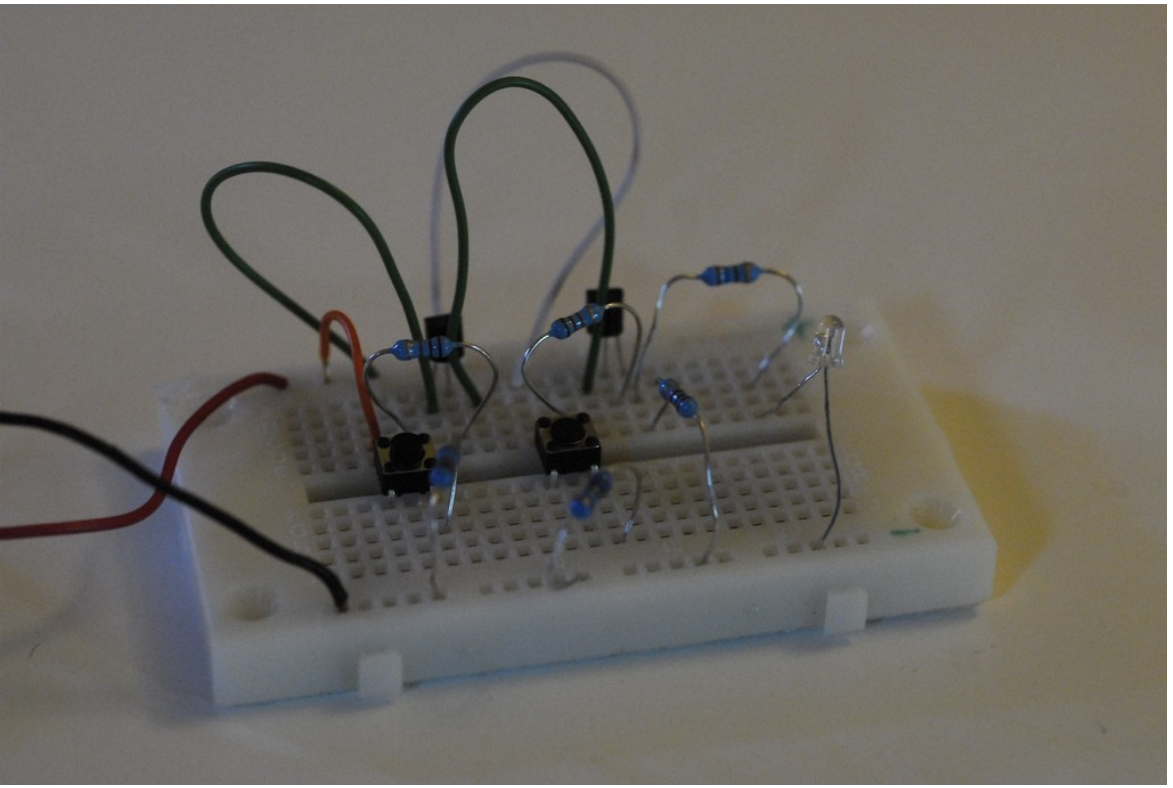


Transistors

Instructor: Morgan Redfield

2010 February 21

2-4:30 PM

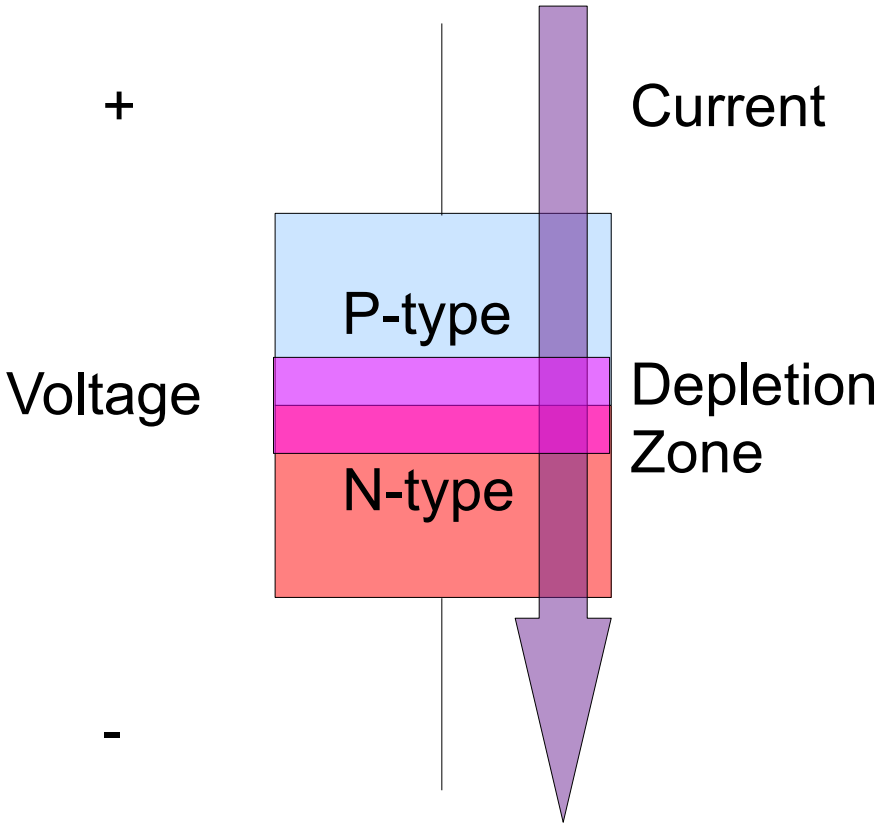
Today we'll be covering

- Background info about diodes
- What are transistors
- BJTs, a very common transistor
- Basic Switches
- Logic Gates
- Amplifiers

What we won't cover

- Why transistors do what they do
- How transistors are made

Diodes: the current valves



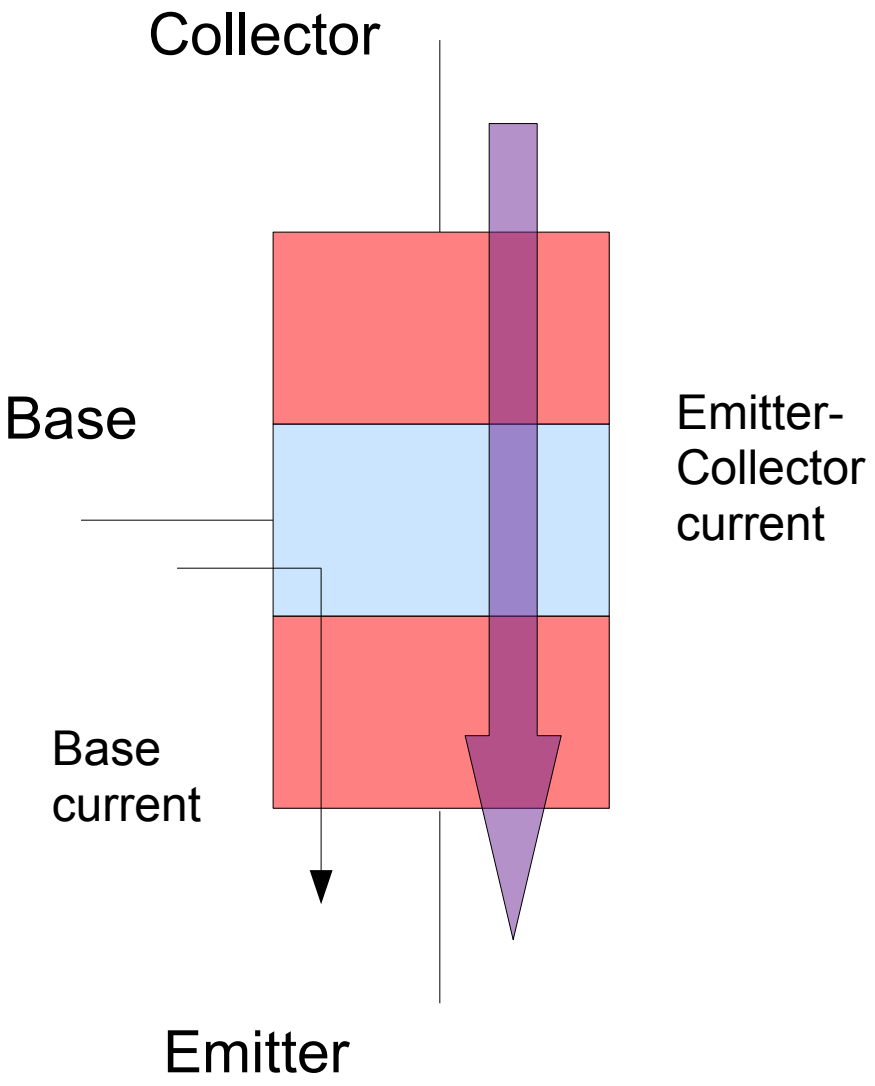
- Diodes let current through in only one direction
- They have a constant voltage drop.
- Two types of semiconductor mashed together (P-N Junction).

What are transistors?

What are transistors (really)?

The semiconductor sandwich

BJTs



Used in:

- Very common as discrete components
- Control current
- Low voltage amplifiers
- Cheap, easy switches

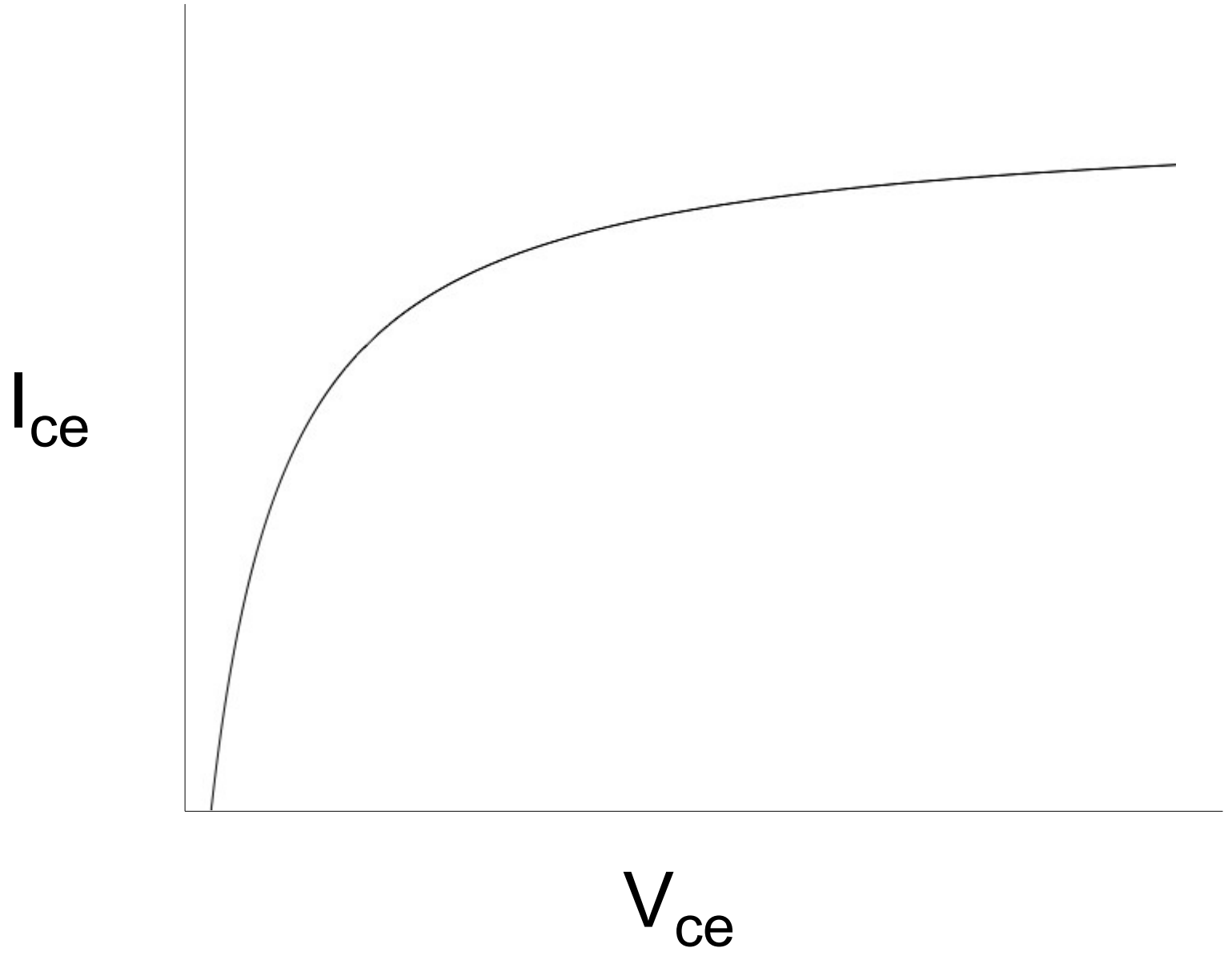
BJT

NPN

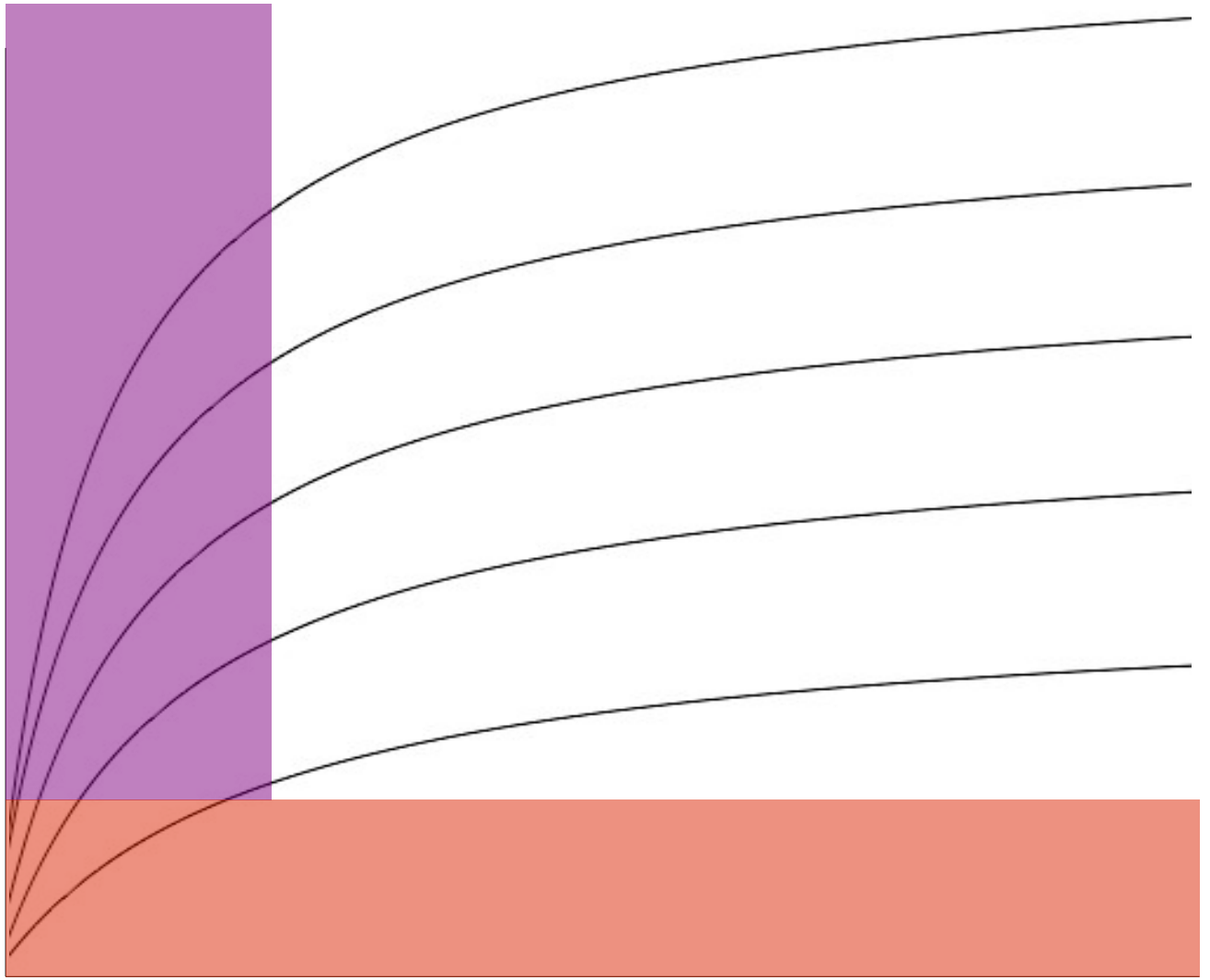
PNP

- Current controlled current amplifier
- Three main regions of operation
- Has current gain parameter β

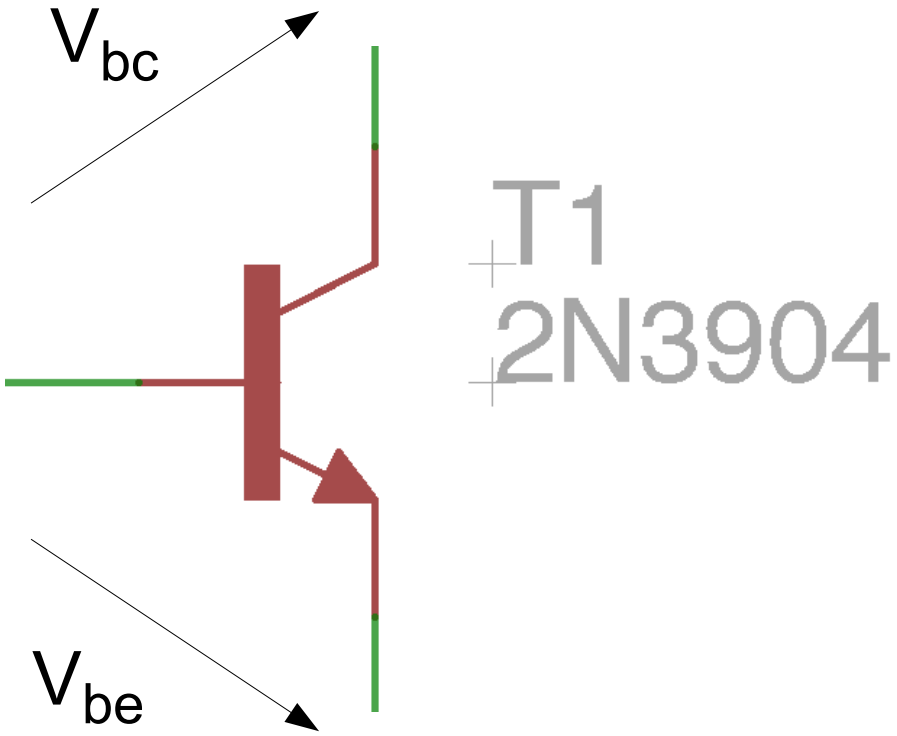
Basic I-V curve



Changing I_{be} changes I-V curve

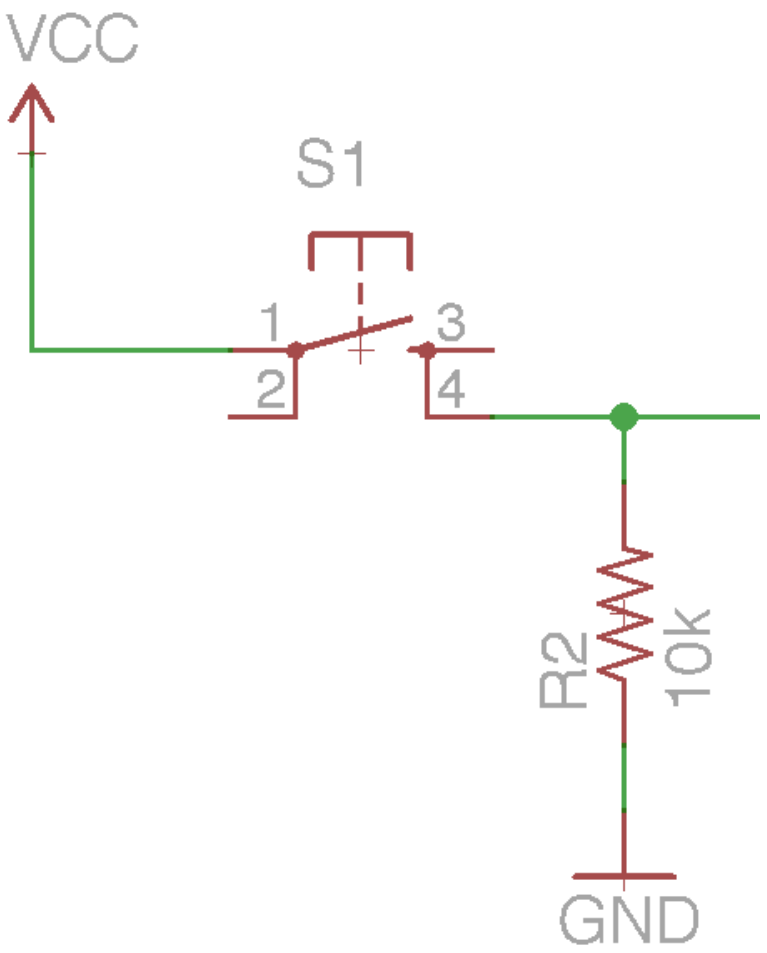


BJT NPN regions of operation



- Cut-off
  - $V_{be} < V_{th}$
  - $I_{ce} = 0$
- Forward Active
  - $V_{be} > V_{th}$, $V_{bc} < 0$
  - $I_{ce} = \beta_F I_{be}$
- Saturation
  - $V_{be} > V_{th}$, $V_{bc} > 0$
  - I_{ce} depends on load

Pull-down resistors

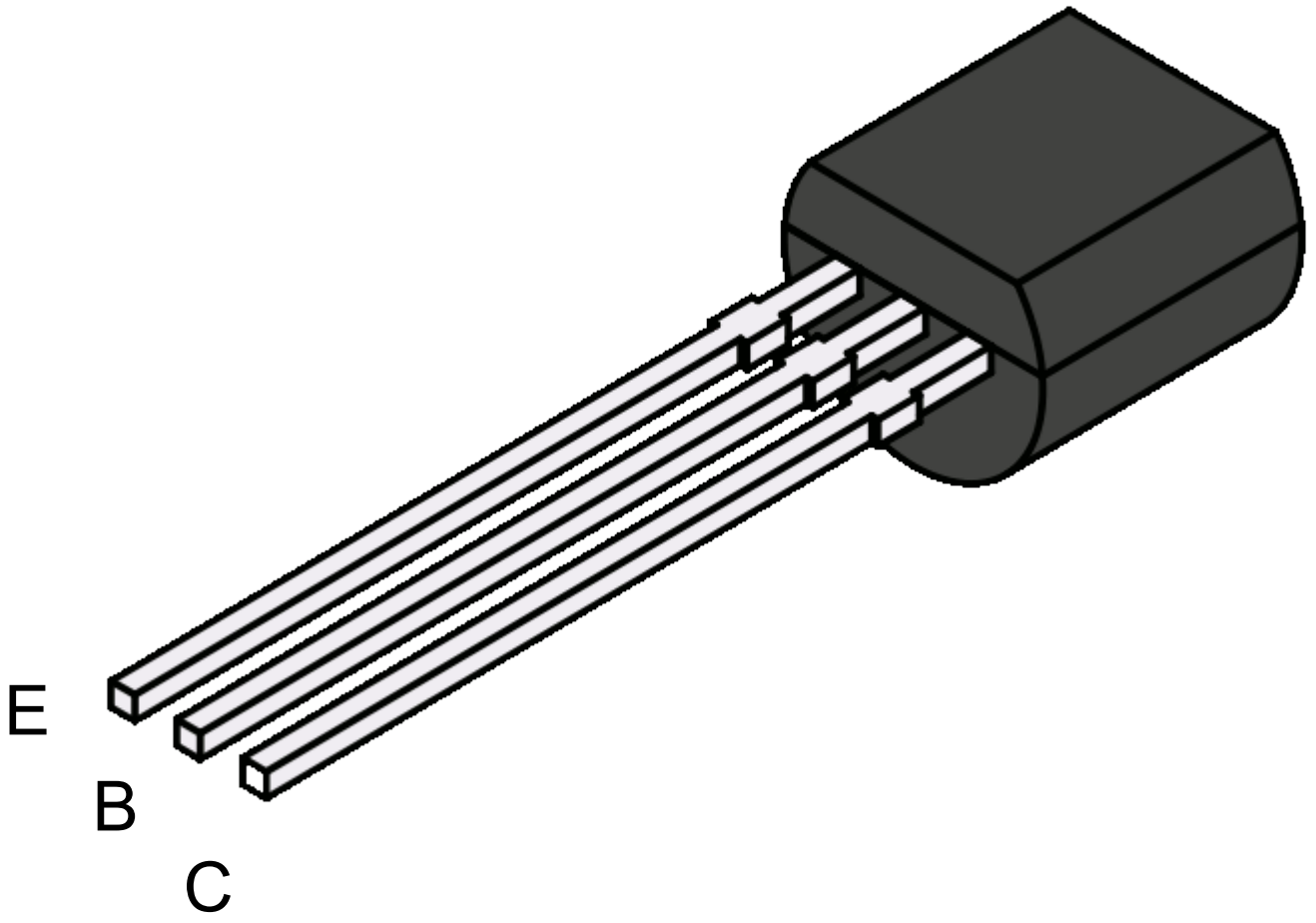


- Ensures that the input sees a certain voltage at all times
- Resistance is arbitrary
- Larger resistances are better (smaller current)

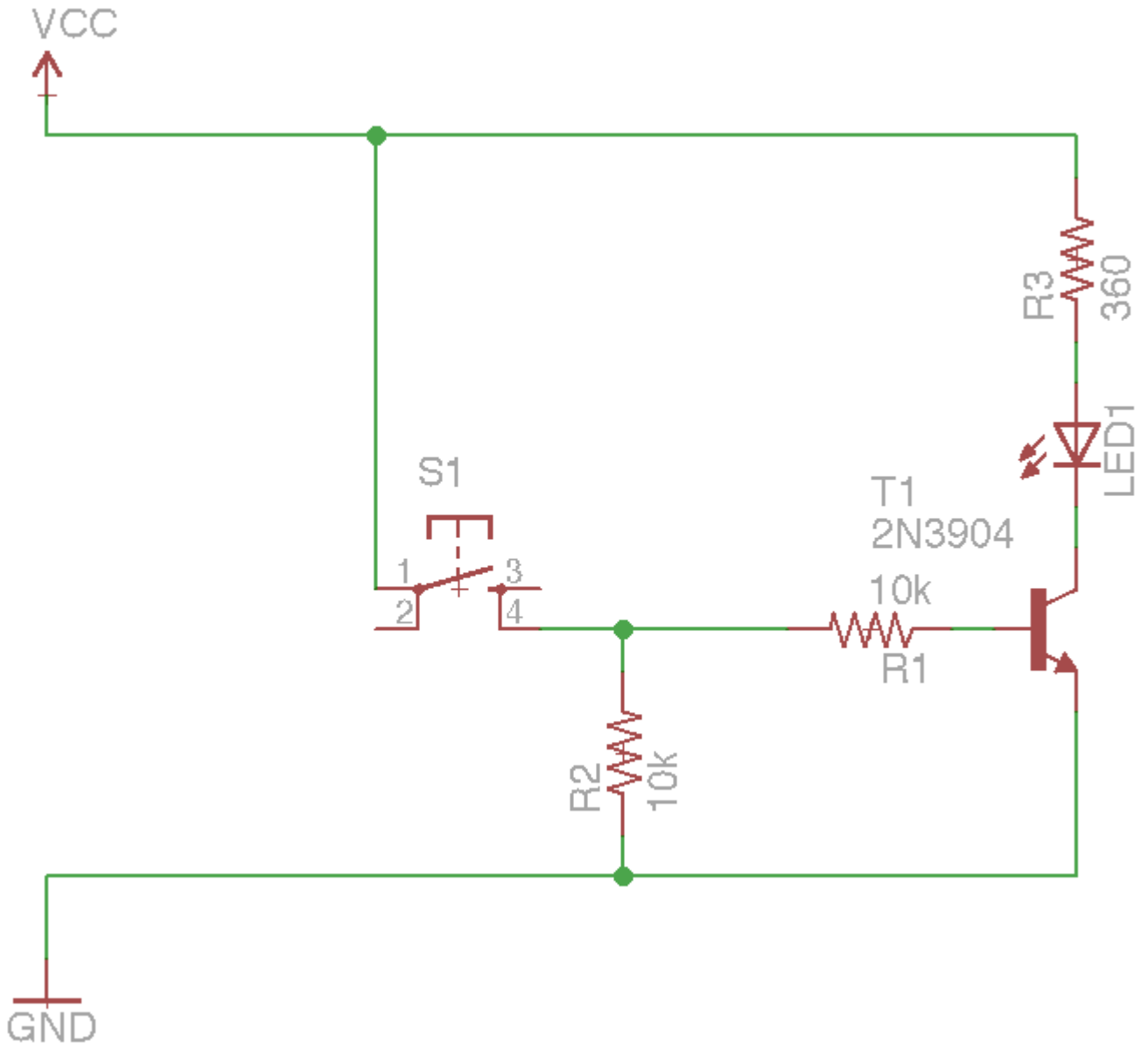
Current limiting resistors

- Sets I_{be} (and thus I_{ce})
- We know desired I_{ce}
  - $I_{be} = I_{ce} / \beta$
- Calculate R via Ohm's Law
  - $R = V/I_{be}$
  - $V = V_{total} - V_{be}$

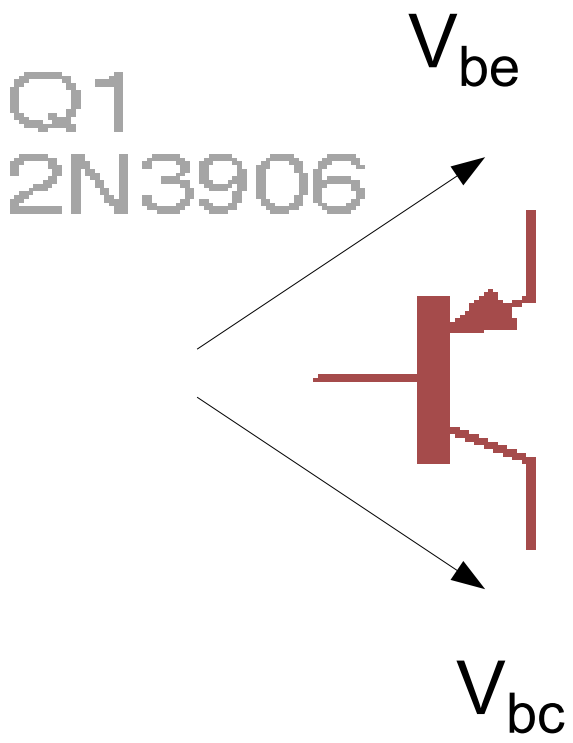
The TO-92 package



NPN Switch

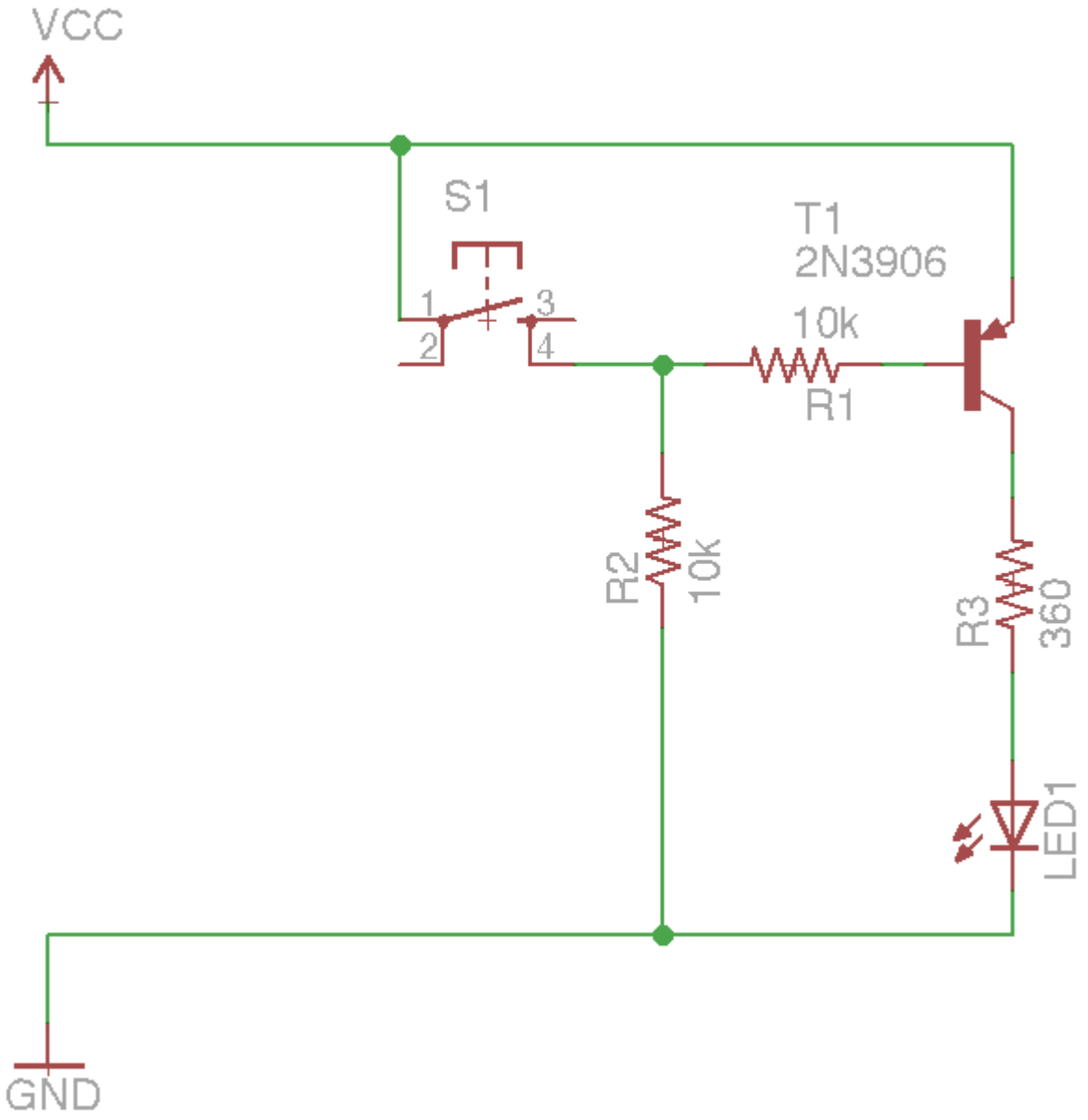


BJT PNP regions of operation



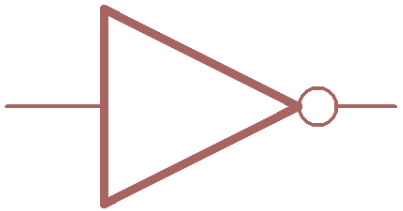
- Cut-off
  - $V_{be} > -V_{th}$, $V_{bc} < 0$
  - $I_{ce} = 0$
- Forward Active
  - $V_{be} < -V_{th}$, $V_{bc} > 0$
  - $I_{ce} = \beta_F I_{be}$
- Saturation
  - $V_{be} < -V_{th}$, $V_{bc} > 0$
  - I_{ce} depends on load

PNP Switch

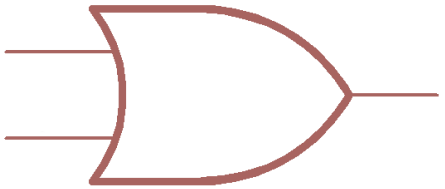


Logic Gates

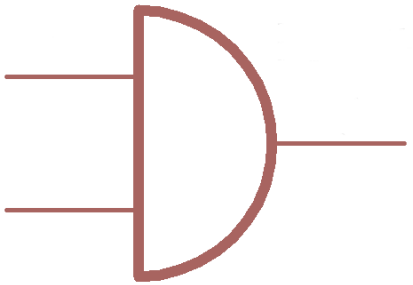
not



or

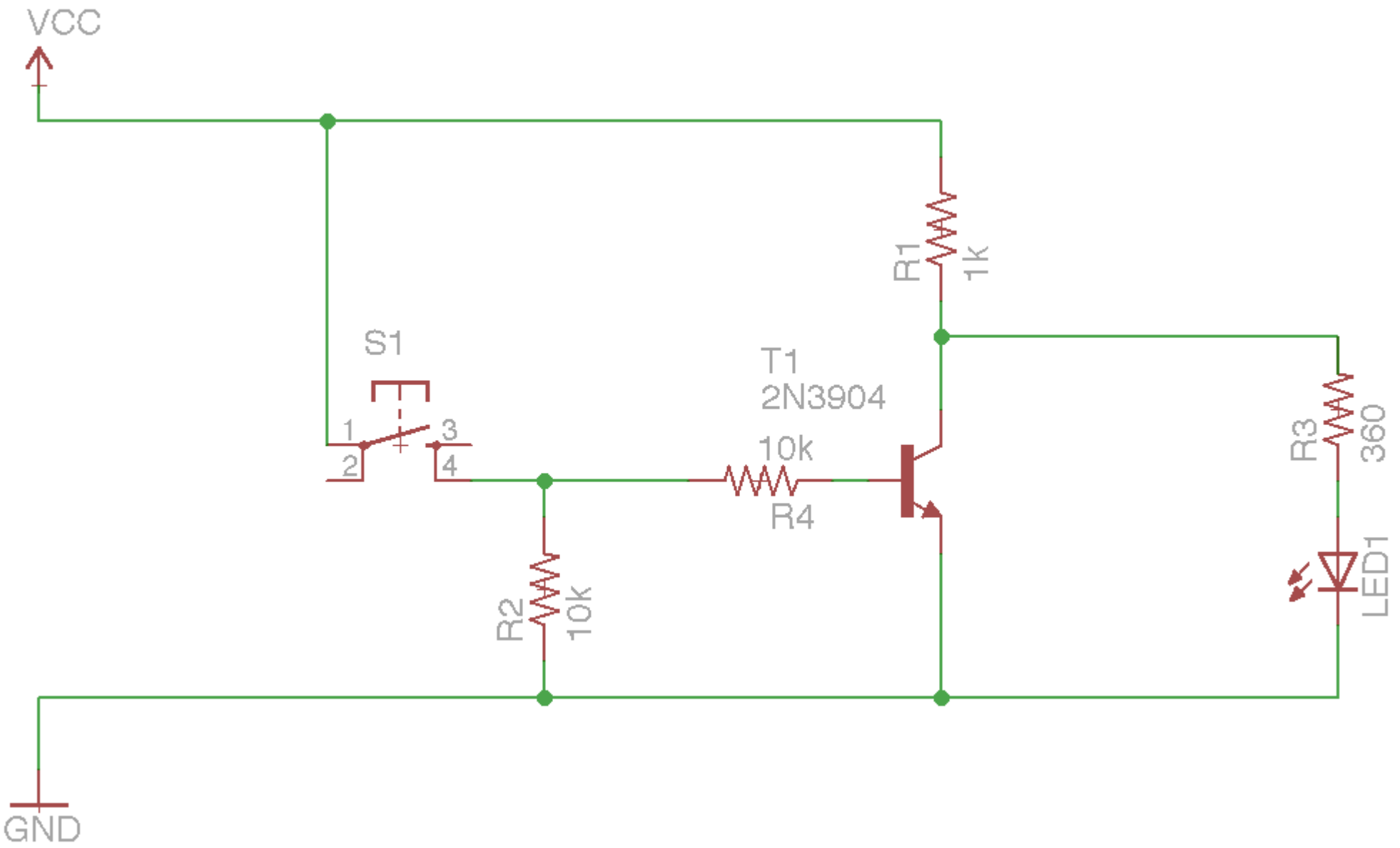


and

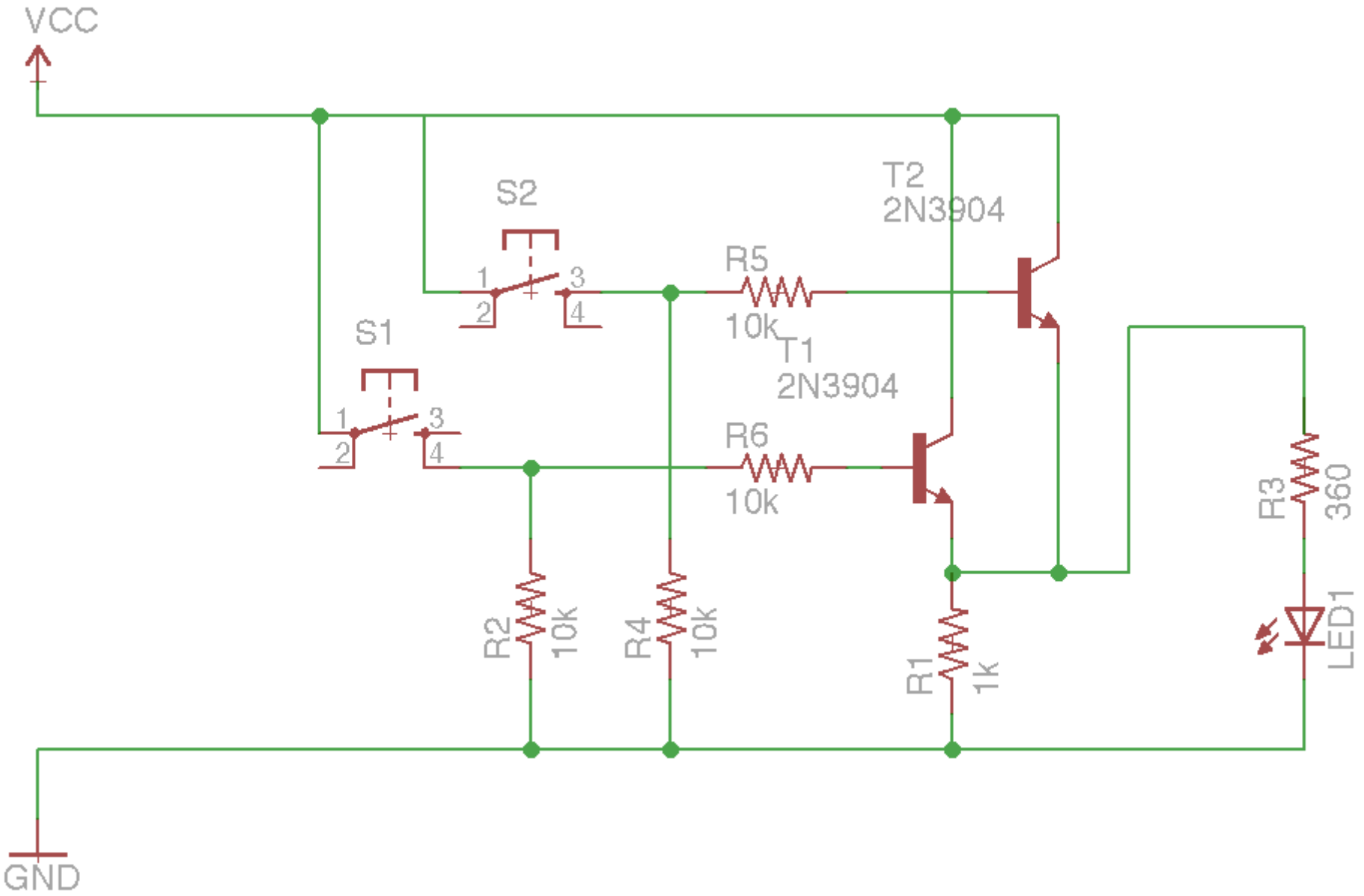


- Generate binary output from binary inputs
- Can be chained together to create complex systems
- BJT logic gates operate in the saturation and cut-off regions

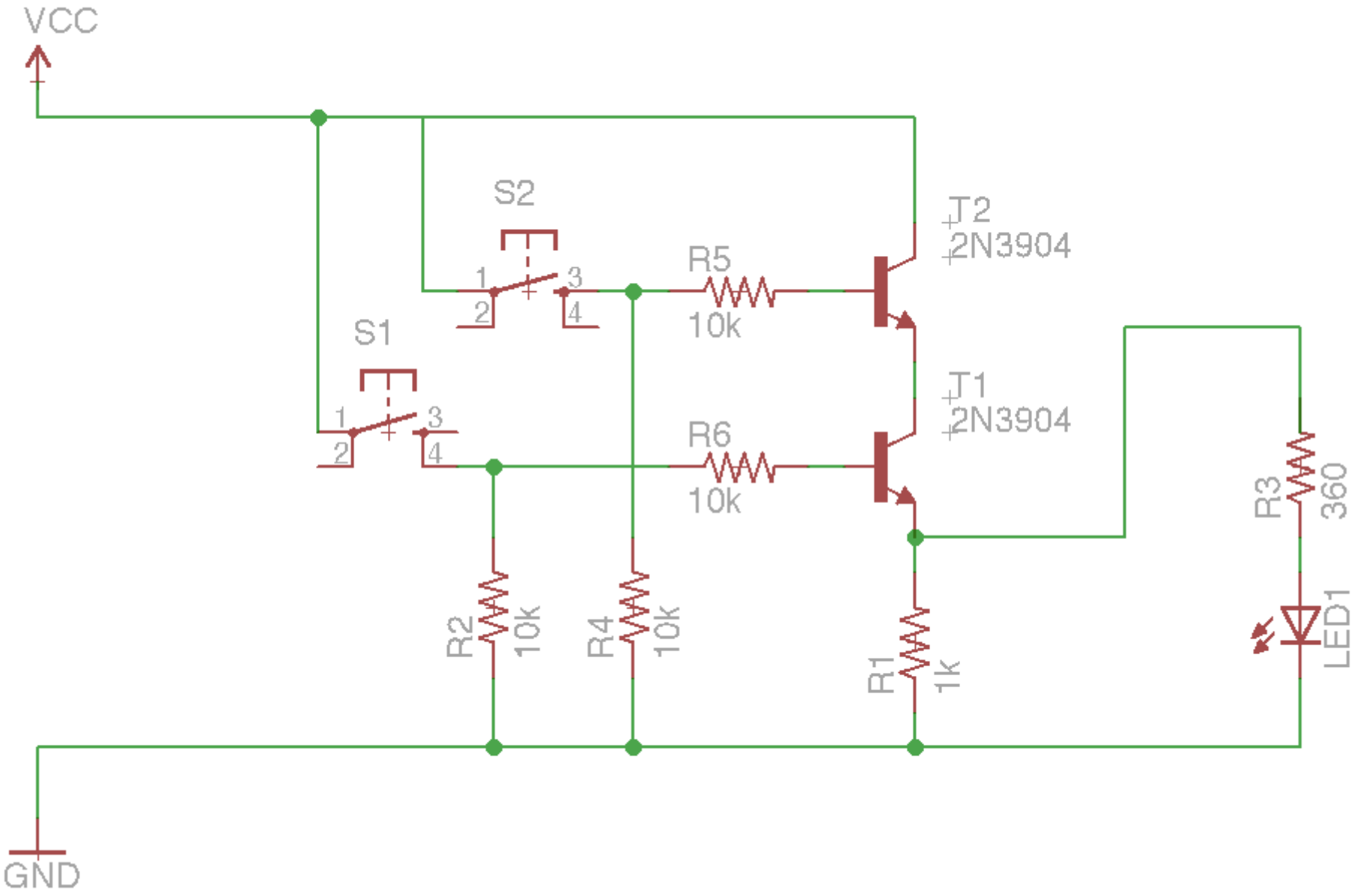
Not Gate



Or Gate


VCC
S2
S1
T2
2N3904
R5
10k
T1
2N3904
R6
10k
R2
10k
R4
10k
R1
1k
R3
360
LED1
GND

And Gate


VCC
S2
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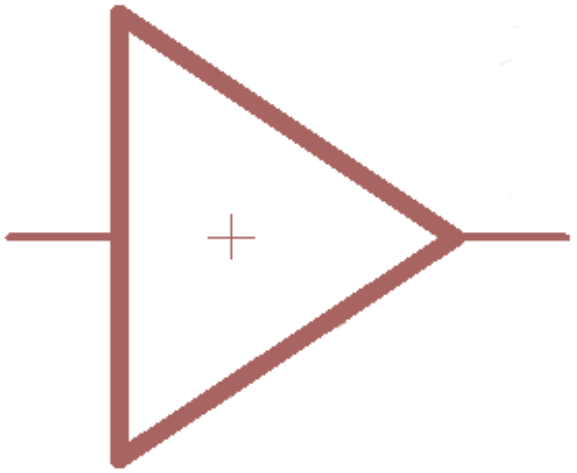
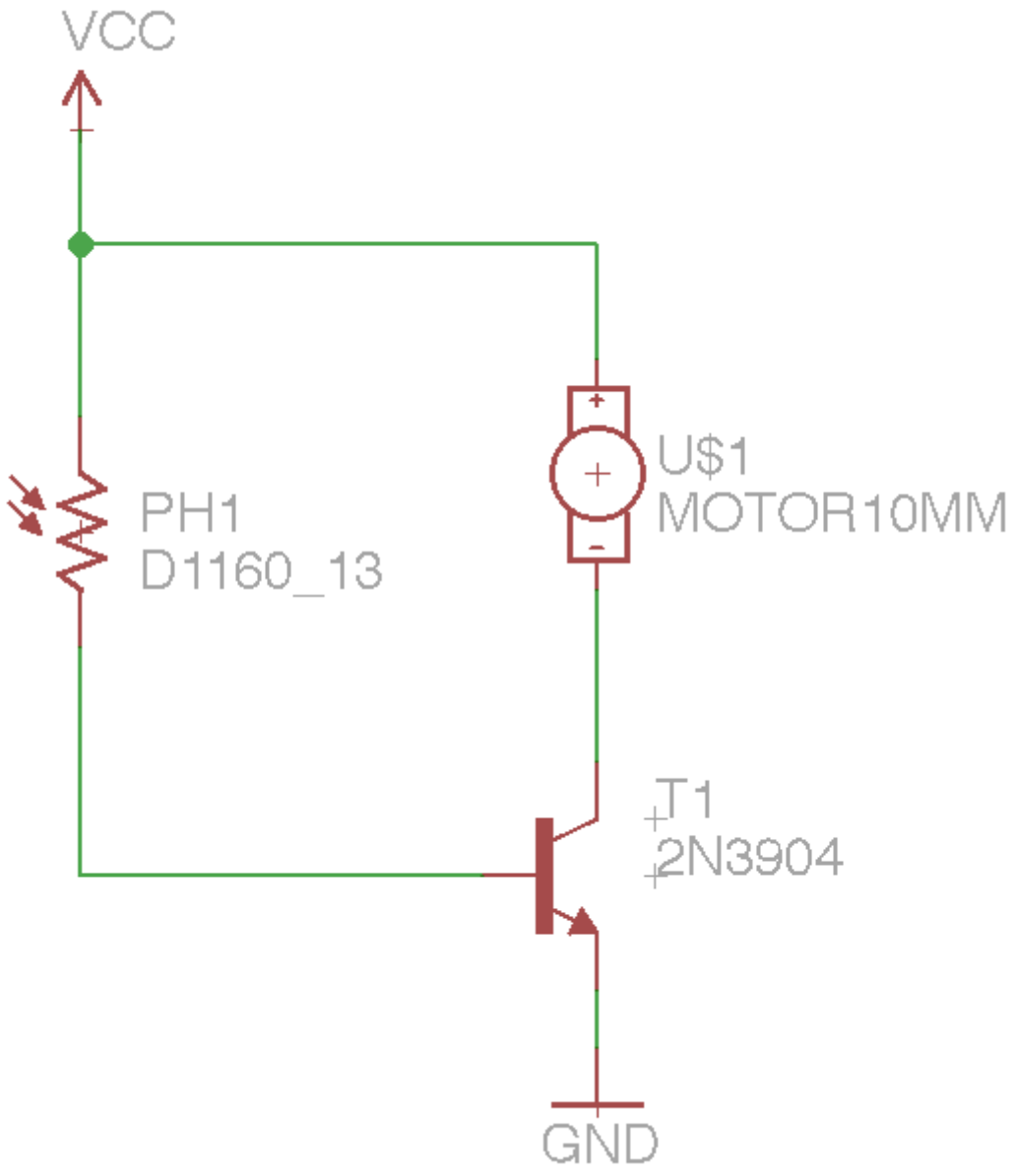
10k
T2
2N3904
T1
2N3904
R2
10k
R4
10k
R1
1k
R3
360
LED1
GND

Amplifiers



- Take a small signal and make it bigger
- Not a passive component (needs external power)
- Often used in audio, sensing, and communications

The simplest amplifier



Where do you go next?

- PSPICE
- Code, by Charles Petzold
- AC amps

Thanks to

- Jason Zack for the switch photo on slide 4
- Matthew Bowden for the faucet photo on slide 5
- Michael Frey for the TO-92 graphic on slide 14