

# SynShop Prototyping

Presented by Charley Jones, PMP aka Dataman





# SynShop Prototyping

## Charley Jones, PMP Dataman



Database Admin for Clark County  
I develop apps that store and retrieve  
data like time sheets, customer  
statements, and training requests.  
Because once its in a database, it's  
easier to track.



SynShop  
Prototyping

# Charley Jones, PMP



Graduate New England Institute of  
Technology, Electronics Engineering.  
Over 15 projects published in the  
public domain.



SynShop  
Prototyping

**Pololu Robotics**  
**An amazing local resource**

**Word class robotics and component  
supply right here in Las Vegas.**

**Ryan?**



SynShop  
Prototyping

Tonight

Prototyping

Rapidly taking an idea from thought to proof of concept.



SynShop  
Prototyping

# SynShop The Las Vegas Hacker Space

We are like minded individuals that  
freely share our knowledge and  
experience.



# SynShop

## Prototyping

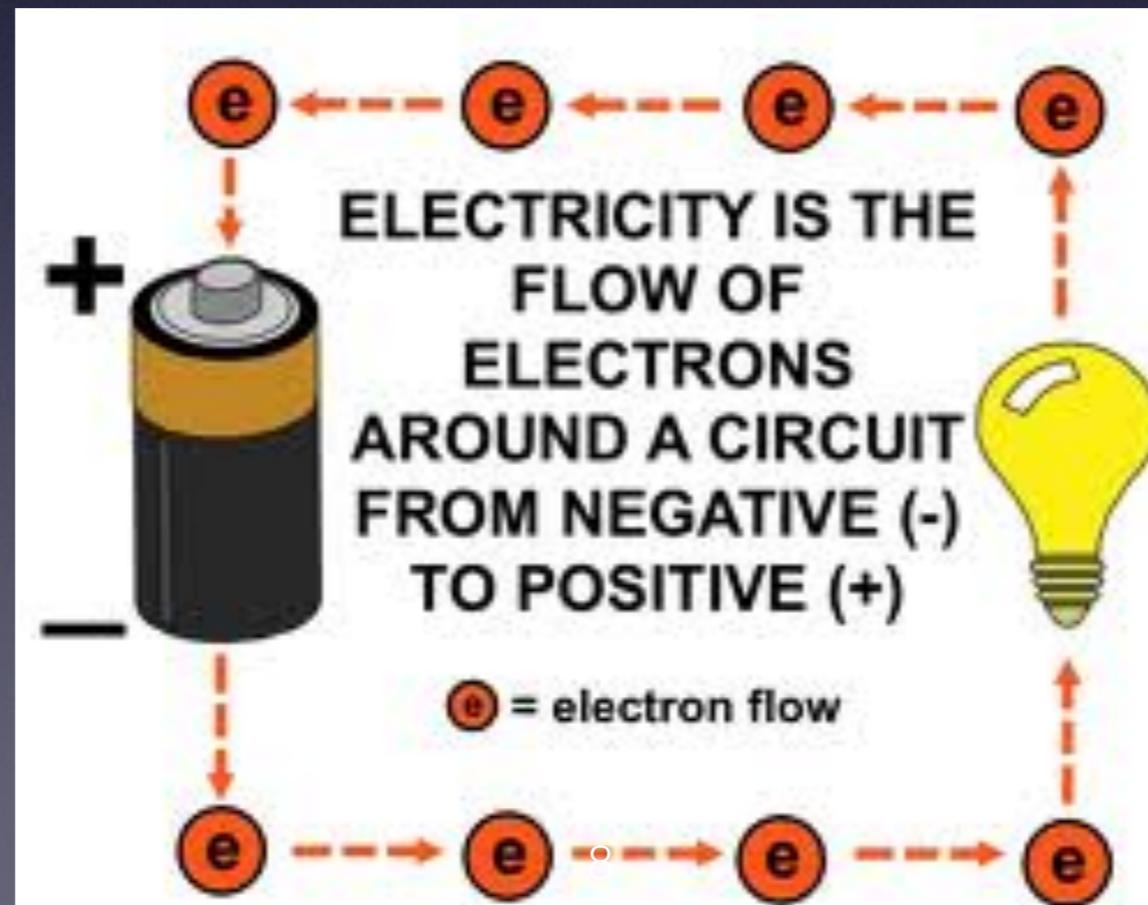
**Let's start with the basics**

**Basic Electronics**



# SynShop Prototyping

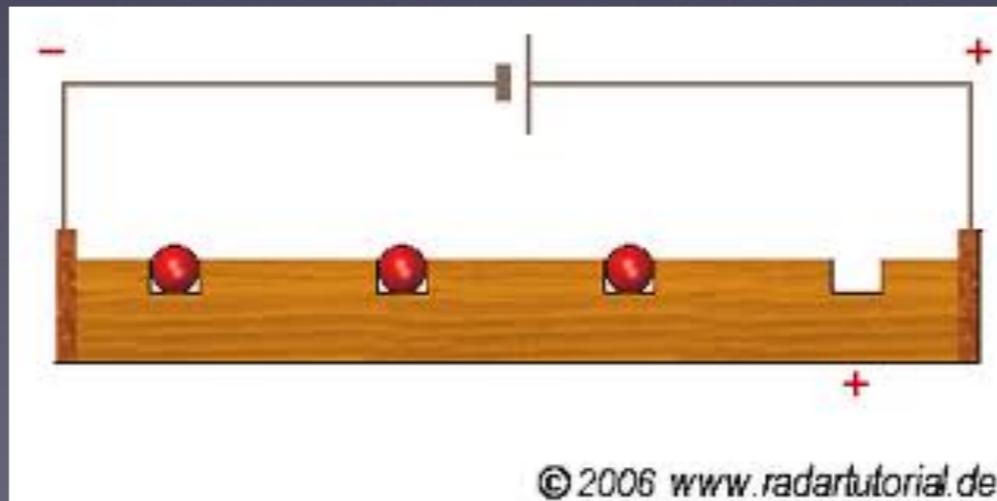
It is widely held that Electrons flow from negative to positive





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Prototyping

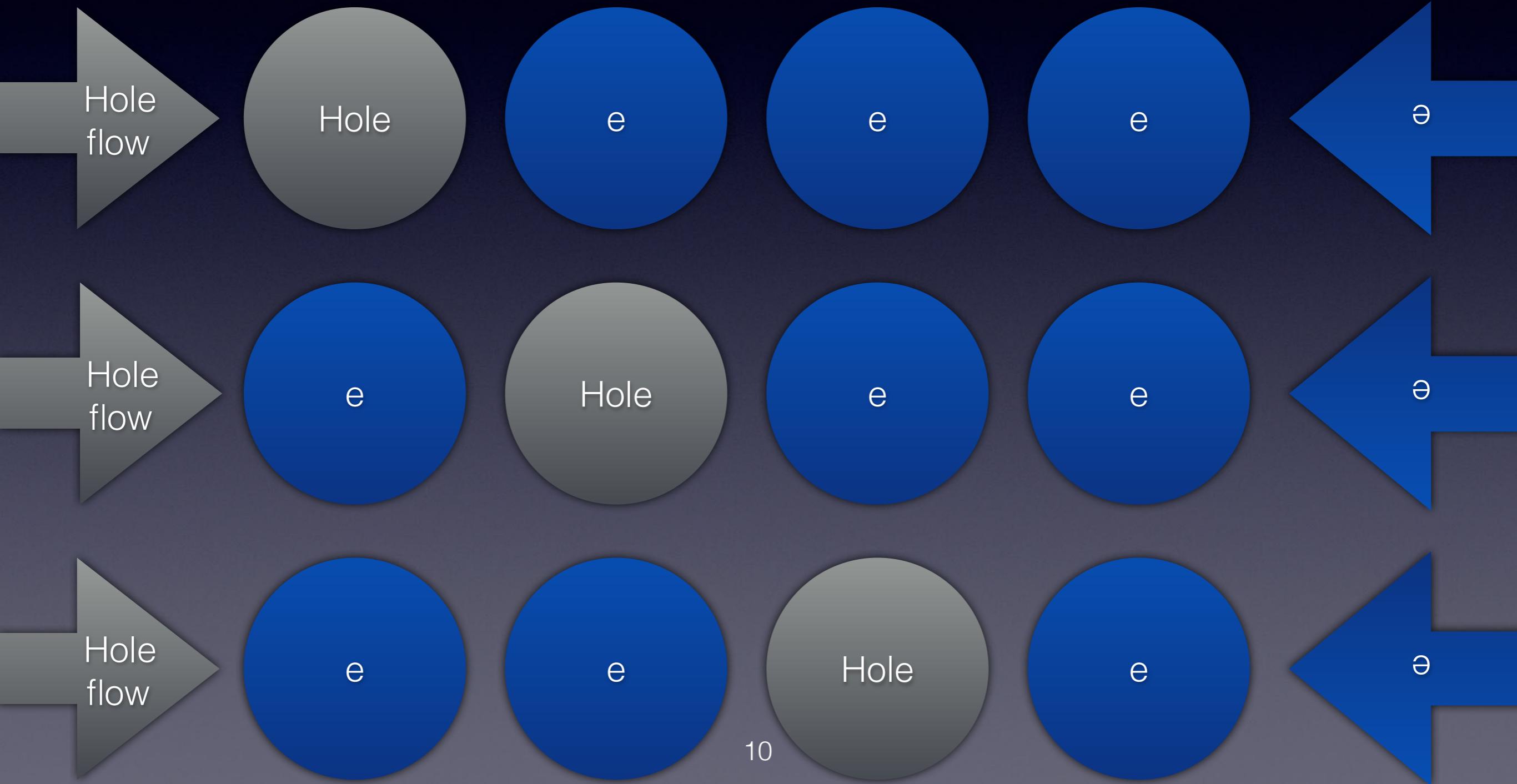
**Physicists and engineers study hole flow, that is, the space vacated by an electron as it moves through a circuit.  
Positive to Negative.**





# SynShop Prototyping

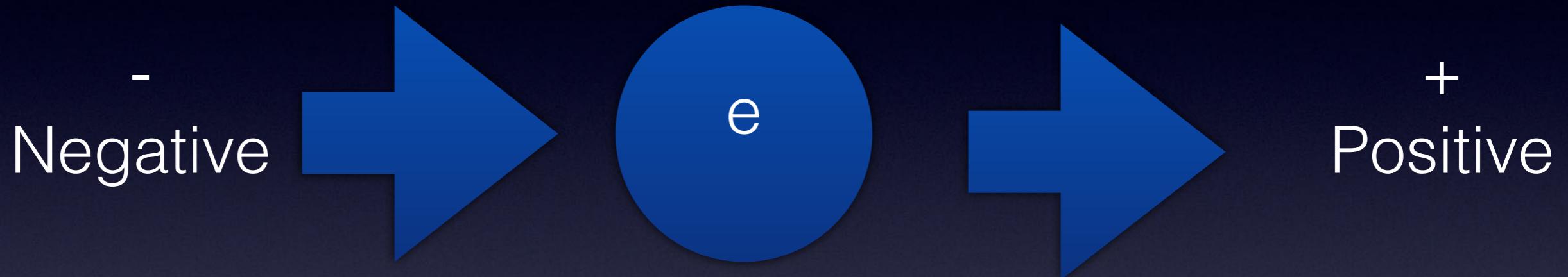
## Hole flow



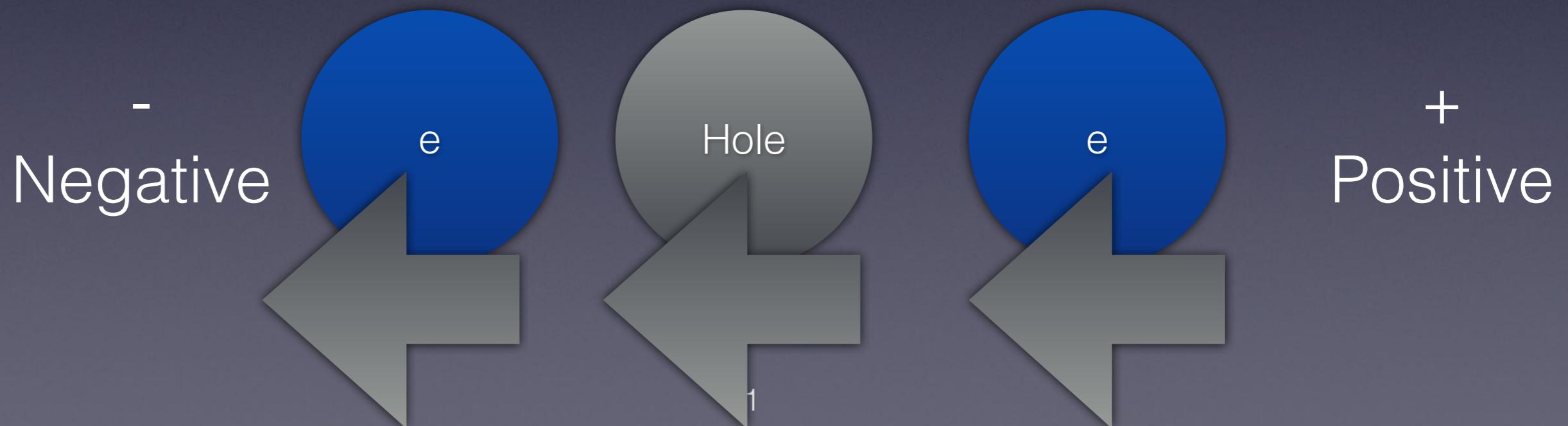


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**Electron flow, negative to positive**



**Hole flow, positive to negative**





SynShop  
Prototyping

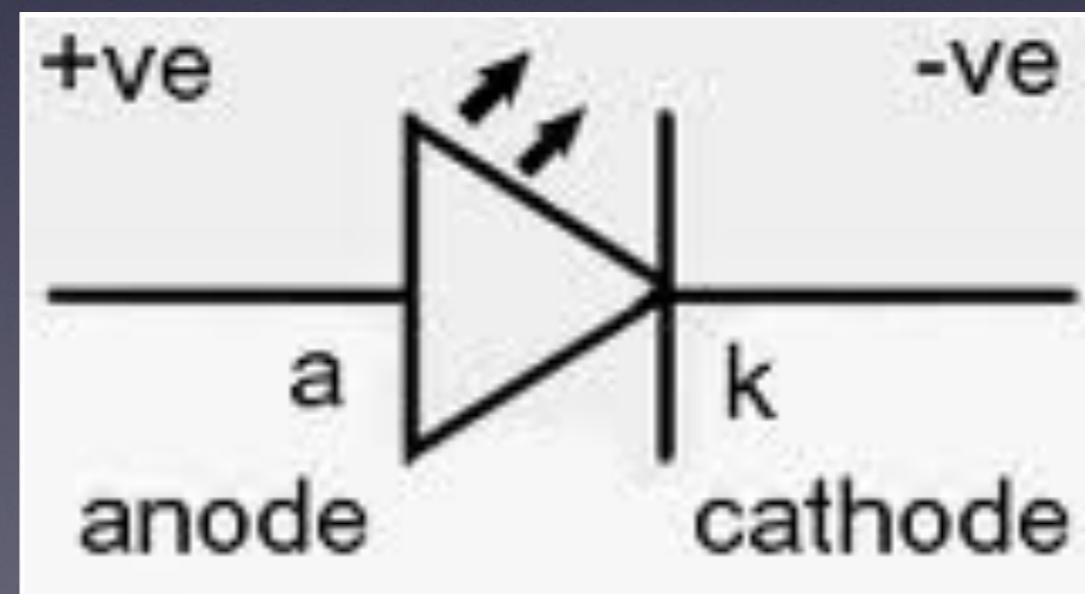
**Positive to Negative  
Negative to Positive  
Who cares?**



# SynShop Prototyping

**Engineers got to design the symbols that we use. So, arrows typically point to negative.  
(hole flow)**

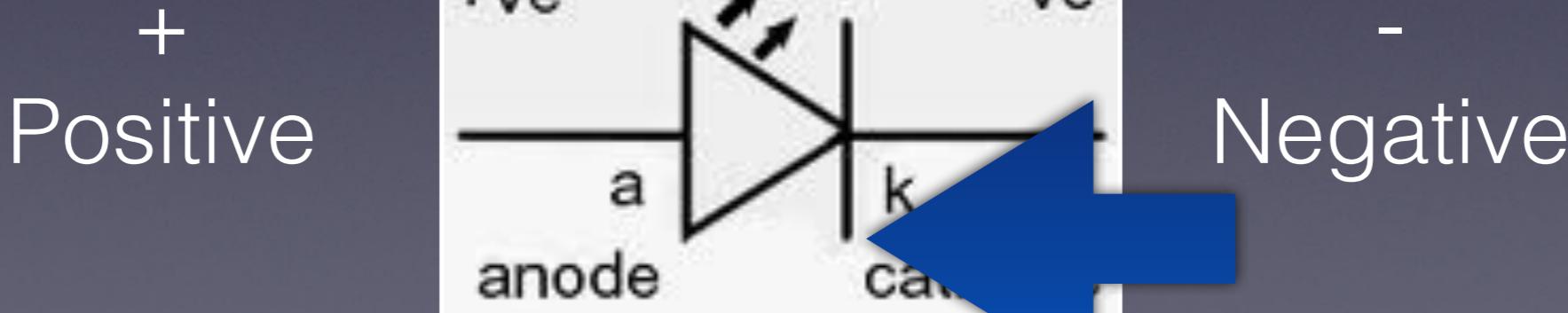
+  
Positive





# SynShop Prototyping

So just remember  
You're a salmon  
Swimming up river...





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Prototyping

## Voltage

How badly electrons want to move.

1,000v is stronger than 10v.

A fire hydrant has a potential to move water.





# SynShop Prototyping

## Current

How quickly electrons are moving.  
Amps... Like mph...  
Water moving through a firehose.

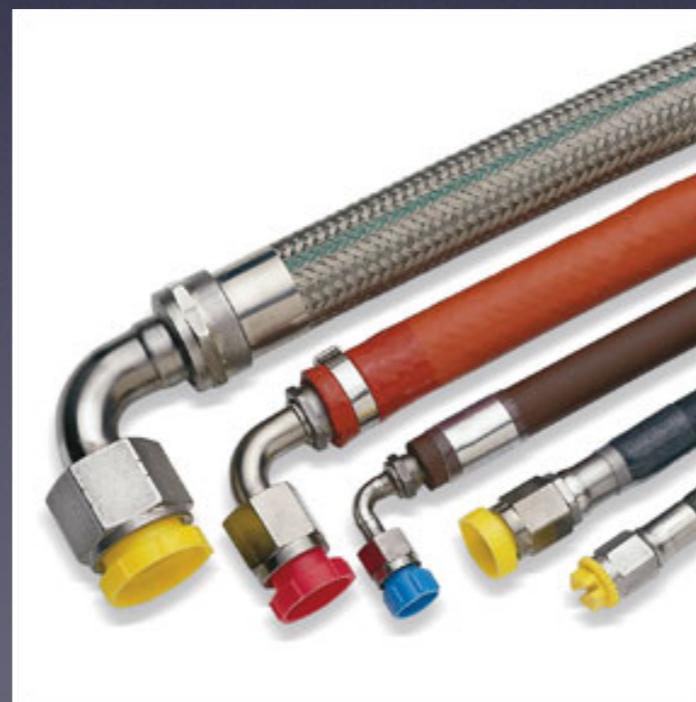




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Prototyping

## Resistance

How much current is allowed to flow. Ohms. A bigger hose allows more water. A smaller hose is more resistive to flow.





# SynShop Prototyping

**There is a direct correlation  
between voltage, current, and resistance.  
It's predictable.  
Ohms law.**

$$V=IR$$

$$R=V/I$$

$$I=V/R$$

**So in a 6v circuit with 1k resistance  
 $I = 6v / 1000 \text{ ohms}$   
There must be 0.167 amps  
167 millamps**



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Mega x 1 Million  
Kilo x 1 Thousand  
Milli / Thousand  
Micro / Million  
Nano / Billion

1k ohm = 1,000 ohms

1milli volt = 0.001 volts



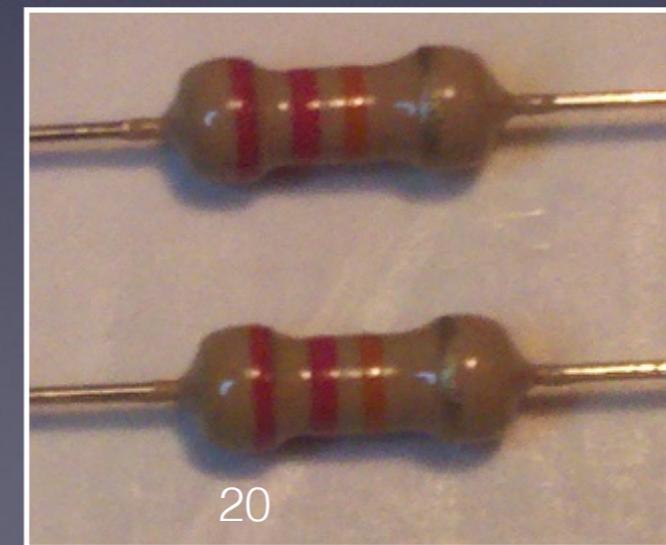
SynShop  
Prototyping

# Resistor

**Most common electrical part.**

**Resists current.**

**The higher the value,  
the higher the resistance**

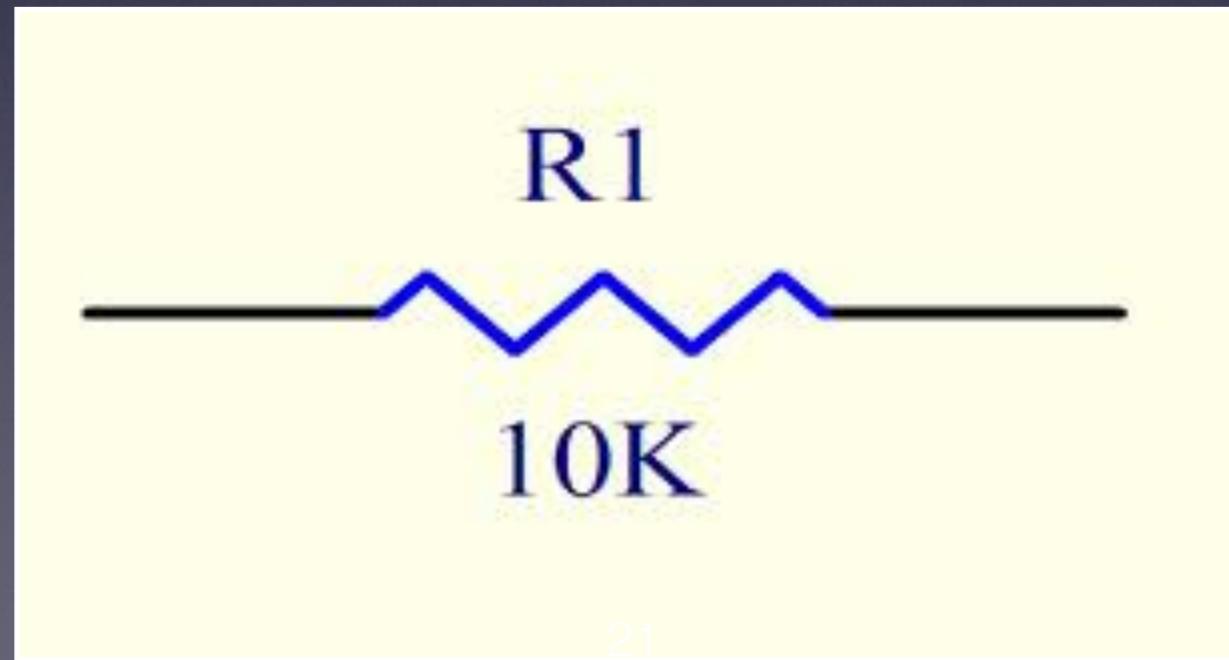




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## Resistor

On a schematic they look like this





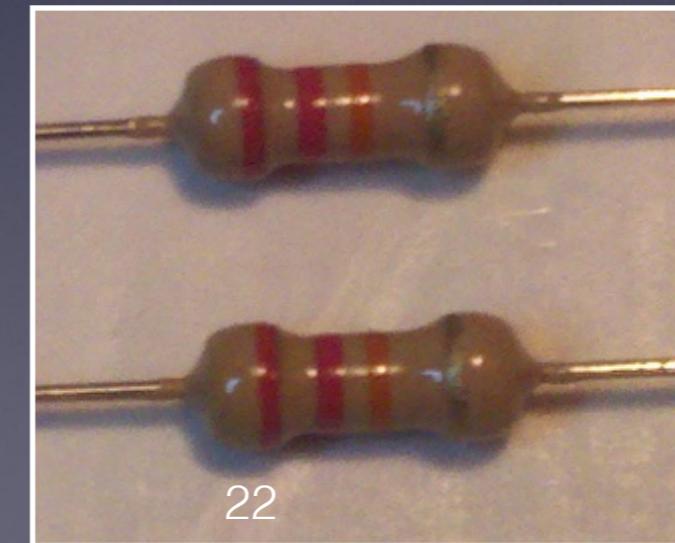
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**Resistor**  
**Measured in ohms.  $\Omega$**   
**Color determines value.**

**100  $\Omega$**



**22k  $\Omega$**



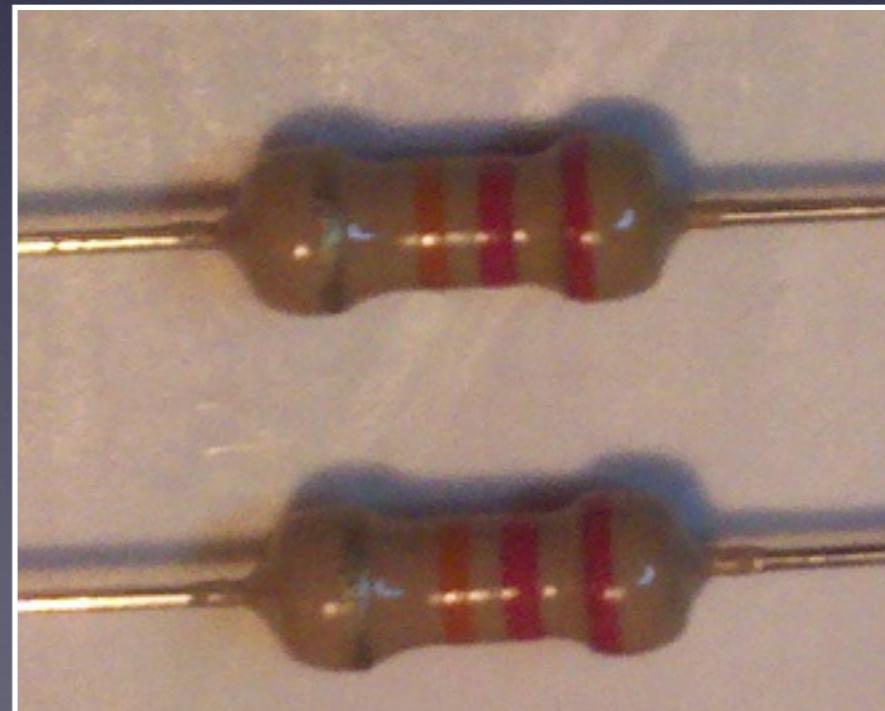
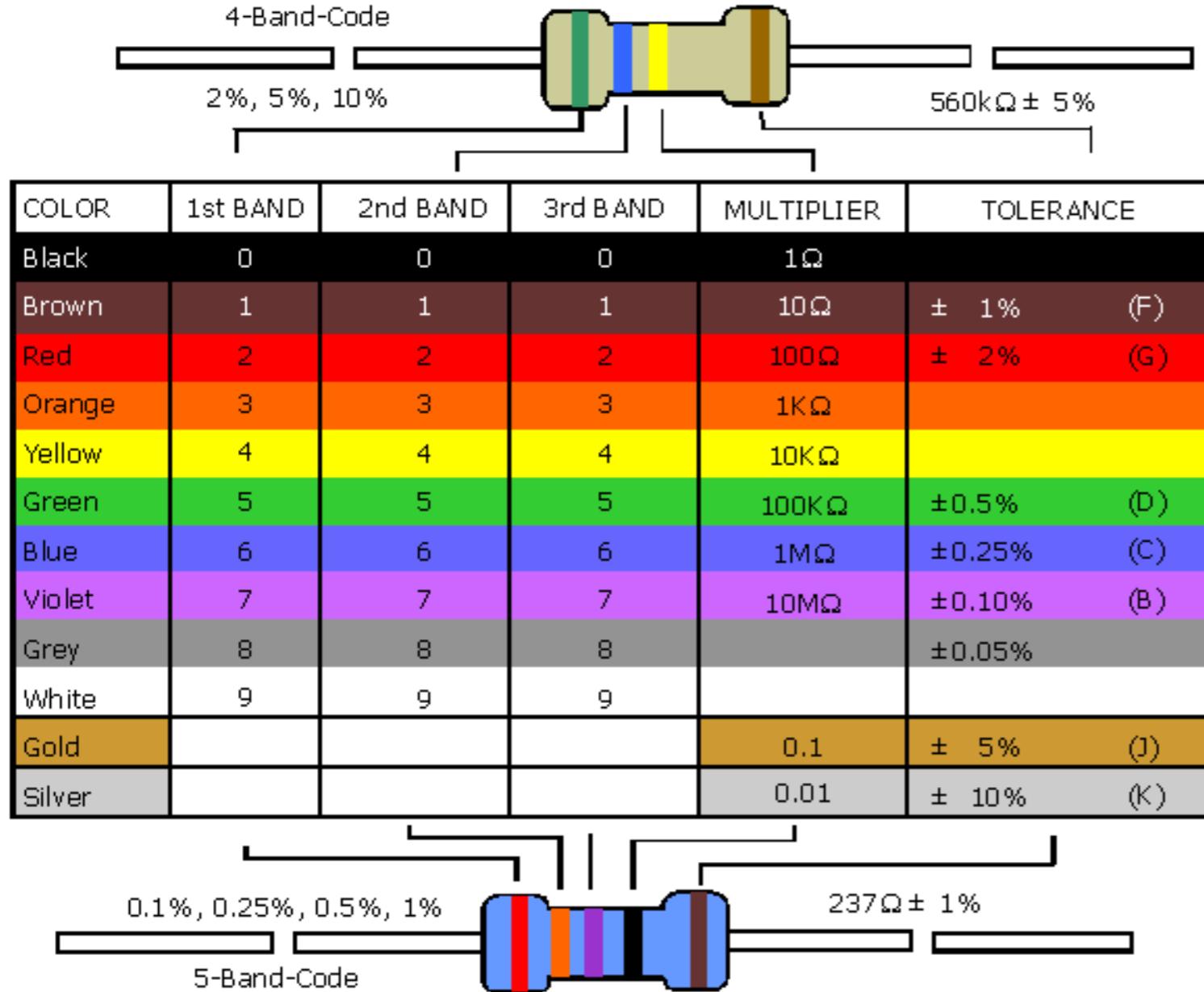
**330k  $\Omega$**





# SynShop Prototyping

## How to read a resistor



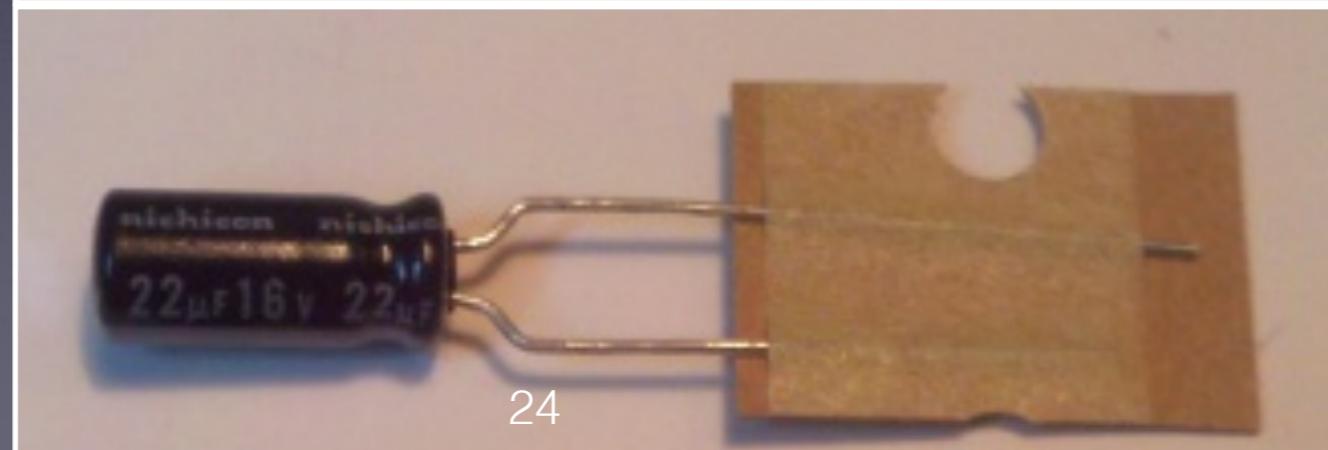


SynShop  
Prototyping

# Capacitors

Think of capacitors as tiny batteries.

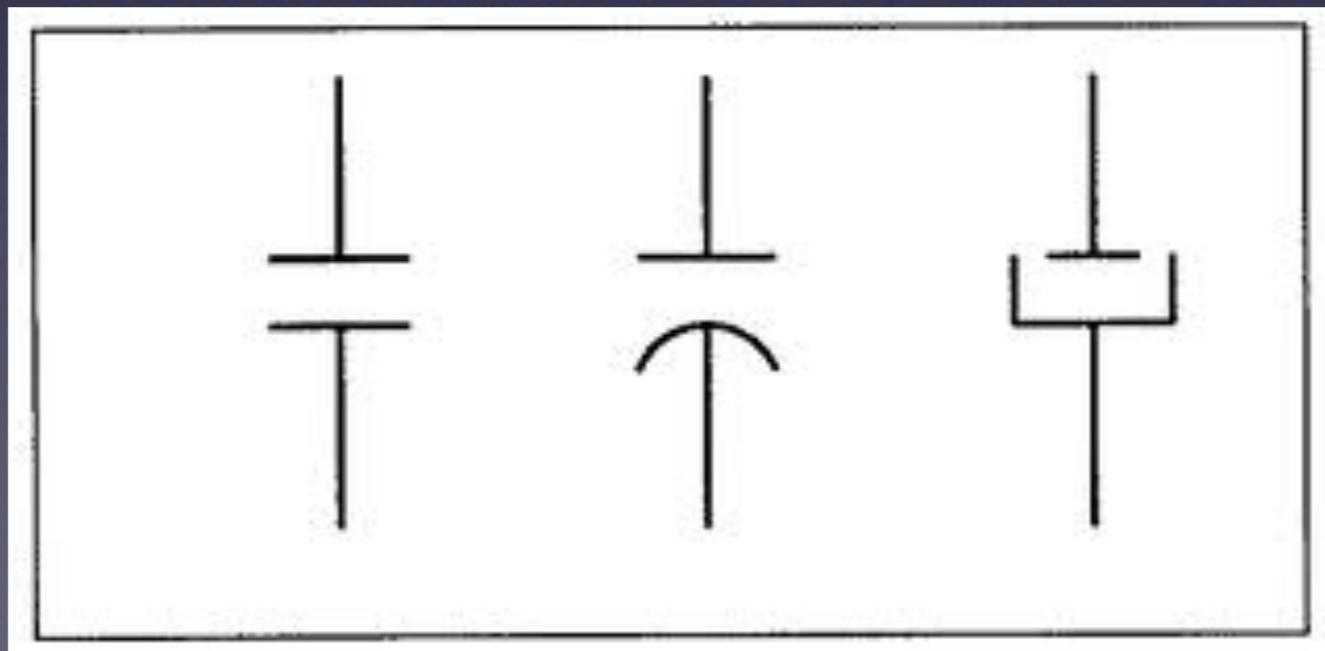
They resist changes in voltage.





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Prototyping

**Capacitors**  
**Schematic symbols.**  
**Measured in farads, f.**  
**uf, microfarads are common**

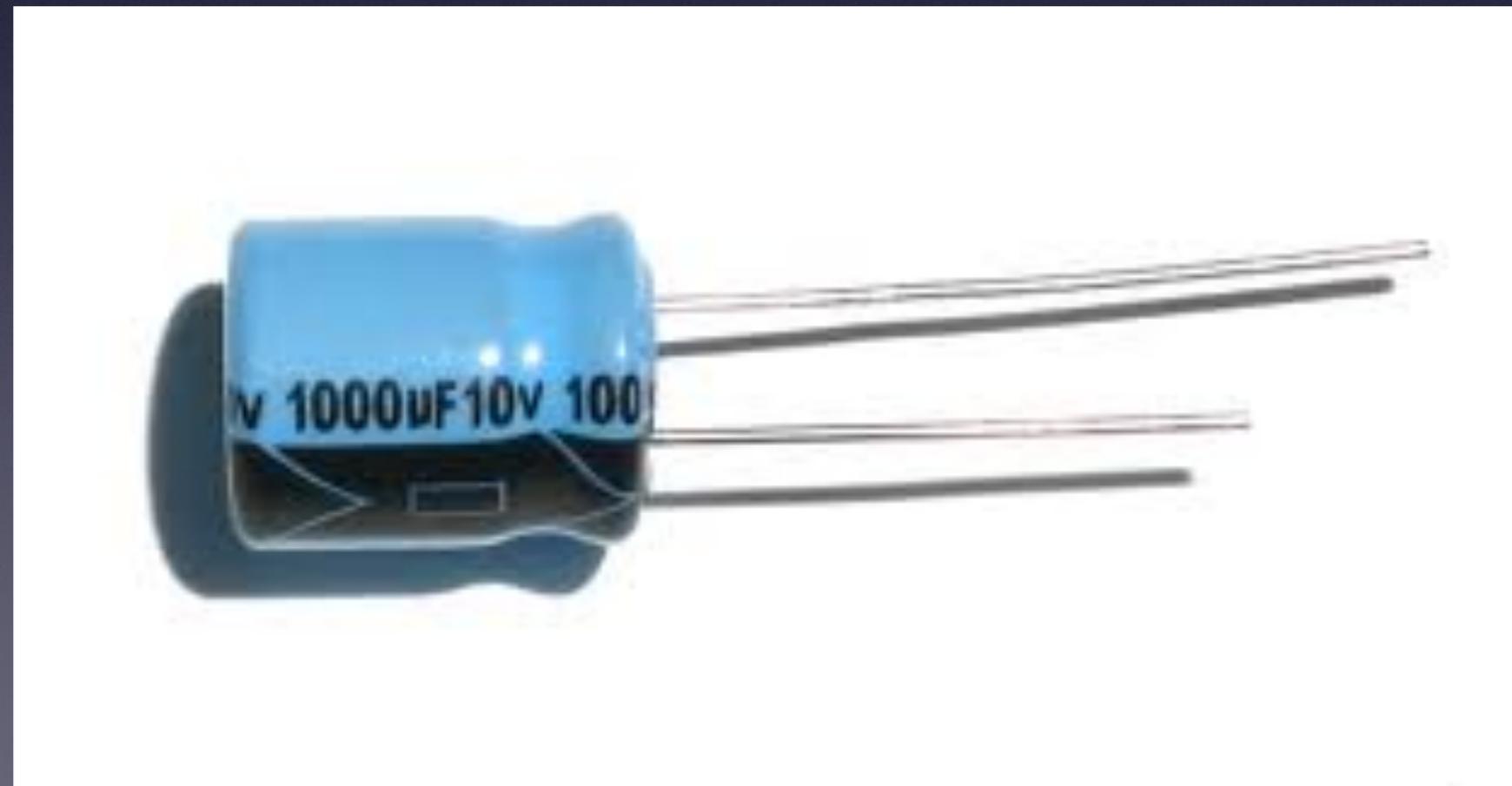




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Prototyping

## Capacitors

Values are typically written on the side. Values are in Farads. Typically micro farads, uf.





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Prototyping

# Capacitors

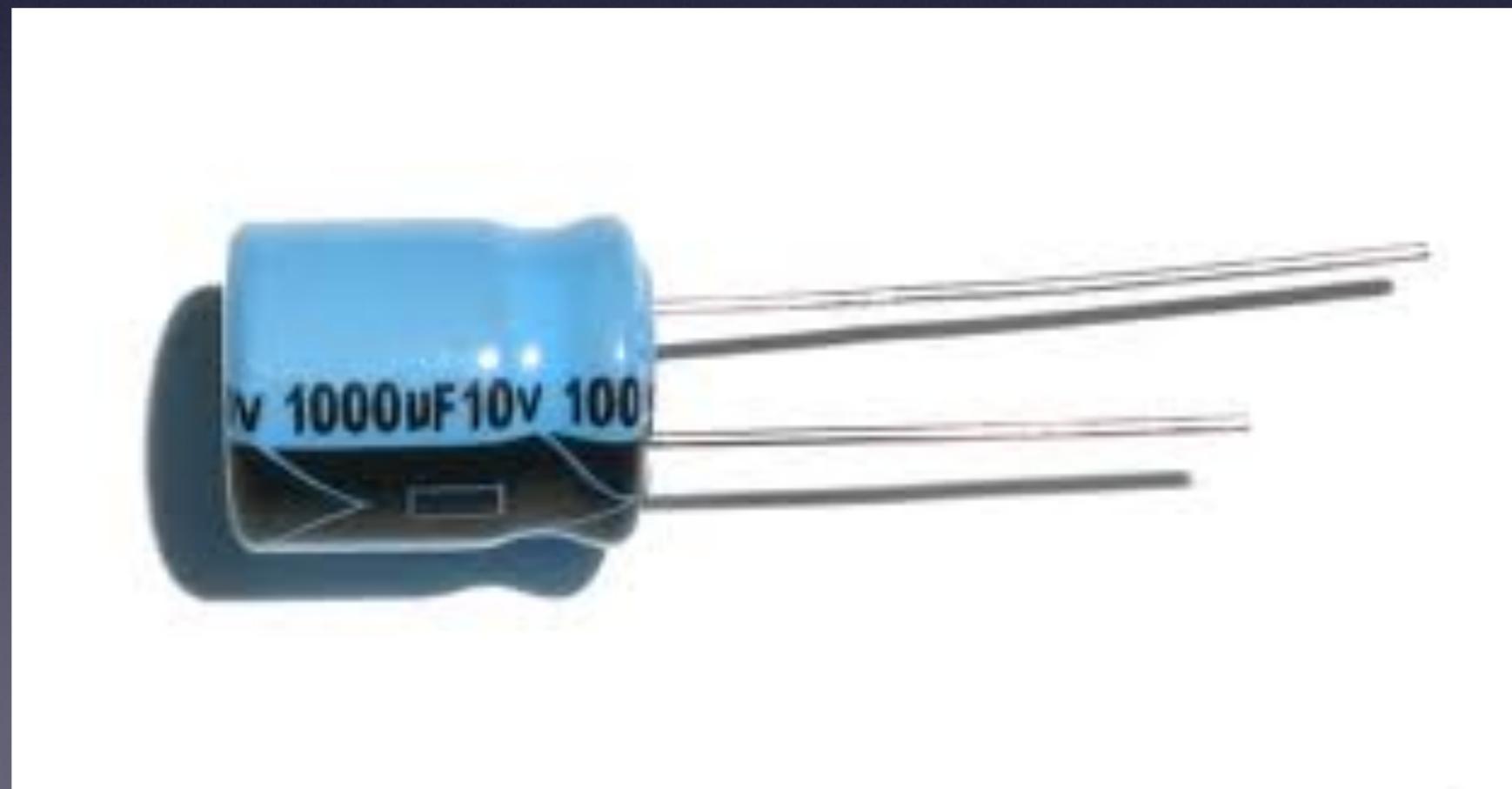
**Electrolytic capacitors must be inserted correctly into the circuit.  
Else they go pop!**





SynShop  
Prototyping

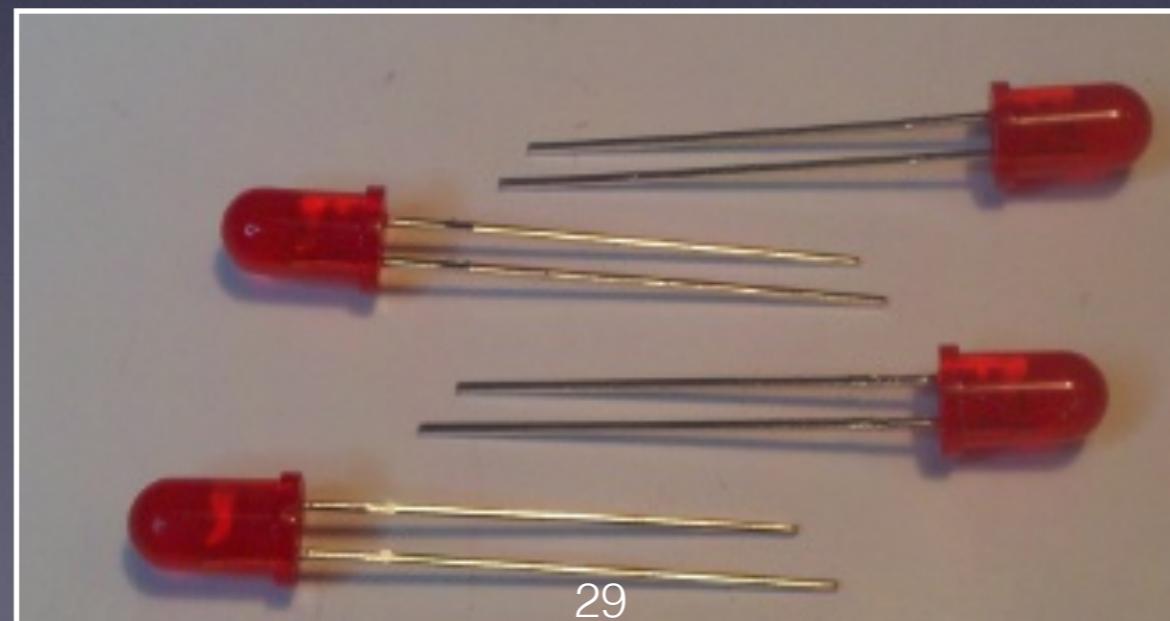
**Capacitors**  
**Long lead is positive,**  
**Short lead is negative**





SynShop  
Prototyping

**LEDs**  
**Light Emitting Diode**  
**Only allows current flow in one direction.**



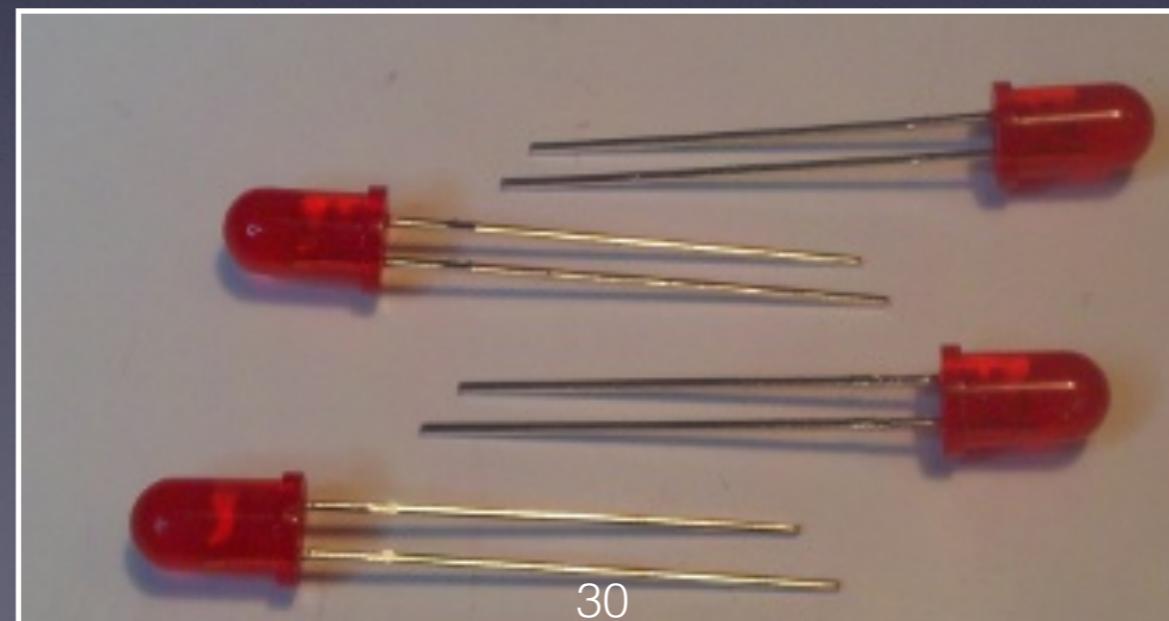


SynShop  
Prototyping

## LEDs

Also polarized, like electrolytics.

Long leg is positive,  
Short leg negative, flat spot.

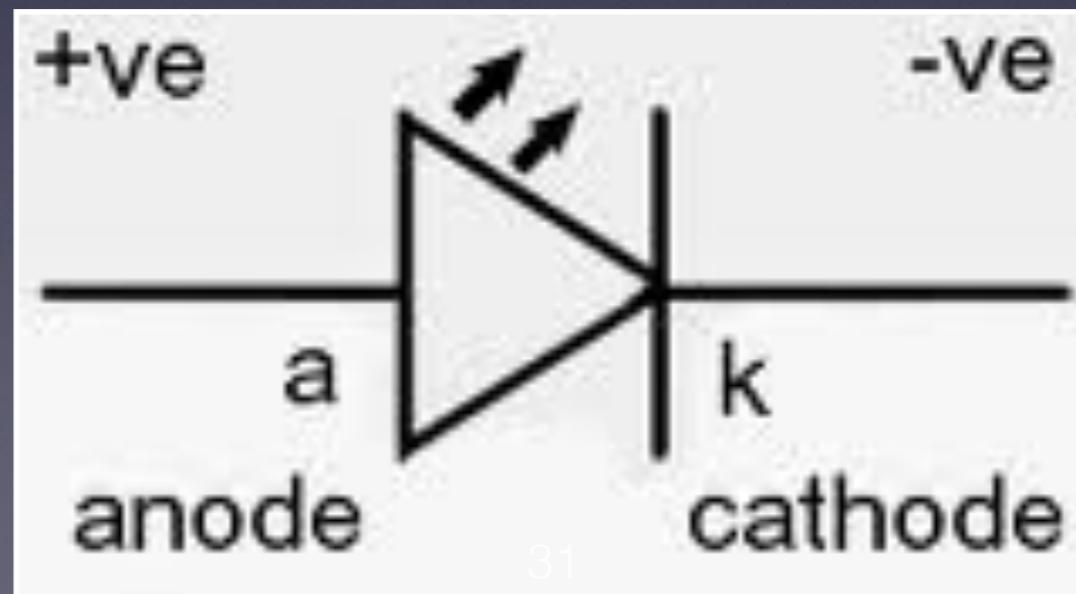




SynShop  
Prototyping

## LEDs

If you put them in backwards,  
They may pop,  
But will not light.

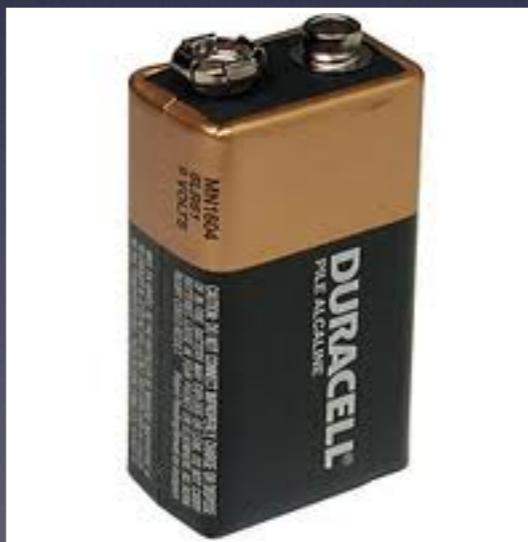




SynShop  
Prototyping

# Battery

**Red + is positive.  
Black - is negative.**



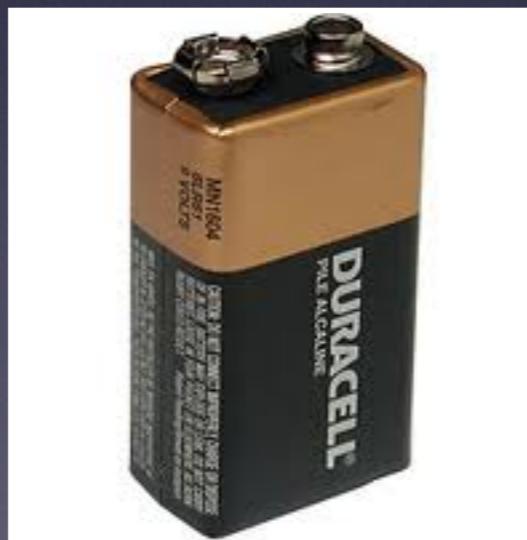
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## Battery

The battery clip is designed in such a way that red and black are connected correctly.



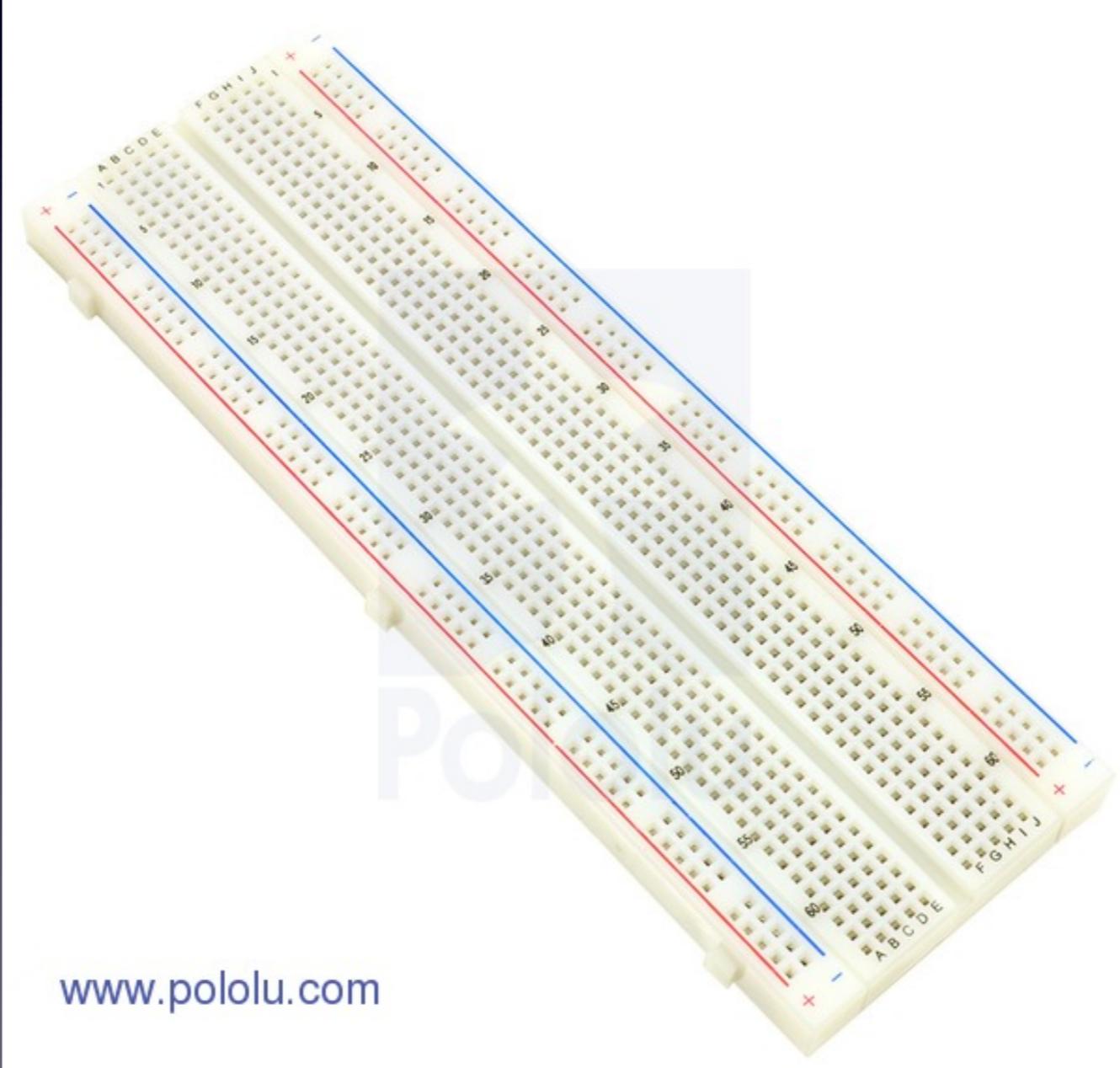
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Prototyping

# Breadboard

# #1 Electronics Prototyping Tool

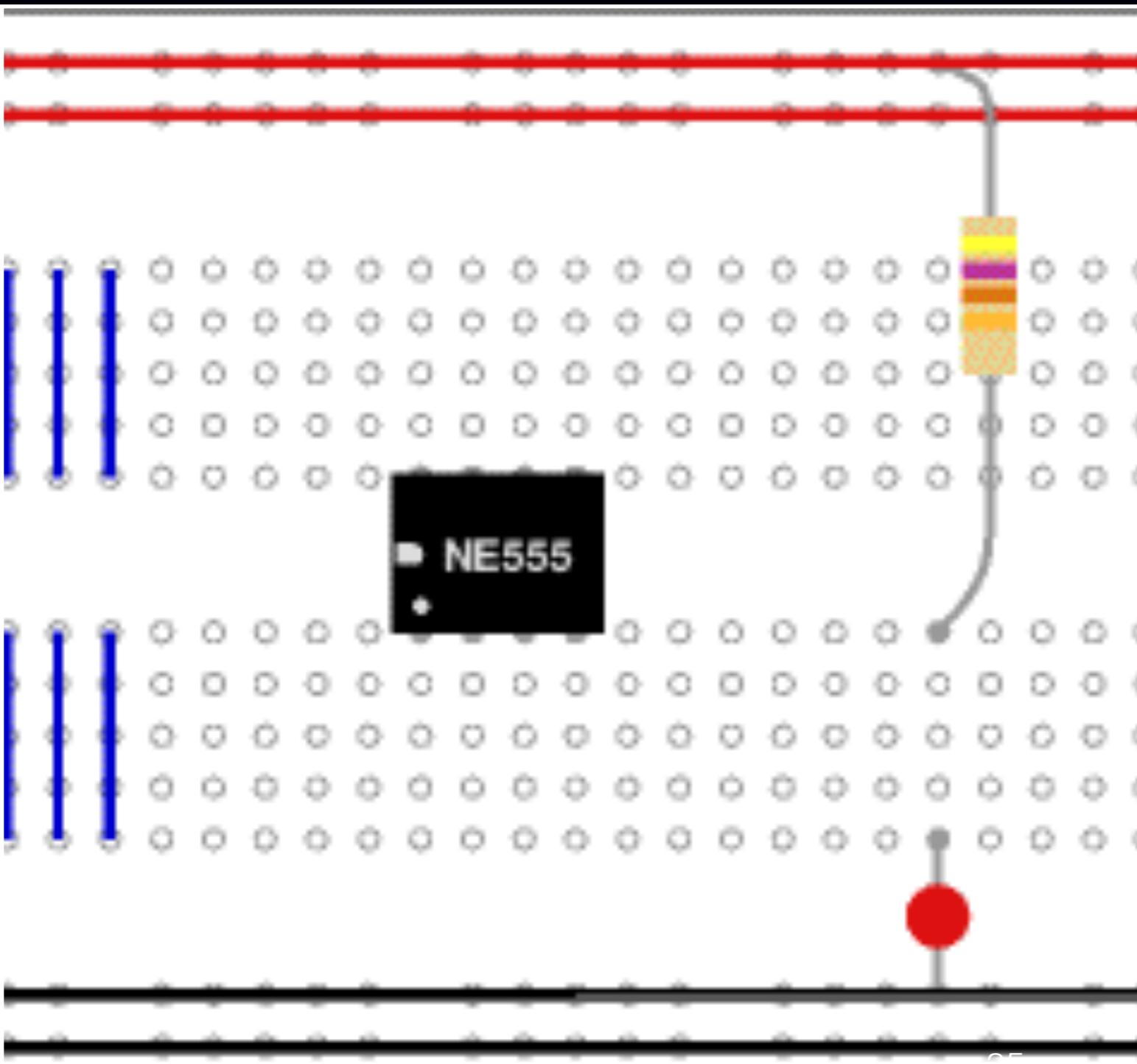


[www.pololu.com](http://www.pololu.com)



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Prototyping

# Breadboard



Top and bottom rails are connected horizontally

Rows are connected vertically, not across the center gap.

In this example the led lights because power flows from negative rail, through led, through resistor, to positive.



**So far we've looked at:**

**Battery (provides voltage)**

**Resistors (resist current)**

**Capacitor (resist voltage change)**

**LEDs (they light up)**

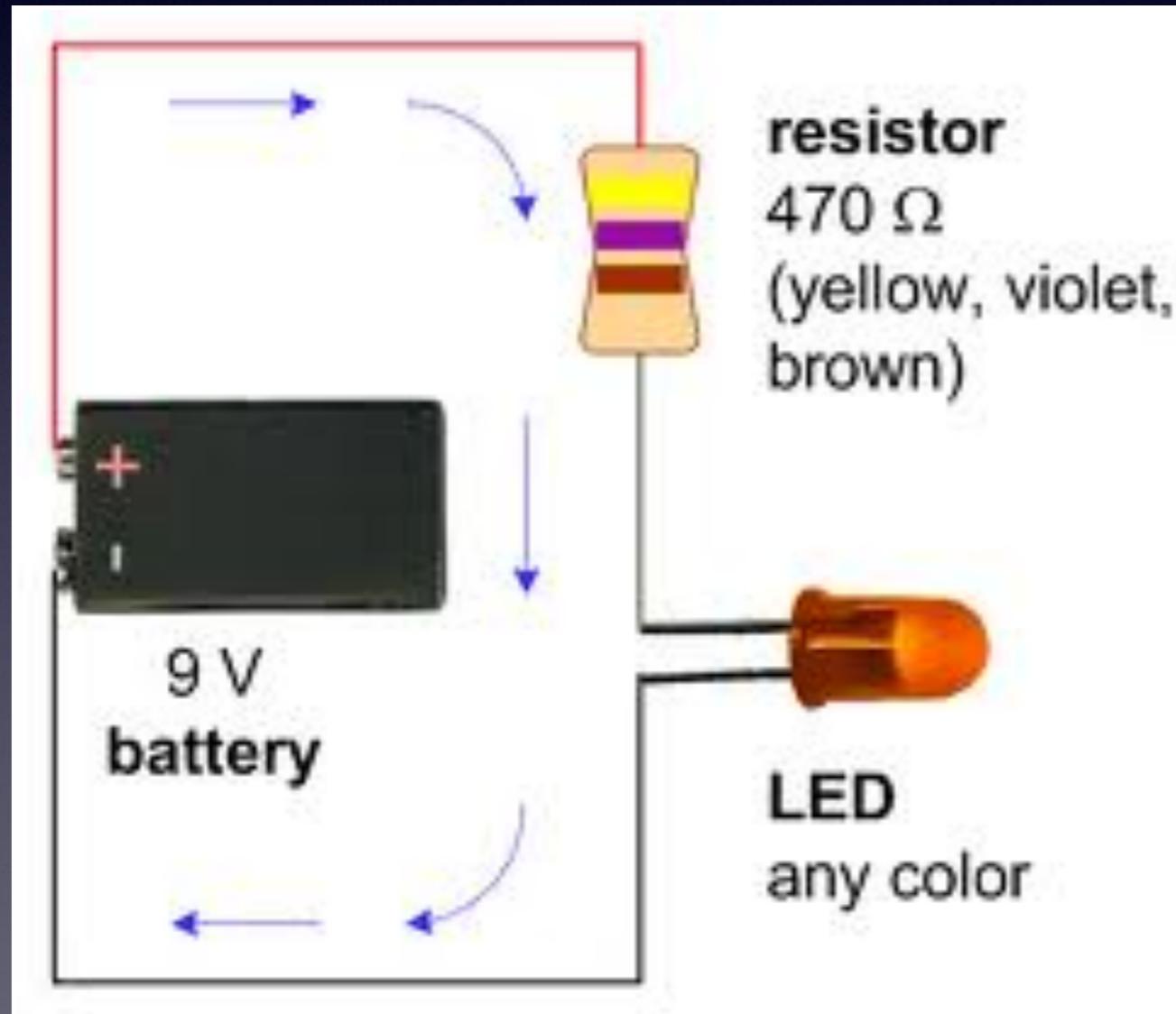
**Breadboard (simple place to build)**



# SynShop

## Prototyping

# That brings us to the first build



I'm Alive  
Simple Breadboard  
Setup and status.

See, the engineers  
snuck in hole flow  
again.



SynShop  
Prototyping

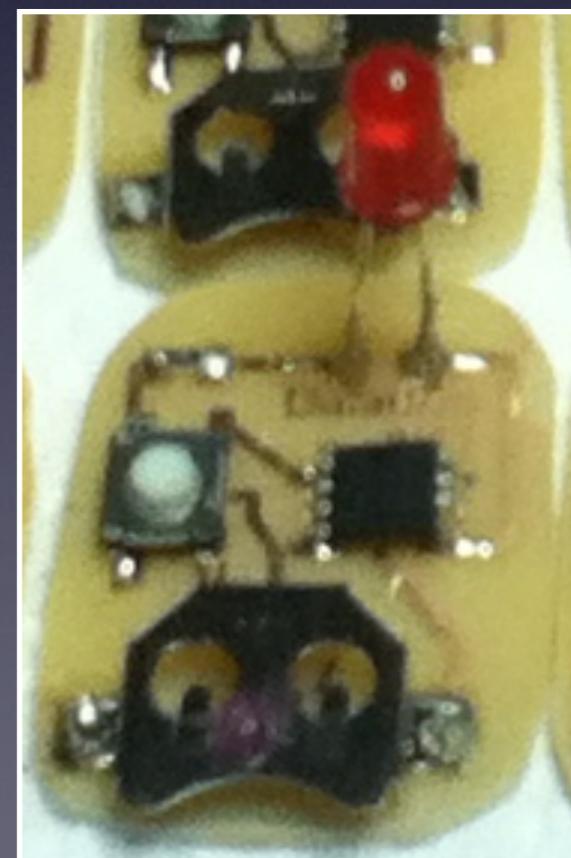
## SynShop Guinea Pig

You have been recruited as a guinea pig for the Buildup Timer.

Click at start of step.

Perform step.

Click at end of step.

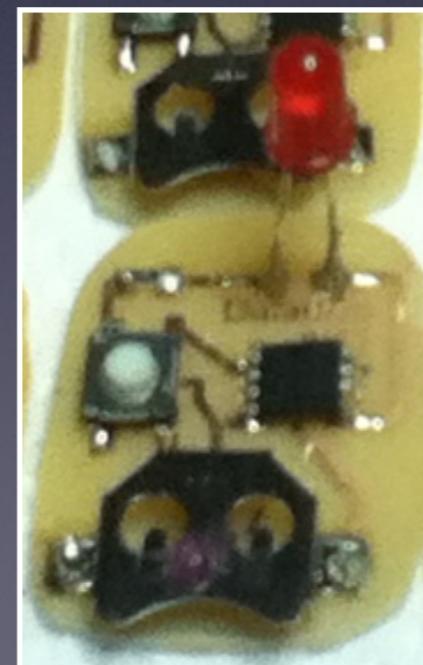




SynShop  
Prototyping

## SynShop Guinea Pig

**Builder Timer blinks faster each minute. Let's us know who's having trouble. It's not a race!**





# SynShop Prototyping

## I'm Alive Build

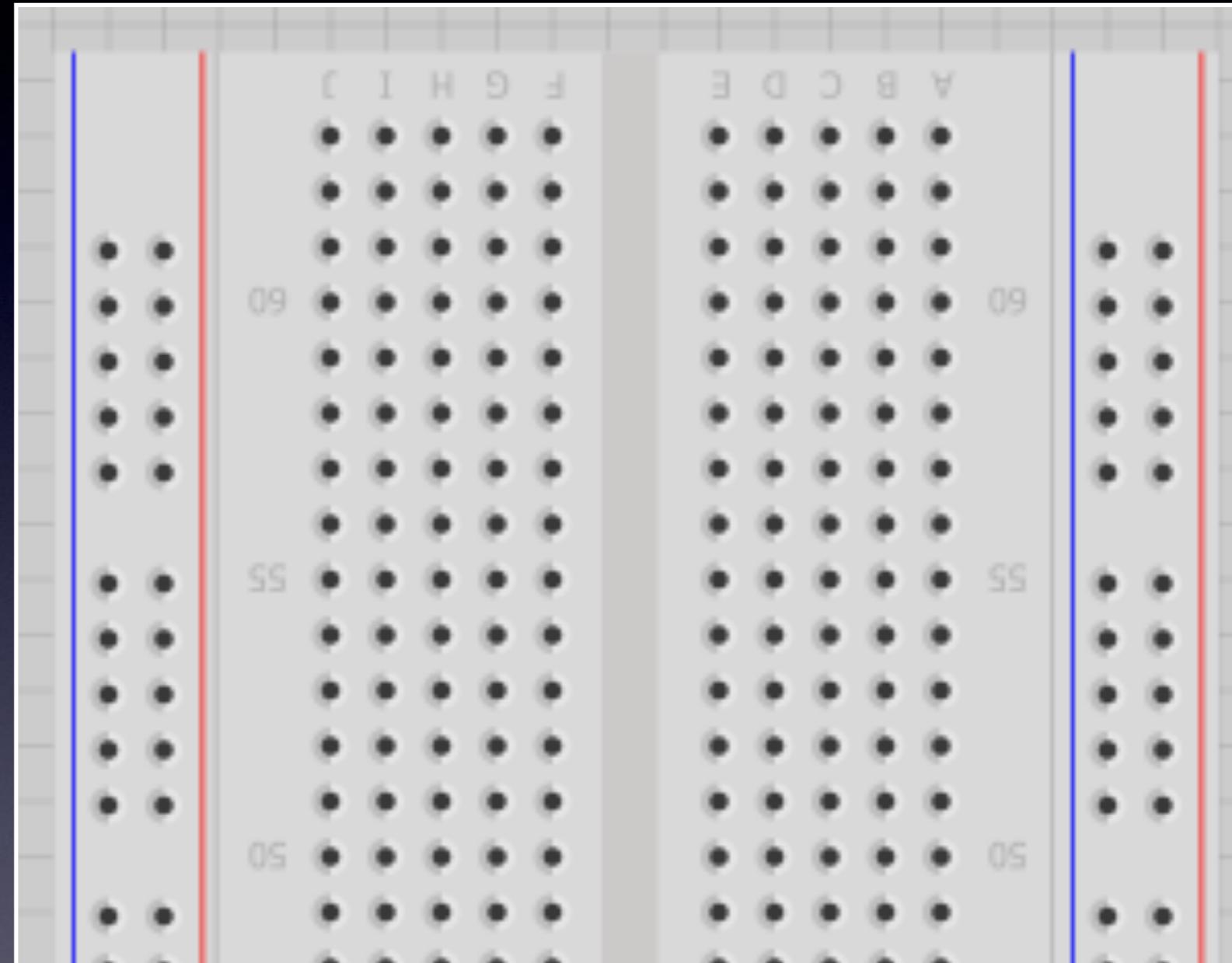


# SynShop

## Prototyping

### Step 1

Orientate  
board with  
high  
numbers  
at the top.



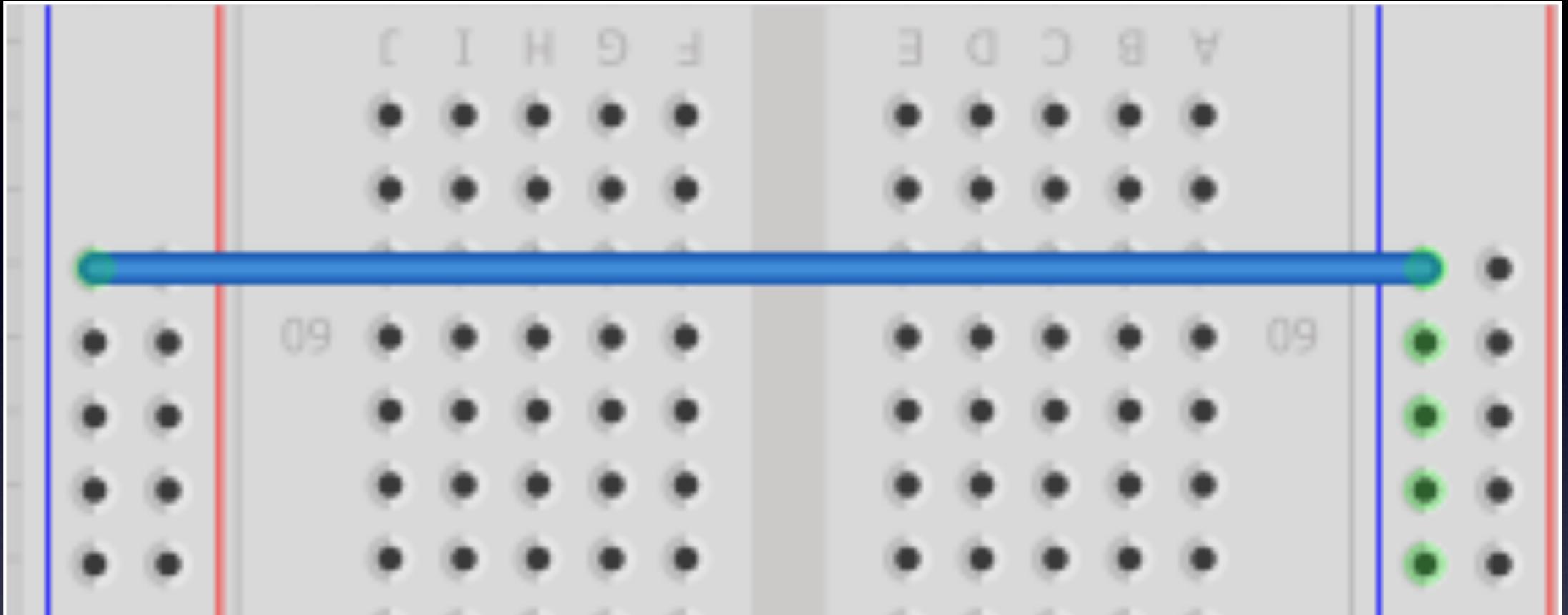


# SynShop

## Prototyping

### Step 2

Tie the  
two  
negative  
rails (blue)  
together.



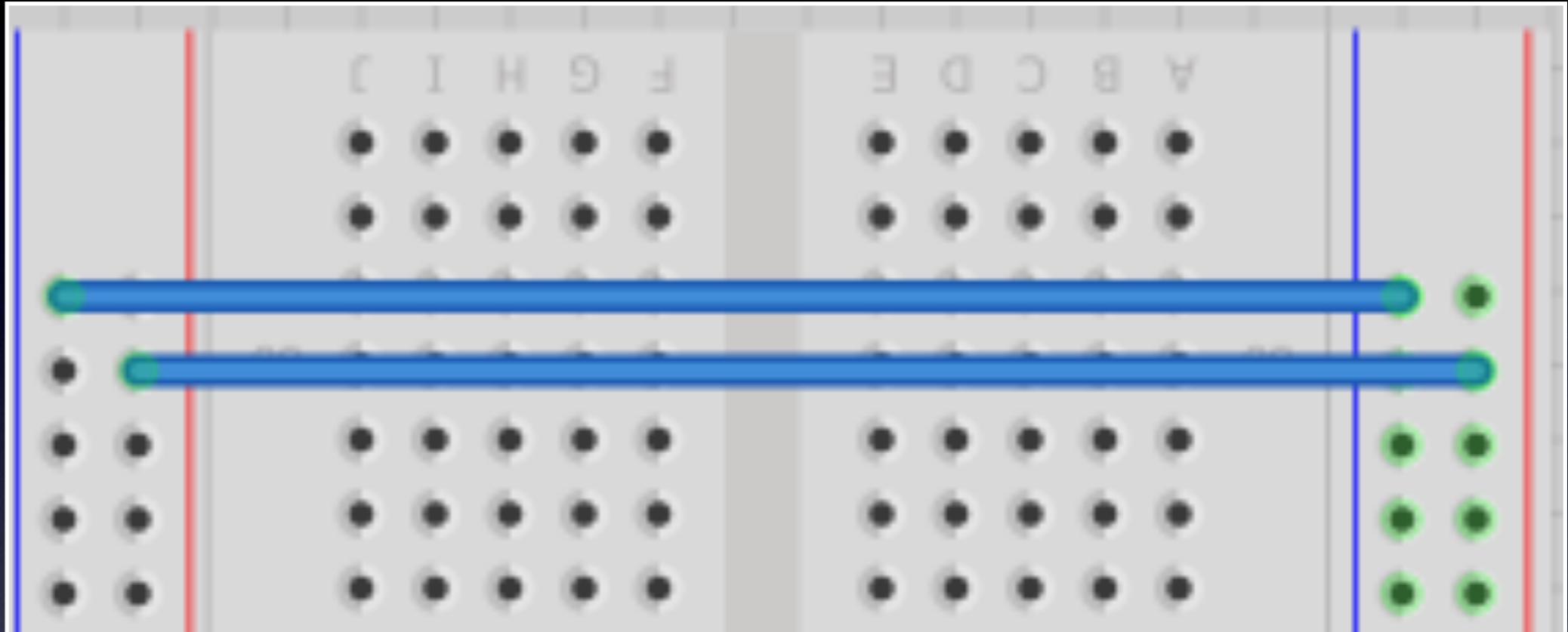


# SynShop

## Prototyping

### Step 3

Tie the  
two  
positive  
rails (red)  
together.



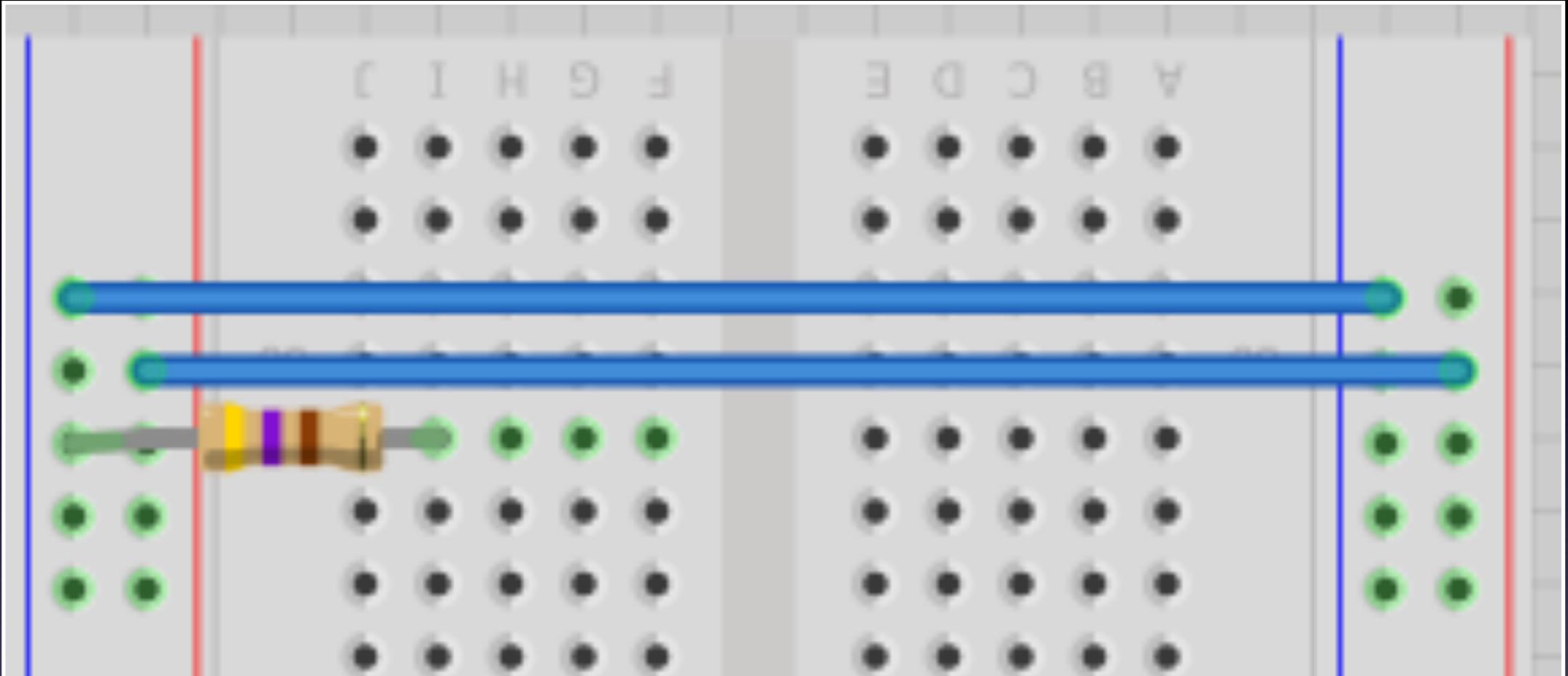


# SynShop

## Prototyping

### Step 4

Insert 470 ohm resistor from NR (negative rail) to row 59 as shown.





# SynShop

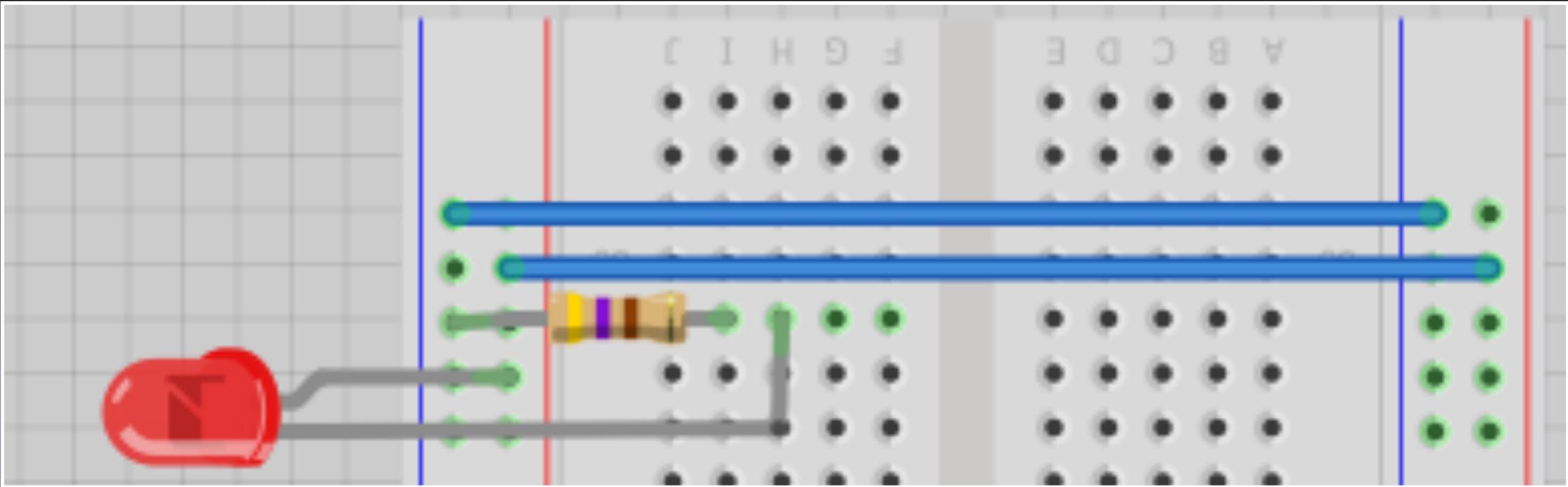
## Prototyping

**Step 5**

**Insert LED**

**Long leg  
into PR  
(positive  
rail)**

**Short leg  
into row  
59.**

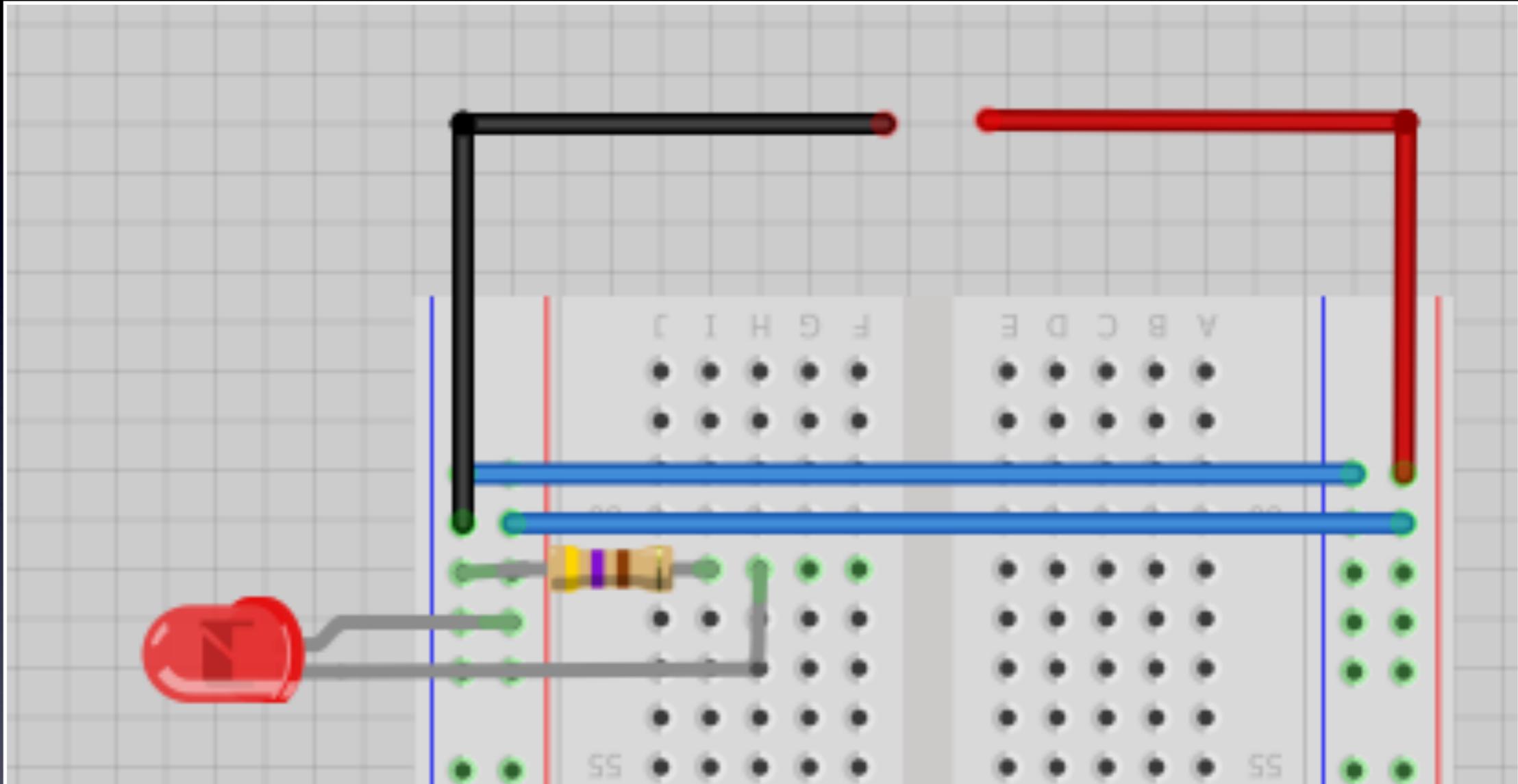




# SynShop

## Prototyping

**Step 6**  
**Attach**  
**battery**  
**clip black**  
**wire to**  
**NR.**  
**Attach**  
**battery**  
**clip red**  
**wire to**  
**PR.**  
**Attach**  
**battery,**  
**LED**  
**should**  
**light.**





# SynShop Prototyping

**Tying rails together is  
common when using breadboard,  
But not required.**



SynShop  
Prototyping

## Disconnect Battery

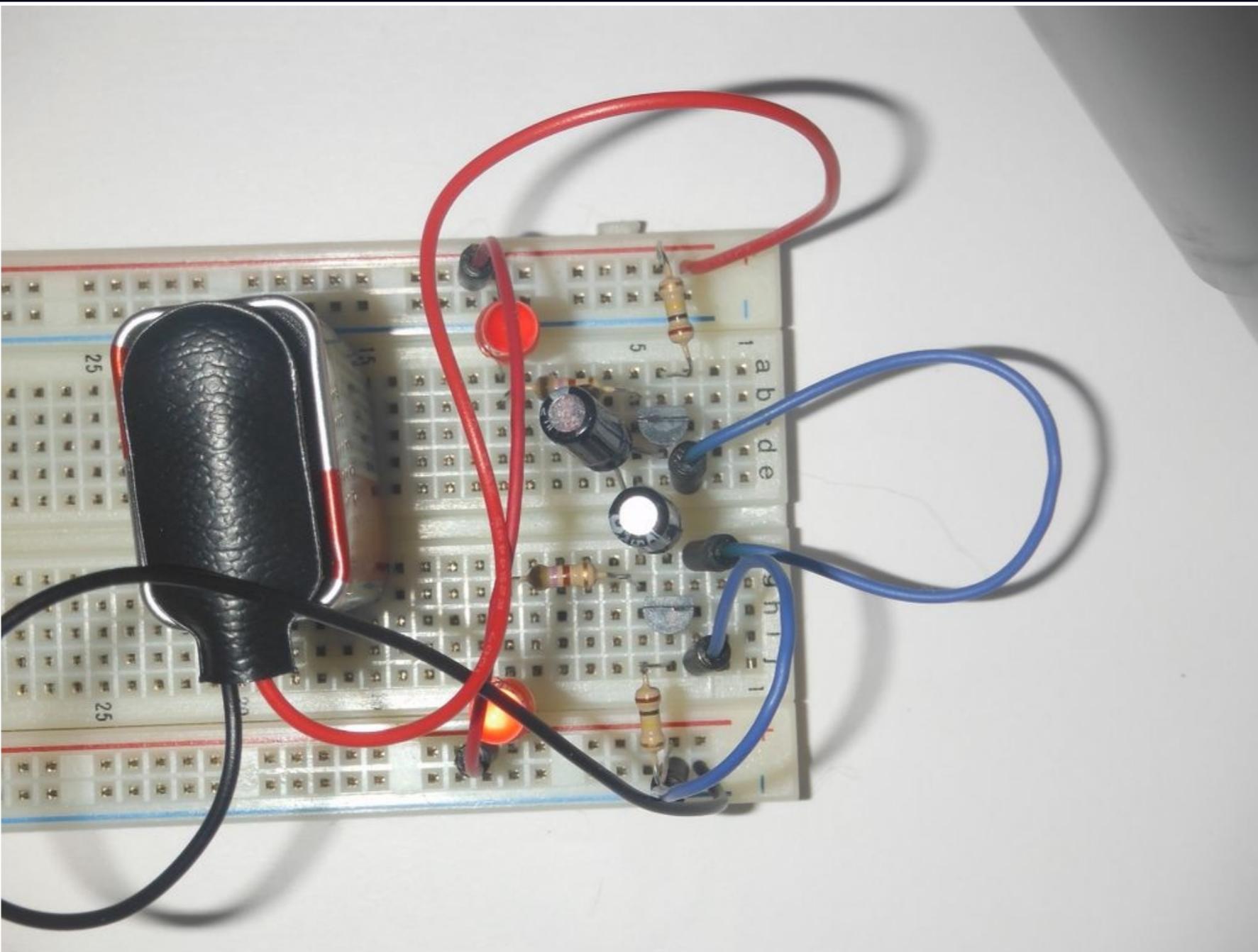
**Never work with circuit powered on.  
May destroy parts.  
Worse, you may get zapped.**





SynShop  
Prototyping

# Next build, STOP and GO





# SynShop Prototyping

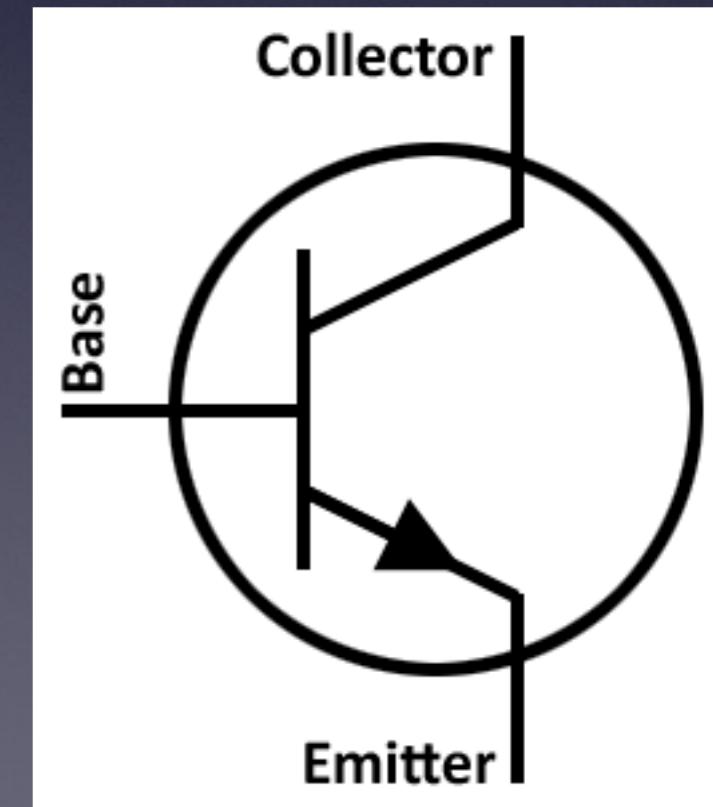
**In the next build we are placing 10 components and two jumpers.**

**One of those components is new, the Transistor. And theres a new concept, the RC Time constant.**



## Transistor

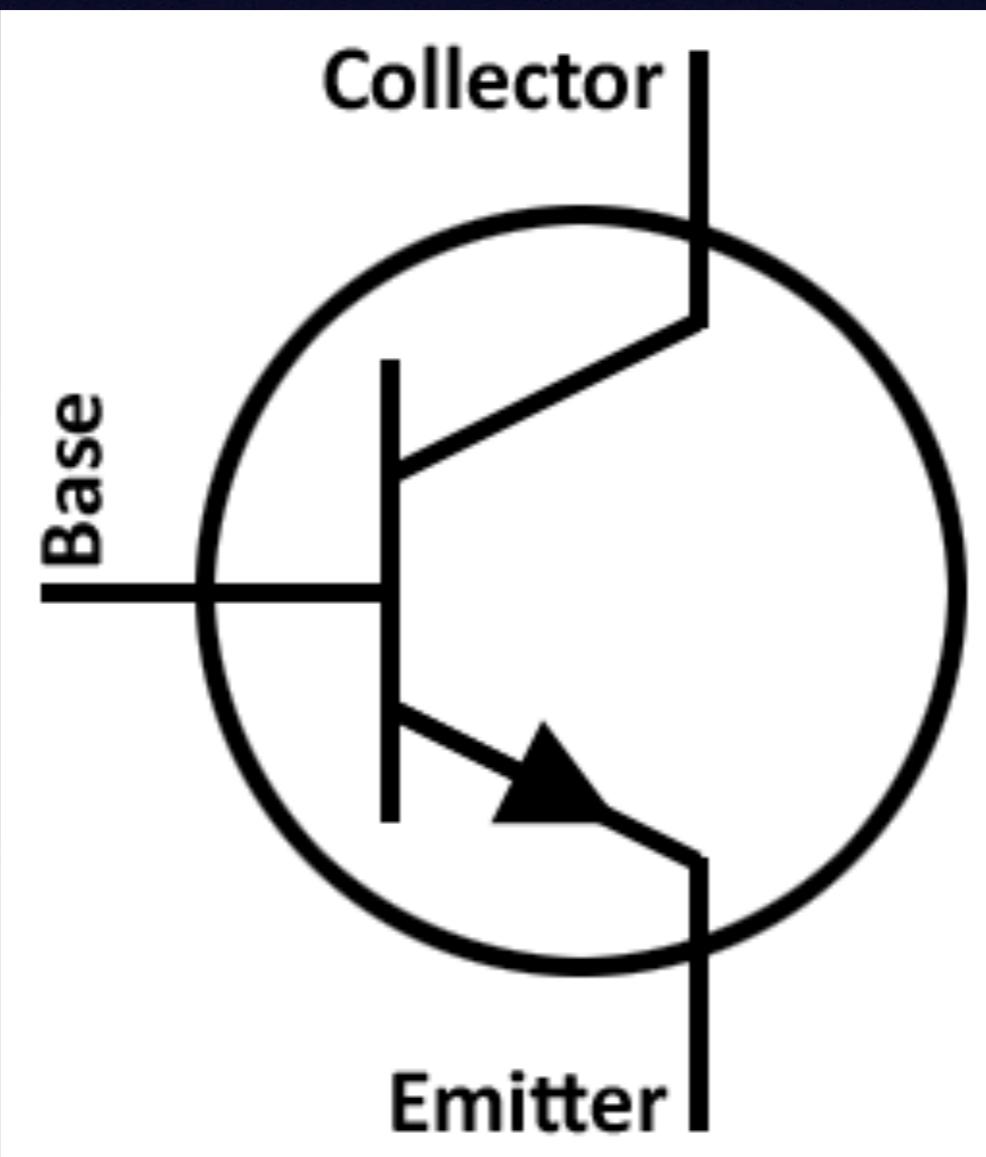
A transistor is simply an electronic switch. When a sufficient voltage is placed at the BASE, current is allowed to flow.





SynShop  
Prototyping

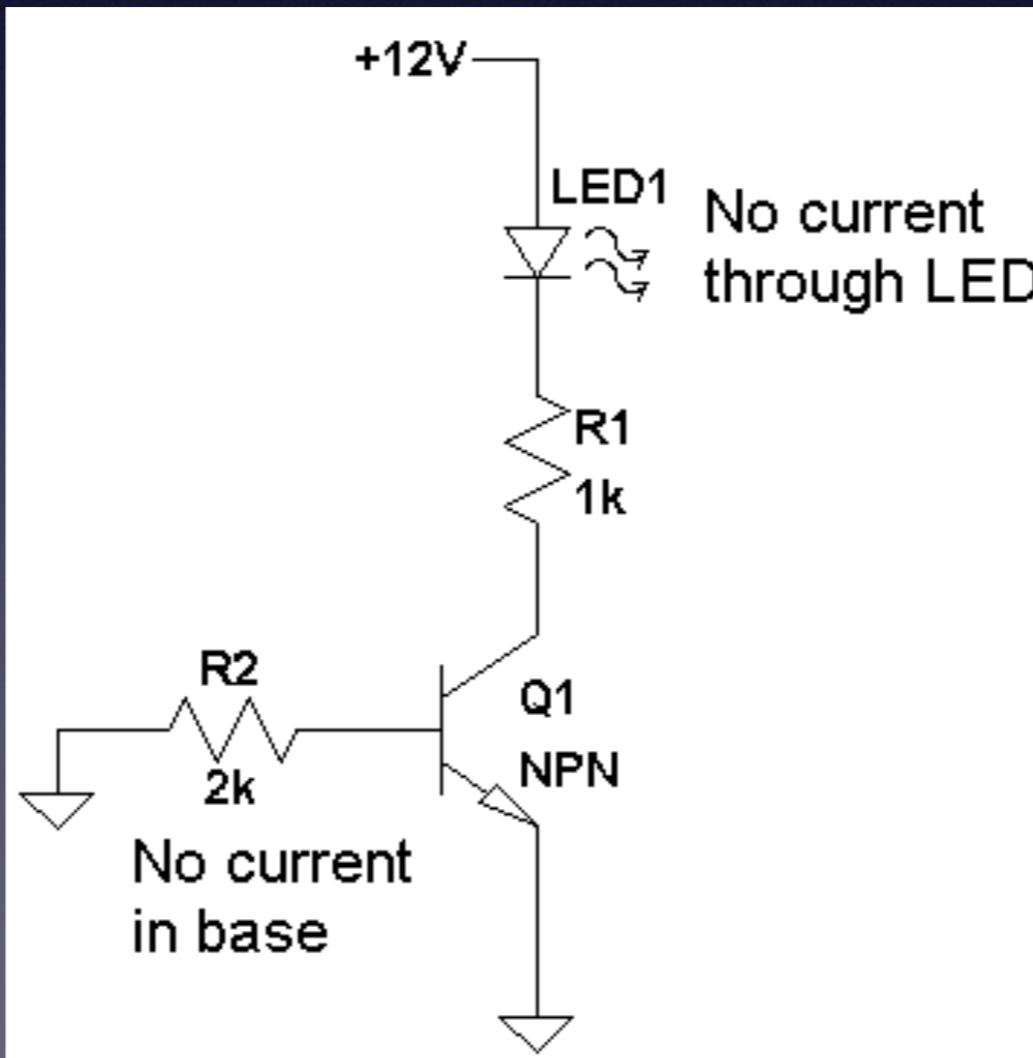
There are 3 leads on a transistor.  
**Collector, Base, Emitter.**





# SynShop Prototyping

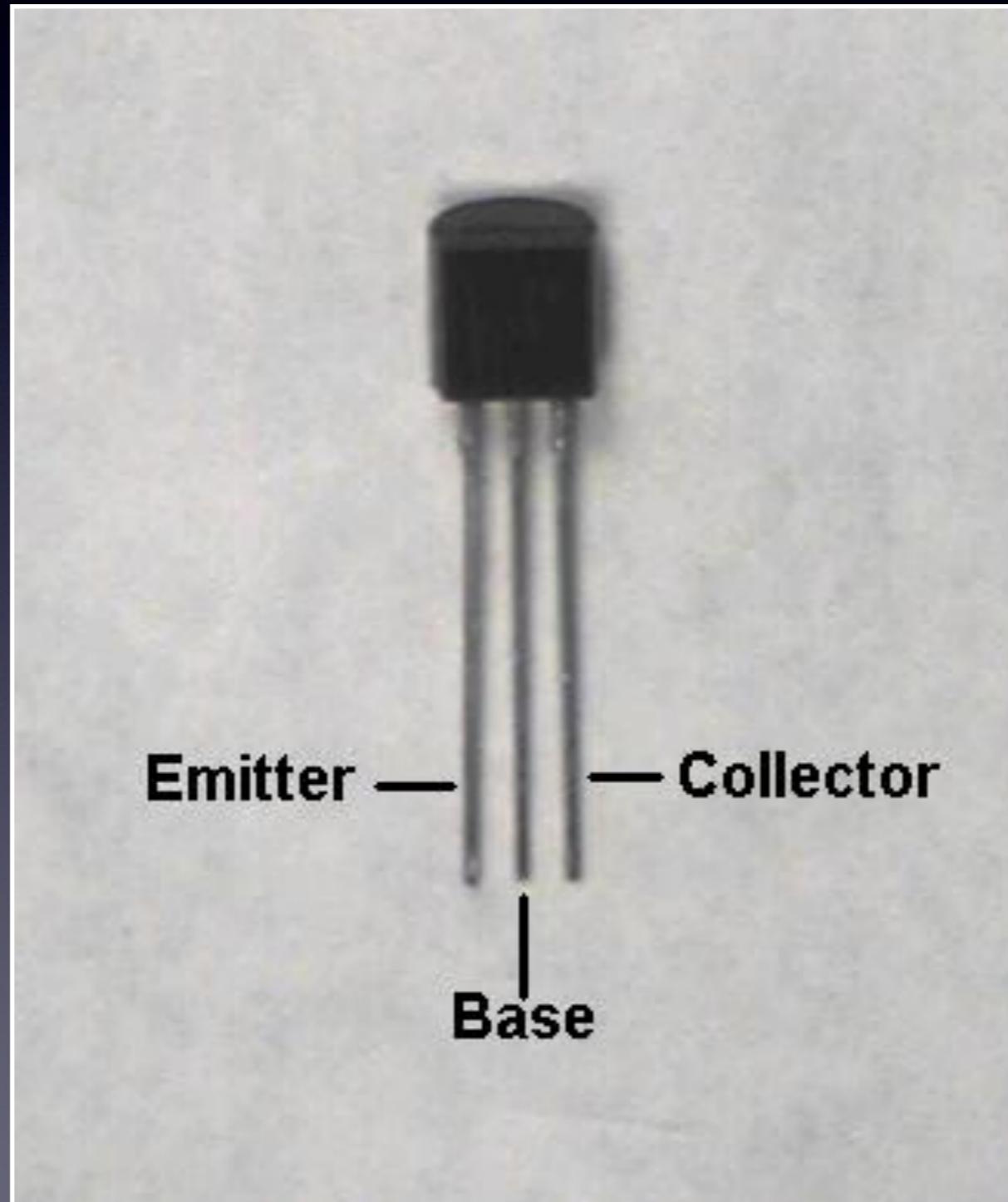
## A sufficient voltage at the base lets current flow between the collector and emitter.





SynShop  
Prototyping

# Common pinout...





## RC Time Constant

A resistor and capacitor in series  
will charge at a known rate...

**RC seconds = R ohms x C farads**

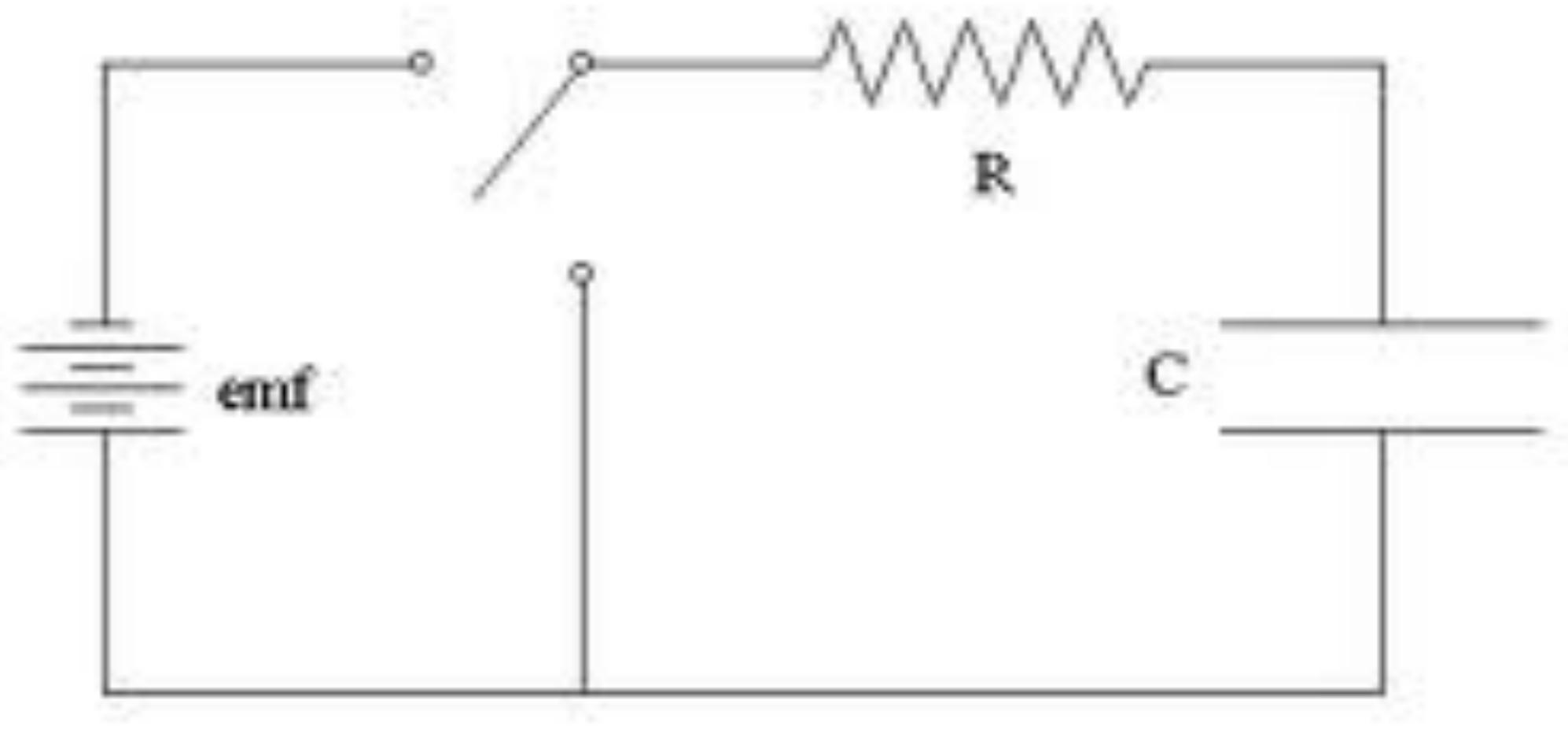
**RC = 100k ohms x 10u farads**

**RC = 100,000 ohms x 0.000,010f**

**RC = 1 second**



# SynShop Prototyping





SynShop  
Prototyping

**Stop and Go  
Build**

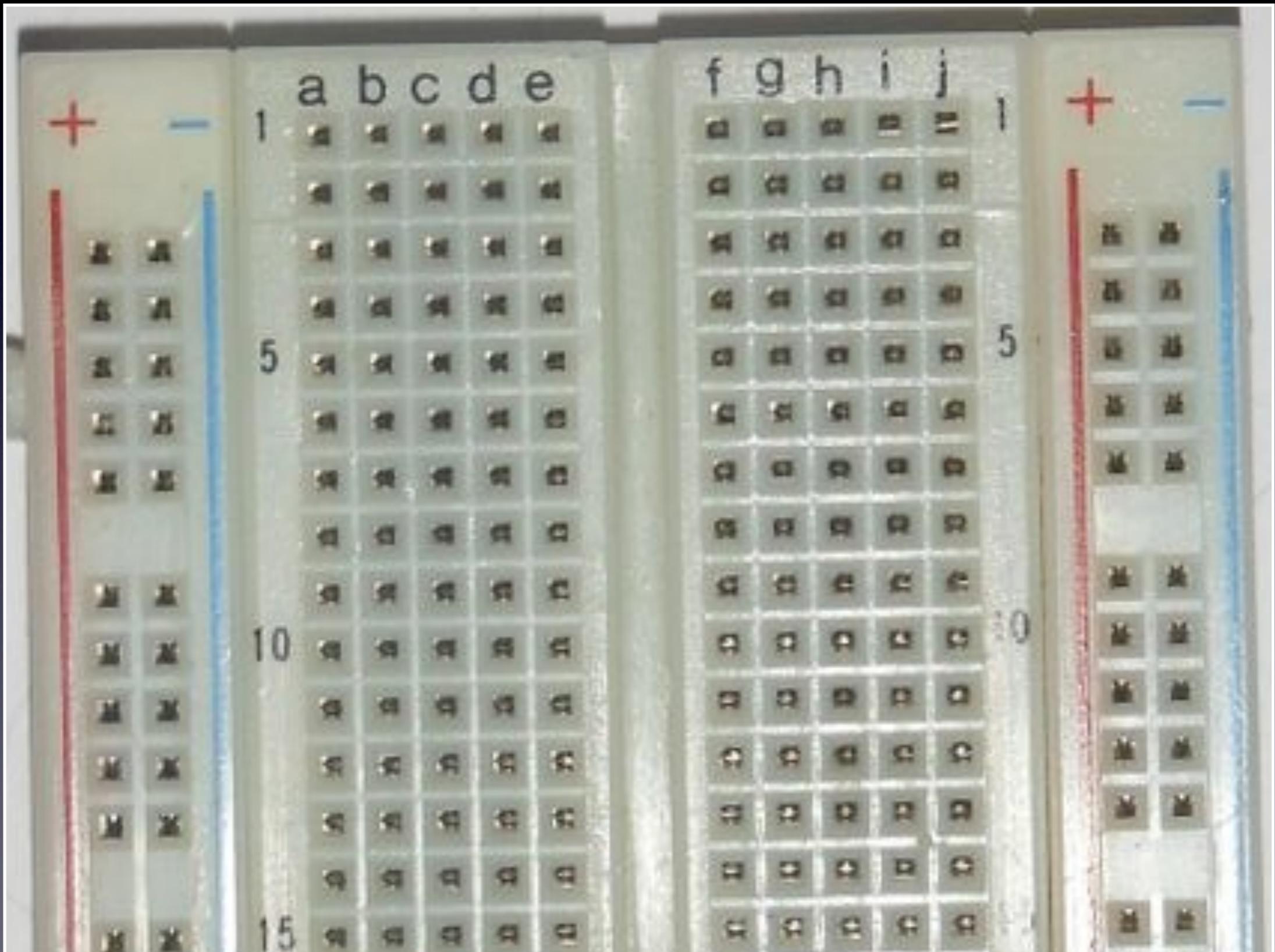


# SynShop

## Prototyping

### Step 1

Orientate  
board with  
low  
numbers  
at the top.





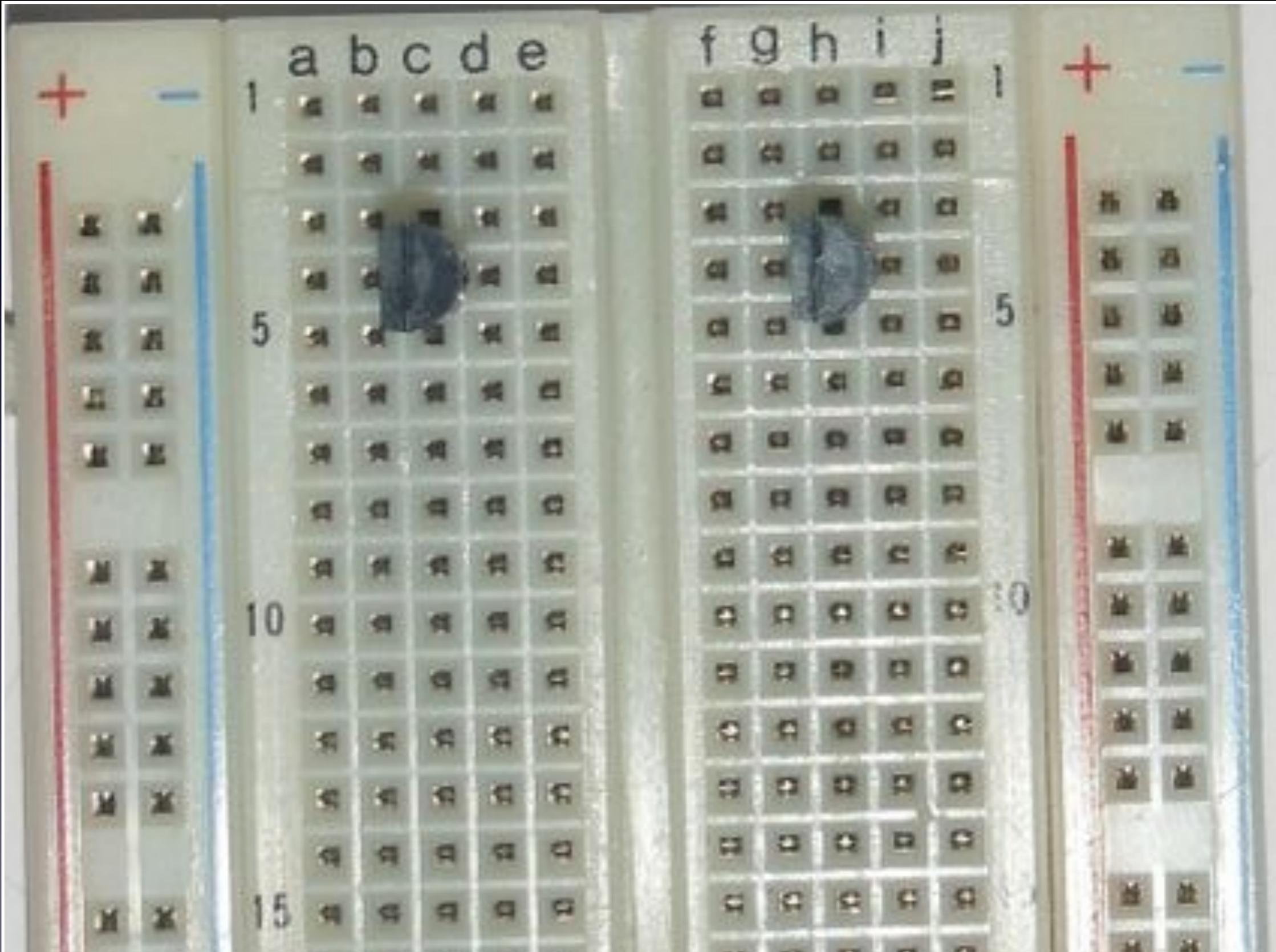
# SynShop

## Prototyping

### Step 2

Place two  
transistor,  
flat side  
facing left.

C3-C5  
H3-H5





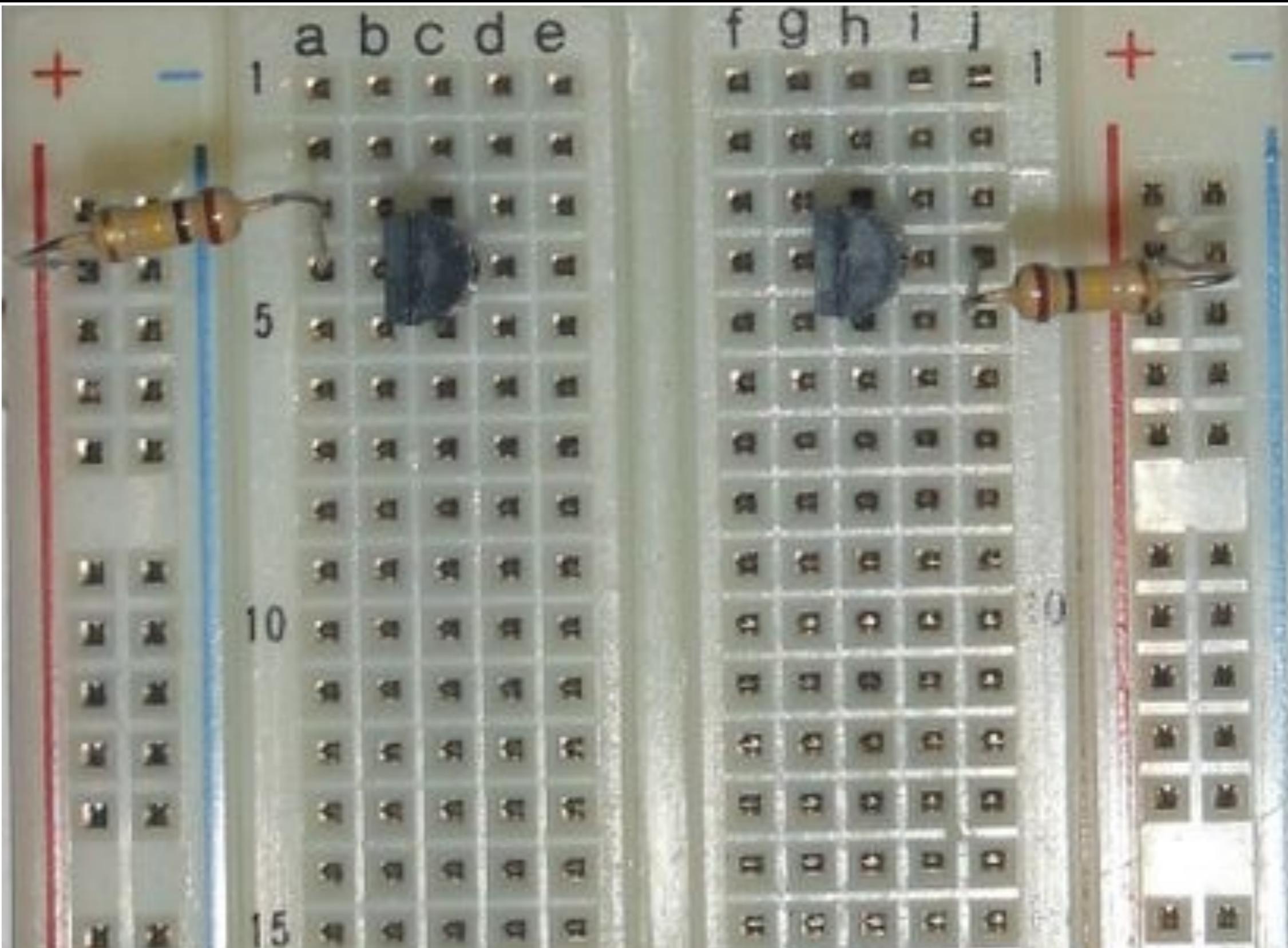
# SynShop

## Prototyping

**Step 3**

**Place 100k  
resistors  
from base  
to positive  
rail.**

**A4-PR  
J4-PR**





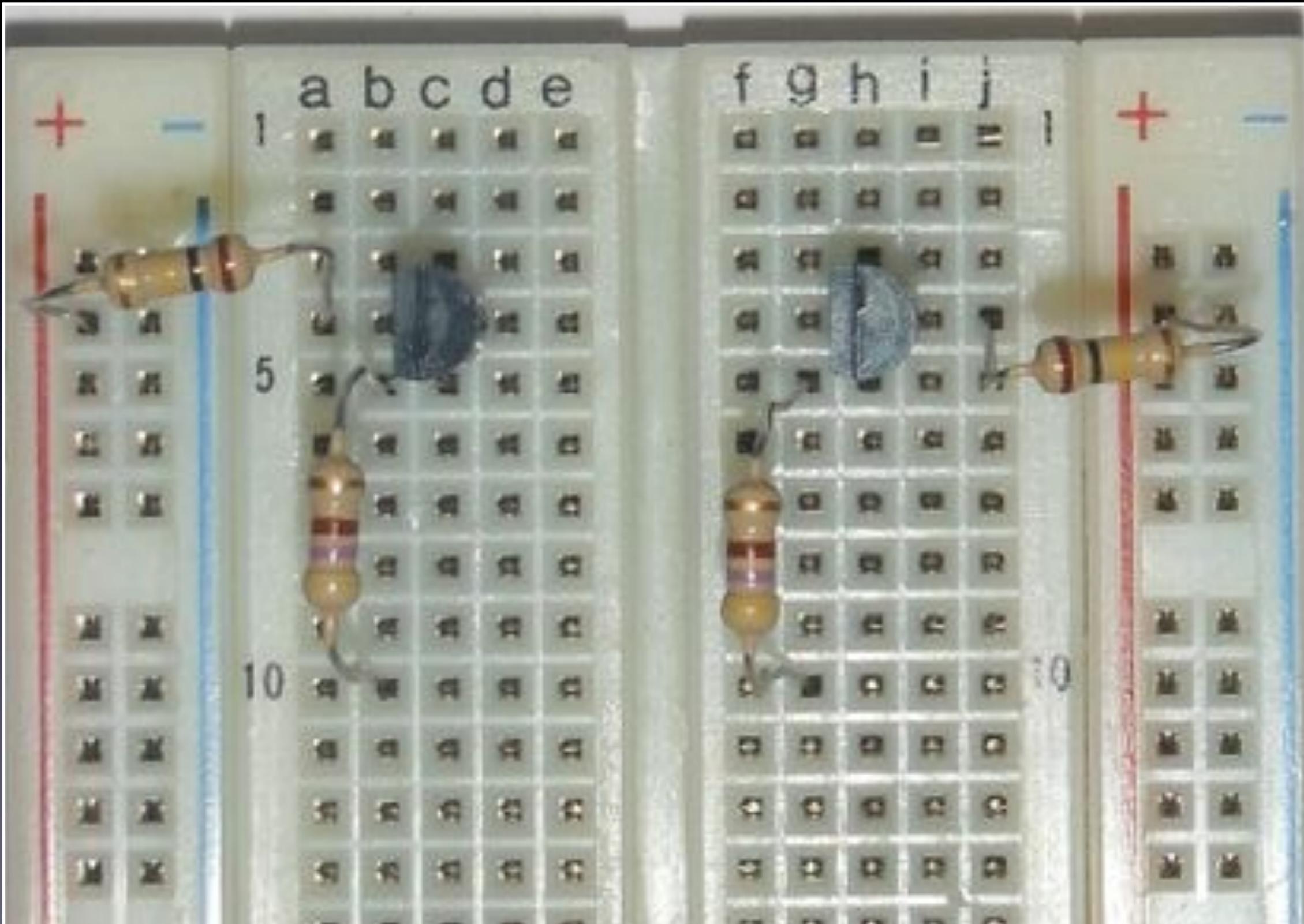
# SynShop

## Prototyping

### Step 4

Place 470 ohm resistors from collector to row 10.

B5-B10  
J5-J10





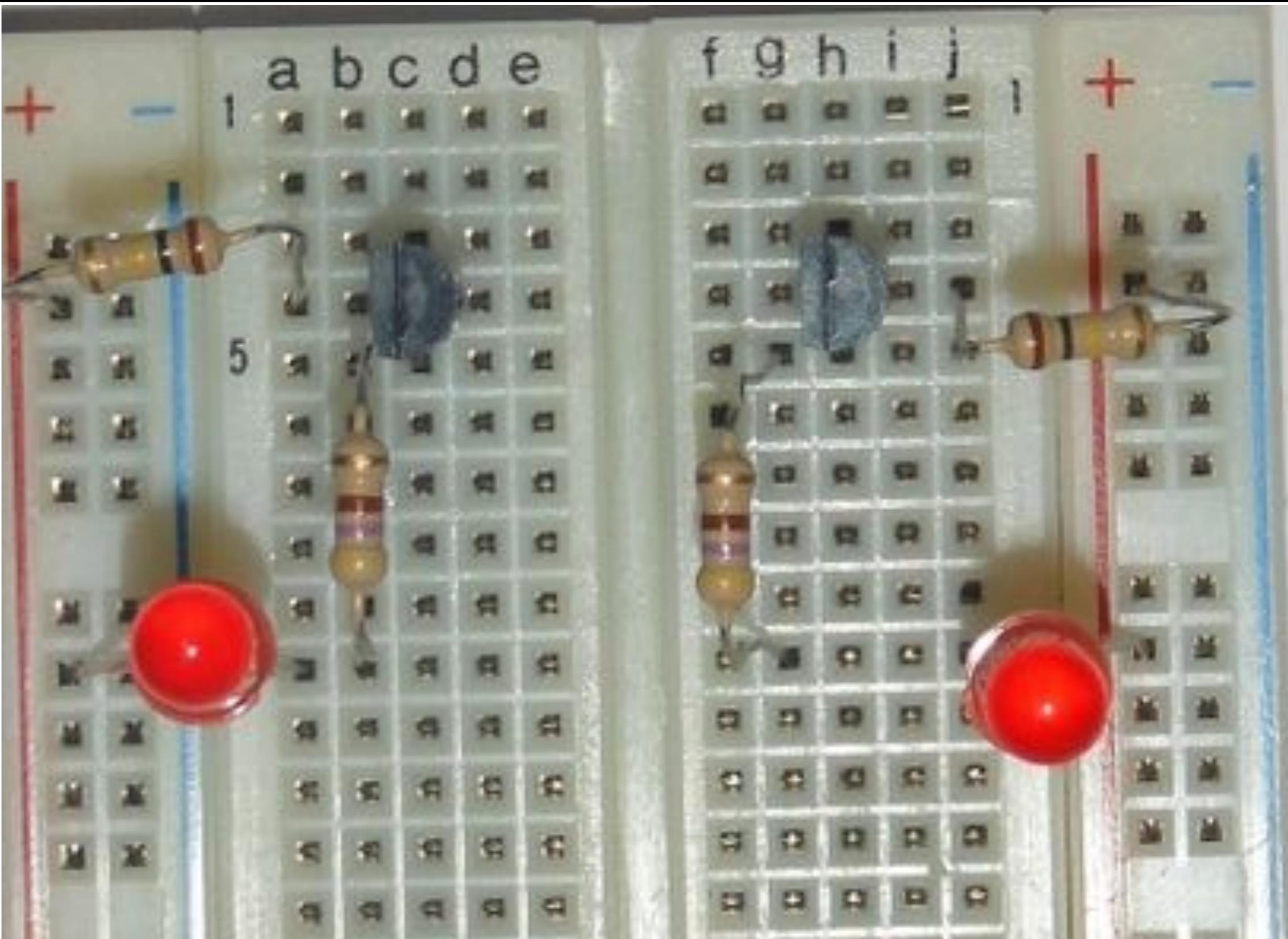
# SynShop

## Prototyping

### Step 5

Place two  
LEDs,  
long leg in  
Positive  
Rail, short  
leg on row  
10.

PR+ A10-  
PR+ J10-





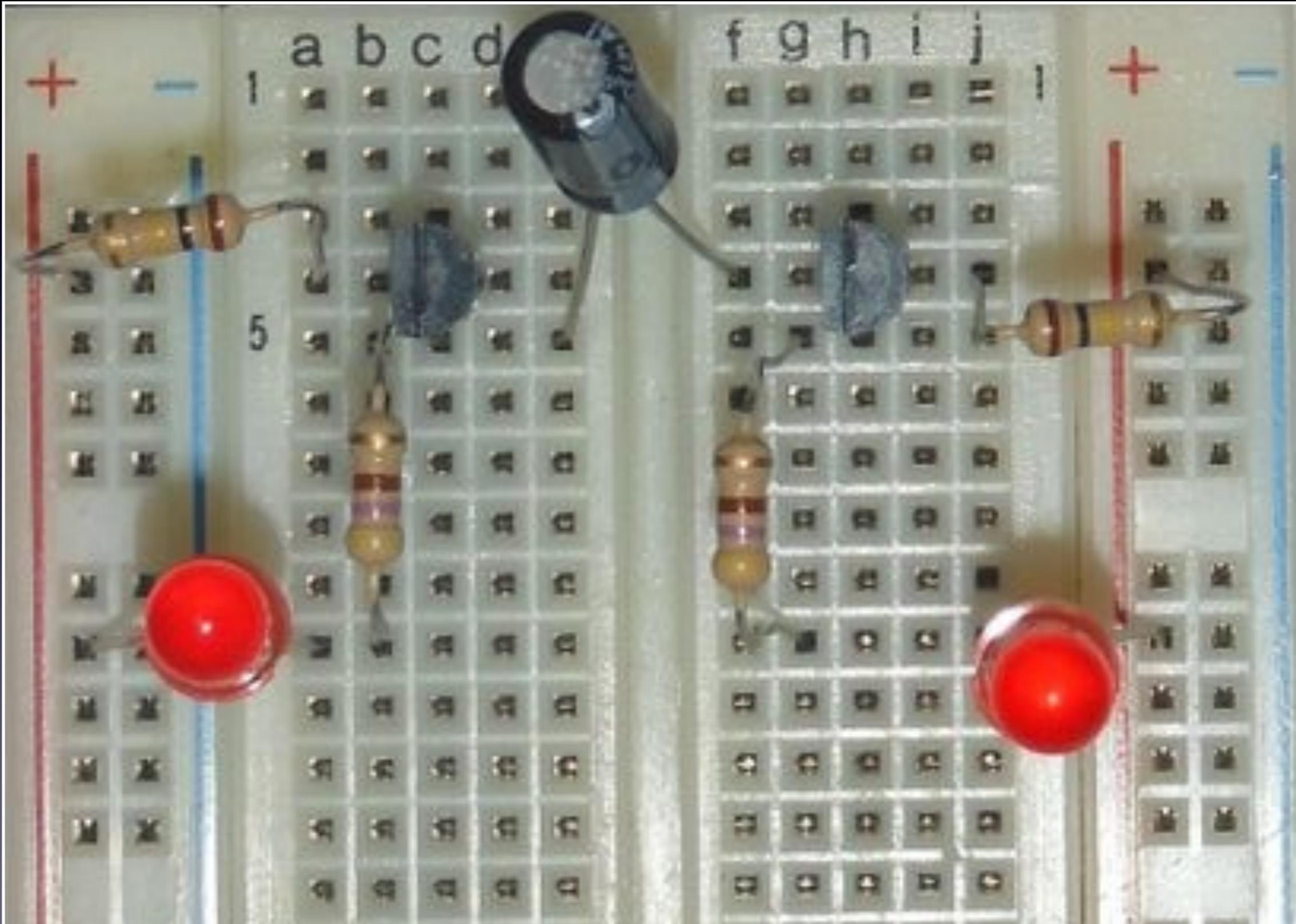
# SynShop

## Prototyping

### Step 6

Place 10uf capacitor,  
long leg  
emitter, to  
opposite  
transistor  
base short  
leg.

E5+ F4-





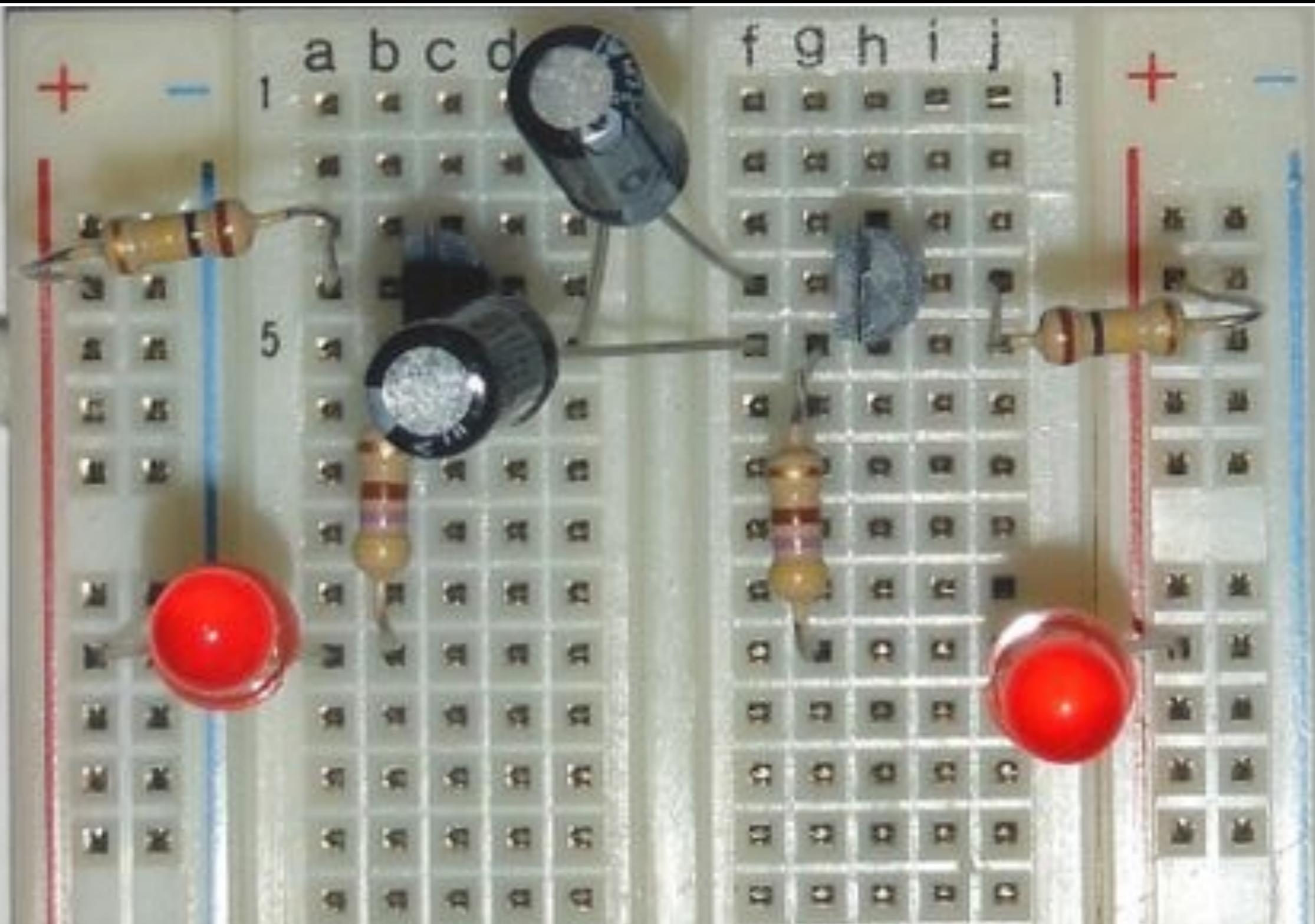
# SynShop

## Prototyping

### Step 7

Place 10uf capacitor,  
long leg  
emitter, to  
opposite  
transistor  
base short  
leg.

F4+ D4-





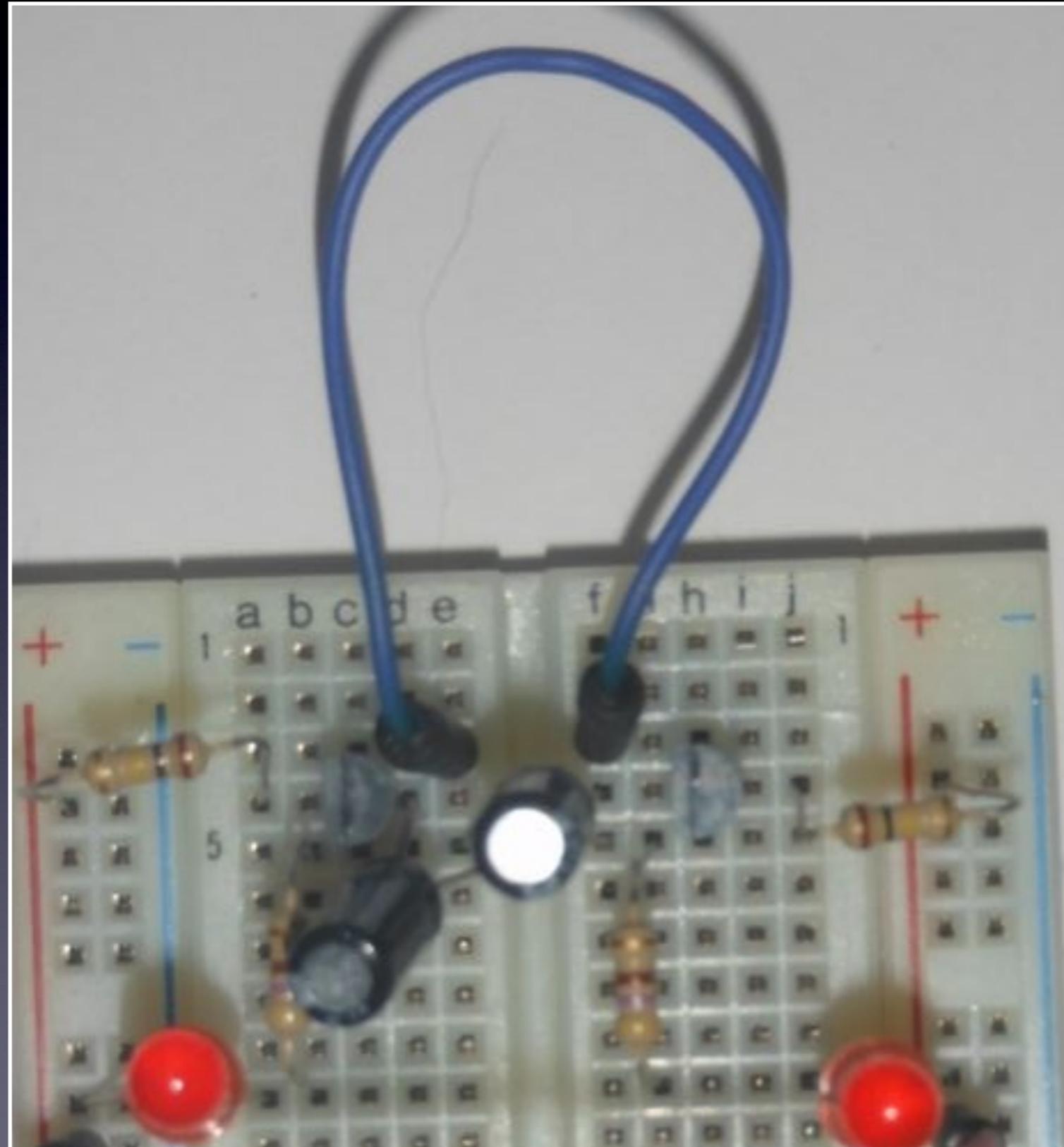
# SynShop

## Prototyping

### Step 8

Place a  
jumper to  
connect  
both  
emitters.

E3-F3





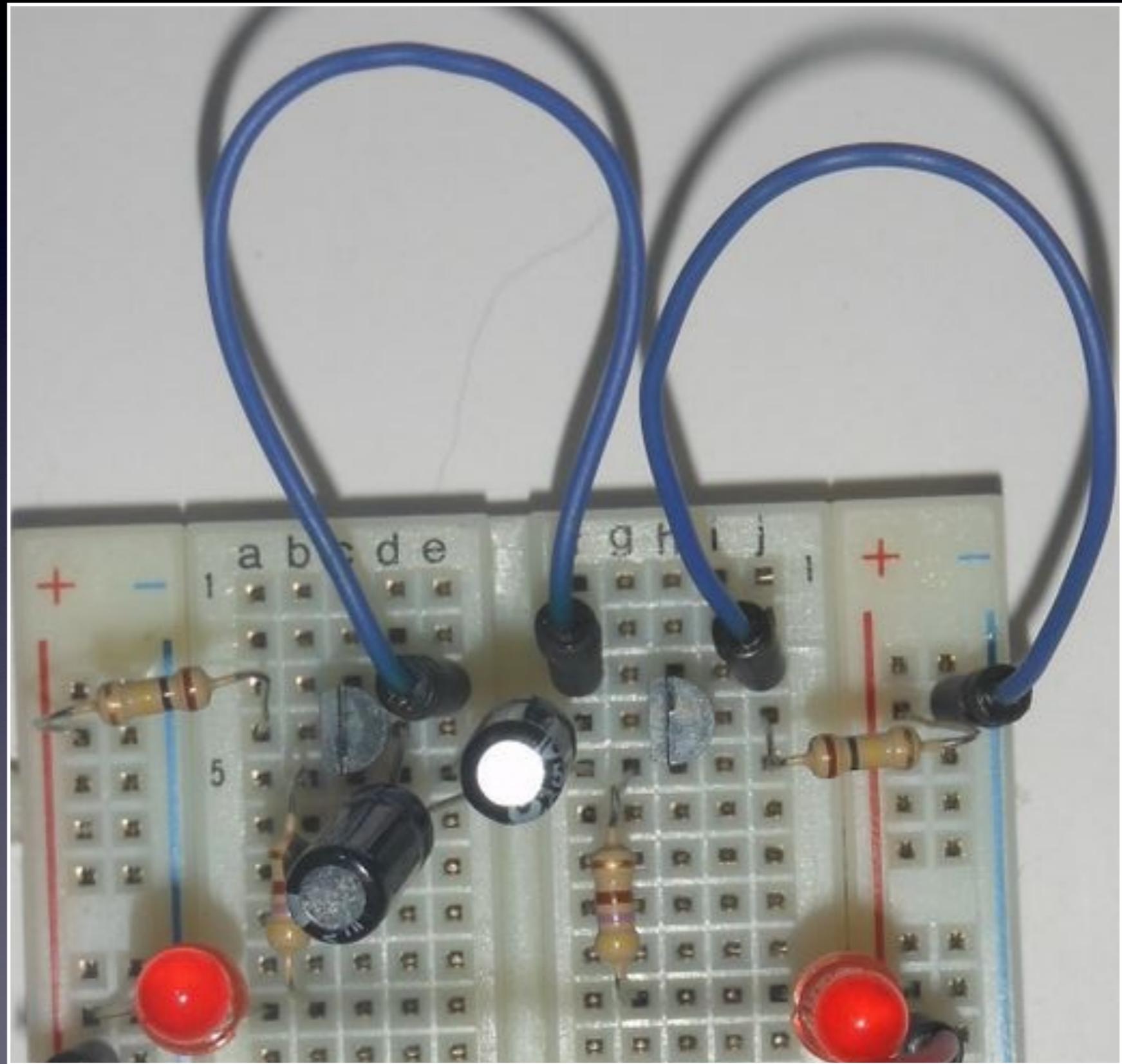
# SynShop

## Prototyping

**Step 9**

**Connect  
emitters to  
ground.**

**J3-NR**





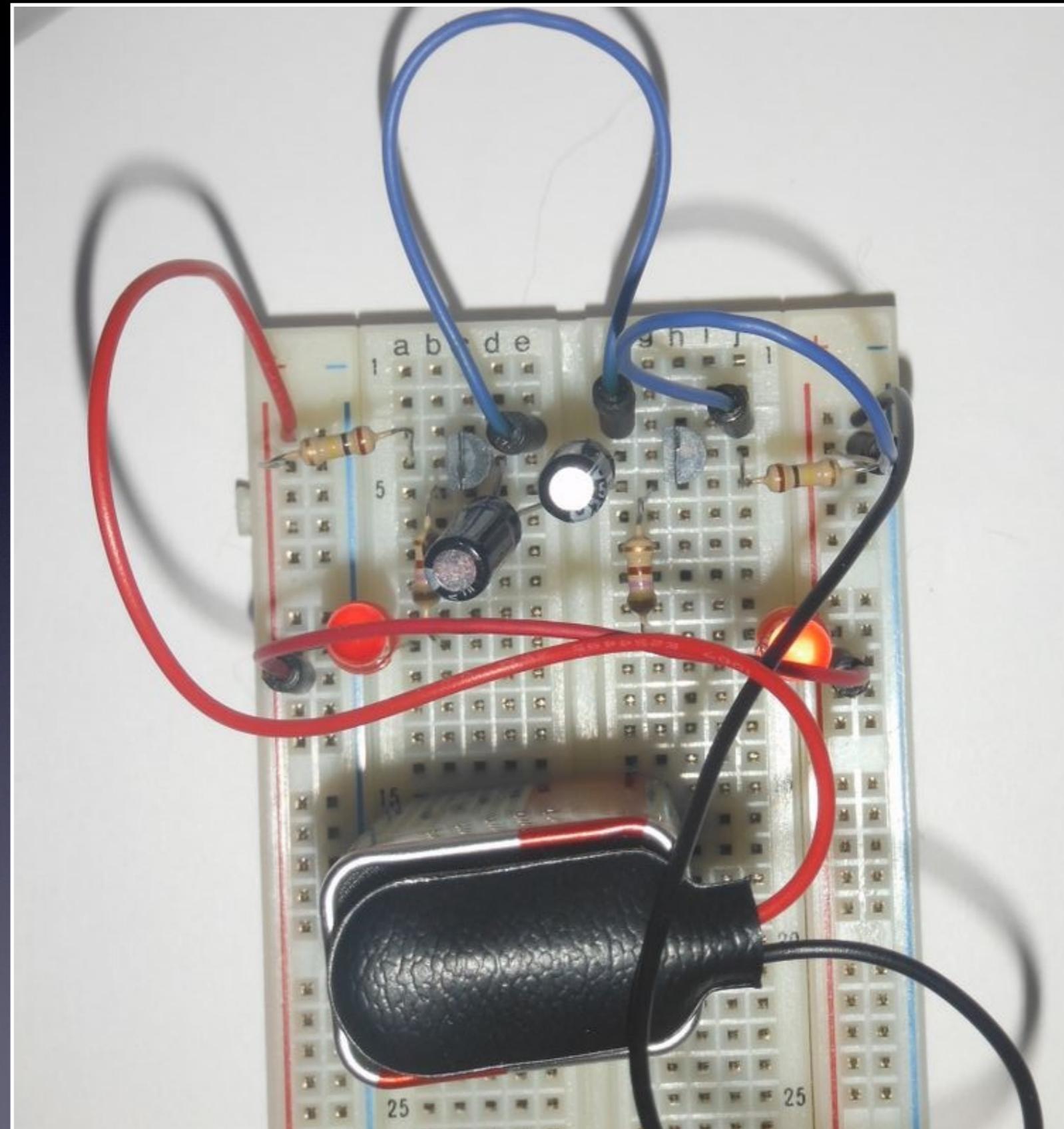
# SynShop

## Prototyping

**Step 10**

**Reconnect  
battery.**

**Should be  
blinking.**





SynShop  
Prototyping

## Disconnect Battery

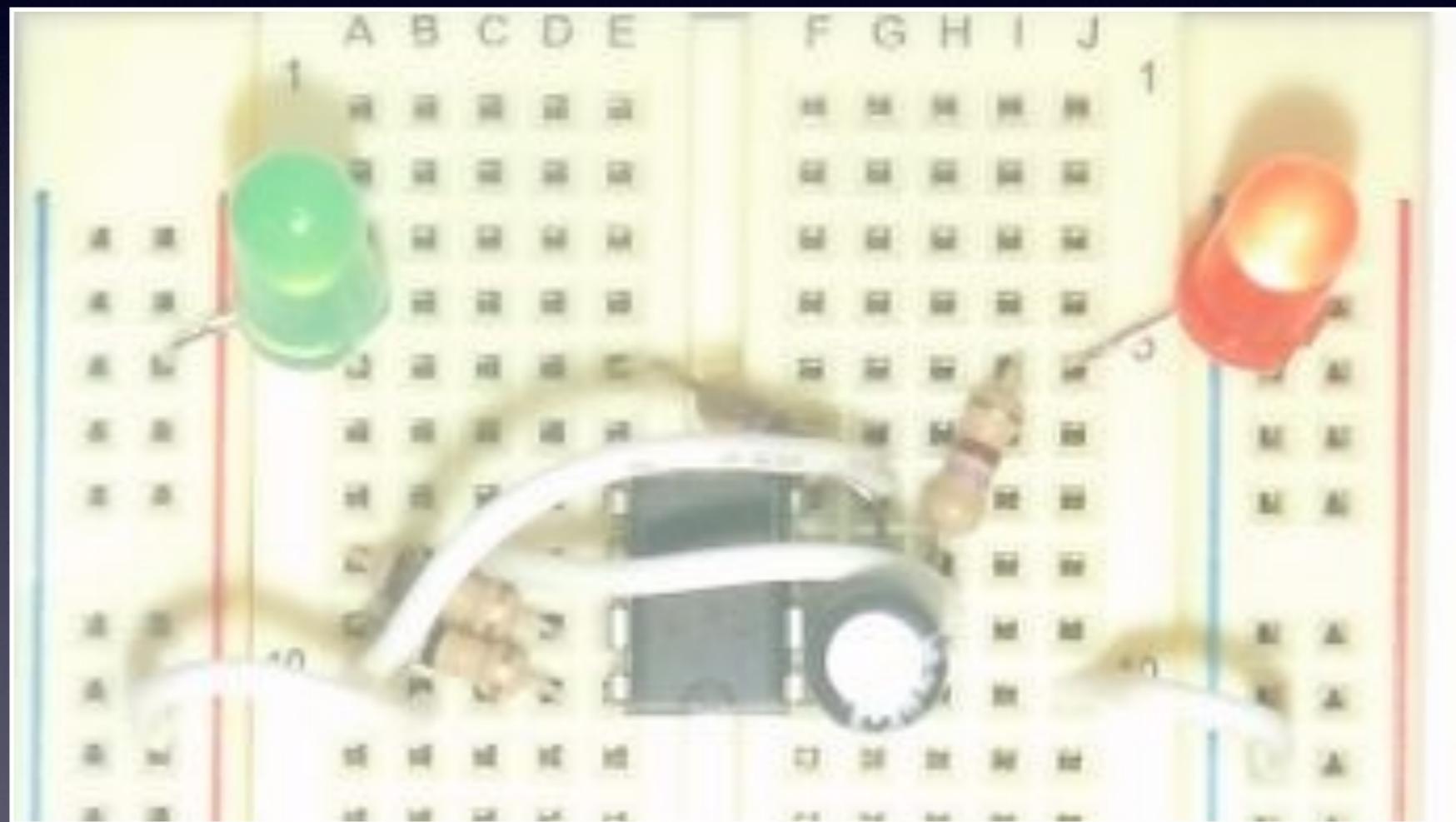
**Never work with circuit powered on.  
May destroy parts.  
Worse, you may get zapped.**





SynShop  
Prototyping

# Next build, STOP and GO 555





# SynShop Prototyping

**In the next build we are placing 2 less components.**

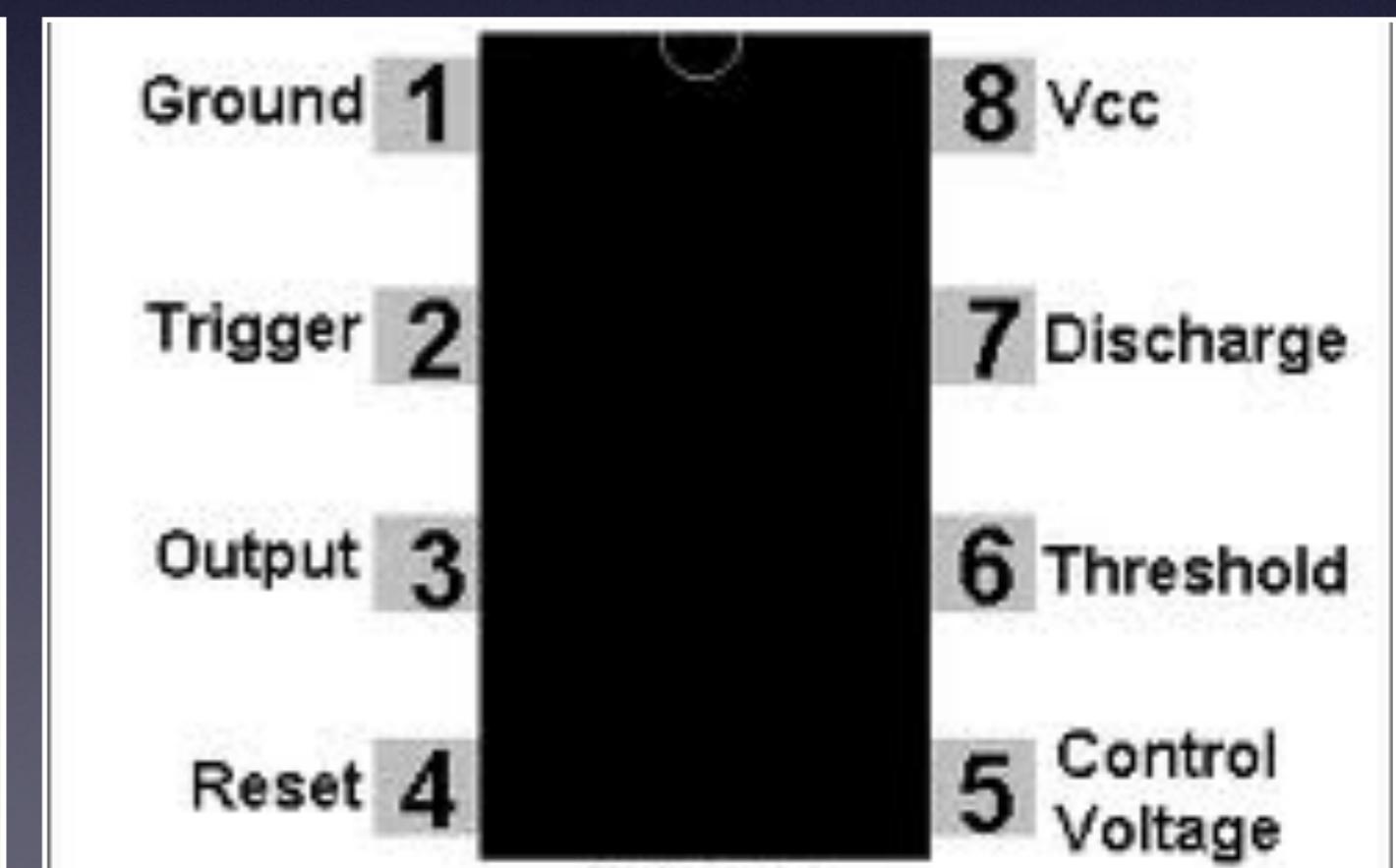
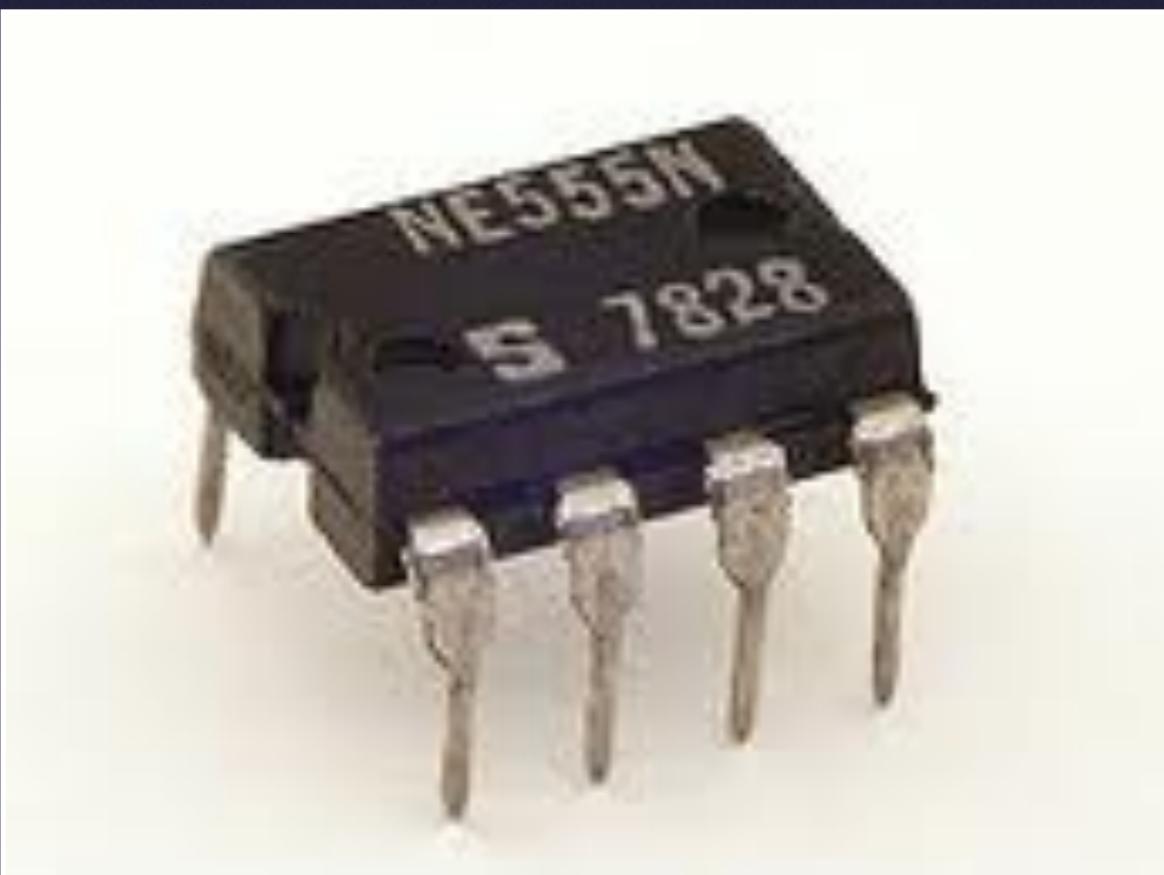
**One of those components is new,  
the Integrated Circuit, IC.**



# SynShop Prototyping

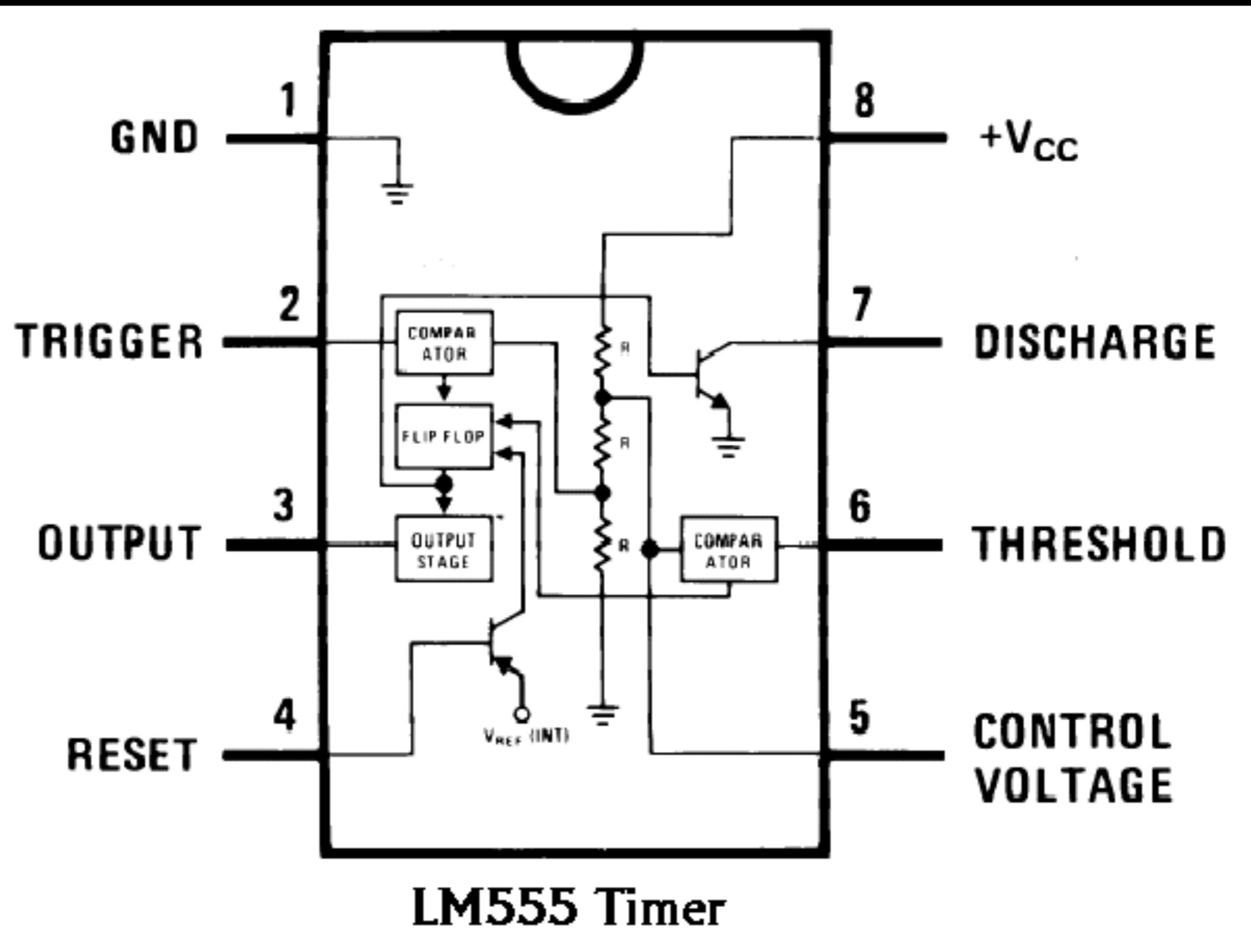
IC

Notch typically goes to the left.  
Pin 1 is lower left.





# SynShop Prototyping

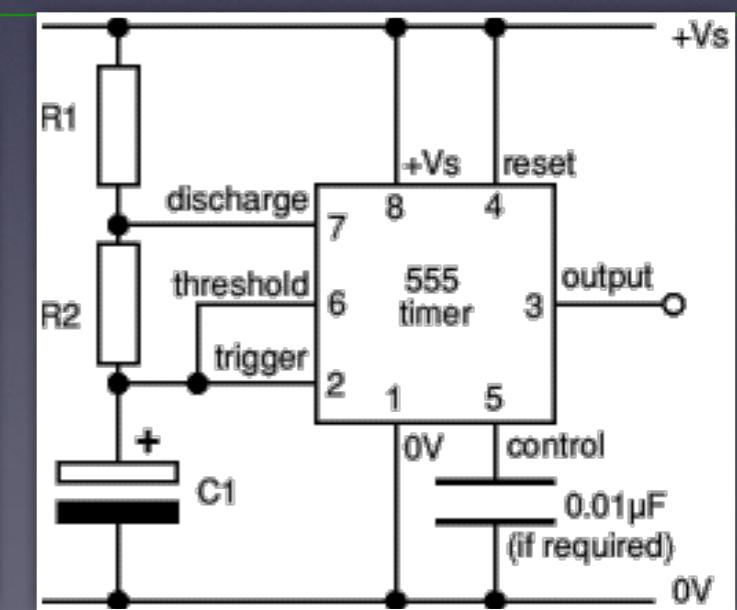
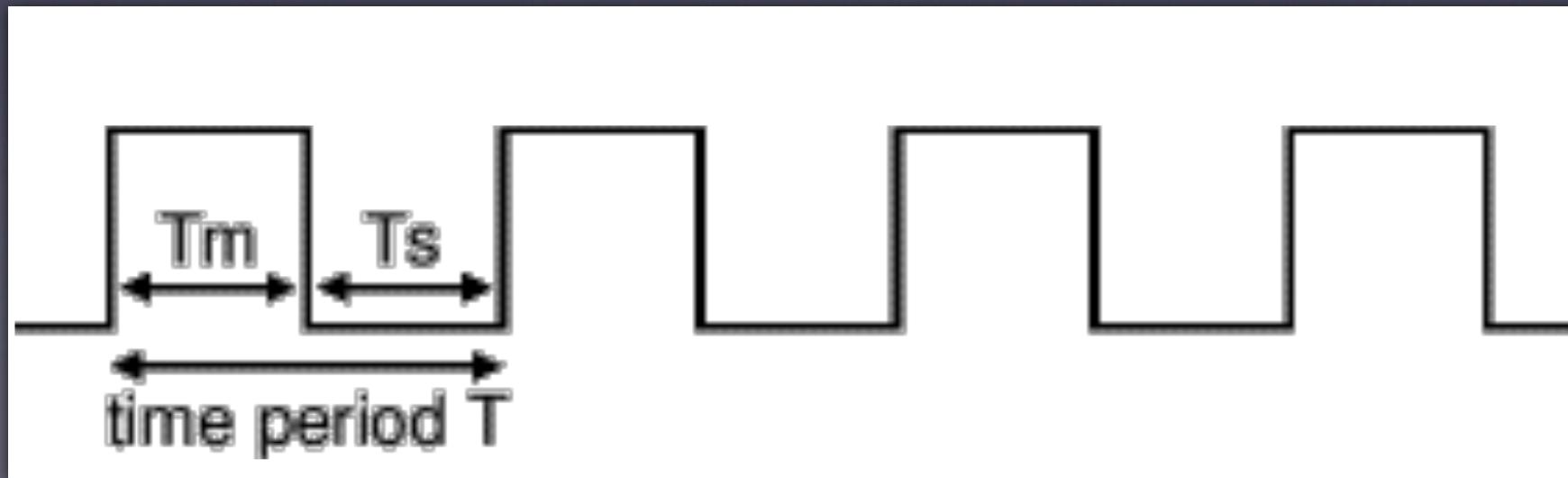




# SynShop Prototyping

## But why this chip? What does it do?

In our circuit, the timer controls the on and off time of the LEDs.





SynShop  
Prototyping

# Stop and Go 555 Build

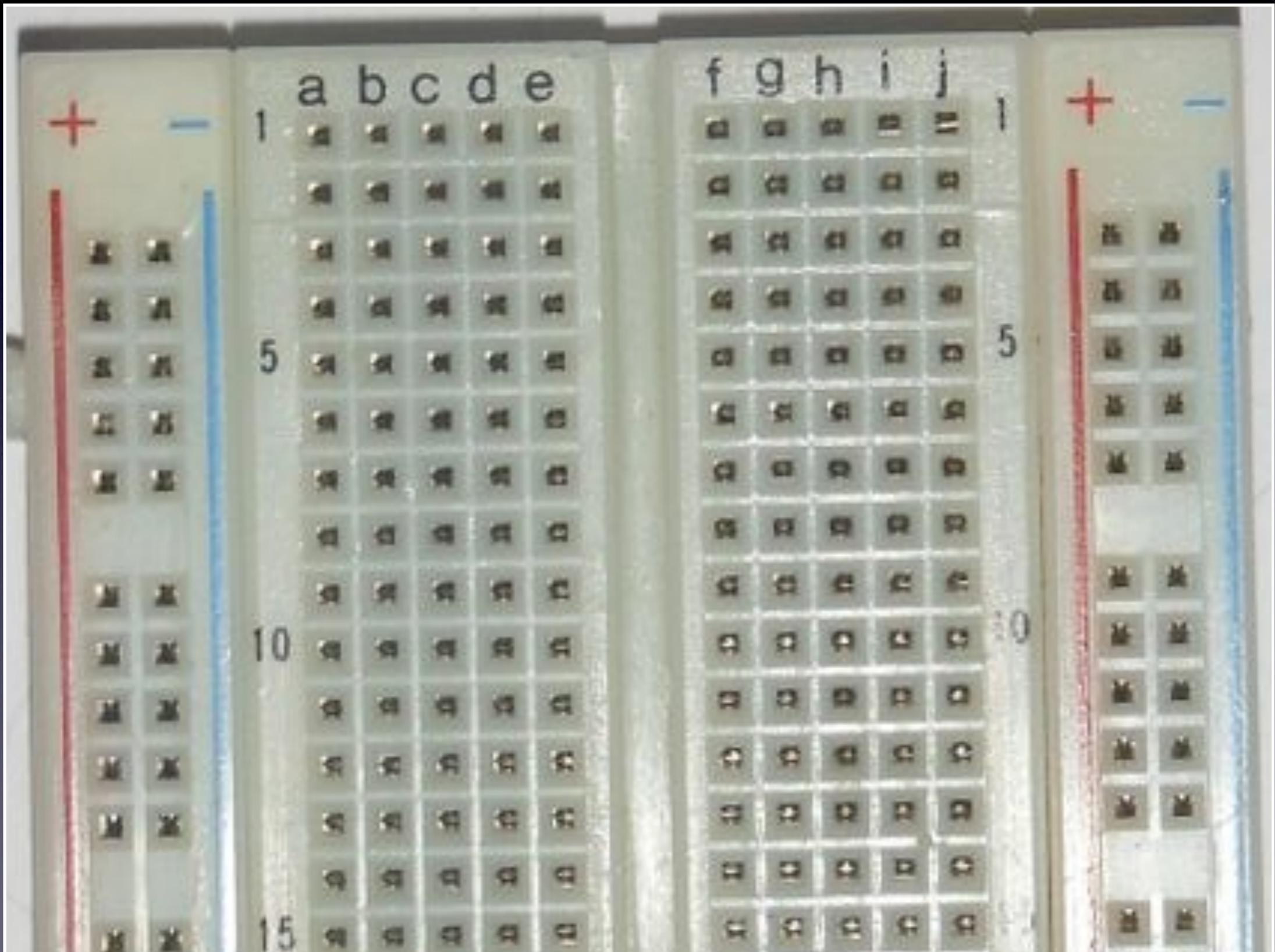


# SynShop

## Prototyping

### Step 1

Orientate  
board with  
low  
numbers  
at the top.



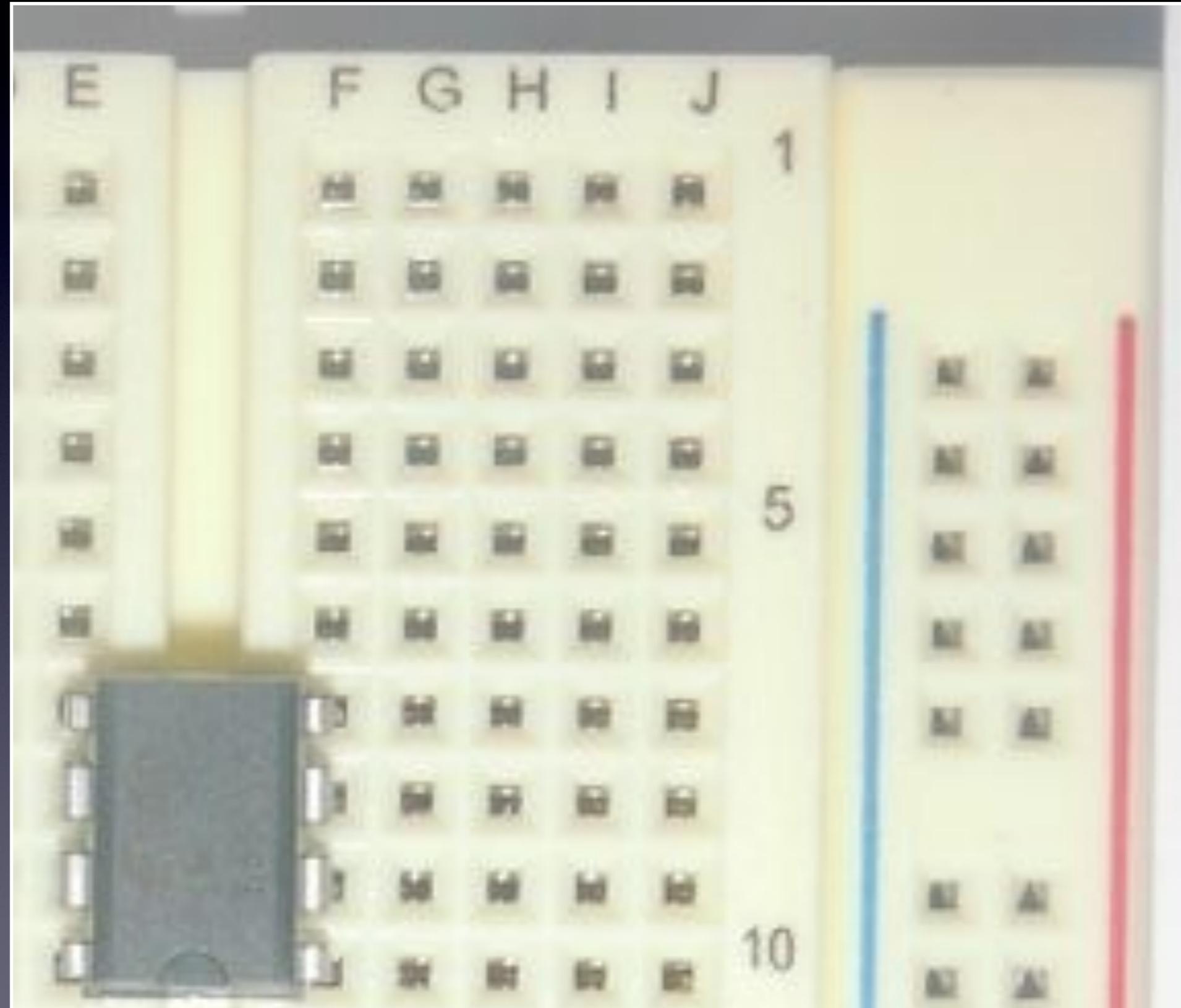


# SynShop Prototyping

## Step 2

Place IC  
with pin 1  
at F10.

E7-F10



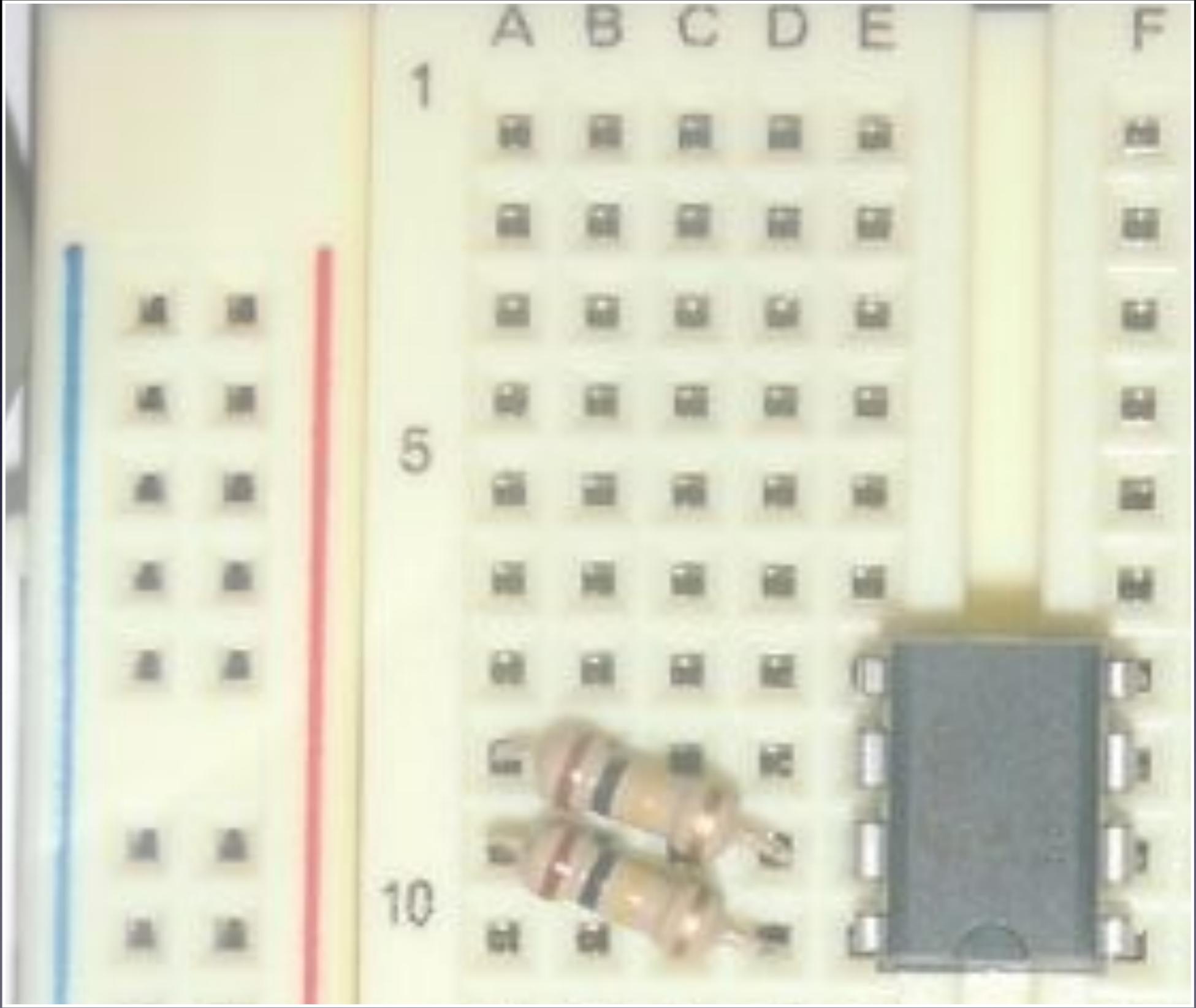


# SynShop Prototyping

## Step 3

Place 100k  
resistors  
from pins  
8-7, and  
pins 7-6.

A9-D10  
A8-D9





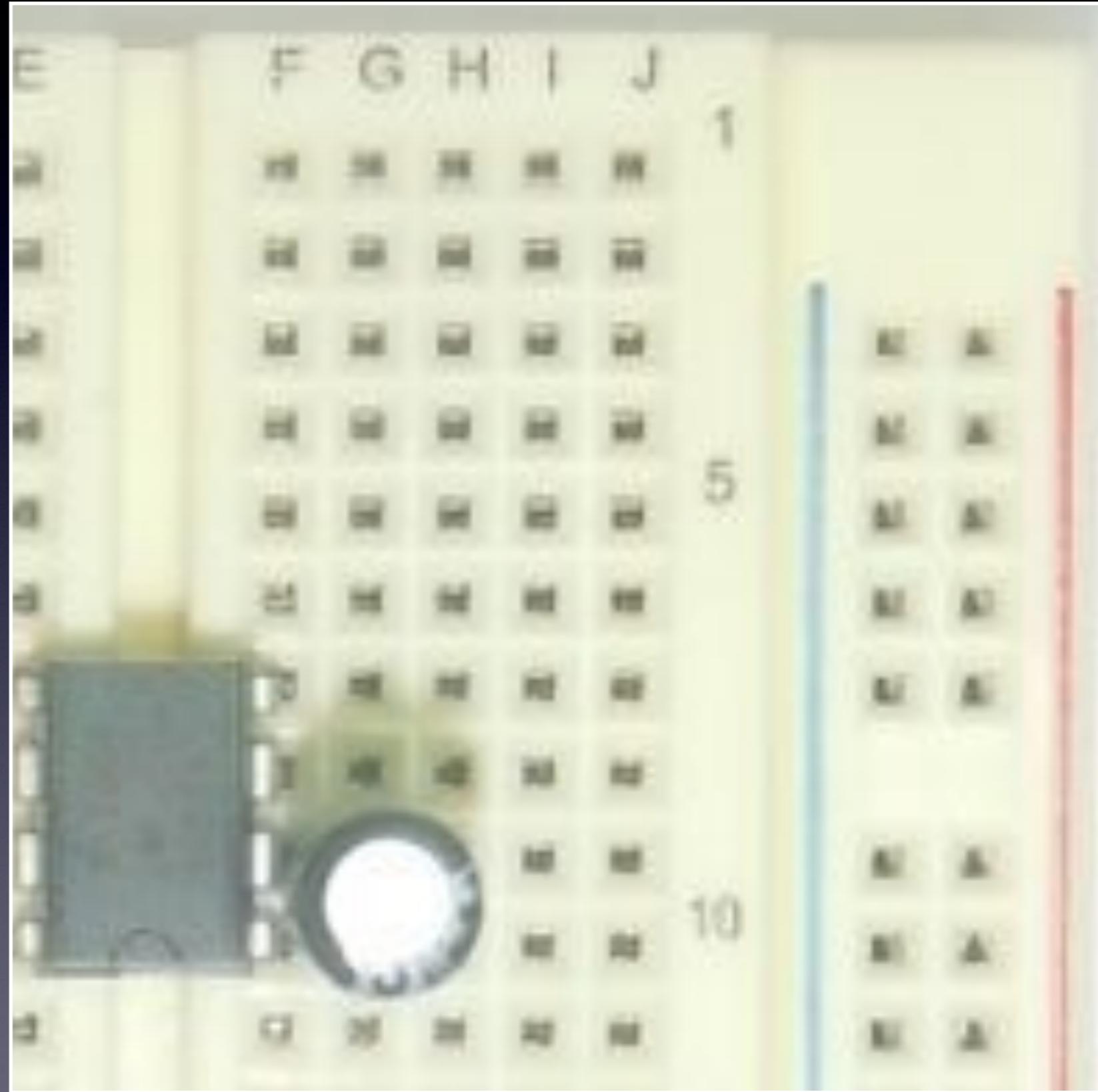
# SynShop

## Prototyping

### Step 4

Place  
capacitor  
long leg at  
pin 2,  
short leg  
at pin 1.

G9+ G10-



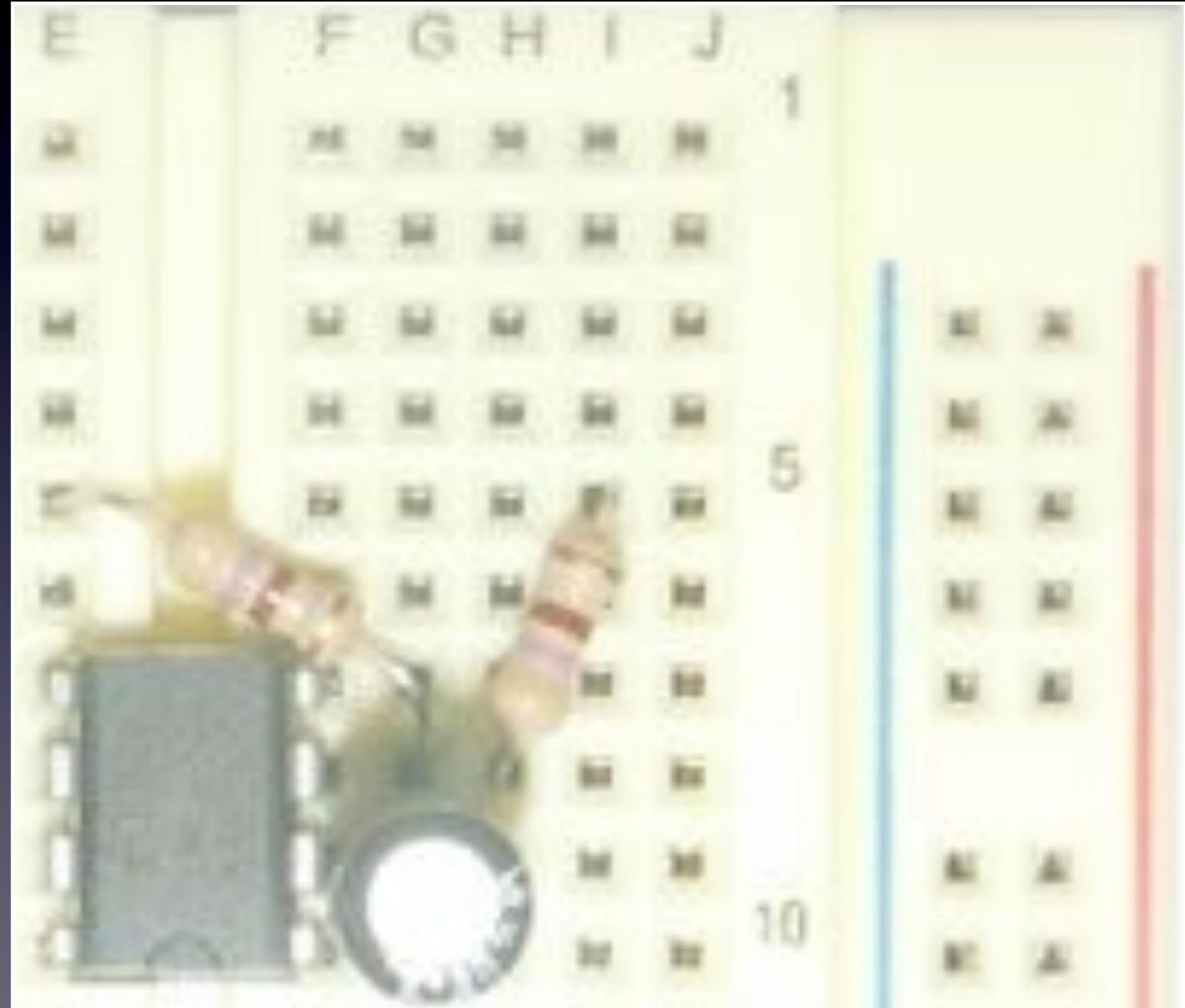


# SynShop Prototyping

## Step 5

Place 470 ohm resistors from pin 3 to row 5.

E5-G8  
I5-H8





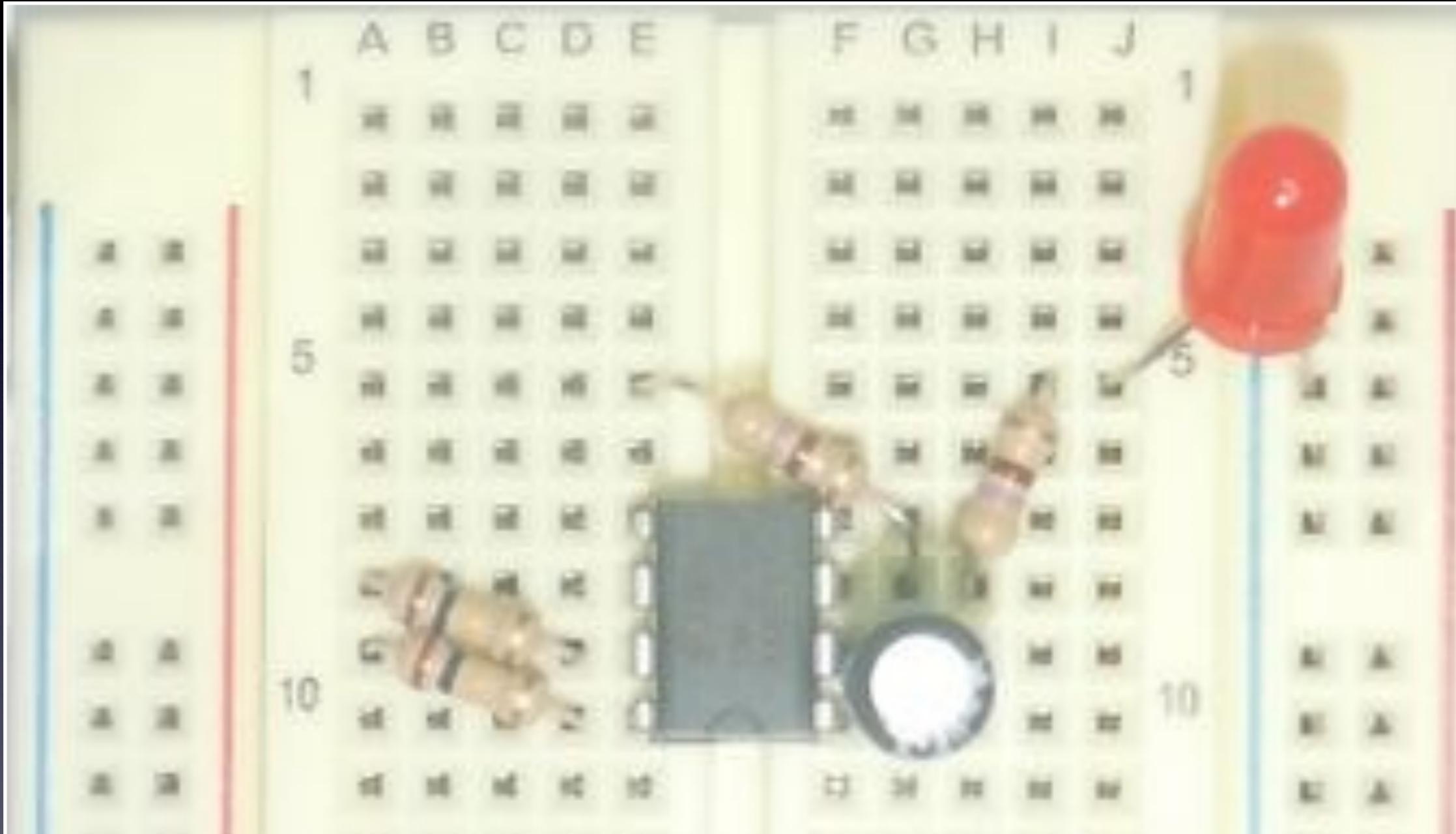
# SynShop

## Prototyping

### Step 6

**Place LED  
from row  
10 long  
leg to  
Ground  
Rail short  
leg.**

**J5+ GR-**





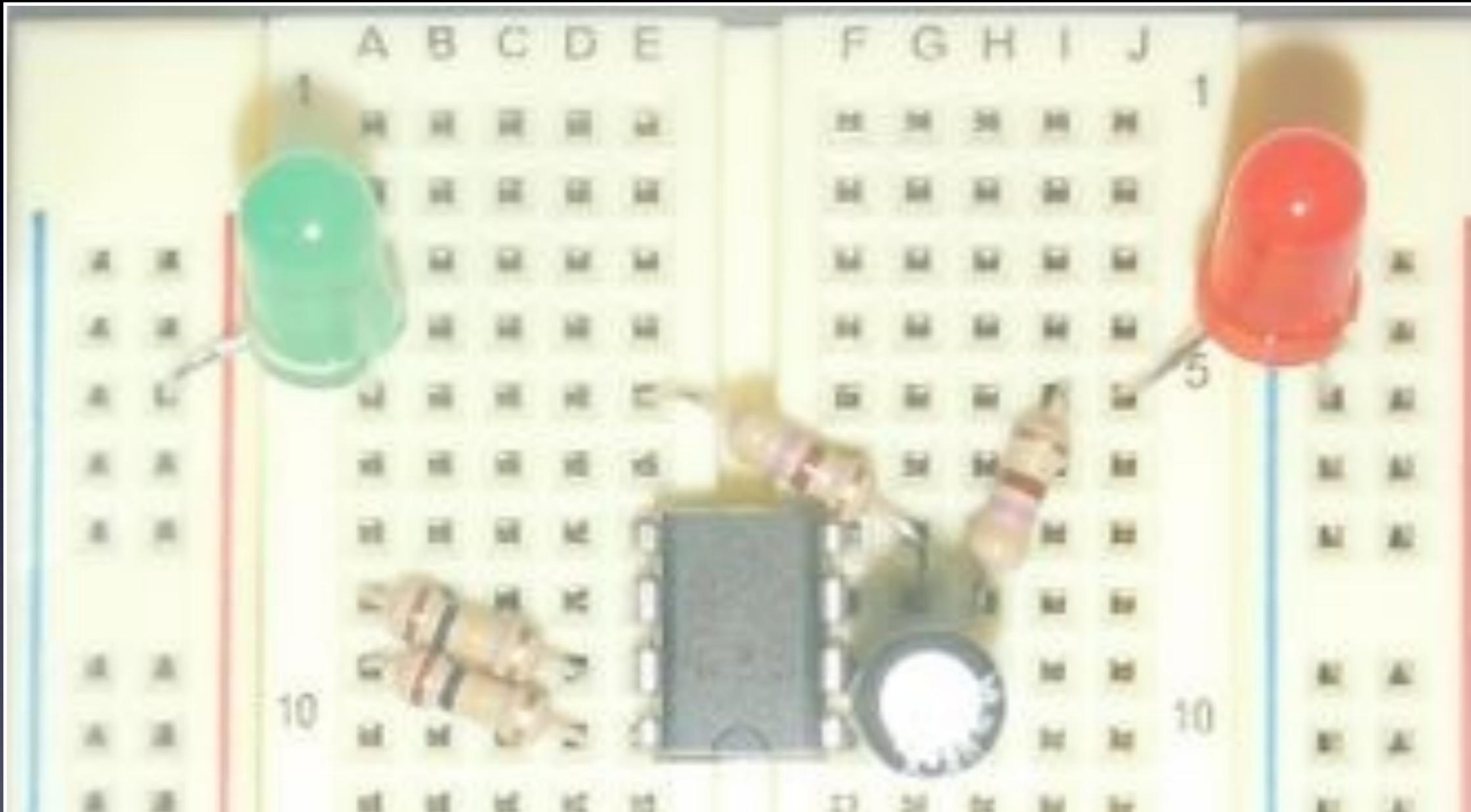
# SynShop

## Prototyping

### Step 7

Place  
green LED  
from row  
10 short  
leg to  
positive  
rail long  
leg.

A5- PR+





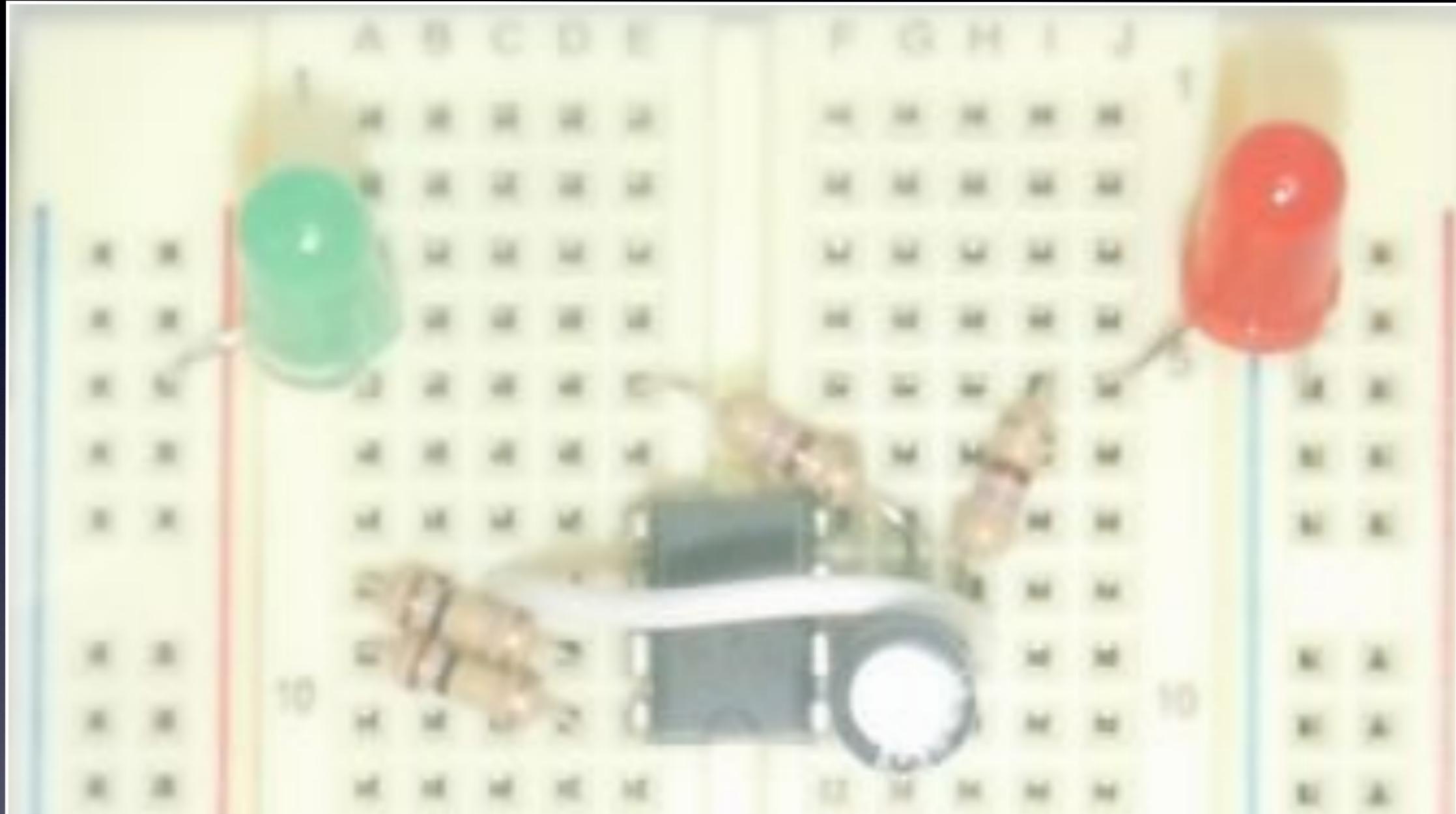
# SynShop

## Prototyping

**Step 8**

**Jumper  
pin 6 to  
pin 2.**

**C8-H9**





# SynShop

## Prototyping

**Step 9**

**Jumper  
pin 8 to  
pin 4.**

**A10-G7**





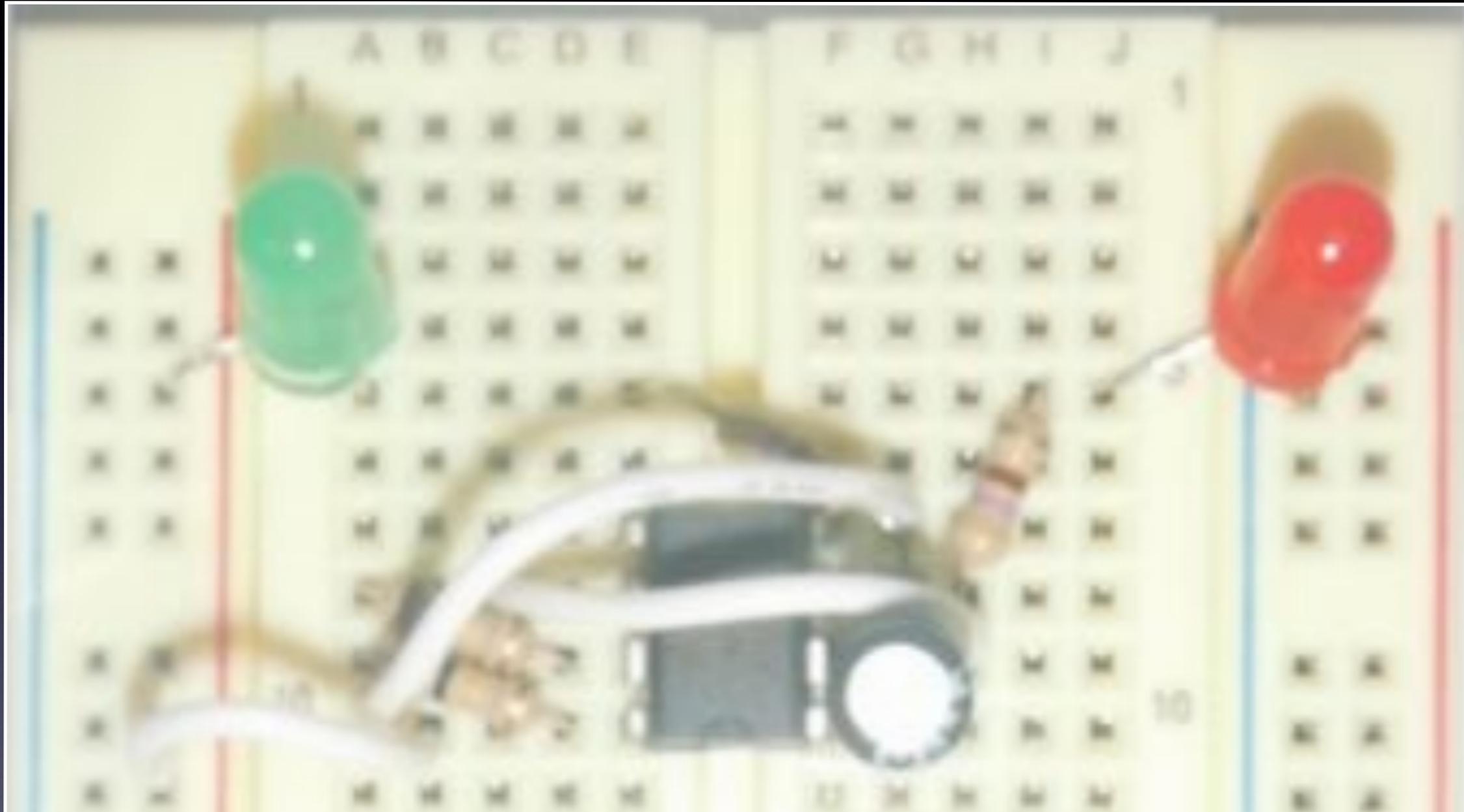
# SynShop

## Prototyping

**Step 10**

**Jumper  
pin 8 to  
positive  
rail.**

**B10-PR**





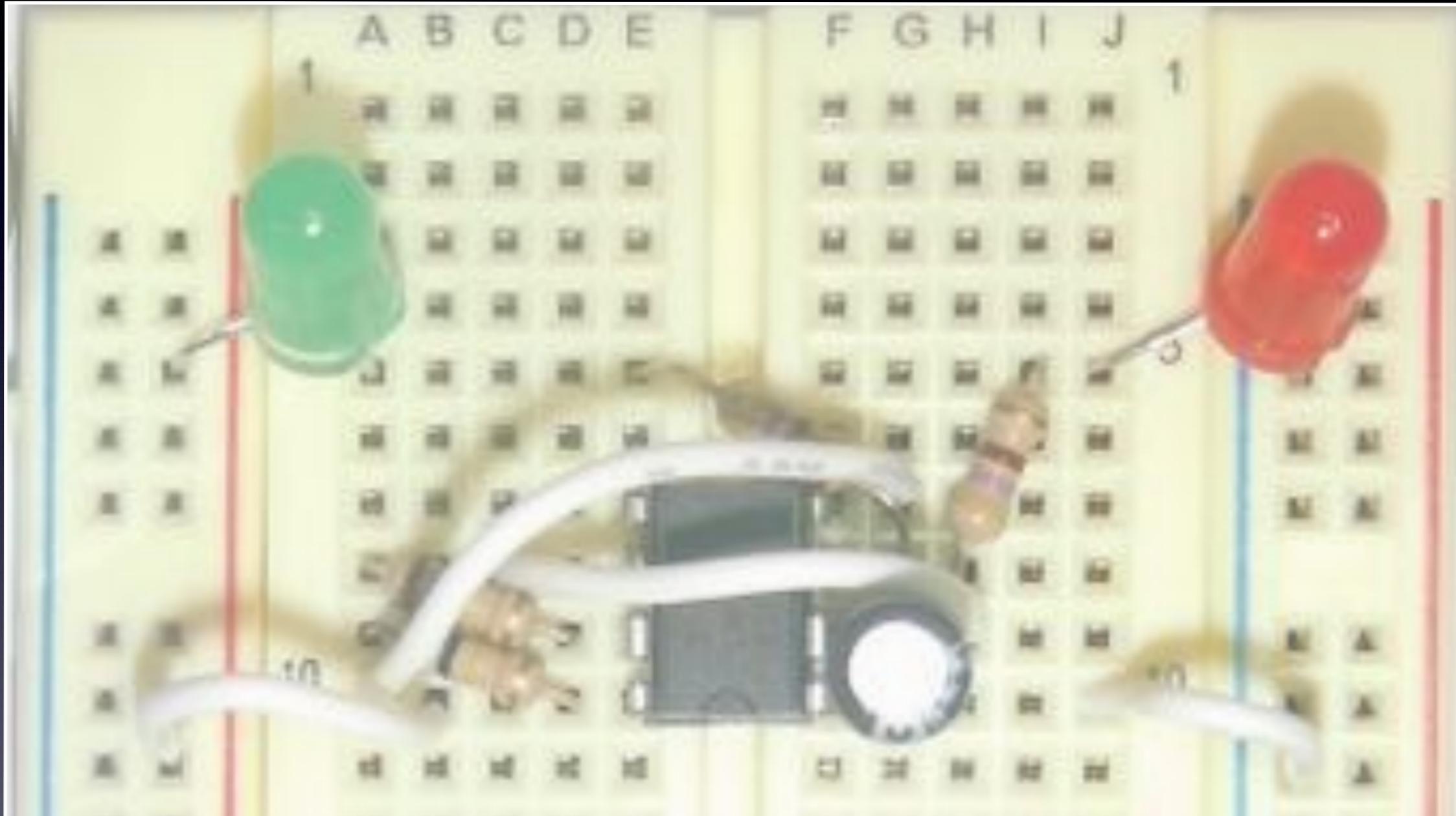
# SynShop

## Prototyping

**Step 11**

**Jumper  
pin 1 to  
pin  
negative  
rail.**

**J10-NR**





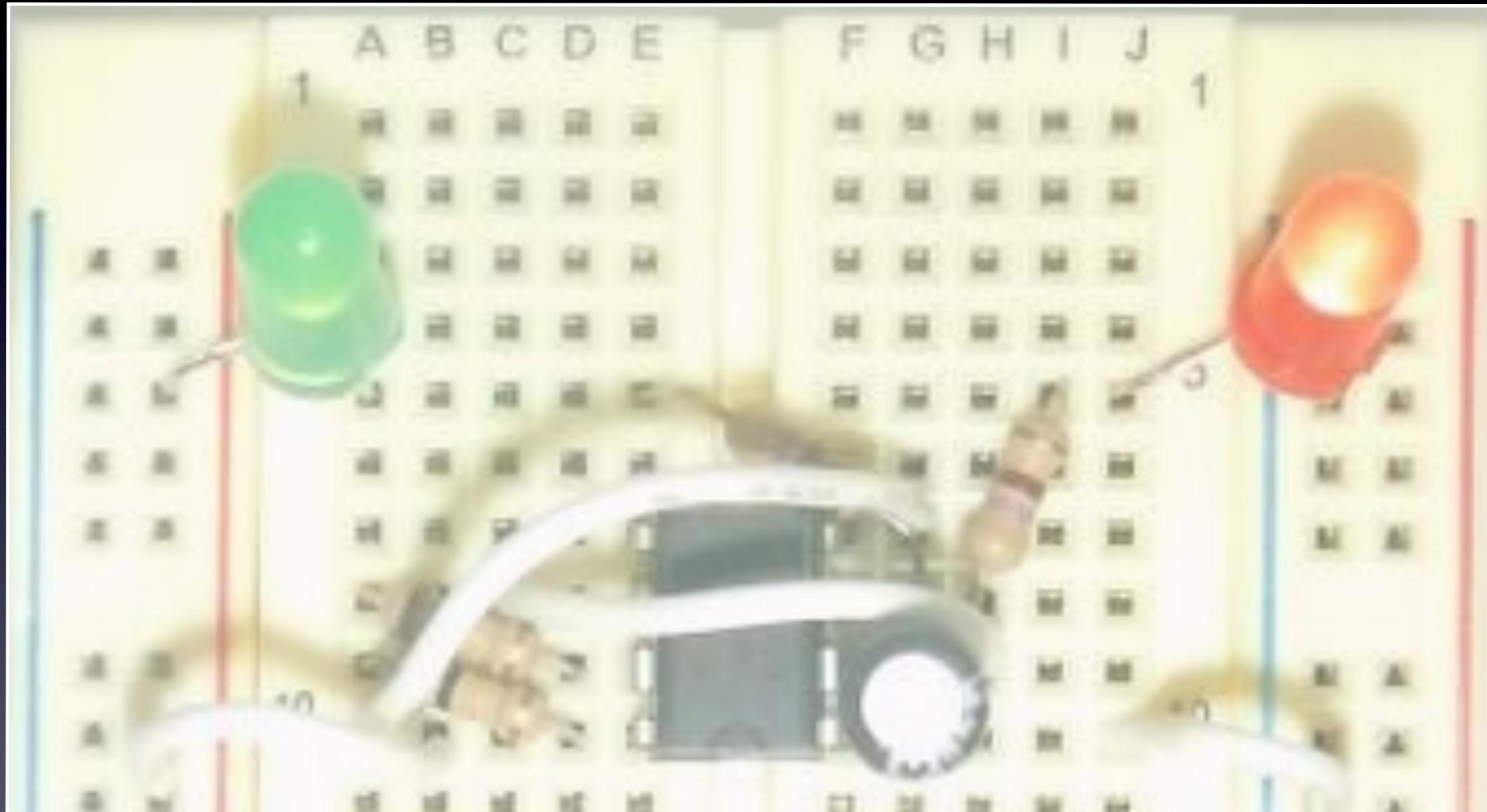
# SynShop

## Prototyping

**Step 12**

**Connect  
battery.**

**Should  
start  
blinking.**





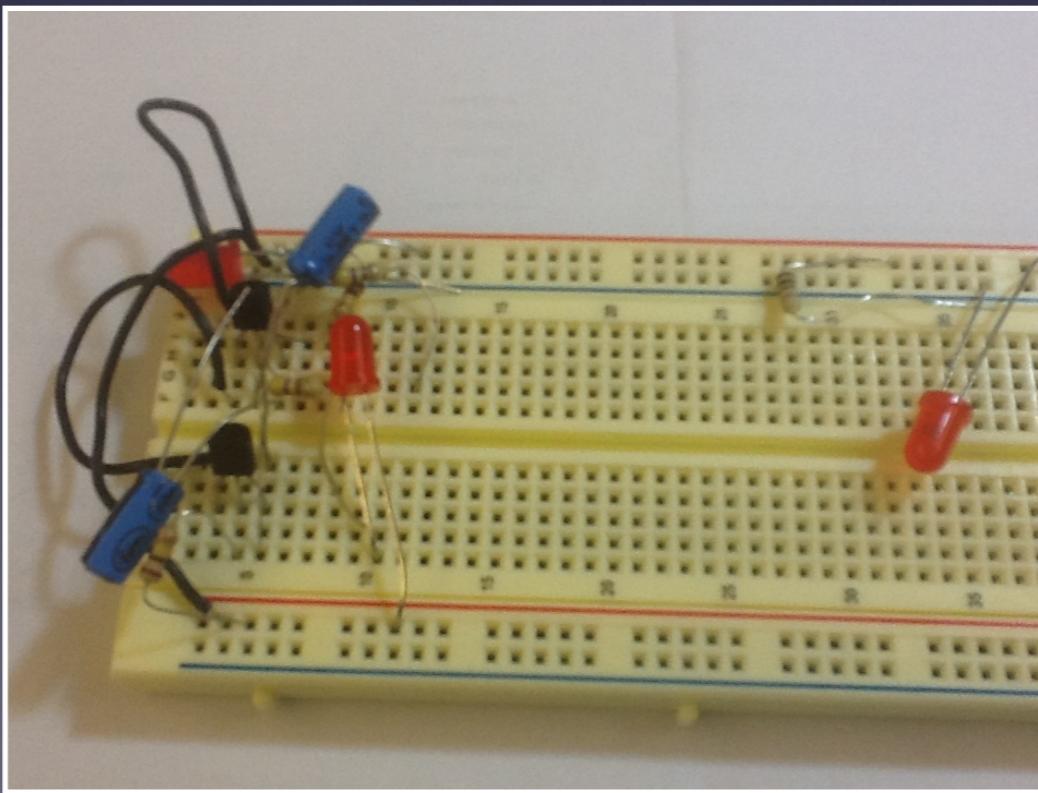
# SynShop Prototyping

## Going farther...



SynShop  
Prototyping

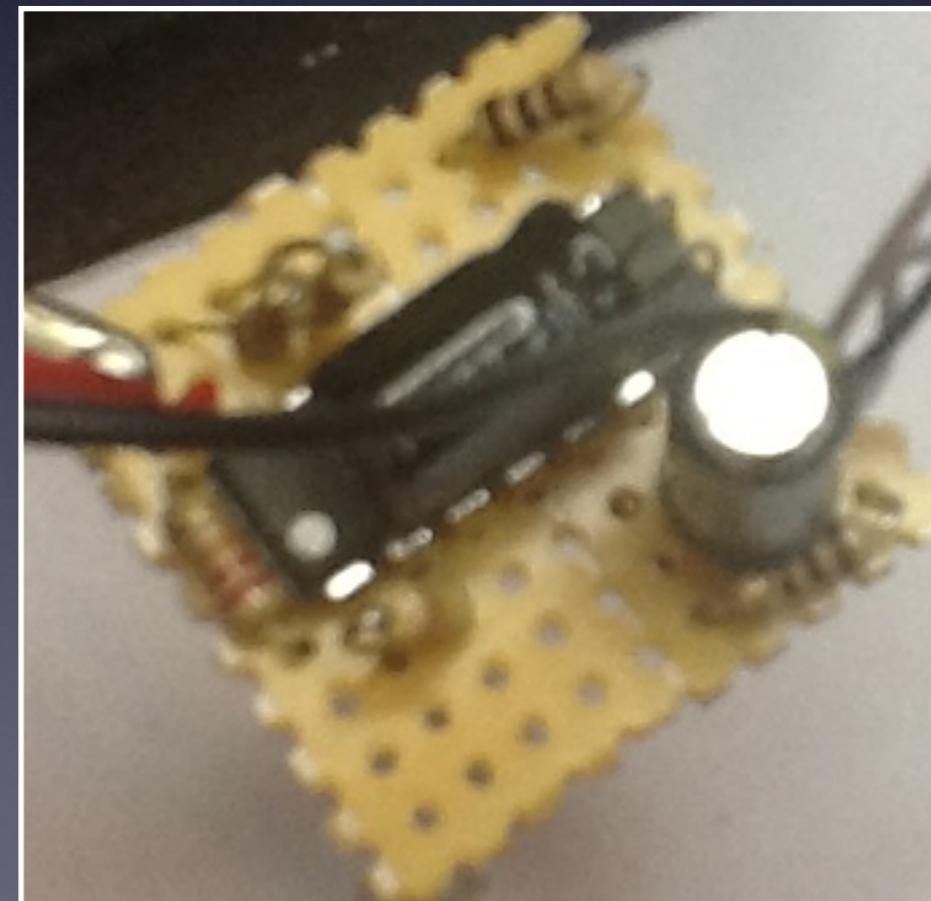
**Breadboards are great for fast builds, but not very permanent. Parts can easily get smushed or fall out.**





SynShop  
Prototyping

**Protoboard is simply a preprinted Printed Circuit Board (Pcb) that we use like a breadboard.**





# SynShop

## Prototyping

**Except that we solder the stuff in.  
Typically messy due to the number  
of connections we have to make.**



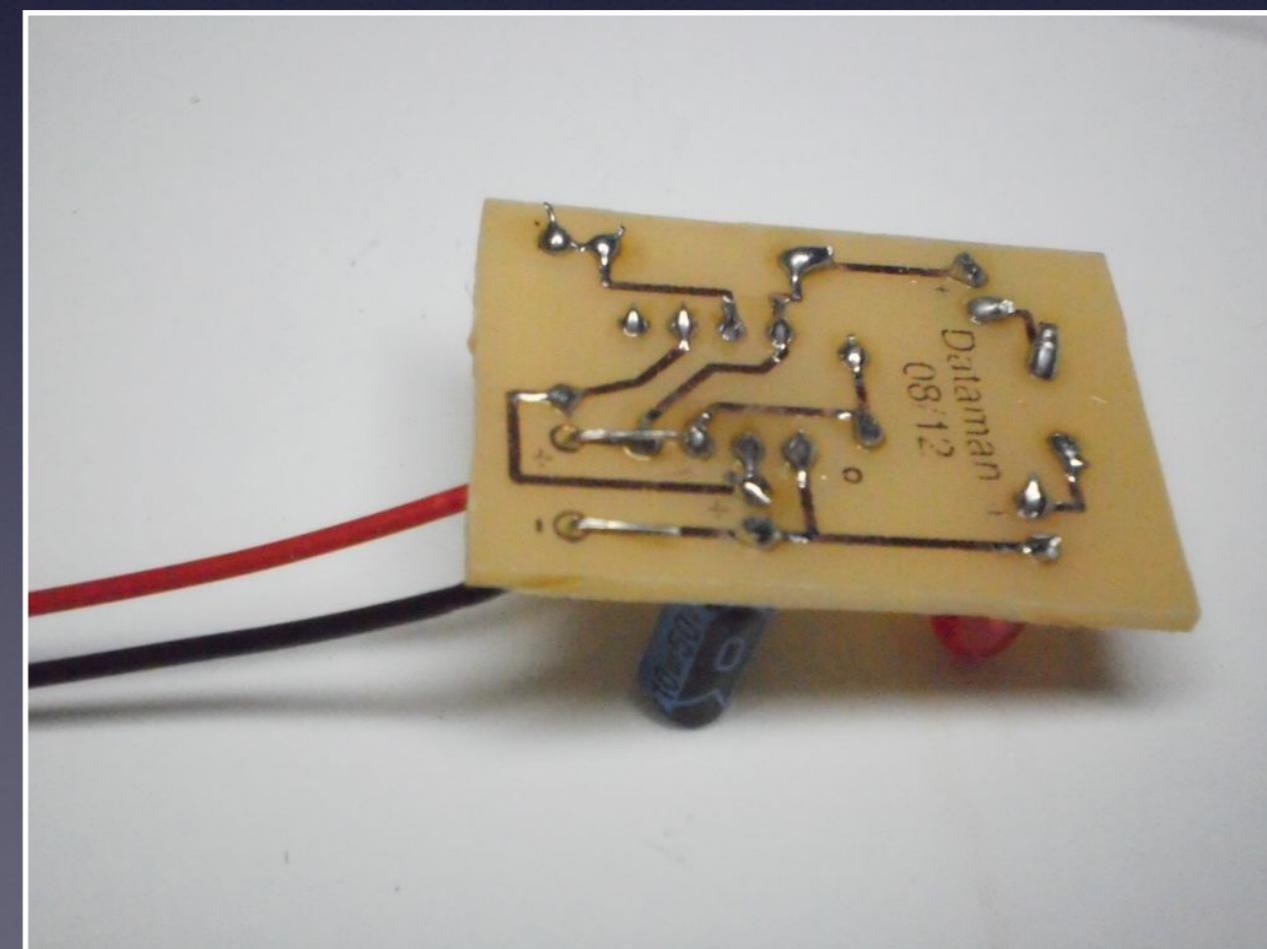


# SynShop Prototyping

Printed circuits boards (pcb) are customized designed to out circuit and make all the connections.



91

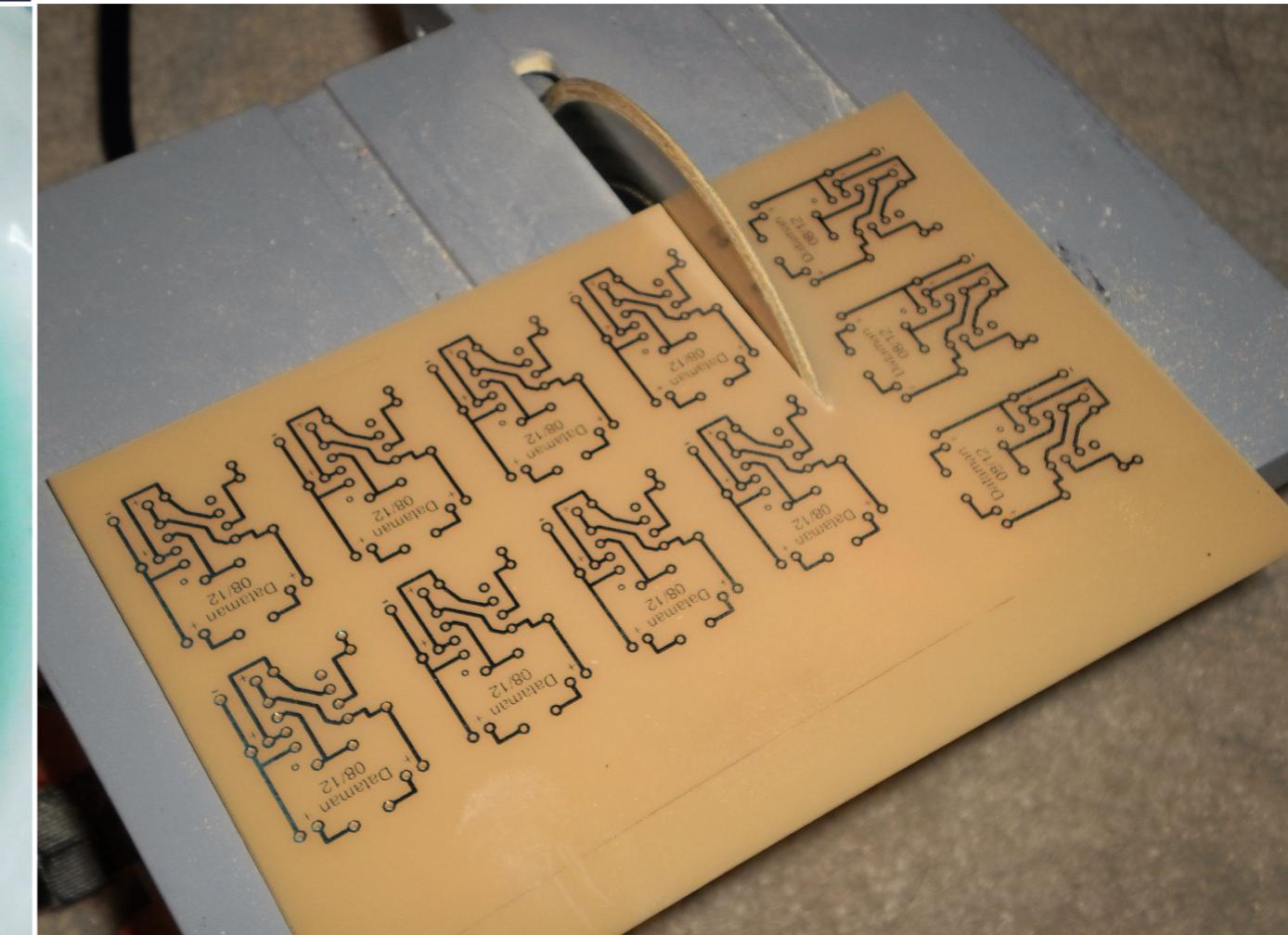
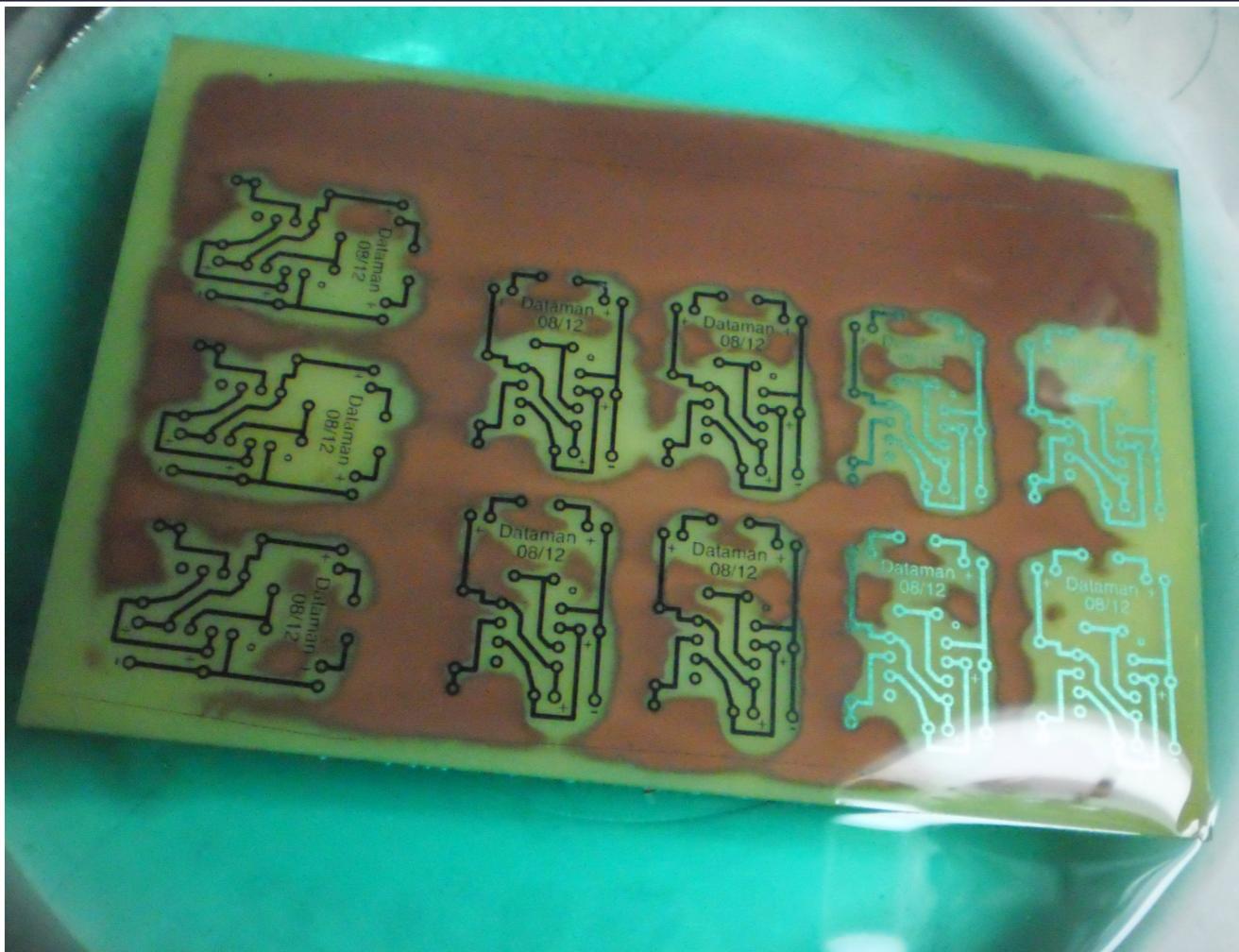




# SynShop

## Prototyping

You can even  
make your own PCBs.





SynShop  
Prototyping

We cover both  
protoboards and PCBs  
in the next class:

Soldering Buildup.



# SynShop Prototyping

**And that's the class.**



SynShop  
Prototyping

**And that's 3 full circuits!**

**Take home the parts!  
Build this over and over.**



# SynShop Prototyping



**There was no cost for this class, but I did have out of pocket expenses. (\$2.50/kit)**  
**Please leave a couple bucks in the tip jar if possible. Anything above cost goes to Synshop.**



SynShop  
Prototyping

This entire course is published  
[github.com/dataman/Prototyping-Buildup](https://github.com/dataman/Prototyping-Buildup)

Or simply go to  
[github.com/dataman](https://github.com/dataman)





# SynShop Prototyping



Thank You!