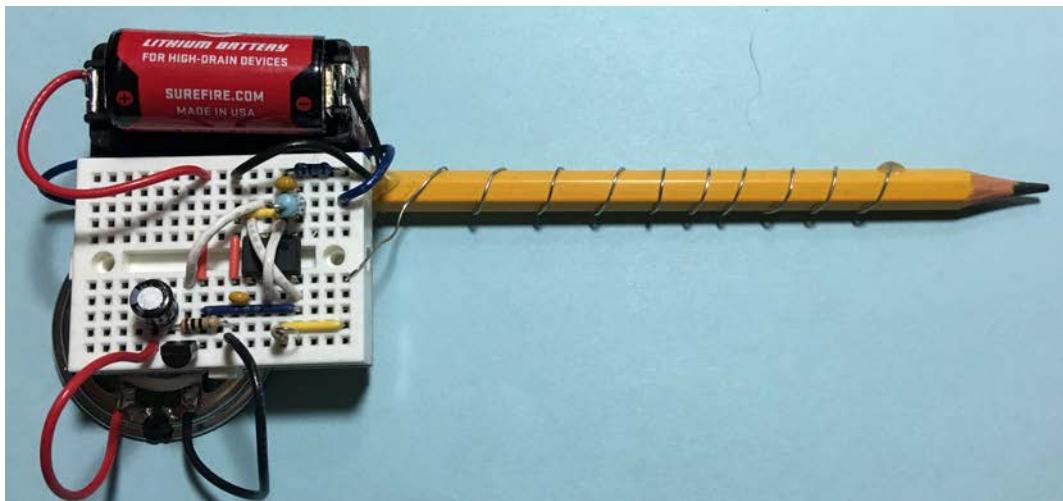


Drawdio – Perfboard Edition

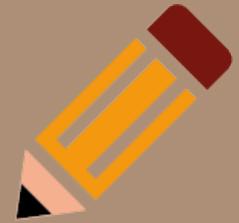


Based on work by Jay Silver in the Lifelong Kindergarten group at the MIT Media Lab



Designed by: Jim Windgassen
REV - 24 April 2018

What's a Drawdio ?



Imagine you could draw musical instruments on normal paper with any pencil (cheap circuit thumb-tacked on) and then play them with your finger.

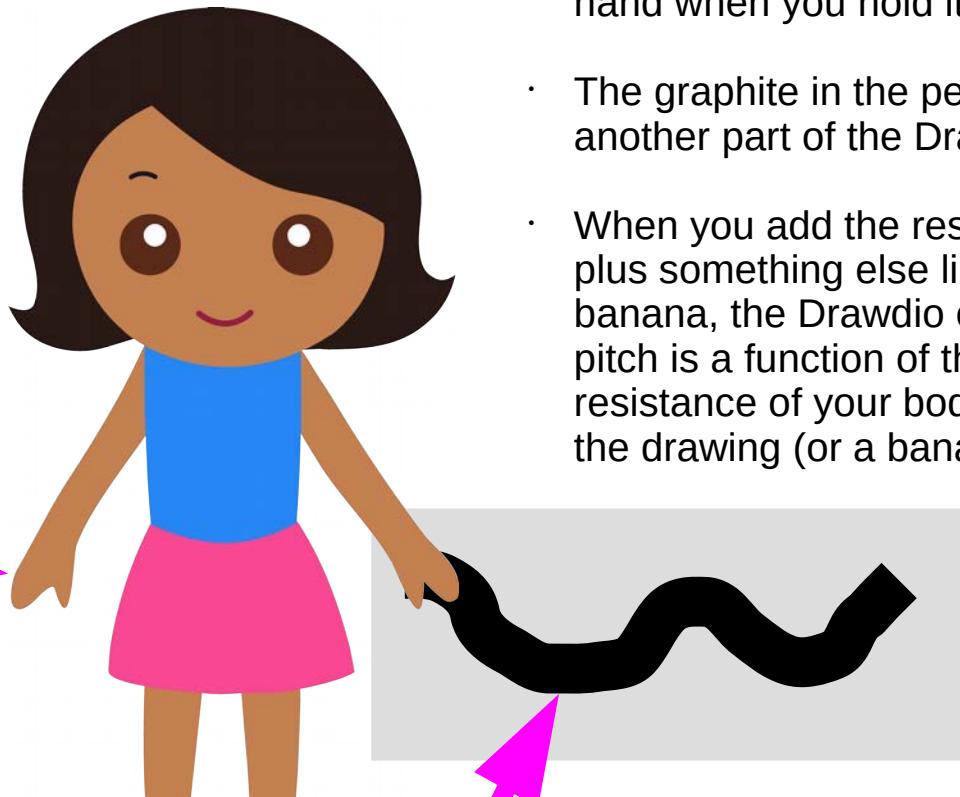
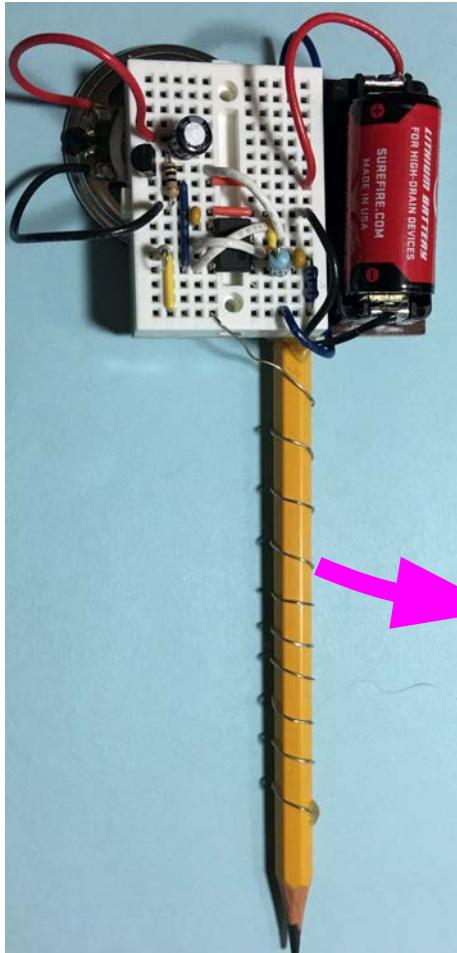
The Drawdio circuit-craft lets you MacGyver your everyday objects into musical instruments: paintbrushes, macaroni, trees, grandpa, even the kitchen sink...

How Does Drawdio Work ?



Drawdio uses an electronic oscillator (something that creates a voltage that changes in time) to drive a speaker. The frequency (pitch) of the oscillator is determined by the electrical resistance that it measures.....that's where you and your drawings come in !

How Does Drawdio Work ?



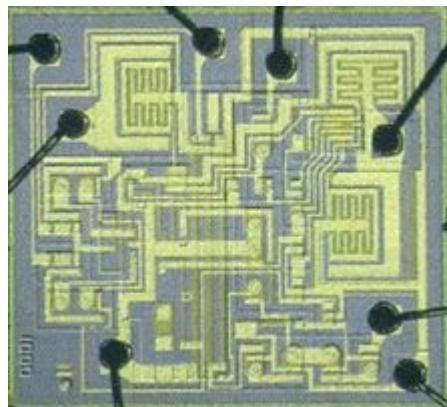
- The outside wire on the Drawdio makes electrical contact with your body through your hand when you hold it.
- The graphite in the pencil is connected to another part of the Drawdio circuit.
- When you add the resistance of your body plus something else like a pencil drawing or a banana, the Drawdio emits a tone whose pitch is a function of the sum of the resistance of your body plus the resistance of the drawing (or a banana).

How Does Drawdio Work ?



The oscillator circuit in Drawdio is based around a low voltage version of a 555 timer IC (integrated circuit) called a TLC551.

The 555 was first invented by Hans Camenzind in 1971 and it is the most popular IC ever manufactured; over 1 billion are made every year !



The silicon die inside a 555 IC
(1mm x 0.7mm)



555 Timer in a common 8 pin
DIP package

Safety Rules

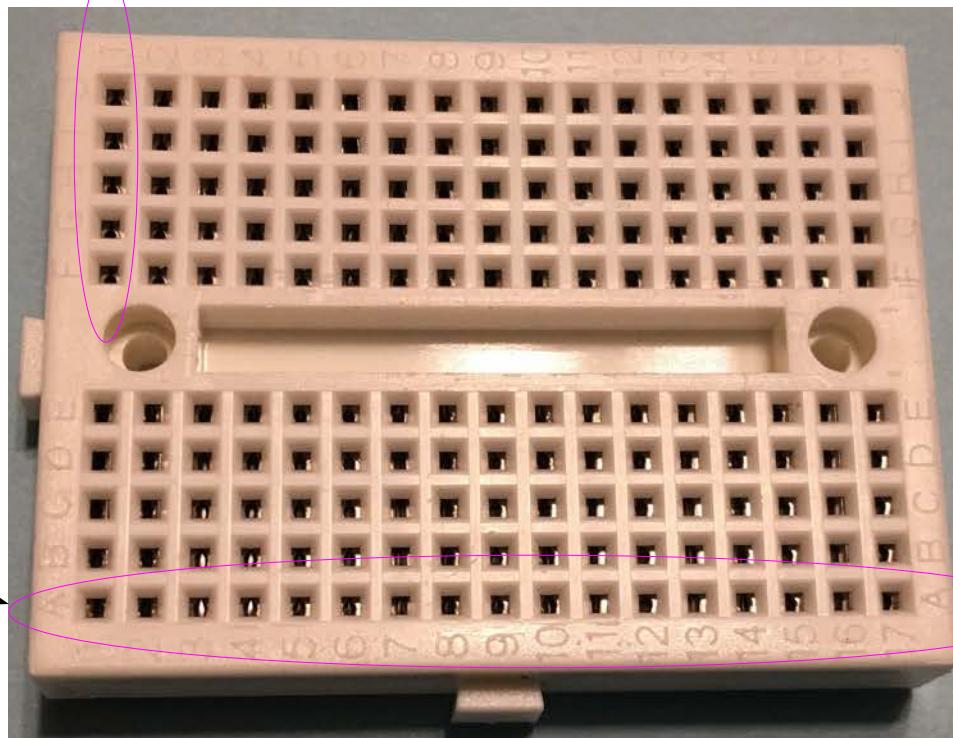


- 1) You must wear safety glasses when cutting wires or leads. Sometimes pieces of wire go flying when wires are cut !
- 2) Aim the ends of the leads or wires downwards so that if they do go flying, they hit the table and don't go in someone's face.
- 3) Hot melt glue is HOT !! Treat it with respect !

Solderless Breadboard



5 holes are common electrical connection



Rows are Letters A-J.
Columns are numbered 1-17.

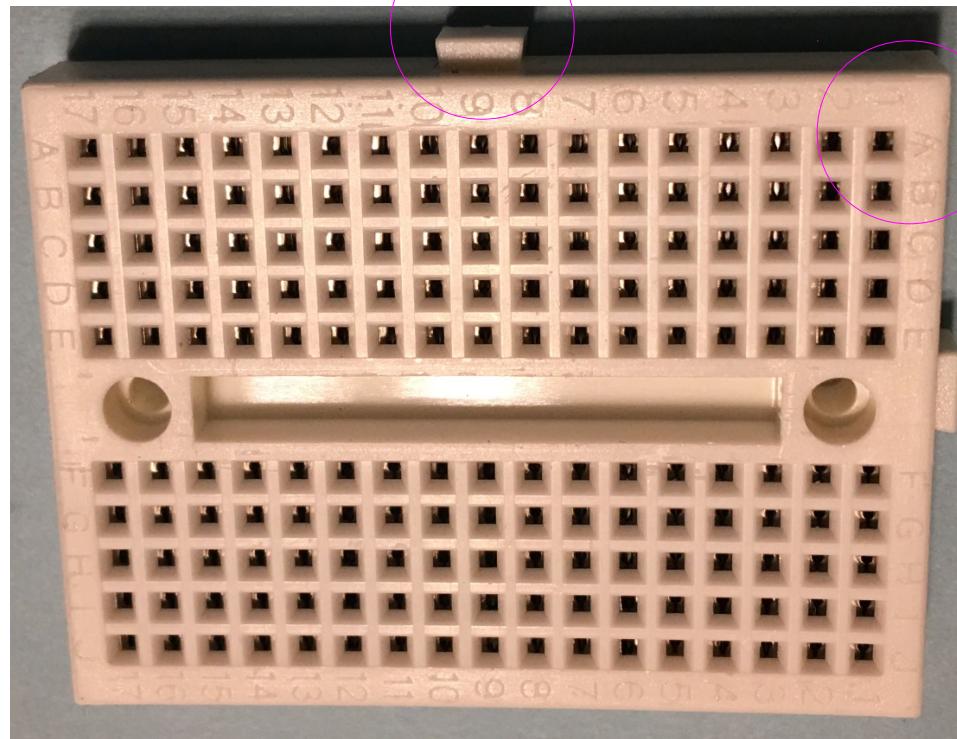


Step 1 – Orient Breadboard

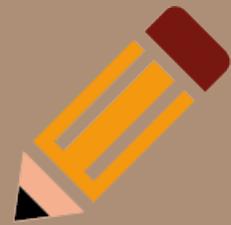


Orient breadboard
with tab facing away
from you.

Breadboard position
A1 will be in upper
right corner

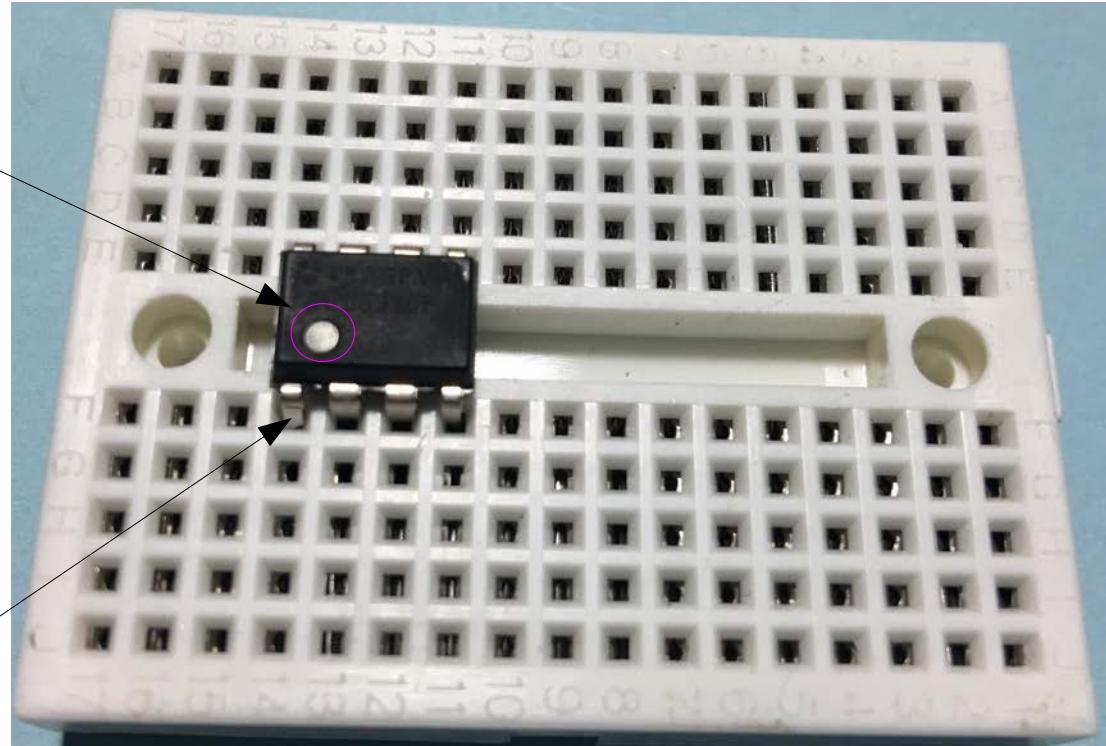


Step 2 – Install U1 (555 IC)

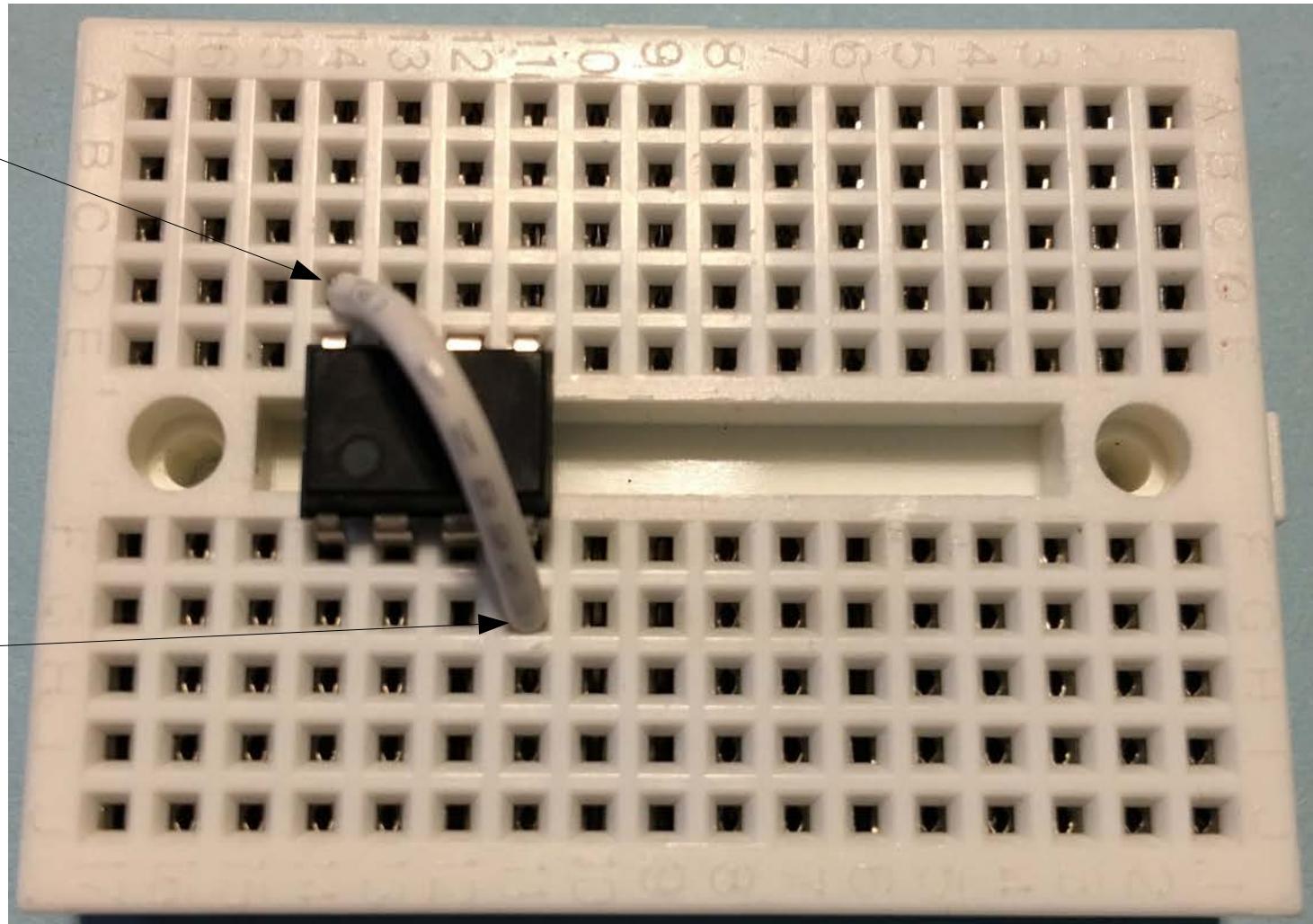


Pin 1 Marker

U1 pin 1 in breadboard
position F14



Step 3 – Install White Wire U1-8 to U1-4

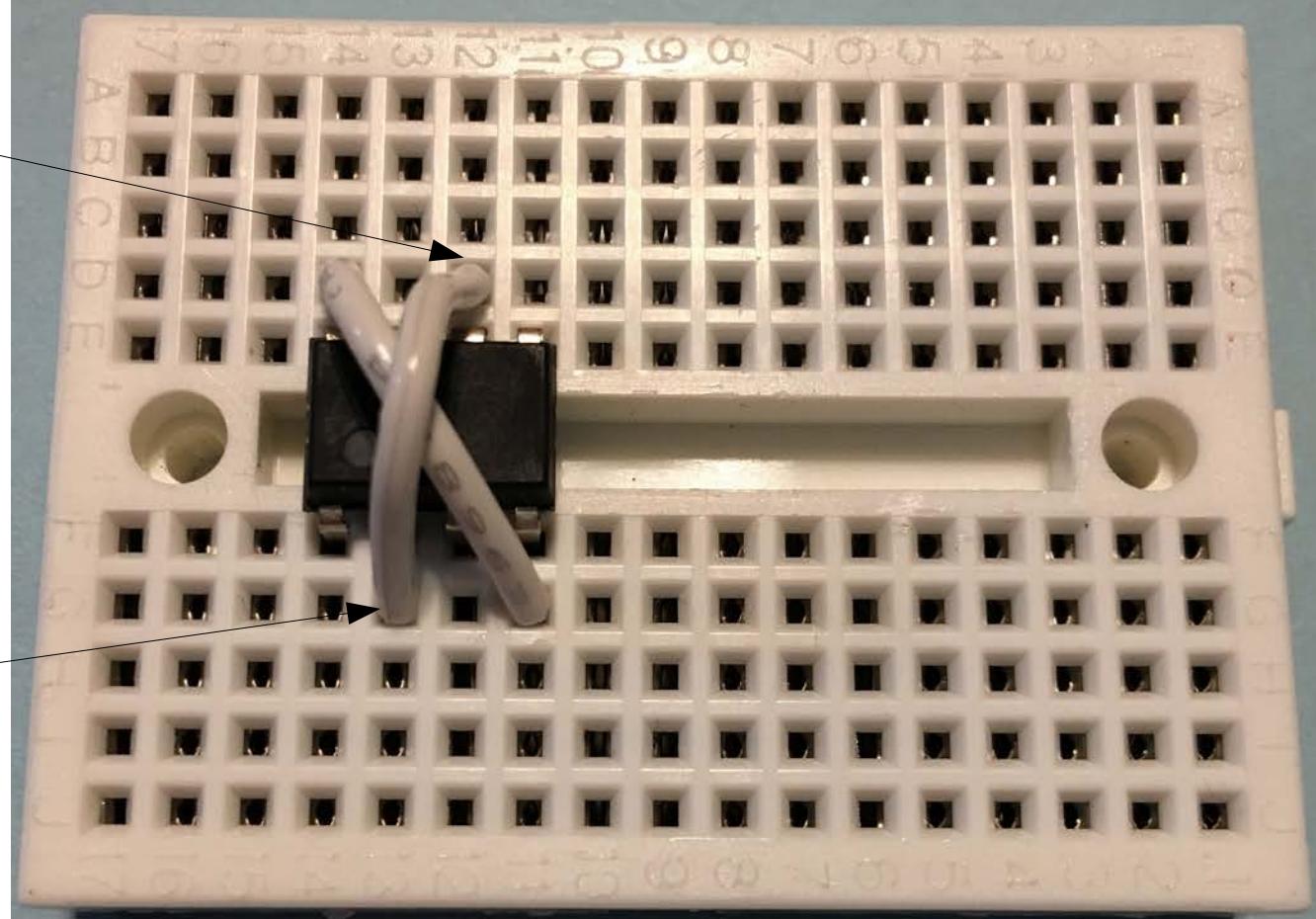


This step connects U1-8 (Vcc) to U1-4 (Reset)

Step 4 – Install White Wire U1-2 to U1-6



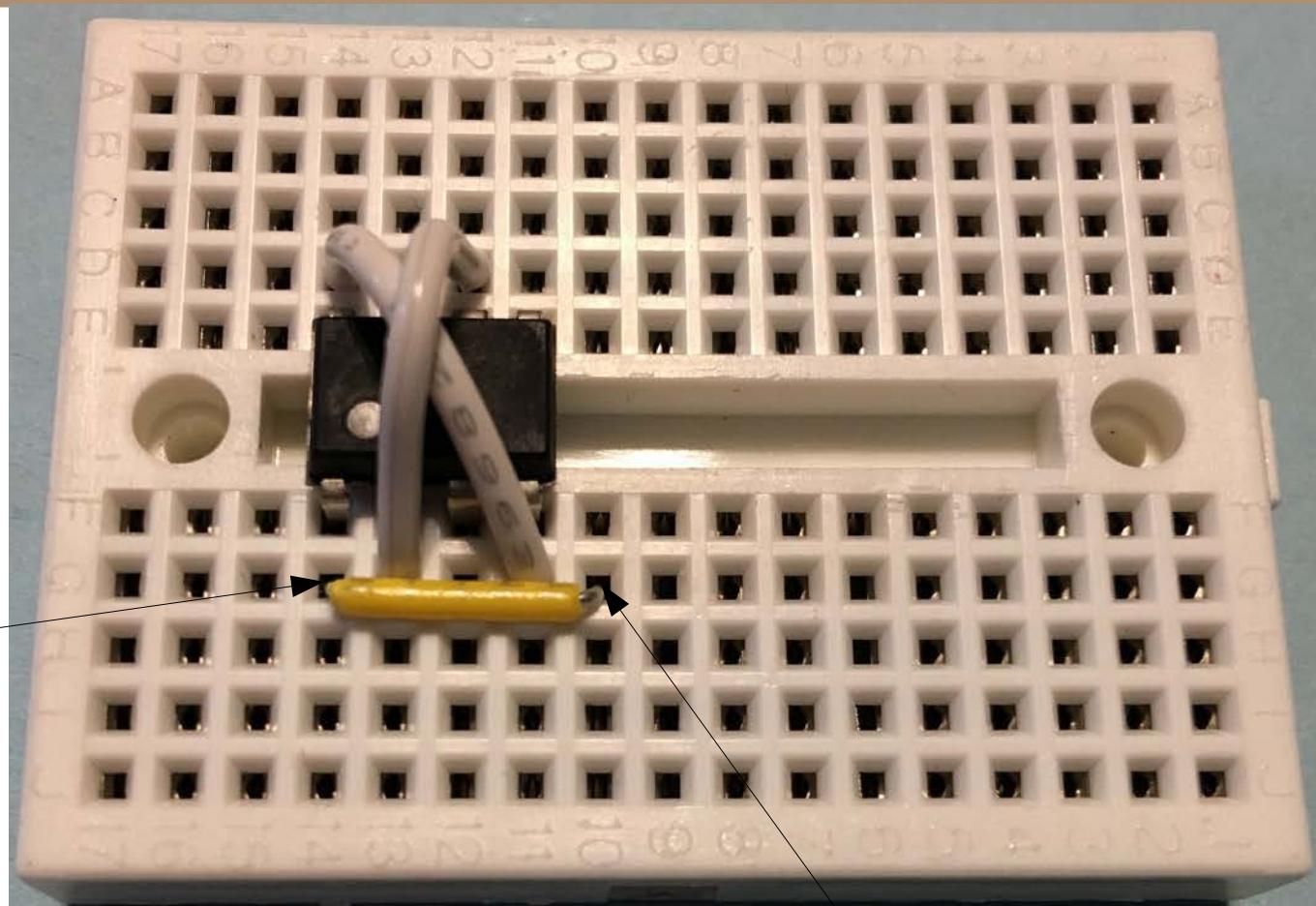
Breadboard D12



Breadboard G13

This step connects U1-2 (Trigger) to U1-6 (Threshold)

Step 5 – Install Yellow Wire 1



Breadboard G10

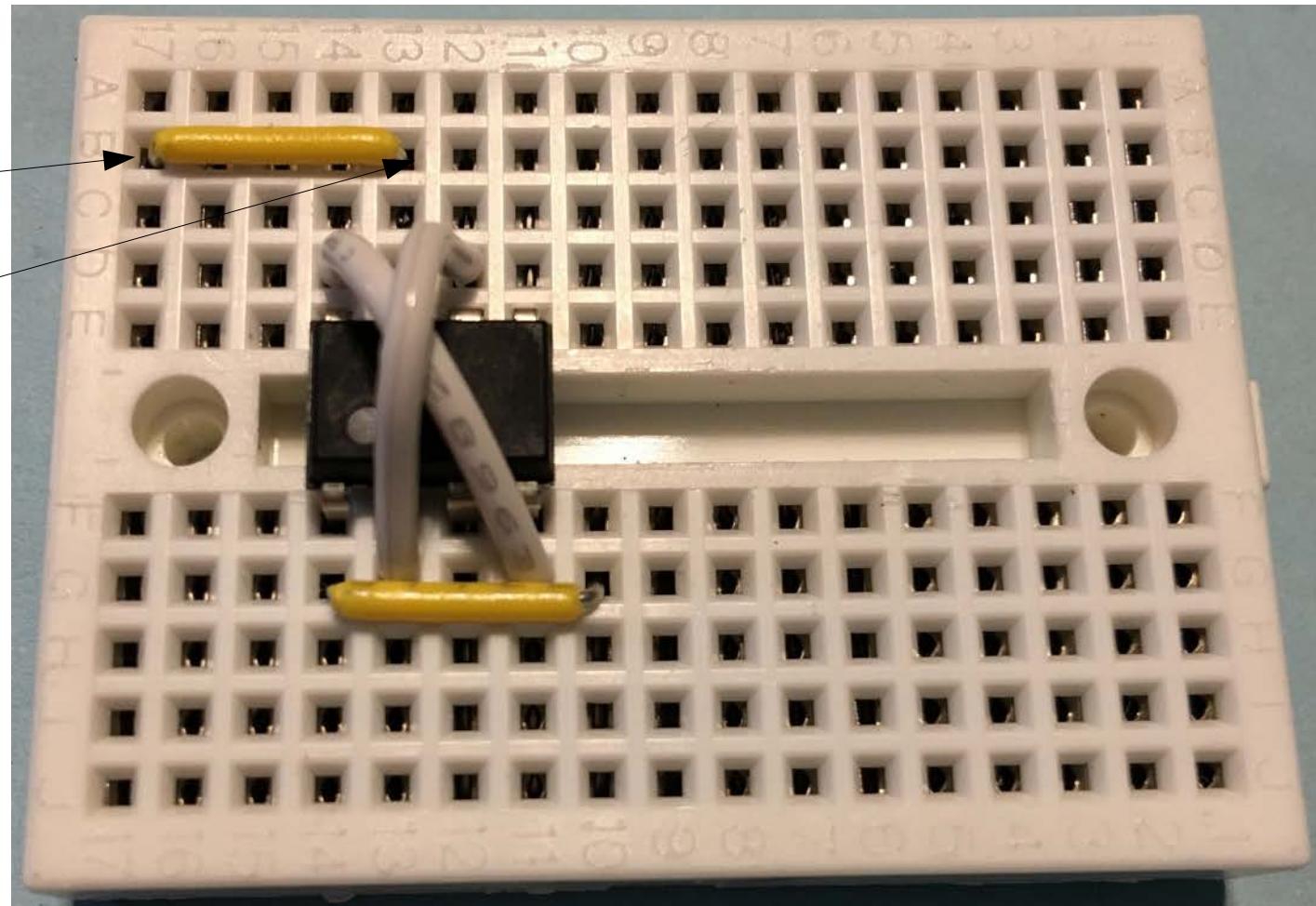
This step connects U1-1 (Ground) to column 10 on the board which is being used as Ground for the board. Ground in this case is the negative terminal of the battery.

Step 6 – Install Yellow Wire 2



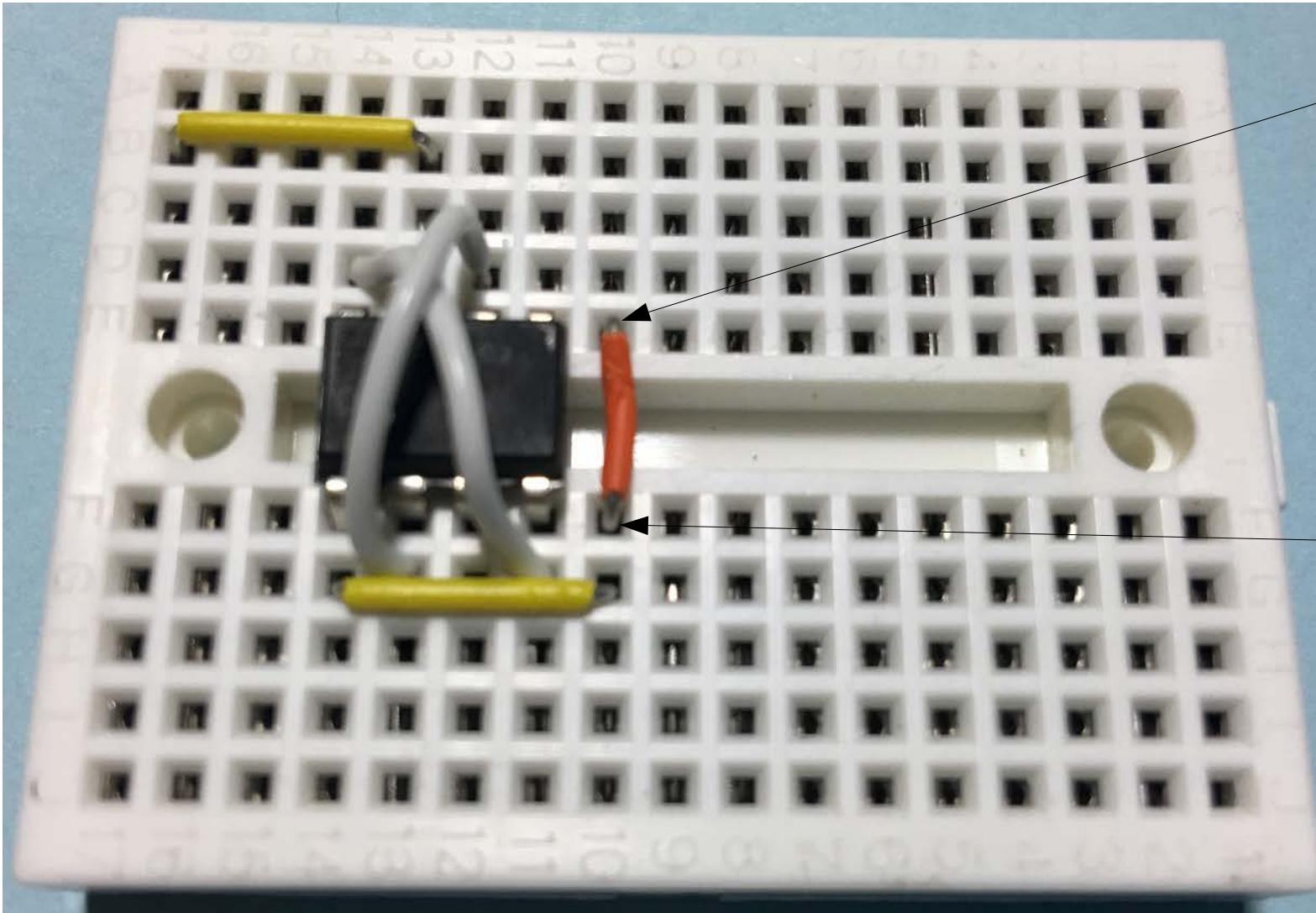
Breadboard B17

Breadboard B13



This step connects U1-7 (Discharge) to the edge of the breadboard where it will connect to the user's hand

Step 7 – Install Orange Wire 1

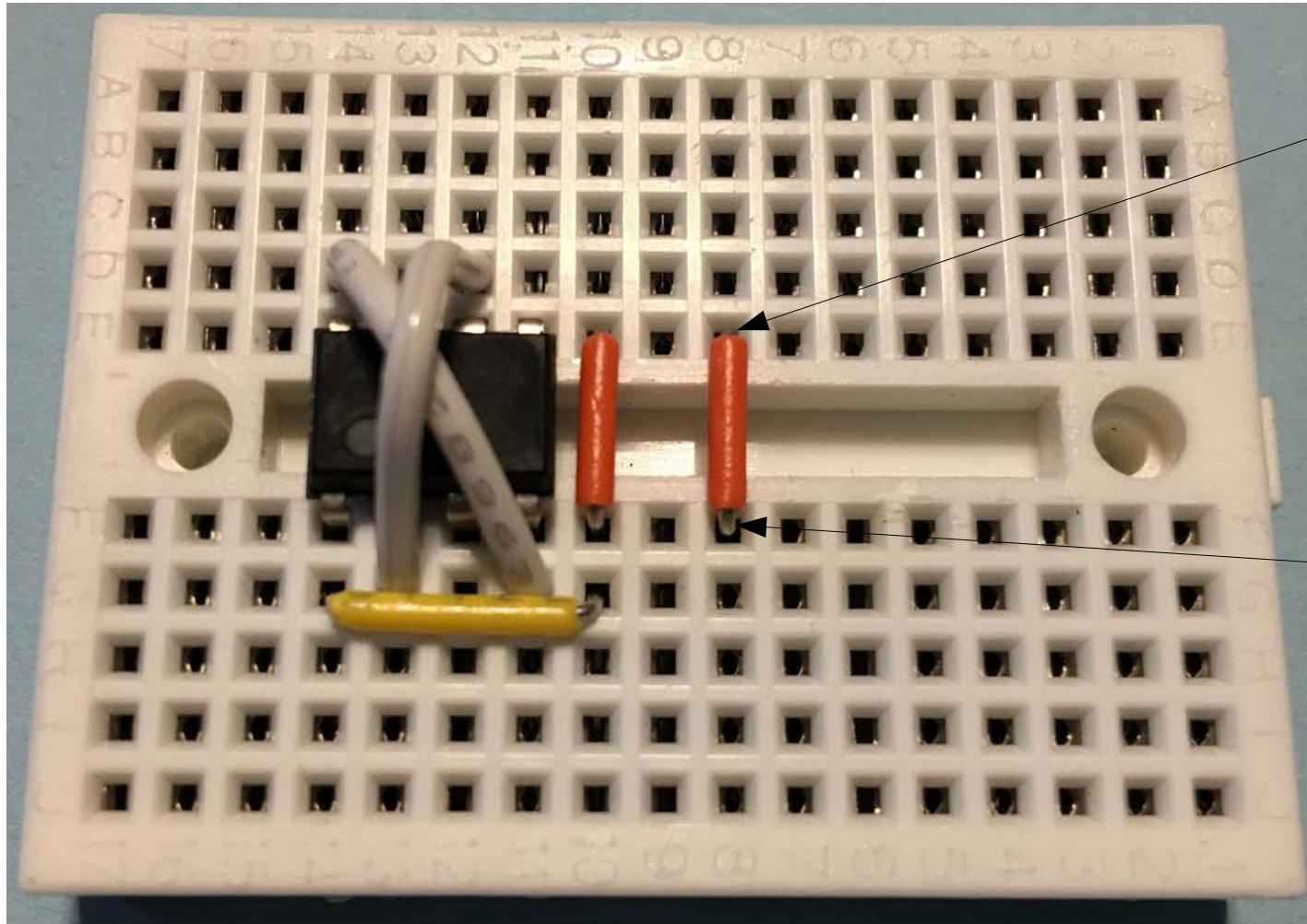


Breadboard E10

Breadboard F10

This step connects the other side of the board to Ground so that the decoupling capacitor added to pin 5 in a later step has a path to ground.

Step 8 – Install Orange Wire 2



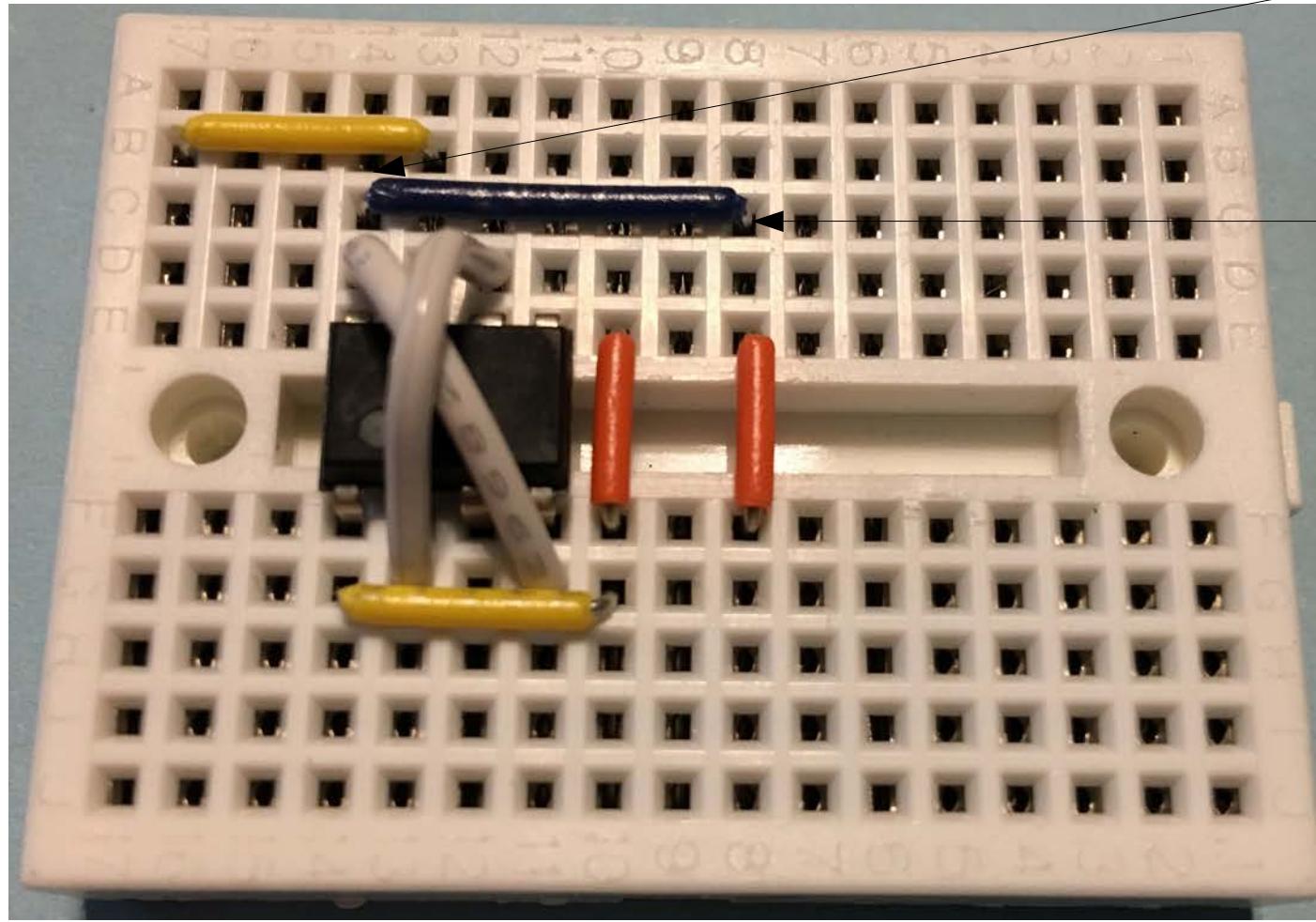
This step connects the two sides of the breadboard to allow +3V from the battery which will be connected later to the opposite side of the board.

Step 9 – Install Blue Wire



Breadboard C14

Breadboard C8

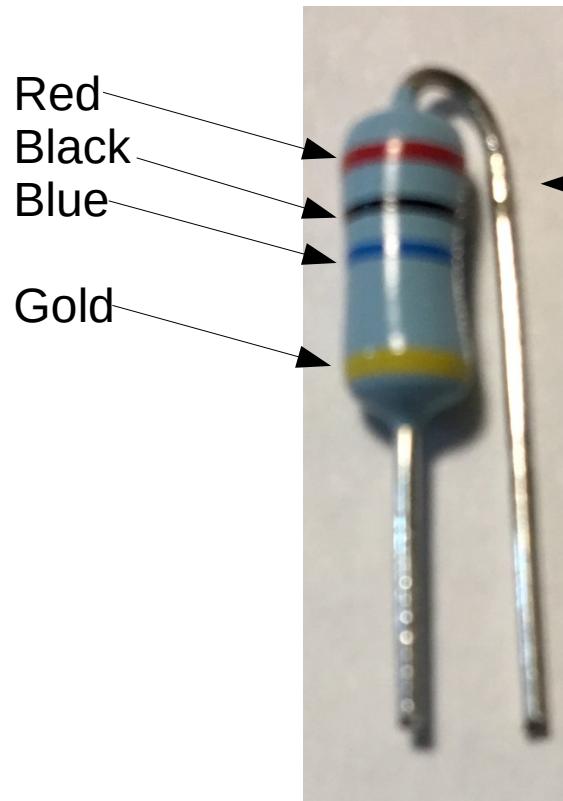


This step connects +3V to the Vdd pin (U1-8).

Step 10 – Bend & Cut R1 (20MΩ)



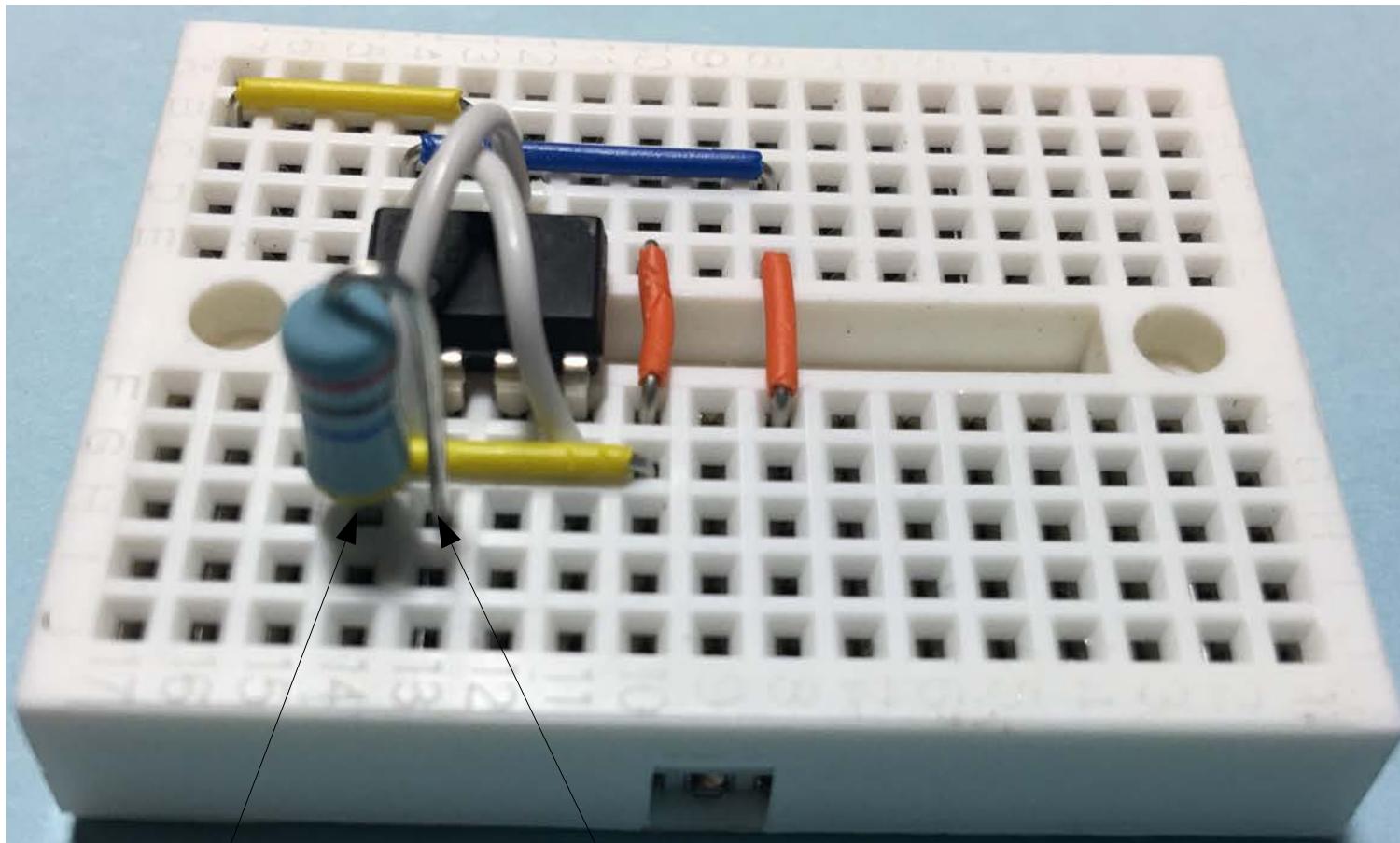
Find the 20 meg-ohm resistor in your kit.
It will have 4 colored bands (red, black, blue and then gold)



1) Bend the lead around and down as shown

2) Trim leads to be 8-10mm long from bottom of resistor.

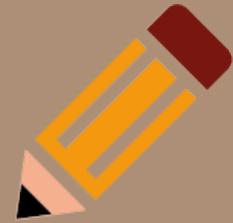
Step 11 – Install R1



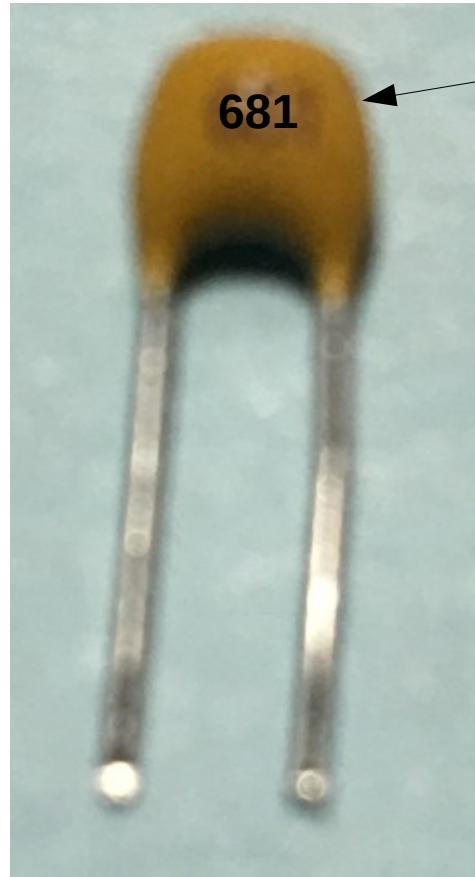
Breadboard H14

Breadboard H13

Step 12 – Trim C1 (680pF)



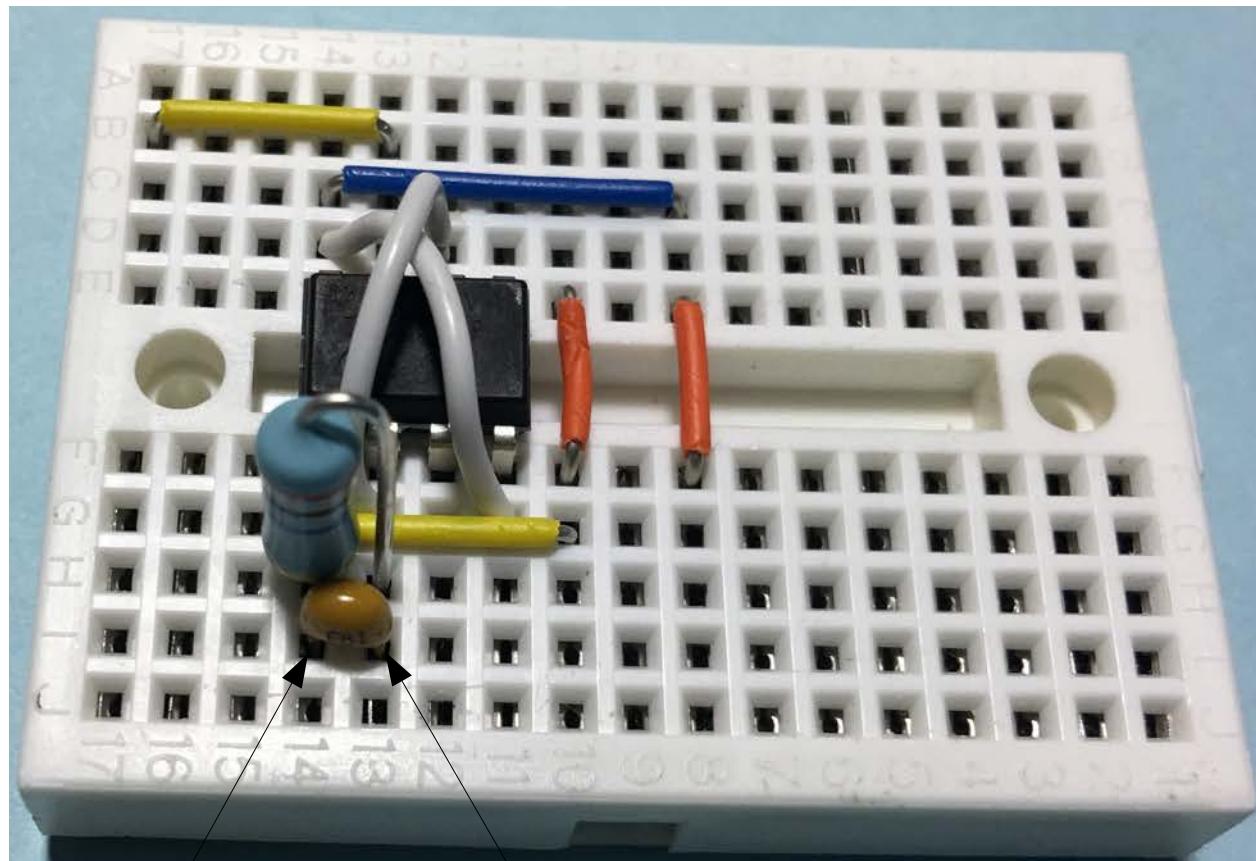
Find the 680 pF (picofarad) capacitor in your kit.
It is yellow and will have the number 681 on the side.



Text says 681 on one side; there may be other text on opposite side.

Trim leads to be 8-10mm long from bottom of capacitor.

Step 13 – Install C1 (680pF)



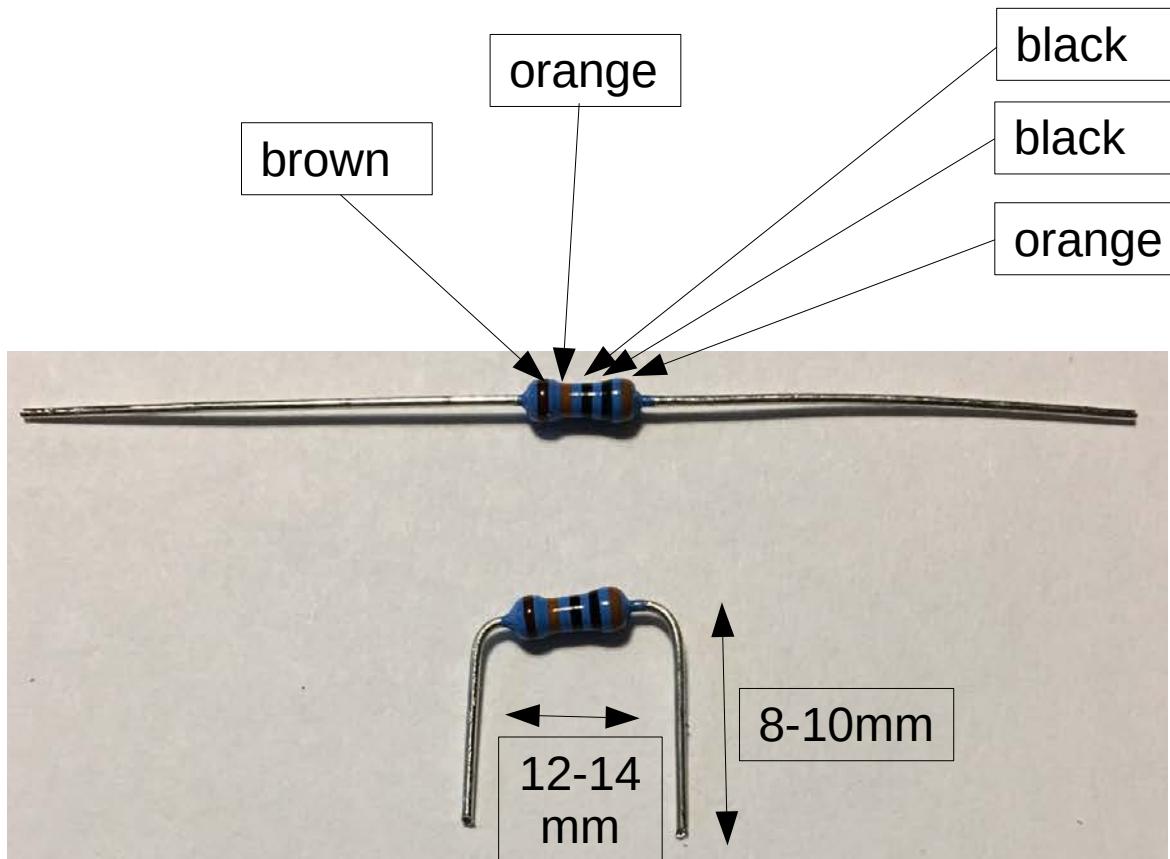
Breadboard I14

Breadboard I13

Step 14 – Bend and Cut R2 (300kΩ)

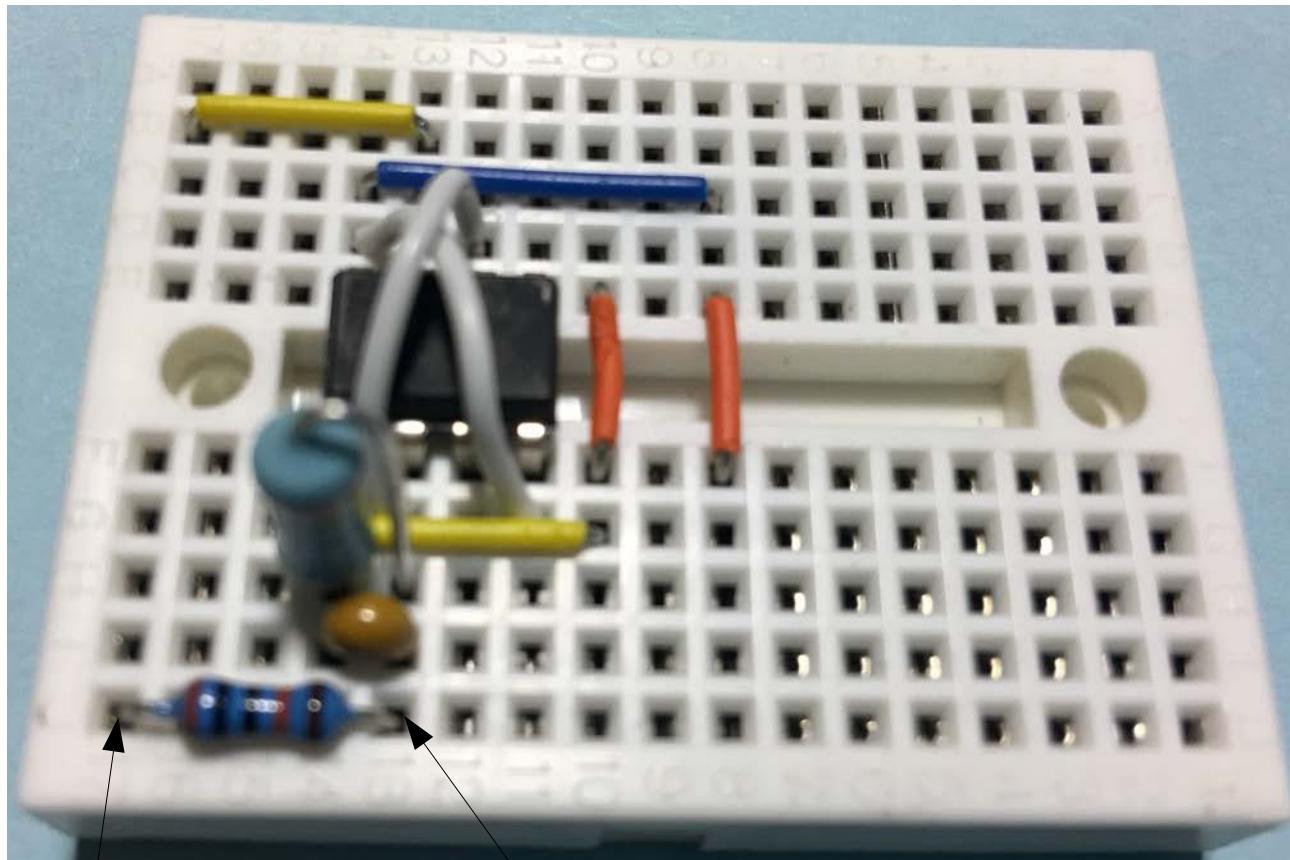


Find the 300 kilohm resistor in your kit.
It will have 5 colored bands (orange, black, black, orange, brown)



- 1) Bend leads of resistor as shown so that the pitch (distance between the pins) is about 12-14mm.
- 2) Trim leads to be 8-10mm long from bottom of resistor.

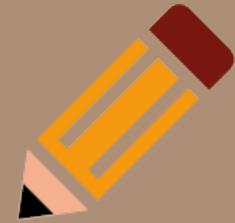
Step 15 – Install R2 (300kΩ)



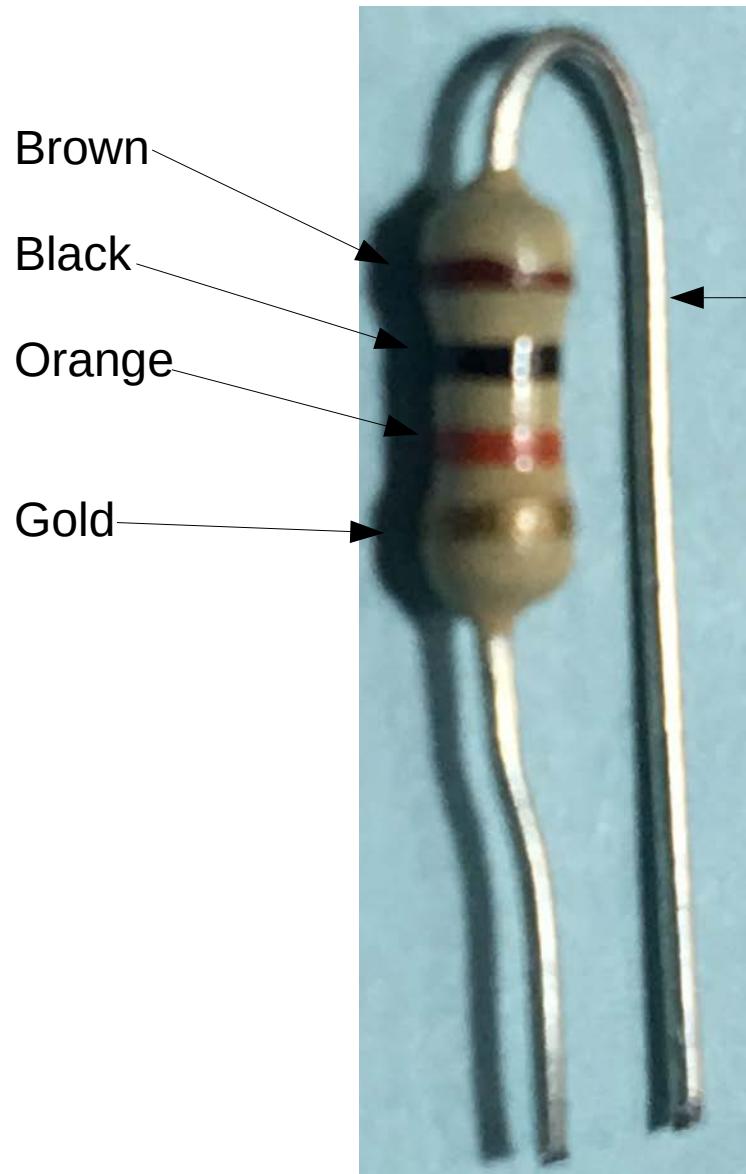
Breadboard J17

Breadboard J13

Step 16 – Bend and Cut R3 (10kΩ)



Find the 10 kilohm resistor in your kit.
It will have 4 colored bands (brown, black, orange, gold)



1) Bend the lead around and down as shown

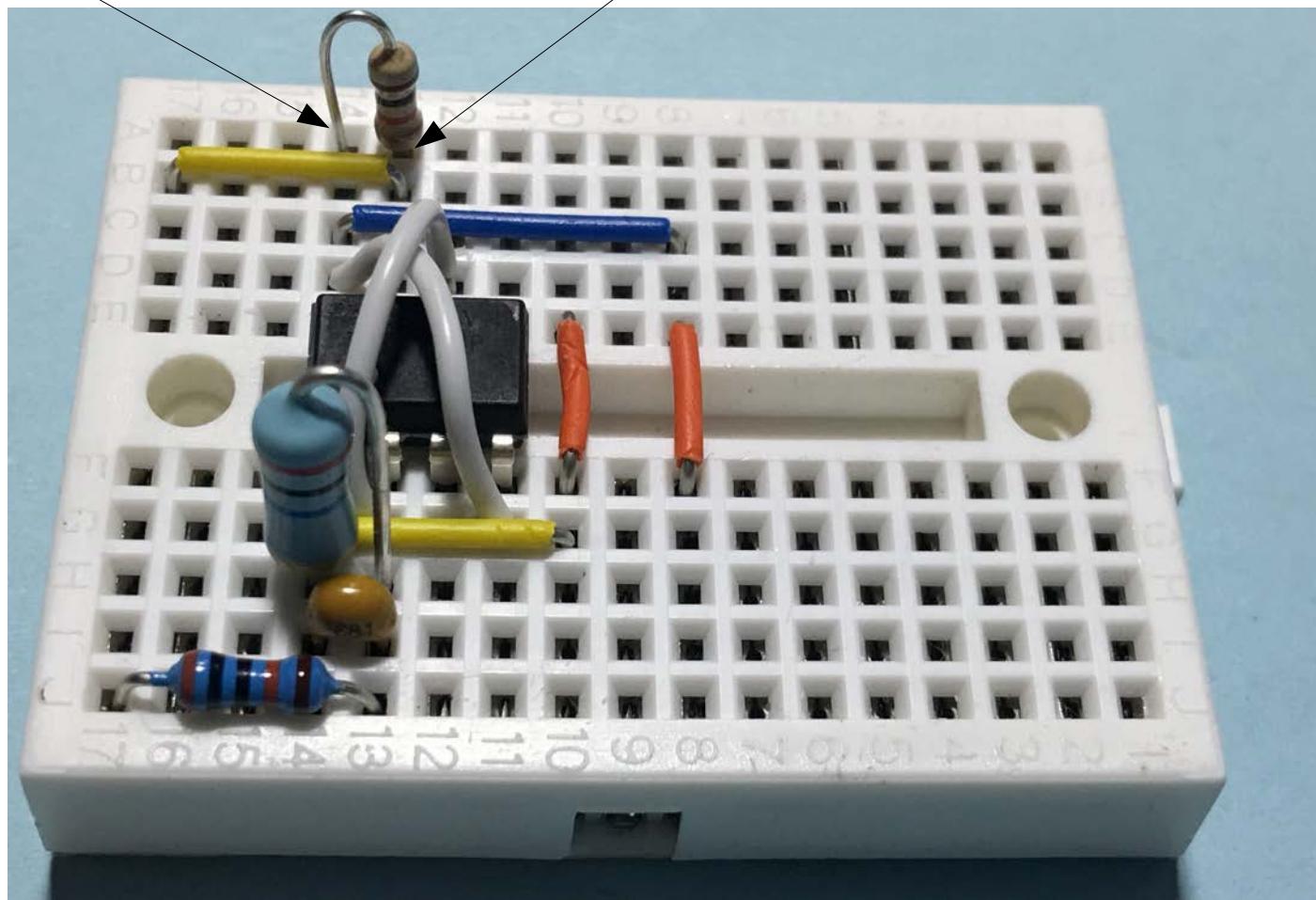
2) Trim leads to be 8-10mm long from bottom of resistor

Step 17 – Install R3 ($10k\Omega$)

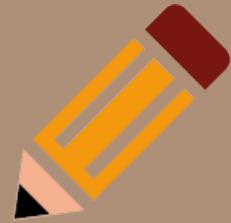


Breadboard A14

Breadboard A13

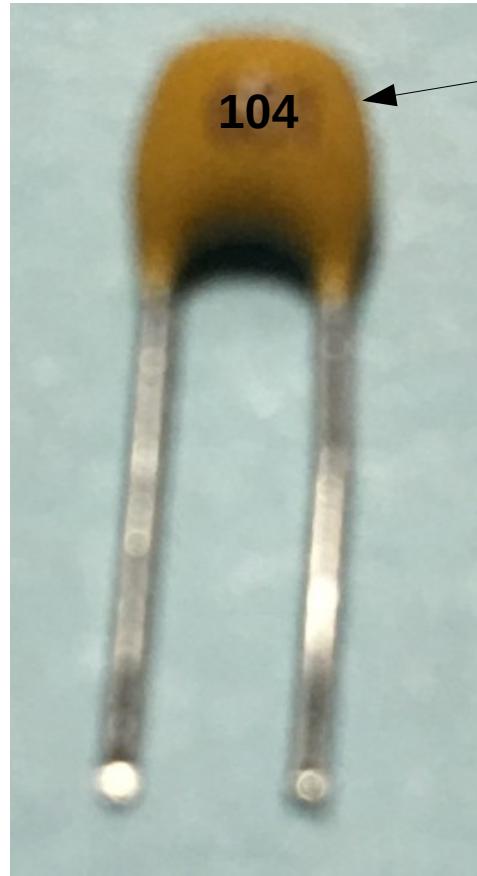


Step 18 – Trim C2 (0.1 μ F)



Find the 0.1 μ F (microfarad) capacitor in your kit.
It is yellow and will have the number 104 on the side.

The leads on your capacitor may already be short enough. Skip this step if so.



Text says 104 on one side; there may be other text on opposite side.

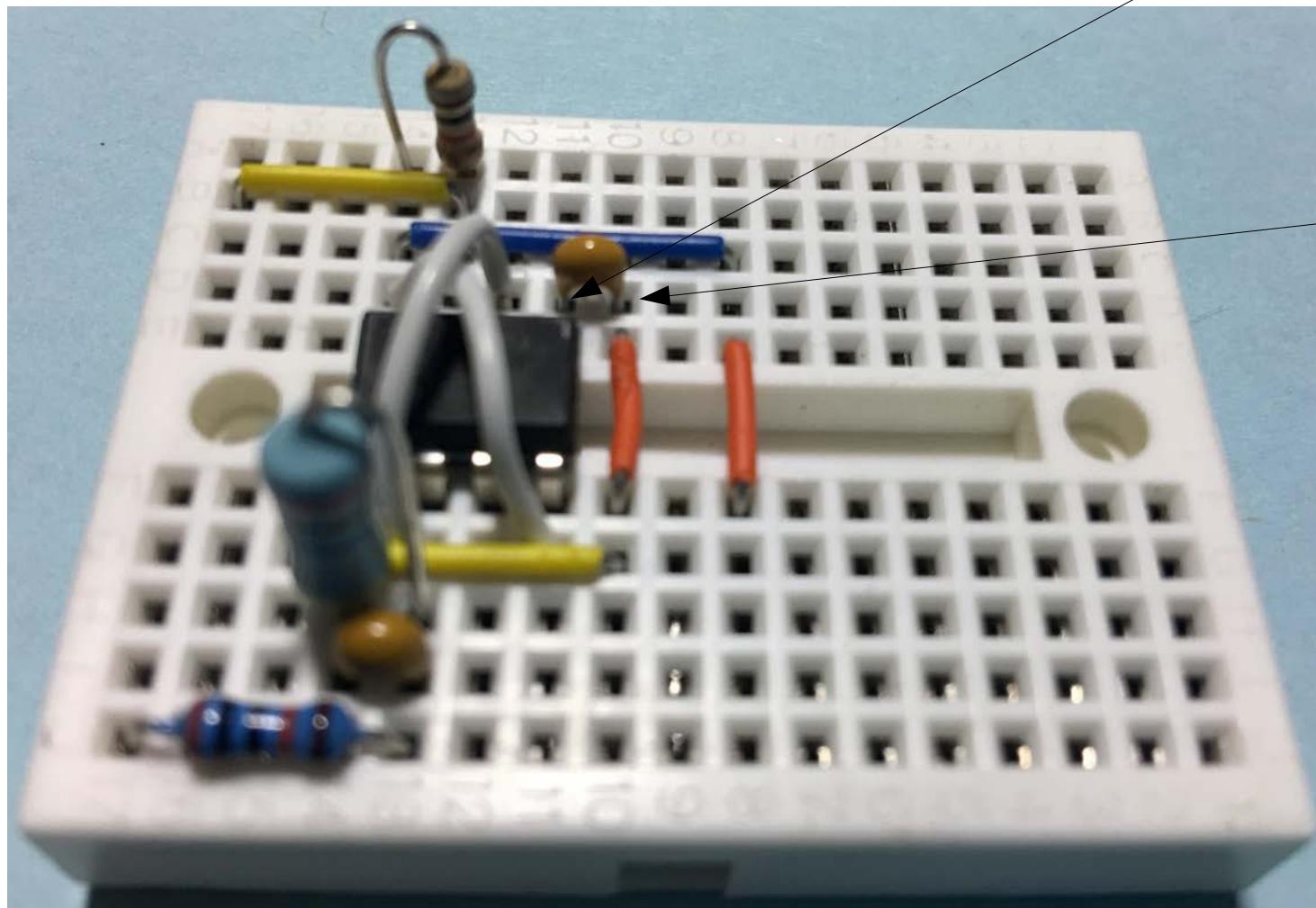
Trim leads to be 8-10mm long from bottom of capacitor.

Step 19 – Install C2 (0.1 μ F)



Breadboard D11

Breadboard D10

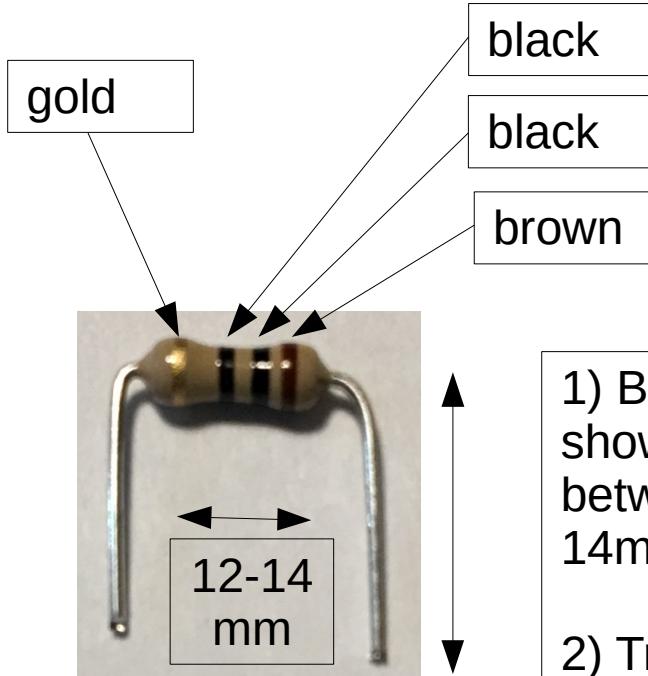


Step 20 – Bend and Cut R4 (10Ω)



Find the 10 ohm resistor in your kit.

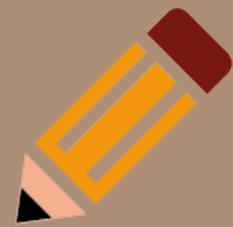
It will have 4 colored bands (brown, black, black, gold)



1) Bend leads of resistor as shown so that the pitch (distance between the pins is about 12-14mm).

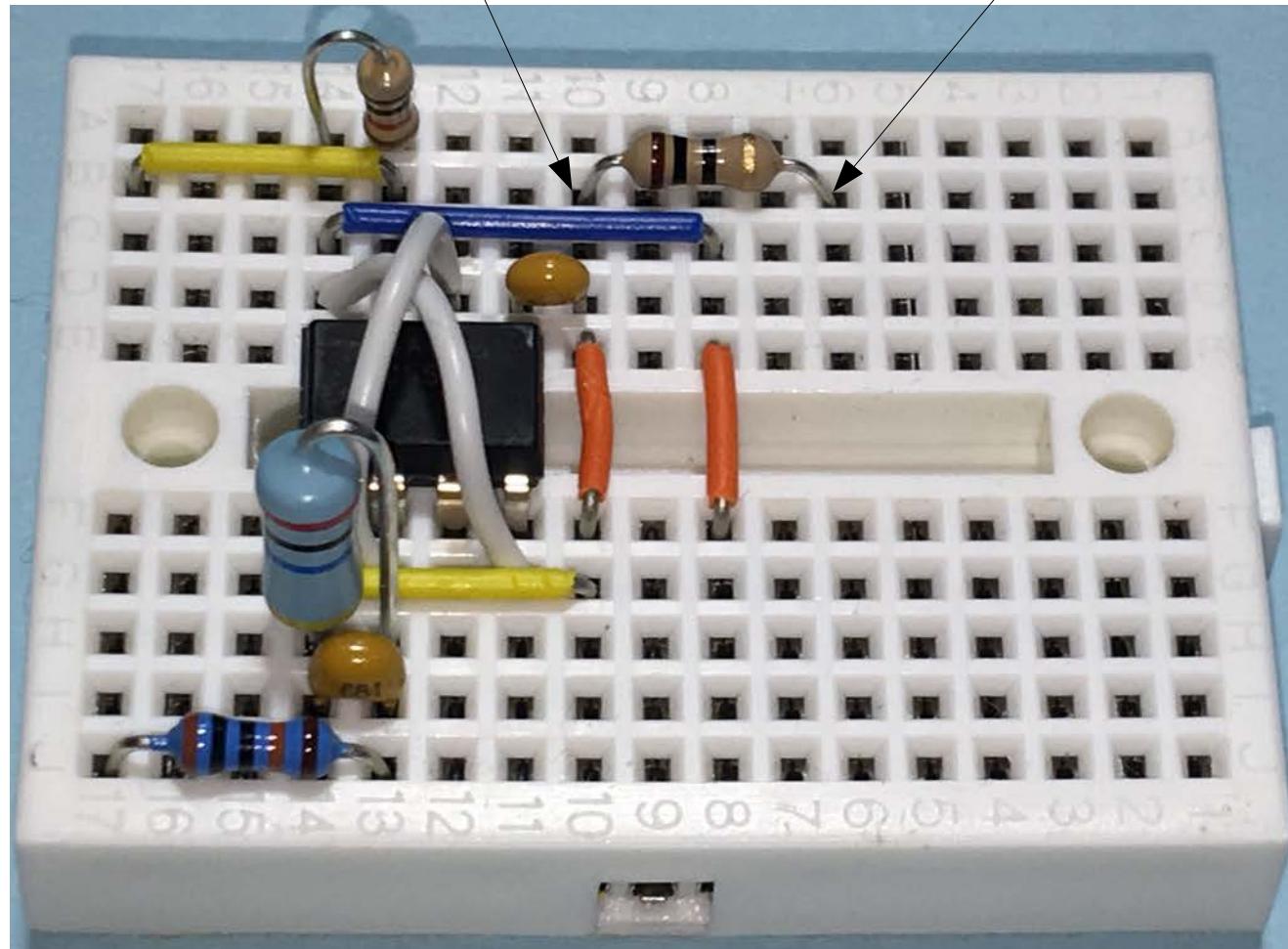
2) Trim leads to be 8-10mm long from bottom of resistor.

Step 21 – Install R4

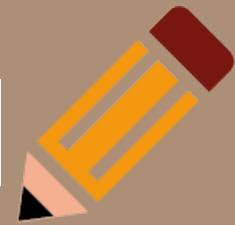


Breadboard B10

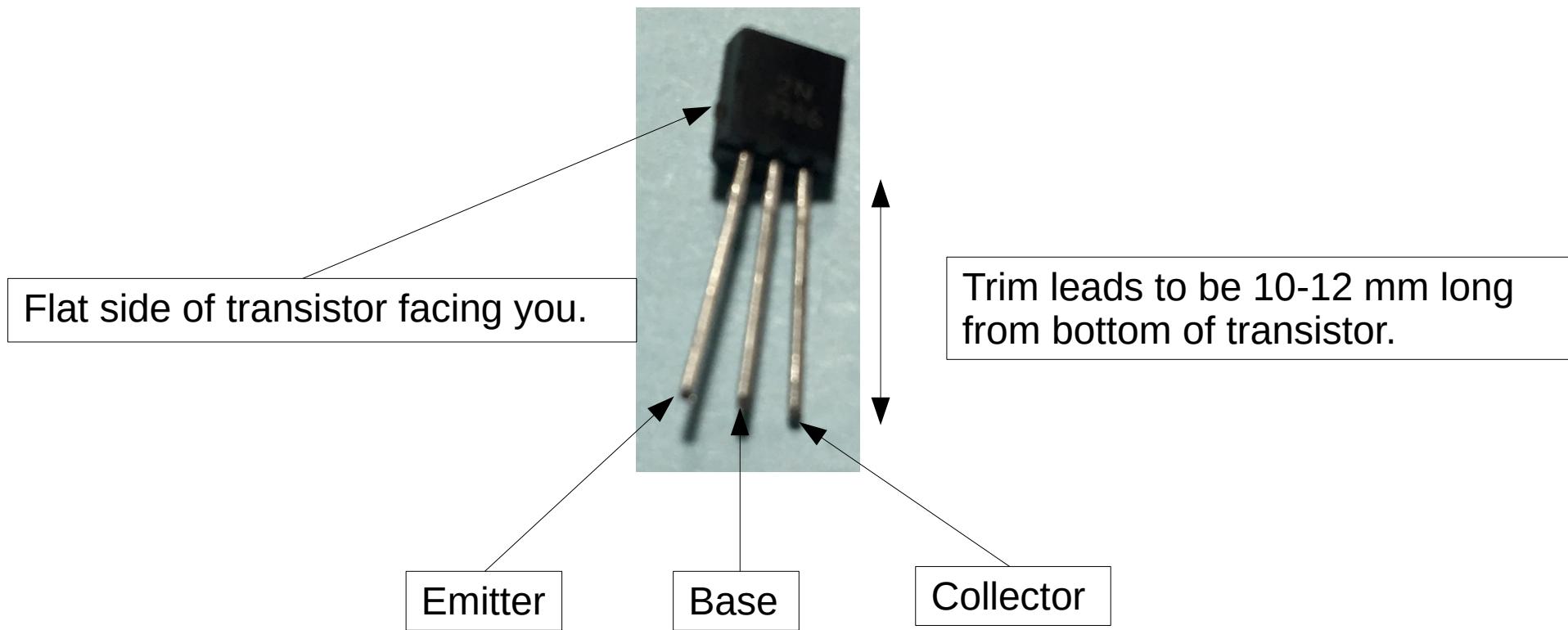
Breadboard B6



Step 22 – Trim Q1 (PNP Transistor)



Find the 2N3906 PNP transistor.



Step 23 – Install Q1 (PNP Transistor)

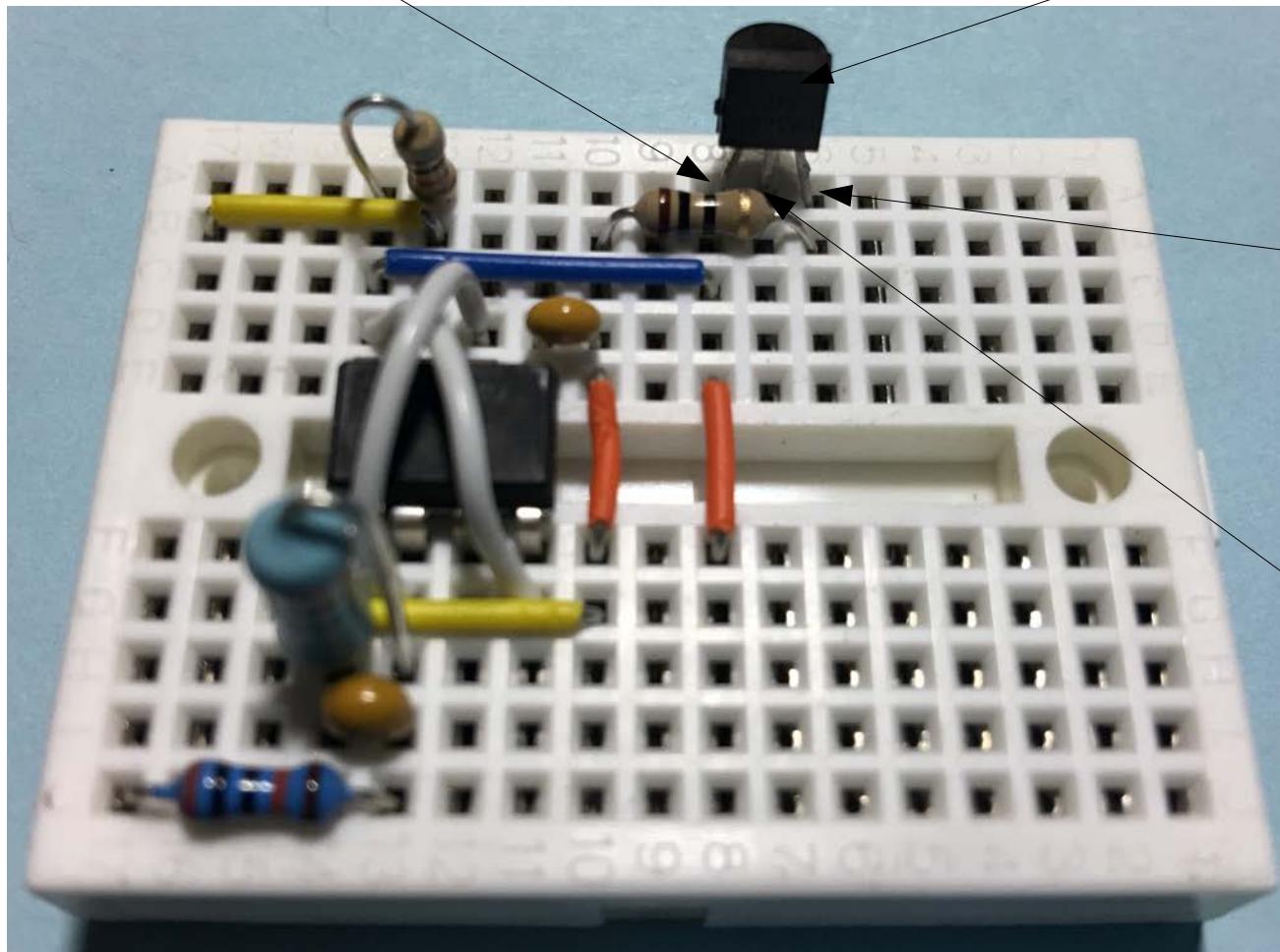


Breadboard A8
Emitter

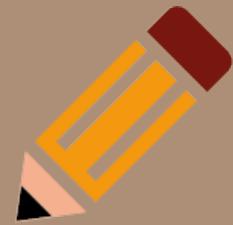
Flat side forward

Breadboard A6
Collector

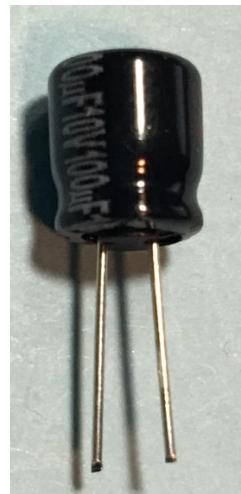
Breadboard A7
Base



Step 24 – Trim C3 (100 μ F)



Find the 100 μ F (micro farad) electrolytic capacitor.



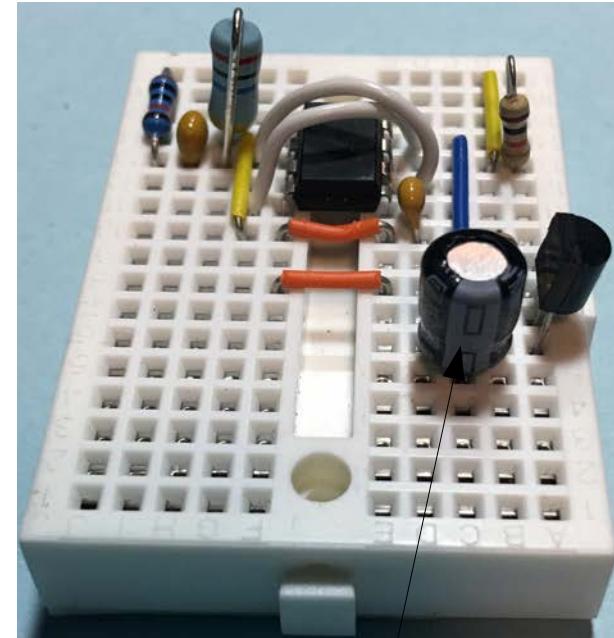
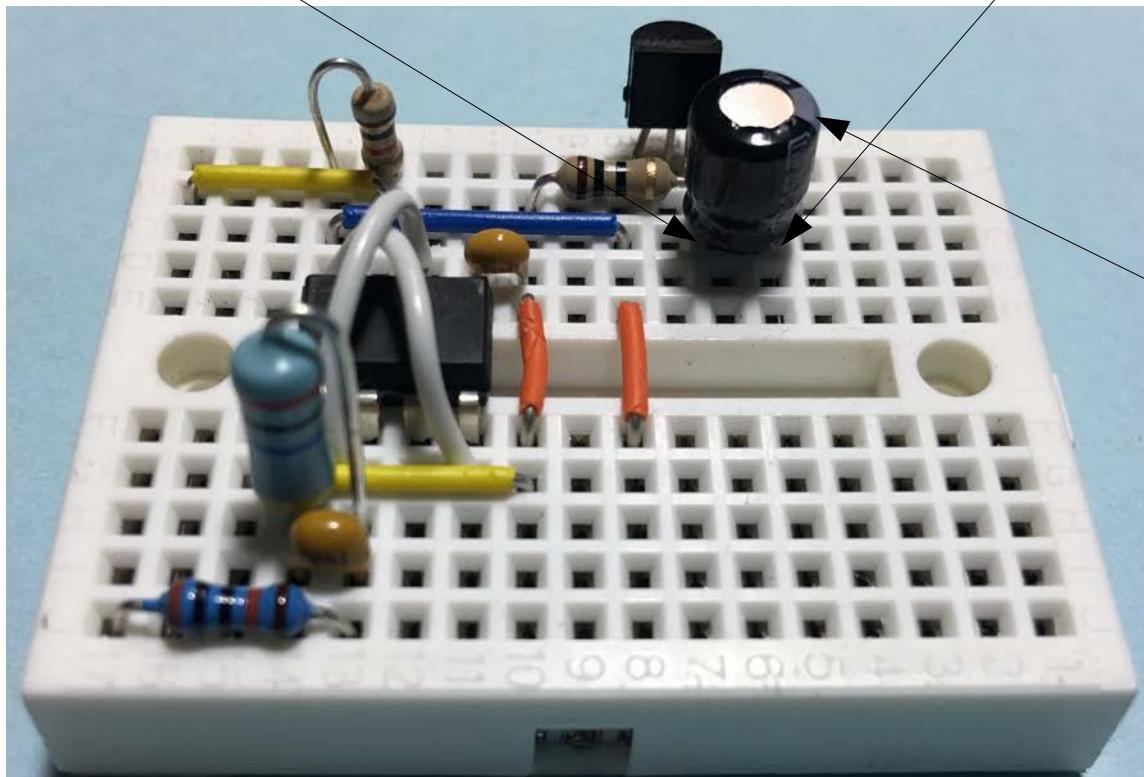
Trim leads to be 8 - 10 mm long from bottom of capacitor.

Step 25 – Install C3



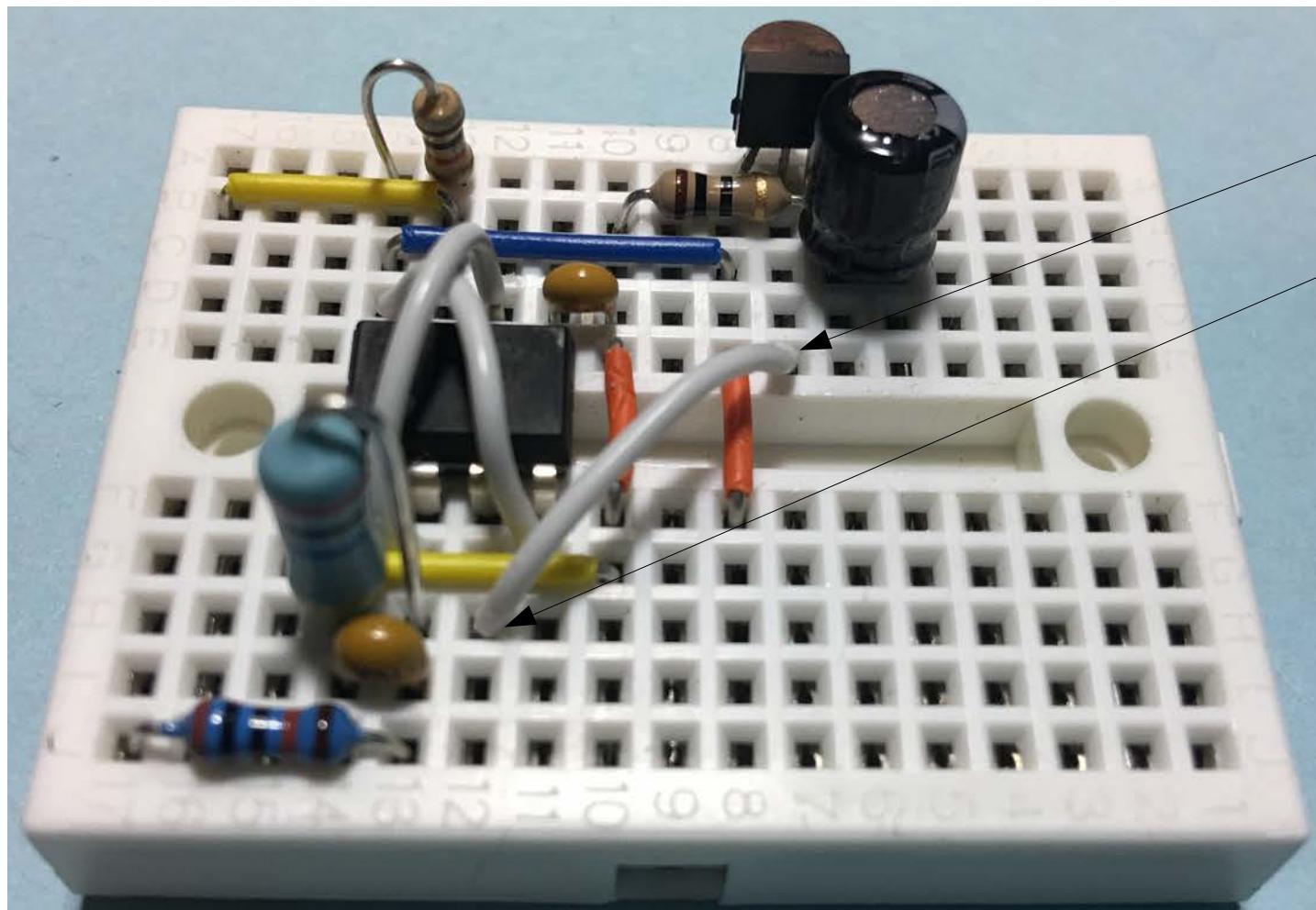
Capacitor (+)
Breadboard C6

Capacitor (-)
Breadboard C5



Capacitor (-) side must be in breadboard hole C5.
(-) mark is shown on side of the capacitor as shown above.
Electrolytic capacitors are polarized !

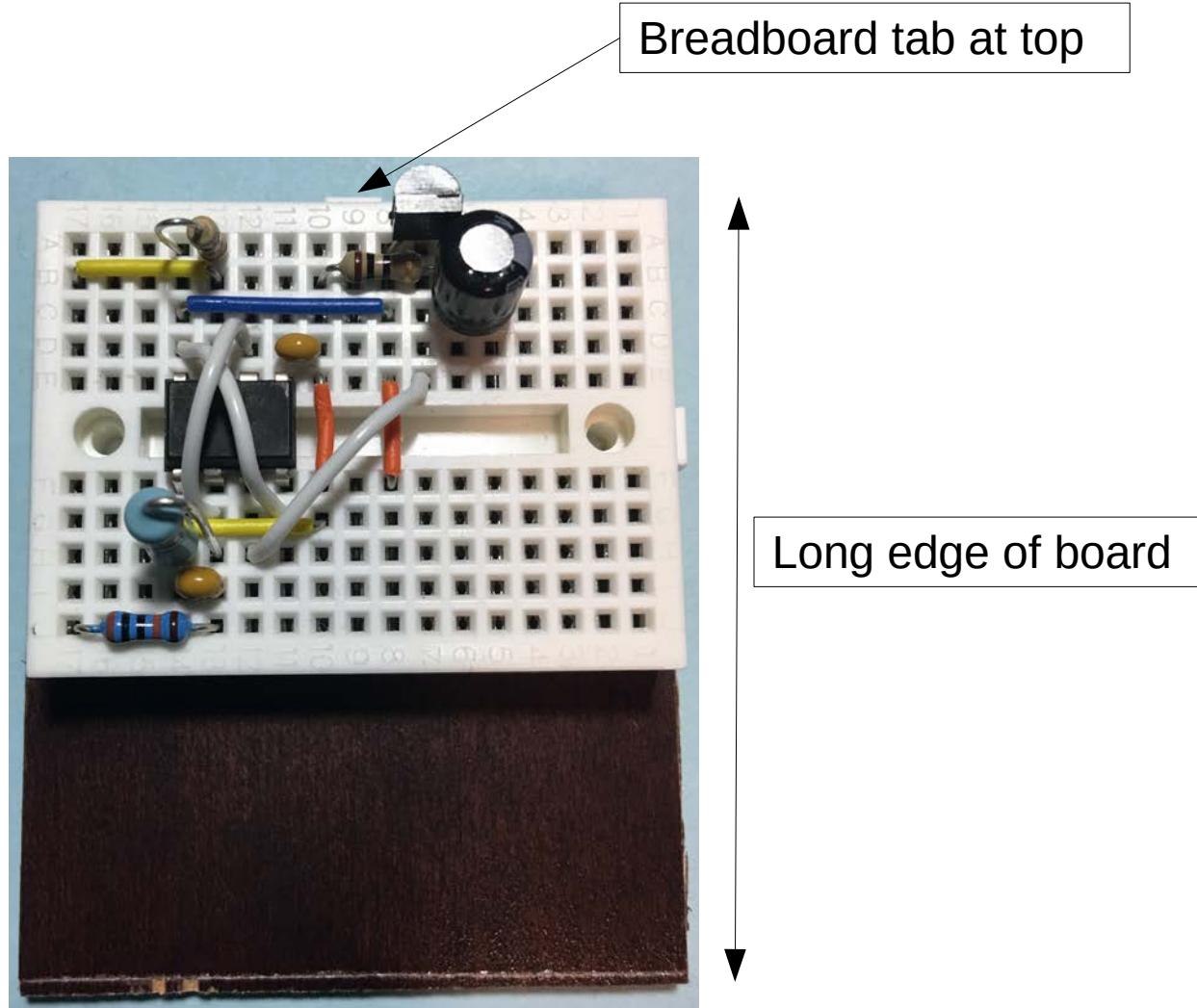
Step 26 – Install White Wire



Step 27 – Stick Breadboard to Board



Breadboard has self-adhesive tape on the back. Remove the backer paper and then simply press the breadboard to the board.



Step 28 – Trim Leads from Battery Holder



Cut these 2 tabs off



So it looks like this:



You **must** wear safety glasses when you cut these tabs !

Aim the tab down towards the table when you cut it to avoid having it fly through the air !

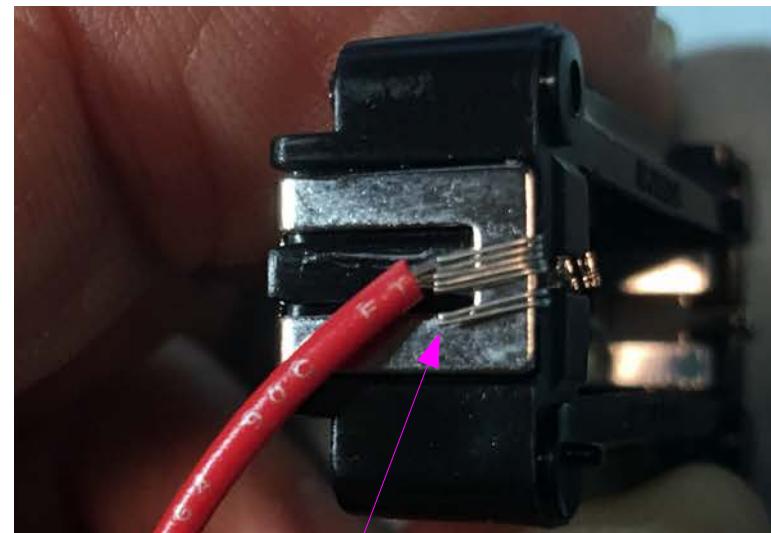
Step 29 – Connect Wires to Battery Holder



- 1) Find the 60mm long red and black wires. Strip both ends of each wire 8 – 10 mm.
- 2) Locate the end of the battery holder with the + sign.
- 3) Lift the tab at the end of the + end of the battery holder and slide the stripped end of the red wire through it as shown. A small screwdriver may be helpful.
- 4) Lift the tab at the end of the - end of the battery holder and slide the stripped end of the black wire through it as shown. *Note that stranded wire is shown in the pictures; your kit will have solid wire.*

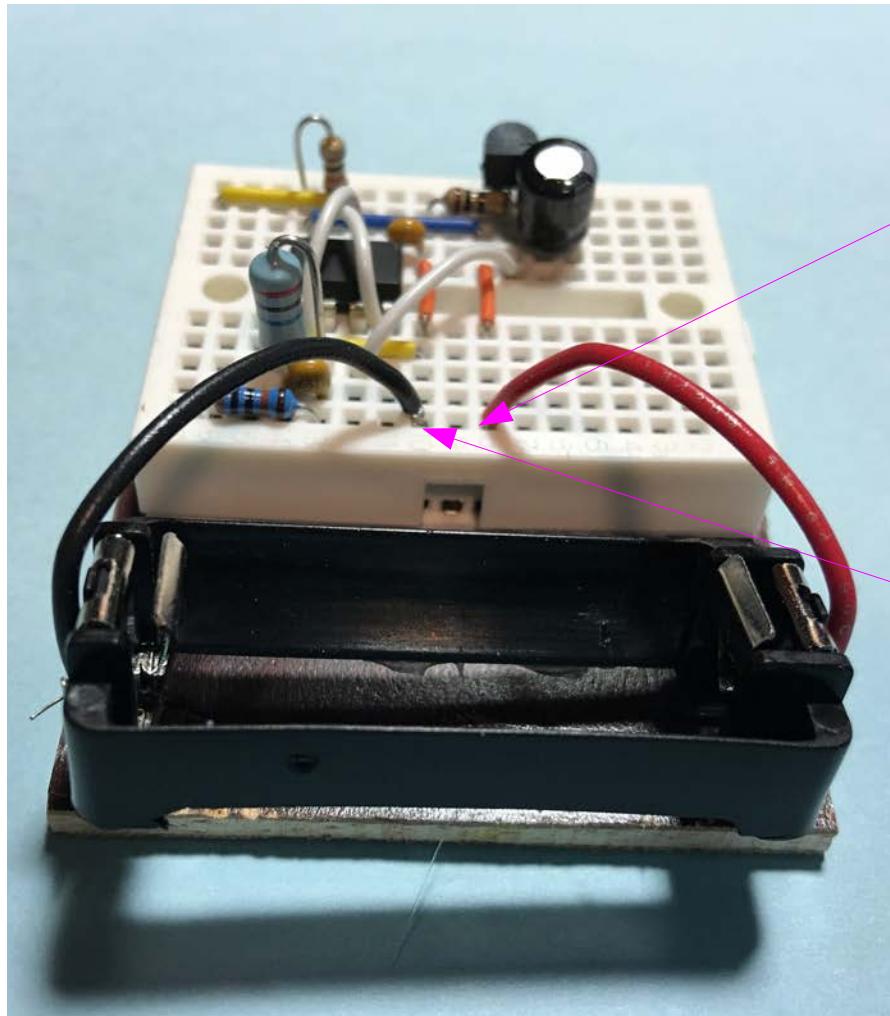


+ Marker



Put wires under tab as shown

Step 30 – Connect Battery Holder



Red Wire (+)
Breadboard J8

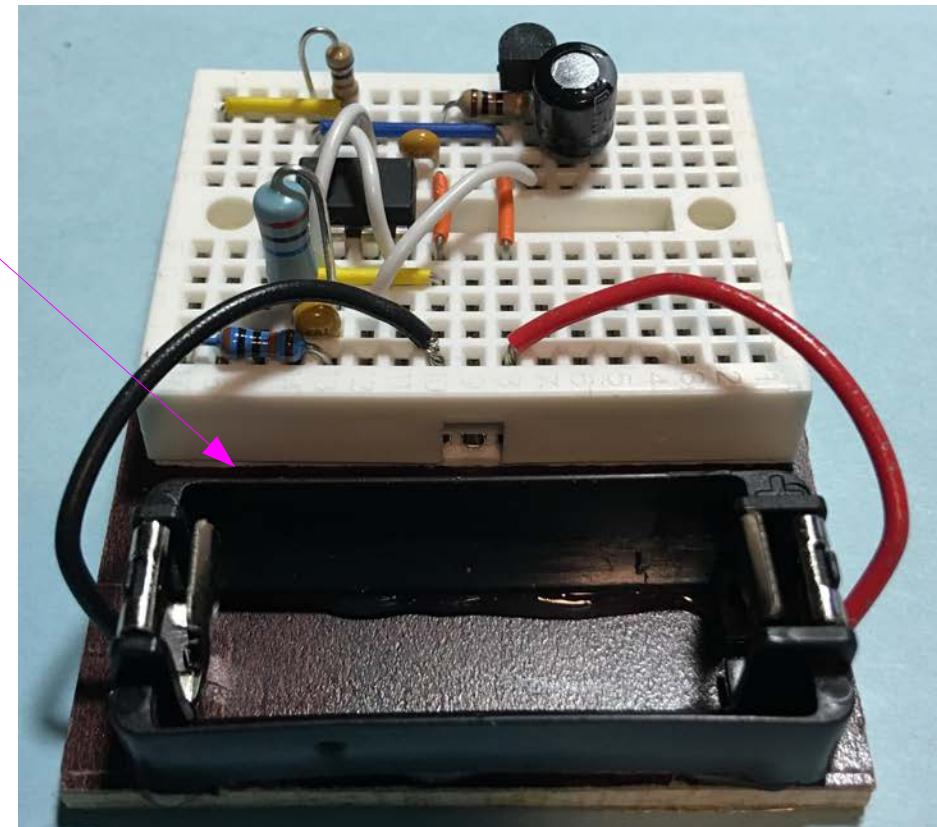
Black wire (-)
Breadboard J10

Step 31 – Glue Battery Holder to Board



Apply 2 stripes of hot melt glue to underside of battery holder and bond to board as shown

Leave gap between battery holder and breadboard.



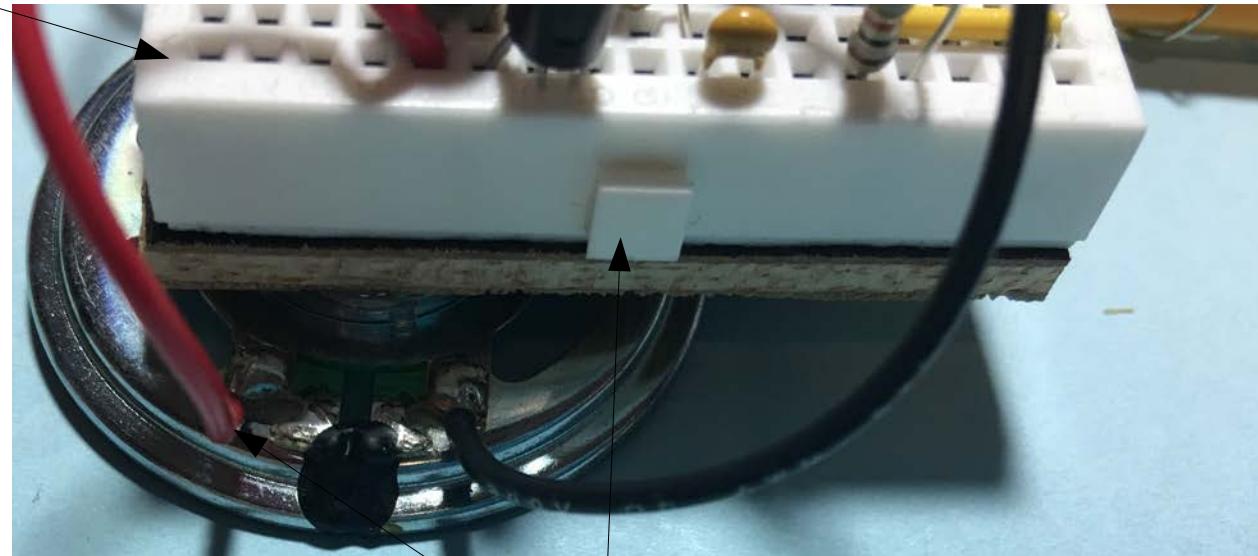
Step 32 – Glue Speaker to Back



Breadboard A1

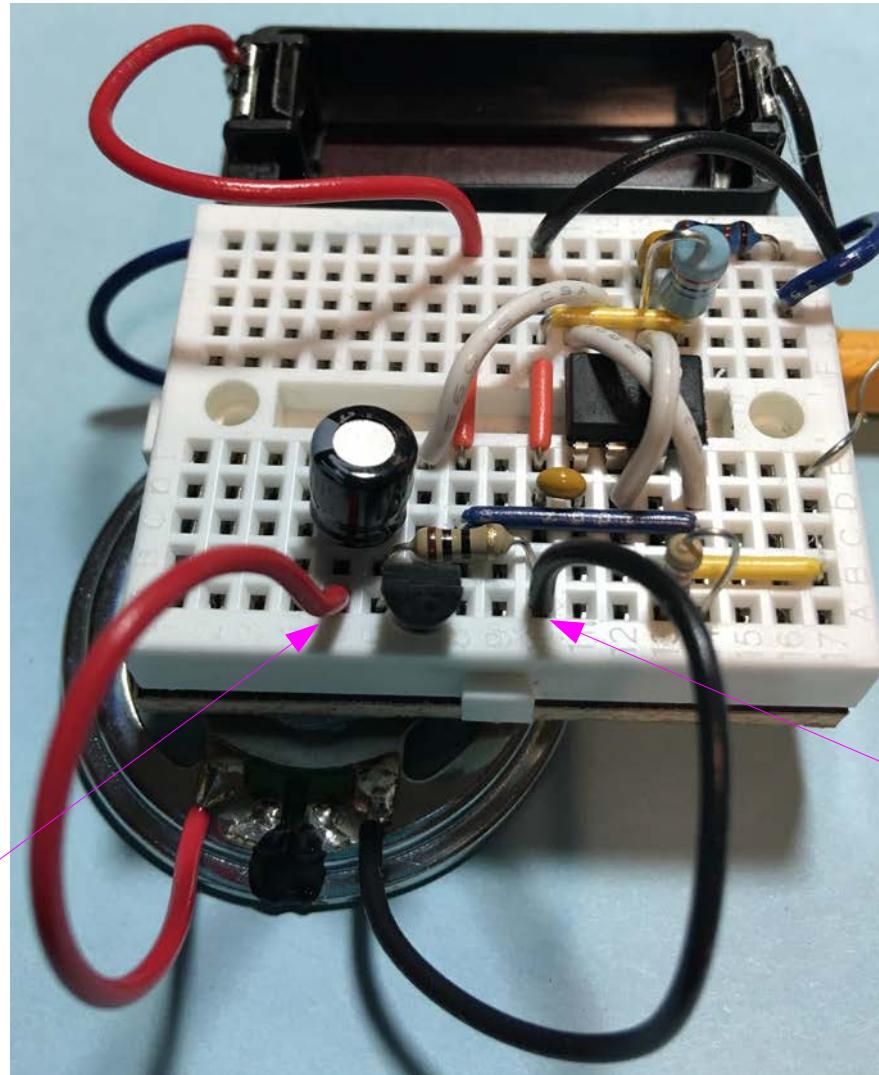


Use hot melt glue to attach speaker to backside corner of board. Put speaker mostly off board to leave room for pencil later.



Wires come out on tab side

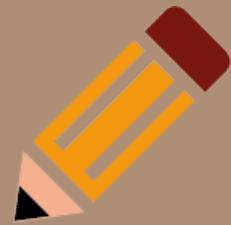
Step 33 – Plug in Speaker Wires



Speaker red
wire plugs into
breadboard A5

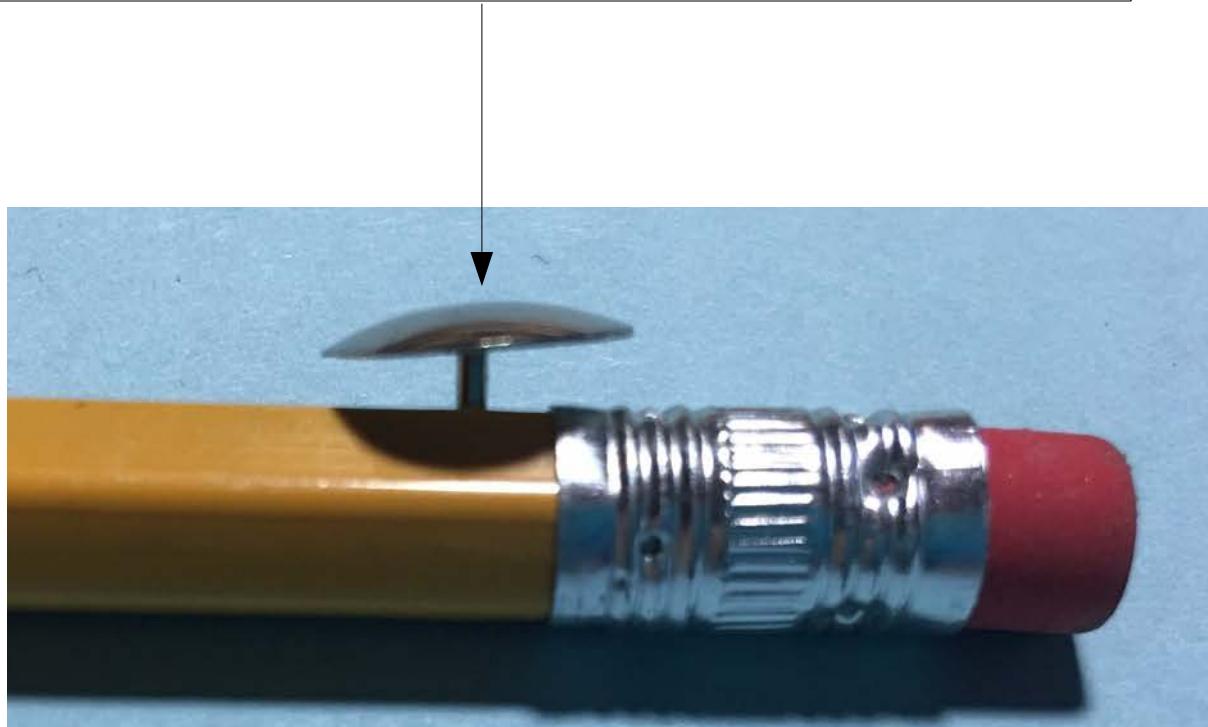
Speaker black
wire plugs into
breadboard A10

Step 34 – Press Tack into Pencil



Press tack $\frac{1}{2}$ way into side of pencil just below eraser.
This provides an electrical connection to the pencil lead.

This takes some strength. Ask for help from a mentor if you have trouble doing this !



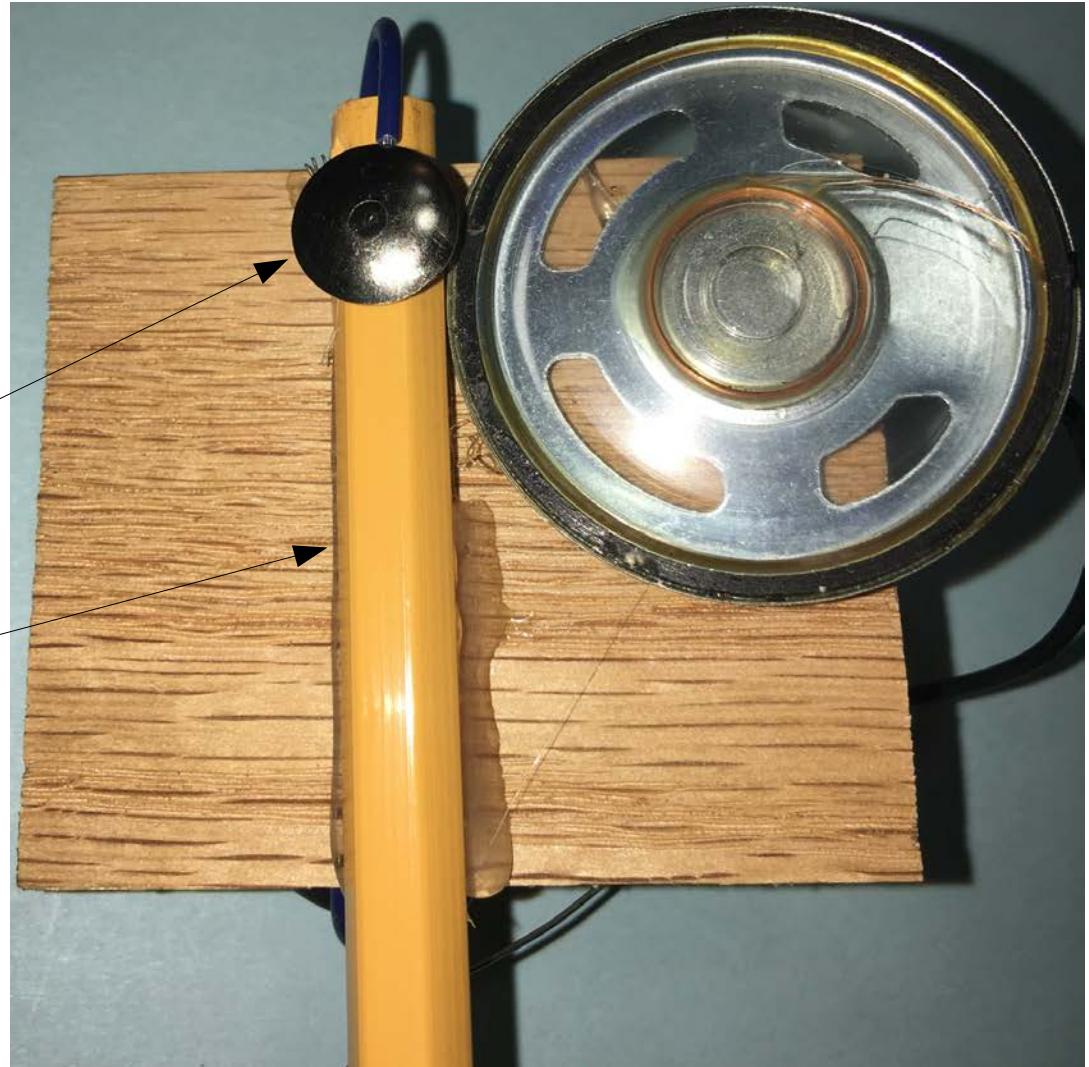
Step 35 – Glue Pencil On



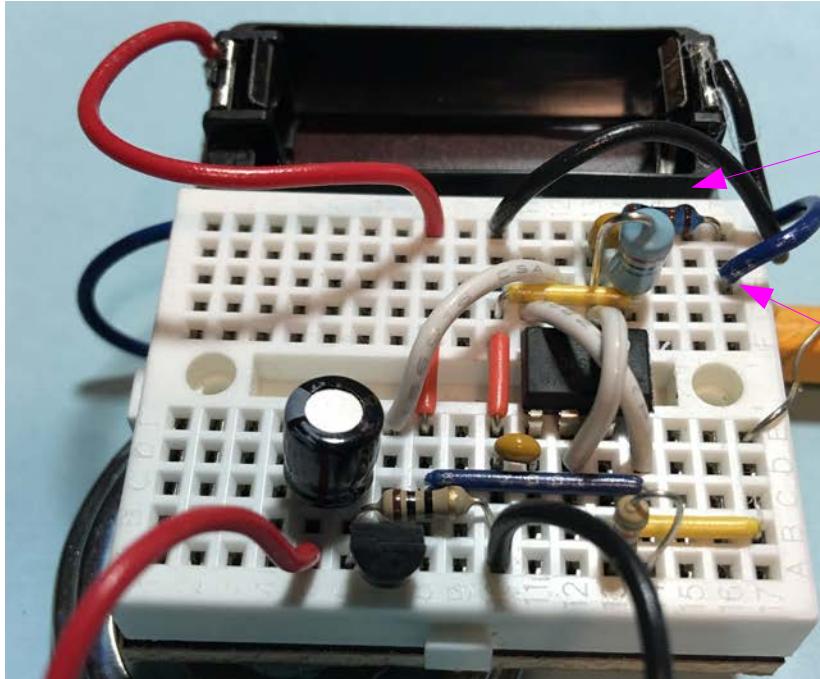
Put a stripe of hot melt glue down the center line of the back side of the board and glue the pencil to it with the tack facing outwards.

Tack faces
outwards

Glue on
backside of
board



Step 36 – Attach Graphite Wire



1) Find the 100mm long white wire. Strip one end 8 – 10mm long. Strip the other end 15-18mm long.

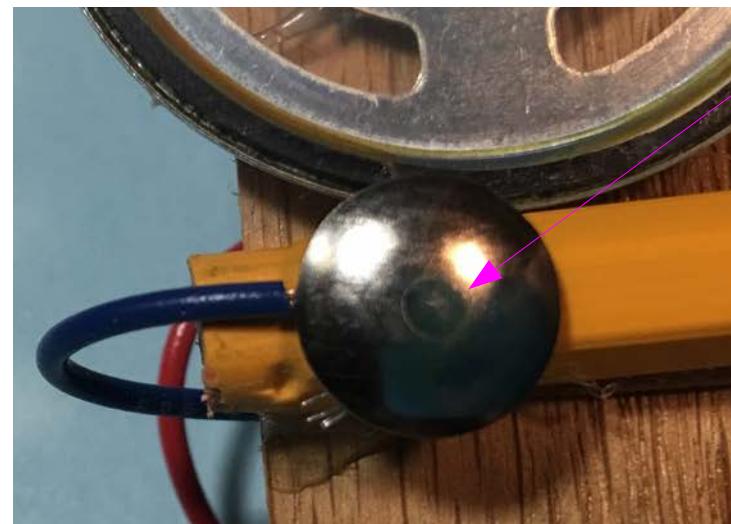
Notes:

a) Wire shown in picture above is blue, not white; white wire was not available.

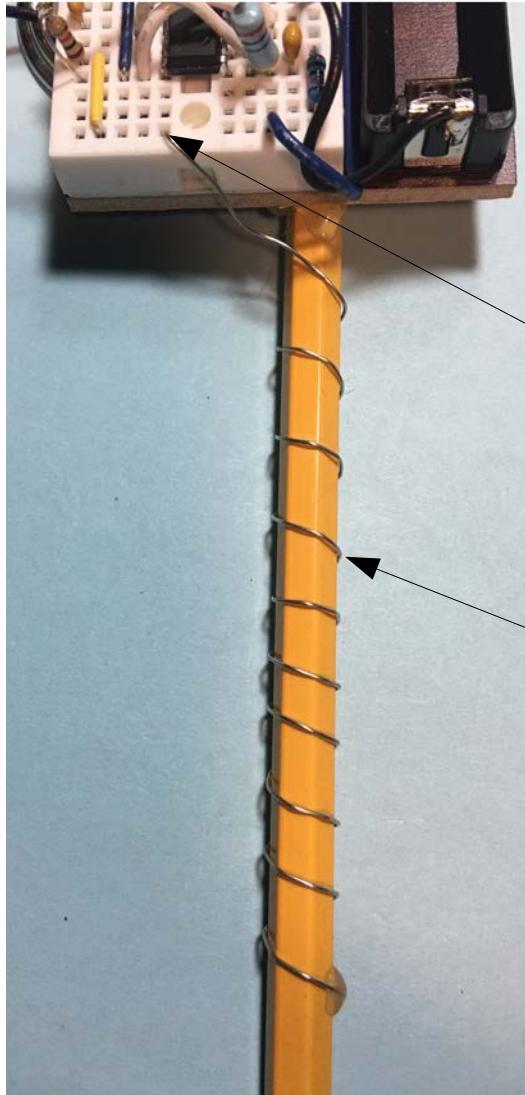
3) Route white wire through gap between battery holder and breadboard.

2) Plug short stripped end of white wire into breadboard H17.

4) Wrap other stripped end of wire around tack 2-3 times and press tack in fully



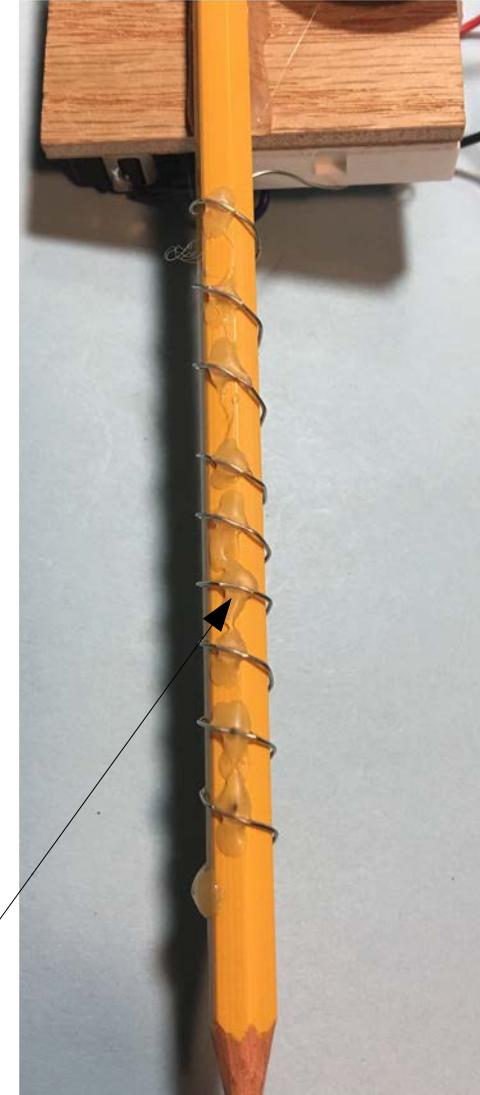
Step 37 – Add Hand Contact Wire



1) Find the 400mm long bare silver colored wire. Plug one end into breadboard E17

2) Wind the wire tightly down the length of the pencil in a spiral.

Tack the wire to the pencil with hot melt glue. Cover as little of the wire as possible so it can make good contact with your hand.

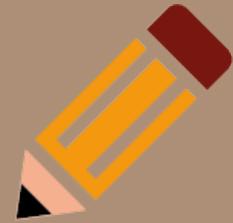


Step 38 – Inspect



- 1) Double check polarity of wires on battery holder (red goes to + end, black to – end).
- 2) Double check that battery wires are in the correct holes and are not swapped (Red in J8 and Black in J10).
- 3) Double check polarity of the electrolytic capacitor C3.
- 4) Double check that speaker wires are in correct holes.

Step 39 – Test Circuit



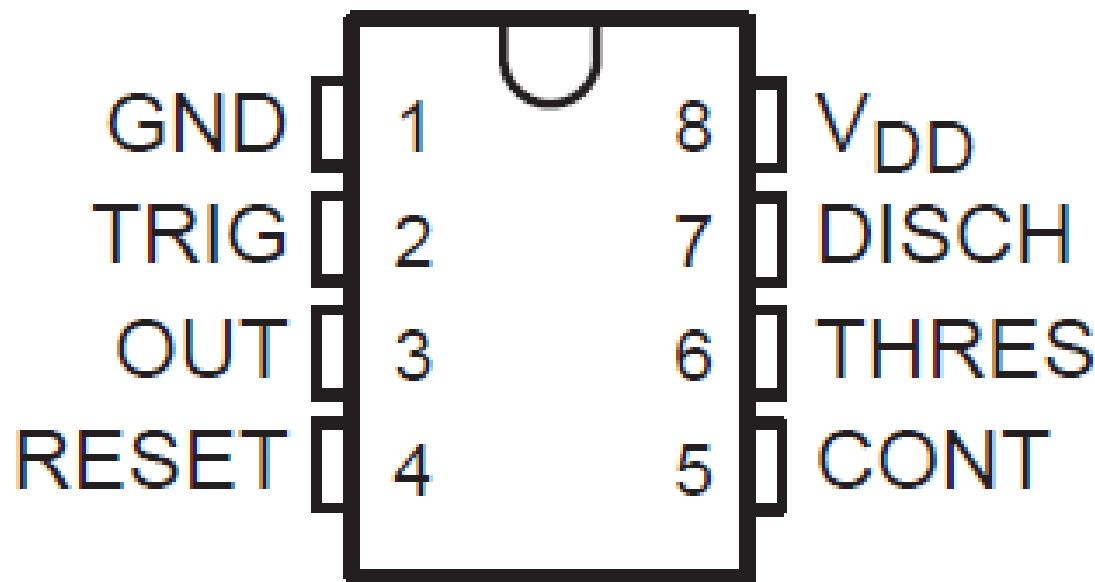
1) Insert the CR123A battery into the holder with the + end of the battery into the + end of the holder.



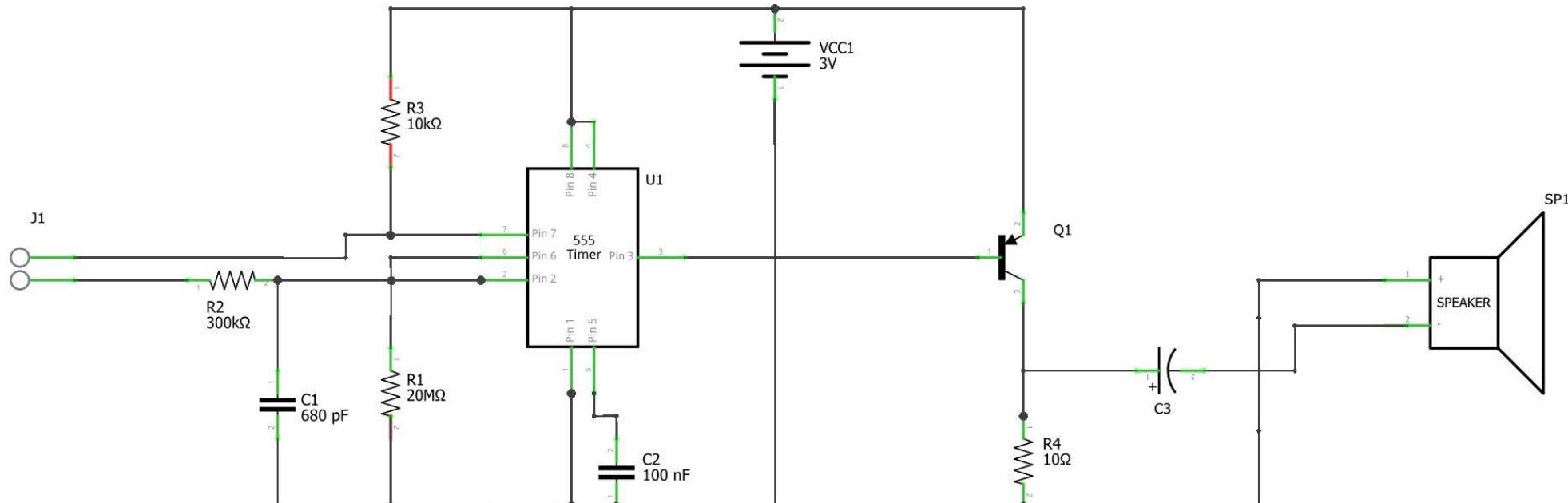
2) Hold the pencil in one hand, maintaining contact with the spiral wire on the outside. Moisten a spot on your other hand and touch the spot with the tip of the pencil. You should hear a tone ! If so you are ready to begin playing with your Drawdio !

3) If you don't hear a tone when you touch your other hand, check to see if the transistor or 555 IC are getting hot. Remove the battery if this happens and ask for help.

555 IC Pin Names

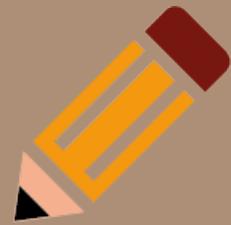


Drawdio Schematic



fritzing

555 IC Block Diagram



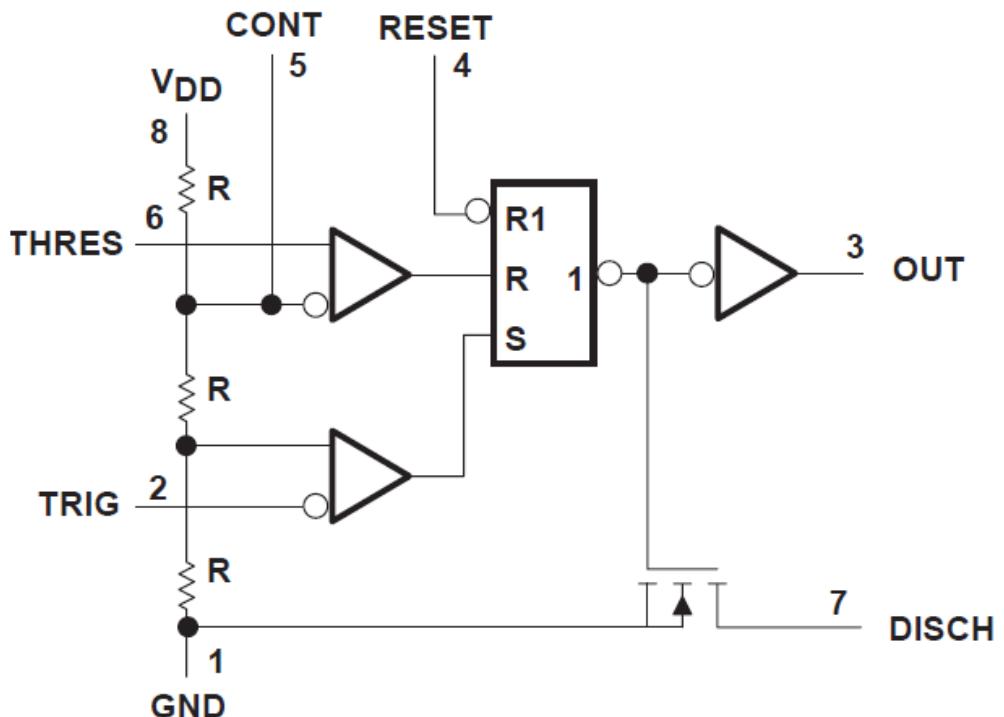
The 555 IC has the following functions inside of it:

Two analog comparators (devices that detect when a voltage has crossed a threshold).

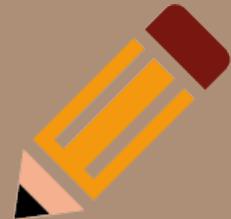
A set-reset (SR) flip flop which is a device that can “latch” the values applied to its set and reset pins

A transistor which is switched by the output of the flip-flop which comes out of the “DISCH” pin.

An output buffer.



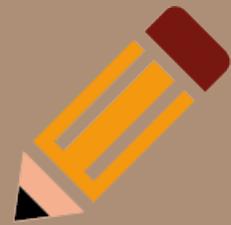
Drawdio Parts List



QTY	MFR PART NO.	MFR	DIST PART NO.	DIST	DESCRIPTION	REF DESIGNATOR	Price Ea 100	Price Ext 100 kits	Notes
1	VR3700002005JR500	Vishay	26R4228	Newark	Through Hole Resistor, 20 Mohm, VR37 Series, 3.5 kV, Metal Foil, Axial Leaded, 500 mW	R1	\$0.16	\$0.16	
1	MCCFR0W4J0100A50	Multicomp	58K4999	Newark	Through Hole Resistor, 10 ohm, MCCFR0W4J Series, 250 V, Carbon Film, Axial Leaded, 250 mW	R2	\$0.02	\$0.02	
1	MCF 0.25W 10K	Multicomp	38K0328	Newark	Through Hole Resistor, 10 kohm, MCF Series, 250 V, Carbon Film, Axial Leaded, 250 mW	Ra	\$0.03	\$0.03	
1	MCMF0W4FF3003A50	Multicomp	59K8670	Newark	Through Hole Resistor, 300 kohm, MCMF Series, 250 V, Metal Film, Axial Leaded, 250 mW	Rb	\$0.01	\$0.01	
1	MC0805N681J101A2.54MM	Multicomp	46P6621	Newark	Multilayer Ceramic Capacitor, 680 pF, 100 V, MC Series, ± 5%, Radial Leaded, C0G / NP0	C1	\$0.15	\$0.15	
1	ECEA1AKA101	Panasonic	5Y4595	Newark	Electrolytic Capacitor, 100 µF, 10 V, KA Series, ± 20%, Radial Leaded, 6.3 mm	C2	\$0.08	\$0.08	
1	C320C104K5R5TA	Kemet	13K6284	Newark	Multilayer Ceramic Capacitor, Gold Max, 0.1 µF, 50 V, Goldmax, 300 Series, ± 10%, Radial Leaded	C3	\$0.12	\$0.12	
1	2N3906	Multicomp	08N8112	Newark	Bipolar (BJT) Single Transistor, High Speed Switching, PNP, 40 V, 250 MHz, 625 mW, 200 mA, 100 hFE	Q1	\$0.07	\$0.07	
1	TLC551CP	TI	08F9140	Newark	Timer, Oscillator & Pulse Generator IC, LinCMOS, 1.8 MHz, Astable, 1 V to 15 V, DIP-8	U1	\$0.67	\$0.67	
1	MCKP2644SP1F-4748	Multicomp	25R0927	Newark	Speaker, 8 ohm, 90 dB, 0 Hz to 20 kHz	SPK1	\$0.46	\$0.46	
0	MCKPSP4050MN-08/0.25A-4768	Multicomp	25R0803	Newark	Speaker, Buzzer, 8 ohm, 89 dB, 0 Hz to 5 kHz		\$0.22	\$0.00	
0	MCKPSP2950PN-16/0.25A-4763	Multicomp	25R0799	Newark	Speaker, Buzzer, 16 ohm, 84 dB, 0 Hz to 3.5 kHz		\$0.75	\$0.00	
160		Remington Industries	http://a.co/1iZz3WZ	Amazon	Wire, PVC, Red, 22 AWG, 100 ft, 30.5 m	Battery Holder +	\$0.00	\$0.06	100ft roll (units used are mm)
160		Remington Industries	http://a.co/fAafp9S	Amazon	Wire, PVC, Black, 22 AWG, 100 ft, 30.5 m	Battery Holder -	\$0.00	\$0.06	100ft roll (units used are mm)
100		Remington Industries	http://a.co/bshVJYH	Amazon	Wire, PVC, White, 22 AWG, 100 ft, 30.5 m	Wire to Tack	\$0.00	\$0.04	100ft roll (units used are inches)
2	923345-04-C	3M	19M8562	Newark	200 Pcs. Jumper Wire Pack, 22 AWG, 0.4" L, Solid Tin Copper, Yellow PVC, 1/4" Stripped/Bent 90° Ends		\$0.09	\$0.17	200pcs/pack
2	923345-03-C	3M	19M8561	Newark	200 Pcs. Jumper Wire Pack, 22 AWG, 0.3" L, Solid Tin Copper, Orange PVC, 1/4" Stripped/Bent 90° Ends		\$0.09	\$0.17	200pcs/pack
1	923345-06-C	3M	87F4059	Newark	150 Pcs. Jumper Wire Pack, 22 AWG, 0.6" L, Solid Tinned Copper, Blue PVC, 1/4" Stripped/Bent 90° Ends		\$0.14	\$0.14	150pcs/pack
3	923345-09-C	3M	83F3531	Newark	150 Pcs. Jumper Wire Pack, 22AWG, 0.9" L, Solid Tinned Copper, White PVC, 1/4" Stripped/Bent 90° Ends		\$0.14	\$0.41	150pcs/pack
1	N/A	LampVPath	http://a.co/2iuKnnH	Amazon	12 Pack, 170 point Mini Solderless Breadboard	Board	\$0.83	\$0.83	Come in pack of 12
1	10110	Lorell	http://a.co/4rpQsW5	Amazon	5/16-Inch Steel Thumb Tacks	Tack	\$0.04	\$0.04	Come in pack of 100
1	DIX13881	Dixon Ticonderoga	http://a.co/4c0DbWk	Amazon	Dixon Ticonderoga Company Ticonderoga Pencil, with Eraser, No 1, Extra Soft, Yellow	Pencil	\$0.08	\$0.08	Come in pack of 144
400	3819-100	Jameco	http://a.co/bQk5eI4	Amazon	Jameco Valuepro 3819-100 Hook-up Wire, 24 AWG, Solid Tinned-Copper Bus Bar, 100' L	Wrap Wire	\$0.00	\$0.14	Roll of 100' (units used are mm)
1	CR123A	Tenergy	http://a.co/3OzE95v	Amazon	Propel 3V CR123A Lithium Battery, High Performance CR123A Cell Batteries PTC Protected for Cameras, Flashlight Replacement CR123A Batteries, 40-Pack	Battery	\$1.12	\$1.12	40 pack
1	BH123A	MPD	BH123A-ND	Digikey	BATTERY HOLDER CR123A THRU HOLE	Battery Holder	\$0.88	\$0.88	
1	N/A	N/A	https://www.homedepot.com	Home Depot	60 x 50 x 3mm hardboard (actually 1/8" thick)	Mount	\$0.03	\$0.03	Need to cut, comes as 2' x 4' piece)
								\$0.00	

\$5.92

Drawdio Notes



Material Notes:

- 1) Red and black wires for battery holder are 80mm length.
- 2) Red and black wires for speaker are 80 mm length.
- 3) Graphite wire is 100mm long.
- 4) Hand contact wire is 400mm long.
- 5) Wood piece is 60 x 50 x 3mm.

Required Tools:

- Metric ruler in mm
- Wire cutters (flush cutters preferred)
- Hot melt glue gun
- Small screwdriver or other tool for prying battery tab in step 29
- Wire stripper
- Needle nose pliers (optional)