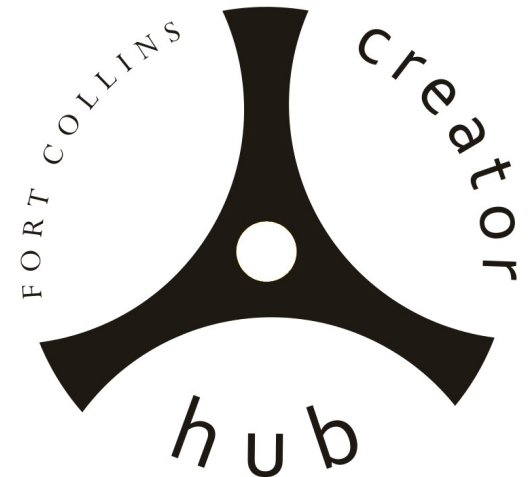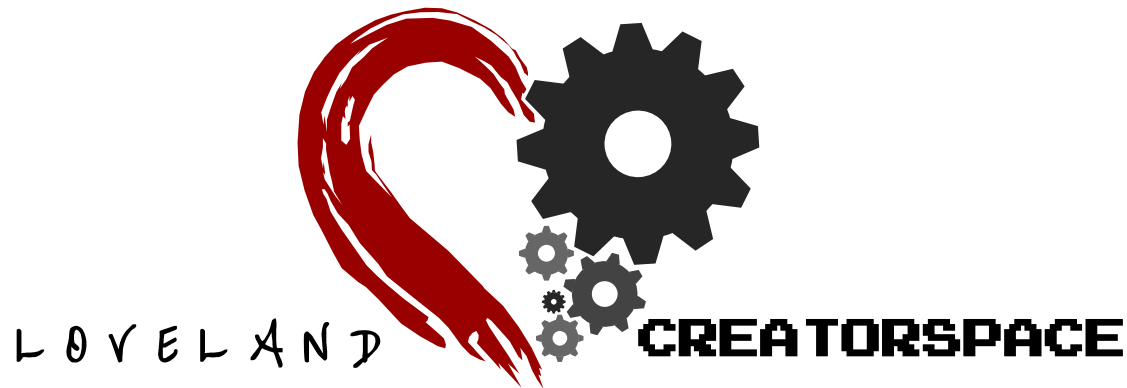# Building Oscillating Circuits
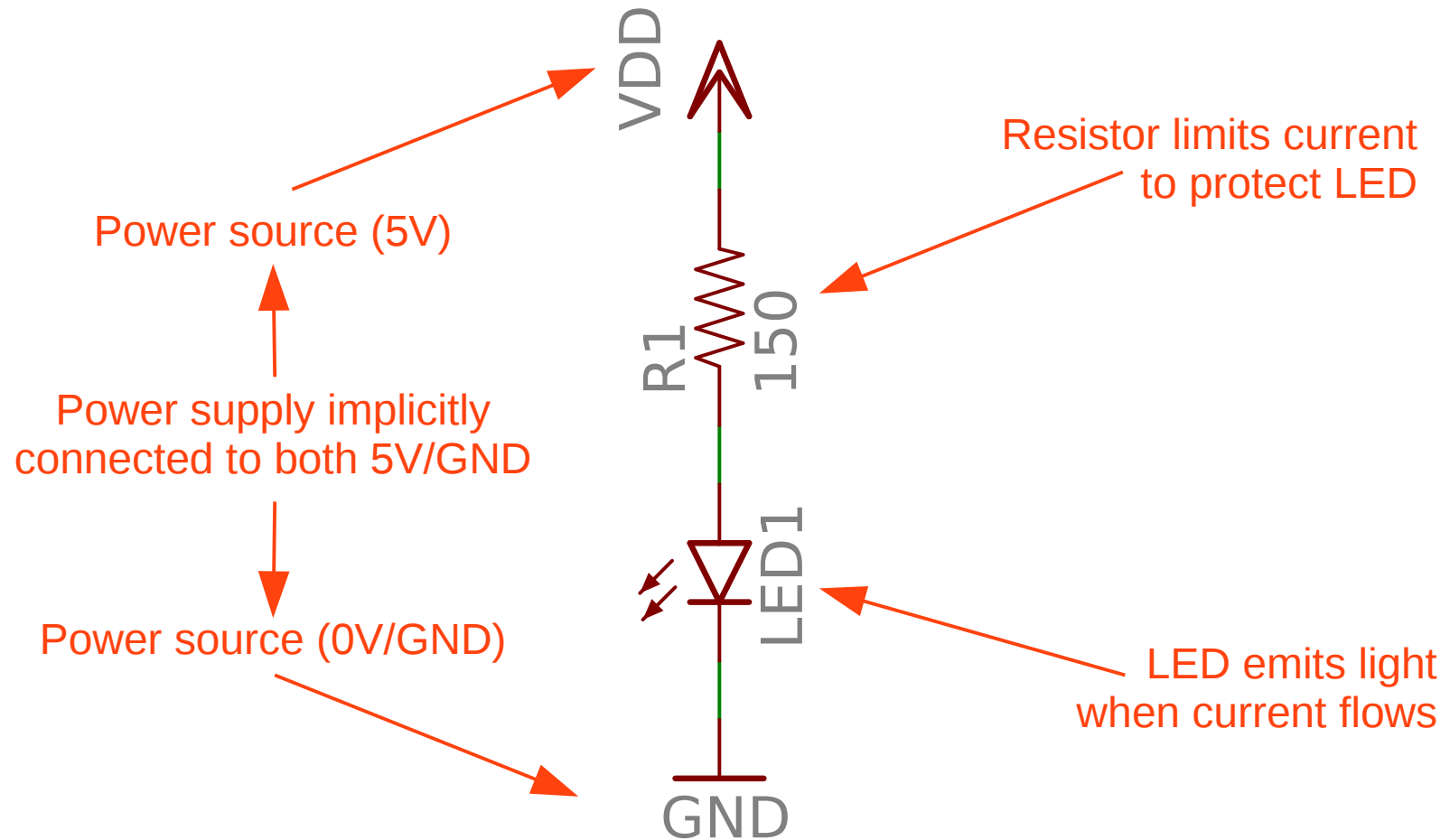## (multivibrators)
Using Transistors

Introduction

- What is a multivibrator?
- Different types (bistable, monostable, astable)
- Walk through of the circuits
- Build the circuits

What's a multivibrator?

- Circuit that has two states, and changes (vibrates, oscillates) between them

- Bistable – Stable in both states (Bi: 2)

  - Moves between states only when forced externally

- Monostable – Stable in just one state (Mono: 1)

  - Moves from state A to B by external force

  - Moves from state B to A after a time delay

- Astable – Stable in neither state (A: Not)

 - Autonomously oscillates between the states

LED Circuit

VDD

Power source (5V)

Power supply implicitly
connected to both 5V/GND

Power source (0V/GND)

Resistor limits current
to protect LED

R1
150

LED1

LED emits light
when current flows
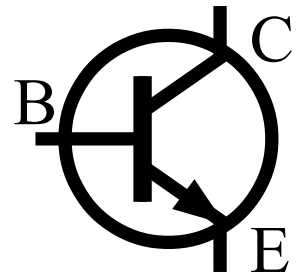
GND

(Bipolar) Transistors

- A transistor can be a switch,
  or electronically controlled variable resistor

- Transistors generally have 3 pins

- For Bipolar transistors, these are named:

  - Collector

  - Base

  - Emitter

- Base voltage controls whether (how much) the
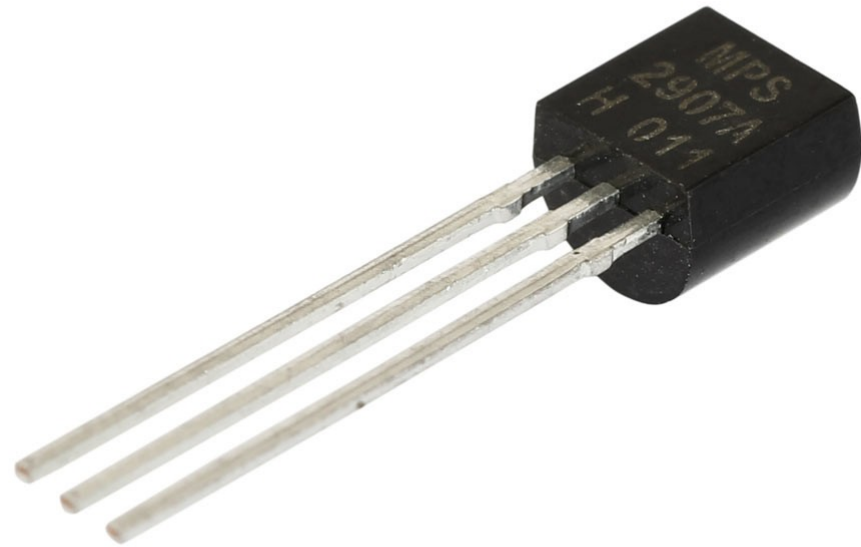 Collector and Emitter are connected

Transistor – Pictures and Symbols
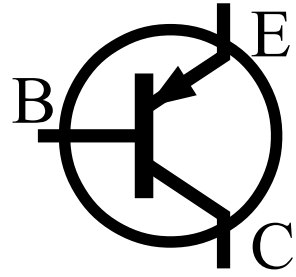
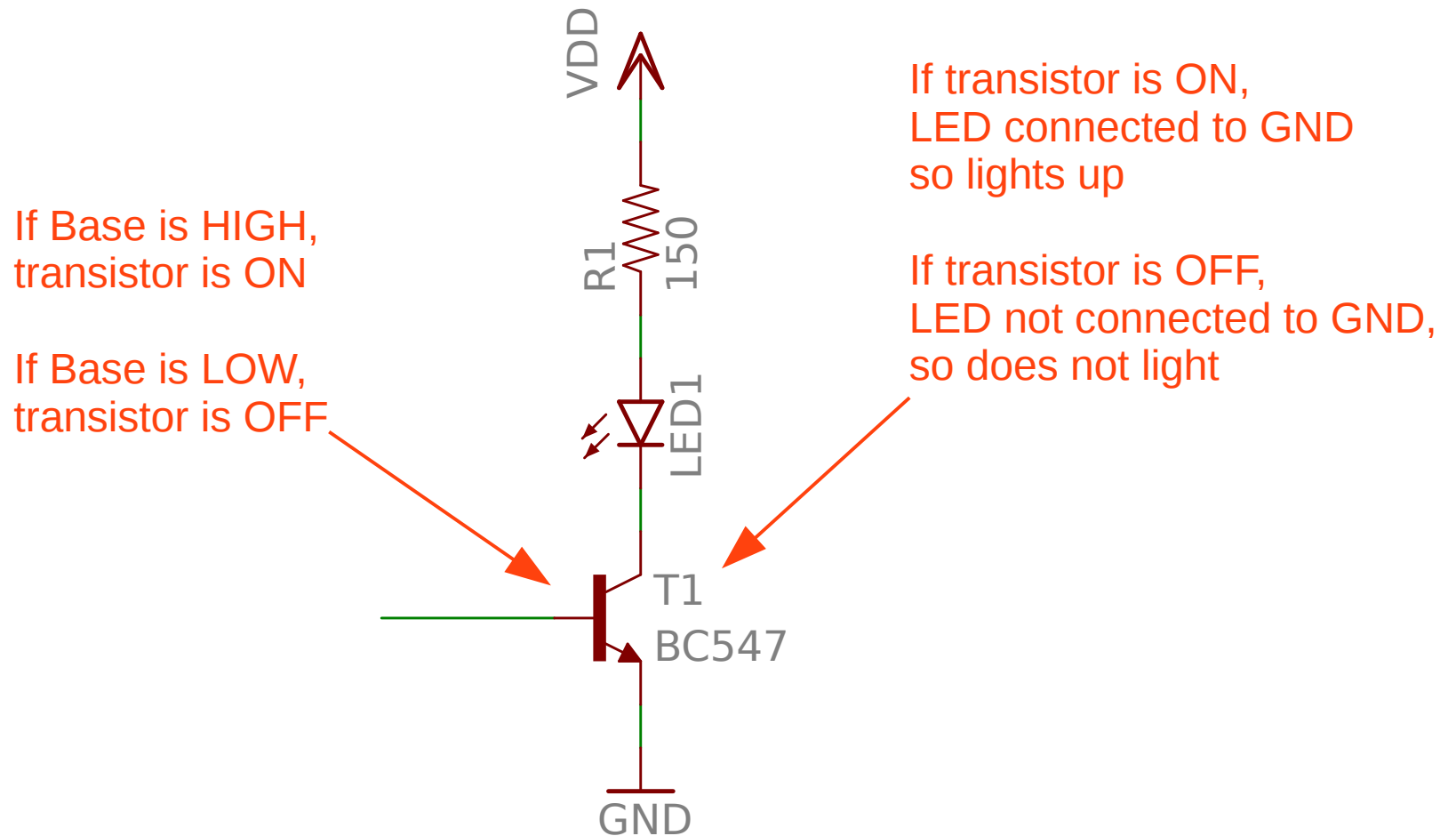PNP
(**P**ointing i**N P**roudly)
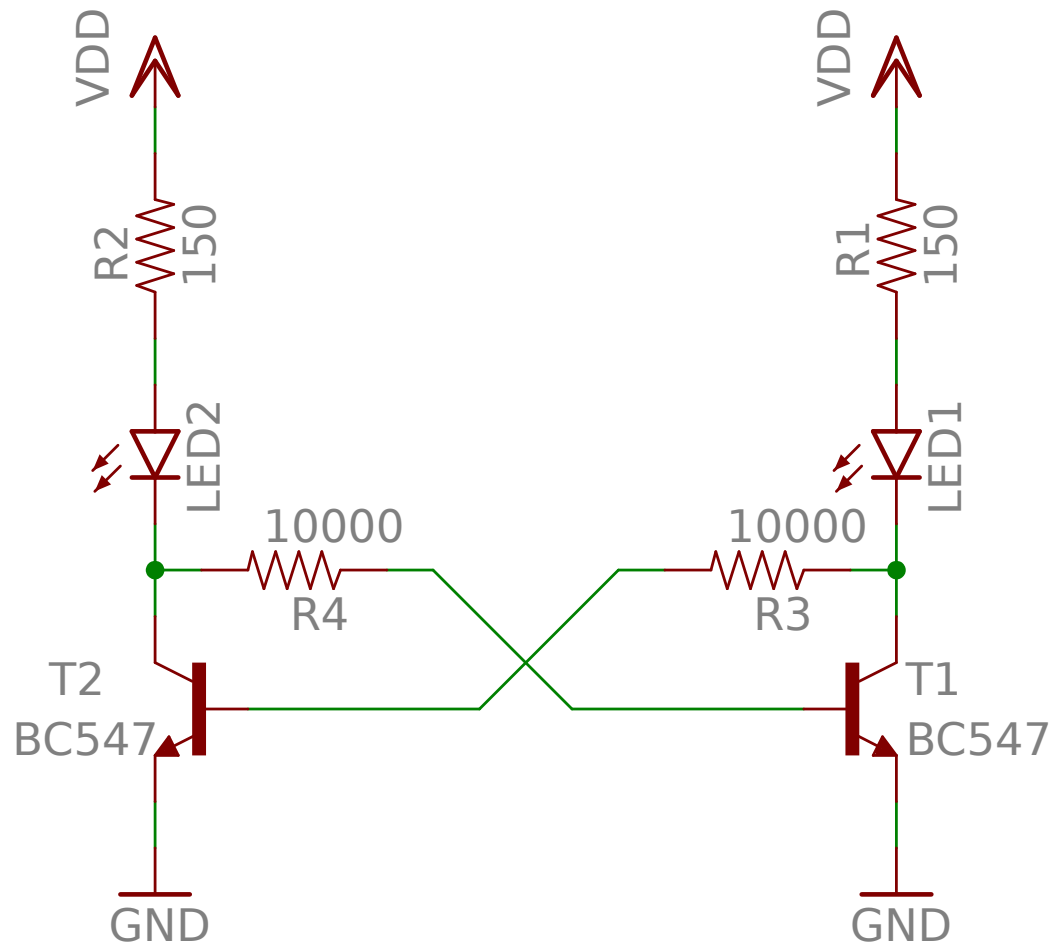
NPN
(**N**ot **P**ointing i**N**)

Transistors - Operation

- Base-Emitter current determines
  Collector-Emitter current

- Transistors often characterized as amplifying current:
  The more Base current flows,
  the more Collector-Emitter current can flow.

- A Base voltage is required
  to cause a Base current to flow

- NPN: Turns on when Base is high (cf. Emitter)

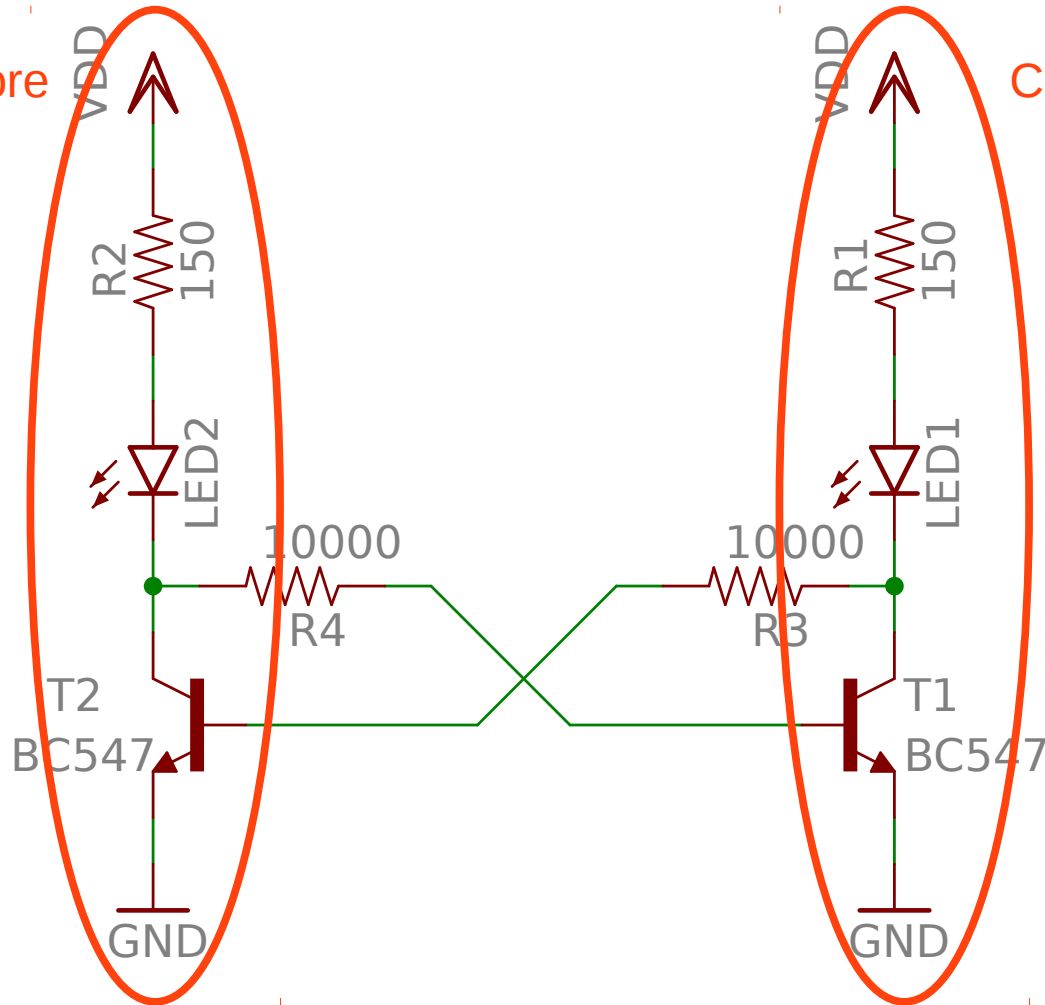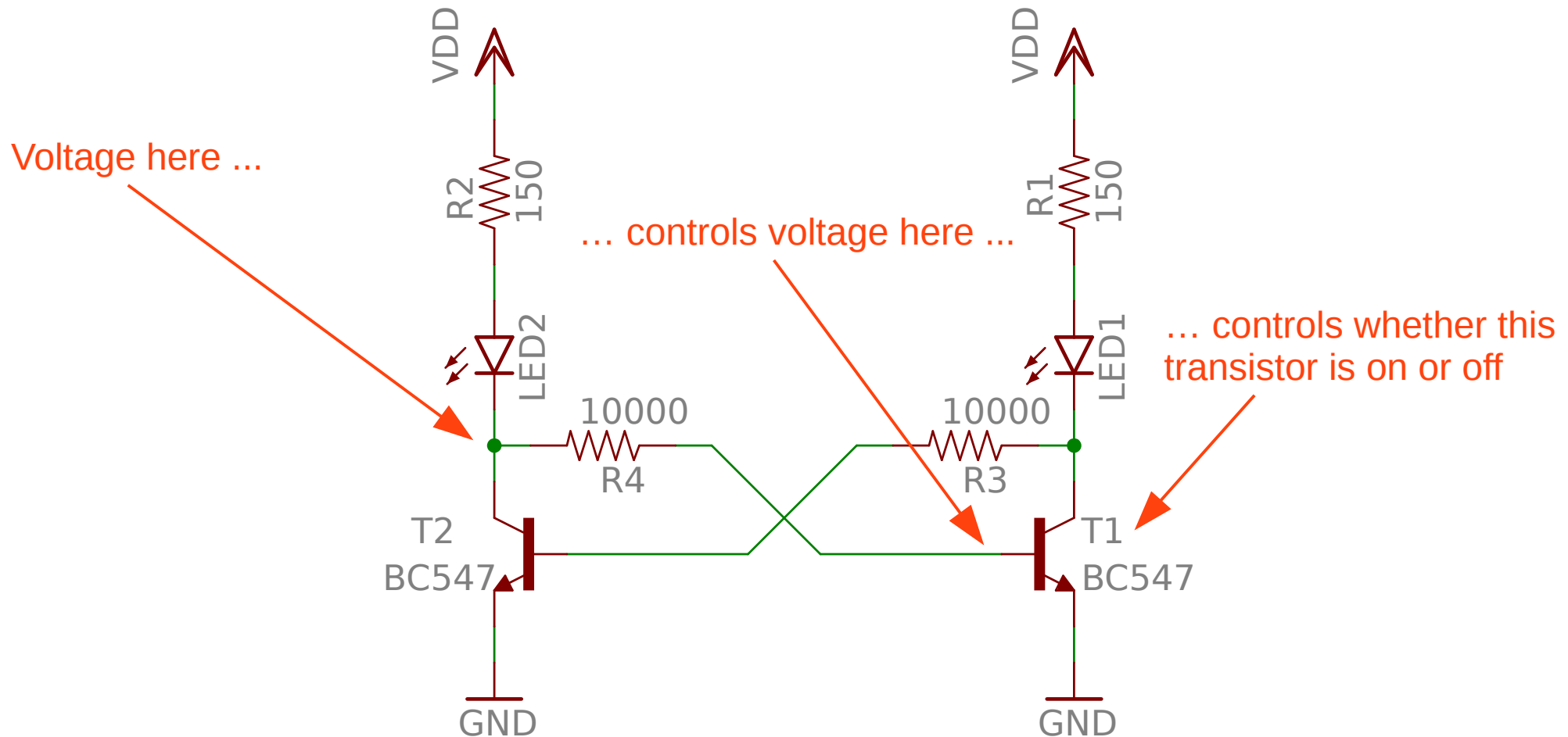- PNP: Turns on when Base is low (cf. Emitter)

Transistor Circuit

VDD

R1
150

LED1

T1
BC547

GND

If Base is HIGH,
transistor is ON

If Base is LOW,
transistor is OFF

If transistor is ON,
LED connected to GND
so lights up

If transistor is OFF,
LED not connected to GND,
so does not light
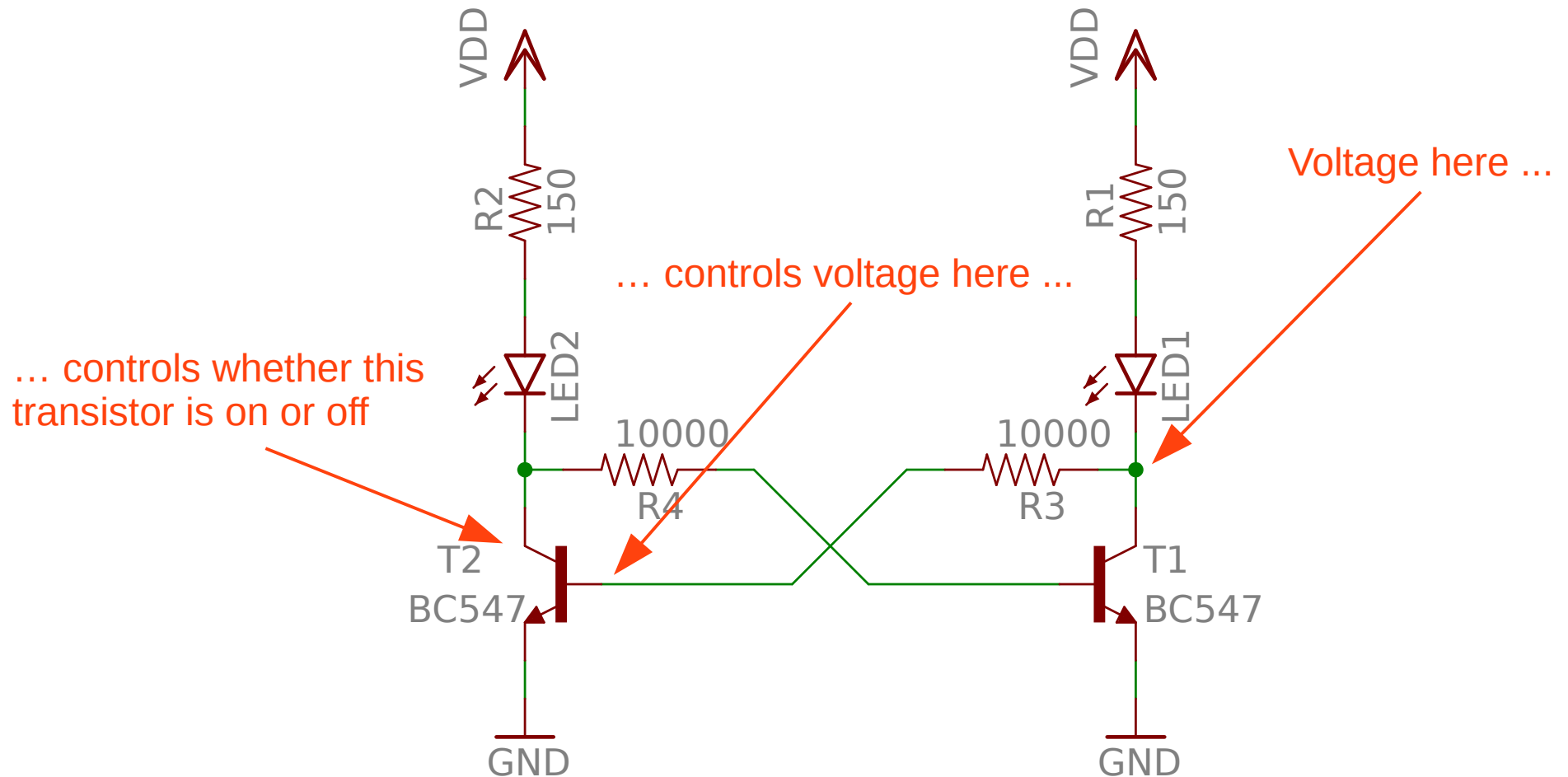
LOVELAND
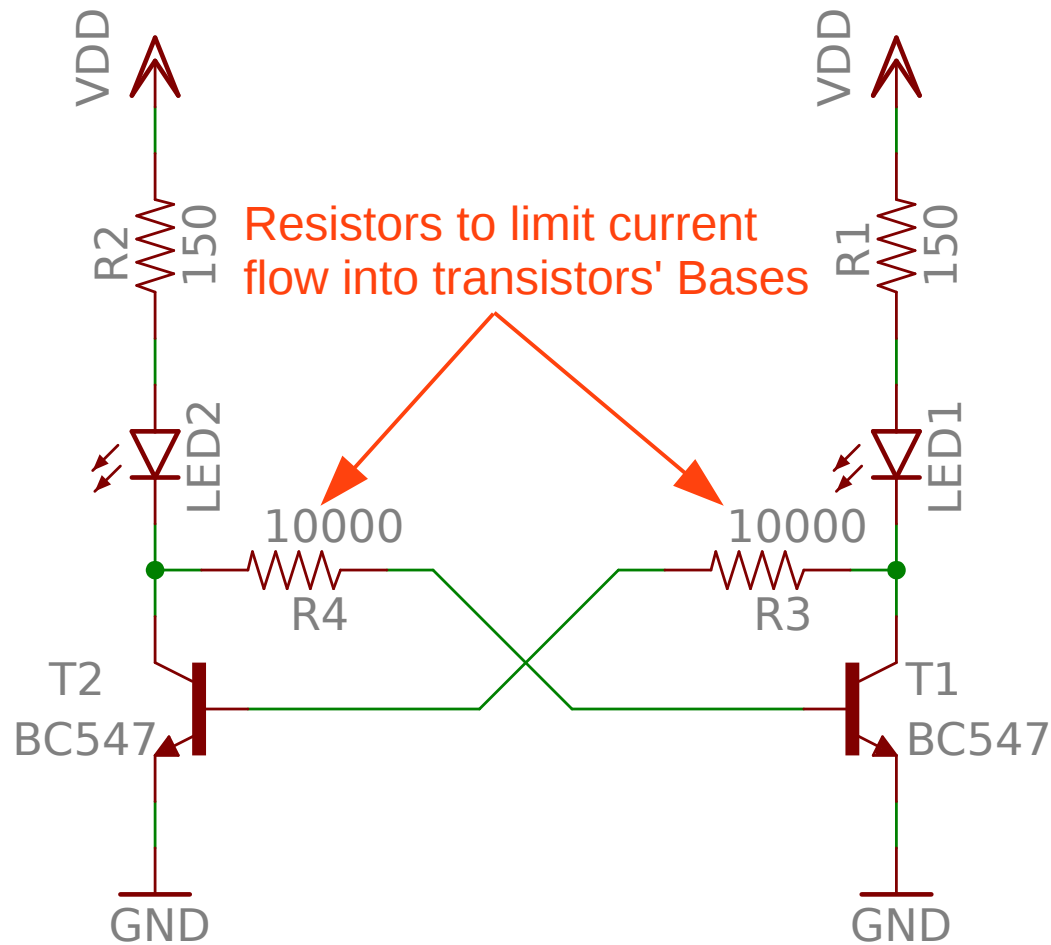CREATORSPACE

FORT COLLINS
creator
hub

Bistable Circuit
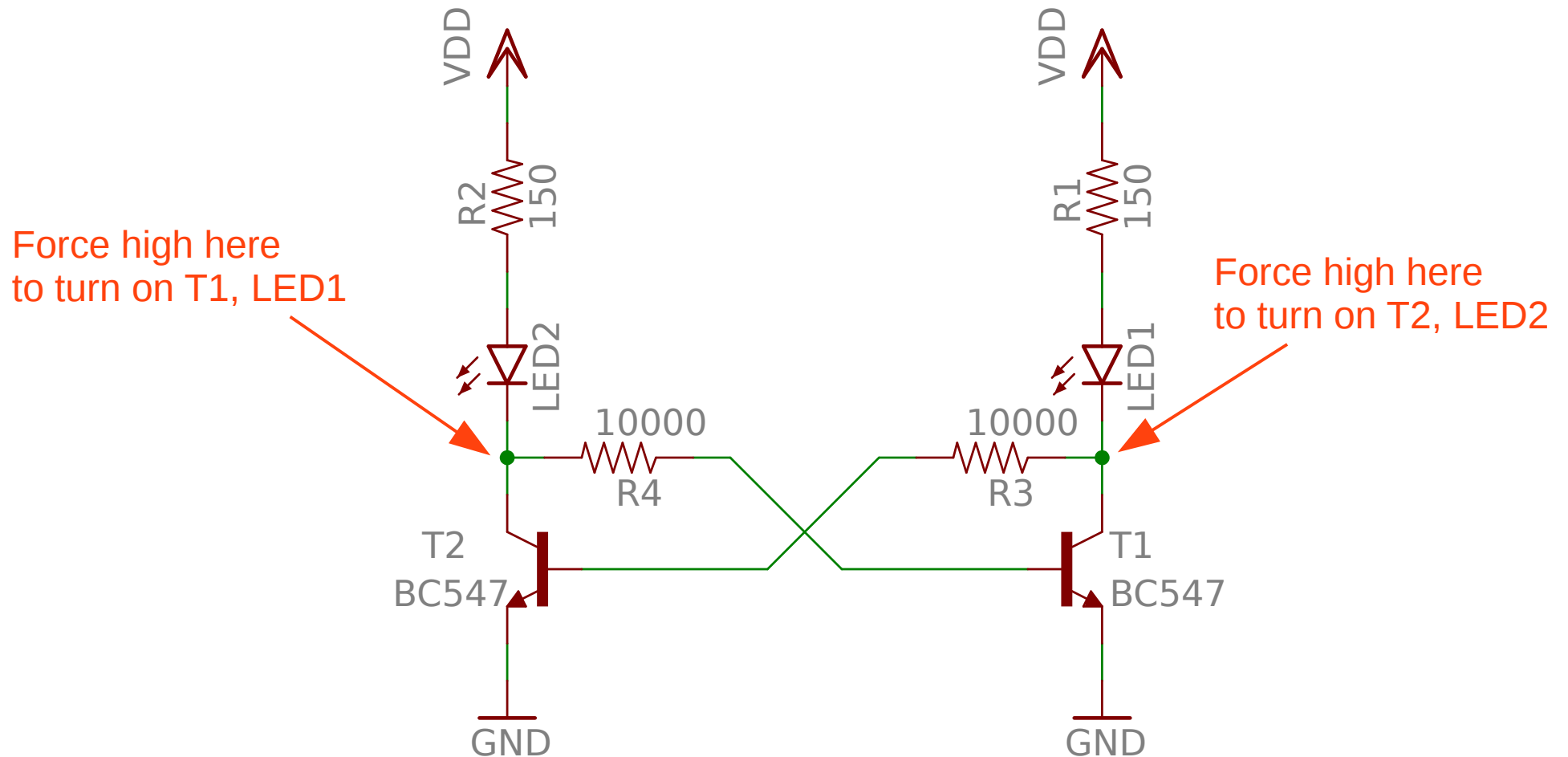
Bistable Circuit

Bistable Circuit

Bistable Circuit

Bistable Circuit

Resistors to limit current
flow into transistors' Bases

VDD

R2 150

LED2

10000
R4

T2
BC547

GND

VDD

R1 150

LED1

10000
R3

T1
BC547

GND
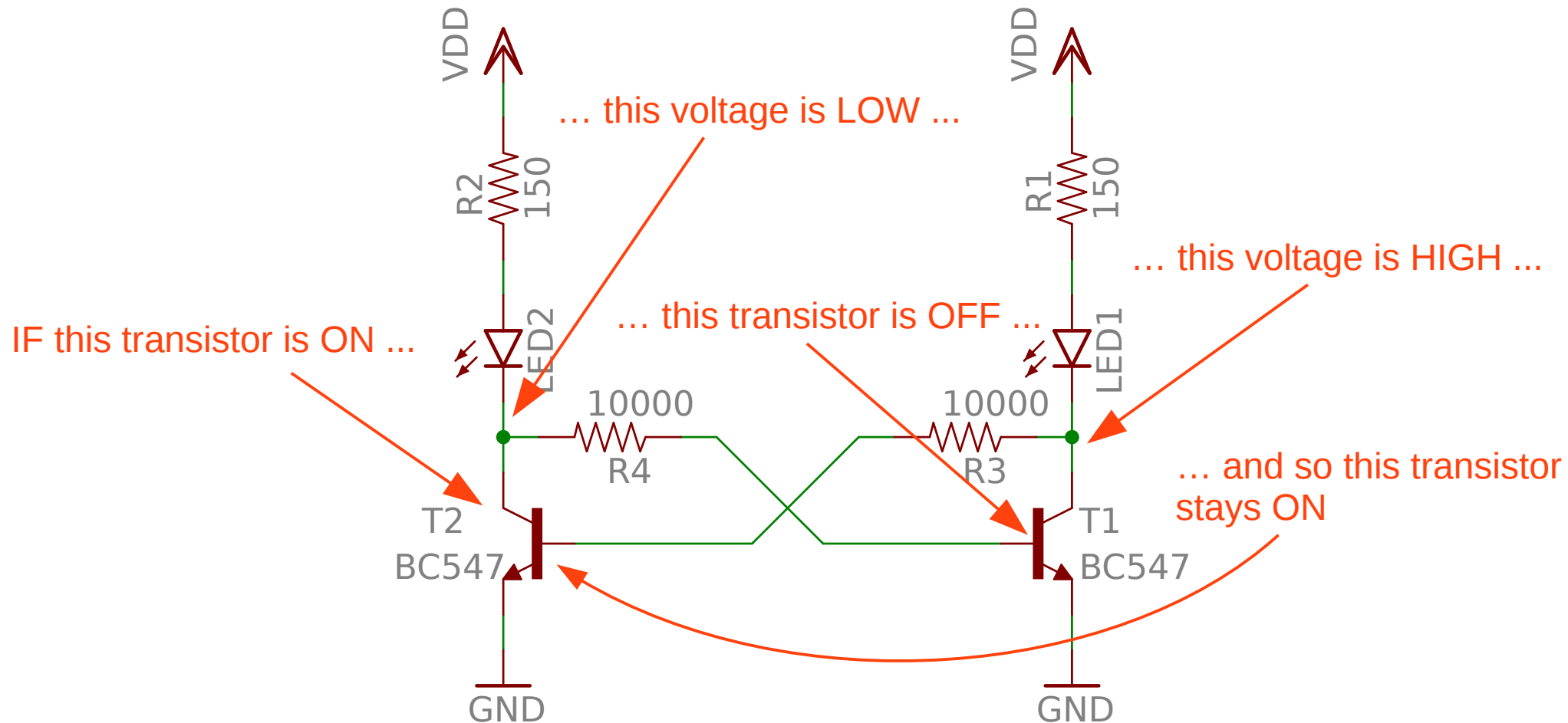
Bistable Circuit
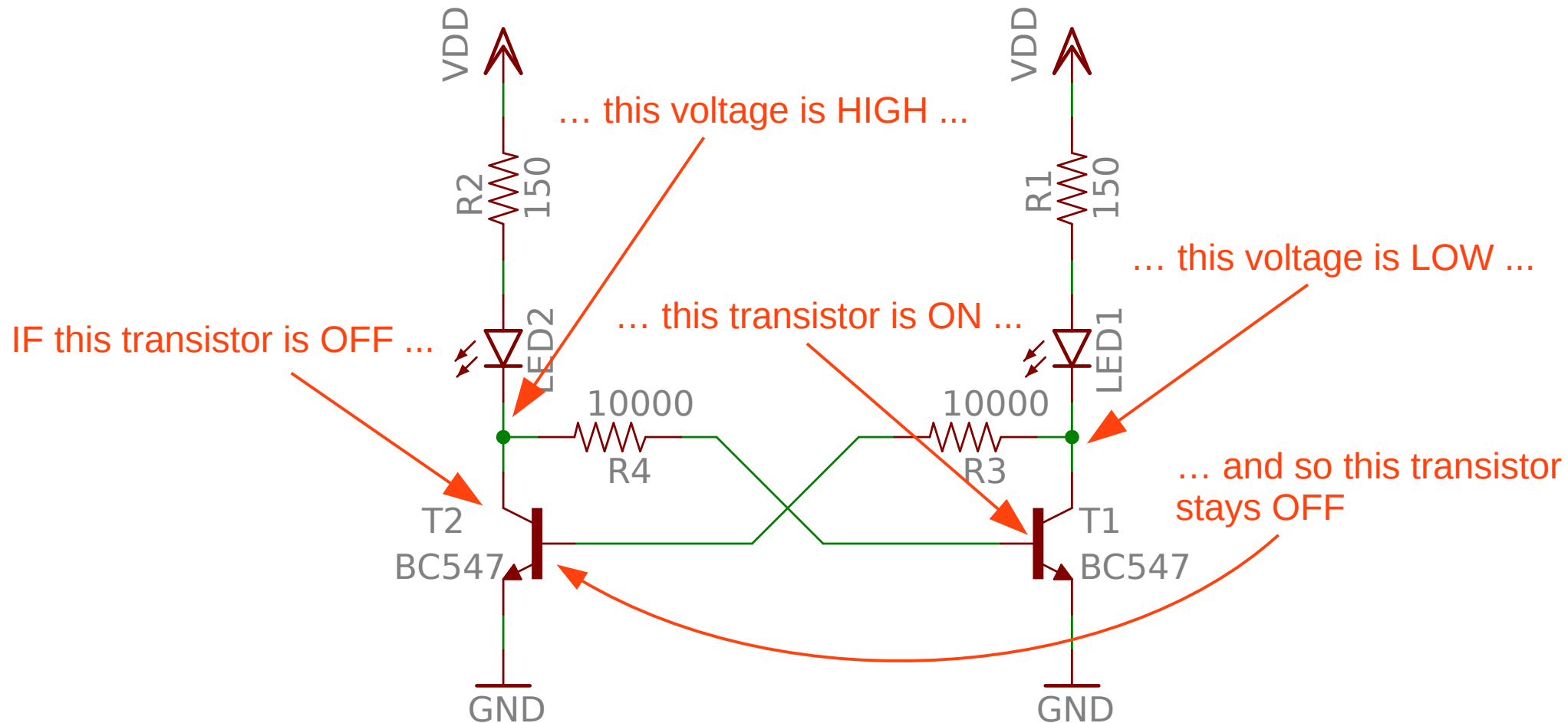
Bistable Circuit

Bistable Circuit

Bistable Animation

http://www.falstad.com/circuit/e-multivib-bi.html

Let's Build The Circuit!

Breadboards

- Used for quick circuit prototyping
- Holes to plug components' wires into
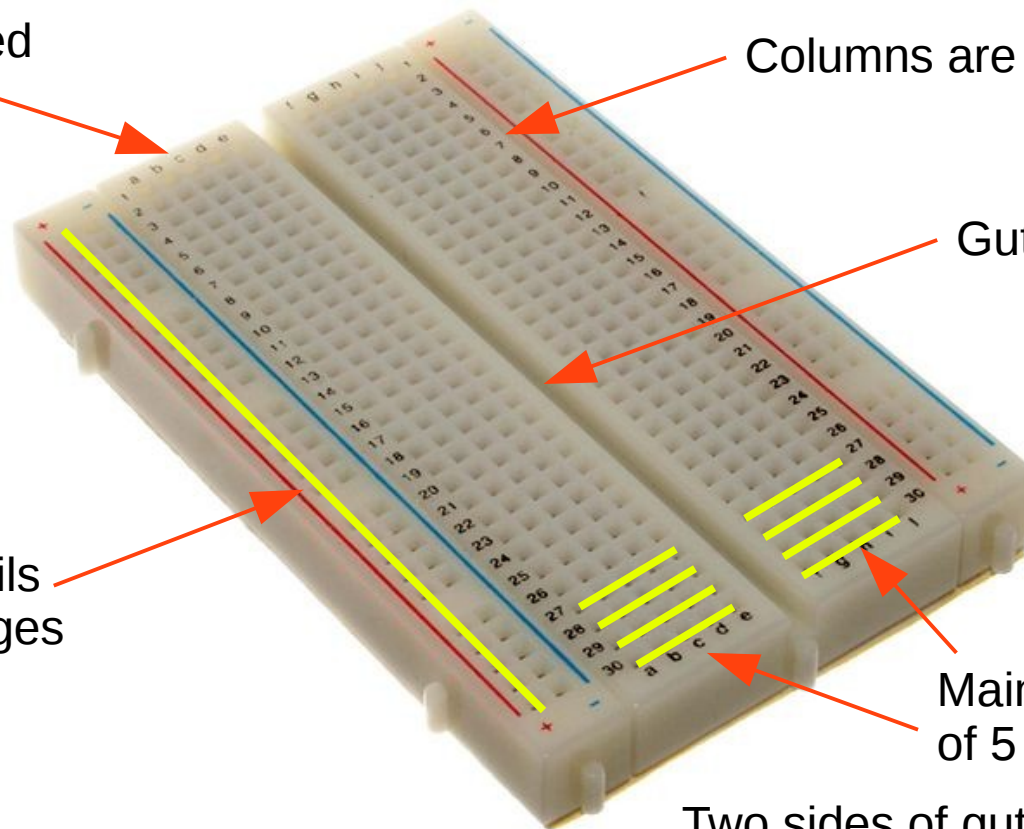- Internal wires connect some of the holes

Rows are named

Columns are numbered

Gutter for ICs

Power rails along edges

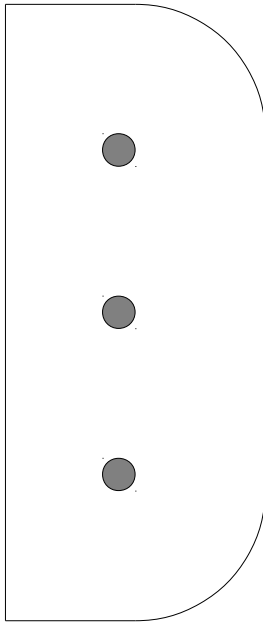Main body is columns of 5 connected holes

Two sides of gutter not connected
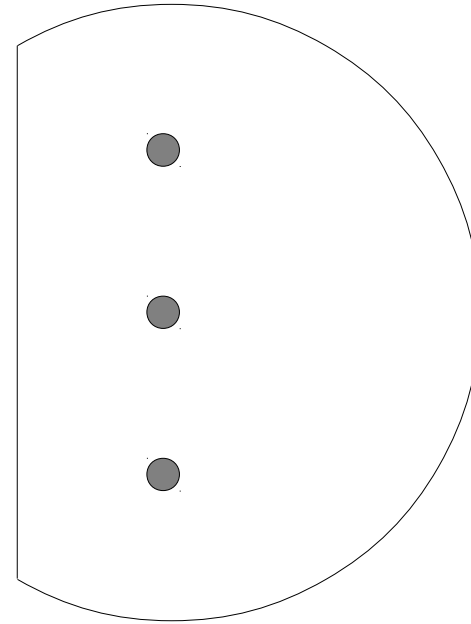
Placing components

- Polarity
  - Some components don't work backwards
- Don't bend pins
  - Slight angling OK, no need for kinks
- Don't burn out LEDs
  - By connecting to power with no resistor
- Don't connect power until circuit is complete
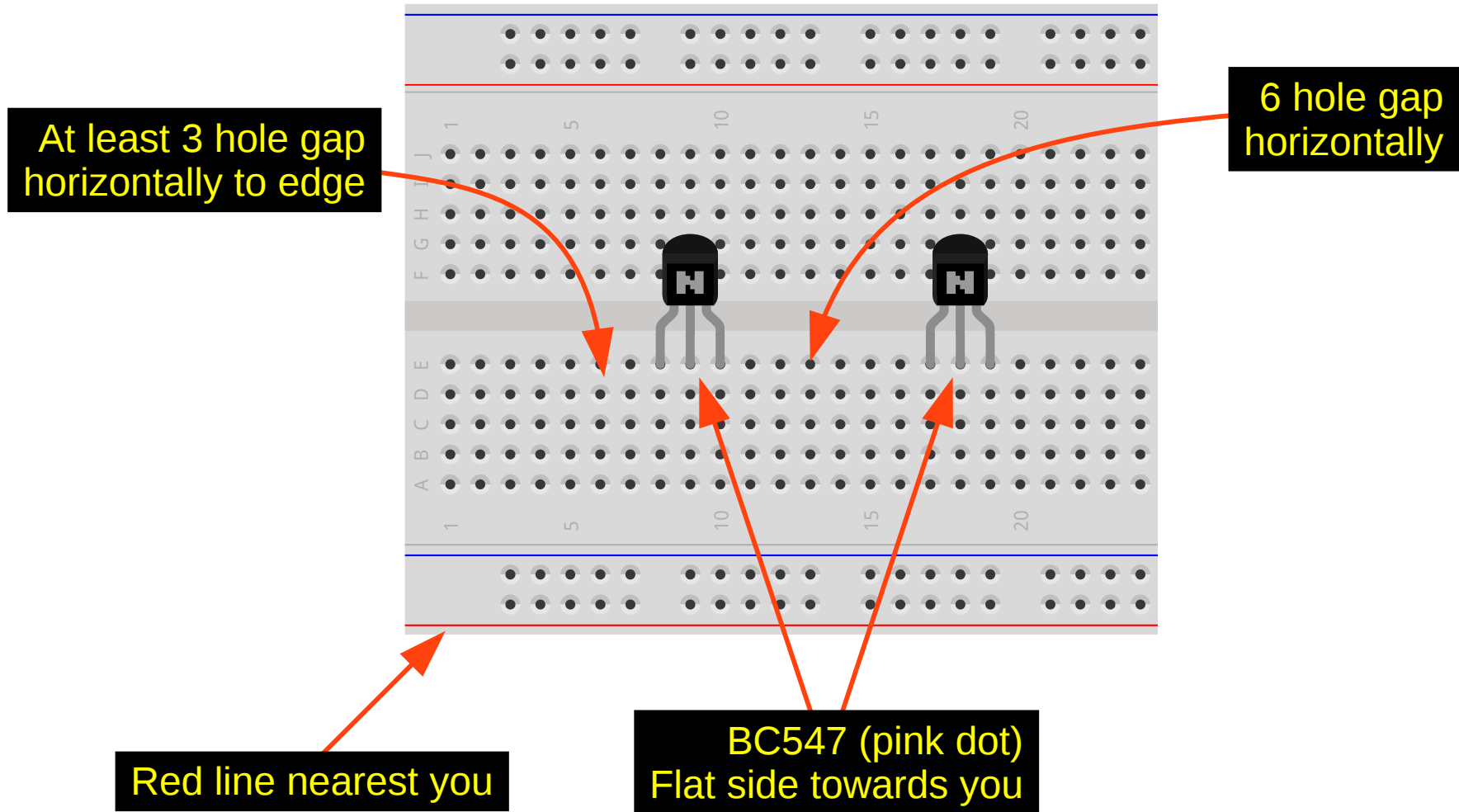
Transistor Packages

E-line package

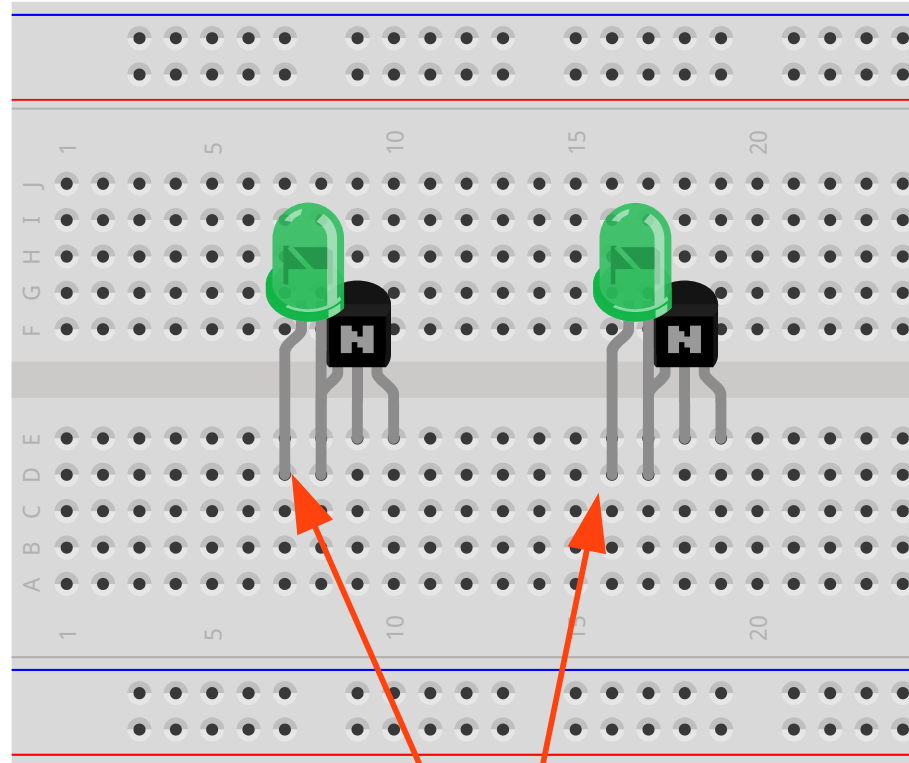Kit contains:
ZVP2110A (we won't use this)

TO-92 package

Kit contains:
BC547 (use this; has pink dot on back)
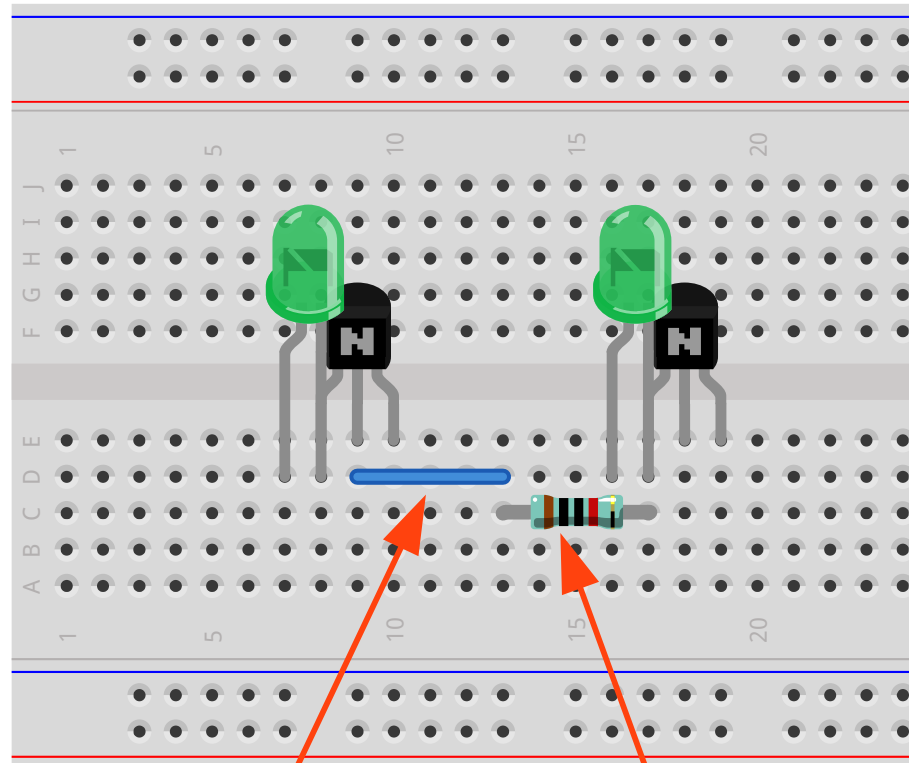BS170 (we won't use this)

Bistable – Step 1

At least 3 hole gap horizontally to edge

6 hole gap horizontally

Red line nearest you

BC547 (pink dot)
Flat side towards you

LOVELAND
CREATORSPACE

FORT COLLINS creator hub

Bistable – Step 2

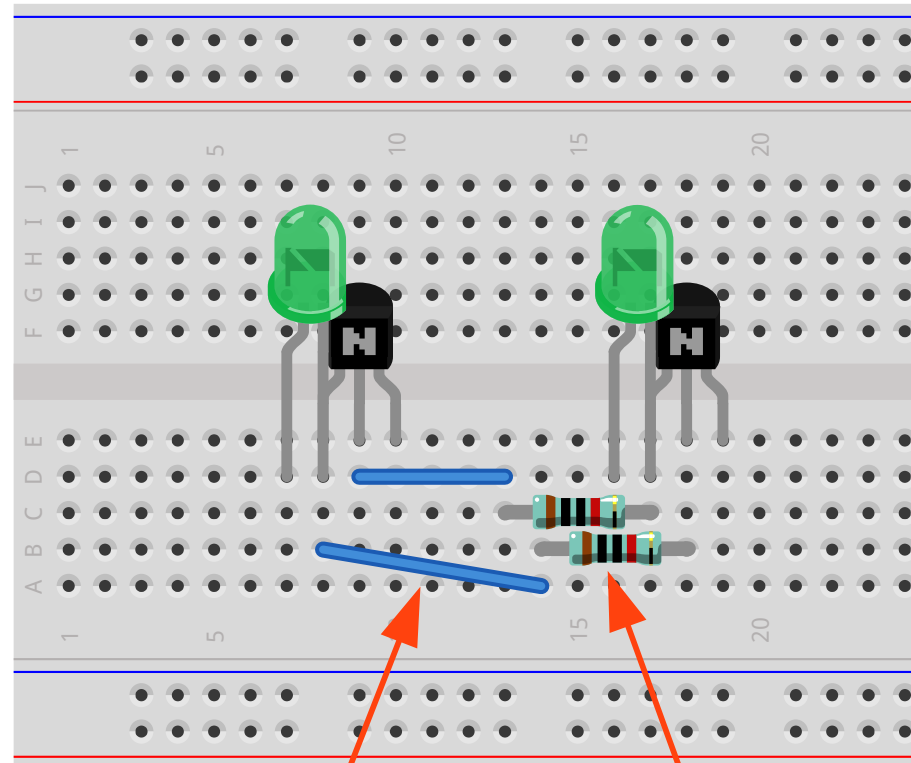LED: cathode on right
(flat side, short leg)

Bistable – Step 3

Wire

10kΩ resistor
Brown, black, black, red

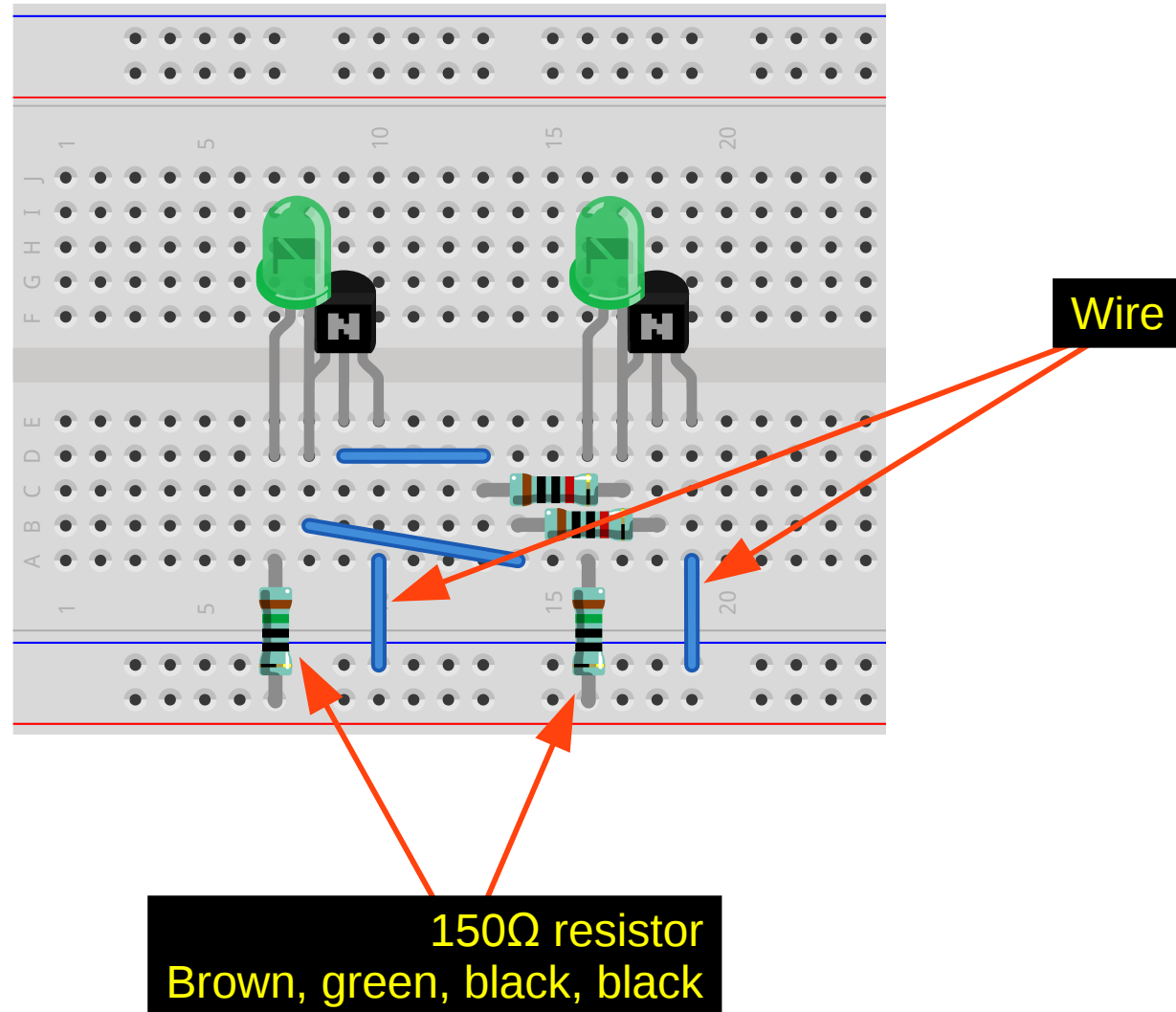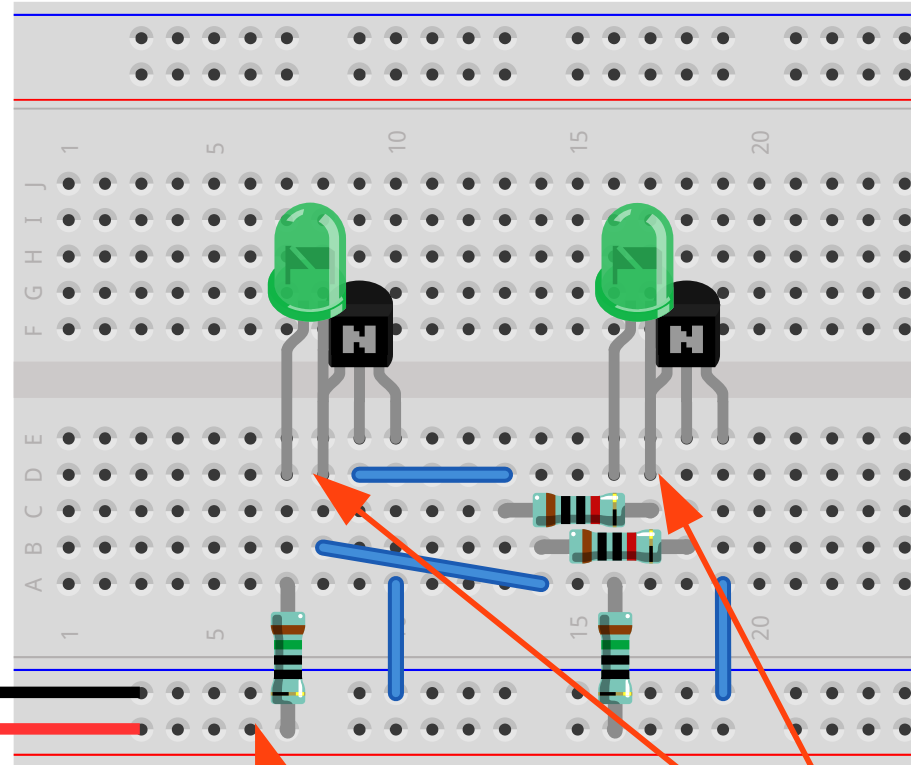# Bistable – Step 4

Wire
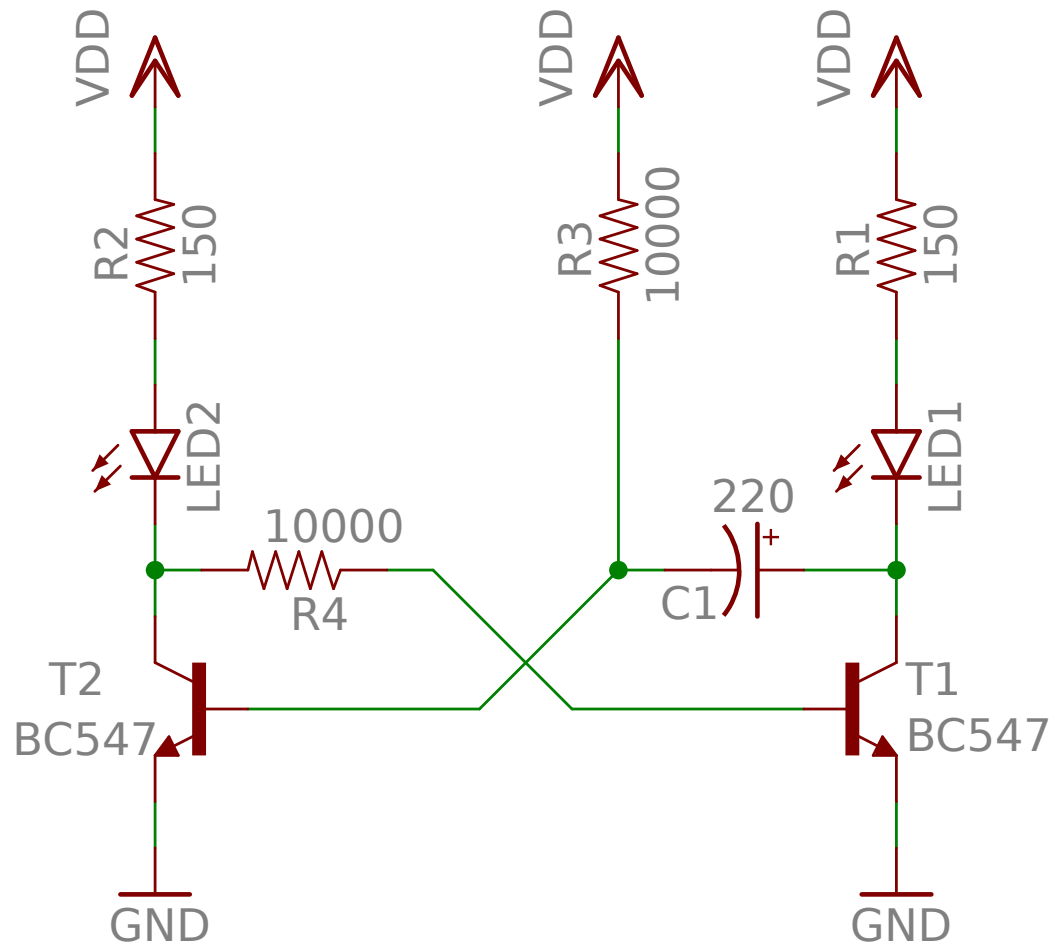
10kΩ resistor
Brown, black, black, red

Bistable – Final

Wire

150Ω resistor
Brown, green, black, black

Bistable – Test
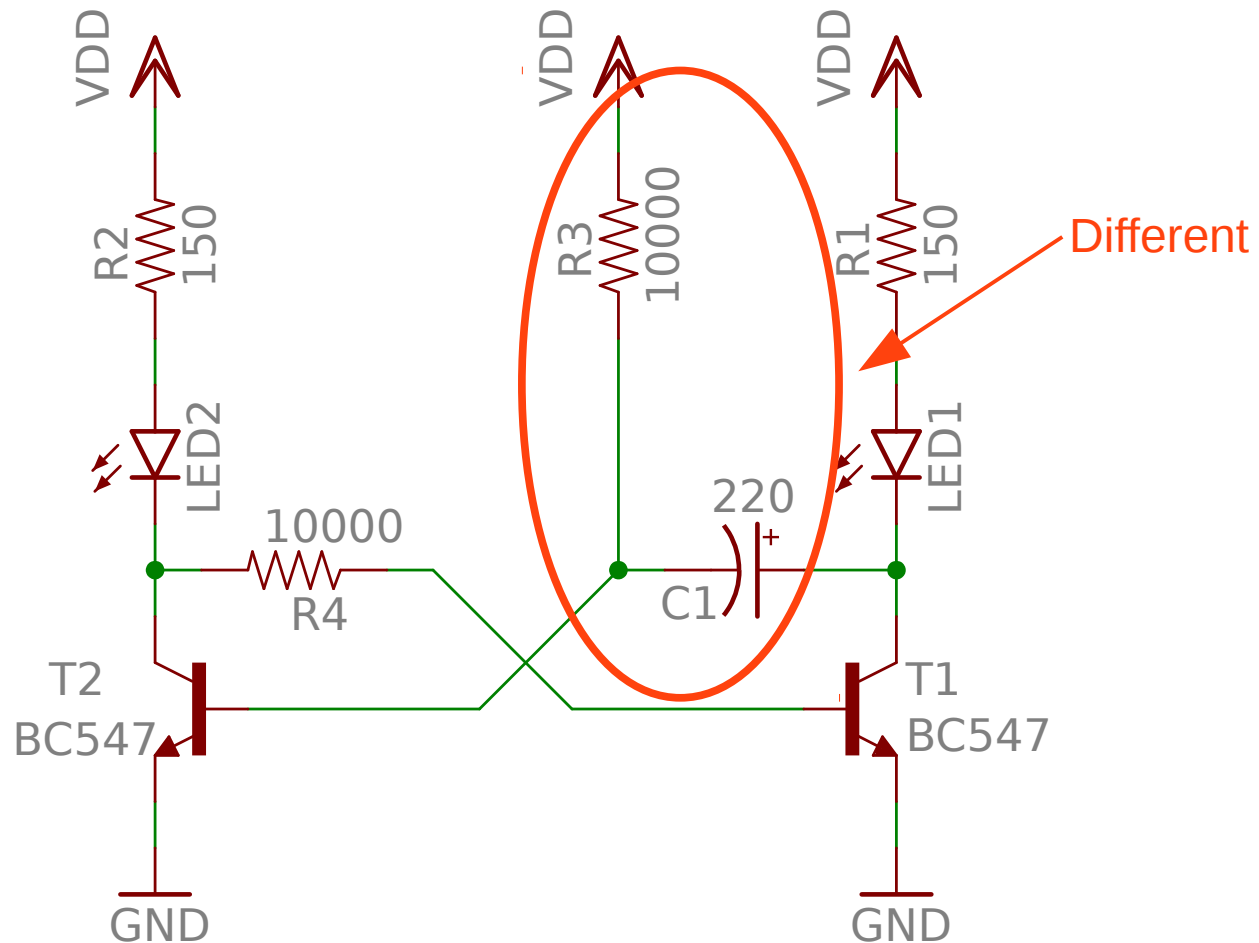

Apply power
Match heat-shrink colors

Touch wire from POWER … to either LED's right pin
One pin at a time

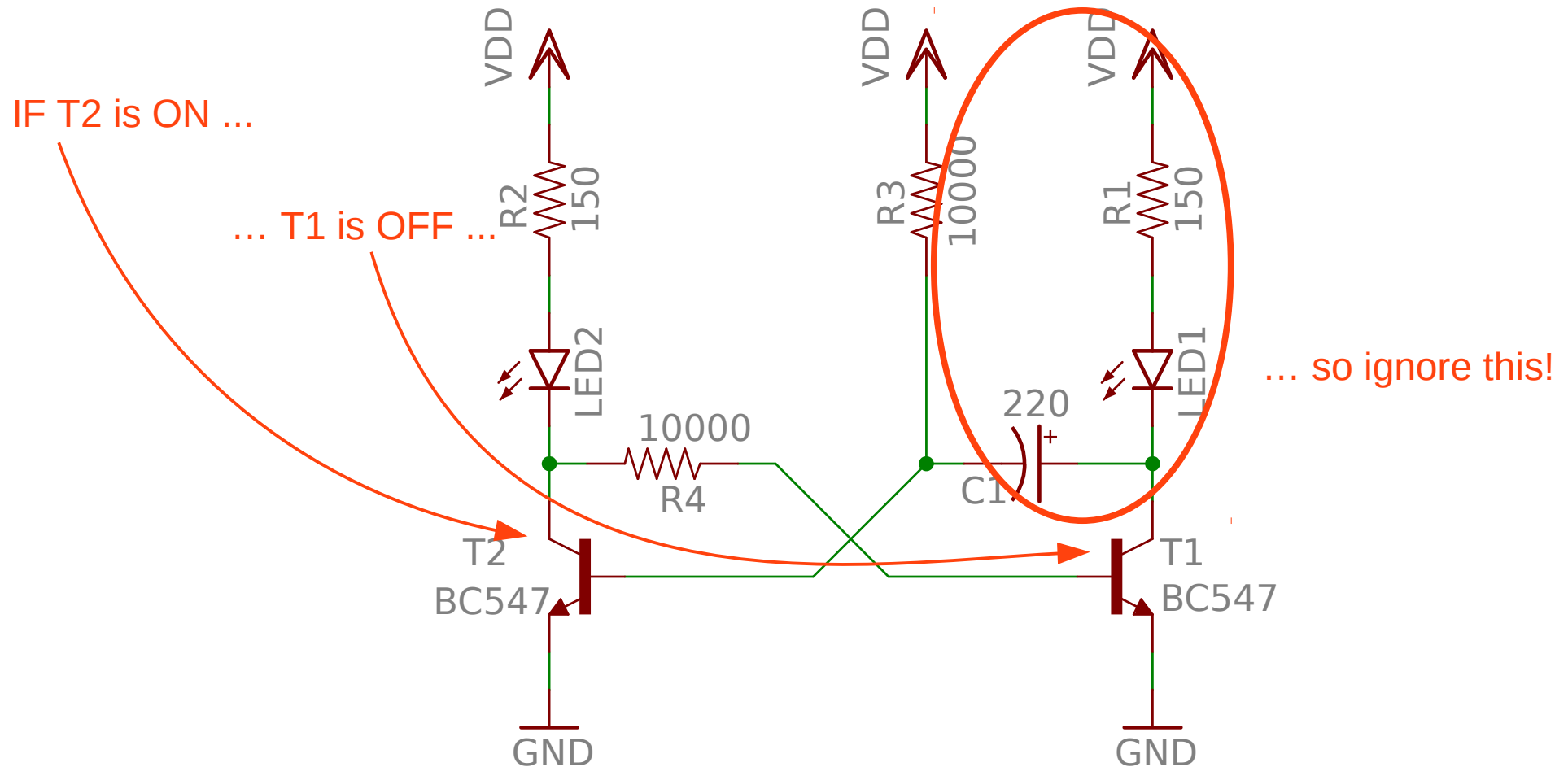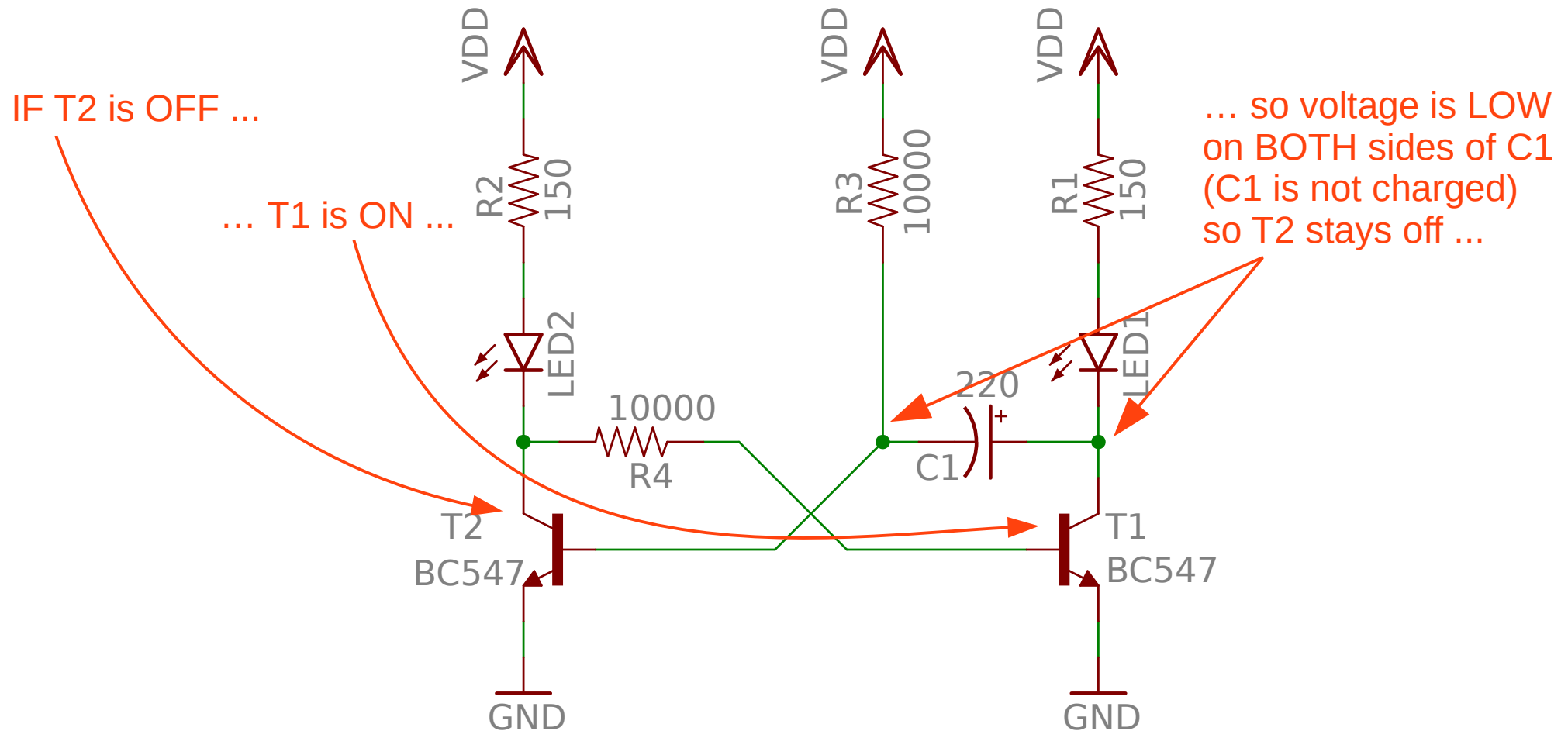LOVELAND
CREATORSPACE

FORT COLLINS creator hub

Monostable Circuit
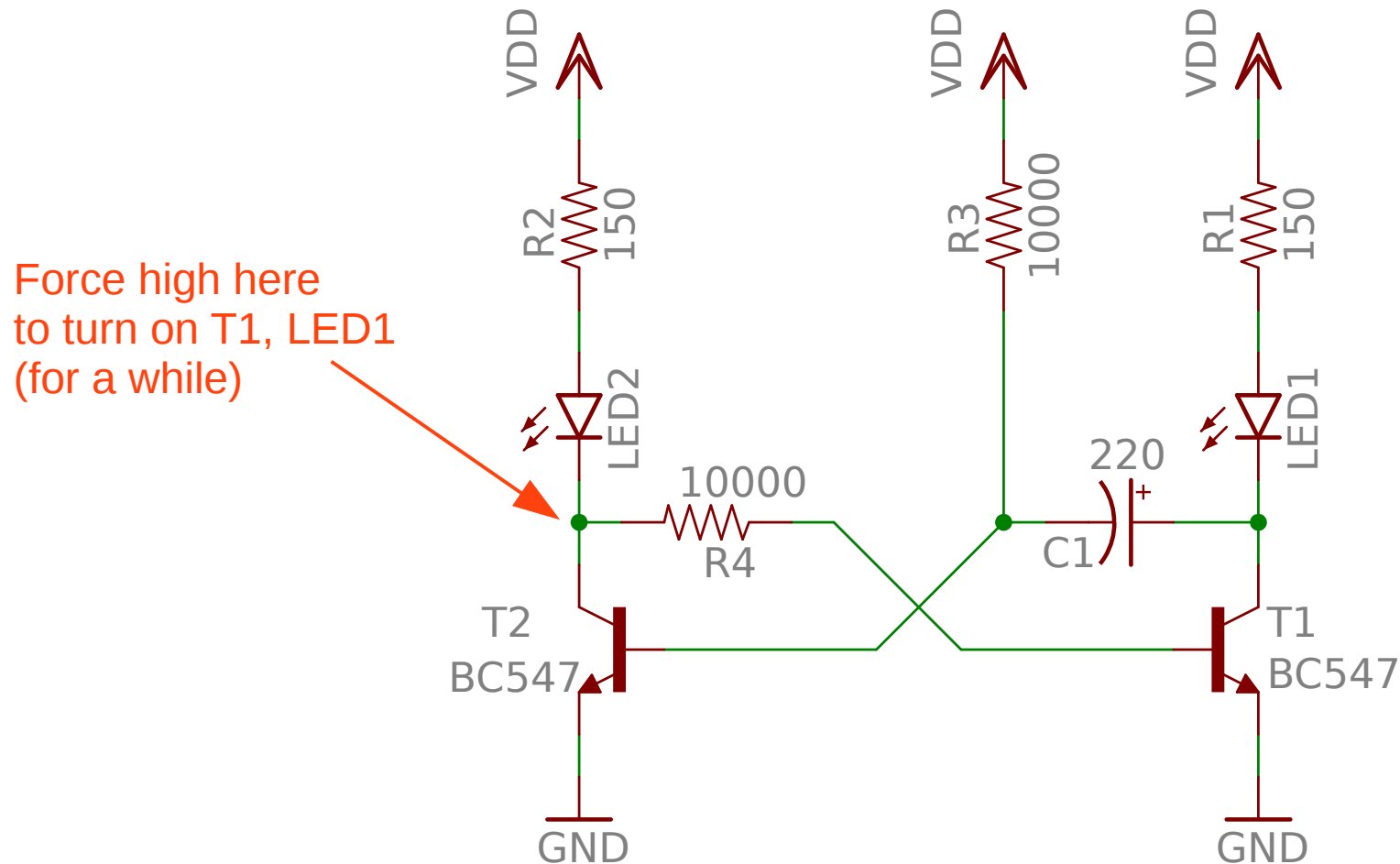
Monostable Circuit

Monostable Circuit – Stable State

IF T2 is ON ...

... T1 is OFF ...

... so ignore this!

Monostable Circuit – Unstable State

Monostable Circuit – Unstable State

… C1 charges,

voltage across C1 increases, so voltage becomes high here

So T2 turns ON and T1 turns OFF

(circuit flips state by itself)

VDD

R2 150

LED2

10000
R4

VDD

R3 10000

220
C1

T2
BC547

VDD

R1 150

LED1

T1
BC547

GND

GND
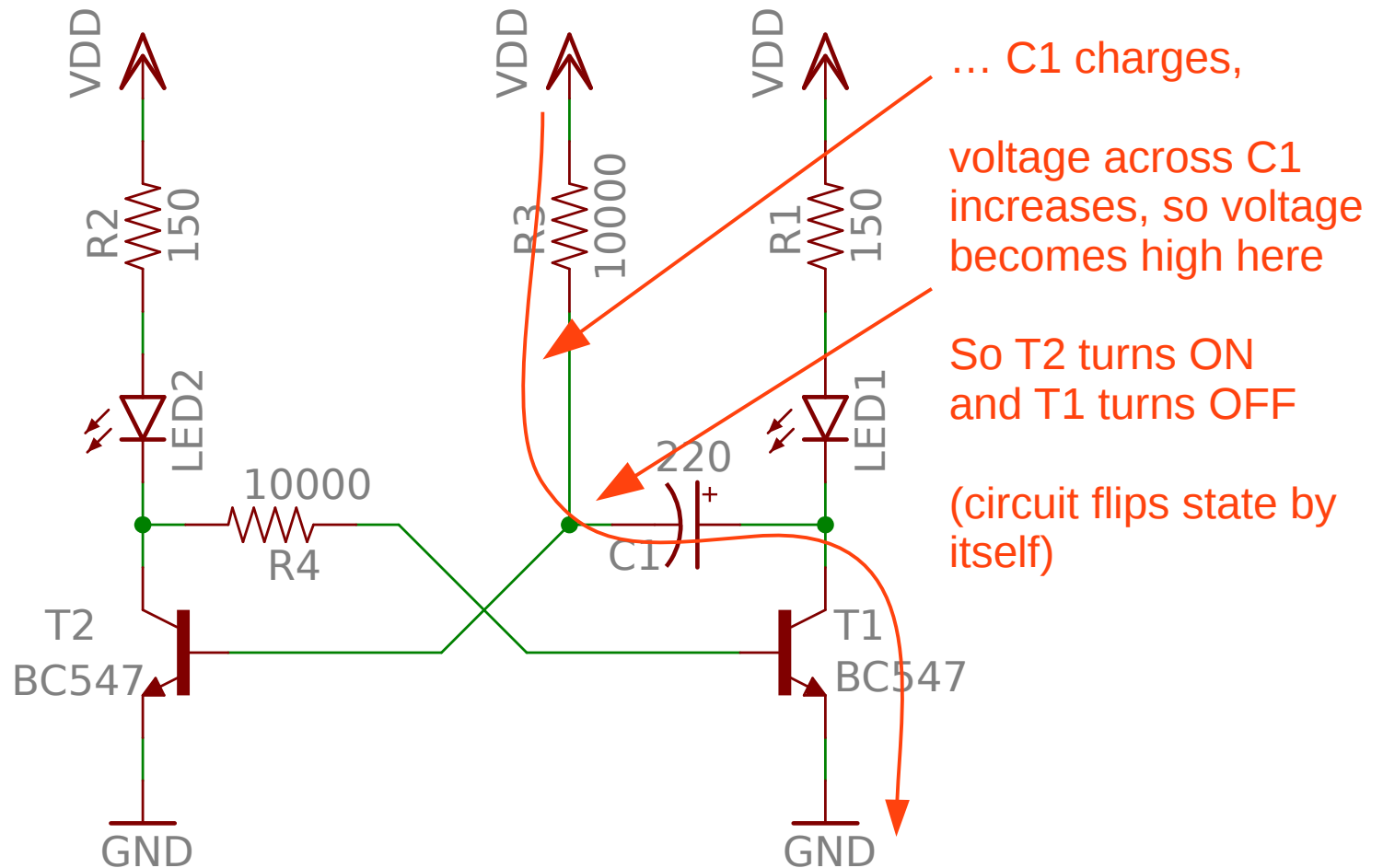
Monostable Circuit – Unstable State

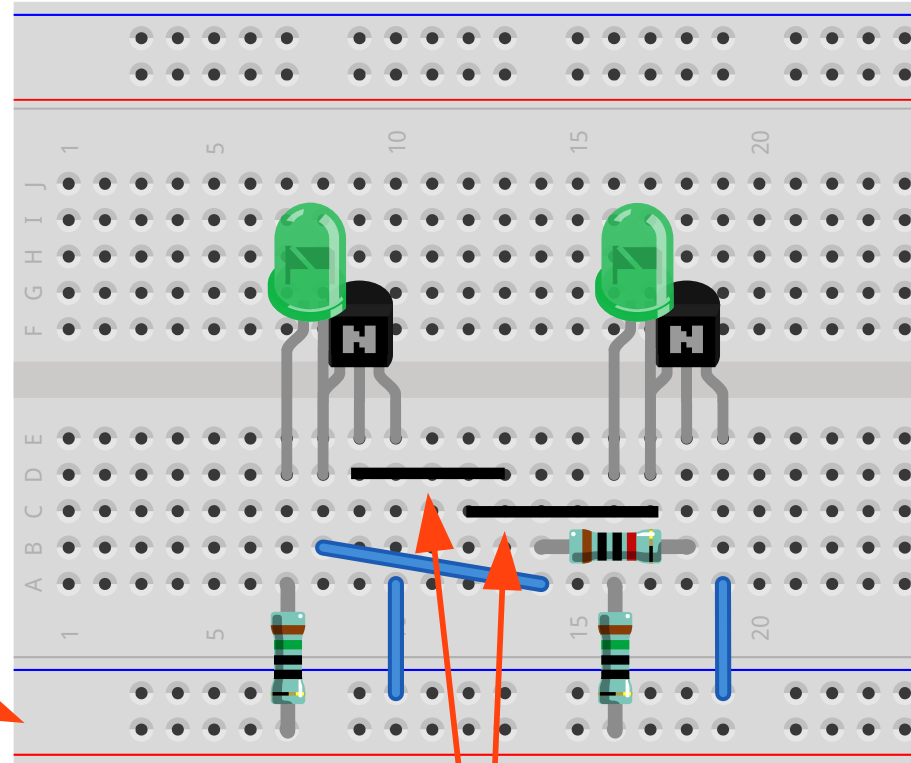# Monostable Animation

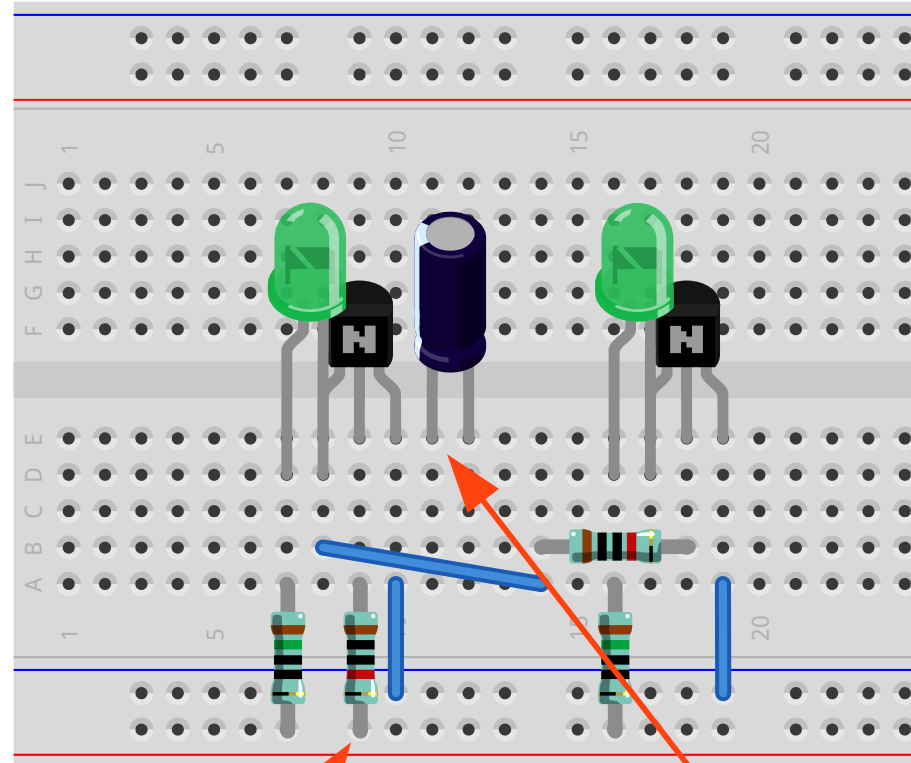http://www.falstad.com/circuit/e-multivib-mono.html

Monostable – Step 1

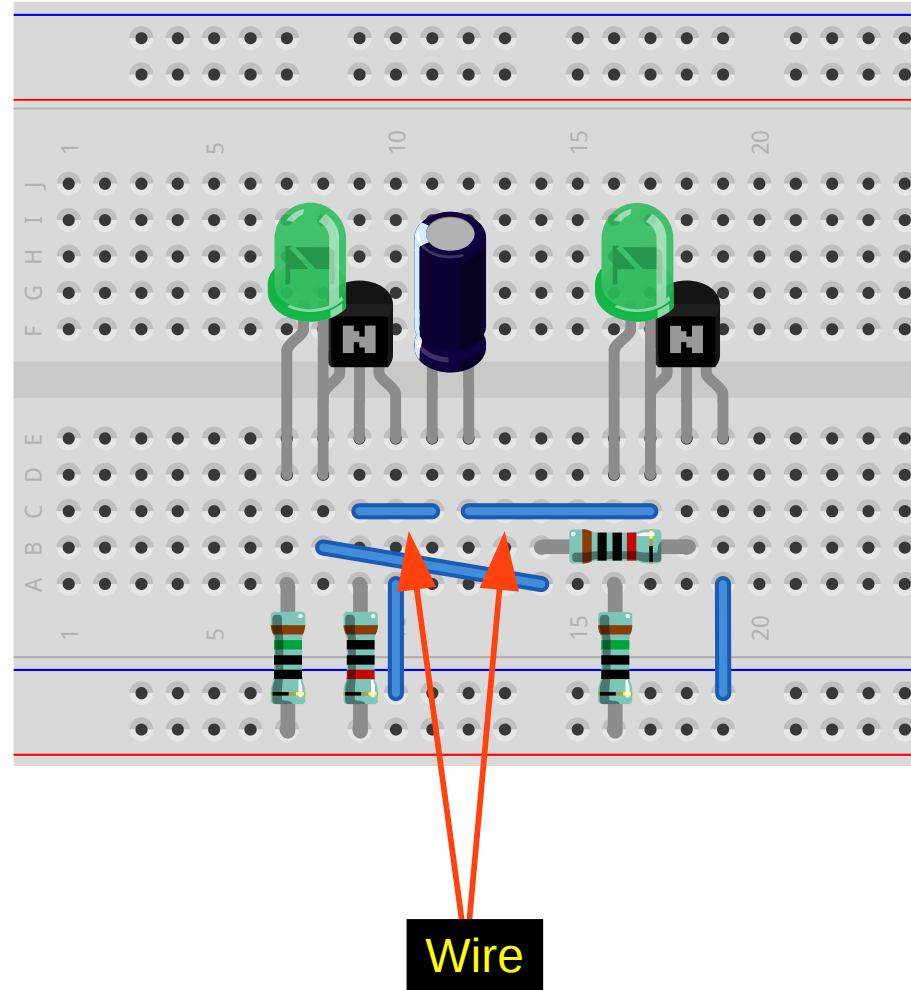Remove power

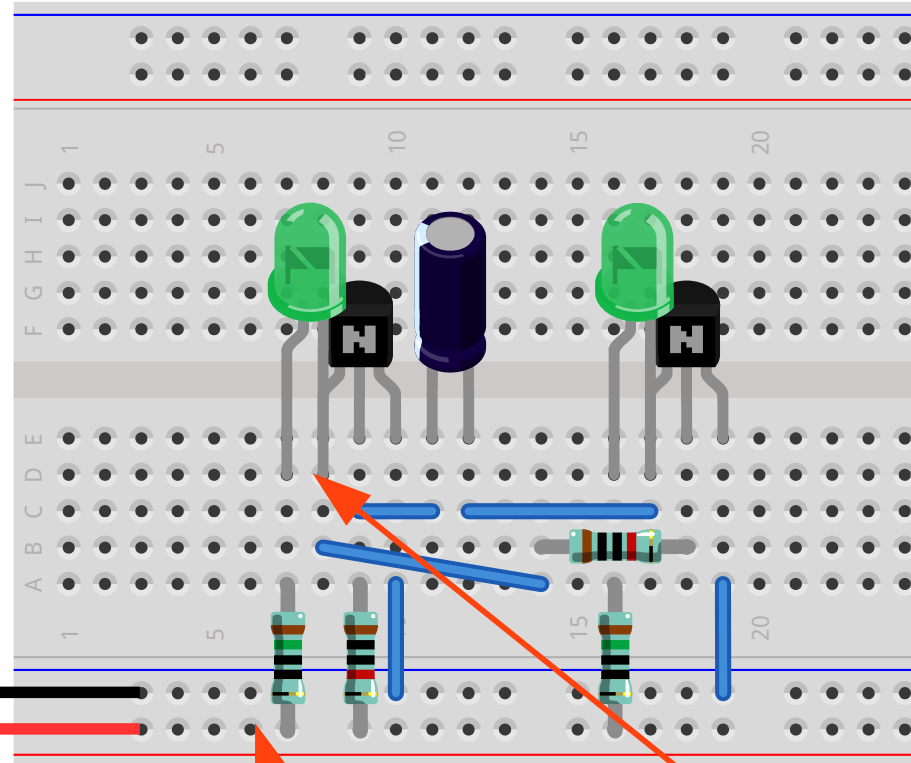Delete rear wire, resistor

Monostable – Step 2

10kΩ resistor
Brown, black, black, red

220µF capacitor
Negative pin (stripe) on left
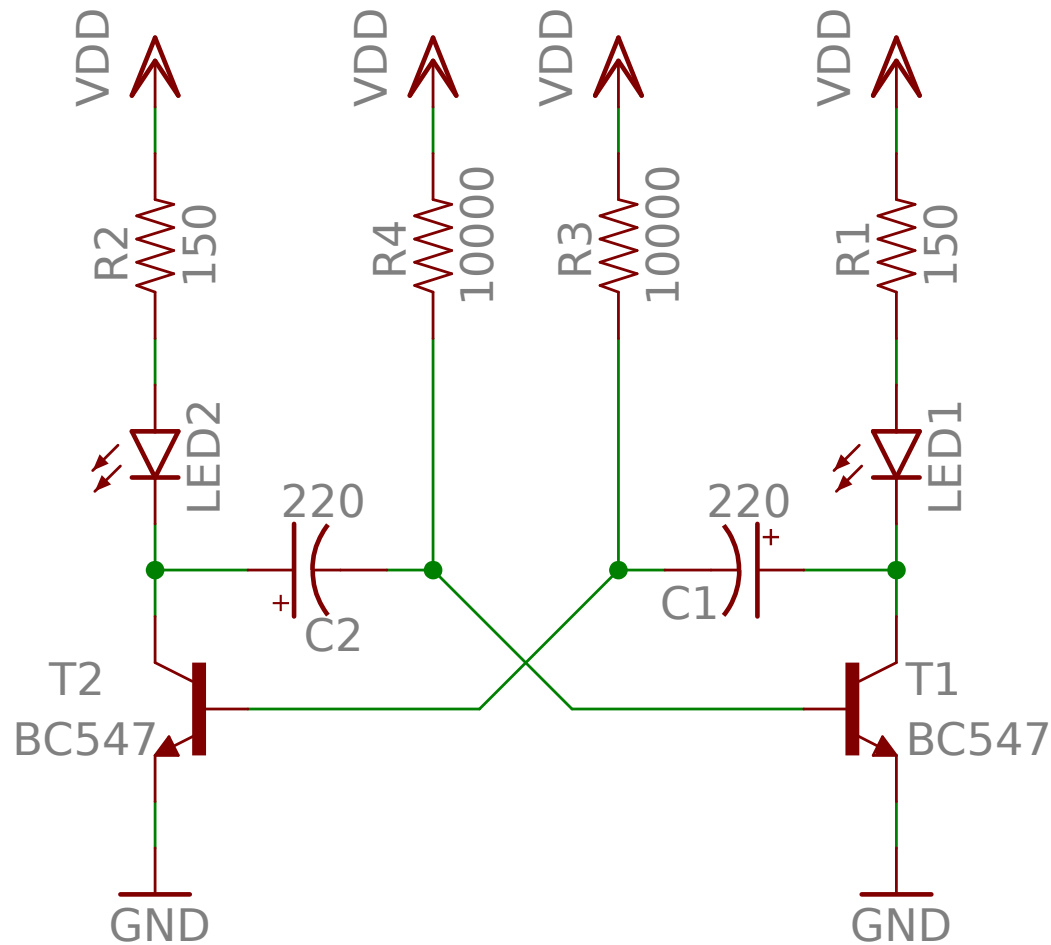
Monostable – Final
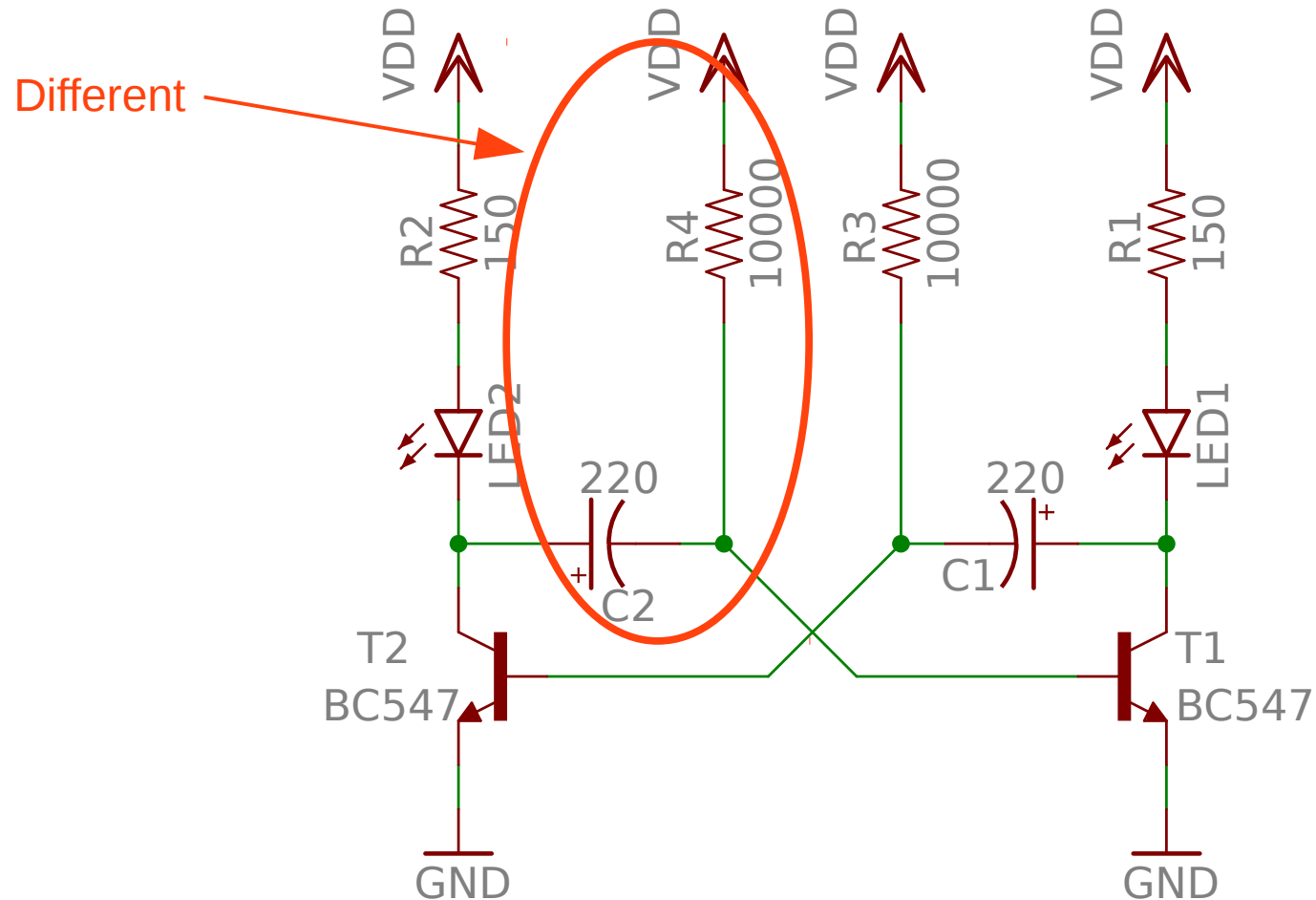

Wire

Monostable – Test

Apply power
Match heat-shrink colors

Touch wire from POWER … to left LED's right pin
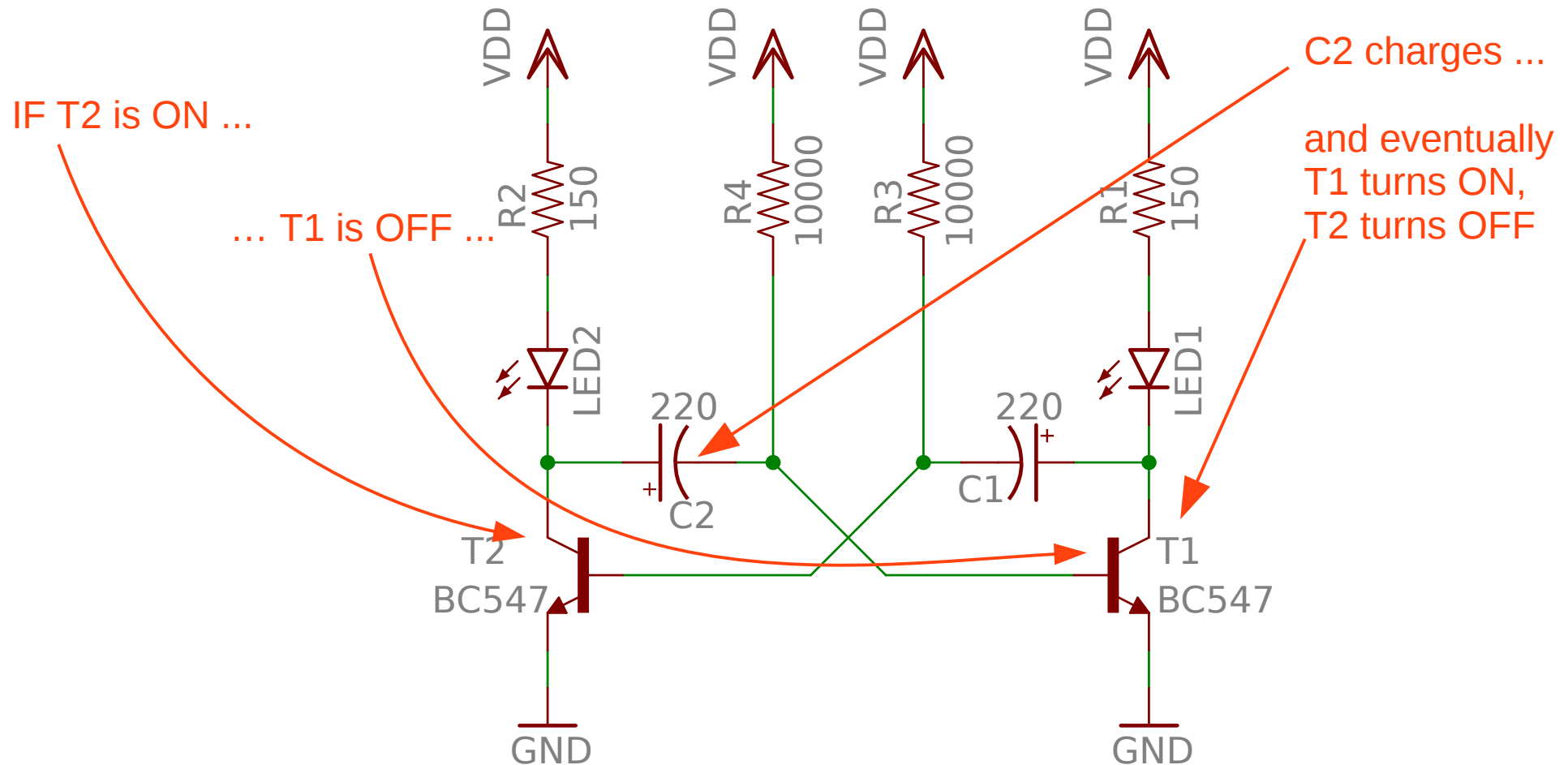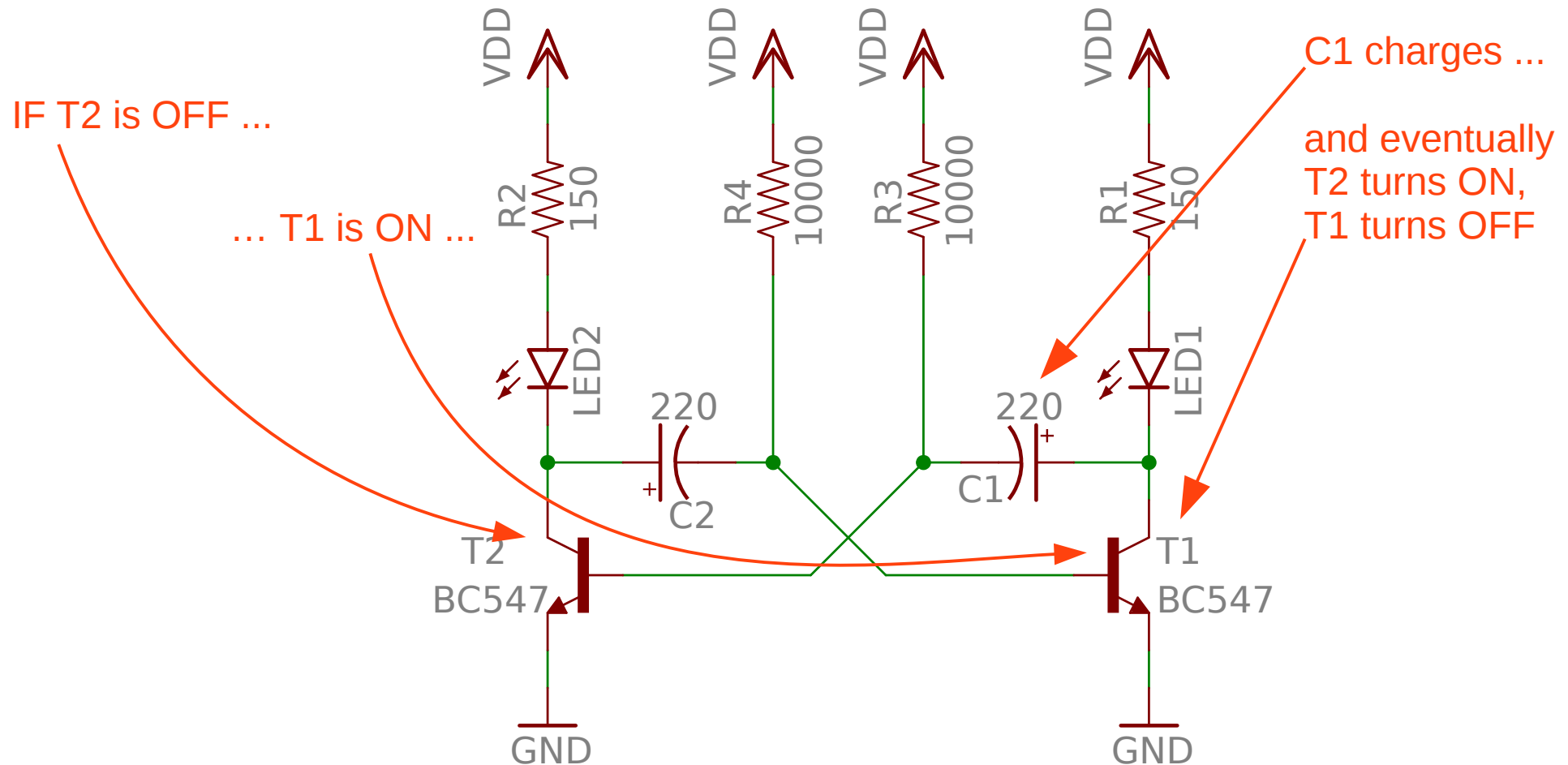Wait for LEDs to change automatically

Astable Circuit

Astable Circuit

Astable Circuit – Unstable state 1
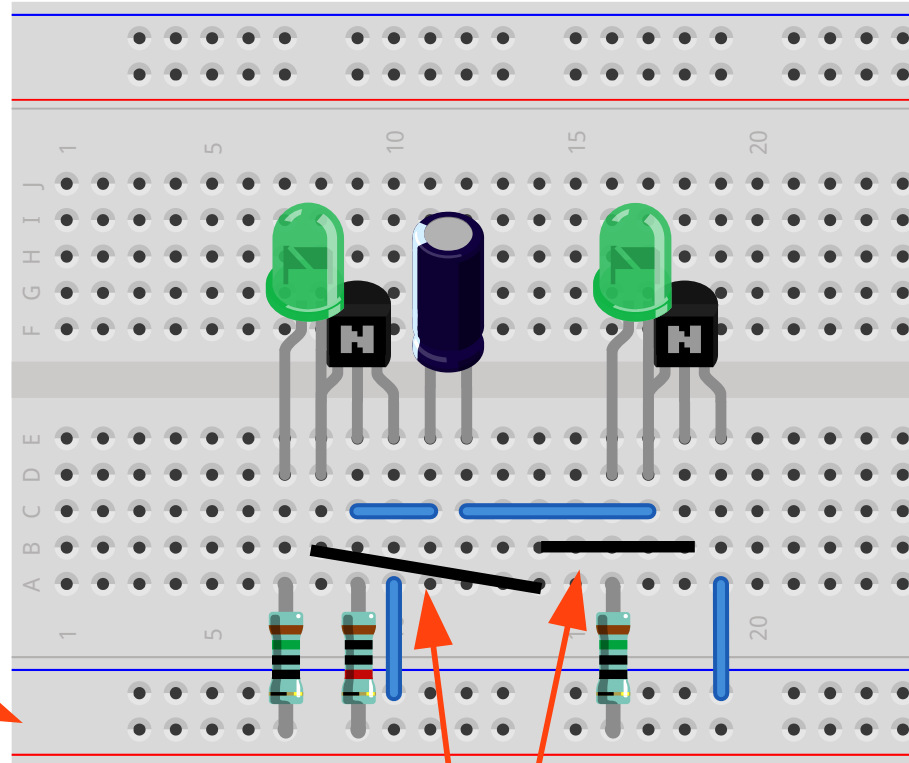
Astable Circuit – Unstable state 2

IF T2 is OFF ...

... T1 is ON ...

C1 charges ...

and eventually
T2 turns ON,
T1 turns OFF

VDD

VDD

VDD

VDD

R2 150

R4 10000

R3 10000

R1 150

LED2

LED1

220

220

C2

C1

T2
BC547

T1
BC547

GND

GND

Astable Animation

http://www.falstad.com/circuit/e-multivib-a.html
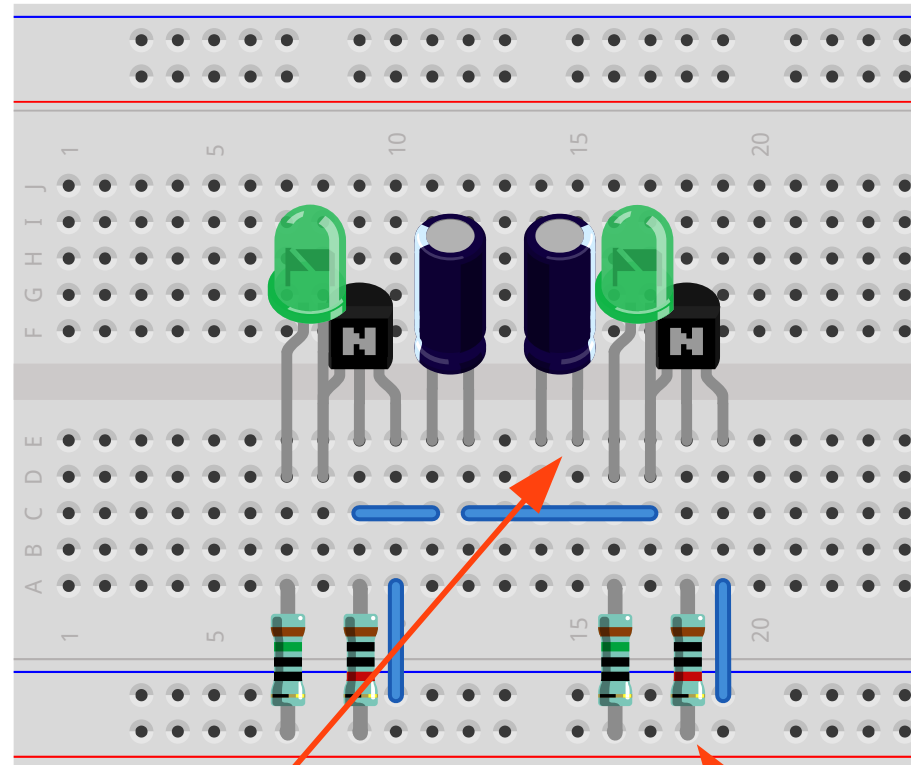
Astable – Step 1

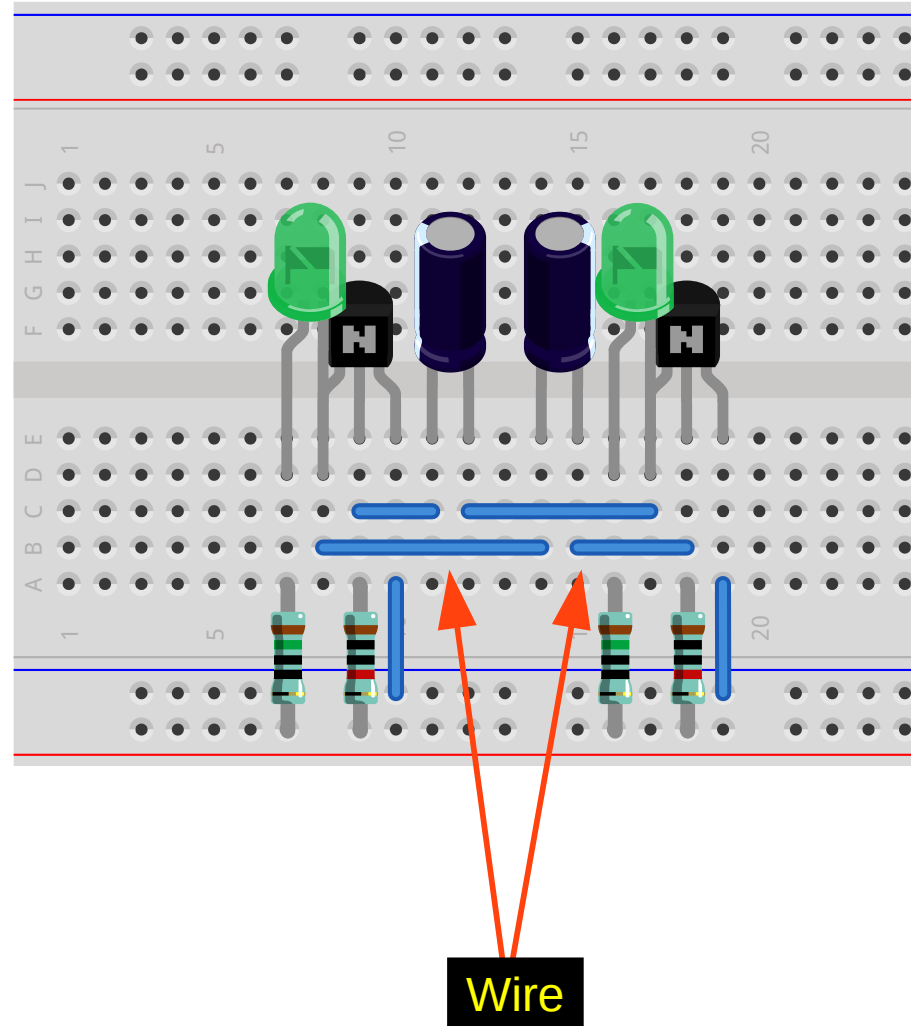Remove power

Delete front wire, resistor

Astable – Step 2

220µF capacitor
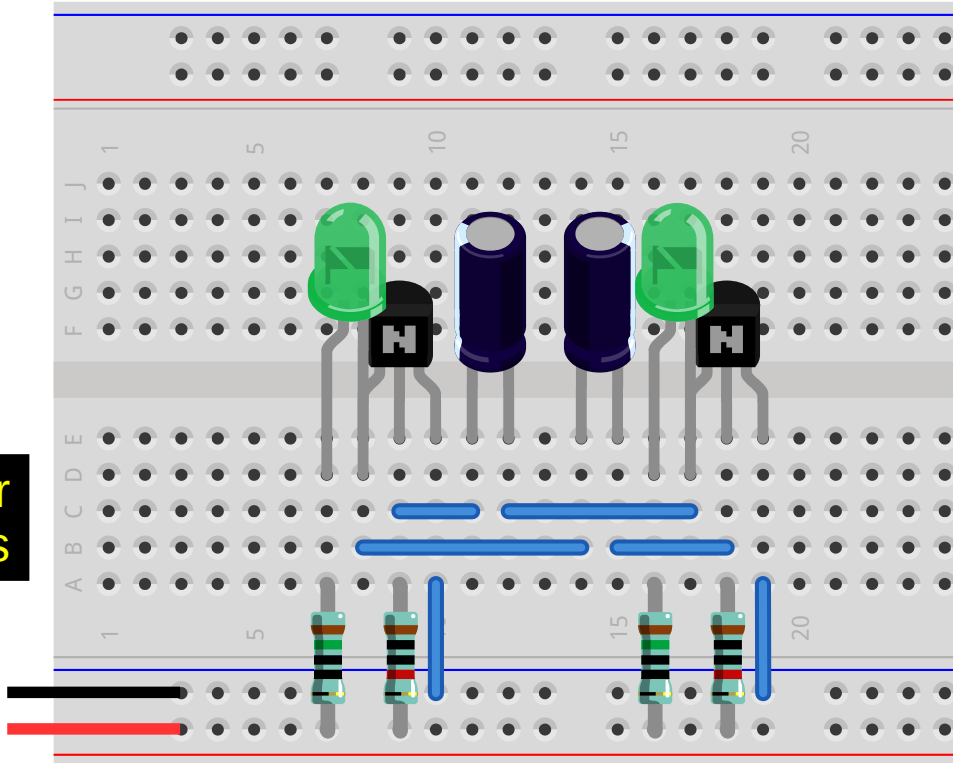Negative pin (stripe) on right

10kΩ resistor
Brown, black, black, red

Astable – Final

Wire

Astable – Test

Apply power
Match heat-shrink colors

Observe circuit switching back and forth
between two states automatically

Questions

(and congratulations for getting through nearly 50 slides!)