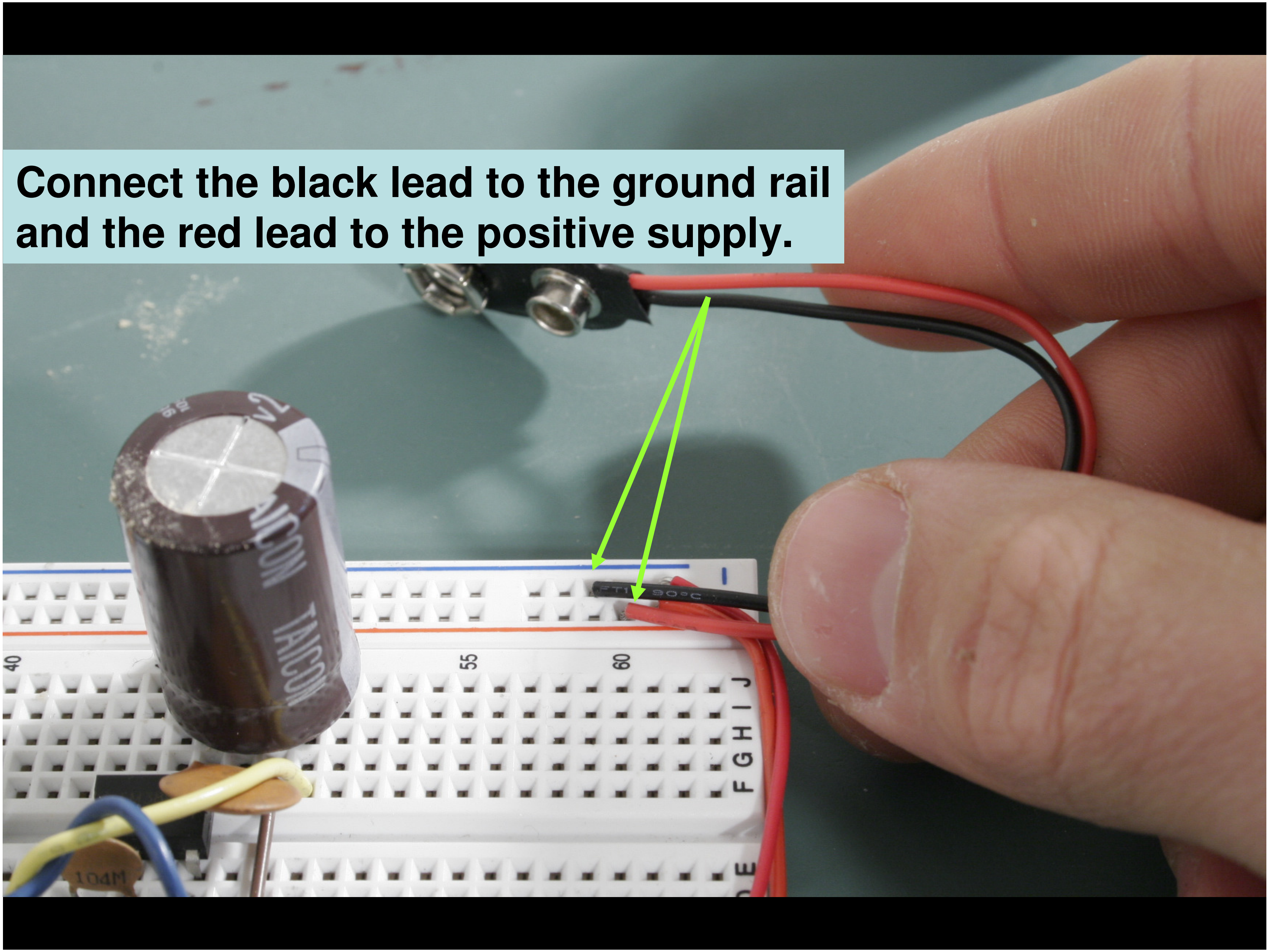


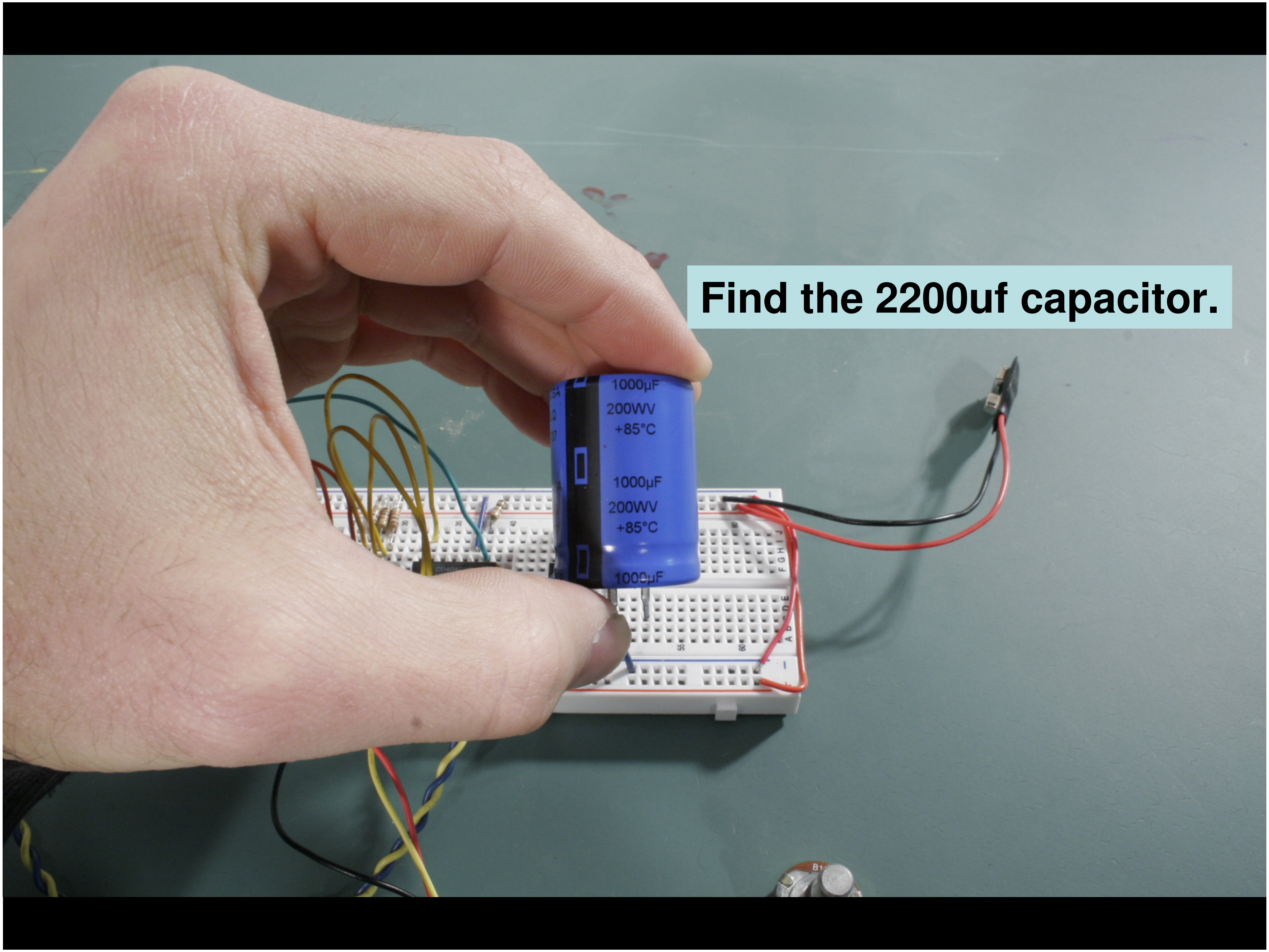

The “+” speaker wire connects
to the 220 uF capacitor on row 50
CD4040BE
H9806
LM386N
473
104N

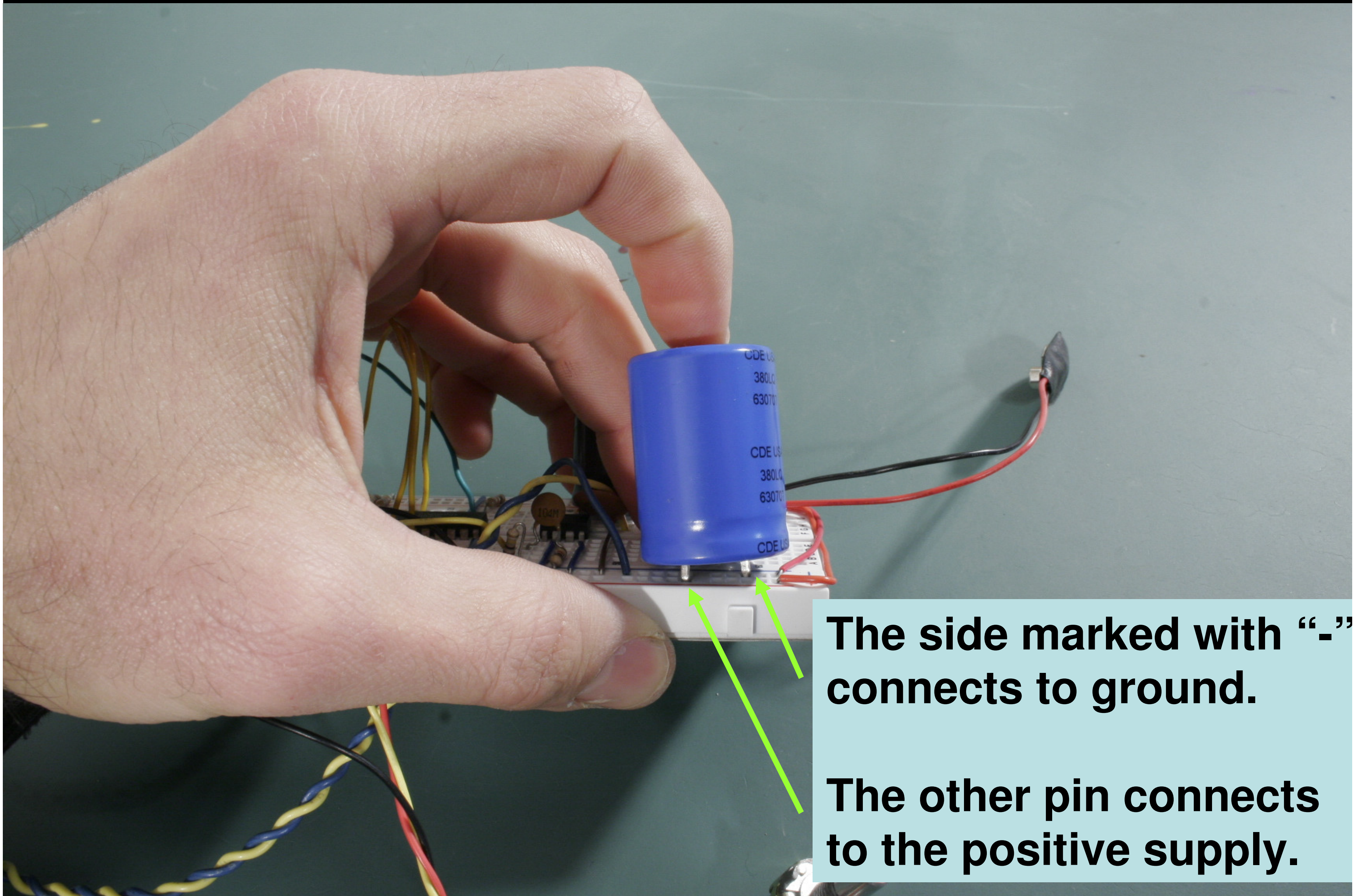

The “+” speaker wire connects to the 220 uF capacitor on row 50
The “-” speaker wire connects to ground
CD4040BE
104M
473


Grab the battery connector.

Connect the black lead to the ground rail and the red lead to the positive supply.

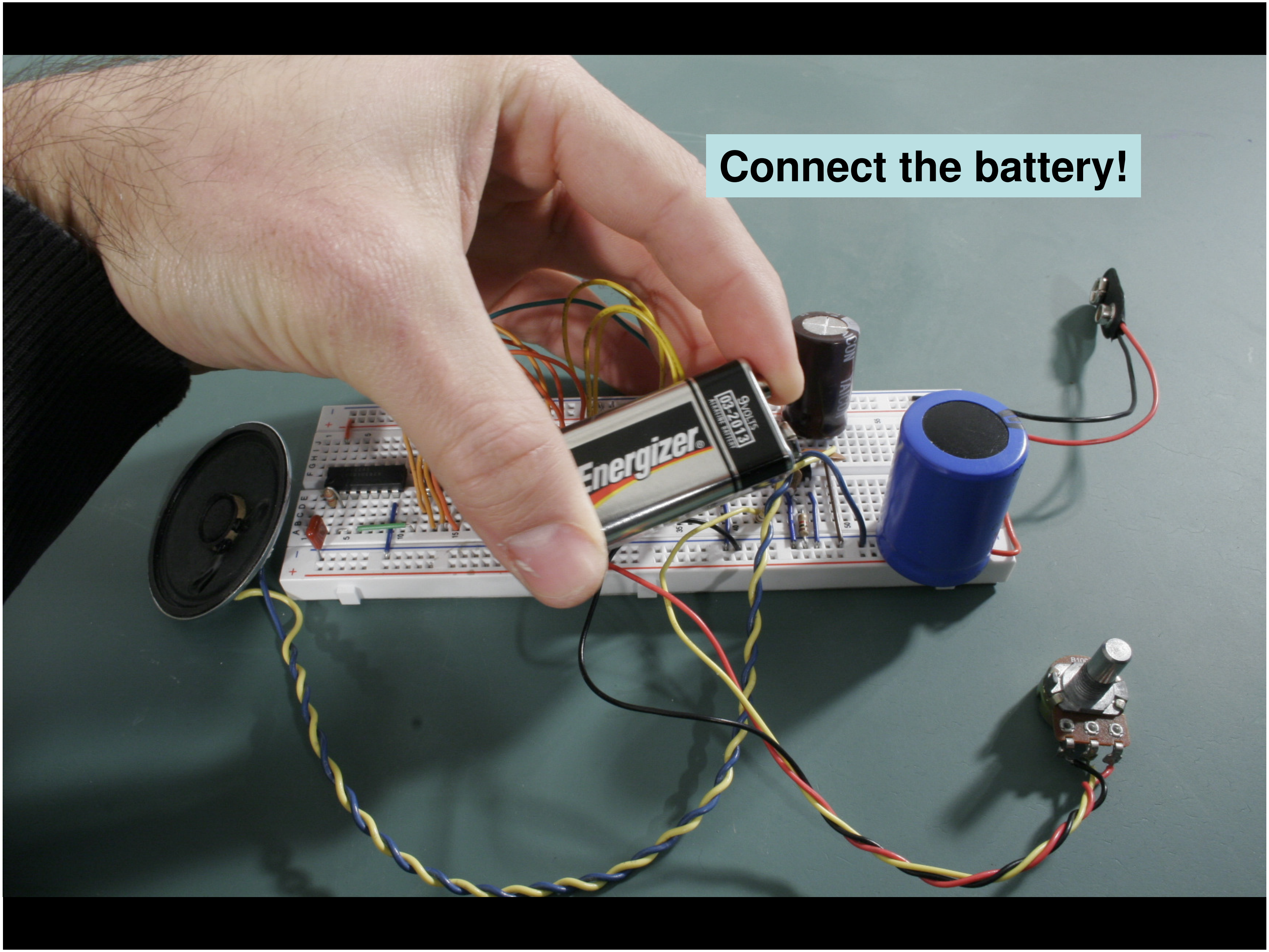



Find the 2200uf capacitor.
1000µF
200WV
+85°C
1000µF
200WV
+85°C
1000µF

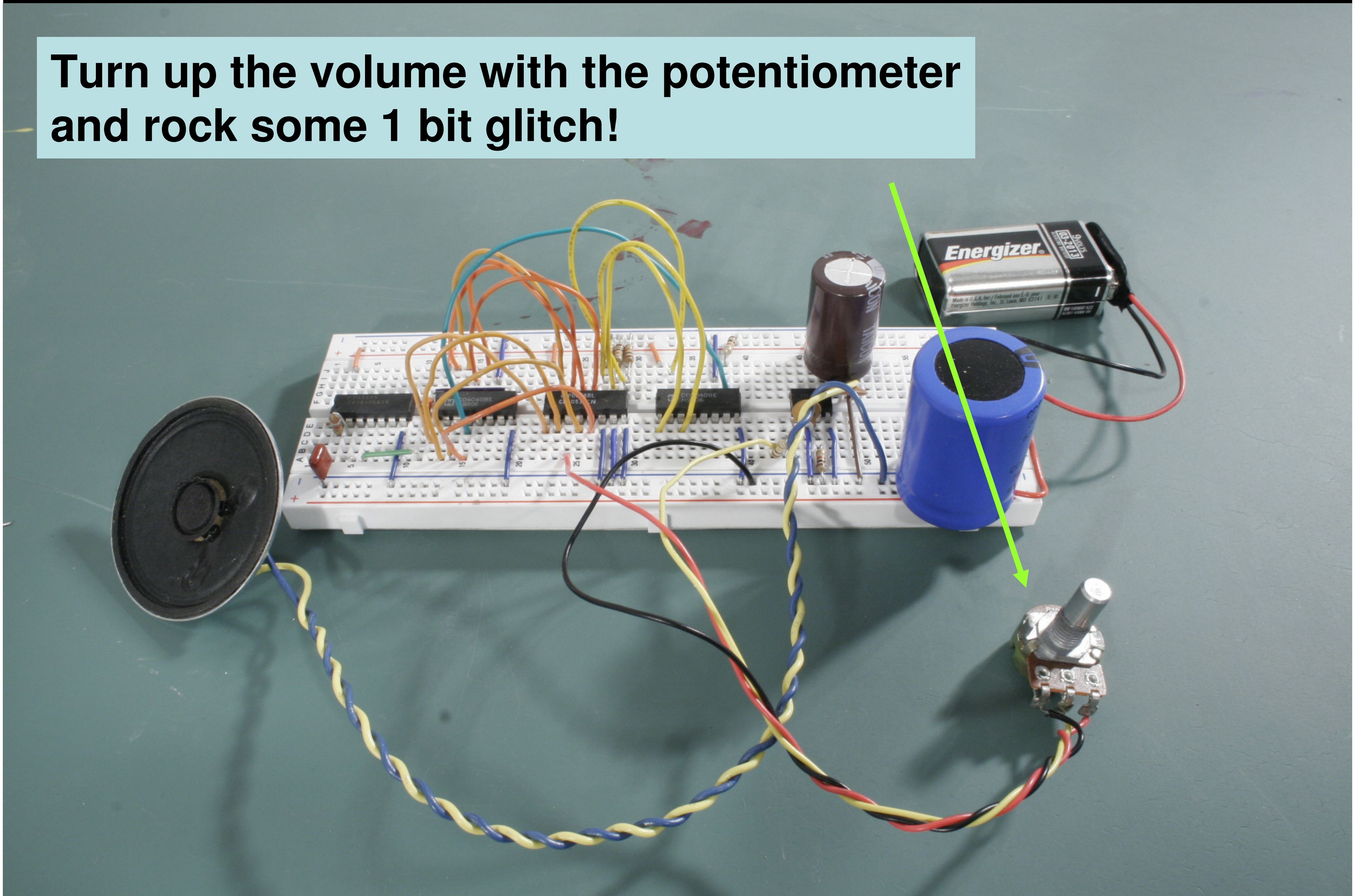


The side marked with “-” connects to ground.

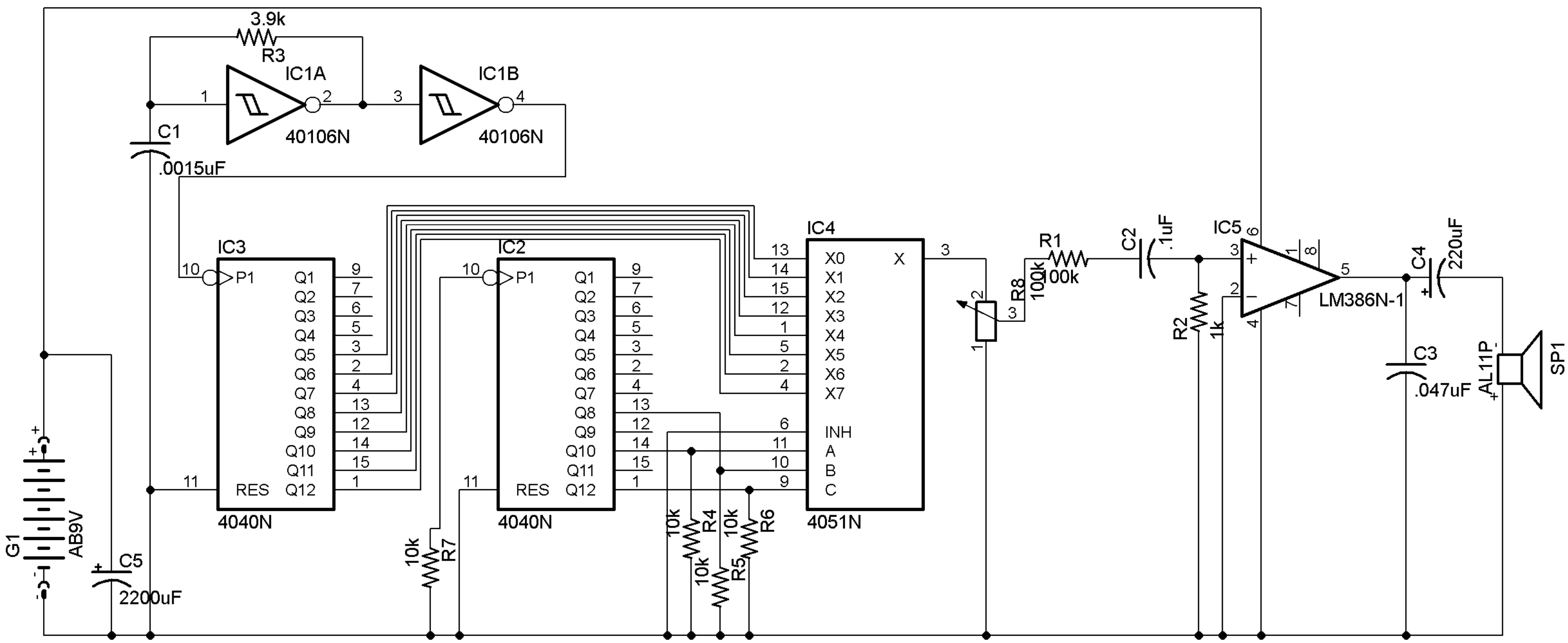
The other pin connects to the positive supply.

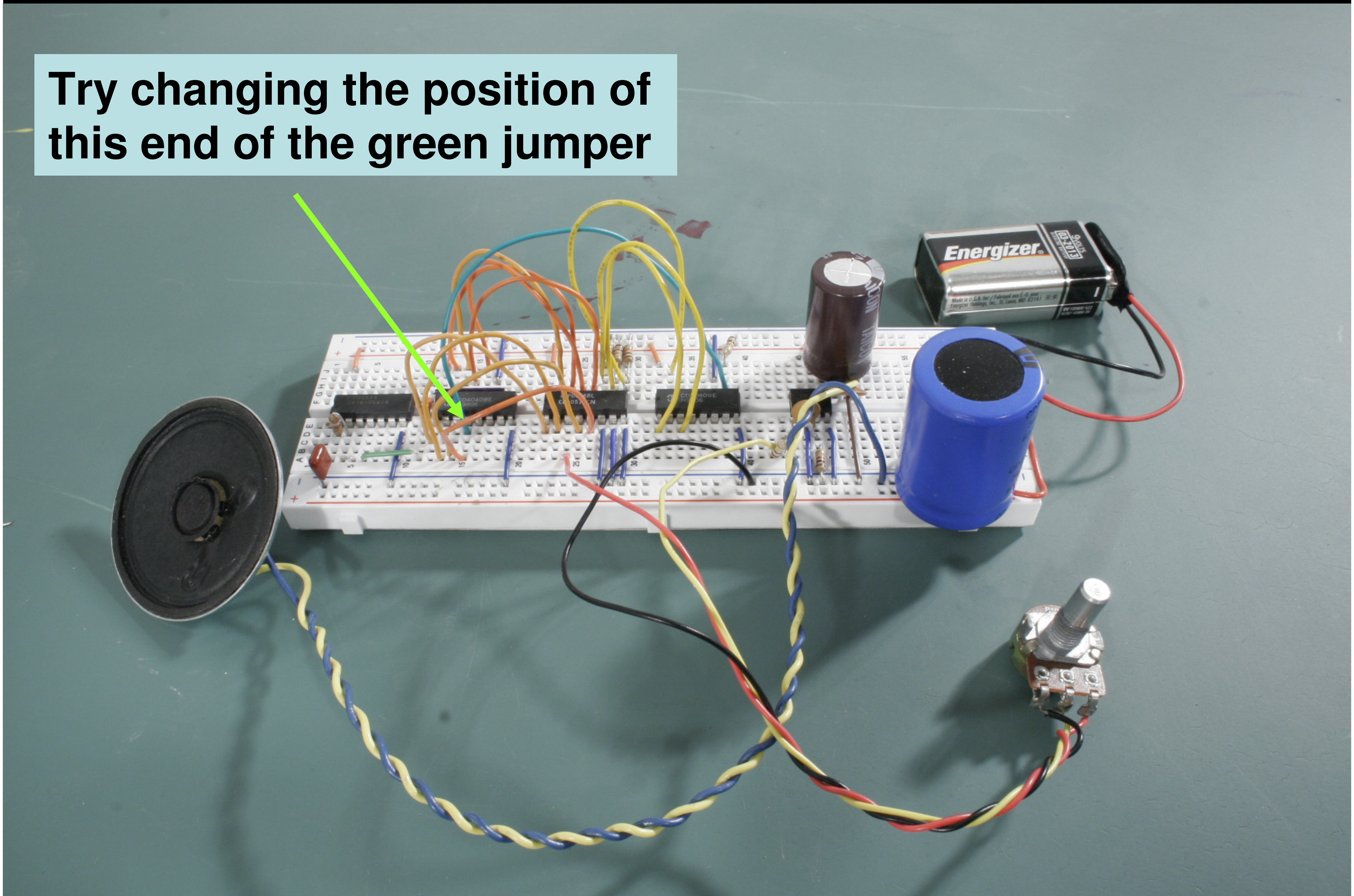

Connect the battery!
Energizer

Turn up the volume with the potentiometer and rock some 1 bit glitch!

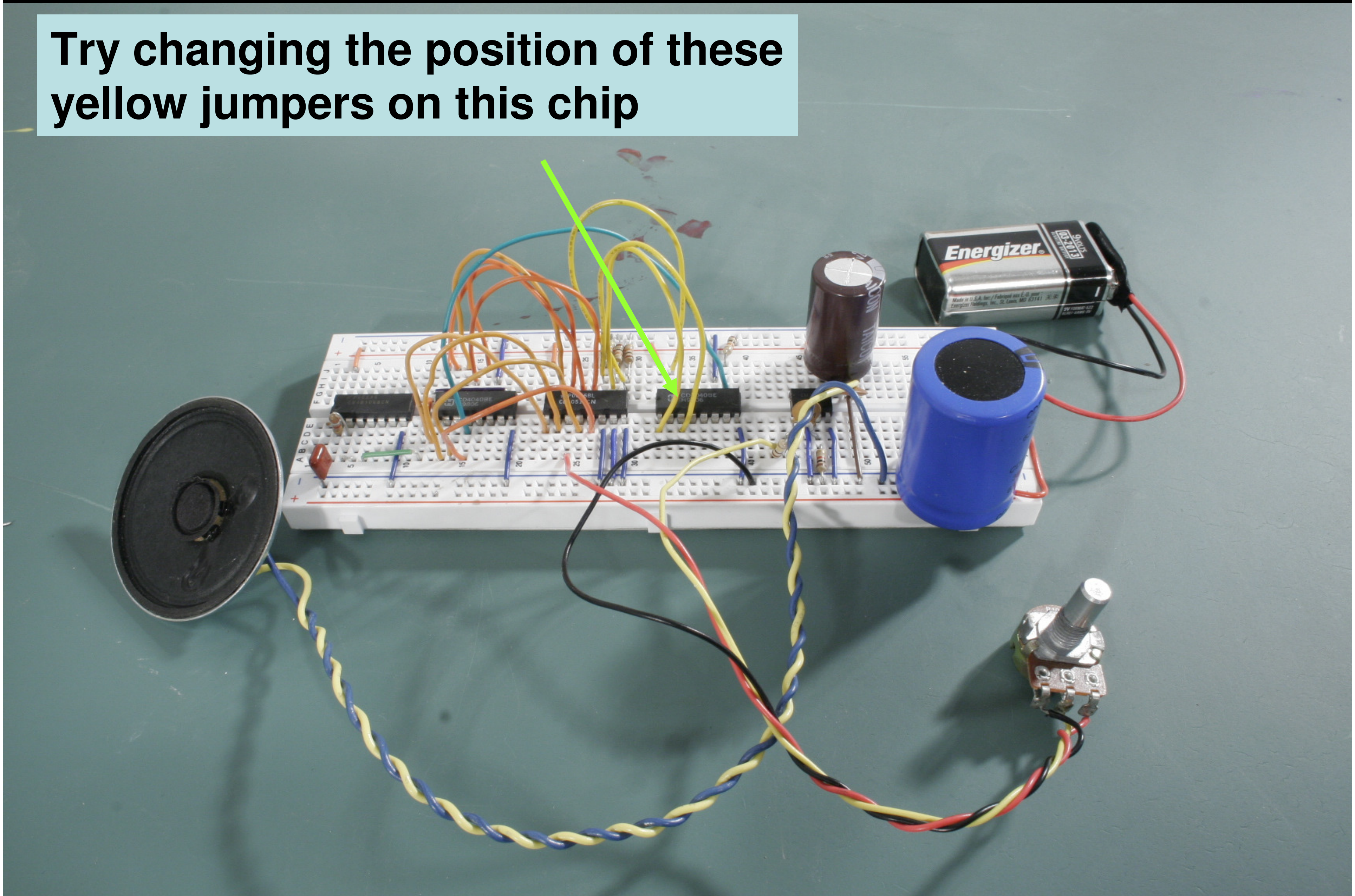


Full Schematic




Try changing the position of
this end of the green jumper
Energizer

Try changing the position of these yellow jumpers on this chip



You can also change the position of these orange jumpers on this chip